

# **DATA SHEET**

## **SAA7108AE; SAA7109AE HD-CODEC**

Product specification  
Supersedes data of 2003 Mar 26

2004 Jun 29

**HD-CODEC****SAA7108AE; SAA7109AE**

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## 1 FEATURES

## 1.1 Video decoder

- Six analog inputs, internal analog source selectors, e.g.  $6 \times$  CVBS or  $(2 \times$  Y/C and  $2 \times$  CVBS) or  $(1 \times$  Y/C and  $4 \times$  CVBS)
- Two analog preprocessing channels in differential CMOS style for best S/N performance
- Fully programmable static gain or Automatic Gain Control (AGC) for the selected CVBS or Y/C channel
- Switchable white peak control
- Two built-in analog anti-aliasing filters
- Two 9-bit video CMOS Analog-to-Digital Converters (ADCs), digitized CVBS or Y/C signals are available on the Image Port Data (IPD) port under I<sup>2</sup>C-bus control
- On-chip clock generator
- Line-locked system clock frequencies
- Digital PLL for horizontal sync processing and clock generation, horizontal and vertical sync detection
- Requires only one crystal (either 24.576 MHz or 32.11 MHz) for all standards
- Automatic detection of 50 and 60 Hz field frequency, and automatic switching between PAL and NTSC standards
- Luminance and chrominance signal processing for PAL BGHI, PAL N, combination PAL N, PAL M, NTSC M, NTSC-Japan, NTSC N, NTSC 4.43 and SECAM
- User programmable luminance peaking or aperture correction
- Cross-colour reduction for NTSC by chrominance comb filtering
- PAL delay line for correcting PAL phase errors
- Brightness Contrast Saturation (BCS) and hue control on-chip
- Two multi functional real-time output pins controlled by the I<sup>2</sup>C-bus
- Multi-standard VBI data slicer decoding World Standard Teletext (WST), North-American Broadcast Text System (NABTS), Closed Caption (CC), Wide Screen Signalling (WSS), Video Programming System (VPS), Vertical Interval Time Code (VITC) variants (EBU/SMPTE) etc.
- Standard ITU 656 Y-C<sub>B</sub>-C<sub>R</sub> 4 : 2 : 2 format (8-bit) on IPD output bus

- Enhanced ITU 656 output format on IPD output bus containing:
  - active video
  - raw CVBS data for INTERCAST applications (27 MHz data rate)
  - decoded VBI data
- Detection of copy protected input signals according to the Macrovision<sup>TM(1)</sup> standard. Can be used to prevent unauthorized recording of pay-TV or video tape signals.

## 1.2 Video scaler

- Both up and downscaling
- Conversion to square pixel format
- NTSC to 288 lines (video phone)
- Phase accuracy better than  $1/64$  pixel or line, horizontally or vertically
- Independent scaling definitions for odd and even fields
- Anti-alias filter for horizontal scaling
- Provides output as:
  - scaled active video
  - raw CVBS data for INTERCAST, WAVE-PHORE, POPCON applications or general VBI data decoding (27 MHz or sample rate converted)
- Local video output for Y-C<sub>B</sub>-C<sub>R</sub> 4 : 2 : 2 format (VMI, VIP, ZV).

(1) Macrovision<sup>TM</sup> is a trademark of the Macrovision Corporation.

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### 1.3 Video encoder

- Digital PAL/NTSC encoder with integrated high quality scaler and anti-flicker filter for TV output from a PC
- Supports Intel® Digital Video Out (DVO) low voltage interfacing to graphics controller
- 27 MHz crystal-stable subcarrier generation
- Maximum graphics pixel clock 85 MHz at double edged clocking, synthesized on-chip or from external source
- Programmable assignment of clock edge to bytes (in double edged mode)
- Synthesizable pixel clock (PIXCLK) with minimized output jitter, can be used as reference clock for the VGC, as well
- PIXCLK output and bi-phase PIXCLK input (VGC clock loop-through possible)
- Hot-plug detection through dedicated interrupt pin
- Supported VGA resolutions for PAL or NTSC legacy video output up to  $1280 \times 1024$  graphics data at 60 or 50 Hz frame rate
- Supported VGA resolutions for HDTV output up to  $1920 \times 1080$  interlaced graphics data at 60 or 50 Hz frame rate
- Three Digital-to-Analog Converters (DACs) for CVBS (BLUE,  $C_B$ ), VBS (GREEN, CVBS) and C (RED,  $C_R$ ) at 27 MHz sample rate (signals in parenthesis are optionally selected), all at 10-bit resolution
- Non-interlaced  $C_B$ -Y- $C_R$  or RGB input at maximum 4 : 4 : 4 sampling
- Downscaling and upscaling from 50 to 400 %
- Optional interlaced  $C_B$ -Y- $C_R$  input of Digital Versatile Disk (DVD) signals
- Optional non-interlaced RGB output to drive second VGA monitor (bypass mode, maximum 85 MHz)
- 3 × 256 bytes RGB Look-Up Table (LUT)
- Support for hardware cursor
- HDTV up to  $1920 \times 1080$  interlaced and  $1280 \times 720$  progressive, including 3-level sync pulses
- Programmable border colour of underscan area
- Programmable 5 line anti-flicker filter
- On-chip 27 MHz crystal oscillator (3rd-harmonic or fundamental 27 MHz crystal)
- Fast I<sup>2</sup>C-control port (400 kHz)
- Encoder can be master or slave

- Adjustable output levels for the DACs
- Programmable horizontal and vertical input synchronization phase
- Programmable horizontal sync output phase
- Internal Colour Bar Generator (CBG)
- Optional support of various Vertical Blanking Interval (VBI) data insertion
- Macrovision Pay-per-View copy protection system rev. 7.01, rev. 6.1 and rev. 1.03 (525p) as option; this applies to SAA7108AE only. The device is protected by USA patent numbers 4631603, 4577216 and 4819098 and other intellectual property rights. Use of the Macrovision anti-copy process in the device is licensed for non-commercial home use only. Reverse engineering or disassembly is prohibited. Please contact your nearest Philips Semiconductors sales office for more information.

### 1.4 Common features

- 5 V tolerant digital I/O ports
- I<sup>2</sup>C-bus controlled (full read-back ability by an external controller, bit rate up to 400 kbit/s)
- Versatile power-save modes
- Boundary scan test circuit complies with the "IEEE Std. 1149.1-1994" (separate ID codes for decoder and encoder)
- Monolithic CMOS 3.3 V device
- BGA156 package
- Moisture Sensitive Level (MSL): e3.

## 2 APPLICATIONS

- Notebook (low-power consumption)
- PCMCIA card application
- AGP based graphics cards
- PC editing
- Image processing
- Video phone applications
- INTERCAST and PC teletext applications
- Security applications
- Hybrid satellite set-top boxes.

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## 3 GENERAL DESCRIPTION

The SAA7108AE; SAA7109AE is a new multi-standard video decoder and encoder chip, offering high quality video input and TV output processing as required by PC-99 specifications. It enables hardware manufacturers to implement versatile video functions on a significantly reduced printed-circuit board area at very competitive costs.

Separate pins for supply voltages as well as for I<sup>2</sup>C-bus control and boundary scan test have been provided for the video encoder and decoder sections to ensure both flexible handling and optimized noise behaviour.

The **video encoder** is used to encode PC graphics data at maximum 1280 × 1024 resolution (optionally 1920 × 1080 interlaced) to PAL (50 Hz) or NTSC (60 Hz) video signals. A programmable scaler and anti-flicker filter (maximum 5 lines) ensures properly sized and flicker-free TV display as CVBS or S-video output.

Alternatively, the three Digital-to-Analog Converters (DACs) can output RGB signals together with a TTL composite sync to feed SCART connectors.

When the scaler/interlacer is bypassed, a second VGA monitor can be connected to the RGB outputs and separate H and V-syncs as well, thereby serving as an auxiliary monitor at maximum 1280 × 1024 resolution/60 Hz (PIXCLK < 85 MHz). Alternatively this port can provide Y, P<sub>B</sub> and P<sub>R</sub> signals for HDTV monitors.

The encoder section includes a sync/clock generator and on-chip DACs.

All inputs intended to interface to the host graphics controller are designed for low-voltage signals down to 1.1 V and up to 3.45 V.

The **video decoder**, a 9-bit video input processor, is a combination of a 2-channel analog pre-processing circuit including source selection, anti-aliasing filter and Analog-to-Digital Converter (ADC), automatic clamp and gain control, a Clock Generation Circuit (CGC), and a digital multi-standard decoder (PAL BGHI, PAL M, PAL N, combination PAL N, NTSC M, NTSC-Japan, NTSC N, NTSC 4.43 and SECAM).

The decoder includes a brightness, contrast and saturation control circuit, a multi-standard VBI data slicer and a 27 MHz VBI data bypass. The pure 3.3 V (5 V compatible) CMOS circuit SAA7108AE; SAA7109AE, consisting of an analog front-end and digital video decoder, a digital video encoder and analog back-end, is a highly integrated circuit especially designed for desktop video applications.

The decoder is based on the principle of line-locked clock decoding and is able to decode the colour of PAL, SECAM and NTSC signals into ITU-R BT.601 compatible colour component values.

The encoder can operate fully independently at its own variable pixel clock, transporting graphics input data, and at the line-locked, single crystal-stable video encoding clock.

As an option, it is possible to slave the video PAL/NTSC encoding to the video decoder clock with the encoder FIFO acting as a buffer to decouple the line-locked decoder clock from the crystal-stable encoder clock.

## 4 ORDERING INFORMATION

TYPE NUMBER	PACKAGE		
	NAME	DESCRIPTION	VERSION
SAA7108AE	BGA156	plastic ball grid array package; 156 balls; body 15 × 15 × 1.15 mm	SOT472-1
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## 5 QUICK REFERENCE DATA

SYMBOL	PARAMETER	CONDITIONS	MIN.	TYP.	MAX.	UNIT
$V_{DDD}$	digital supply voltage		3.15	3.3	3.45	V
$V_{DDA}$	analog supply voltage		3.15	3.3	3.45	V
$T_{amb}$	ambient temperature		0	–	70	°C
$P_{A+D}$	analog and digital power dissipation	note 1	–	–	1.7	W

## Note

1. Power dissipation is extremely dependent on programming and selected application.

## 6 BLOCK DIAGRAMS

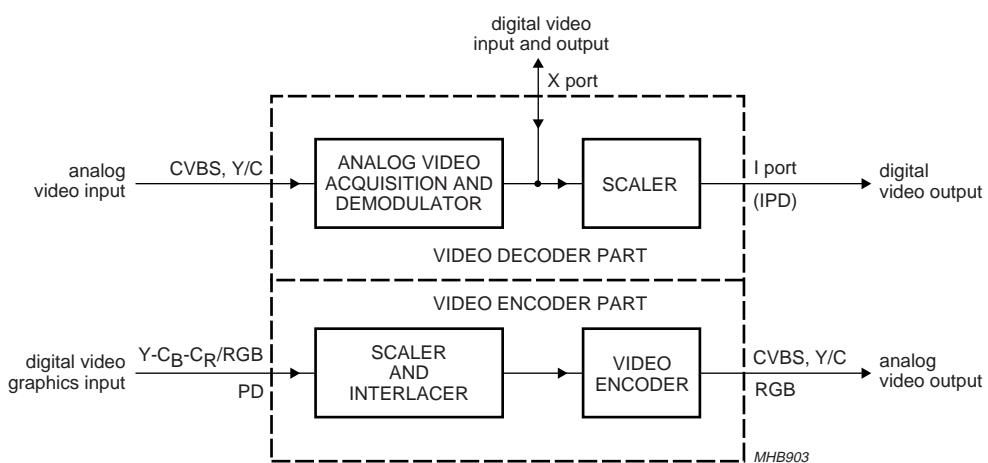


Fig.1 Simplified block diagram.

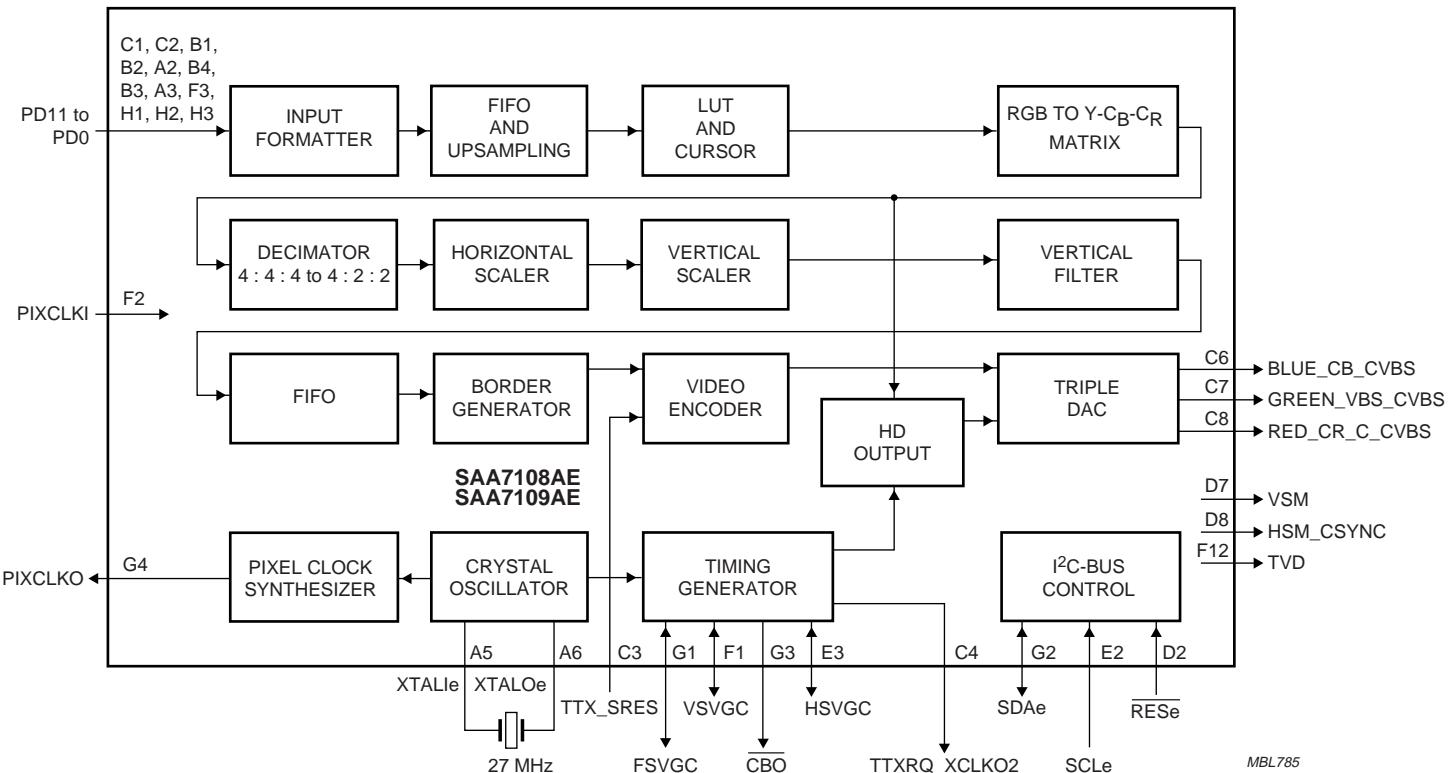


Fig.2 Block diagram (video encoder part).

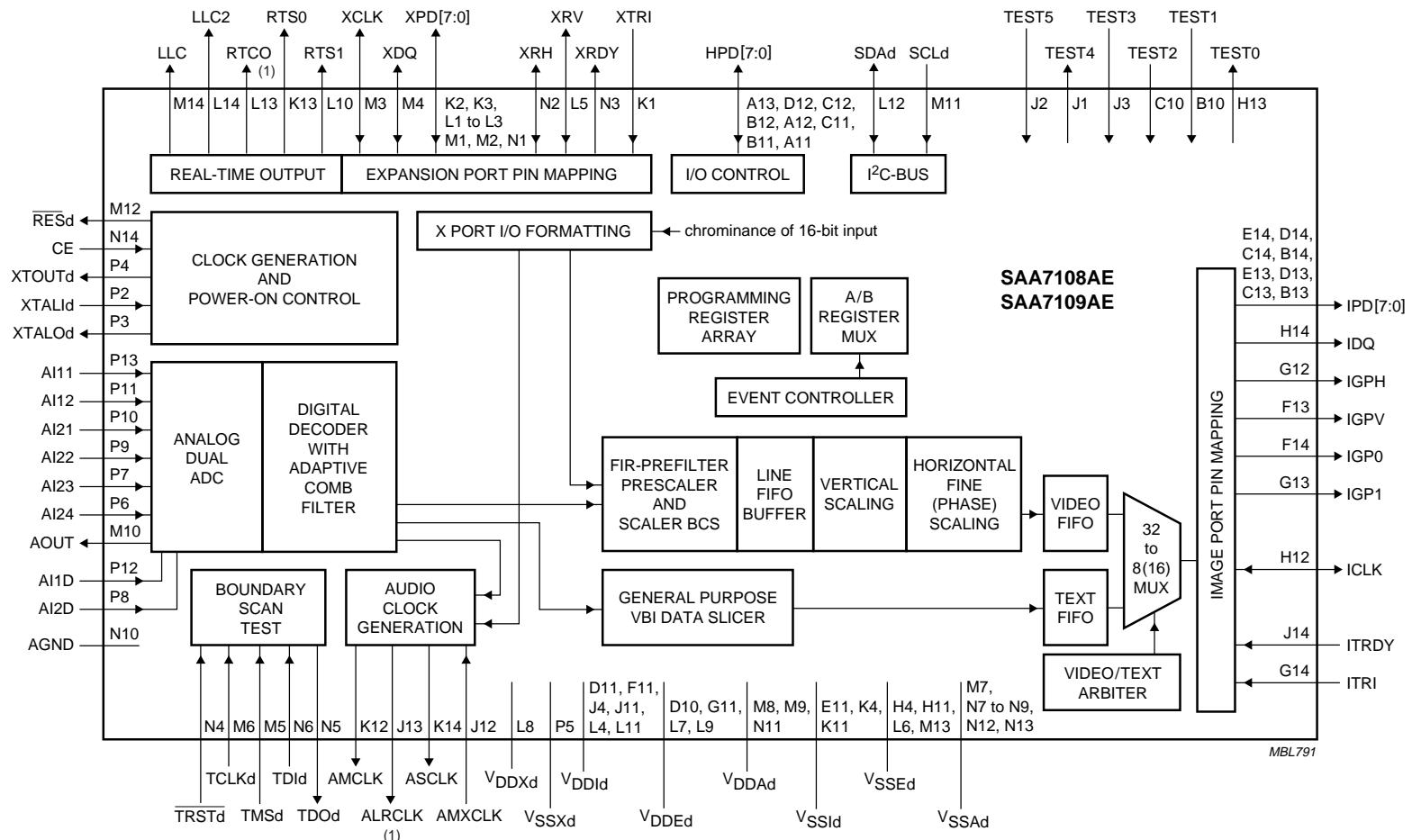


Fig.3 Block diagram (video decoder part).

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## 7 PINNING

SYMBOL	PIN	TYPE <sup>(1)</sup>	DESCRIPTION
PD7	A2	I	MSB of encoder input bus with C <sub>B</sub> -Y-C <sub>R</sub> 4 : 2 : 2; see Tables 9 to 15 for pin assignment
PD4	A3	I	MSB – 3 of encoder input bus with C <sub>B</sub> -Y-C <sub>R</sub> 4 : 2 : 2; see Tables 9 to 15 for pin assignment
TRSTe	A4	I/pu	test reset input for Boundary Scan Test (BST) (encoder); active LOW; with internal pull-up; notes 2 and 3
XTALIe	A5	I	27 MHz crystal input (encoder)
XTALOe	A6	O	27 MHz crystal output (encoder)
DUMP	A7	O	DAC reference pin (encoder), 12 Ω resistor connected to V <sub>SSAe</sub>
V <sub>SSXe</sub>	A8	S	ground for oscillator (encoder)
RSET	A9	O	DAC reference pin (encoder), 1 kΩ resistor connected to V <sub>SSAe</sub>
V <sub>DDAe</sub>	A10	S	3.3 V analog supply voltage (encoder)
HPD0	A11	I/O	MSB – 7 of Host Port Data (HPD) output bus
HPD3	A12	I/O	MSB – 4 of HPD output bus
HPD7	A13	I/O	MSB of HPD output bus
PD9	B1	I	see Tables 9, 14 and 15 for pin assignment with different encoder input formats
PD8	B2	I	see Tables 9, 14 and 15 for pin assignment with different encoder input formats
PD5	B3	I	MSB – 2 of encoder input bus with C <sub>B</sub> -Y-C <sub>R</sub> 4 : 2 : 2; see Tables 9 to 15 for pin assignment
PD6	B4	I	MSB – 1 of encoder input bus with C <sub>B</sub> -Y-C <sub>R</sub> 4 : 2 : 2; see Tables 9 to 15 for pin assignment
TDIe	B5	I/pu	test data input for BST (encoder); note 4
V <sub>DDAe</sub>	B6	S	3.3 V analog supply voltage (encoder)
DUMP	B7	O	DAC reference pin (encoder); connected to A7
V <sub>SSAe</sub>	B8	S	analog ground (encoder)
V <sub>DDAe</sub>	B9	S	3.3 V analog supply voltage (encoder)
TEST1	B10	I	scan test input 1, do not connect
HPD1	B11	I/O	MSB – 6 of HPD output bus
HPD4	B12	I/O	MSB – 3 of HPD output bus
IPD0	B13	O	MSB – 7 of IPD output bus
IPD4	B14	O	MSB – 3 of Image Port Data (IPD) output bus
PD11	C1	I	see Tables 9, 14 and 15 for pin assignment with different encoder input formats
PD10	C2	I	see Tables 9, 14 and 15 for pin assignment with different encoder input formats
TTX_SRES	C3	I	teletext input or sync reset input (encoder)
TTXRQ_XCLKO2	C4	O	teletext request output or 13.5 MHz clock output of the crystal oscillator (encoder)
V <sub>SSIe</sub>	C5	S	digital ground core (encoder)
BLUE_CB_CVBS	C6	O	BLUE or C <sub>B</sub> or CVBS output

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SYMBOL	PIN	TYPE <sup>(1)</sup>	DESCRIPTION
GREEN_VBS_CVBS	C7	O	GREEN or VBS or CVBS output
RED_CR_C_CVBS	C8	O	RED or C <sub>R</sub> or C or CVBS output
V <sub>DDAe</sub>	C9	S	3.3 V analog supply voltage (encoder)
TEST2	C10	I	scan test input 2, do not connect
HPD2	C11	I/O	MSB – 5 of HPD output bus
HPD5	C12	I/O	MSB – 2 of HPD output bus
IPD1	C13	O	MSB – 6 of IPD output bus
IPD5	C14	O	MSB – 2 of IPD output bus
TDOe	D1	O	test data output for BST (encoder); note 4
RESe	D2	I	reset input (encoder); active LOW
TMSe	D3	I/pu	test mode select input for BST (encoder); note 4
V <sub>DDIEe</sub>	D4	S	3.3 V digital supply voltage for core and peripheral cells (encoder)
V <sub>SSle</sub>	D5	S	digital ground core (encoder)
V <sub>DDXe</sub>	D6	S	3.3 V supply voltage for oscillator (encoder)
VSM	D7	O	vertical synchronization output to VGA monitor (non-interlaced)
HSM_CSYNC	D8	O	horizontal synchronization output to VGA monitor (non-interlaced) or composite sync for RGB-SCART
V <sub>DDAe</sub>	D9	S	3.3 V analog supply voltage (encoder)
V <sub>DDEd</sub>	D10	S	3.3 V digital supply voltage for peripheral cells (decoder)
V <sub>DDId</sub>	D11	S	3.3 V digital supply voltage for core (decoder)
HPD6	D12	I/O	MSB – 1 of HPD output bus
IPD2	D13	O	MSB – 5 of IPD output bus
IPD6	D14	O	MSB – 1 of IPD output bus
TCKe	E1	I/pu	test clock input for BST (encoder); note 4
SCLe	E2	I	I <sup>2</sup> C-bus serial clock input (encoder)
HSVGC	E3	I/O	horizontal synchronization output to Video Graphics Controller (VGC) (optional input)
V <sub>SSEe</sub>	E4	S	digital ground peripheral cells (encoder)
V <sub>SSId</sub>	E11	S	digital ground core (decoder)
n.c.	E12	–	not connected
IPD3	E13	O	MSB – 4 of IPD output bus
IPD7	E14	O	MSB of IPD output bus
VSVGC	F1	I/O	vertical synchronization output to VGC (optional input)
PIXCLKI	F2	I	pixel clock input (looped through)
PD3	F3	I	MSB – 4 of encoder input bus with C <sub>B</sub> -Y-C <sub>R</sub> 4 : 2 : 2; see Tables 9 to 15 for pin assignment
V <sub>DD(DVO)</sub>	F4	S	digital supply voltage for DVO cells
V <sub>DDId</sub>	F11	S	3.3 V digital supply voltage for core (decoder)
TVD	F12	O	TV Detector; hot-plug interrupt pin, HIGH if TV is connected
IGPV	F13	O	multi-purpose vertical reference output with IPD output bus
IGP0	F14	O	general purpose output signal 0 with IPD output bus

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SYMBOL	PIN	TYPE <sup>(1)</sup>	DESCRIPTION
FSVGC	G1	I/O	frame synchronization output to VGC (optional input)
SDAe	G2	I/O	I <sup>2</sup> C-bus serial data input/output (encoder)
CBO	G3	O	composite blanking output to VGC; active LOW
PIXCLKO	G4	O	pixel clock output to VGC
V <sub>DDEd</sub>	G11	S	3.3 V digital supply voltage for peripheral cells (decoder)
IGPH	G12	O	multi-purpose horizontal reference output with IPD output bus
IGP1	G13	O	general purpose output signal 1 with IPD output bus
ITRI	G14	I(O)	programmable control signals for IPD output bus
PD2	H1	I	MSB – 5 of encoder input bus with C <sub>B</sub> -Y-C <sub>R</sub> 4 : 2 : 2; see Tables 9 to 15 for pin assignment
PD1	H2	I	MSB – 6 of encoder input bus with C <sub>B</sub> -Y-C <sub>R</sub> 4 : 2 : 2; see Tables 9 to 15 for pin assignment
PD0	H3	I	MSB – 7 of encoder input bus with C <sub>B</sub> -Y-C <sub>R</sub> 4 : 2 : 2; see Tables 9 to 15 for pin assignment
V <sub>SSEd</sub>	H4	S	digital ground for peripheral cells (decoder)
V <sub>SSEd</sub>	H11	S	digital ground for peripheral cells (decoder)
ICLK	H12	I/O	clock for IPD output bus (optional clock input)
TEST0	H13	O	scan test output, do not connect
IDQ	H14	O	data qualifier for IPD output bus
TEST4	J1	O	scan test output, do not connect
TEST5	J2	I	scan test input, do not connect
TEST3	J3	I	scan test input, do not connect
V <sub>DDId</sub>	J4	S	3.3 V digital supply voltage for core (decoder)
V <sub>DDId</sub>	J11	S	3.3 V digital supply voltage for core (decoder)
AMXCLK	J12	I	audio master external clock input
ALRCLK	J13	(I/O)	audio left/right clock output; can be strapped to supply via a 3.3 kΩ resistor to indicate that the default 24.576 MHz crystal (ALRCLK = 0; internal pull-down) has been replaced by a 32.110 MHz crystal (ALRCLK = 1); notes 5 and 6
ITRDY	J14	I	target ready input for IPD output bus
XTRI	K1	I	control signal for all X port pins
XPD7	K2	I/O	MSB of XPD bus
XPD6	K3	I/O	MSB – 1 of XPD bus
V <sub>SSId</sub>	K4	S	digital ground core (decoder)
V <sub>SSId</sub>	K11	S	digital ground core (decoder)
AMCLK	K12	O	audio master clock output, must be less than 50 % of crystal clock
RTS0	K13	O	real-time status or sync information line 0
ASCLK	K14	O	audio serial clock output
XPD5	L1	I/O	MSB – 2 of XPD bus
XPD4	L2	I/O	MSB – 3 of XPD bus
XPD3	L3	I/O	MSB – 4 of XPD bus
V <sub>DDId</sub>	L4	S	3.3 V digital supply voltage for core (decoder)
XRV	L5	I/O	vertical reference for XPD bus

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SYMBOL	PIN	TYPE <sup>(1)</sup>	DESCRIPTION
V <sub>SSEd</sub>	L6	S	digital ground for peripheral cells (decoder)
V <sub>DDEd</sub>	L7	S	3.3 V digital supply voltage for peripheral cells (decoder)
V <sub>DDXd</sub>	L8	S	3.3 V supply voltage for oscillator (decoder)
V <sub>DDEd</sub>	L9	S	3.3 V digital supply voltage for peripheral cells (decoder)
RTS1	L10	O	real-time status or sync information line 1
V <sub>DDId</sub>	L11	S	3.3 V digital supply voltage for core (decoder)
SDAd	L12	I/O	I <sup>2</sup> C-bus serial data input/output (decoder)
RTCO	L13	(I/O)	real-time control output; contains information about actual system clock frequency, field rate, odd/even sequence, decoder status, subcarrier frequency and phase and PAL sequence (see external document "RTC Functional Description", available on request); the RTCO pin is enabled via I <sup>2</sup> C-bus bit RTCE; see notes 5 and 7 and Table 150
LLC2	L14	O	line-locked 1/2 clock output (13.5 MHz nominal)
XPD2	M1	I/O	MSB – 5 of XPD bus
XPD1	M2	I/O	MSB – 6 of XPD bus
XCLK	M3	I/O	clock for XPD bus
XDQ	M4	I/O	data qualifier for XPD bus
TMSd	M5	I/pu	test mode select input for BST (decoder); note 4
TCKd	M6	I/pu	test clock input for BST (decoder); note 4
V <sub>SSAd</sub>	M7	S	analog ground (decoder)
V <sub>DDAd</sub>	M8	S	3.3 V analog supply voltage (decoder)
V <sub>DDAd</sub>	M9	S	3.3 V analog supply voltage (decoder)
AOUT	M10	O	analog test output (do not connect)
SCLd	M11	I	I <sup>2</sup> C-bus serial clock input (decoder)
RESd	M12	O	reset output signal; active LOW (decoder)
V <sub>SSEd</sub>	M13	S	digital ground for peripheral cells (decoder)
LLC	M14	O	line-locked clock output (27 MHz nominal)
XPD0	N1	I/O	MSB – 7 of XPD bus
XRH	N2	I/O	horizontal reference for XPD bus
XRDY	N3	O	data input ready for XPD bus
TRSTd	N4	I/pu	test reset input for BST (decoder); active LOW; with internal pull-up; notes 2 and 3
TDOd	N5	O	test data output for BST (decoder); note 4
TDId	N6	I/pu	test data input for BST (decoder); note 4
V <sub>SSAd</sub>	N7	S	analog ground (decoder)
V <sub>SSAd</sub>	N8	S	analog ground (decoder)
V <sub>SSAd</sub>	N9	S	analog ground (decoder)
AGND	N10	S	analog ground (decoder) connected to substrate
V <sub>DDAd</sub>	N11	S	3.3 V analog supply voltage (decoder)
V <sub>SSAd</sub>	N12	S	analog ground (decoder)
V <sub>SSAd</sub>	N13	S	analog ground (decoder)
CE	N14	I	chip enable or reset input (with internal pull-up)

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SYMBOL	PIN	TYPE <sup>(1)</sup>	DESCRIPTION
XTALId	P2	I	27 MHz crystal input (decoder)
XTALOd	P3	O	27 MHz crystal output (decoder)
XTOUTd	P4	O	crystal oscillator output signal (decoder); auxiliary signal
V <sub>SSXd</sub>	P5	S	ground for crystal oscillator (decoder)
AI24	P6	I	analog input 24
AI23	P7	I	analog input 23
AI2D	P8	I	differential analog input for channel 2; connect to ground via a capacitor
AI22	P9	I	analog input 22
AI21	P10	I	analog input 21
AI12	P11	I	analog input 12
AI1D	P12	I	differential analog input for channel 1; connect to ground via a capacitor
AI11	P13	I	analog input 11

## Notes

1. Pin type: I = input, O = output, S = supply, pu = pull-up.
2. For board design without boundary scan implementation connect TRSTe and TRSTD to ground.
3. This pin provides easy initialization of the Boundary Scan Test (BST) circuit. TRSTe and TRSTD can be used to force the Test Access Port (TAP) controller to the TEST\_LOGIC\_RESET state (normal operation) at once.
4. In accordance with the "IEEE1149.1" standard the pads TD<sub>l</sub>e (TD<sub>l</sub>d), TM<sub>s</sub>e (TM<sub>s</sub>d), TC<sub>k</sub>e (TC<sub>k</sub>d) and TRSTe (TRSTD) are input pads with an internal pull-up resistor and TD<sub>o</sub>e (TD<sub>o</sub>d) is a 3-state output pad.
5. Pin strapping is done by connecting the pin to supply via a 3.3 kΩ resistor. During the power-up reset sequence the corresponding pins are switched to input mode to read the strapping level. For the default setting no strapping resistor is necessary (internal pull-down).
6. Pin ALRCLK: 0 = 24.576 MHz crystal (default); 1 = 32.110 MHz crystal.
7. Pin RTCO: operates as I<sup>2</sup>C-bus slave address pin; RTCO = 0 slave address 42H/43H (default); RTCO = 1 slave address 40H/41H.

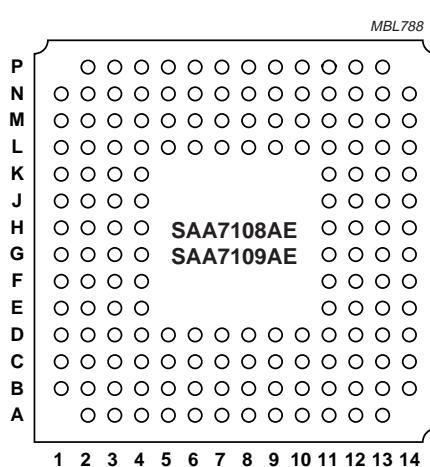


Fig.4 Pin configuration.

**Table 1** Pin assignment (top view)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14
<b>A</b>		PD7	PD4	$\overline{\text{TRSTe}}$	XTALie	XTALOe	DUMP	$V_{\text{SSXe}}$	RSET	$V_{\text{DDAe}}$	HPD0	HPD3	HPD7	
<b>B</b>	PD9	PD8	PD5	PD6	TDle	$V_{\text{DDAe}}$	DUMP	$V_{\text{SSAe}}$	$V_{\text{DDAe}}$	TEST1	HPD1	HPD4	IPD0	IPD4
<b>C</b>	PD11	PD10	TTX_SRES	TTXRQ_XCLKO2	$V_{\text{SSle}}$	BLUE_CB_CVBS	GREEN_VBS_CVBS	RED_CR_C_CVBS	$V_{\text{DDAe}}$	TEST2	HPD2	HPD5	IPD1	IPD5
<b>D</b>	TDOe	$\overline{\text{RESe}}$	TMSe	$V_{\text{DDIEe}}$	$V_{\text{SSle}}$	$V_{\text{DDXe}}$	VSM	HSM_CSYNC	$V_{\text{DDAe}}$	$V_{\text{DDEd}}$	$V_{\text{DDId}}$	HPD6	IPD2	IPD6
<b>E</b>	TCKe	SCLe	HSVGC	$V_{\text{SSEe}}$							$V_{\text{SSId}}$	n.c.	IPD3	IPD7
<b>F</b>	VSVGC	PIXCLKI	PD3	$V_{\text{DD(DVO)}}$							$V_{\text{DDId}}$	TVD	IGPV	IGP0
<b>G</b>	FSVGC	SDAe	$\overline{\text{CBO}}$	PIXCLKO							$V_{\text{DDEd}}$	IGPH	IGP1	ITRI
<b>H</b>	PD2	PD1	PD0	$V_{\text{SSEd}}$							$V_{\text{SSEd}}$	ICLK	TEST0	IDQ
<b>J</b>	TEST4	TEST5	TEST3	$V_{\text{DDId}}$							$V_{\text{DDId}}$	AMXCLK	ALRCLK	ITRDY
<b>K</b>	XTRI	XPD7	XPD6	$V_{\text{SSId}}$							$V_{\text{SSId}}$	AMCLK	RTS0	ASCLK
<b>L</b>	XPD5	XPD4	XPD3	$V_{\text{DDId}}$	XRV	$V_{\text{SSEd}}$	$V_{\text{DDEd}}$	$V_{\text{DDXd}}$	$V_{\text{DDEd}}$	RTS1	$V_{\text{DDId}}$	SDAd	RTCO	LLC2
<b>M</b>	XPD2	XPD1	XCLK	XDQ	TMSd	TCKd	$V_{\text{SSAd}}$	$V_{\text{DDAd}}$	$V_{\text{DDAd}}$	AOUT	SCLd	$\overline{\text{RESd}}$	$V_{\text{SSEd}}$	LLC
<b>N</b>	XPD0	XRH	XRDY	$\overline{\text{TRSTD}}$	TDOd	TDId	$V_{\text{SSAd}}$	$V_{\text{SSAd}}$	$V_{\text{SSAd}}$	AGND	$V_{\text{DDAd}}$	$V_{\text{SSAd}}$	$V_{\text{SSAd}}$	CE
<b>P</b>		XTALId	XTALOd	XTOUTd	$V_{\text{SSXd}}$	AI24	AI23	AI2D	AI22	AI21	AI12	AI1D	AI11	

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## 8 FUNCTIONAL DESCRIPTION OF DIGITAL VIDEO ENCODER PART

The digital video encoder encodes digital luminance and colour difference signals ( $C_B-Y-C_R$ ) or digital RGB signals into analog CVBS, S-video and, optionally, RGB or  $C_R-Y-C_B$  signals. NTSC M, PAL B/G and sub-standards are supported.

The SAA7108AE; SAA7109AE can be directly connected to a PC video graphics controller with a maximum resolution of  $1280 \times 1024$  (progressive) or  $1920 \times 1080$  (interlaced) at a 50 or 60 Hz frame rate. A programmable scaler scales the computer graphics picture so that it will fit into a standard TV screen with an adjustable underscan area. Non-interlaced-to-interlaced conversion is optimized with an adjustable anti-flicker filter for a flicker-free display at a very high sharpness.

Besides the most common 16-bit 4 : 2 : 2  $C_B-Y-C_R$  input format (using 8 pins with double edge clocking), other  $C_B-Y-C_R$  and RGB formats are also supported; see Tables 9 to 15.

A complete  $3 \times 256$  bytes Look-Up Table (LUT), which can be used, for example, as a separate gamma corrector, is located in the RGB domain; it can be loaded either through the video input port PD (Pixel Data) or via the I<sup>2</sup>C-bus.

The SAA7108AE; SAA7109AE supports a  $32 \times 32 \times 2$ -bit hardware cursor, the pattern of which can also be loaded through the video input port or via the I<sup>2</sup>C-bus.

It is also possible to encode interlaced 4 : 2 : 2 video signals such as PC-DVD; for that the anti-flicker filter, and in most cases the scaler, will simply be bypassed.

Besides the applications for video output, the SAA7108AE; SAA7109AE can also be used for generating a kind of auxiliary VGA output, when the RGB non-interlaced input signal is fed to the DACs. This may be of interest for example, when the graphics controller provides a second graphics window at its video output port.

The basic encoder function consists of subcarrier generation, colour modulation and insertion of synchronization signals at a crystal-stable clock rate of 13.5 MHz (independent of the actual pixel clock used at the input side), corresponding to an internal 4 : 2 : 2 bandwidth in the luminance/colour difference domain. Luminance and chrominance signals are filtered in accordance with the standard requirements of "RS-170-A" and "ITU-R BT.470-3".

For ease of analog post filtering the signals are twice oversampled to 27 MHz before digital-to-analog conversion.

The total filter transfer characteristics (scaler and anti-flicker filter are not taken into account) are illustrated in Figs 5 to 10. All three DACs are realized with full 10-bit resolution. The  $C_R-Y-C_B$  to RGB dematrix can be bypassed (optionally) in order to provide the upsampled  $C_R-Y-C_B$  input signals.

The 8-bit multiplexed  $C_B-Y-C_R$  formats are "ITU-R BT.656" (D1 format) compatible, but the SAV and EAV codes can be decoded optionally, when the device is operated in slave mode. For assignment of the input data to the rising or falling clock edge see Tables 9 to 15.

In order to display interlaced RGB signals through a euro-connector TV set, a separate digital composite sync signal (pin HSM\_CSYNC) can be generated; it can be advanced up to 31 periods of the 27 MHz crystal clock in order to be adapted to the RGB processing of a TV set.

The SAA7108AE; SAA7109AE synthesizes all necessary internal signals, colour subcarrier frequency and synchronization signals from that clock.

It is also possible to connect pin RTCO of the decoder section to pin RTCL of the encoder section. Thus, information containing actual subcarrier frequency, PAL-ID etc. is available in case the line-locked clock of the decoder section is used for re-encoding of the encoder section.

Wide screen signalling data can be loaded via the I<sup>2</sup>C-bus and is inserted into line 23 for standards using a 50 Hz field rate.

VPS data for program dependent automatic start and stop of such featured VCRs is loadable via the I<sup>2</sup>C-bus.

The IC also contains Closed Caption and extended data services encoding (line 21), and supports teletext insertion for the appropriate bit stream format at a 27 MHz clock rate (see Fig.51). It is also possible to load data for the copy generation management system into line 20 of every field (525/60 line counting).

A number of possibilities are provided for setting different video parameters such as:

- Black and blanking level control
- Colour subcarrier frequency
- Variable burst amplitude etc.

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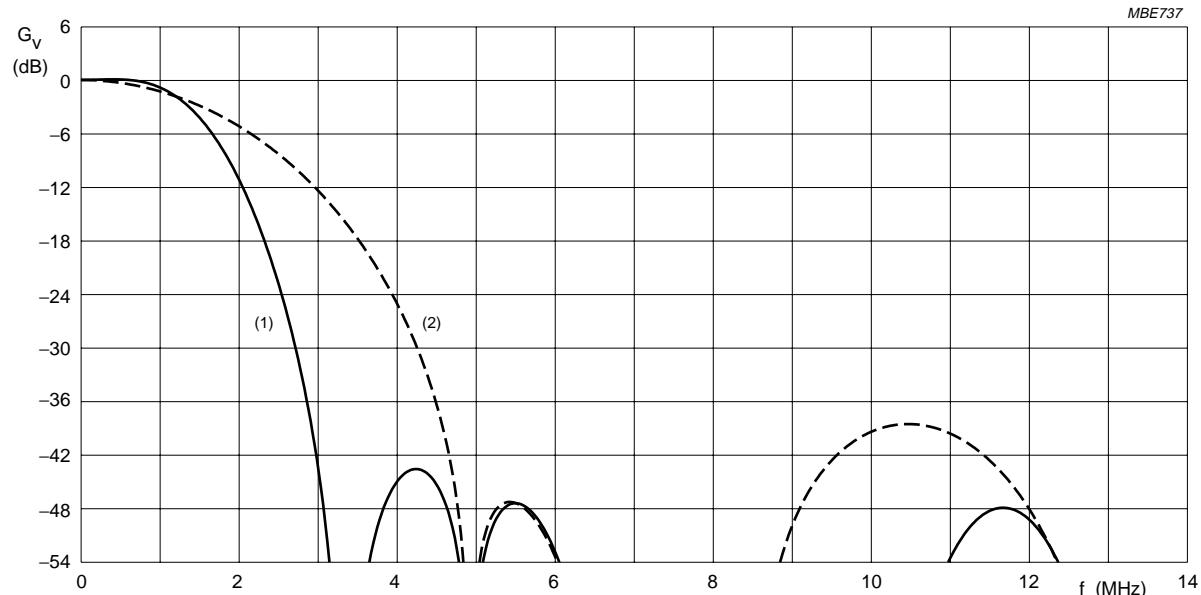


Fig.5 Chrominance transfer characteristic 1.

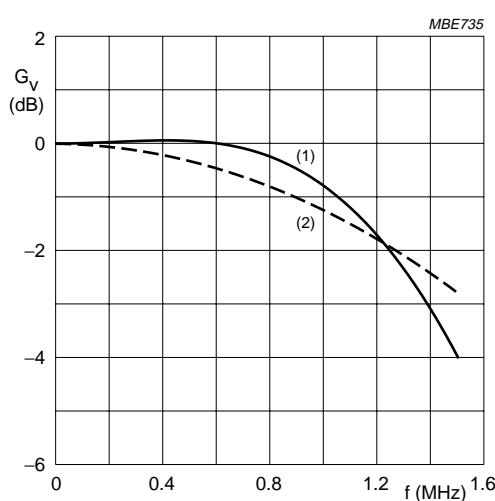


Fig.6 Chrominance transfer characteristic 2.

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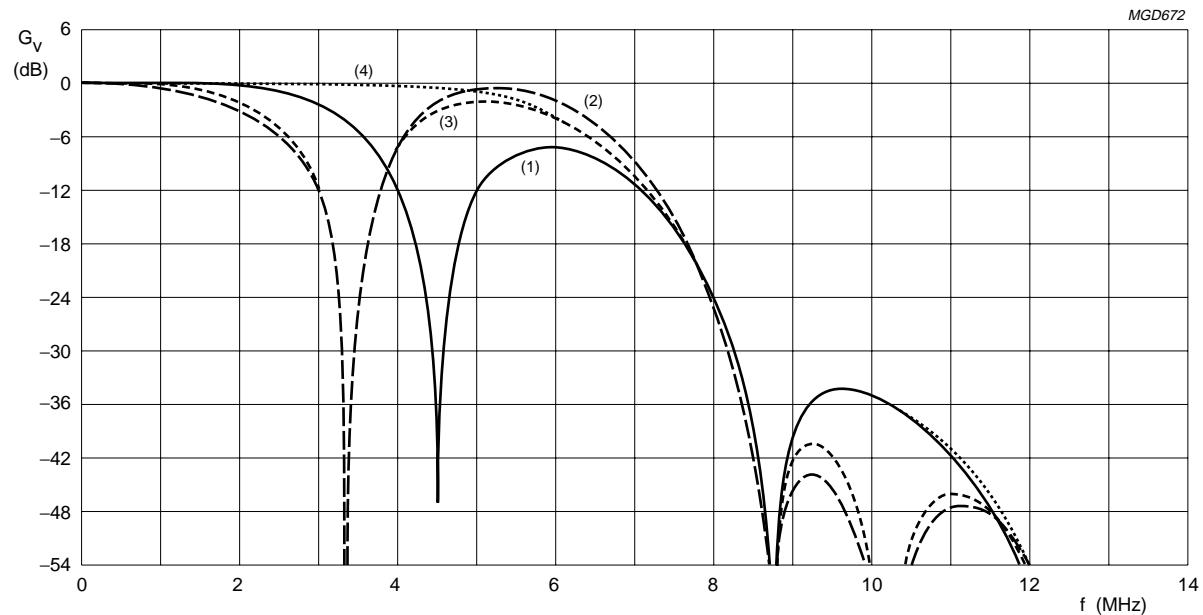


Fig.7 Luminance transfer characteristic 1 (excluding scaler).

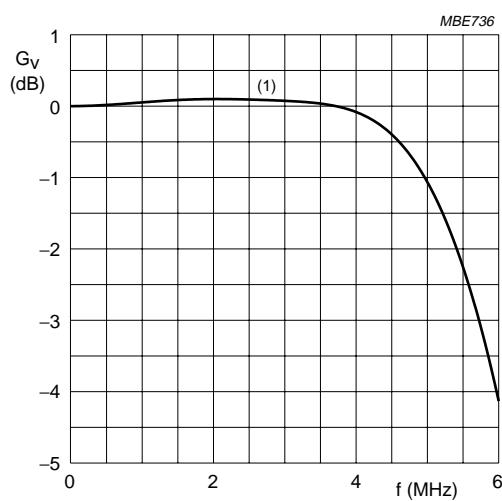


Fig.8 Luminance transfer characteristic 2 (excluding scaler).

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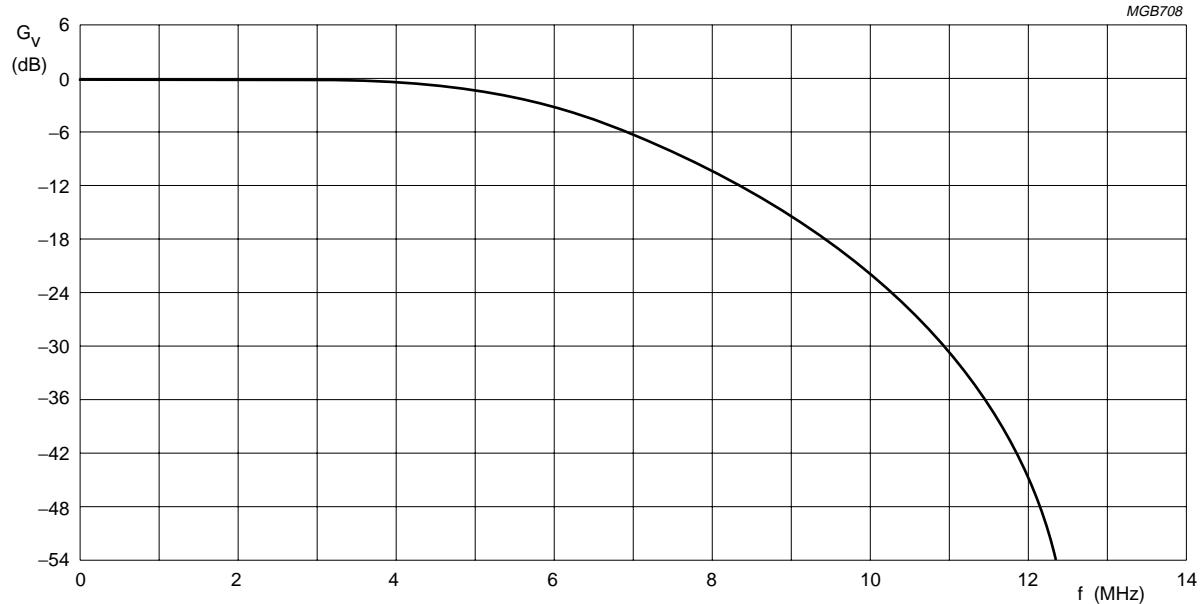


Fig.9 Luminance transfer characteristic in RGB (excluding scaler).

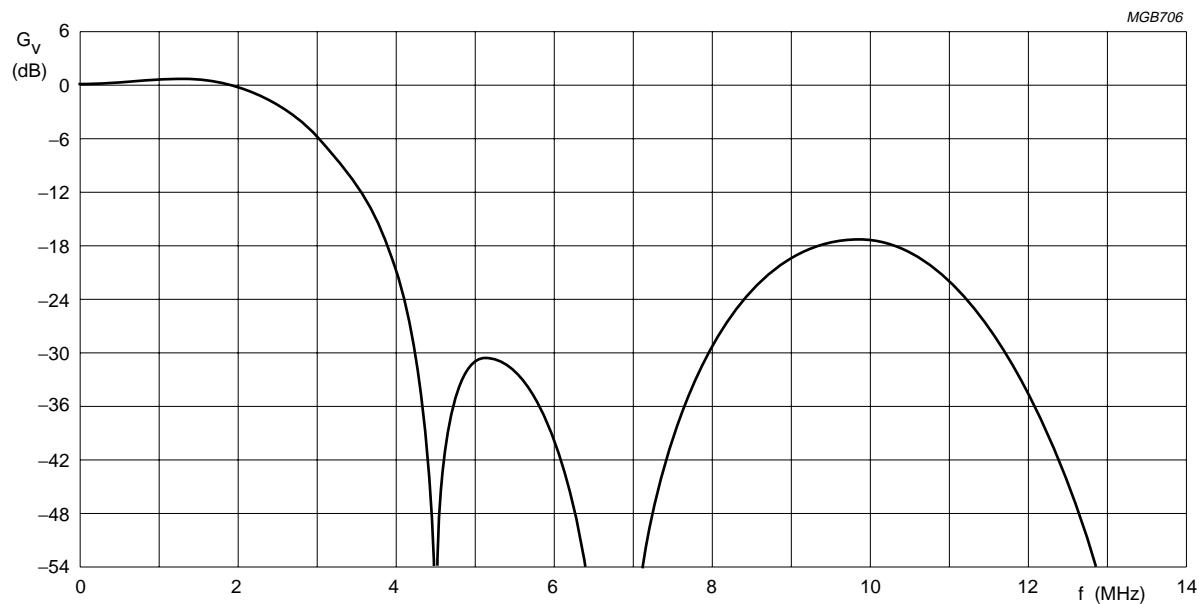


Fig.10 Colour difference transfer characteristic in RGB (excluding scaler).

## HD-CODEC

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**8.1 Reset conditions**

To activate the reset a pulse at least of 2 crystal clocks duration is required.

During reset (RESET = LOW) plus an extra 32 crystal clock periods, FSVGC, VSVGC, CBO, HSVGC and TTX\_SRES are set to input mode and HSM\_CS<sub>YNC</sub> and VSM are set to 3-state. A reset also forces the I<sup>2</sup>C-bus interface to abort any running bus transfer and sets it into receive condition.

After reset, the state of the I/Os and other functions is defined by the strapping pins until an I<sup>2</sup>C-bus access redefines the corresponding registers; see Table 2.

**Table 2** Strapping pins

PIN	TIED	PRESET
FSVGC (pin G1)	LOW	NTSC M encoding, PIXCLK fits to 640 × 480 graphics input
	HIGH	PAL B/G encoding, PIXCLK fits to 640 × 480 graphics input
VSVGC (pin F1)	LOW	4 : 2 : 2 Y-C <sub>B</sub> -C <sub>R</sub> graphics input (format 0)
	HIGH	4 : 4 : 4 RGB graphics input (format 3)
CBO (pin G3)	LOW	input demultiplex phase: LSB = LOW
	HIGH	input demultiplex phase: LSB = HIGH
HSVGC (pin E3)	LOW	input demultiplex phase: MSB = LOW
	HIGH	input demultiplex phase: MSB = HIGH
TTXRQ_XCLKO2 (pin C4)	LOW	slave (FSVGC, VSVGC and HSVGC are inputs, internal colour bar is active)
	HIGH	master (FSVGC, VSVGC and HSVGC are outputs)

**8.2 Input formatter**

The input formatter converts all accepted PD input data formats, either RGB or Y-C<sub>B</sub>-C<sub>R</sub>, to a common internal RGB or Y-C<sub>B</sub>-C<sub>R</sub> data stream.

When double-edge clocking is used, the data is internally split into portions PPD1 and PPD2. The clock edge assignment must be set according to the I<sup>2</sup>C-bus control bits SLOT and EDGE for correct operation.

If Y-C<sub>B</sub>-C<sub>R</sub> is being applied as a 27 Mbyte/s data stream, the output of the input formatter can be used directly to feed the video encoder block.

The horizontal upscaling is supported via the input formatter. According to the programming of the pixel clock dividers (see Section 8.10), it will upsample the data stream to 1 ×, 2 × or 4 × the input data rate. An optional interpolation filter is available. The clock domain transition is handled by a 4 entries wide FIFO which gets initialized every field or explicitly at request. A bypass for the FIFO is available, especially for high input data rates.

**8.3 RGB LUT**

The three 256-byte RAMs of this block can be addressed by three 8-bit wide signals, thus it can be used to build any transformation, e.g. a gamma correction for RGB signals. In the event that the indexed colour data is applied, the RAMs are addressed in parallel.

The LUTs can either be loaded by an I<sup>2</sup>C-bus write access or can be part of the pixel data input through the PD port. In the latter case, 256 × 3 bytes for the R, G and B LUT are expected at the beginning of the input video line, two lines before the line that has been defined as first active line, until the middle of the line immediately preceding the first active line. The first 3 bytes represent the first RGB LUT data, and so on.

**8.4 Cursor insertion**

A 32 × 32 dots cursor can be overlaid as an option; the bit map of the cursor can be uploaded by an I<sup>2</sup>C-bus write access to specific registers or in the pixel data input via the PD port. In the latter case the 256 bytes defining the cursor bit map (2 bits per pixel) are expected immediately following the last RGB LUT data in the line preceding the first active line.

The cursor bit map is set up as follows: each pixel occupies 2 bits. The meaning of these bits depends on the CMODE I<sup>2</sup>C-bus register as described in Table 5. Transparent means that the input pixels are passed through, the 'cursor colours' can be programmed in separate registers.

The bit map is stored with 4 pixels per byte, aligned to the least significant bit. So the first pixel is in bits 0 and 1, the next pixel in bits 3 and 4 and so on. The first index is the column, followed by the row; index 0,0 is the upper left corner.

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**Table 3** Layout of a byte in the cursor bit map

D7	D6	D5	D4	D3	D2	D1	D0
pixel n + 3		pixel n + 2		pixel n + 1		pixel n	
D1	D0	D1	D0	D1	D0	D1	D0

For each direction, there are 2 registers controlling the position of the cursor, one controls the position of the 'hot spot', the other register controls the insertion position. The hot spot is the 'tip' of the pointer arrow. It can have any position in the bit map. The actual position registers describe the co-ordinates of the hot spot. Again 0,0 is the upper left corner. While it is not possible to move the hot spot beyond the left respectively upper screen border this is perfectly legal for the right respectively lower border. It should be noted that the cursor position is described relative to the input resolution.

**Table 4** Cursor bit map

BYTE	D7	D6	D5	D4	D3	D2	D1	D0
0	row 0 column 3		row 0 column 2		row 0 column 1		row 0 column 0	
1	row 0 column 7		row 0 column 6		row 0 column 5		row 0 column 4	
2	row 0 column 11		row 0 column 10		row 0 column 9		row 0 column 8	
...	...		...		...		...	
6	row 0 column 27		row 0 column 26		row 0 column 25		row 0 column 24	
7	row 0 column 31		row 0 column 30		row 0 column 29		row 0 column 28	
...	...		...		...		...	
254	row 31 column 27		row 31 column 26		row 31 column 25		row 31 column 24	
255	row 31 column 31		row 31 column 30		row 31 column 29		row 31 column 28	

**Table 5** Cursor modes

CURSOR PATTERN	CURSOR MODE	
	CMODE = 0	CMODE = 1
00	second cursor colour	second cursor colour
01	first cursor colour	first cursor colour
10	transparent	transparent
11	inverted input	auxiliary cursor colour

**8.5 RGB Y-C<sub>B</sub>-C<sub>R</sub> matrix**

RGB input signals to be encoded to PAL or NTSC are converted to the Y-C<sub>B</sub>-C<sub>R</sub> colour space in this block. The colour difference signals are fed through low-pass filters and formatted to a ITU-R BT.601 like 4 : 2 : 2 data stream for further processing.

A gain adjust option corrects the level swing of the graphics world (black-to-white as 0 to 255) to the required range of 16 to 235.

The matrix and formatting blocks can be bypassed for Y-C<sub>B</sub>-C<sub>R</sub> graphics input.

When the auxiliary VGA mode is selected, the output of the cursor insertion block is immediately directed to the triple DAC.

**8.6 Horizontal scaler**

The high quality horizontal scaler operates on the 4 : 2 : 2 data stream. Its control engines compensate the colour phase offset automatically.

The scaler starts processing after a programmable horizontal offset and continues with a number of input pixels. Each input pixel is a programmable fraction of the current output pixel (XINC/4096). A special case is XINC = 0, this sets the scaling factor to 1.

If the SAA7108AE; SAA7109AE input data is in accordance with "ITU-R BT.656", the scaler enters another mode. In this event, XINC needs to be set to 2048 for a scaling factor of 1. With higher values, upscaling will occur.

The phase resolution of the circuit is 12 bits, giving a maximum offset of 0.2 after 800 input pixels. Small FIFOs rearrange a 4 : 2 : 2 data stream at the scaler output.

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### 8.7 Vertical scaler and anti-flicker filter

The functions scaling, Anti-Flicker Filter (AFF) and re-interlacing are implemented in the vertical scaler.

Besides the entire input frame, it receives the first and last lines of the border to allow anti-flicker filtering.

The circuit generates the interlaced output fields by scaling down the input frames with different offsets for odd and even fields. Increasing the YSKIP setting reduces the anti-flicker function. A YSKIP value of 4095 switches it off; see Table 120.

An additional, programmable vertical filter supports the anti-flicker function. This filter is not available at upscaling factors of more than 2.

The programming is similar to the horizontal scaler. For the re-interlacing, the resolutions of the offset registers are not sufficient, so the weighting factors for the first lines can also be adjusted. YINC = 0 sets the scaling factor to 1; YIWGTO and YIWGTE must not be 0.

Due to the re-interlacing, the circuit can perform upscaling by a maximum factor of 2. The maximum factor depends on the setting of the anti-flicker function and can be derived from the formulae given in Section 8.20.

An additional upscaling mode enables the upscaling factor to be increased to a maximum of 4 as it is required for the old VGA modes like  $320 \times 240$ .

### 8.8 FIFO

The FIFO acts as a buffer to translate from the PIXCLK clock domain to the XTAL clock domain. The write clock is PIXCLK and the read clock is XTAL. An underflow or overflow condition can be detected via the I<sup>2</sup>C-bus read access.

In order to avoid underflows and overflows, it is essential that the frequency of the synthesized PIXCLK matches to the input graphics resolution and the desired scaling factor.

### 8.9 Border generator

When the graphics picture is to be displayed as interlaced PAL, NTSC, S-video or RGB on a TV screen, it is desired in many cases not to lose picture information due to the inherent overscanning of a TV set. The desired amount of underscan area, which is achieved through appropriate scaling in the vertical and horizontal direction, can be filled in the border generator with an arbitrary true colour tint.

### 8.10 Oscillator and Discrete Time Oscillator (DTO)

The master clock generation is realized as a 27 MHz crystal oscillator, which can operate with either a fundamental wave crystal or a 3rd-harmonic crystal.

The crystal clock supplies the DTO of the pixel clock synthesizer, the video encoder and the I<sup>2</sup>C-bus control block. It also usually supplies the triple DAC, with the exception of the auxiliary VGA mode, where the triple DAC is clocked by the pixel clock (PIXCLK).

The DTO can be programmed to synthesize all relevant pixel clock frequencies between circa 40 and 85 MHz. Two programmable dividers provide the actual clock to be used externally and internally. The dividers can be programmed to factors of 1, 2, 4 and 8. For the internal pixel clock, a divider ratio of 8 makes no sense and is thus forbidden.

The internal clock can be switched completely to the pixel clock input. In this event, the input FIFO is useless and will be bypassed.

The entire pixel clock generation can be locked to the vertical frequency. Both pixel clock dividers get re-initialized every field. Optionally, the DTO can be cleared with each V-sync. At proper programming, this will make the pixel clock frequency a precise multiple of the vertical and horizontal frequencies. This is required for some graphic controllers.

### 8.11 Low-pass Clock Generation Circuit (CGC)

This block reduces the phase jitter of the synthesized pixel clock. It works as a tracking filter for all relevant synthesized pixel clock frequencies.

### 8.12 Encoder

#### 8.12.1 VIDEO PATH

The encoder generates luminance and colour subcarrier output signals from the Y, C<sub>B</sub> and C<sub>R</sub> baseband signals, which are suitable for use as CVBS or separate Y and C signals.

Input to the encoder, at 27 MHz clock (e.g. DVD), is either originated from computer graphics at pixel clock, fed through the FIFO and border generator, or a ITU-R BT.656 style signal.

Luminance is modified in gain and in offset (the offset is programmable in a certain range to enable different black level set-ups). A blanking level can be set after insertion of a fixed synchronization pulse tip level, in accordance with standard composite synchronization schemes.

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Other manipulations used for the Macrovision anti-taping process, such as additional insertion of AGC super-white pulses (programmable in height), are supported by the SAA7108AE only.

To enable easy analog post filtering, luminance is interpolated from a 13.5 MHz data rate to a 27 MHz data rate, thereby providing luminance in a 10-bit resolution. The transfer characteristics of the luminance interpolation filter are illustrated in Figs 7 and 8. Appropriate transients at start/end of active video and for synchronization pulses are ensured.

Chrominance is modified in gain (programmable separately for  $C_B$  and  $C_R$ ), and a standard dependent burst is inserted, before baseband colour signals are interpolated from a 6.75 MHz data rate to a 27 MHz data rate. One of the interpolation stages can be bypassed, thus providing a higher colour bandwidth, which can be used for the Y and C output. The transfer characteristics of the chrominance interpolation filter are illustrated in Figs 5 and 6.

The amplitude (beginning and ending) of the inserted burst, is programmable in a certain range that is suitable for standard signals and for special effects. After the succeeding quadrature modulator, colour is provided on the subcarrier in 10-bit resolution.

The numeric ratio between the Y and C outputs is in accordance with the standards.

#### 8.12.2 TELETEXT INSERTION AND ENCODING (NOT SIMULTANEOUSLY WITH REAL-TIME CONTROL)

Pin TTX\_SRES receives a WST or NABTS teletext bitstream sampled at the crystal clock. At each rising edge of the output signal (TTXRQ) a single teletext bit has to be provided after a programmable delay at input pin TTX\_SRES.

Phase variant interpolation is achieved on this bitstream in the internal teletext encoder, providing sufficient small phase jitter on the output text lines.

TTXRQ\_XCLK02 provides a fully programmable request signal to the teletext source, indicating the insertion period of bitstream at lines which can be selected independently for both fields. The internal insertion window for text is set to 360 (PAL WST), 296 (NTSC WST) or 288 (NABTS) teletext bits including clock run-in bits. The protocol and timing are illustrated in Fig.51.

Alternatively, this pin can be provided with a buffered crystal clock (XCLK) of 13.5 MHz.

#### 8.12.3 VIDEO PROGRAMMING SYSTEM (VPS) ENCODING

Five bytes of VPS information can be loaded via the I<sup>2</sup>C-bus and will be encoded in the appropriate format into line 16.

#### 8.12.4 CLOSED CAPTION ENCODER

Using this circuit, data in accordance with the specification of Closed Caption or extended data service, delivered by the control interface, can be encoded (line 21). Two dedicated pairs of bytes (two bytes per field), each pair preceded by run-in clocks and framing code, are possible.

The actual line number in which data is to be encoded, can be modified in a certain range.

The data clock frequency is in accordance with the definition for NTSC M standard 32 times horizontal line frequency.

Data LOW at the output of the DACs corresponds to 0 IRE, data HIGH at the output of the DACs corresponds to approximately 50 IRE.

It is also possible to encode Closed Caption data for 50 Hz field frequencies at 32 times the horizontal line frequency.

#### 8.12.5 ANTI-TAPING (SAA7108AE ONLY)

For more information contact your nearest Philips Semiconductors sales office.

### 8.13 RGB processor

This block contains a dematrix in order to produce RED, GREEN and BLUE signals to be fed to a SCART plug.

Before Y,  $C_B$  and  $C_R$  signals are de-matrixed, individual gain adjustment for Y and colour difference signals and 2 times oversampling for luminance and 4 times oversampling for colour difference signals is performed. The transfer curves of luminance and colour difference components of RGB are illustrated in Figs 9 and 10.

### 8.14 Triple DAC

Both Y and C signals are converted from digital-to-analog in a 10-bit resolution at the output of the video encoder. Y and C signals are also combined into a 10-bit CVBS signal.

The CVBS output signal occurs with the same processing delay as the Y, C and optional RGB or  $C_R$ -Y- $C_B$  outputs. Absolute amplitude at the input of the DAC for CVBS is reduced by  $15/16$  with respect to Y and C DACs to make maximum use of the conversion ranges.

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RED, GREEN and BLUE signals are also converted from digital-to-analog, each providing a 10-bit resolution.

The reference currents of all three DACs can be adjusted individually in order to adapt for different output signals. In addition, all reference currents can be adjusted commonly to compensate for small tolerances of the on-chip band gap reference voltage.

Alternatively, all currents can be switched off to reduce power dissipation.

All three outputs can be used to sense for an external load (usually  $75\ \Omega$ ) during a pre-defined output. A flag in the I<sup>2</sup>C-bus status byte reflects whether a load is applied or not. An automatic sense mode can also be activated, which will immediately indicate any  $75\ \Omega$  load at any of the three outputs at the dedicated interrupt pin TVD.

If the SAA7108AE; SAA7109AE is required to drive a second (auxiliary) VGA monitor or an HDTV set, the DACs receive the signal coming from the HD data path. In this event, the DACs are clocked at the incoming PIXCLKI instead of the 27 MHz crystal clock used in the video encoder.

### 8.15 HD data path

This data path enables the SAA7108AE; SAA7109AE to be used with VGA or HDTV monitors. It receives its data directly from the cursor generator and supports RGB and Y-P<sub>B</sub>-P<sub>R</sub> output formats (RGB not with Y-P<sub>B</sub>-P<sub>R</sub> input formats). No scaling is done in this mode.

A gain adjustment either leads the full level swing to the digital-to-analog converters or reduces the amplitude by a factor of 0.69. This enables sync pulses to be added to the signal as it is required for display units that require signals with sync pulses, either regular or 3-level syncs.

### 8.16 Timing generator

The synchronization of the SAA7108AE; SAA7109AE is able to operate in two modes; slave mode and master mode.

In slave mode, the circuit accepts sync pulses on the bidirectional FSVGc (frame sync), VSVGc (vertical sync) and HSVGc (horizontal sync) pins: the polarities of the signals can be programmed. The frame sync signal is only necessary when the input signal is interlaced, in other cases it may be omitted. If the frame sync signal is present, it is possible to derive the vertical and the horizontal phase from it by setting the HFS and VFS bits. HSVGc and VSVGc are not necessary in this case, so it is possible to switch the pins to output mode.

Alternatively, the device can be triggered by auxiliary codes in a ITU-R BT.656 data stream via PD7 to PD0.

Only vertical frequencies of 50 and 60 Hz are allowed with the SAA7108AE; SAA7109AE. In slave mode, it is not possible to lock the encoders colour carrier to the line frequency with the PHRES bits.

In the (more common) master mode, the time base of the circuit is continuously free-running. The IC can output a frame sync at pin FSVGc, a vertical sync at pin VSVGc, a horizontal sync at pin HSVGc and a composite blanking signal at pin CBO. All of these signals are defined in the PIXCLK domain. The duration of HSVGc and VSVGc are fixed, they are 64 clocks for HSVGc and 1 line for VSVGc. The leading slopes are in phase and the polarities can be programmed.

The input line length can be programmed. The field length is always derived from the field length of the encoder and the pixel clock frequency that is being used.

CBO acts as a data request signal. The circuit accepts input data at a programmable number of clocks after CBO goes active. This signal is programmable and it is possible to adjust the following (see Figs 49 and 50):

- The horizontal offset
- The length of the active part of the line
- The distance from active start to first expected data
- The vertical offset separately for odd and even fields
- The number of lines per input field.

In most cases, the vertical offsets for odd and even fields are equal. If they are not, then the even field will start later. The SAA7108AE; SAA7109AE will also request the first input lines in the even field, the total number of requested lines will increase by the difference of the offsets.

As stated above, the circuit can be programmed to accept the look-up and cursor data in the first 2 lines of each field. The timing generator provides normal data request pulses for these lines; the duration is the same as for regular lines. The additional request pulses will be suppressed with LUTL set to logic 0; see Table 143. The other vertical timings do not change in this case, so the first active line can be number 2, counted from 0.

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**8.17 Pattern generator for HD sync pulses**

The pattern generator provides an appropriate synchronization pattern for the video data path in auxiliary monitor or HDTV mode, respectively. It provides maximum flexibility in terms of raster generation for all interlaced and non-interlaced computer graphics or ATSC formats. The sync engine is capable of providing a combination of event-value pairs which can be used to insert certain values at specified times in the outgoing data stream. It can also be used to generate digital signals associated with time events. They can be used as digital horizontal and vertical synchronization signals on pins HSM\_CSYNC and VSM.

The picture position is adjustable through the programmable relationship between the sync pulses and the video contents.

The generation of embedded analog sync pulses is bound to a number of events which can be defined for a line. Several of these line timing definitions can exist in parallel. For the final sync raster composition a certain sequence of lines with different sync event properties has to be defined. The sequence specifies a series of line types and the number of occurrences of this specific line type. After the sequence has been completed, it restarts from the beginning. All pulse shapes are filtered internally in order to avoid ringing after analog post filters.

The sequence of the generated pulse stream must fit precisely to the incoming data stream in terms of the total number of pixels per line and lines per frame.

The sync engines flexibility is achieved by using a sequence of linked lists carrying the properties for the image, the lines as well as fractions of lines. Figure 11 illustrates the context between the various tables.

The first table serves as an array to hold the correct sequence of lines composing the synchronization raster. It can contain up to 16 entries. Each entry holds a 4-bit index to the next table and a 10-bit counter value which specifies how often this particular line is invoked. If the necessary line count for a particular line exceeds the 10 bits, it has to use two table entries.

The 4-bit index in the line count array points to the line type array. It holds up to 15 entries where, index 0 is not used, index 1 points to the first entry, index 2 to the second entry of the line type array etc.

Each entry of the line type array can hold up to 8 index pointers to another table. These indices point to portions of a line pulse pattern: A line could be split up e.g. into a sync, a blank, and an active portion followed by another blank portion, occupying four entries in one table line.

Each index of this table points to a particular line in the next table in the linked list. This table is called the line pattern array and each of the up to seven entries stores up to four pairs of a duration in pixel clock cycles and an index to a value table. The table entries are used to define portions of a line representing a certain value for a certain number of clock cycles.

The value specified in this table is actually another 3-bit index into a value array which can hold up to eight 8-bit values. If bit 4 (MSB) of the index is logic 1, the value is inserted into the G or Y signal only; if bit 4 = 0, the associated value is inserted into all three signals.

Two additional bits of the entries in the value array (LSBs of the second byte) determine if the associated events appear as a digital pulse on the HSM\_CSYNC and/or VSM outputs.

To ease the trigger set-up for the sync generation module, a set of registers is provided to set up the screen raster defined as width and height. A trigger position can be specified as an x, y co-ordinate within the overall dimensions of the screen raster. If the x, y counter matches the specified co-ordinates, a trigger pulse is generated which pre-loads the tables with their initial values.

Table 6 outlines an example on how to set up the sync tables for a 1080i HD raster.

**Important note:**

Due to a problem in the programming interface, writing to the line pattern array (address D2) might destroy the data of the line type array (address D1). A work around is to write the line pattern array data before writing the line type array. Reading of the arrays is possible but all address pointers must be initialized before the next write operation.

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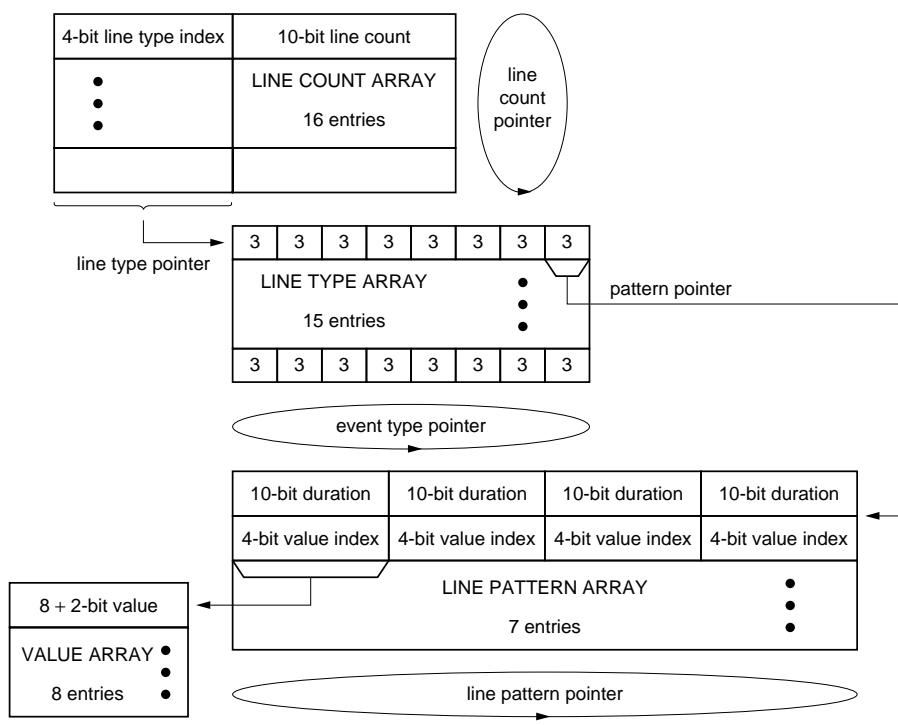


Fig.11 Context between the pattern generator tables for DH sync pulses.

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**Table 6** Example for set-up of the sync tables

SEQUENCE	COMMENT
<b>Write to subaddress D0H</b>	
00	points to first entry of line count array (index 0)
05 20	generate 5 lines of line type index 2 (remember, it is the second entry of the line type array); will be the first vertical raster pulse
01 40	generate 1 line of line type index 4; will be sync-black-sync-black sequence after the first vertical pulse
0E 60	generate 14 lines of line type index 6; will be the following lines with sync-black sequence
1C 12	generate 540 lines of line type index 1; will be lines with sync and active video
02 60	generate 2 lines of line type index 6; will be the following lines with sync-black sequence
01 50	generate 1 line of line type index 5; will be the following line (line 563) with sync-black-sync-black-null sequence (null is equivalent to sync tip)
04 20	generate 4 lines of line type index 2; will be the second vertical raster pulse
01 30	generate 1 line of line type index 3; will be the following line with sync-null-sync-black sequence
0F 60	generate 15 lines of line type index 6; will be the following lines with sync-black sequence
1C 12	generate 540 lines of line type index 1; will be lines with sync and active video
02 60	generate 2 lines of line type index 6; will be the following lines with sync-black sequence; now, 1125 lines are defined
<b>Write to subaddress D2H (insertion is done into all three analog output signals)</b>	
00	points to first entry of line pattern array (index 1)
6F 33 2B 30 00 00 00 00	$880 \times \text{value}(3) + 44 \times \text{value}(3)$ ; (subtract 1 from real duration)
6F 43 2B 30 00 00 00 00	$880 \times \text{value}(4) + 44 \times \text{value}(3)$
3B 30 BF 03 BF 03 2B 30	$60 \times \text{value}(3) + 960 \times \text{value}(0) + 960 \times \text{value}(0) + 44 \times \text{value}(3)$
2B 10 2B 20 57 30 00 00	$44 \times \text{value}(1) + 44 \times \text{value}(2) + 88 \times \text{value}(3)$
3B 30 BF 33 BF 33 2B 30	$60 \times \text{value}(3) + 960 \times \text{value}(3) + 960 \times \text{value}(3) + 44 \times \text{value}(3)$
<b>Write to subaddress D1H</b>	
00	points to first entry of line type array (index 1)
34 00 00 00	use pattern entries 4 and 3 in this sequence (for sync and active video)
24 24 00 00	use pattern entries 4, 2, 4 and 2 in this sequence (for 2 × sync-black-null-black)
24 14 00 00	use pattern entries 4, 2, 4 and 1 in this sequence (for sync-black-null-black-null)
14 14 00 00	use pattern entries 4, 1, 4 and 1 in this sequence (for sync-black-sync-black)
14 24 00 00	use pattern entries 4, 1, 4 and 2 in this sequence (for sync-black-sync-black-null)
54 00 00 00	use pattern entries 4 and 5 in this sequence (for sync-black)

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SEQUENCE	COMMENT
<b>Write to subaddress D3H (no signals are directed to pins HSM_CSYNC and VSM)</b>	
00	points to first entry of value array (index 0)
CC 00	black level, to be added during active video
80 00	sync level LOW (minimum output voltage)
0A 00	sync level HIGH (3-level sync)
CC 00	black level (needed elsewhere)
80 00	null (identical with sync level LOW)
<b>Write to subaddress DCH</b>	
0B	insertion is active, gain for signal is adapted accordingly

**8.18 I<sup>2</sup>C-bus interface**

The I<sup>2</sup>C-bus interface is a standard slave transceiver, supporting 7-bit slave addresses and 400 kbit/s guaranteed transfer rate. It uses 8-bit subaddressing with an auto-increment function. All registers are read and write, except two read only status bytes.

The register bit map consists of an RGB Look-Up Table (LUT), a cursor bit map and control registers. The LUT contains three banks of 256 bytes, where each RGB triplet is assigned to one address. Thus a write access needs the LUT address and three data bytes following subaddress FFH. For further write access auto-incrementing of the LUT address is performed. The cursor bit map access is similar to the LUT access but contains only a single byte per address.

The I<sup>2</sup>C-bus slave address is defined as 88H.

**8.19 Power-down modes**

In order to reduce the power consumption, the SAA7108AE; SAA7109AE supports 2 Power-down modes, accessible via the I<sup>2</sup>C-bus. The analog Power-down mode (DOWNA = 1) turns off the digital-to-analog converters and the pixel clock synthesizer. The digital down mode turns off all internal clocks and sets the digital outputs to LOW except the I<sup>2</sup>C-bus interface. The IC retains its programming and can still be accessed in this mode, but not all registers can be read from or written to. Reading or writing to the look-up tables, the cursor and the HD sync generator require a valid pixel clock. The typical supply current in full power-down is approximately 5 mA.

Due to the fact that the analog Power-down mode turns off the pixel clock synthesizer, there are limitations in some applications. If there is no pixel clock, the IC is not able to set its outputs to LOW.

So in most cases, DOWNA and DOWND should be set to logic 1 simultaneously. If the EIDIV bit is logic 1, it should be set to logic 0 before power-down.

**8.20 Programming the graphics acquisition scaler of the video encoder**

The encoder section needs to provide a continuous data stream at its analog outputs as well as receive a continuous stream from its data source. Due to the fact that there is no frame memory isolating the data streams, restrictions apply to the input frame timings.

Input and output processing of the encoder section are only coupled through the vertical frequencies. In master mode, the encoder provides a vertical sync and an odd/even pulse to the input processing, in slave mode, the encoder receives them.

The parameters of the input field are mainly given by the memory capacity of the encoder section. The rule is that the scaler and thus the input processing needs to provide the video data in the same time frames as the encoder reads them. So the vertical active video times (and the vertical frequencies) need to be the same.

The second rule is that there has to be data in the buffer FIFO when the encoder enters the active video area. So the vertical offset in the input path needs to be a bit shorter than the offset of the encoder.

The following gives the set of equations required to program the IC for the most common application: A post processor in master mode with non-interlaced video input data.

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Some variables are defined below:

- InPix: the number of active pixels per input line
- InPpl: the length of the entire input line in pixel clocks
- InLin: the number of active lines per input field/frame
- TPclk: the pixel clock period
- RiePclk: the ratio of internal to external pixel clock
- OutPix: the number of active pixels per output line
- OutLin: the number of active lines per output field
- TXclk: the encoder clock period (37.037 ns).

## 8.20.1 TV DISPLAY WINDOW

At 60 Hz, the first visible pixel has the index 256, 710 pixels can be encoded; at 50 Hz, the index is 284, 702 pixels can be visible.

The output lines should be centred on the screen. It should be noted that the encoder has 2 clocks per pixel; see Table 93.

$$ADWHS = 256 + 710 - OutPix \text{ (60 Hz);}$$

$$ADWHS = 284 + 702 - OutPix \text{ (50 Hz);}$$

$$ADWHE = ADWHS + OutPix \times 2 \text{ (all frequencies)}$$

For vertical, the procedure is the same. At 60 Hz, the first line with video information is number 19, 240 lines can be active. For 50 Hz, the numbers are 23 and 287; see Table 99.

$$FAL = 19 + \frac{240 - OutLin}{2} \text{ (60 Hz);}$$

$$FAL = 23 + \frac{287 - OutLin}{2} \text{ (50 Hz);}$$

$$LAL = FAL + OutLin \text{ (all frequencies)}$$

Most TV sets use overscan, and not all pixels respectively lines are visible. There is no standard for the factor, it is highly recommended to make the number of output pixels and lines adjustable. A reasonable underscan factor is 10 %, giving approximately 640 output pixels per line.

## 8.20.2 INPUT FRAME AND PIXEL CLOCK

The total number of pixel clocks per line and the input horizontal offset need to be chosen next. The only constraint is that the horizontal blanking has at least 10 clock pulses.

The required pixel clock frequency can be determined in the following way: Due to the limited internal FIFO size, the input path has to provide all pixels in the same time frame as the encoders vertical active time. The scaler also has to process the first and last border lines for the anti-flicker function.

$$\text{Thus: } TPclk = \frac{262.5 \times 1716 \times TXclk}{InPpl \times \text{integer}\left(\frac{InLin + 2}{OutLin} \times 262.5\right)} \text{ (60 Hz)}$$

$$TPclk = \frac{312.5 \times 1728 \times TXclk}{InPpl \times \text{integer}\left(\frac{InLin + 2}{OutLin} \times 312.5\right)} \text{ (50 Hz)}$$

and for the pixel clock generator

$$PCL = \frac{TXclk}{TPclk} \times 2^{20 + PCLE} \text{ (all frequencies);}$$

see Tables 102, 104 and 105. The divider PCLE should be set according to Table 104. PCLI may be set to a lower or the same value. Setting a lower value means that the internal pixel clock is higher and the data get sampled up. The difference may be 1 at 640 × 480 pixels resolution and 2 at resolutions with 320 pixels per line as a rule of thumb. This allows horizontal upscaling by a maximum factor of 2 respectively 4 (this is the parameter RiePclk).

$$PCLI = PCLE - \frac{\log RiePclk}{\log 2} \text{ (all frequencies)}$$

The equations ensure that the last line of the field has the full number of clock cycles. Many graphic controllers require this. Note that the bit PCLSY needs to be set to ensure that there is not even a fraction of a clock left at the end of the field.

## 8.20.3 HORIZONTAL SCALER

XOFS can be chosen arbitrarily, the condition being that  $XOFS + XPIX \leq HLEN$  is fulfilled. Values given by the VESA display timings are preferred.

$$HLEN = InPpl \times RiePclk - 1$$

$$XPIX = \frac{InPix}{2} \times RiePclk$$

$$XINC = \frac{OutPix}{InPix} \times \frac{4096}{RiePclk}$$

XINC needs to be rounded up, it needs to be set to 0 for a scaling factor of 1.

## 8.20.4 VERTICAL SCALER

The input vertical offset can be taken from the assumption that the scaler should have just finished writing the first line when the encoder starts reading it:

$$YOFS = \frac{FAL \times 1716 \times TXclk}{InPpl \times TPclk} - 2.5 \text{ (60 Hz)}$$

$$YOFS = \frac{FAL \times 1728 \times TXclk}{InPpl \times TPclk} - 2.5 \text{ (50 Hz)}$$

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In most cases the vertical offsets will be the same for odd and even fields. The results should be rounded down.

$$YPIX = InLin$$

YSKIP defines the anti-flicker function. 0 means maximum flicker reduction but minimum vertical bandwidth, 4095 gives no flicker reduction and maximum bandwidth. Note that the maximum value for YINC is 4095. It might be necessary to reduce the value of YSKIP to fulfil this requirement.

$$YINC = \frac{OutLin}{InLin + 2} \times \left(1 + \frac{YSKIP}{4095}\right) \times 4096$$

$$YIWGTO = \frac{YINC}{2} + 2048$$

$$YIWGTE = \frac{YINC - YSKIP}{2}$$

When YINC = 0 it sets the scaler to scaling factor 1. The initial weighting factors must not be set to 0 in this case. YIWGTE may go negative. In this event, YINC should be added and YOFSE incremented. This can be repeated as often as necessary to make YIWGTE positive.

Note that these equations assume that the input is non-interlaced while the output is interlaced. If the input is interlaced, the initial weighting factors need to be adapted to get the proper phase offsets in the output frame.

If vertical upscaling beyond the upper capabilities is required, the parameter YUPSC may be set to 1. This extends the maximum vertical scaling factor by a factor 2. Only the parameter YINC gets affected, it needs to be divided by 2 to get the same effect.

There are restrictions in this mode:

- The vertical filter YFILT is not available in this mode; the circuit will ignore this value
- The horizontal blanking needs to be long enough to transfer an output line between 2 memory locations. This is 710 internal pixel clocks

Or the upscaling factor needs to be limited to 1.5 and the horizontal upscaling factor is also limited to less than ~1.5. In this case a normal blanking length is sufficient.

## 8.21 Input levels and formats

The SAA7108AE; SAA7109AE accepts digital Y, C<sub>B</sub>, C<sub>R</sub> or RGB data with levels (digital codes) in accordance with "ITU-R BT.601". An optional gain adjustment also allows data to be accepted with the full level swing of 0 to 255.

For C and CVBS outputs, deviating amplitudes of the colour difference signals can be compensated for by independent gain control setting, while gain for luminance is set to predefined values, distinguishable for 7.5 IRE set-up or without set-up.

The RGB, respectively C<sub>R</sub>-Y-C<sub>B</sub> path features an individual gain setting for luminance (GY) and colour difference signals (GCD). Reference levels are measured with a colour bar, 100 % white, 100 % amplitude and 100 % saturation.

The encoder section of the SAA7108AE; SAA7109AE has special input cells for the VGC port. They operate at a wider supply voltage range and have a strict input threshold at  $1/2V_{DD(DVO)}$ . To achieve full speed of these cells, the EIDIV bit needs to be set to logic 1. In this case the impedance of these cells is approximately 6 kΩ. This may cause trouble with the bootstrapping pins of some graphic chips. So the power-on reset forces the bit to logic 0, the input impedance is regular in this mode.

**Table 7** "ITU-R BT.601" signal component levels

COLOUR	SIGNALS <sup>(1)</sup>					
	Y	C <sub>B</sub>	C <sub>R</sub>	R	G	B
White	235	128	128	235	235	235
Yellow	210	16	146	235	235	16
Cyan	170	166	16	16	235	235
Green	145	54	34	16	235	16
Magenta	106	202	222	235	16	235
Red	81	90	240	235	16	16
Blue	41	240	110	16	16	235
Black	16	128	128	16	16	16

### Note

1. Transformation:

- a)  $R = Y + 1.3707 \times (C_R - 128)$
- b)  $G = Y - 0.3365 \times (C_B - 128) - 0.6982 \times (C_R - 128)$ .
- c)  $B = Y + 1.7324 \times (C_B - 128)$ .

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**Table 8** Usage of bits SLOT and EDGE

DATA SLOT CONTROL (EXAMPLE FOR FORMAT 0)			
SLOT	EDGE	1st DATA	2nd DATA
0	0	at rising edge G3/Y3	at falling edge R7/C <sub>R</sub> 7
0	1	at falling edge G3/Y3	at rising edge R7/C <sub>R</sub> 7
1	0	at rising edge R7/C <sub>R</sub> 7	at falling edge G3/Y3
1	1	at falling edge R7/C <sub>R</sub> 7	at rising edge G3/Y3

**Table 9** Pin assignment for input format 0

8 + 8 + 8-BIT 4 : 4 : 4 NON-INTERLACED RGB/C <sub>B</sub> -Y-C <sub>R</sub>		
PIN	FALLING CLOCK EDGE	RISING CLOCK EDGE
PD11	G3/Y3	R7/C <sub>R</sub> 7
PD10	G2/Y2	R6/C <sub>R</sub> 6
PD9	G1/Y1	R5/C <sub>R</sub> 5
PD8	G0/Y0	R4/C <sub>R</sub> 4
PD7	B7/C <sub>B</sub> 7	R3/C <sub>R</sub> 3
PD6	B6/C <sub>B</sub> 6	R2/C <sub>R</sub> 2
PD5	B5/C <sub>B</sub> 5	R1/C <sub>R</sub> 1
PD4	B4/C <sub>B</sub> 4	R0/C <sub>R</sub> 0
PD3	B3/C <sub>B</sub> 3	G7/Y7
PD2	B2/C <sub>B</sub> 2	G6/Y6
PD1	B1/C <sub>B</sub> 1	G5/Y5
PD0	B0/C <sub>B</sub> 0	G4/Y4

**Table 10** Pin assignment for input format 1

5 + 5 + 5-BIT 4 : 4 : 4 NON-INTERLACED RGB		
PIN	FALLING CLOCK EDGE	RISING CLOCK EDGE
PD7	G2	X
PD6	G1	R4
PD5	G0	R3
PD4	B4	R2
PD3	B3	R1
PD2	B2	R0
PD1	B1	G4
PD0	B0	G3

**Table 11** Pin assignment for input format 2

5 + 6 + 5-BIT 4 : 4 : 4 NON-INTERLACED RGB		
PIN	FALLING CLOCK EDGE	RISING CLOCK EDGE
PD7	G2	R4
PD6	G1	R3
PD5	G0	R2
PD4	B4	R1
PD3	B3	R0
PD2	B2	G5
PD1	B1	G4
PD0	B0	G3

**Table 12** Pin assignment for input format 3

8 + 8 + 8-BIT 4 : 2 : 2 NON-INTERLACED C <sub>B</sub> -Y-C <sub>R</sub>				
PIN	FALLING CLOCK EDGE n	RISING CLOCK EDGE n	FALLING CLOCK EDGE n + 1	RISING CLOCK EDGE n + 1
PD7	C <sub>B</sub> 7(0)	Y7(0)	C <sub>R</sub> 7(0)	Y7(1)
PD6	C <sub>B</sub> 6(0)	Y6(0)	C <sub>R</sub> 6(0)	Y6(1)
PD5	C <sub>B</sub> 5(0)	Y5(0)	C <sub>R</sub> 5(0)	Y5(1)
PD4	C <sub>B</sub> 4(0)	Y4(0)	C <sub>R</sub> 4(0)	Y4(1)
PD3	C <sub>B</sub> 3(0)	Y3(0)	C <sub>R</sub> 3(0)	Y3(1)
PD2	C <sub>B</sub> 2(0)	Y2(0)	C <sub>R</sub> 2(0)	Y2(1)
PD1	C <sub>B</sub> 1(0)	Y1(0)	C <sub>R</sub> 1(0)	Y1(1)
PD0	C <sub>B</sub> 0(0)	Y0(0)	C <sub>R</sub> 0(0)	Y0(1)

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**Table 13** Pin assignment for input format 4

8 + 8 + 8-BIT 4 : 2 : 2 INTERLACED C <sub>B</sub> -Y-C <sub>R</sub> (ITU-R BT.656, 27 MHz CLOCK)				
PIN	RISING CLOCK EDGE n	RISING CLOCK EDGE n + 1	RISING CLOCK EDGE n + 2	RISING CLOCK EDGE n + 3
PD7	C <sub>B</sub> 7(0)	Y7(0)	C <sub>R</sub> 7(0)	Y7(1)
PD6	C <sub>B</sub> 6(0)	Y6(0)	C <sub>R</sub> 6(0)	Y6(1)
PD5	C <sub>B</sub> 5(0)	Y5(0)	C <sub>R</sub> 5(0)	Y5(1)
PD4	C <sub>B</sub> 4(0)	Y4(0)	C <sub>R</sub> 4(0)	Y4(1)
PD3	C <sub>B</sub> 3(0)	Y3(0)	C <sub>R</sub> 3(0)	Y3(1)
PD2	C <sub>B</sub> 2(0)	Y2(0)	C <sub>R</sub> 2(0)	Y2(1)
PD1	C <sub>B</sub> 1(0)	Y1(0)	C <sub>R</sub> 1(0)	Y1(1)
PD0	C <sub>B</sub> 0(0)	Y0(0)	C <sub>R</sub> 0(0)	Y0(1)

**Table 14** Pin assignment for input format 5; note 1

8-BIT NON-INTERLACED INDEX COLOUR		
PIN	FALLING CLOCK EDGE	RISING CLOCK EDGE
PD11	X	X
PD10	X	X
PD9	X	X
PD8	X	X
PD7	INDEX7	X
PD6	INDEX6	X
PD5	INDEX5	X
PD4	INDEX4	X
PD3	INDEX3	X
PD2	INDEX2	X
PD1	INDEX1	X
PD0	INDEX0	X

**Note**

1. X = don't care.

**Table 15** Pin assignment for input format 6

8 + 8 + 8-BIT 4 : 4 : 4 NON-INTERLACED RGB/C <sub>B</sub> -Y-C <sub>R</sub>		
PIN	FALLING CLOCK EDGE	RISING CLOCK EDGE
PD11	G4/Y4	R7/C <sub>R</sub> 7
PD10	G3/Y3	R6/C <sub>R</sub> 6
PD9	G2/Y2	R5/C <sub>R</sub> 5
PD8	B7/C <sub>B</sub> 7	R4/C <sub>R</sub> 4
PD7	B6/C <sub>B</sub> 6	R3/C <sub>R</sub> 3
PD6	B5/C <sub>B</sub> 5	G7/Y7
PD5	B4/C <sub>B</sub> 4	G6/Y6
PD4	B3/C <sub>B</sub> 3	G5/Y5
PD3	G0/Y0	R2/C <sub>R</sub> 2
PD2	B2/C <sub>B</sub> 2	R1/C <sub>R</sub> 1
PD1	B1/C <sub>B</sub> 1	R0/C <sub>R</sub> 0
PD0	B0/C <sub>B</sub> 0	G1/Y1

## HD-CODEC

## SAA7108AE; SAA7109AE

**9 FUNCTIONAL DESCRIPTION OF DIGITAL VIDEO DECODER PART****9.1 Decoder****9.1.1 ANALOG INPUT PROCESSING**

The SAA7108AE; SAA7109AE offers six analog signal inputs, two analog main channels with source switch, clamp circuit, analog amplifier, anti-alias filter and video 9-bit CMOS ADC; see Fig.15.

**9.1.2 ANALOG CONTROL CIRCUITS**

The anti-alias filters are adapted to the line-locked clock frequency via a filter control circuit. The characteristics are illustrated in Fig.12. During the vertical blanking period, gain and clamping control is frozen.

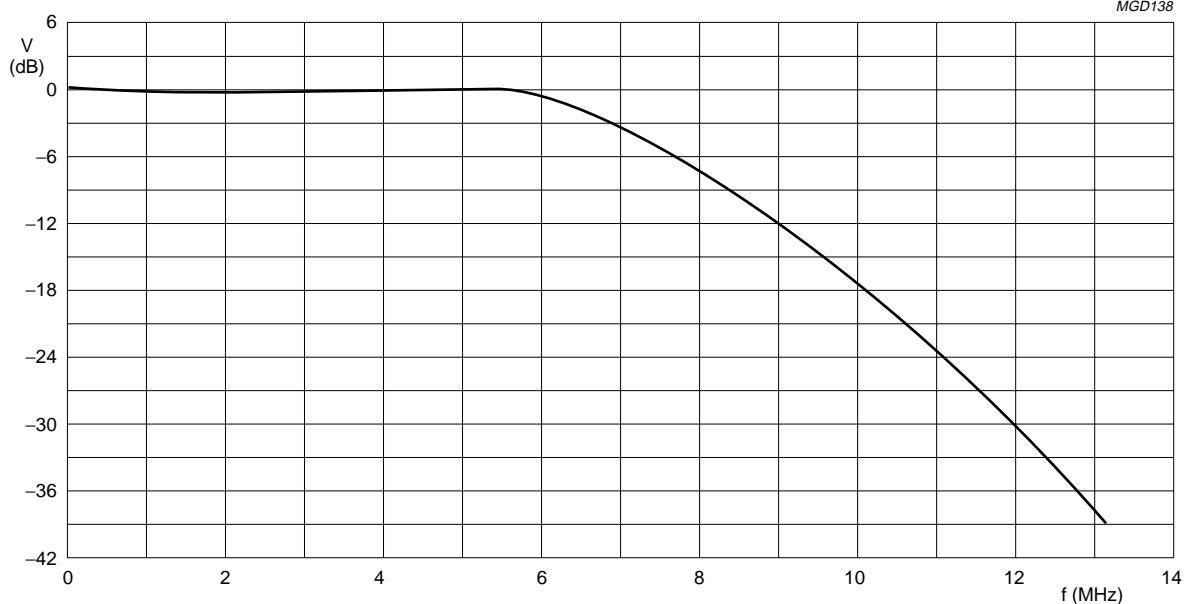


Fig.12 Anti-alias filter.

## HD-CODEC

## SAA7108AE; SAA7109AE

9.1.2.1 *Clamping*

The clamping control circuit controls the correct clamping of the analog input signals. A coupling capacitor is used to store and filter the clamping voltage. An internal digital clamp comparator generates the information with respect to clamp-up or clamp-down. The clamping levels for the two ADC channels are fixed for luminance (60) and chrominance (128). Clamping time in normal use is set with the HCL pulse at the back porch of the video signal.

9.1.2.2 *Gain control*

The gain control circuit receives (via the I<sup>2</sup>C-bus) the static gain levels for the two analog amplifiers, or controls one of these amplifiers automatically via a built-in Automatic Gain Control (AGC) as part of the Analog Input Control (AICO).

The AGC (automatic gain control for luminance) is used to amplify a CVBS or Y signal to the required signal amplitude, which is matched to the ADCs input voltage range. The AGC active time is the sync bottom of the video signal.

Signal (white) peak control limits the gain at signal overshoots. The influence of supply voltage variation within the specified range is automatically eliminated by clamping and automatic gain control. The flow charts show more details of the AGC; see Figs 16 and 17.

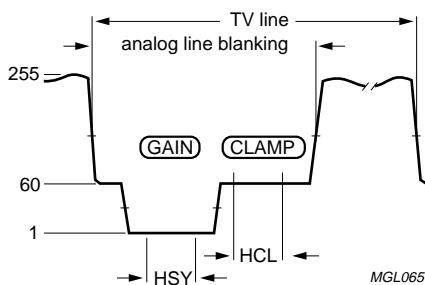


Fig.13 Analog line with clamp (HCL) and gain range (HSY).

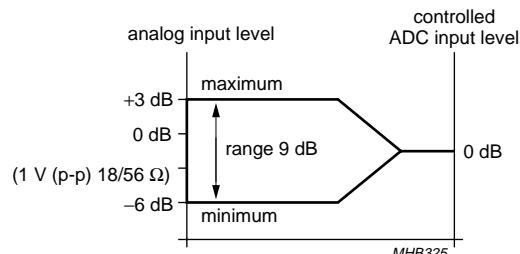


Fig.14 Automatic gain range.

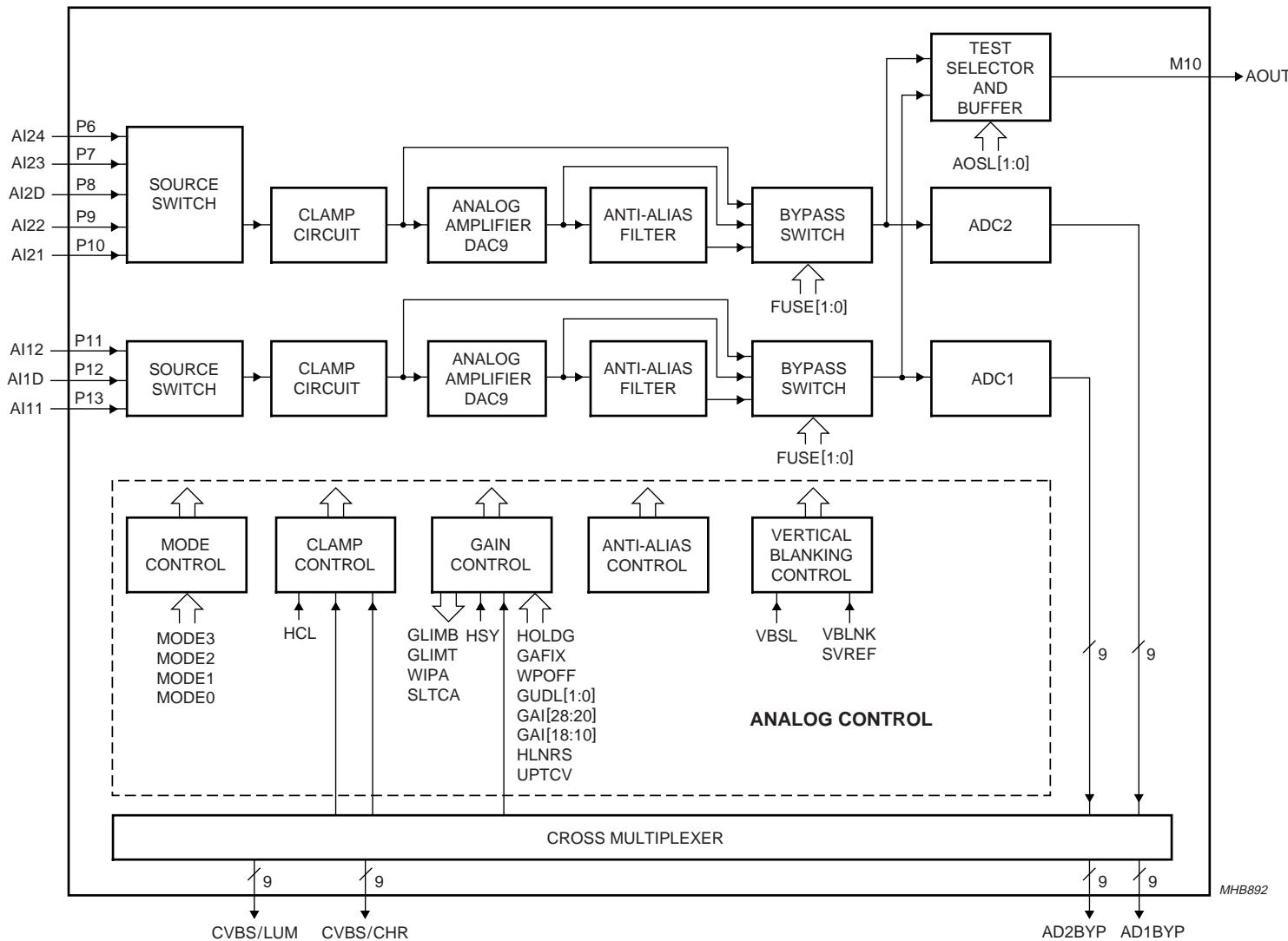
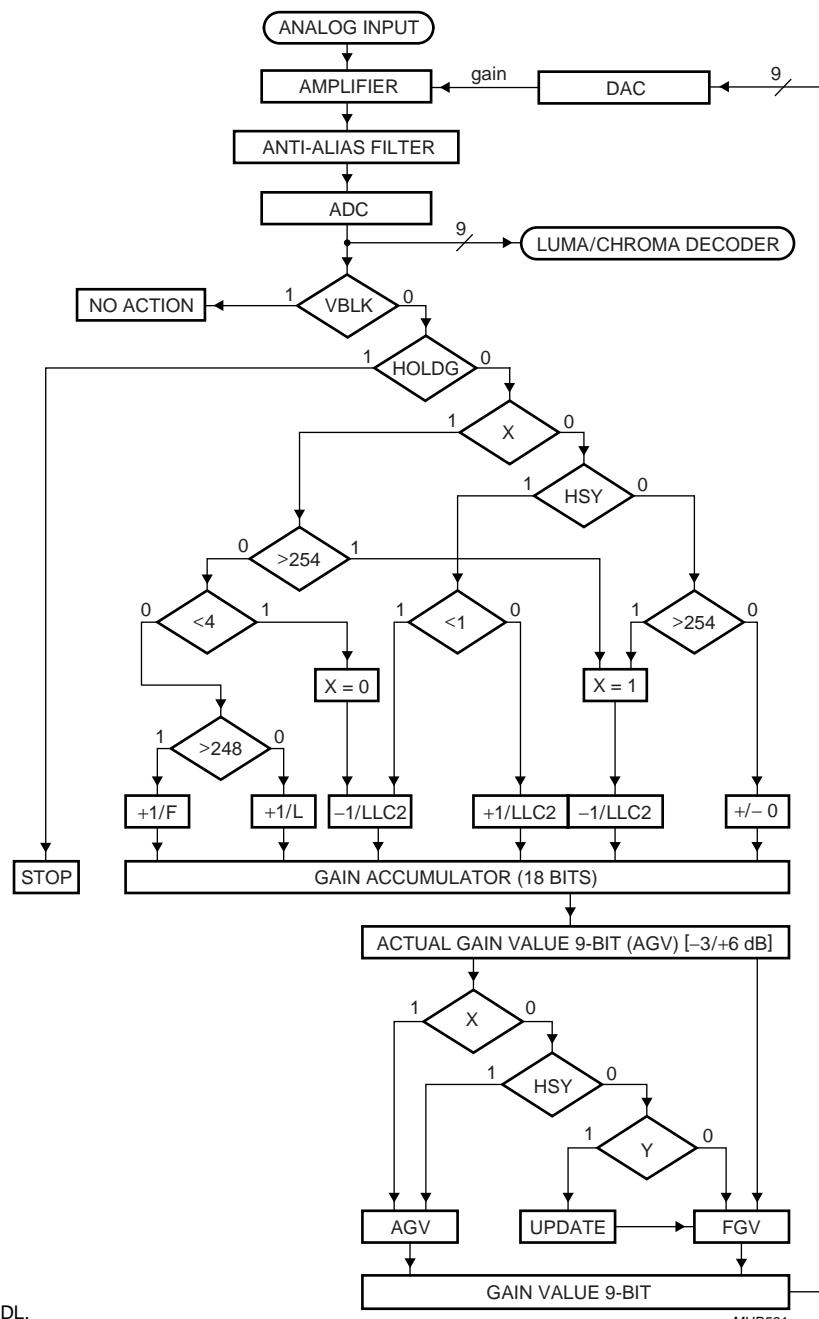


Fig.15 Analog input processing using the SAA7108AE; SAA7109AE as differential front-end with 9-bit ADC.

## HD-CODEC

## SAA7108AE; SAA7109AE



X = system variable.

Y = (IAGV - FGV) &gt; GUDL.

VBLK = vertical blanking pulse.

HSY = horizontal sync pulse.

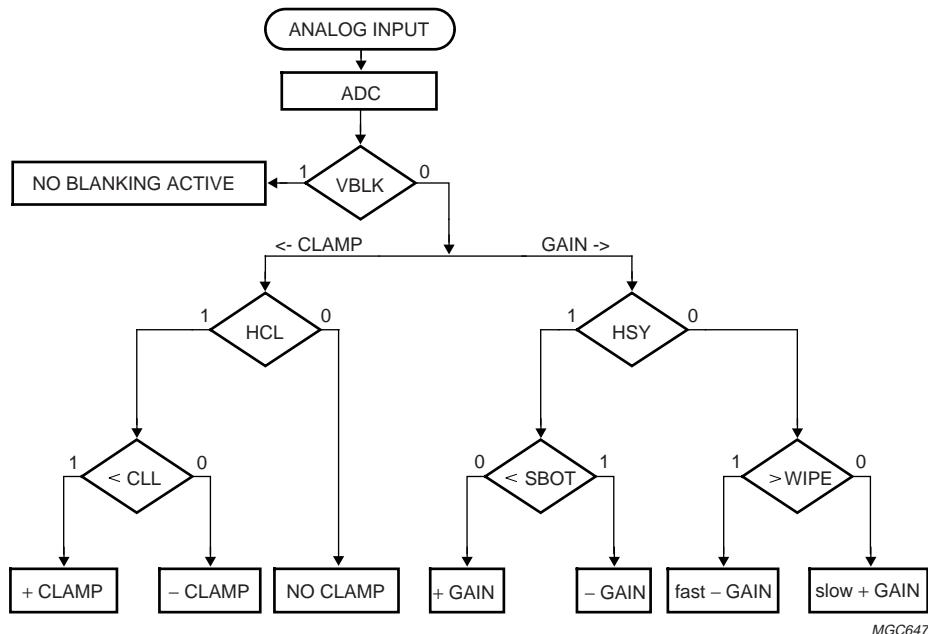
AGV = actual gain value.

FGV = frozen gain value.

Fig.16 Gain flow chart.

## HD-CODEC

## SAA7108AE; SAA7109AE



WIPE = white peak level (254).

SBOT = sync bottom level (1).

CLL = clamp level [60 Y (128 C)].

HSY = horizontal sync pulse.

HCL = horizontal clamp pulse.

Fig.17 Clamp and gain flow.

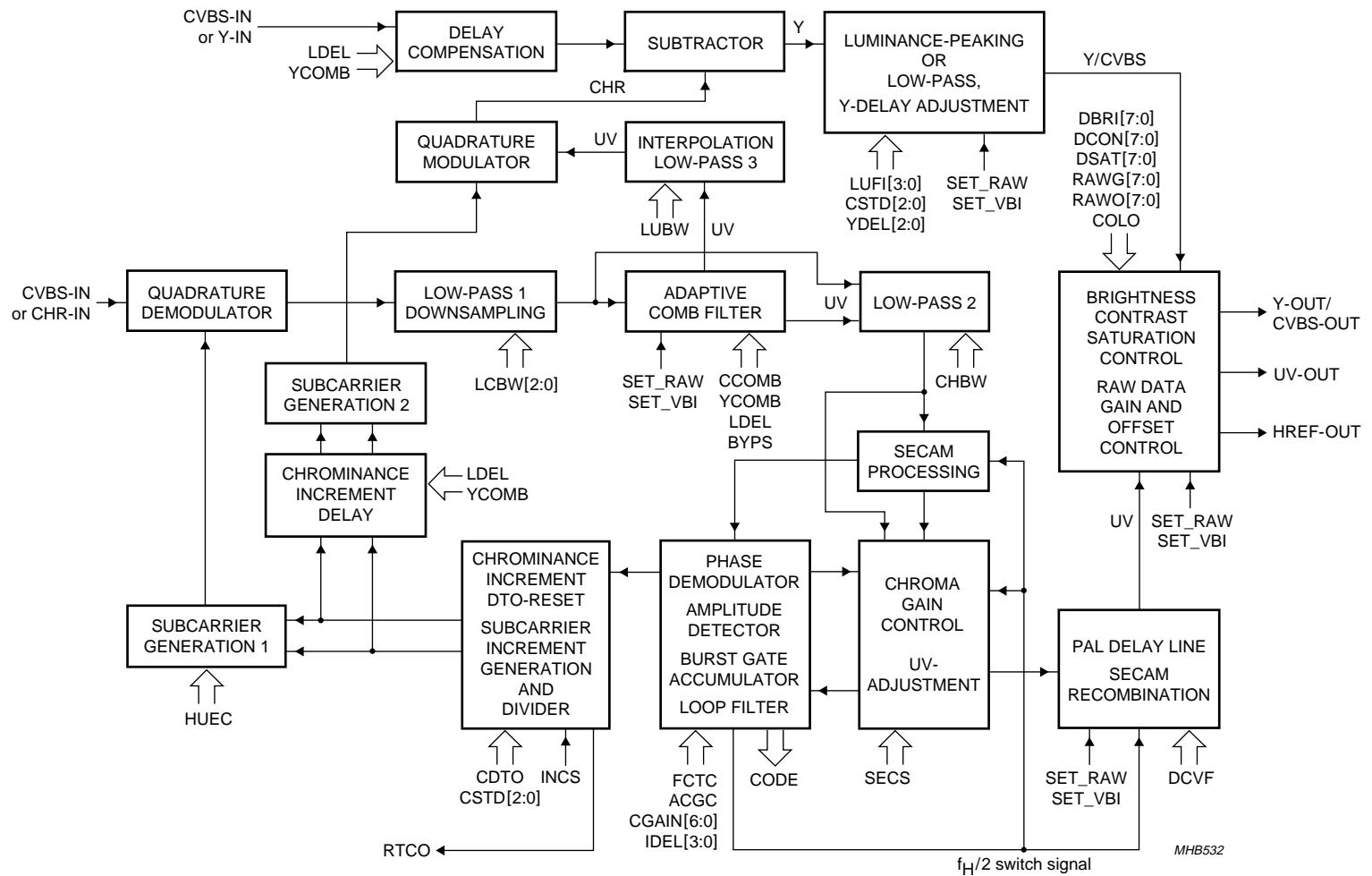


Fig.18 Chrominance and luminance processing.

## HD-CODEC

## SAA7108AE; SAA7109AE

9.1.3.1 *Chrominance path*

The 9-bit CVBS or chrominance input signal is fed to the input of a quadrature demodulator, where it is multiplied by two time-multiplexed subcarrier signals from the subcarrier generation block 1 (0 and 90° phase relationship to the demodulator axis). The frequency is dependent on the chosen colour standard.

The time-multiplexed output signals of the multipliers are low-pass filtered (low-pass 1). Eight characteristics are programmable via LCBW3 to LCBW0 to achieve the desired bandwidth for the colour difference signals (PAL, NTSC) or the 0° and 90° FM signals (SECAM).

The chrominance low-pass 1 characteristic also influences the grade of cross-luminance reduction during horizontal colour transients (large chrominance bandwidth means strong suppression of cross-luminance). If the Y comb filter is disabled when YCOMB = 0 the filter directly influences the width of the chrominance notch within the luminance path (large chrominance bandwidth means wide chrominance notch resulting to lower luminance bandwidth).

The low-pass filtered signals are fed to the adaptive comb filter block. The chrominance components are separated from the luminance via a two-line vertical stage (four lines for PAL standards) and a decision logic circuit between the filtered and the non-filtered output signals: this block is bypassed for SECAM signals. The comb filter logic can be enabled independently for the succeeding luminance and chrominance processing by YCOMB (subaddress 09H, bit 6) and/or CCOMB (subaddress 0EH, bit 0). It is always bypassed during VBI or raw data lines, programmable by the LCRn registers (subaddresses 41H to 57H); see Section 9.2.

The separated  $C_B$ - $C_R$  components are further processed by a second filter stage (low-pass 2) to modify the chrominance bandwidth without influencing the luminance path. Its characteristic is controlled by CHBW (subaddress 10H, bit 3). For the complete transfer characteristic of low-pass filters 1 and 2 see Figs 19 and 20.

The SECAM processing (bypassed for QAM standards) contains the following blocks:

- Baseband 'bell' filters to reconstruct the amplitude and phase equalized 0° and 90° FM signals
- Phase demodulator and differentiator (FM demodulation)
- De-emphasis filter to compensate the pre-emphasized input signal, including frequency offset compensation (DB or DR white carrier values are subtracted from the signal, controlled by the SECAM switch signal).

The succeeding chrominance gain control block amplifies or attenuates the  $C_B$ - $C_R$  signal according to the required ITU 601/656 levels. It is controlled by the output signal from the amplitude detection circuit within the burst processing block.

The burst processing block provides the feedback loop of the chrominance PLL and contains the following:

- Burst gate accumulator
- Colour identification and killer
- Comparison nominal/actual burst amplitude (PAL/NTSC standards only)
- Loop filter chrominance gain control (PAL/NTSC standards only)
- Loop filter chrominance PLL (only active for PAL/NTSC standards)
- PAL/SECAM sequence detection, H/2-switch generation.

The increment generation circuit produces the Discrete Time Oscillator (DTO) increment for both subcarrier generation blocks. It contains a division by the increment of the line-locked clock generator to create a stable phase-locked sine signal under all conditions (e.g. for non-standard signals).

The PAL delay line block eliminates crosstalk between the chrominance channels in accordance with the PAL standard requirements. For NTSC colour standards, the delay line can be used as an additional vertical filter. If desired, it can be switched off by DCVF = 1. It is always disabled during VBI or raw data lines programmable by the LCRn registers (subaddresses 41H to 57H); see Section 9.2. The embedded line delay is also used for SECAM recombination (cross-over switches).

## HD-CODEC

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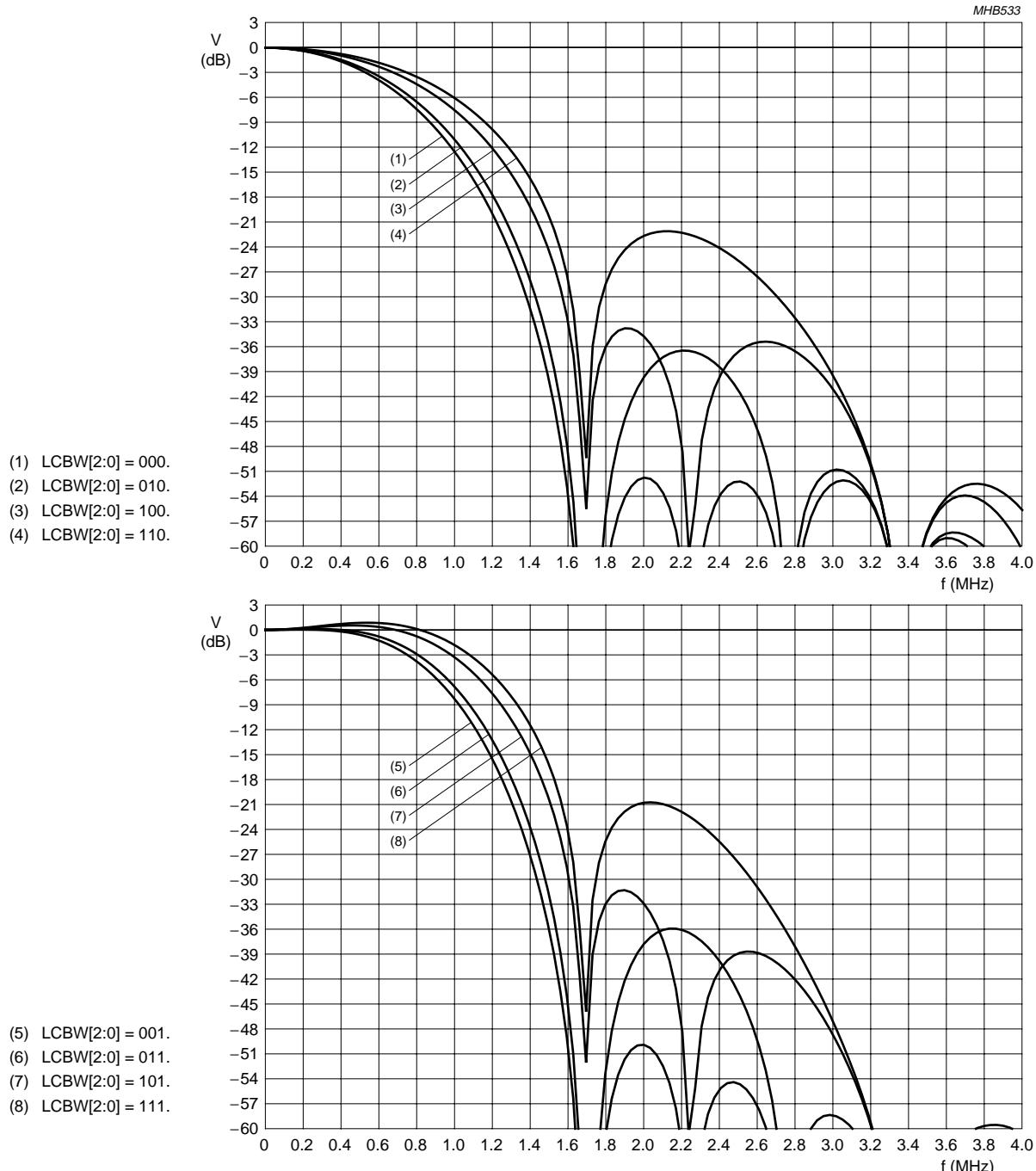


Fig.19 Transfer characteristics of the chrominance low-pass at CHBW = 0.

## HD-CODEC

## SAA7108AE; SAA7109AE

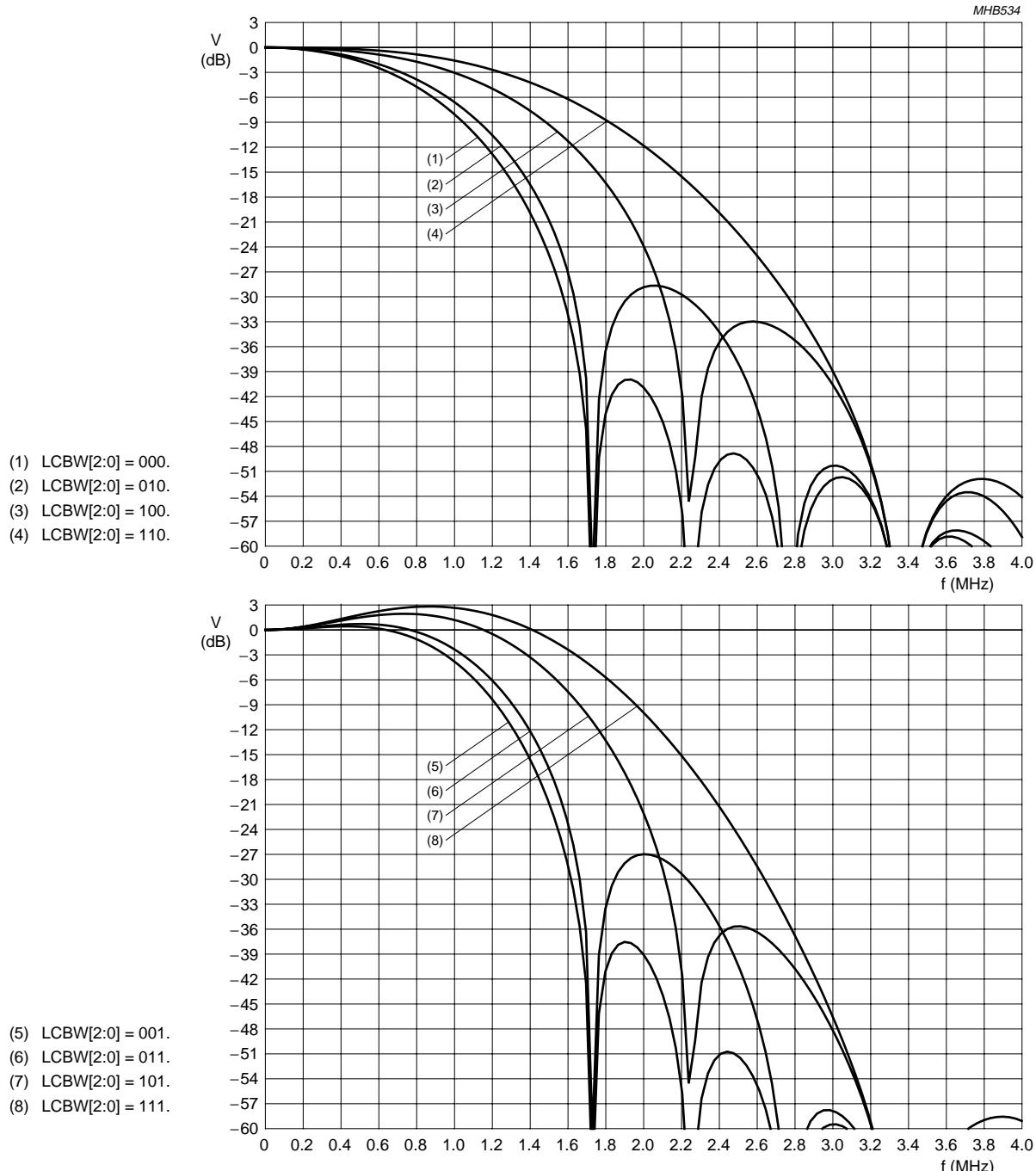


Fig.20 Transfer characteristics of the chrominance low-pass at CHBW = 1.

## HD-CODEC

## SAA7108AE; SAA7109AE

9.1.3.2 *Luminance path*

The rejection of the chrominance components within the 9-bit CVBS or Y input signal is done by subtracting the re-modulated chrominance signal from the CVBS input.

The comb filtered  $C_B$ - $C_R$  components are interpolated (upsampled) by the low-pass 3 block. Its characteristic is controlled by LUBW (subaddress 09H, bit 4) to modify the width of the chrominance 'notch' without influencing the chrominance path. The programmable frequency characteristics available, in conjunction with the LCBW2 to LCBW0 settings, can be seen in Figs 21 to 24. It should be noted that these frequency curves are only valid for Y comb disabled filter mode (YCOMB = 0). In comb filter mode the frequency response is flat. The centre frequency of the notch is automatically adapted to the chosen colour standard.

The interpolated  $C_B$ - $C_R$  samples are multiplied by two time-multiplexed subcarrier signals from the subcarrier generation block 2. This second DTO is locked to the first subcarrier generator by an increment delay circuit matched to the processing delay, which is different for PAL and NTSC standards according to the chosen comb filter algorithm. The two modulated signals are finally added to create the re-modulated chrominance signal.

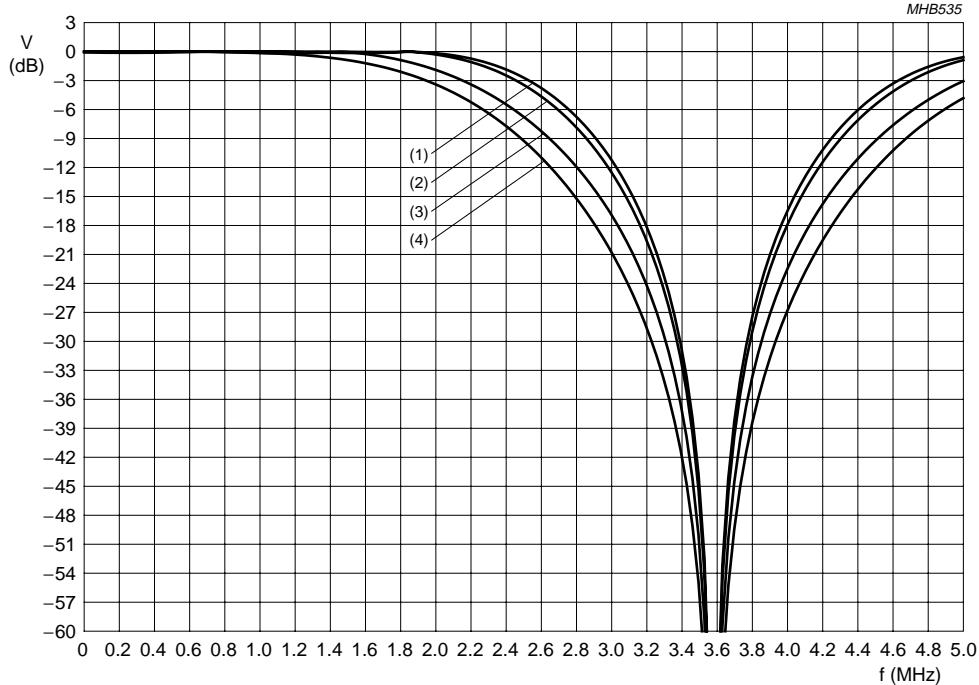
The frequency characteristic of the separated luminance signal can be further modified by the succeeding luminance filter block. It can be configured as peaking (resolution enhancement) or low-pass block by LUF13 to LUF10 (subaddress 09H, bits 3 to 0). The 16 resulting frequency characteristics can be seen in Fig.25. The LUF13 to LUF10 settings can be used as a user programmable sharpness control.

The luminance filter block also contains the adjustable Y delay part; programmable by YDEL2 to YDEL0 (subaddress 11H, bits 2 to 0).

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(1) LCBW[2:0] = 000.  
 (2) LCBW[2:0] = 010.  
 (3) LCBW[2:0] = 100.  
 (4) LCBW[2:0] = 110.



(5) LCBW[2:0] = 001.  
 (6) LCBW[2:0] = 011.  
 (7) LCBW[2:0] = 101.  
 (8) LCBW[2:0] = 111.

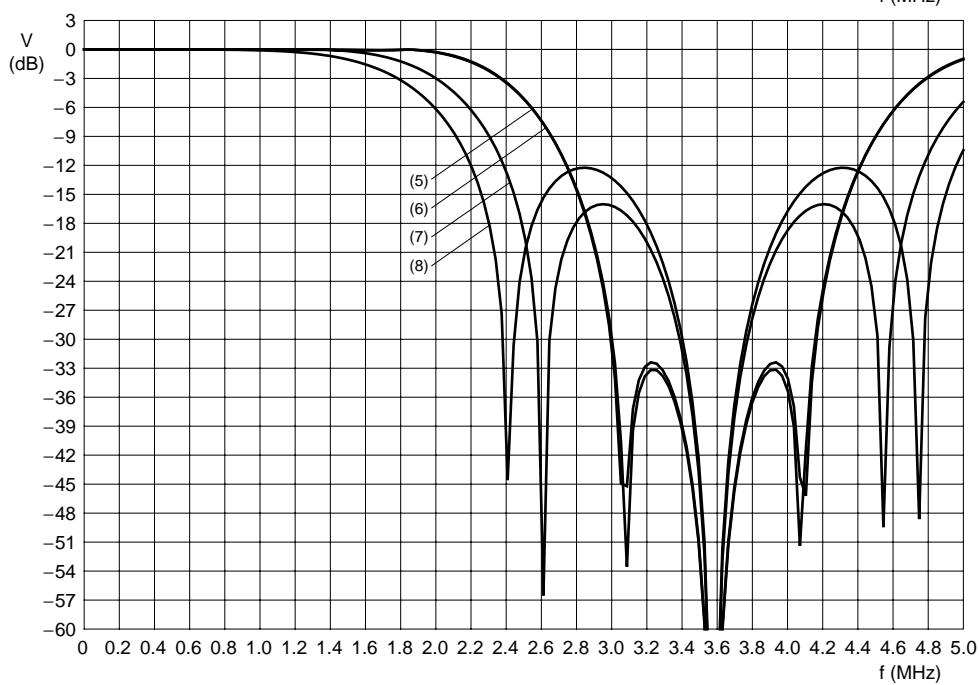
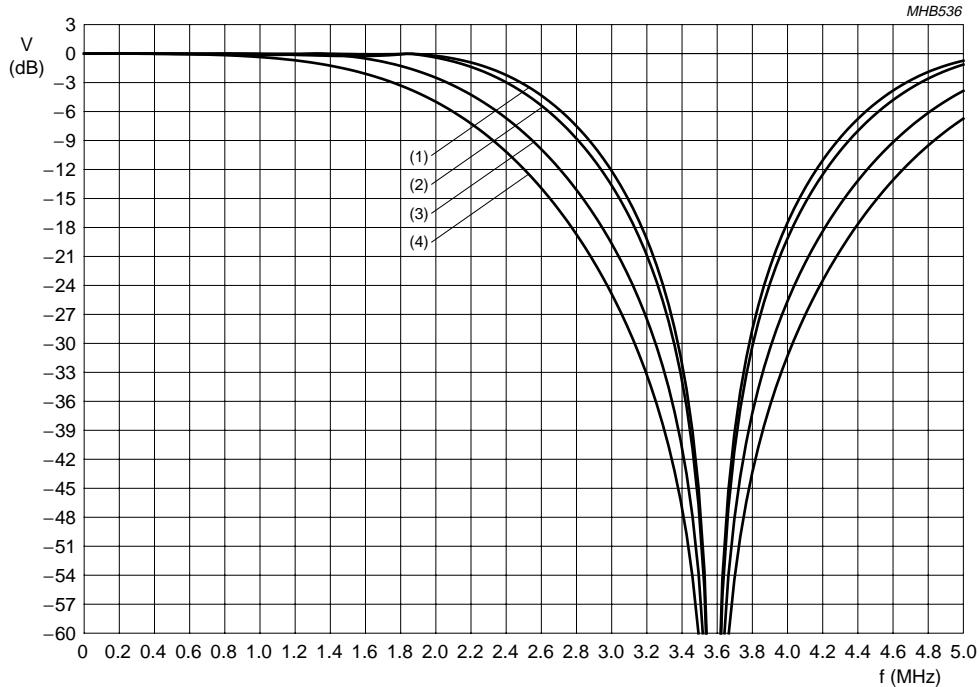


Fig.21 Transfer characteristics of the luminance notch filter in 3.58 MHz mode (Y-comb filter disabled) at LUBW = 0.

## HD-CODEC

## SAA7108AE; SAA7109AE

(1) LCBW[2:0] = 000  
 (2) LCBW[2:0] = 010  
 (3) LCBW[2:0] = 100  
 (4) LCBW[2:0] = 110



(5) LCBW[2:0] = 001  
 (6) LCBW[2:0] = 011  
 (7) LCBW[2:0] = 101  
 (8) LCBW[2:0] = 111

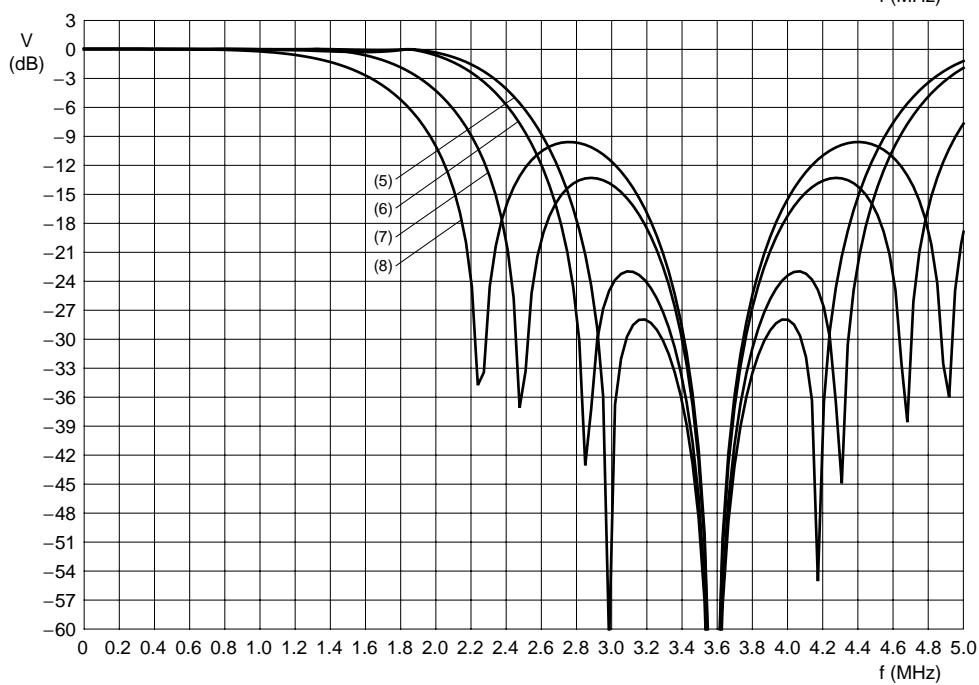


Fig.22 Transfer characteristics of the luminance notch filter in 3.58 MHz mode (Y-comb filter disabled) at LUBW = 1.

## HD-CODEC

## SAA7108AE; SAA7109AE

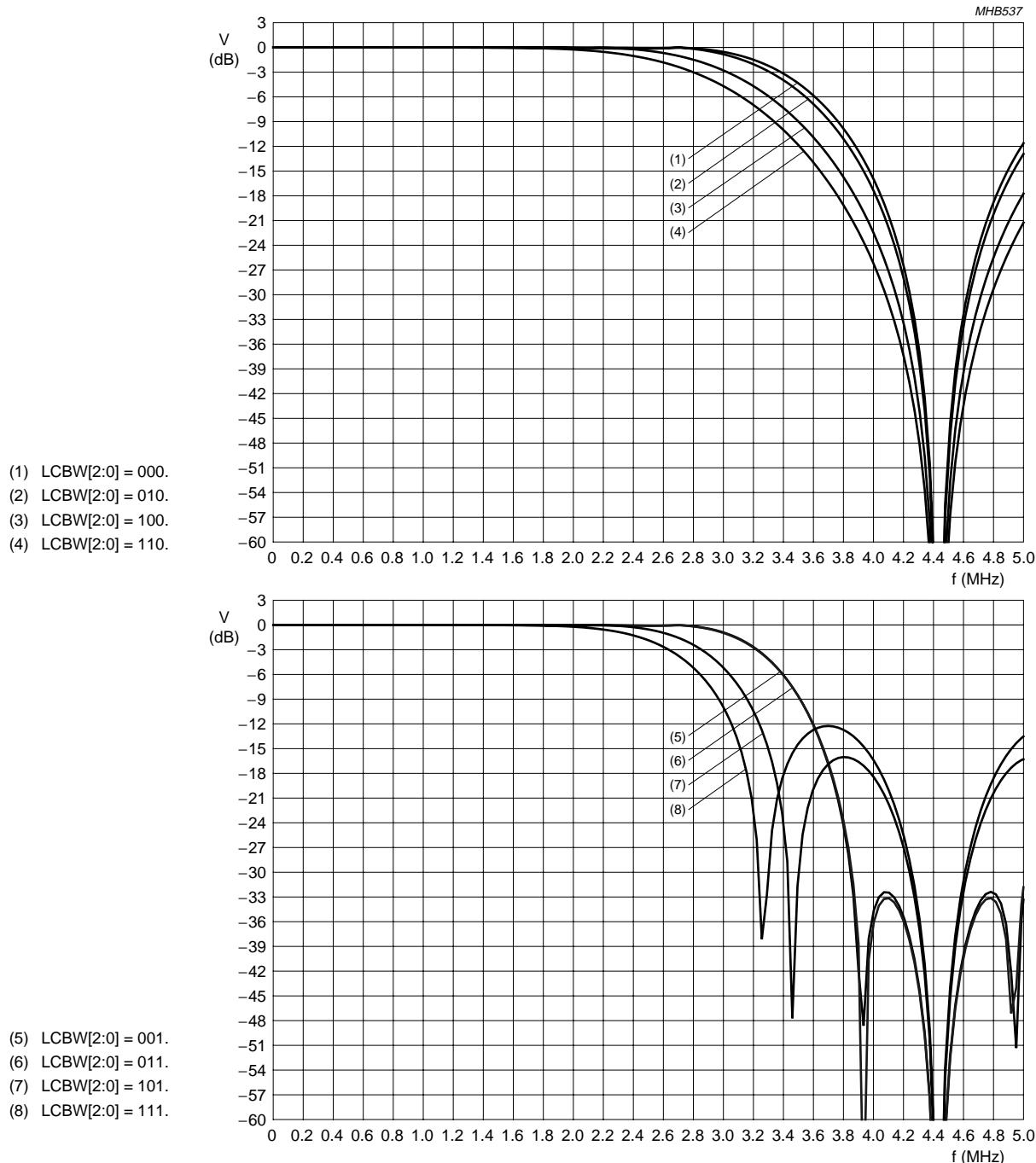


Fig.23 Transfer characteristics of the luminance notch filter in 4.43 MHz mode (Y-comb filter disabled) at LUBW = 0.

## HD-CODEC

## SAA7108AE; SAA7109AE

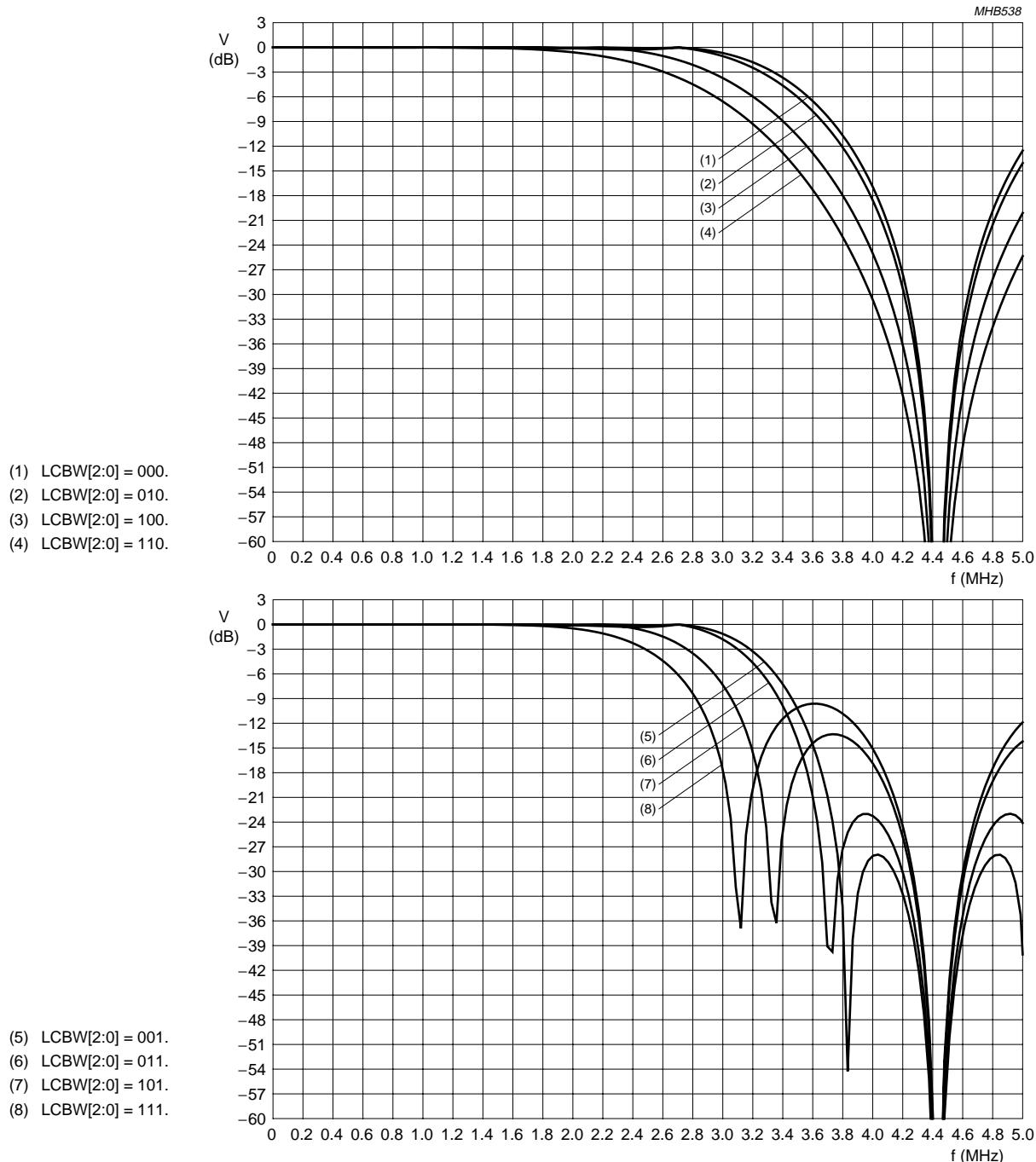


Fig.24 Transfer characteristics of the luminance notch filter in 4.43 MHz mode (Y-comb filter disabled) at LUBW = 1.

## HD-CODEC

## SAA7108AE; SAA7109AE

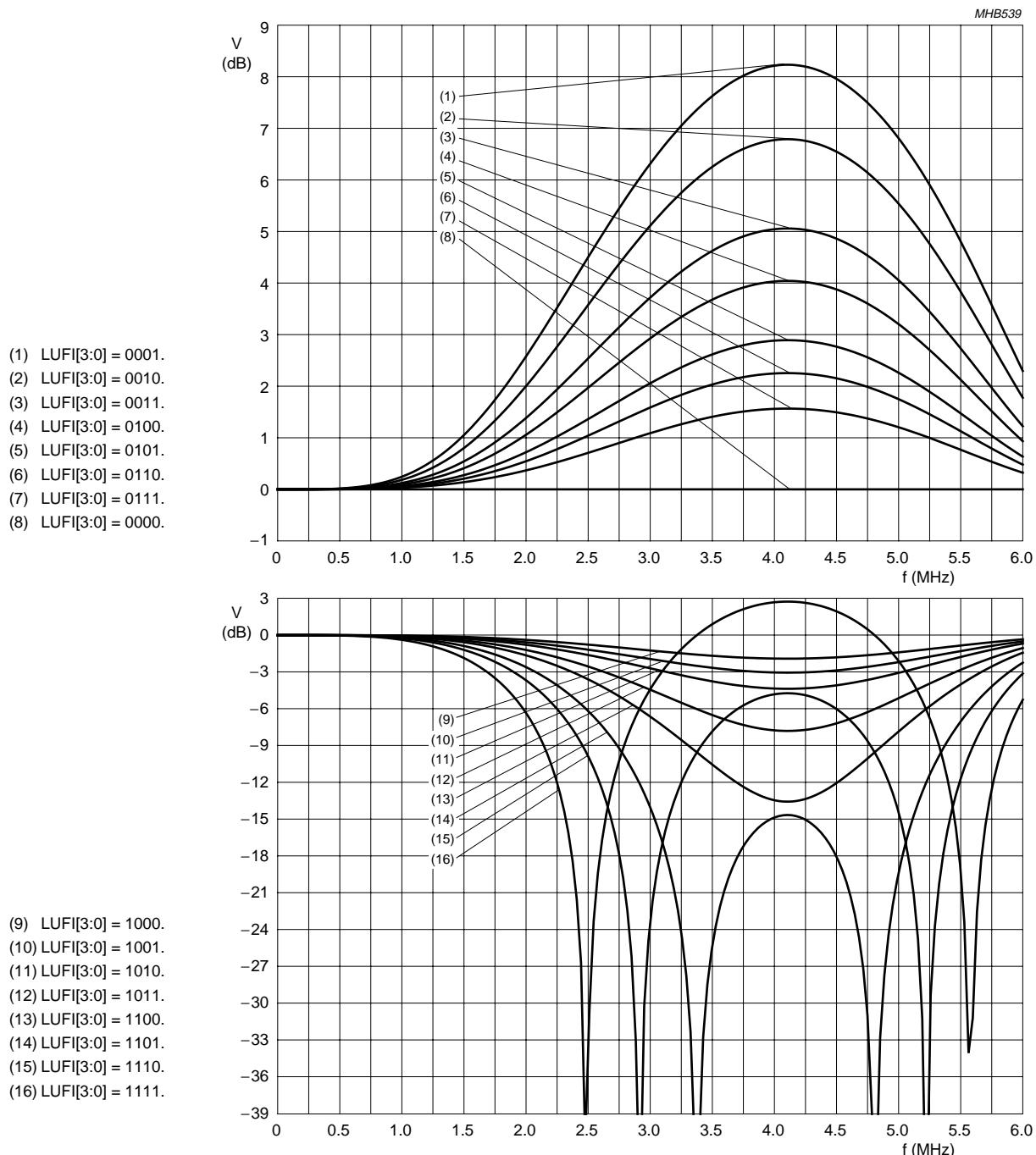


Fig.25 Transfer characteristics of the luminance peaking/low-pass filter (sharpness).

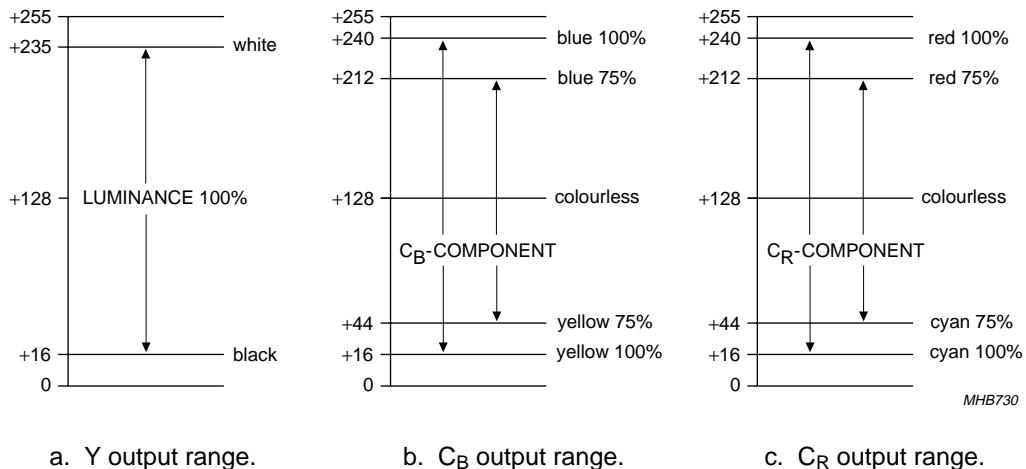
## HD-CODEC

## SAA7108AE; SAA7109AE

## 9.1.3.3 Brightness Contrast Saturation (BCS) control and decoder output levels

The resulting Y (CVBS) and C<sub>B</sub>-C<sub>R</sub> signals are fed to the BCS block, which contains the following functions:

- Chrominance saturation control by DSAT7 to DSAT0
- Luminance contrast and brightness control by DCON7 to DCON0 and DBRI7 to DBRI0
- Raw data (CVBS) gain and offset adjustment by RAWG7 to RAWG0 and RAWO7 to RAWO0
- Limiting Y-C<sub>B</sub>-C<sub>R</sub> or CVBS to the values 1 (minimum) and 254 (maximum) to fulfil "ITU Recommendation 601/656".



"ITU Recommendation 601/656" digital levels with default BCS (decoder) settings DCON[7:0] = 44H, DBRI[7:0] = 80H and DSAT[7:0] = 40H. Equations for modification to the Y-C<sub>B</sub>-C<sub>R</sub> levels via BCS control I<sup>2</sup>C-bus bytes DBRI, DCON and DSAT.

$$\text{Luminance: } Y_{\text{OUT}} = \text{Int}\left[\frac{\text{DCON}}{68} \times (Y - 128)\right] + \text{DBRI}$$

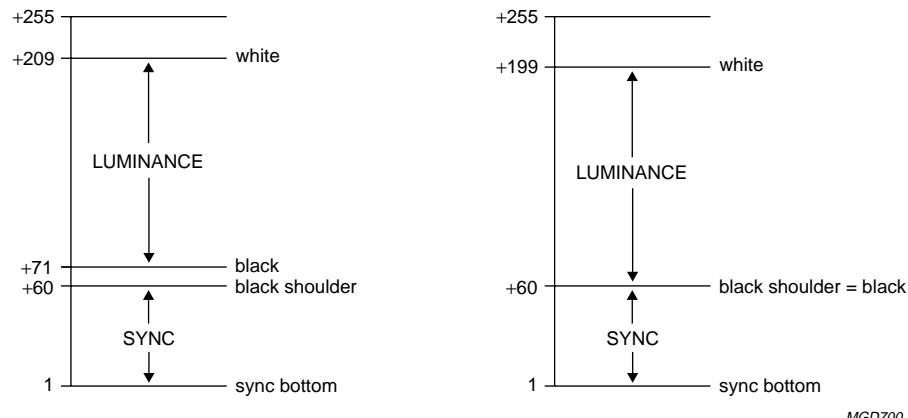
$$\text{Chrominance: } (C_R C_B)_{\text{OUT}} = \text{Int}\left[\frac{\text{DSAT}}{64} \times (C_R, C_B - 128)\right] + 128$$

It should be noted that the resulting levels are limited to 1 to 254 in accordance with "ITU Recommendation 601/656".

Fig.26 Y-C<sub>B</sub>-C<sub>R</sub> range for scaler input and X port output.

## HD-CODEC

## SAA7108AE; SAA7109AE



a. Sources containing 7.5 IRE black level offset (e.g. NTSC M).      b. Sources not containing black level offset.

CVBS levels with default settings RAWG[7:0] = 64 and RAWO[7:0] = 128.

Equation for modification of the raw data levels via bytes RAWG and RAWO:

$$CVBS_{OUT} = \text{Int}\left[\frac{RAWG}{64} \times (CVBS_{nom} - 128)\right] + RAWO$$

It should be noted that the resulting levels are limited to 1 to 254 in accordance with "ITU Recommendation 601/656".

Fig.27 CVBS (raw data) range for scaler input, data slicer and X port output.

## HD-CODEC

## SAA7108AE; SAA7109AE

## 9.1.4 SYNCHRONIZATION

The prefiltered luminance signal is fed to the synchronization stage. Its bandwidth is further reduced to 1 MHz by a low-pass filter. The sync pulses are sliced and fed to the phase detectors where they are compared with the sub-divided clock frequency. The resulting output signal is applied to the loop filter to accumulate all phase deviations. Internal signals (e.g. HCL and HSY) are generated in accordance with analog front-end requirements. The loop filter signal drives an oscillator to generate the line frequency control signal (LFCO); see Fig.28.

The detection of 'pseudo syncs' as part of the Macrovision copy protection standard is also done within the synchronization circuit.

The result is reported as flag COPRO within the decoder status byte at subaddress 1FH.

## 9.1.5 CLOCK GENERATION CIRCUIT

The internal CGC generates all clock signals required for the video input processor.

The internal signal LFCO is a digital-to-analog converted signal provided by the horizontal PLL. It is a multiple of the line frequency:

$$6.75 \text{ MHz} = 429 \times f_H \text{ (50 Hz), or}$$

$$6.75 \text{ MHz} = 432 \times f_H \text{ (60 Hz).}$$

The LFCO signal is multiplied internally by a factor of 2 and 4 in the PLL circuit (including phase detector, loop filtering, VCO and frequency divider) to obtain the output clock signals. The rectangular output clocks have a 50 % duty cycle.

**Table 16** Decoder clock frequencies

CLOCK	FREQUENCY (MHz)
XTAL	24.576 or 32.110
LLC	27
LLC2	13.5
LLC4 (internal)	6.75
LLC8 (virtual)	3.375

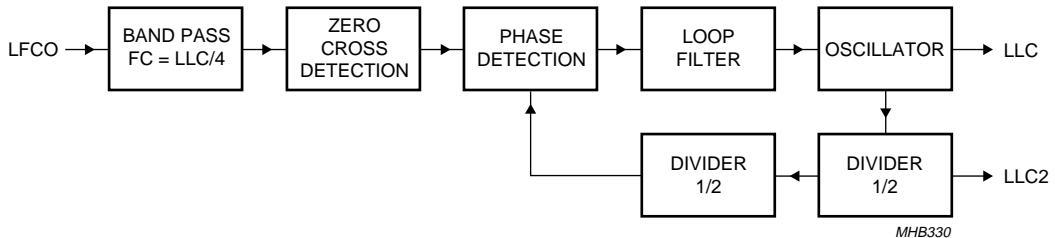


Fig.28 Block diagram of the clock generation circuit.

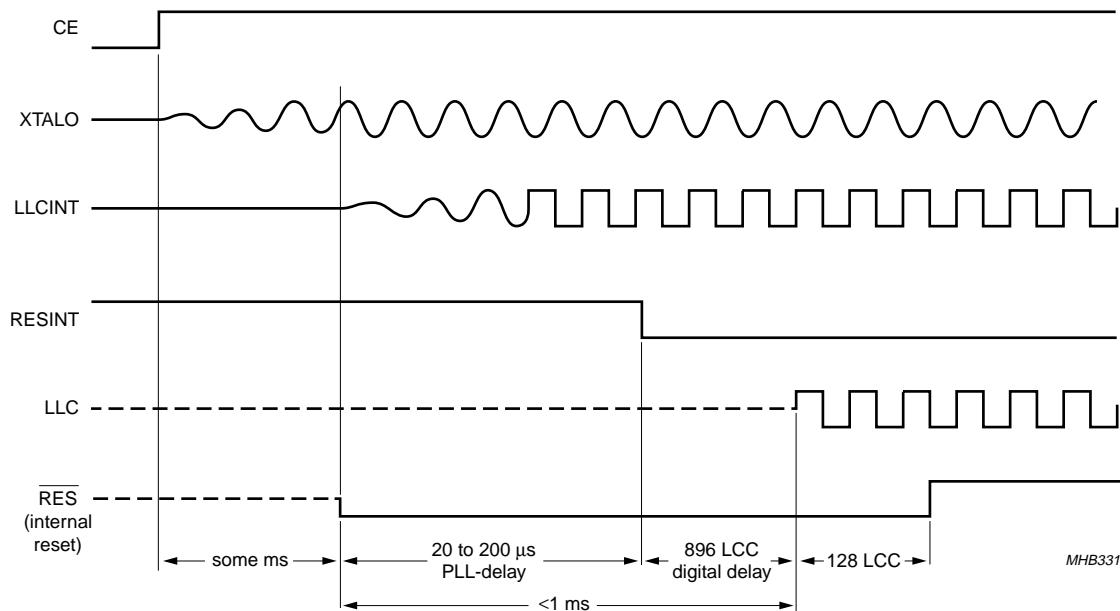
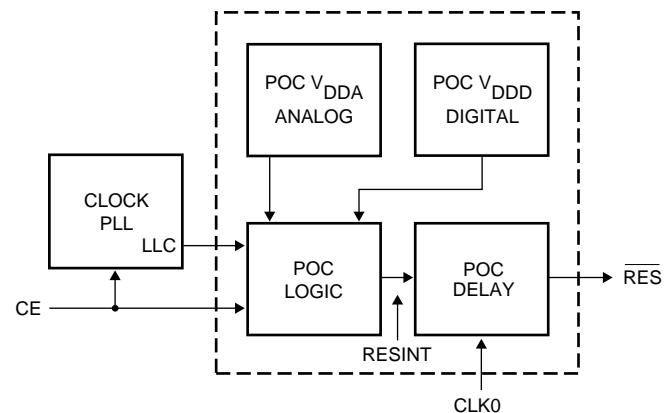
## 9.1.6 POWER-ON RESET AND CE INPUT

A missing clock, insufficient digital or analog  $V_{DDA_d}$  supply voltages (below 2.7 V) will start the reset sequence; all outputs are forced to 3-state (see Fig.29). The indicator output  $\overline{RES_d}$  is LOW for approximately 128 LLC after the internal reset and can be applied to reset other circuits of the digital TV system.

It is possible to force a reset by pulling the Chip Enable (CE) to ground. After the rising edge of CE and sufficient power supply voltage, the outputs LLC, LLC2 and  $SDA_d$  return from 3-state to active, while the other signals have to be activated via programming.

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POC = Power-on Control.

CE = chip enable input.

XTALO = crystal oscillator output.

LLCINT = internal system clock.

RESINT = internal reset.

LLC = line-locked clock output.

RES = reset output.

Fig.29 Power-on control circuit.

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## SAA7108AE; SAA7109AE

**9.2 Decoder output formatter**

The output interface block of the decoder part contains the ITU 656 formatter for the expansion port data output XPD7 to XPD0 (see Section 10.4.1) and the control circuit for the signals needed for the internal paths to the scaler and data slicer part. It also controls the selection of the reference signals for the RT port (RTCO, RTS0 and RTS1) and the expansion port (XRH, XRV and XDQ).

The generation of the decoder data type control signals SET\_RAW and SET\_VBI is also done within this block. These signals are decoded from the requested data type for the scaler input and/or the data slicer, selectable by the control registers LCR2 to LCR24; see Section 18.2.4.2.

For each LCR value, from 2 to 23, the data type can be programmed individually. LCR2 to LCR23 refer to line numbers. The selection in LCR24 values is valid for the rest of the corresponding field. The upper nibble contains the value for field 1 (odd), the lower nibble for field 2 (even). The relationship between LCR values and line numbers can be adjusted via VOFF8 to VOFF0, located in subaddresses 5BH (bit 4) and 5AH (bits 7 to 0) and FOFF subaddress 5BH (bit 7). The recommended values are VOFF[8:0] = 03H for 50 Hz sources (with FOFF = 0) and VOFF[8:0] = 06H for 60 Hz sources (with FOFF = 1), to accommodate line number conventions as used for PAL, SECAM and NTSC standards; see Tables 18 to 21.

**Table 17** Data formats at decoder output

DATA TYPE NUMBER	DATA TYPE	DECODER OUTPUT DATA FORMAT
0	teletext EuroWST, CCST	raw
1	European Closed Caption	raw
2	Video Programming Service (VPS)	raw
3	Wide screen signalling bits	raw
4	US teletext (WST)	raw
5	US Closed Caption (line 21)	raw
6	video component signal, VBI region	Y-C <sub>B</sub> -C <sub>R</sub> 4 : 2 : 2
7	CVBS data	raw
8	teletext	raw
9	VITC/EBU time codes (Europe)	raw
10	VITC/SMPTE time codes (USA)	raw
11	reserved	raw
12	US NABTS	raw
13	MOJI (Japanese)	raw
14	Japanese format switch (L20/22)	raw
15	video component signal, active video region	Y-C <sub>B</sub> -C <sub>R</sub> 4 : 2 : 2

**Table 18** Relationship of LCR to line numbers in 525 lines/60 Hz systems (part 1)

Vertical line offset, VOFF[8:0] = 06H (subaddresses 5BH[4] and 5AH[7:0]); horizontal pixel offset, HOFF[10:0] = 347H (subaddresses 5BH[2:0] and 59H[7:0]); FOFF = 1 (subaddress 5BH[7])

Line number (1st field)	521	522	523	524	525	1	2	3	4	5	6	7	8	9
	active video					equalization pulses			serration pulses			equalization pulses		
Line number (2nd field)	259	260	261	262	263	264	265	266	267	268	269	270	271	272
	active video					equalization pulses			serration pulses			equalization pulses		
LCR	24					2	3	4	5	6	7	8	9	

**Table 19** Relationship of LCR to line numbers in 525 lines/60 Hz systems (part 2)

Vertical line offset, VOFF[8:0] = 06H (subaddresses 5BH[4] and 5AH[7:0]); horizontal pixel offset, HOFF[10:0] = 347H (subaddresses 5BH[2:0] and 59H[7:0]); FOFF = 1 (subaddress 5BH[7])

Line number (1st field)	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
	nominal VBI lines F1															active video
Line number (2nd field)	273	274	275	276	277	278	279	280	281	282	283	284	285	286	287	288
	nominal VBI lines F2															active video
LCR	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	

**Table 20** Relationship of LCR to line numbers in 625 lines/50 Hz systems (part 1)

Vertical line offset, VOFF[8:0] = 03H (subaddresses 5BH[4] and 5AH[7:0]); horizontal pixel offset, HOFF[10:0] = 347H (subaddresses 5BH[2:0] and 59H[7:0]); FOFF = 0 (subaddress 5BH[7])

Line number (1st field)	621	622	623	624	625	1	2	3	4	5
	active video			equalization pulses			serration pulses			equalization pulses
Line number (2nd field)	309	310	311	312	313	314	315	316	317	318
	active video			equalization pulses			serration pulses			equalization pulses
LCR	24					2	3	4	5	

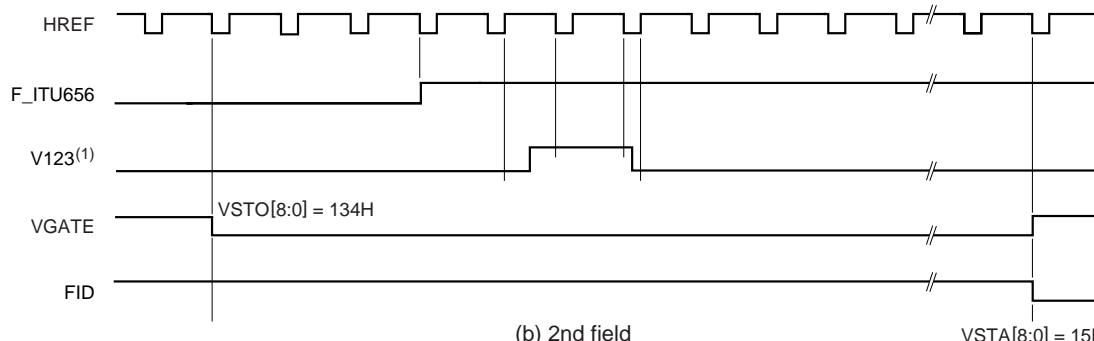
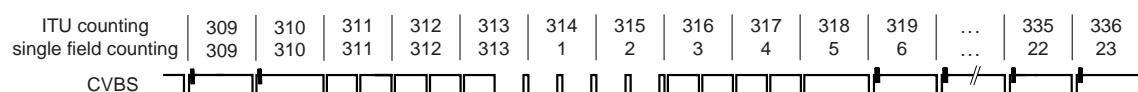
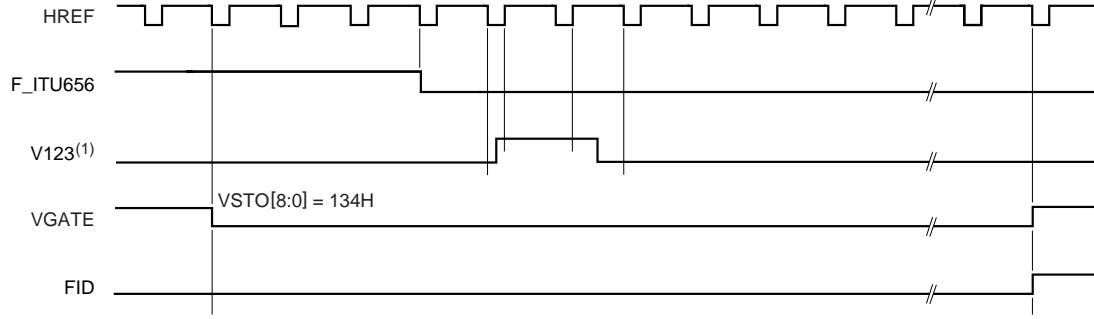
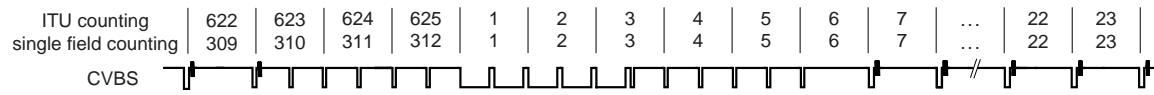
**Table 21** Relationship of LCR to line numbers in 625 lines/50 Hz systems (part 2)

Vertical line offset, VOFF[8:0] = 03H (subaddresses 5BH[4] and 5AH[7:0]); horizontal pixel offset, HOFF[10:0] = 347H (subaddresses 5BH[2:0] and 59H[7:0]); FOFF = 0 (subaddress 5BH[7])

Line number (1st field)	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
	nominal VBI lines F1																			active video
Line number (2nd field)	319	320	321	322	323	324	325	326	327	328	329	330	331	332	333	334	335	336	337	338
	nominal VBI lines F2																			active video
LCR	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	

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(1) The inactive going edge of the V123 signal indicates whether the field is odd or even. If HREF is active during the falling edge of V123, the field is ODD (field 1). If HREF is inactive during the falling edge of V123, the field is EVEN. The specific position of the slope is dependent on the internal processing delay and may change a few clock cycles from version to version.

The control signals listed above are available on pins RTS0, RTS1, XRH and XRV according to the following table:

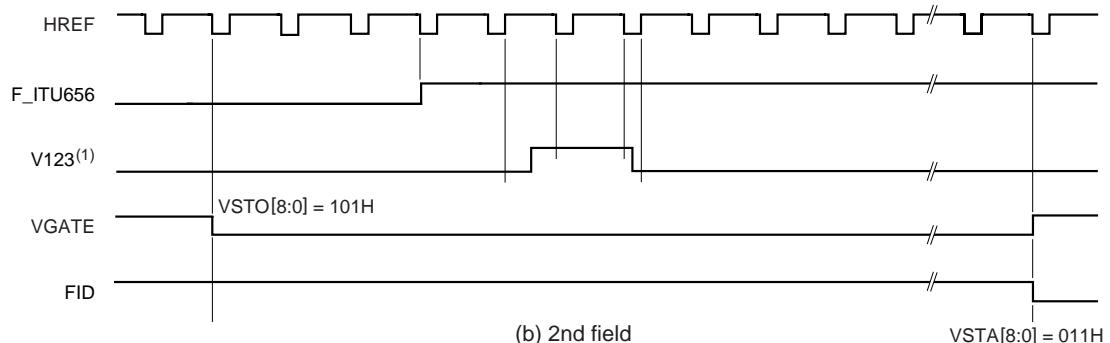
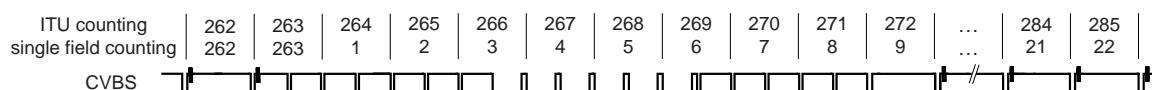
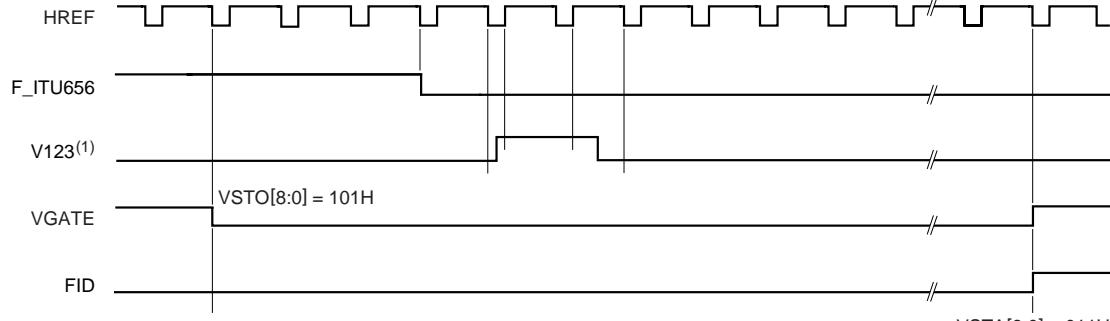
NAME	RTS0 (PIN K13)	RTS1 (PIN L10)	XRH (PIN N2)	XRV (PIN L5)
HREF	X	X	X	-
F_ITU656	-	-	-	X
V123	X	X	-	X
VGATE	X	X	-	-
FID	X	X	-	-

For further information see programming section, Tables 171, 172 and 173.

Fig.30 Vertical timing diagram for 50 Hz/625 line systems.

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(1) The inactive going edge of the V123 signal indicates whether the field is odd or even. If HREF is active during the falling edge of V123, the field is ODD (field 1). If HREF is inactive during the falling edge of V123, the field is EVEN. The specific position of the slope is dependent on the internal processing delay and may change a few clock cycles from version to version.

The control signals listed above are available on pins RTS0, RTS1, XRH and XRV according to the following table:

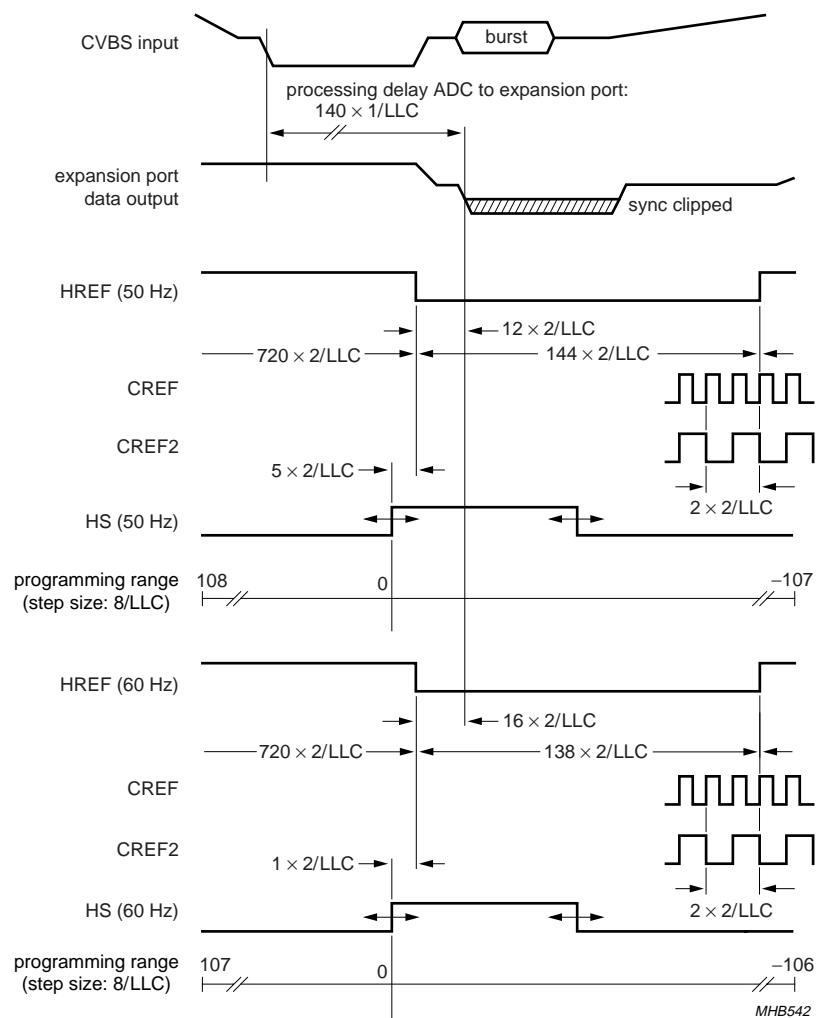
NAME	RTS0 (PIN K13)	RTS1 (PIN L10)	XRH (PIN N2)	XRV (PIN L5)
HREF	X	X	X	-
F_ITU656	-	-	-	X
V123	X	X	-	X
VGATE	X	X	-	-
FID	X	X	-	-

For further information see programming section, Tables 171, 172 and 173.

Fig.31 Vertical timing diagram for 60 Hz/525 line systems.

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The signals HREF, HS, CREF2 and CREF are available on pins RTS0 and/or RTS1 (see Section 18.2.2.19 Tables 171 and 172); their polarity can be inverted via RTP0 and/or RTP1.

The signals HREF and HS are available on pin XRH (see Section 18.2.2.20 Table 173).

Fig.32 Horizontal timing diagram (50/60 Hz).

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## 9.3 Scaler

The High Performance video Scaler (HPS) is based on the system as implemented in the SAA7140, but enhanced in some aspects. Vertical upsampling is supported and the processing pipeline buffer capacity is enhanced, to allow more flexible video stream timing at the image port, discontinuous transfers and handshake. The internal data flow from block to block is discontinuous dynamically, due to the scaling process.

The flow is controlled by internal data valid and data request flags (internal handshake signalling) between the sub-blocks. Therefore the entire scaler acts as a pipeline buffer. Depending on the actually programmed scaling parameters the effective buffer can exceed to an entire line. The access/bandwidth requirements to the VGA frame buffer are reduced significantly.

The high performance video scaler in the SAA7108AE; SAA7109AE has the following major blocks.

- Acquisition control (horizontal and vertical timer) and task handling (the region/field/frame based processing)
- Prescaler, for horizontal downscaling by an integer factor, combined with appropriate band limiting filters, especially anti-aliasing for CIF format
- Brightness, saturation and contrast control for scaled output data
- Line buffer, with asynchronous read and write, to support vertical upscaling (e.g. for videophone application, converting 240 into 288 lines, Y-C<sub>B</sub>-C<sub>R</sub> 4 : 2 : 2)
- Vertical scaling, with phase accurate Linear Phase Interpolation (LPI) for zoom and downscaling, or phase accurate Accumulation Mode (ACM) for large downscaling ratios and better anti-alias suppression
- Variable Phase Delay (VPD), operates as horizontal phase accurate interpolation for arbitrary non-integer scaling ratios, supporting conversion between square and rectangular pixel sampling
- Output formatter for scaled Y-C<sub>B</sub>-C<sub>R</sub> 4 : 2 : 2, Y-C<sub>B</sub>-C<sub>R</sub> 4 : 1 : 1 and Y only (format also for raw data)
- FIFO, 32-bit wide, with 64 pixel capacity in Y-C<sub>B</sub>-C<sub>R</sub> formats
- Output interface, 8 or 16-bit (only if extended by H port) data pins wide, synchronous or asynchronous operation, with stream events on discrete pins, or coded in the data stream.

The overall H and V zooming (HV\_zoom) is restricted by the input/output data rate relationships. With a safety margin of 2 % for running in and running out, the maximum HV\_zoom is equal to:

$$0.98 \times \frac{T_{\text{input\_field}} - T_{\text{v\_blanking}}}{\text{in\_pixel} \times \text{in\_lines} \times \text{out\_cycle\_per\_pix} \times T_{\text{out\_clk}}}$$

For example:

1. Input from decoder: 50 Hz, 720 pixel, 288 lines, 16-bit data at 13.5 MHz data rate, 1 cycle per pixel; output: 8-bit data at 27 MHz, 2 cycles per pixel; the maximum HV\_zoom is equal to:

$$0.98 \times \frac{20 \text{ ms} - 24 \times 64 \mu\text{s}}{720 \times 288 \times 2 \times 37 \text{ ns}} = 1.18$$

2. Input from X port: 60 Hz, 720 pixel, 240 lines, 8-bit data at 27 MHz data rate (ITU 656), 2 cycles per pixel; output via I + H port: 16-bit data at 27 MHz clock, 1 cycle per pixel; the maximum HV\_zoom is equal to:

$$0.98 \times \frac{16.666 \text{ ms} - 22 \times 64 \mu\text{s}}{720 \times 240 \times 1 \times 37 \text{ ns}} = 2.34$$

The video scaler receives its input signal from the video decoder or from the expansion port (X port). It gets 16-bit Y-C<sub>B</sub>-C<sub>R</sub> 4 : 2 : 2 input data at a continuous rate of 13.5 MHz from the decoder. A discontinuous data stream can be accepted from the expansion port, normally 8-bit wide ITU 656 like Y-C<sub>B</sub>-C<sub>R</sub> data, accompanied by a pixel qualifier on XDQ.

The input data stream is sorted into two data paths, one for luminance (or raw samples), and one for time multiplexed chrominance C<sub>B</sub> and C<sub>R</sub> samples. A Y-C<sub>B</sub>-C<sub>R</sub> 4 : 1 : 1 input format is converted to 4 : 2 : 2 for the horizontal prescaling and vertical filter scaling operation.

The scaler operation is defined by two programming pages A and B, representing two different tasks that can be applied field alternating or to define two regions in a field (e.g. with different scaling range, factors, and signal source during odd and even fields).

Each programming page contains control for:

- Signal source selection and formats
- Task handling and trigger conditions
- Input and output acquisition window definition
- H prescaler, V scaler and H phase scaling.

Raw VBI data will be handled as specific input format and need its own programming page (equals own task).

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In VBI pass through operation the processing of prescaler and vertical scaling has to be disabled, however the horizontal fine scaling VPD can be activated. Upscaling (oversampling, zooming), free of frequency folding, up to factor 3.5 can be achieved, as required by some software data slicing algorithms.

These raw samples are transported through the image port as valid data and can be output as Y only format. The lines are framed by SAV and EAV codes.

### 9.3.1 ACQUISITION CONTROL AND TASK HANDLING (SUBADDRESSES 80H, 90H, 91H, 94H TO 9FH AND C4H TO CFH)

The acquisition control receives horizontal and vertical synchronization signals from the decoder section or from the X port. The acquisition window is generated via pixel and line counters at the appropriate places in the data path. Only qualified pixels and lines (lines with qualified pixel) are counted from the X port.

The acquisition window parameters are as follows:

- Signal source selection: input video stream and formats from the decoder, or from the X port (programming bits SCSRC[1:0] 91H[5:4] and FSC[2:0] 91H[2:0])
- **Remark:** The input of raw VBI data from the internal decoder should be controlled via the decoder output formatter and the LCR registers (see Section 9.2)
- Vertical offset: defined in lines of the video source, parameter YO[11:0] 99H[3:0] 98H[7:0]
- Vertical length: defined in lines of the video source, parameter YS[11:0] 9BH[3:0] 9AH[7:0]
- Vertical length: defined in number of target lines, as a result of vertical scaling, parameter YD[11:0] 9FH[3:0] 9EH[7:0]
- Horizontal offset: defined in number of pixels of the video source, parameter XO[11:0] 95H[3:0] 94H[7:0]
- Horizontal length: defined in number of pixels of the video source, parameter XS[11:0] 97H[3:0] 96H[7:0]
- Horizontal destination size: defined in target pixels after fine scaling, parameter XD[11:0] 9DH[3:0] 9CH[7:0].

The source start offset XO(11:0) and YO(11:0) opens the acquisition window, and the target size (XD11 to XD0, YD11 to YD0) closes the window, however the window is cut vertically if there are less output lines than required.

The trigger events for the pixel and line counts are the horizontal and vertical reference edges as defined in subaddress 92H.

The task handling is controlled by subaddress 90H; see Section 9.3.1.2.

#### 9.3.1.1 *Input field processing*

The trigger event for the field sequence detection from external signals (X port) are defined in subaddress 92H. The state of the scalers horizontal reference signal at the time of the vertical reference edge is taken from the X port as field sequence identifier (FID). For example, if the falling edge of the XRV input signal is the reference and the state of XRH input is logic 0 at that time, the detected field ID is logic 0.

The bits XFDV[92H[7]] and XFDH[92H[6]] define the detection event and state of the flag from the X port. For the default setting of XFDV and XFDH at '00' is taken from the state of the horizontal input at the falling edge of the vertical input.

The scaler gets corresponding field ID information directly from the SAA7108AE; SAA7109AE decoder path.

The FID flag is used to determine whether the first or second field of a frame is going to be processed within the scaler, and it is also used as trigger conditions for the task handling (see bits STRC[1:0] 90H[1:0]).

According to ITU 656, FID at logic 0 means first field of a frame. To ease the application, the polarities of the detection results on the X port signals and the internal decoder ID can be changed via XFDH.

As the V sync from the decoder path has a half line timing (due to the interlaced video signal), but the scaler processing only recognises full lines, during 1st fields from the decoder the line count of the scaler can possibly shift by one line, compared to the 2nd field. This can be compensated for by switching the vertical trigger event, as defined by XDV0, to the opposite V sync edge or by using the vertical scalers phase offsets. The vertical timing of the decoder can be seen in Figs 30 and 31.

As the horizontal and vertical reference events inside the ITU 656 data stream (from X port) and the real-time reference signals from the decoder path are processed differently, the trigger events for the input acquisition also have to be programmed differently.

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**Table 22** Processing trigger and start

XDV1 92H[5]	XDVO 92H[4]	XDH 92H[2]	DESCRIPTION
			<b>Internal decoder:</b> The processing triggers at the falling edge of the V123 pulse (see Figs 30 (50 Hz) and 31 (60 Hz)), and starts earliest with the rising edge of the decoder HREF at line number: 0 1 0 4/7 (50/60 Hz, 1st field), respectively 3/6 (50/60 Hz, 2nd field) (decoder count) 0 0 0 2/5 (50/60 Hz, 1st field), respectively 2/5 (50/60 Hz, 2nd field) (decoder count)
0	0	0	<b>External ITU 656 stream:</b> The processing starts earliest with SAV at line number 23 (50 Hz system), respectively line 20 (60 Hz system) (according ITU 656 count)

## 9.3.1.2 Task handling

The task handler controls the switching between the two programming register sets. It is controlled by subaddresses 90H and C0H. A task is enabled via the global control bits TEA[80H[4]] and TEB[80H[5]]. The handler is then triggered by events which can be defined for each register set.

In the event of a programming error the task handling and the complete scaler can be reset to the initial states by the software reset bit SWRST[88H[5]] being set to logic 0. A software reset **must** be done after programming especially if the programming registers, related acquisition window and scaler are reprogrammed while a task is active.

The difference in the disabling/enabling of a task, which is evaluated at the end of a running task (when SWRST is set to logic 0) is that it sets the internal state machines directly to their idle states.

The start condition for the handler is defined by bits STRC[1:0] 90H[1:0] and means: start immediately, wait for next V sync, next FID at logic 0 or next FID at logic 1. The FID is evaluated if the vertical and horizontal offsets are reached.

With RPTSK[90H[2]] at logic 1 the actual running task is repeated (under the defined trigger conditions) before handing control over to the alternate task.

To support field rate reduction, the handler is also enabled to skip fields (bits FSKP[2:0] 90H[5:3]) before executing the task. A TOGGLE flag is generated (used for the correct output field processing), which changes state at the beginning of a task every time a task is activated; examples are given in Section 9.3.1.3.

## Remarks:

- **To activate a task, the start condition must be fulfilled and the acquisition window offsets must be reached.** For example, in case of 'start immediately', and two regions are defined for one field, the offset of the lower region must be greater than (offset + length) of the upper region, if not, the actual counted H and V position at the end of the upper task is beyond the programmed offsets and the processing will 'wait for next V'.
- **Basically, the trigger conditions are checked when a task is activated.** It is important to know that they are not checked while a task is inactive. So it is not possible to trigger to the next logic 0 or logic 1 with overlapping offset and active video ranges between the tasks (e.g. task A STRC[2:0] = 2, YO[11:0] = 310 and task B STRC[2:0] = 3, YO[11:0] = 310 results in an output field rate of 50/3 Hz).
- **After power-on or software reset (via SWRST[88H[5]]) task B gets priority over task A.**

**HD-CODEC****SAA7108AE; SAA7109AE****9.3.1.3 Output field processing**

As a reference for the output field processing, two signals are available for the back-end hardware.

These signals are the input field ID from the scaler source and a TOGGLE flag, which shows that an active task is used an odd (1, 3, 5...) or even (2, 4, 6...) number of times. Using a single or both tasks and reducing the field or frame rate with the task handling functionality, the TOGGLE information can be used to reconstruct an interlaced scaled picture at a reduced frame rate. The TOGGLE flag is not synchronized to the input field detection, as it is only dependent on the interpretation of this information by the external hardware i.e. whether the output of the scaler is processed correctly; see Section 9.3.3.

When OFIDC = 0, the scalers input field ID is available as output field ID on bit 6 of SAV and EAV, and respectively on pin IGP0 (IGP1), if the FID output is selected.

When OFIDC[90H[6]] = 1, the TOGGLE information is available as output field ID on bit 6 of SAV and EAV, and respectively on pin IGP0 (IGP1) if the FID output is selected.

Additionally bit 7 of SAV and EAV can be defined via CONLH[90H[7]]. When CONLH[90H[7]] = 0 (default) it sets bit 7 to logic 1; a logic 1 inverts the SAV/EAV bit 7. So it is possible to mark the output of both tasks by different SAV/EAV codes. This bit can also be seen as 'task flag' on pins IGP0 (IGP1), if the TASK output is selected.

**Table 23** Example for field processing

SUBJECT	FIELD SEQUENCE FRAME/FIELD																		
	EXAMPLE 1 <sup>(1)</sup>			EXAMPLE 2 <sup>(2)(3)</sup>				EXAMPLE 3 <sup>(2)(4)(5)</sup>						EXAMPLE 4 <sup>(2)(4)(6)</sup>					
	1/1	1/2	2/1	1/1	1/2	2/1	2/2	1/1	1/2	2/1	2/2	3/1	3/2	1/1	1/2	2/1	2/2	3/1	3/2
Processed by task	A	A	A	B	A	B	A	B	B	A	B	B	A	B	B	A	B	A	
State of detected ITU 656 FID	0	1	0	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	
TOGGLE flag	1	0	1	1	1	0	0	1	0	1	1	0	0	0 <sup>(7)</sup>	1	1	1 <sup>(7)</sup>	0	0
Bit 6 of SAV/EAV byte	0	1	0	0	1	0	1	1	0	1	1	0	0	0 <sup>(7)</sup>	1	1	1 <sup>(7)</sup>	0	0
Required sequence conversion at the vertical scaler <sup>(8)</sup>	UP ↓	LO ↓	UP ↓	UP ↓	LO ↓	UP ↓	LO ↓	UP ↓	LO ↓	UP ↓	LO ↓	UP ↓	LO ↓	UP ↓	LO ↓	UP ↓	LO ↓	UP ↓	
Output <sup>(9)</sup>	O	O	O	O	O	O	O	O	O	O	O	O	NO	O	O	NO	O	O	

**Notes**

1. Single task every field; OFIDC = 0; subaddress 90H at 40H; TEB[80H[5]] = 0.
2. Tasks are used to scale to different output windows, priority on task B after SWRST.
3. Both tasks at  $\frac{1}{2}$  frame rate; OFIDC = 0; subaddresses 90H at 43H and C0H at 42H.
4. In examples 3 and 4 the association between input FID and tasks can be flipped, dependent on which time the SWRST is de-asserted.
5. Task B at  $\frac{2}{3}$  frame rate constructed from neighbouring motion phases; task A at  $\frac{1}{3}$  frame rate of equidistant motion phases; OFIDC = 1; subaddresses 90H at 41H and C0H at 45H.
6. Task A and B at  $\frac{1}{3}$  frame rate of equidistant motion phases; OFIDC = 1; subaddresses 90H at 41H and C0H at 49H.
7. State of prior field.
8. It is assumed that input/output FID = 0 (upper lines); UP = upper lines; LO = lower lines.
9. O = data output; NO = no output.

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## 9.3.2 HORIZONTAL SCALING

The overall horizontal scaling factor has to be split into a binary and a rational value according to the following

equation: H scale ratio =  $\frac{\text{output pixel}}{\text{input pixel}}$

$$\text{H scale ratio} = \frac{1}{\text{XPSC}[5:0]} \times \frac{1024}{\text{XSCY}[12:0]}$$

where, the parameter of the prescaler  $\text{XPSC}[5:0] = 1$  to 63 and the parameter of VPD phase interpolation  $\text{XSCY}[12:0] = 300$  to 8191 (0 to 299 are only theoretical values). For example,  $\frac{1}{3.5}$  is split into  $\frac{1}{4} \times 1.14286$ . The binary factor is processed by the prescaler, the arbitrary non-integer ratio is achieved via the variable phase delay VPD circuitry, called horizontal fine scaling. The latter calculates horizontally interpolated new samples with a 6-bit phase accuracy, which relates to less than 1 ns jitter for regular sampling schemes. Together the prescaler and fine scaler form the horizontal scaler of the SAA7108AE; SAA7109AE.

Using the accumulation length function of the prescaler ( $\text{XACL}[5:0]$  A1H[5:0]), application and destination dependent (e.g. scale for display or for a compression machine), a compromise between visible bandwidth and alias suppression can be found.

#### 9.3.2.1 Horizontal prescaler (subaddresses A0H to A7H and D0H to D7H)

The prescaling function consists of an FIR anti-alias filter stage and an integer prescaler, which together form an adaptive prescale dependent low-pass filter to balance the sharpness and aliasing effects.

The FIR pre-filter stage implements different low-pass characteristics to reduce the anti-alias for downscales in the range of 1 to  $\frac{1}{2}$ . A CIF optimized filter is built-in, which reduces artefacts for CIF output formats (to be used in combination with the prescaler set to  $\frac{1}{2}$  scale); see Table 24.

The function of the prescaler is defined by:

- An integer prescaling ratio  $\text{XPSC}[5:0]$  A0H[5:0] (equals 1 to 63), which covers the integer downscale range 1 to  $\frac{1}{63}$
- An averaging sequence length  $\text{XACL}[5:0]$  A1H[5:0] (equals 0 to 63); range 1 to 64
- A DC gain renormalization  $\text{XDCG}[2:0]$  A2H[2:0]; 1 down to  $\frac{1}{128}$

- The bit XC2\_1[A2H[3]], which defines the weighting of the incoming pixels during the averaging process
  - $\text{XC2\_1} = 0 \Rightarrow 1 + 1 + \dots + 1 + 1$
  - $\text{XC2\_1} = 1 \Rightarrow 1 + 2 + \dots + 2 + 1$ .

The prescaler creates a prescale dependent FIR low-pass, with up to  $64 + 7$  filter taps. The parameter  $\text{XACL}[5:0]$  can be used to vary the low-pass characteristic for a given integer prescale of  $\frac{1}{\text{XPSC}[5:0]}$ . The user can therewith decide between signal bandwidth (sharpness impression) and alias.

The equation for the  $\text{XPSC}[5:0]$  calculation is:

$$\text{XPSC}[5:0] = \text{lower integer of } \frac{\text{Npix\_in}}{\text{Npix\_out}}$$

Where:

the range is 1 to 63 (**value 0 is not allowed**);

$\text{Npix\_in}$  = number of input pixel, and

$\text{Npix\_out}$  = number of desired output pixel over the complete horizontal scaler.

**The use of the prescaler results in a  $\text{XACL}[5:0]$  and  $\text{XC2\_1}$  dependent gain amplification.** The amplification can be calculated according to the equation:

$$\text{DC gain} = [(\text{XACL}[5:0] - \text{XC2\_1}) + 1] \times (\text{XC2\_1} + 1)$$

It is recommended to use sequence lengths and weights, which results in a  $2^N$  DC gain amplification, as these amplitudes can be renormalized by the  $\text{XDCG}[2:0]$

controlled  $\frac{1}{2^N}$  shifter of the prescaler.

The renormalization range of  $\text{XDCG}[2:0]$  is 1,  $\frac{1}{2}$ ... down to  $\frac{1}{128}$ .

Other amplifications have to be normalized by using the following BCS control circuitry. In these cases the prescaler has to be set to an overall gain  $\leq 1$ , e.g. for an accumulation sequence of '1 + 1 + 1' ( $\text{XACL}[5:0] = 2$  and  $\text{XC2\_1} = 0$ ),  $\text{XDCG}[2:0]$  must be set to '010', which equals  $\frac{1}{4}$  and the BCS has to amplify the signal to  $\frac{4}{3}$  ( $\text{SATN}[7:0]$  and  $\text{CONT}[7:0]$  value = lower integer of  $\frac{4}{3} \times 64$ ).

**The use of  $\text{XACL}[5:0]$  is  $\text{XPSC}[5:0]$  dependent.  $\text{XACL}[5:0]$  must be  $< 2 \times \text{XPSC}[5:0]$ .**

$\text{XACL}[5:0]$  can be used to find a compromise between bandwidth (sharpness) and alias effects.

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**Remark:** Due to bandwidth considerations XPSC[5:0] and XACL[5:0] can be chosen differently to the previously mentioned equations or Table 25, as the horizontal phase scaling is able to scale in the range from zooming up by factor 3 to downscaling by a factor of  $1024/8191$ .

Figs 35 and 36 show some frequency characteristics of the prescaler.

Table 25 shows the recommended prescaler programming. Other programming, than given in Table 25, may result in better alias suppression, but the resulting DC gain amplification needs to be compensated by the BCS control, according to the equation:

$$\text{CONT}[7:0] = \text{SATN}[7:0] = \text{lower integer of } \frac{2^{\text{XDCG}[2:0]}}{\text{DC gain} \times 64}$$

Where:

$$2^{\text{XDCG}[2:0]} \geq \text{DC gain}$$

$$\text{DC gain} = (\text{XC2\_1} + 1) \times \text{XACL}[5:0] + (1 - \text{XC2\_1}).$$

**Table 24** FIR prefilter functions

PFUV[1:0] A2H[7:6] PFY[1:0] A2H[5:4]	LUMINANCE FILTER COEFFICIENTS	CHROMINANCE COEFFICIENTS
00	bypassed	bypassed
01	1 2 1	1 2 1
10	-1 1 1.75 4.5 1.75 1 -1	3 8 10 8 3
11	1 2 2 2 1	1 2 2 2 1

For example, if XACL[5:0] = 5, XC2\_1 = 1, then DC gain = 10 and the required XDCG[2:0] = 4.

The horizontal source acquisition timing and the prescaling ratio is identical for both the luminance and chrominance path, but the FIR filter settings can be defined differently in the two channels.

Fade-in and fade-out of the filters is achieved by copying an original source sample each as first and last pixel after prescaling.

Figs 33 and 34 show the frequency characteristics of the selectable FIR filters.

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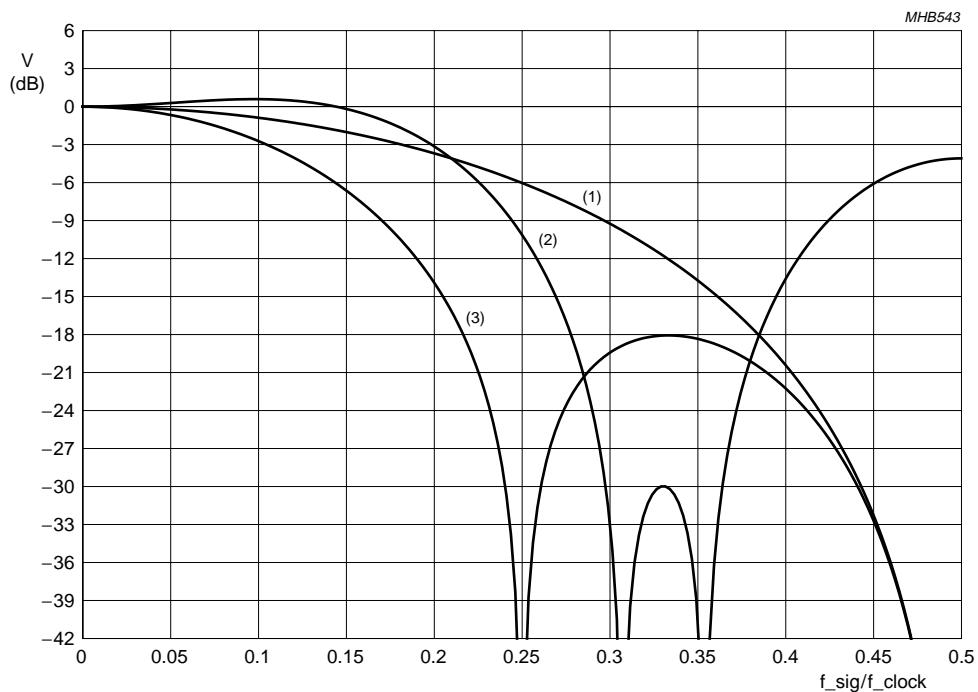


Fig.33 Luminance prefilter characteristic.

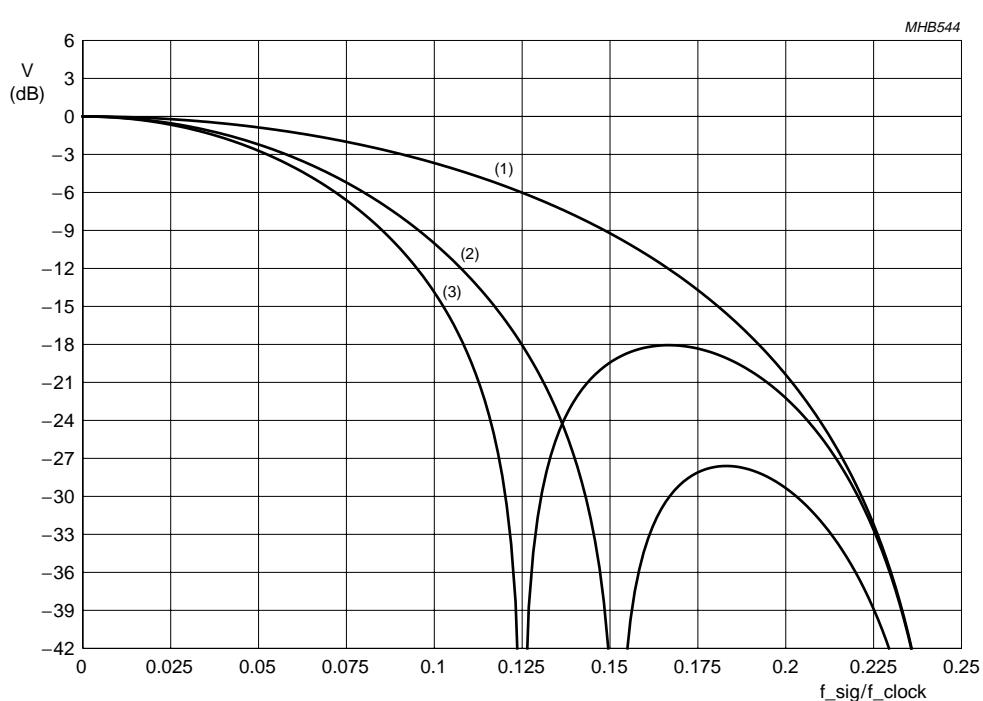


Fig.34 Chrominance prefilter characteristic.

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XC2\_1 = 0; Zero's at  
 $f = n \times \frac{1}{XACL + 1}$   
 with XACL = (1), (2), (3),  
 (4) or (5)

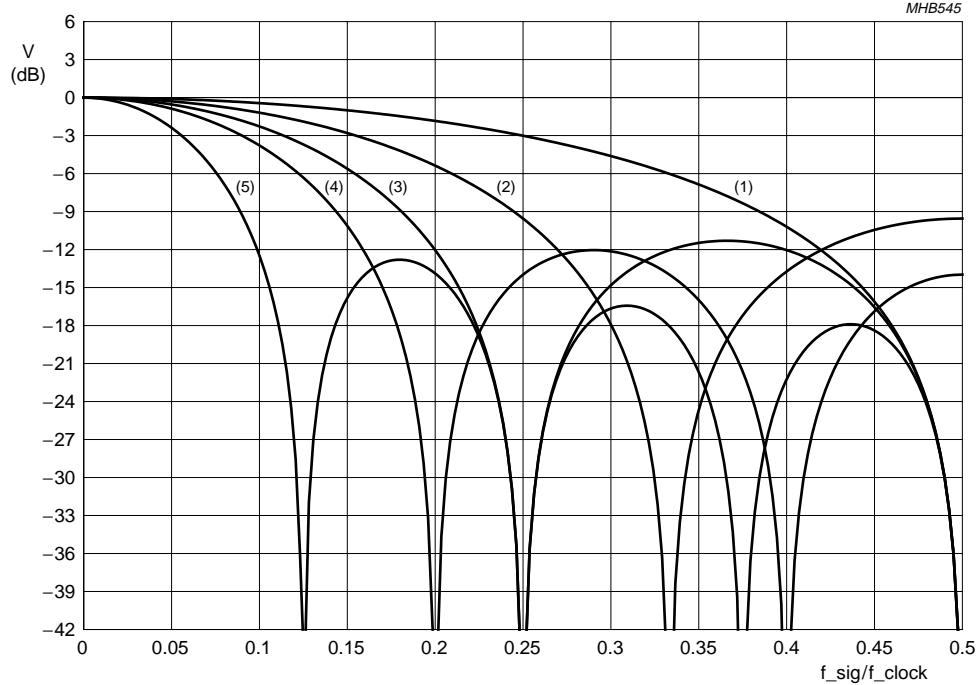


Fig.35 Examples for prescaler filter characteristics: effect of increasing XACL[5:0].

- (1) XC2\_1 = 0 and XACL[5:0] = 1.
- (2) XC2\_1 = 1 and XACL[5:0] = 2.
- (3) XC2\_1 = 0 and XACL[5:0] = 3.
- (4) XC2\_1 = 1 and XACL[5:0] = 4.
- (5) XC2\_1 = 0 and XACL[5:0] = 7.
- (6) XC2\_1 = 1 and XACL[5:0] = 8.

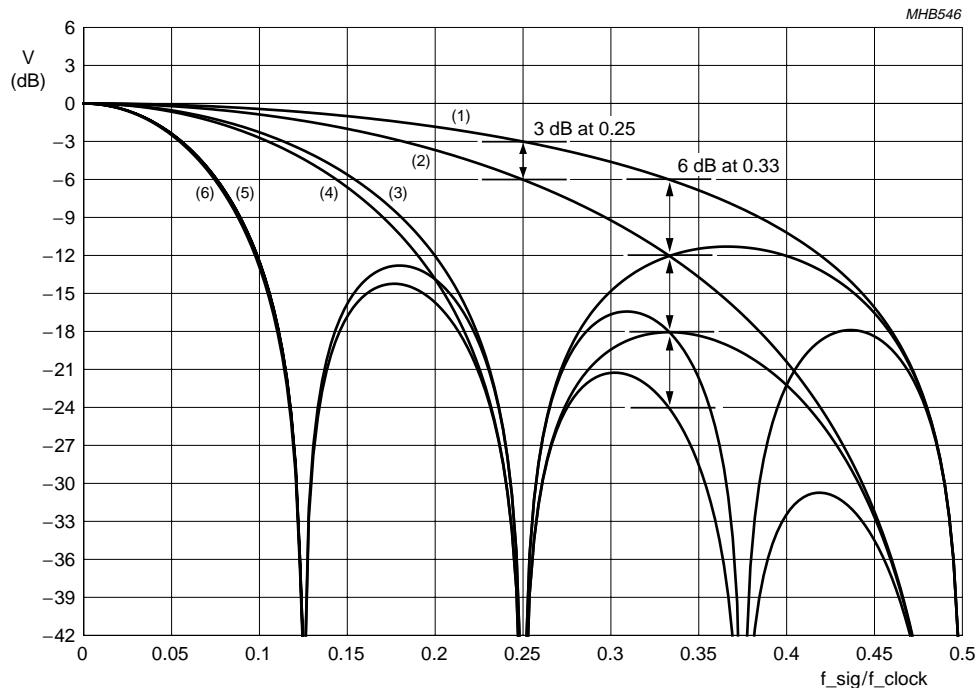


Fig.36 Examples for prescaler filter characteristics: setting XC2\_1 = 1.

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**Table 25** Example of XACL[5:0] usage

PRESCALE RATIO	XPSC [5:0]	RECOMMENDED VALUES						FIR PREFILTER PFY[1:0]/ PFUV[1:0]	
		FOR LOWER BANDWIDTH REQUIREMENTS			FOR HIGHER BANDWIDTH REQUIREMENTS				
		XACL[5:0]	XC2_1	XDCG[2:0]	XACL[5:0]	XC2_1	XDCG[2:0]		
1	1	0	0	0	0	0	0	0 to 2	
$\frac{1}{2}$	2	2	1	2	1	0	1	0 to 2	
		$(1\ 2\ 1) \times \frac{1}{4}^{(1)}$			$(1\ 1) \times \frac{1}{2}^{(1)}$				
$\frac{1}{3}$	3	4	1	3	3	0	2	2	
		$(1\ 2\ 2\ 2\ 1) \times \frac{1}{8}^{(1)}$			$(1\ 1\ 1\ 1) \times \frac{1}{4}^{(1)}$				
$\frac{1}{4}$	4	7	0	3	4	1	3	2	
		$(1\ 1\ 1\ 1\ 1\ 1\ 1\ 1) \times \frac{1}{8}^{(1)}$			$(1\ 2\ 2\ 2\ 1) \times \frac{1}{8}^{(1)}$				
$\frac{1}{5}$	5	8	1	4	7	0	3	2	
		$(1\ 2\ 2\ 2\ 2\ 2\ 2\ 1) \times \frac{1}{16}^{(1)}$			$(1\ 1\ 1\ 1\ 1\ 1\ 1\ 1) \times \frac{1}{8}^{(1)}$				
$\frac{1}{6}$	6	8	1	4	7	0	3	3	
		$(1\ 2\ 2\ 2\ 2\ 2\ 2\ 1) \times \frac{1}{16}^{(1)}$			$(1\ 1\ 1\ 1\ 1\ 1\ 1\ 1) \times \frac{1}{8}^{(1)}$				
$\frac{1}{7}$	7	8	1	4	7	0	3	3	
		$(1\ 2\ 2\ 2\ 2\ 2\ 2\ 1) \times \frac{1}{16}^{(1)}$			$(1\ 1\ 1\ 1\ 1\ 1\ 1\ 1) \times \frac{1}{8}^{(1)}$				
$\frac{1}{8}$	8	15	0	4	8	1	4	3	
		$(1\ 1\ 1\ 1\ 1\ 1\ 1\ 1\ 1\ 1\ 1\ 1) \times \frac{1}{16}^{(1)}$			$(1\ 2\ 2\ 2\ 2\ 2\ 2\ 1) \times \frac{1}{16}^{(1)}$				
$\frac{1}{9}$	9	15	0	4	8	1	4	3	
		$(1\ 1\ 1\ 1\ 1\ 1\ 1\ 1\ 1\ 1\ 1\ 1\ 1) \times \frac{1}{16}^{(1)}$			$(1\ 2\ 2\ 2\ 2\ 2\ 2\ 2\ 1) \times \frac{1}{16}^{(1)}$				
$\frac{1}{10}$	10	16	1	5	8	1	4	3	
		$(1\ 2\ 2\ 2\ 2\ 2\ 2\ 2\ 2\ 2\ 2\ 2\ 2\ 1) \times \frac{1}{32}^{(1)}$			$(1\ 2\ 2\ 2\ 2\ 2\ 2\ 2\ 1) \times \frac{1}{16}^{(1)}$				
$\frac{1}{13}$	13	16	1	5	16	1	5	3	
$\frac{1}{15}$	15	31	0	5	16	1	5	3	
$\frac{1}{16}$	16	31	0	5	16	1	5	3	
$\frac{1}{19}$	19	32	1	6	32	1	6	3	
$\frac{1}{31}$	31	32	1	6	32	1	6	3	
$\frac{1}{32}$	32	63	1	7	32	1	6	3	
$\frac{1}{35}$	35	63	1	7	63	1	7	3	

**Note**

1. Resulting FIR function.

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9.3.2.2 *Horizontal fine scaling (variable phase delay filter; subaddresses A8H to AFH and D8H to DFH)*

The horizontal fine scaling (VPD) should operate at scaling ratios between  $\frac{1}{2}$  and 2 (0.8 and 1.6), but can also be used for direct scaling in the range from  $\frac{1}{7,999}$  to (theoretical) zoom 3.5 (restriction due to the internal data path architecture), without prescaler.

In combination with the prescaler a compromise between sharpness impression and alias can be found, which is signal source and application dependent.

For the luminance channel a filter structure with 10 taps is implemented, for the chrominance a filter with 4 taps.

Luminance and chrominance scale increments ( $XSCY[12:0]$  A9H[4:0] A8H[7:0] and  $XSCC[12:0]$  ADH[4:0] ACH[7:0]) are defined independently, but must be set in a 2 : 1 relationship in the actual data path implementation. The phase offsets XPHY[7:0] AAH[7:0] and XPHC[7:0] AEH[7:0] can be used to shift the sample phases slightly. XPHY[7:0] and XPHC[7:0] covers the phase offset range 7.999T to  $\frac{1}{32}T$ . The phase offsets should also be programmed in a 2 : 1 ratio.

The underlying phase controlling DTO has a 13-bit resolution.

According to the equations

$$XSCY[12:0] = 1024 \times \frac{Npix\_in}{XPSC[5:0]} \times \frac{1}{Npix\_out} \text{ and}$$

$$XSCC[12:0] = \frac{XSCY[12:0]}{2}$$

The VPD covers the scale range from 0.125 to zoom 3.5. The VPD acts equivalent to a polyphase filter with 64 possible phases. In combination with the prescaler, it is possible to get high accurate samples from a highly anti-aliased integer downsampled input picture.

## 9.3.3 VERTICAL SCALING

The vertical scaler of the SAA7108AE; SAA7109AE decoder part consists of a line FIFO buffer for line repetition and the vertical scaler block, which implements the vertical scaling on the input data stream in 2 different operational modes from theoretical zoom by 64 down to icon size  $\frac{1}{64}$ . The vertical scaler is located between the BCS and horizontal fine scaler, so that the BCS can be used to compensate for the DC gain amplification of the ACM mode (see Section 9.3.3.2) as the internal RAMs are only 8-bit wide.

9.3.3.1 *Line FIFO buffer (subaddresses 91H, B4H and C1H, E4H)*

The line FIFO buffer is a dual ported RAM structure for 768 pixels, with asynchronous write and read access. The line buffer can be used for various functions, but not all functions may be available simultaneously.

The line buffer can buffer a complete unscaled active video line or more than one shorter lines (only for non-mirror mode), for selective repetition for vertical zoom-up.

For zooming up from 240 lines to 288 lines e.g., every fourth line is requested (read) twice from the vertical scaling circuitry for calculation.

For conversion of a 4 : 2 : 0 or 4 : 1 : 0 input sampling scheme (MPEG, video phone, Indeo YUV-9) to ITU like sampling scheme 4 : 2 : 2, the chrominance line buffer is read twice or four times, before being refilled again by the source. By means of the input acquisition window definition it has to be preserved, that the processing starts with a line containing luminance and chrominance information for 4 : 2 : 0 and 4 : 1 : 0 input. The bits FSC[2:1] 91H[2:1] define the distance between the Y/C lines. In case of 4 : 2 : 2 and 4 : 1 : 1 FSC2 and FSC1 have to be set to '00'.

The line buffer can also be used for mirroring, i.e. for flipping the image left to right, for the vanity picture in video phone application (bit YMIR[B4H[4]]). In mirror mode only one active prescaled line can be held in the FIFO at a time.

The line buffer can be utilized as excessive pipeline buffer for discontinuous and variable rate transfer conditions at the expansion port or image port.

9.3.3.2 *Vertical scaler (subaddresses B0H to BFH and E0H to EFH)*

Vertical scaling of any ratio from 64 (theoretical zoom) to  $\frac{1}{63}$  (icon) can be applied.

The vertical scaling block consists of another line delay, and the vertical filter structure, that can operate in two different modes. These are the Linear Phase Interpolation (LPI) and Accumulation (ACM) modes, controlled by YMODE[B4H[0]].

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- **LPI mode:** In the linear phase interpolation mode (YMODE = 0) two neighbouring lines of the source video stream are added together, but weighted by factors corresponding to the vertical position (phase) of the target output line relative to the source lines. This linear interpolation has a 6-bit phase resolution, which equals 64 intra line phases. It interpolates between two consecutive input lines only. The LPI mode should be applied for scaling ratios around 1 (down to  $\frac{1}{2}$ ), **it must be applied for vertical zooming.**
- **ACM mode:** The vertical Accumulation (ACM) mode (YMODE = 1) represents a vertical averaging window over multiple lines, sliding over the field. This mode also generates phase correct output lines. The averaging window length corresponds to the scaling ratio, resulting in an adaptive vertical low-pass effect, to greatly reduce aliasing artefacts. ACM can be applied for downscals only from ratio 1 down to  $\frac{1}{64}$ . ACM results in a scale dependent **DC gain amplification**, which has to be precorrected by the BCS control of the scaler part.

The phase and scale controlling DTO calculates in 16-bit resolution, controlled by parameters YSCY[15:0] B1H[7:0] B0H[7:0] and YSCC[15:0] B3H[7:0] B2H[7:0], continuously over the entire field. A start offset can be applied to the phase processing by means of the parameters YPY3[7:0] to YPY0[7:0] in BFH[7:0] to BCH[7:0] and YPC3[7:0] to YPC0[7:0] in BBH[7:0] to B8H[7:0]. The start phase covers the range of  $\frac{255}{32}$  to  $\frac{1}{32}$  lines offset.

By programming appropriate, opposite, vertical start phase values (subaddresses B8H to BFH and E8H to EFH) depending on odd/even field ID of the source video stream and A/B page cycle, frame ID conversion and field rate conversion are supported (i.e. de-interlacing, re-interlacing).

Figs 37 and 38 and Tables 26 and 27 describe the use of the offsets.

**Remark: The vertical start phase, as well as the scaling ratio are defined independently for luminance and chrominance channels, but must be set to the same values in the actual implementation for accurate 4 : 2 : 2 output processing.**

The vertical processing communicates on its input side with the line FIFO buffer. The scale related equations are:

- Scaling increment calculation for ACM and LPI mode, downscale and zoom: YSCY[15:0] and YSCC[15:0]

$$= \text{lower integer of} \left( 1024 \times \frac{\text{Nline\_in}}{\text{Nline\_out}} \right)$$

- BCS value to compensate DC gain in ACM mode (contrast and saturation have to be set): CONT[7:0] A5H[7:0] respectively SATN[7:0] A6H[7:0]
  - = lower integer of  $\left( \frac{\text{Nline\_out}}{\text{Nline\_in}} \times 64 \right)$ , or
  - = lower integer of  $\left( \frac{1024}{\text{YSCY}[15:0]} \times 64 \right)$

### 9.3.3.3 Use of the vertical phase offsets

As shown in Section 9.3.1.3, the scaler processing may run randomly over the interlaced input sequence. Additionally the interpretation and timing between ITU 656 field ID and real-time detection by means of the state of H sync at the falling edge of V sync may result in different field ID interpretation.

A vertically scaled interlaced output also gets a larger vertical sampling phase error, if the interlaced input fields are processed, without regard to the actual scale at the starting point of operation (see Fig.37).

The four events to be considered are illustrated in Fig.38.

In Tables 26 and 27 **PHO** is a usable common phase offset.

It should be noted that the equations in Fig.38 also produce an interpolated output for the unscaled case, as the geometrical reference position for all conversions is the position of the first line of the lower field; see Table 26.

If there is no need for UP-LO and LO-UP conversion and the input field ID is the reference for the back-end operation, then it is UP-LO = UP-UP and LO-UP = LO-LO and the  $\frac{1}{2}$  line phase shift (PHO + 16) that can be skipped; this case is given in Table 27.

The SAA7108AE; SAA7109AE supports 4 phase offset registers per task and component (luminance and chrominance). The value of 20H represents a phase shift of one line.

The registers are assigned to the following events; e.g. subaddresses B8H to BBH:

- B8H: 00 = input field ID 0, task status bit 0 (toggle status, see Section 9.3.1.3)
- B9H: 01 = input field ID 0, task status bit 1
- BAH: 10 = input field ID 1, task status bit 0
- BBH: 11 = input field ID 1, task status bit 1.

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Depending on the input signal (interlaced or non-interlaced) and the task processing (50 Hz or field reduced processing with one or two tasks, see examples in Section 9.3.1.3), other combinations may also be possible, but the basic equations are the same.

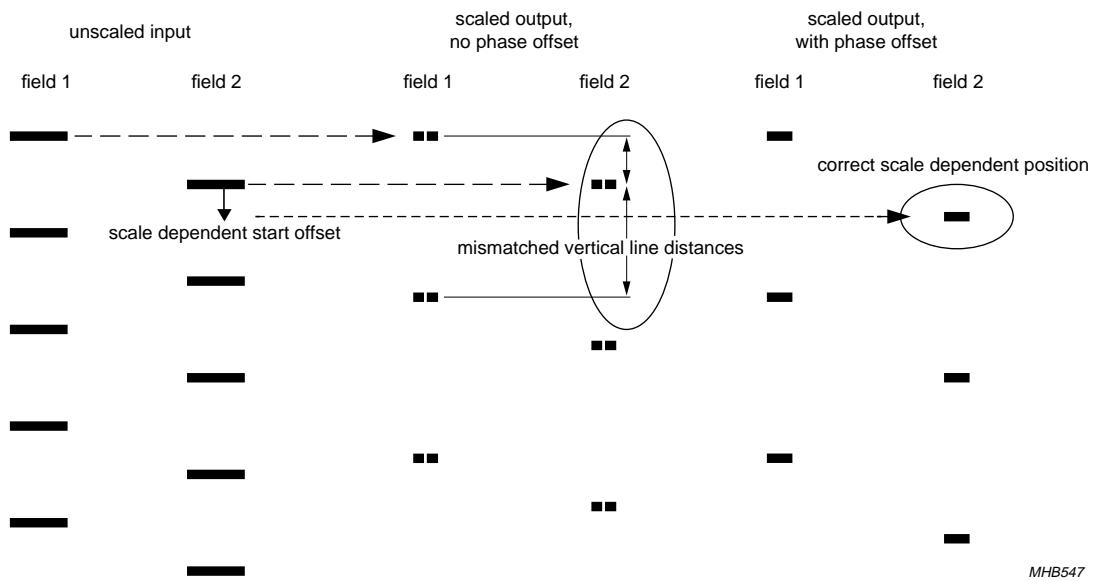
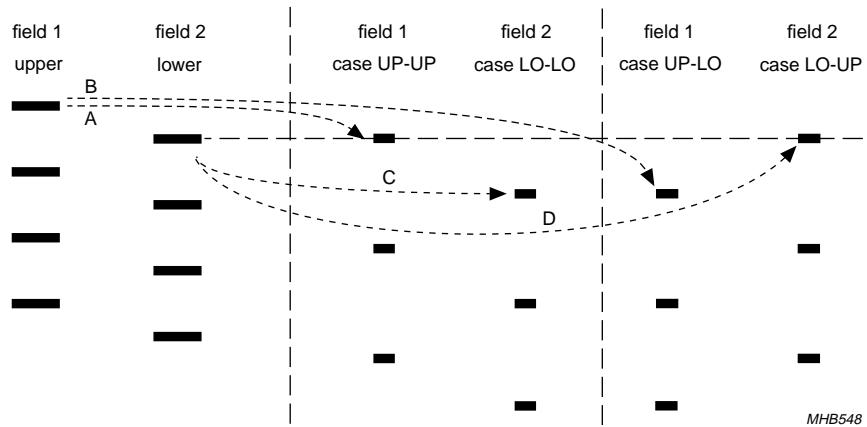


Fig.37 Basic problem of interlaced vertical scaling (example: downscale  $\frac{3}{5}$ ).

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$$\text{Offset} = \frac{1024}{32} = 32 = 1 \text{ line shift}$$

$$C = \frac{1}{2} \text{ scale increment} = \frac{YSCY[15:0]}{64}$$

$$A = \frac{1}{2} \text{ input line shift} = 16$$

$$D = \text{no offset} = 0$$

$$B = \frac{1}{2} \text{ input line shift} + \frac{1}{2} \text{ scale increment} = \frac{YSCY[15:0]}{64} + 16$$

Fig.38 Derivation of the phase related equations (example: interlace vertical scaling down to  $\frac{3}{5}$ , with field conversion).

Table 26 Examples for vertical phase offset usage: global equations

INPUT FIELD UNDER PROCESSING	OUTPUT FIELD INTERPRETED AS	USED ABBREVIATION	EQUATION FOR PHASE OFFSET CALCULATION (DECIMAL VALUES)
Upper input lines	upper output lines	UP-UP	PHO + 16
Upper input lines	lower output lines	UP-LO	PHO + $\frac{YSCY[15:0]}{64} + 16$
Lower input lines	upper output lines	LO-UP	PHO
Lower input lines	lower output lines	LO-LO	PHO + $\frac{YSCY[15:0]}{64}$

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**Table 27** Vertical phase offset usage; assignment of the phase offsets

DETECTED INPUT FIELD ID	TASK STATUS BIT	VERTICAL PHASE OFFSET	CASE	EQUATION TO BE USED
0 = upper lines	0	YPY0[7:0] and YPC0[7:0]	case 1 <sup>(1)</sup>	UP-UP (PHO)
			case 2 <sup>(2)</sup>	UP-UP
			case 3 <sup>(3)</sup>	UP-LO
0 = upper lines	1	YPY1[7:0] and YPC1[7:0]	case 1	UP-UP (PHO)
			case 2	UP-LO
			case 3	UP-UP
1 = lower lines	0	YPY2[7:0] and YPC2[7:0]	case 1	$LO-LO \left( PHO + \frac{YSCY[15:0]}{64} - 16 \right)$
			case 2	LO-UP
			case 3	LO-LO
1 = lower lines	1	YPY3[7:0] and YPC3[7:0]	case 1	$LO-LO \left( PHO + \frac{YSCY[15:0]}{64} - 16 \right)$
			case 2	LO-LO
			case 3	LO-UP

**Notes**

1. Case 1: OFIDC[90H[6]] = 0; scaler input field ID as output ID; back-end interprets output field ID at logic 0 as upper output lines.
2. Case 2: OFIDC[90H[6]] = 1; task status bit as output ID; back-end interprets output field ID at logic 0 as upper output lines.
3. Case 3: OFIDC[90H[6]] = 1; task status bit as output ID; back-end interprets output field ID at logic 1 as upper output lines.

**9.4 VBI data decoder and capture  
(subaddresses 40H to 7FH)**

The SAA7108AE; SAA7109AE contains a versatile VBI data decoder.

The implementation and programming model accords to the VBI data slicer the built-in multimedia video data acquisition circuit of the SAA5284.

The circuitry recovers the actual clock phase during the clock run-in period, slices the data bits with the selected data rate, and groups them into bytes. The result is buffered into a dedicated VBI data FIFO with a capacity of  $2 \times 56$  bytes ( $2 \times 14$  Dwords). The clock frequency, signal source, field frequency and accepted error count must be defined in subaddress 40H.

The VBI data standards that are supported are given in Table 28.

For lines 2 to 24 of a field, per VBI line, 1 of 16 standards can be selected (LCRxxx[41:57[7:0]]:  $23 \times 2 \times 4$ -bit programming bits). The definition for line 24 is valid for the rest of the corresponding field, normally no text data (video data) should be selected there (LCR24 = FFH) to stop the activity of the VBI data slicer during active video.

To adjust the slicers processing to the input signal source, there are offsets in the horizontal and vertical direction available (parameters HOFF[5B,59[2:0,7:0]], VOFF[5B,5A[4,7:0]] and FOFF[5B[7]]).

In difference to the scalers counting, the slicers offsets define the position of the horizontal and vertical trigger events related to the processed video field. The trigger events are the falling edge of HREF and the falling edge of V123 from the decoder processing part.

The relationship of these programming values to the input signal and the recommended values can be seen in Tables 18 to 21.

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**Table 28** Data types supported by the data slicer block

DATA TYPE NUMBER	STANDARD TYPE	DATA RATE (Mbits/s)	FRAMING CODE	FC WINDOW	HAM CHECK
0000	teletext EuroWST, CCST	6.9375	27H	WST625	always
0001	European Closed Caption	0.500	001	CC625	
0010	VPS	5	9951H	VPS	
0011	wide screen signalling bits	5	1E3C1FH	WSS	
0100	US teletext (WST)	5.7272	27H	WST525	always
0101	US Closed Caption (line 21)	0.503	001	CC525	
0110	(video data selected)	5	none	disable	
0111	(raw data selected)	5	none	disable	
1000	teletext	6.9375	programmable	general text	optional
1001	VITC/EBU time codes (Europe)	1.8125	programmable	VITC625	
1010	VITC/SMPTE time codes (USA)	1.7898	programmable	VITC525	
1011		5	programmable	open	
1100	US NABTS	5.7272	programmable	NABTS	optional
1101	MOJI (Japanese)	5.7272	programmable (A7H)	Japtext	
1110	Japanese format switch (L20/22)	5	programmable	open	
1111	no sliced data transmitted (video data selected)	5	none	disable	

**9.5 Image port output formatter  
(subaddresses 84H to 87H)**

The output interface consists of a FIFO for video and for sliced text data, an arbitration circuit, which controls the mixed transfer of video and sliced text data over the I port, and a decoding and multiplexing unit, which generates the 8 or 16-bit wide output data stream together with the accompanying reference and help information.

The clock for the output interface can be derived from an internal clock, decoder, expansion port or an externally provided clock which is appropriate, for example, for the VGA and frame buffer. The clock can be up to 33 MHz. The scaler provides the following video related timing reference events (signals), which are available on pins as defined by subaddresses 84H and 85H:

- Output field ID
- Start and end of vertical active video range
- Start and end of active video line
- Data qualifier or gated clock
- Actually activated programming page (if CONLH is used)
- Threshold controlled FIFO filling flags (empty, full, filled)
- Sliced data marker.

The disconnected data stream at the scaler output is accompanied by a data valid flag (or data qualifier), or is transported via a gated clock. Clock cycles with invalid data on the I port data bus (including the HPD pins in 16-bit output mode) are marked with code 00H.

The output interface also arbitrates the transfer between scaled video data and sliced text data over the I port output.

The bits VITX1 and VITX0 (subaddress 86H) are used to control the arbitration.

The serialization of the internal 32-bit Dwords to 8-bit or 16-bit output (optional), as well as the insertion of the extended ITU 656 codes (SAV/EAV for video data, ANC or SAV/EAV codes for sliced text data) are also done here.

For handshaking with the VGA controller, or other memory or bus interface circuitry, programmable FIFO flags are provided; see Section 9.5.2.

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9.5.1 SCALER OUTPUT FORMATTER  
(SUBADDRESSES 93H AND C3H)

The output formatter organizes the packing into the output FIFO. The following formats are available:

Y-C<sub>B</sub>-C<sub>R</sub> 4 : 2 : 2, Y-C<sub>B</sub>-C<sub>R</sub> 4 : 1 : 1, Y-C<sub>B</sub>-C<sub>R</sub> 4 : 2 : 0,  
Y-C<sub>B</sub>-C<sub>R</sub> 4 : 1 : 0, Y only (e.g. for raw samples). The  
formatting is controlled by FSI[2:0] 93H[2:0], FOI[1:0]  
93H[4:3] and FYSK[93H[5]].

The data formats are defined on Dwords, or multiples thereof, and are similar to the video formats as recommended for PCI multimedia applications (see SAA7146A). Planar formats are not supported.

FSI[2:0] defines the horizontal packing of the data,  
FOI[1:0] defines how many Y only lines are expected  
before a Y/C line will be formatted. If FYSK is set to logic 0  
preceding Y only lines will be skipped, and the output will  
always start with a Y/C line.

Additionally the output formatter limits the amplitude range  
of the video data (controlled by ILLV[85H[5]]); see  
Table 31.

**Table 29** Byte stream for different output formats

OUTPUT FORMAT	BYTE SEQUENCE FOR 8-BIT OUTPUT MODES													
	C <sub>B</sub> 0	Y0	C <sub>R</sub> 0	Y1	C <sub>B</sub> 2	Y2	C <sub>R</sub> 2	Y3	C <sub>B</sub> 4	Y4	C <sub>R</sub> 4	Y5	C <sub>B</sub> 6	Y6
Y-C <sub>B</sub> -C <sub>R</sub> 4 : 1 : 1	C <sub>B</sub> 0	Y0	C <sub>R</sub> 0	Y1	C <sub>B</sub> 4	Y2	C <sub>R</sub> 4	Y3	Y4	Y5	Y6	Y7	C <sub>B</sub> 8	Y8
Y only	Y0	Y1	Y2	Y3	Y4	Y5	Y6	Y7	Y8	Y9	Y10	Y11	Y12	Y13

**Table 30** Explanation to Table 29

NAME	EXPLANATION
C <sub>B</sub> n	C <sub>B</sub> (B - Y) colour difference component, pixel number n = 0, 2, 4 to 718
Yn	Y (luminance) component, pixel number n = 0, 1, 2, 3 to 719
C <sub>R</sub> n	C <sub>R</sub> (R - Y) colour difference component, pixel number n = 0, 2, 4 to 718

**Table 31** Limiting range on I port

LIMIT STEP ILLV[85H[5]]	VALID RANGE			SUPPRESSED CODES (HEXADECIMAL VALUE)	
	DECIMAL VALUE	HEXADECIMAL VALUE	LOWER RANGE	UPPER RANGE	
0	1 to 254	01 to FE	00		FF
1	8 to 247	08 to F7	00 to 07		F8 to FF

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## 9.5.2 VIDEO FIFO (SUBADDRESS 86H)

The video FIFO at the scaler output contains 32 Dwords. That corresponds to 64 pixels in 16-bit Y-C<sub>B</sub>-C<sub>R</sub> 4 : 2 : 2 format. But as the entire scaler can act as a pipeline buffer, the actually available buffer capacity for the image port is much higher, and can exceed beyond a video line.

The image port and the video FIFO, can operate with the video source clock (synchronous mode) or with an externally provided clock (asynchronous, and burst mode), as appropriate for the VGA controller or attached frame buffer.

The video FIFO provides 4 internal flags, which report to what extent the FIFO is actually filled. These are:

- The FIFO Almost Empty (FAE) flag
- The FIFO Combined (FC) flag or FIFO filled, which is set at almost full level and reset, with hysteresis, only after the level crosses below the almost empty mark
- The FIFO Almost Full (FAF) flag
- The FIFO Overflow (FOVL) flag.

The trigger levels for FAE and FAF are programmable by FFL[1:0] 86H[3:2] (16, 24, 28, full) and FEL[1:0] 86H[1:0] (16, 8, 4, empty).

The state of this flag can be seen on pins IGP0 or IGP1. The pin mapping is defined by subaddresses 84H and 85H; see Section 10.5.

## 9.5.3 TEXT FIFO

The data of the terminal VBI data slicer is collected in the text FIFO before transmission over the I port is requested (normally before the video window starts) and partitioned into two FIFO sections. A complete line is fed into the FIFO before a data transfer is requested. So normally, one line of text data is ready for transfer while the next text line is collected. Thus sliced text data is delivered as a block of qualified data, without any qualification gaps in the byte stream of the I port.

The decoded VBI data is collected in the dedicated VBI data FIFO. Once the capture of a line is completed, the FIFO can be streamed through the image port, preceded by a header, giving the line number and standard.

The VBI data period can be signalled via the sliced data flag on pin IGP0 or IGP1. The decoded VBI data is lead by the ITU ancillary data header (DID[5:0] 5DH[5:0] at value <3EH) or by SAV/EAV codes selected by DID[5:0] at value 3EH or 3FH. IGP0 or IGP1 is set if the first byte of the ANC header is valid on the I port bus; it is reset if an SAV occurs. Therefore it may frame multiple lines of text data output, in case the video processing starts with a distance of several video lines to the region of text data. Valid sliced data from the text FIFO is available on the I port as long as the IGP0 or IGP1 flag is set and the data qualifier is active on pin IDQ.

The decoded VBI data is presented in two different data formats, controlled by bit RECODE.

RECODE = 1: values 00H and FFH will be recoded to even parity values 03H and FCH

RECODE = 0: values 00H and FFH may occur in the data stream as detected.

## 9.5.4 VIDEO AND TEXT ARBITRATION (SUBADDRESS 86H)

Sliced text data and scaled video data are transferred over the same bus, the I port. The mixed transfer is controlled by an arbitration circuit. If the video data is transferred without any interrupt and the video FIFO does not need to buffer any output pixel, the text data is inserted after the end of a scaled video line, normally during the video blanking interval.

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## 9.5.5 DATA STREAM CODING AND REFERENCE SIGNAL GENERATION (SUBADDRESSES 84H, 85H AND 93H)

As horizontal and vertical reference signals are logic 1, active gate signals are generated, which frame the transfer of the valid output data. Alternatively, the horizontal and vertical trigger pulses can be generated on the rising edges of the gates.

Due to the dynamic FIFO behaviour of the complete scaler path, the output signal timing has no fixed timing relationship to the real-time input video stream. Thus fixed propagation delays, in terms of clock cycles, related to the analog input can not be defined.

The data stream is accompanied by a data qualifier.

Additionally invalid data cycles are marked with code 00H.

If ITU 656 like codes are not required, they can be suppressed in the output stream.

As a further option, it is possible to provide the scaler with an external gating signal on pin ITRDY. It is therefore possible to hold the data output for a certain time and to get valid output data in bursts of a guaranteed length.

The sketched reference signals and events can be mapped to the I port output pins IDQ, IGPH, IGPV, IGP0 and IGP1. The polarities of all the outputs can be modified to enable flexible use. The default polarity for the qualifier and reference signals is logic 1 (active).

Table 32 shows the relevant and supported SAV and EAV coding.

**Table 32** SAV/EAV codes on the I port

EVENT DESCRIPTION	SAV/EAV CODES ON I PORT <sup>(1)</sup> (HEX)				COMMENT	
	MSB <sup>(2)</sup> OF SAV/EAV BYTE = 0		MSB <sup>(2)</sup> OF SAV/EAV BYTE = 1			
	FIELD ID = 0	FIELD ID = 1	FIELD ID = 0	FIELD ID = 1		
Next pixel is FIRST pixel of any active line	0E	49	80	C7	HREF = active; VREF = active	
Previous pixel was LAST pixel of any active line, but not the last	13	54	9D	DA	HREF = inactive; VREF = active	
Next pixel is FIRST pixel of any V-blanking line	25	62	AB	EC	HREF = active; VREF = inactive	
Previous pixel was LAST pixel of the last active line or of any V-blanking line	38	7F	B6	F1	HREF = inactive; VREF = inactive	
No valid data, do not capture and do not increment pointer	00				IDQ pin inactive	

### Notes

1. The leading byte sequence is: FFH-00H-00H.
2. The MSB of the SAV/EAV code byte is controlled by:
  - a) Scaler output data: task A  $\Rightarrow$  MSB =  $\overline{\text{CONLH}}[90H[7]]$ ; task B  $\Rightarrow$  MSB =  $\overline{\text{CONLH}}[C0H[7]]$ .
  - b) VBI data slicer output data: DID[5:0] 5DH[5:0] = 3EH  $\Rightarrow$  MSB = 1; DID[5:0] 5DH[5:0] = 3FH  $\Rightarrow$  MSB = 0.

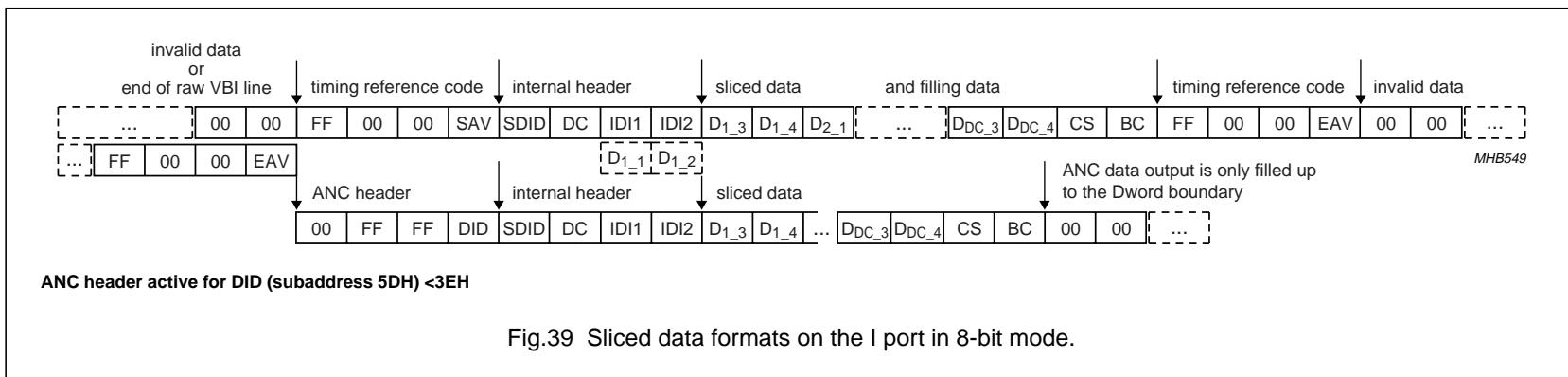


Table 33 Explanation to Fig.39

NAME	EXPLANATION
SAV	start of active data; see Table 34
SDID	sliced data identification: NEP <sup>(1)</sup> , EP <sup>(2)</sup> , SDID5 to SDID0, freely programmable via I <sup>2</sup> C-bus subaddress 5EH, bits 5 to 0, e. g. to be used as source identifier
DC	Dword count: NEP <sup>(1)</sup> , EP <sup>(2)</sup> , DC5 to DC0. DC describes the number of succeeding 32-bit words: <ul style="list-style-type: none"> <li>For SAV/EAV mode DC is fixed to 11 Dwords (byte value 4BH)</li> <li>For ANC mode it is: DC = <math>\frac{1}{4}(C + n)</math>, where C = 2 (the two data identification bytes IDI1 and IDI2) and n = number of decoded bytes according to the chosen text standard.</li> </ul> Note that the number of valid bytes inside the stream can be seen in the BC byte.
IDI1	internal data identification 1: OP <sup>(3)</sup> , FID (field 1 = 0, field 2 = 1), LineNumber8 to LineNumber3 = Dword 1 byte 1; see Table 34
IDI2	internal data identification 2: OP <sup>(3)</sup> , LineNumber2 to LineNumber0, DataType3 to DataType0 = Dword 1 byte 2; see Table 34
D <sub>n_m</sub>	Dword number <b>n</b> , byte number <b>m</b>
D <sub>DC_4</sub>	last Dword byte 4, note: for SAV/EAV framing DC is fixed to 0BH, missing data bytes are filled up; the fill value is A0H
CS	the check sum byte, the check sum is accumulated from the SAV (respectively DID) byte to the D <sub>DC_4</sub> byte
BC	number of valid sliced bytes counted from the IDI1 byte
EAV	end of active data; see Table 34

## Notes

1. Inverted EP (bit 7); for EP see note 2.
2. Even parity (bit 6) of bits 5 to 0.
3. Odd parity (bit 7) of bits 6 to 0.

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**Table 34** Bytes stream of the data slicer

NICK NAME	COMMENT	BIT 7	BIT 6	BIT 5	BIT 4	BIT 3	BIT 2	BIT 1	BIT 0
DID, SAV, EAV	subaddress 5DH = 00H	NEP <sup>(1)</sup>	EP <sup>(2)</sup>	0	1	0	FID <sup>(3)</sup>	I1 <sup>(4)</sup>	I0 <sup>(4)</sup>
	subaddress 5DH; bit 5 = 1	NEP	EP	0	D4[5DH]	D3[5DH]	D2[5DH]	D1[5DH]	D0[5DH]
	subaddress 5DH bit 5 = 3EH; note 5	1	FID <sup>(3)</sup>	V <sup>(6)</sup>	H <sup>(7)</sup>	P3	P2	P1	P0
	subaddress 5DH bit 5 = 3FH; note 5	0	FID <sup>(3)</sup>	V <sup>(6)</sup>	H <sup>(7)</sup>	P3	P2	P1	P0
SDID	programmable via subaddress 5EH	NEP	EP	D5[5EH]	D4[5EH]	D3[5EH]	D2[5EH]	D1[5EH]	D0[5EH]
DC <sup>(8)</sup>		NEP	EP <sup>(2)</sup>	DC5	DC4	DC3	DC2	DC1	DC0
IDI1		OP <sup>(9)</sup>	FID <sup>(3)</sup>	LN8 <sup>(10)</sup>	LN7 <sup>(10)</sup>	LN6 <sup>(10)</sup>	LN5 <sup>(10)</sup>	LN4 <sup>(10)</sup>	LN3 <sup>(10)</sup>
IDI2		OP	LN2 <sup>(10)</sup>	LN1 <sup>(10)</sup>	LN0 <sup>(10)</sup>	DT3 <sup>(11)</sup>	DT2 <sup>(11)</sup>	DT1 <sup>(11)</sup>	DT0 <sup>(11)</sup>
CS	check sum byte	CS6	CS5	CS4	CS3	CS2	CS1	CS0	
BC	valid byte count	OP	0	CNT5	CNT4	CNT3	CNT2	CNT1	CNT0

**Notes**

1. NEP = inverted EP (see note 2).
2. EP = Even Parity of bits 5 to 0.
3. FID = 0: field 1; FID = 1: field 2.
4. I1 = 0 and I0 = 0: before line 1; I1 = 0 and I0 = 1: lines 1 to 23; I1 = 1 and I0 = 0: after line 23; I1 = 1 and I0 = 1: line 24 to end of field.
5. Subaddress 5DH at 3EH and 3FH are used for ITU 656 like SAV/EAV header generation; recommended value.
6. V = 0: active video; V = 1: blanking.
7. H = 0: start of line; H = 1: end of line.
8. DC = Data Count in Dwors according to the data type.
9. OP = Odd Parity of bits 6 to 0.
10. LN = Line Number.
11. DT = Data Type according to table.

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### 9.6 Audio clock generation (subaddresses 30H to 3FH)

The SAA7108AE; SAA7109AE incorporates the generation of a field-locked audio clock, as an auxiliary function for video capture. An audio sample clock, that is locked to the field frequency, ensures that there is always the same predefined number of audio samples associated with a field, or a set of fields. This ensures synchronous playback of audio and video after digital recording (e.g. capture to hard disk), MPEG or other compression or non-linear editing.

#### 9.6.1 MASTER AUDIO CLOCK

The audio clock is synthesized from the same crystal frequency as the line-locked video clock is generated. The master audio clock is defined by the parameters:

- Audio master Clocks Per Field, ACPF[17:0] 32H[1:0] 31H[7:0] 30H[7:0] according to the equation:

$$ACPF[17:0] = \text{round}\left(\frac{\text{audio frequency}}{\text{field frequency}}\right)$$

- Audio master Clocks Nominal Increment, ACNI[21:0] 36H[5:0] 35H[7:0] 34H[7:0] according to the equation:

$$ACNI[21:0] = \text{round}\left(\frac{\text{audio frequency}}{\text{crystal frequency}} \times 2^{23}\right)$$

See Table 35 for examples.

**Remark:** For standard applications the synthesized audio clock AMCLK can be used directly as master clock and as input clock for port AMXCLK (short cut) to generate ASCLK and ALRCLK. For high-end applications it is recommended to use an external analog PLL circuit to enhance the performance of the generated audio clock.

**Table 35** Programming examples for audio master clock generation

CRYSTAL FREQUENCY (MHz)	FIELD (Hz)	ACPF		ACNI	
		DECIMAL	HEX	DECIMAL	HEX
<b>AMCLK = 256 × 48 kHz (12.288 MHz)</b>					
32.11	50	245760	3C000	3210190	30FBCE
	59.94	205005	320CD	3210190	30FBCE
24.576	50	—	—	—	—
	59.94	—	—	—	—
<b>AMCLK = 256 × 44.1 kHz (11.2896 MHz)</b>					
32.11	50	225792	37200	2949362	2D00F2
	59.94	188348	2DFBC	2949362	2D00F2
24.576	50	225792	37200	3853517	3ACCCD
	59.94	188348	2DFBC	3853517	3ACCCD
<b>AMCLK = 256 × 32 kHz (8.192 MHz)</b>					
32.11	50	163840	28000	2140127	20A7DF
	59.94	136670	215DE	2140127	20A7DF
24.576	50	163840	28000	2796203	2AAAAB
	59.94	136670	215DE	2796203	2AAAAB

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## 9.6.2 SIGNALS ASCLK AND ALRCLK

Two binary divided signals ASCLK and ALRCLK are provided for slower serial digital audio signal transmission and for channel-select. The frequencies of these signals are defined by the parameters:

- SDIV[5:0] 38H[5:0] according to the equation:  $f_{ASCLK} = \frac{f_{AMXCLK}}{(SDIV + 1) \times 2} \Rightarrow SDIV[5:0] = \frac{f_{AMXCLK}}{2f_{ASCLK}} - 1$
- LRDIV[5:0] 39H[5:0] according to the equation:  $f_{ALRCLK} = \frac{f_{ASCLK}}{LRDIV \times 2} \Rightarrow LRDIV[5:0] = \frac{f_{ASCLK}}{2f_{ALRCLK}}$

See Table 36 for examples.

**Table 36** Programming examples for ASCLK/ALRCLK clock generation

AMXCLK (MHz)	ASCLK (kHz)	SDIV		ALRCLK (kHz)	LRDIV	
		DECIMAL	HEX		DECIMAL	HEX
12.288	1536	3	03	48	16	10
	768	7	07		8	08
11.2896	1411.2	3	03	44.1	16	10
	2822.4	1	01		32	10
8.192	1024	3	03	32	16	10
	2048	1	01		32	10

## 9.6.3 OTHER CONTROL SIGNALS

Further control signals are available to define reference clock edges and vertical references; see Table 37.

**Table 37** Control signals

CONTROL SIGNAL	DESCRIPTION
APLL[3AH[3]]	Audio PLL mode:
	0: PLL closed
	1: PLL open
AMVR[3AH[2]]	Audio Master clock Vertical Reference:
	0: internal vertical reference
	1: external vertical reference
LRPH[3AH[1]]	ALRCLK Phase:
	0: invert ASCLK, ALRCLK edges triggered by falling edge of ASCLK
	1: do not invert ASCLK, ALRCLK edges triggered by rising edge of ASCLK
SCPH[3AH[0]]	ASCLK Phase:
	0: invert AMXCLK, ASCLK edges triggered by falling edge of AMXCLK
	1: do not invert AMXCLK, ASCLK edges triggered by rising edge of AMXCLK

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**10 INPUT/OUTPUT INTERFACES AND PORTS OF DIGITAL VIDEO DECODER PART**

The SAA7108AE; SAA7109AE has 5 different I/O interfaces. These are:

- Analog video input interface, for analog CVBS and/or Y and C input signals
- Audio clock port
- Digital real-time signal port (RT port)
- Digital video expansion port (X port), for unscaled digital video input and output
- Digital image port (I port) for scaled video data output and programming
- Digital host port (H port) for extension of the image port or expansion port from 8 to 16-bit.

**10.1 Analog terminals**

The SAA7108AE; SAA7109AE has 6 analog inputs AI21 to AI24, AI11 and AI12 (see Table 38) for composite video CVBS or S-video Y/C signal pairs. Additionally, there are two differential reference inputs, which must be connected to ground via a capacitor equivalent to the decoupling capacitors at the 6 inputs. There are no peripheral components required other than the decoupling capacitors and  $18\ \Omega/56\ \Omega$  termination resistors, one set per connected input signal (see also application example in Fig.53). Two anti-alias filters are integrated, and self adjusting via the clock frequency.

Clamp and gain control for the two ADCs are also integrated. An analog video output pin (AOUT) is provided for testing purposes.

**Table 38** Analog pin description

SYMBOL	PIN	I/O	DESCRIPTION	BIT
AI24 to AI21	P6, P7, P9 and P10	I	analog video signal inputs, e.g. 2 CVBS signals and two Y/C pairs can be connected simultaneously	MODE3 to MODE0
AI12 and AI11	P11 and P13			
AOUT	M10	O	analog video output, for test purposes	AOSL1 and AOSL0
AI1D and AI2D	P12 and P8	I	analog reference pins for differential ADC operation	–

**10.2 Audio clock signals**

The SAA7108AE; SAA7109AE also synchronizes the audio clock and sampling rate to the video frame rate, via a very slow PLL. This ensures that the multimedia capture and compression processes always gather the same predefined number of samples per video frame.

An audio master clock AMCLK and two divided clocks, ASCLK and ALRCLK, are generated; see Table 39.

- ASCLK: can be used as audio serial clock
- ALRCLK: audio left/right channel clock.

The ratios are programmable; see Section 9.6.

**Table 39** Audio clock pin description

SYMBOL	PIN	I/O	DESCRIPTION	BIT
AMCLK	K12	O	audio master clock output	ACPF[17:0] 32H[1:0] 31H[7:0] 30H[7:0] and ACNI[21:0] 36H[5:0] 35H[7:0] 34H[7:0]
AMXCLK	J12	I	external audio master clock input for the clock division circuit, can be directly connected to output AMCLK for standard applications	–
ASCLK	K14	O	serial audio clock output, can be synchronized to rising or falling edge of AMXCLK	SDIV[5:0] 38H[5:0] and SCPH[3AH[0]]
ALRCLK	J13	O	audio channel (left/right) clock output, can be synchronized to rising or falling edge of ASCLK	LRDIV[5:0] 39H[5:0] and LRPH[3AH[1]]

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**10.3 Clock and real-time synchronization signals**

A crystal accurate frequency reference is required for the generation of the line-locked video (pixel) clock LLC, and the frame-locked audio serial bit clock. An oscillator is built-in, for fundamental or 3rd-harmonic crystals. The supported crystal frequencies are 32.11 or 24.576 MHz (defined during reset by strapping pin ALRCLK).

Alternatively pins XTALId and XTALIe can be driven from an external single-ended oscillator.

The crystal oscillation can be propagated as clock to other ICs in the system via pin XTOUTd.

The Line-Locked Clock (LLC) is the double pixel clock at a nominal 27 MHz. It is locked to the selected video input, generating baseband video pixels according to "ITU recommendation 601". In order to support interfacing circuits, a direct pixel clock LLC2 is also provided.

The pins for line and field timing reference signals are RTCO, RTS1 and RTS0. Various real-time status information can be selected for the RTS pins. The signals are always available (output) and reflect the synchronization operation of the decoder part in the SAA7108AE; SAA7109AE. The function of the RTS1 and RTS0 pins can be defined by bits RTSE1[3:0] 12H[7:4] and RTSE0[3:0] 12H[3:0]; see Table 40.

**Table 40** Clock and real-time synchronization signals

SYMBOL	PIN	I/O	DESCRIPTION	BIT
<b>Crystal oscillator</b>				
XTALId	P2	I	input for crystal oscillator, or reference clock	–
XTALOd	P3	O	output of crystal oscillator	–
XTOUTd	P4	O	reference (crystal) clock output drive (optional)	XTOUTE[14H[3]]
<b>Real-time signals (RT port)</b>				
LLC	M14	O	line-locked clock; nominal 27 MHz, double pixel clock locked to the selected video input signal	–
LLC2	L14	O	line-locked pixel clock; nominal 13.5 MHz	–
RTCO	L13	O	real-time control output; transfers real-time status information supporting RTC level 3.1 (see external document "RTC Functional Description", available on request)	–
RTS0	K13	O	real-time status information line 0; can be programmed to carry various real-time informations; see Table 171	RTSE0[3:0] 12H[3:0]
RTS1	L10	O	real-time status information line 1; can be programmed to carry various real-time informations; see Table 172	RTSE1[3:0] 12H[7:4]

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**10.4 Video expansion port (X port)**

The expansion port is intended for transporting video streams of image data from other digital video circuits such as MPEG encoder/decoder and video phone codec, to the image port (I port); see Table 41.

The expansion port consists of two groups of signals/pins:

- 8-bit data, I/O, regular video components  $Y-C_B-C_R$  4 : 2 : 2, i.e.  $C_B-Y-C_R-Y$ , byte serial, exceptionally raw video samples (e.g. ADC test). In input mode the data bus can be extended to 16-bit by pins HPD7 to HPD0.
- Clock, synchronization and auxiliary signals, accompanying the data stream, I/O.

As output, these are direct copies of the decoder signals.

The data transfers through the expansion port represent a single D1 port, with half duplex mode. The SAV and EAV codes may be inserted optionally for data input (controlled by bit XCODE[92H[3]]). The input/output direction is switched for complete fields only.

**Table 41** Signals dedicated to the expansion port

SYMBOL	PIN	I/O	DESCRIPTION	BIT
XPD7 to XPD0	K2, K3, L1 to L3, M1, M2 and N1	I/O	X port data: in output mode controlled by decoder section, for data format see Table 42; in input mode $Y-C_B-C_R$ 4 : 2 : 2 serial input data or luminance part of a 16-bit $Y-C_B-C_R$ 4 : 2 : 2 input	OFTS[2:0] 13H[2:0], 91H[7:0] and C1H[7:0]
XCLK	M3	I/O	clock at expansion port: if output, then copy of LLC; as input normally a double pixel clock of up to 32 MHz or a gated clock (clock gated with a qualifier)	XCKS[92H[0]]
XDQ	M4	I/O	data valid flag of the expansion port input (qualifier): if output, then decoder (HREF and VGATE) gate (see Fig.32)	–
XRDY	N3	O	data request flag = ready to receive, to work with optional buffer in external device, to prevent internal buffer overflow; second function: input related task flag A/B	XRQT[83H[2]]
XRH	N2	I/O	horizontal reference signal for the X port: as output: HREF or HS from the decoder (see Fig.32); as input: a reference edge for horizontal input timing and a polarity for input field ID detection can be defined	XRHS[13H[6]], XFDH[92H[6]] and XDH[92H[2]]
XRV	L5	I/O	vertical reference signal for the X port: as output: V123 or field ID from the decoder, see Figs 30 and 31; as input: a reference edge for vertical input timing and for input field ID detection can be defined	XRVS[1:0] 13H[5:4], XFDV[92H[7]] and XDV[1:0] 92H[5:4]
XTRI	K1	I	port control: switches X port input to 3-state	XPE[1:0] 83H[1:0]

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## 10.4.1 X PORT CONFIGURED AS OUTPUT

If the data output is enabled at the expansion port, then the data stream from the decoder is present. The data format of the 8-bit data bus is dependent on the chosen data type which is selectable by the line control registers LCR2 to LCR24; see Table 17. In contrast to the image port, the sliced data format is not available on the expansion port. Instead, raw CVBS samples are always transferred if any sliced data type is selected.

Details of some of the data types on the expansion port are as follows:

- **Active video:** (data type 15) contains components Y-C<sub>B</sub>-C<sub>R</sub> 4 : 2 : 2 signal, 720 active pixels per line. The amplitude and offsets are programmable via DBRI7 to DBRI0, DCON7 to DCON0, DSAT7 to DSAT0, OFFU1, OFFU0, OFFV1 and OFFV0. For nominal levels see Fig.26.
- **Test line:** (data type 6) is similar to the active video format, with some constraints within the data processing:
  - adaptive chrominance comb filter, vertical filter (chrominance comb filter for NTSC standards, PAL phase error correction) within the chrominance processing are disabled
  - adaptive luminance comb filter, peaking and chrominance trap are bypassed within the luminance processing.

This data type is defined for future enhancements. It can be activated for lines containing standard test signals within the vertical blanking period. Currently most sources do not contain test lines. For nominal levels see Fig.26.

- **Raw samples** (data types 0 to 5 and 7 to 14): C<sub>B</sub>-C<sub>R</sub> samples are similar to data type 6, but CVBS samples are transferred instead of processed luminance samples within the Y time slots.

The amplitude and offset of the CVBS signal is programmable via RAWG7 to RAWG0 and RAWO7 to RAWO0, see Chapter 18, Tables 178 and 179. For nominal levels see Fig.27.

The relationship of LCR programming to line numbers is described in Section 9.2; see Tables 18 to 21.

The data type selections by LCR are overruled by setting OFTS2 = 1 (subaddress 13H bit 2). This setting is mainly intended for device production testing. The VPO-bus carries the upper or lower 8 bits of the two ADCs depending on the OFTS[1:0] 13H[1:0] settings; see Table 173. The output configuration is done via MODE[3:0] 02H[3:0] settings; see Table 155. If a Y/C mode is selected, the expansion port carries the multiplexed output signals of both ADCs, in CVBS mode the output of only one ADC. No timing reference codes are generated in this mode.

**Remark:** The LSBs (bit 0) of the ADCs are also available on pin RTS0; see Table 171.

The SAV/EAV timing reference codes define the start and end of valid data regions. The ITU-blanking code sequence '- 80 - 10 - 80 - 10 -...' is transmitted during the horizontal blanking period, between EAV and SAV.

The position of the F bit is constant according to ITU 656; see Tables 44 and 45.

The V bit can be generated in two different ways (see Tables 44 and 45) controlled via OFTS1 and OFTS0; see Table 173.

F and V bits change synchronously with the EAV code.

**Table 42** Data format on the expansion port

BLANKING PERIOD		TIMING REFERENCE CODE (HEX) <sup>(1)</sup>		720 PIXELS Y-C <sub>B</sub> -C <sub>R</sub> 4 : 2 : 2 DATA <sup>(2)</sup>												TIMING REFERENCE CODE (HEX) <sup>(1)</sup>		BLANKING PERIOD				
...	80	10	FF	00	00	SAV	C <sub>B</sub> 0	Y0	C <sub>R</sub> 0	Y1	C <sub>B</sub> 2	Y2	...	C <sub>R</sub> 718	Y719	FF	00	00	EAV	80	10	...

### Notes

1. The generation of the timing reference codes can be suppressed by setting OFTS[2:0] to '010'; see Table 173. In this event the code sequence is replaced by the standard '- 80 - 10 -' blanking values.
2. If raw samples or sliced data are selected by the line control registers (LCR2 to LCR24), the Y samples are replaced by CVBS samples.

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**Table 43** SAV/EAV format on expansion port XPD7 to XPD0

BIT 7	BIT 6 (F)	BIT 5 (V)	BIT 4 (H)	BIT 3 (P3)	BIT 2 (P2)	BIT 1 (P1)	BIT 0 (P0)
1	field bit 1st field: F = 0 2nd field: F = 1	vertical blanking bit VBI: V = 1 active video: V = 0	format H = 0 in SAV format H = 1 in EAV format	reserved; evaluation not recommended (protection bits according to ITU 656)			

**Table 44** 525 lines/60 Hz vertical timing

LINE NUMBER	F (ITU 656)	V	
		OFTS[2:0] = 000 (ITU 656)	OFTS[2:0] = 001
1 to 3	1	1	according to selected VGATE position type via VSTA and VSTO (subaddresses 15H to 17H); see Tables 175 to 177
4 to 19	0	1	
20	0	0	
21	0	0	
22 to 261	0	0	
262	0	0	
263	0	0	
264 and 265	0	1	
266 to 282	1	1	
283	1	0	
284	1	0	
285 to 524	1	0	
525	1	0	

**Table 45** 625 lines/50 Hz vertical timing

LINE NUMBER	F (ITU 656)	V	
		OFTS[2:0] = 000 (ITU 656)	OFTS[1:0] = 10
1 to 22	0	1	according to selected VGATE position type via VSTA and VSTO (subaddresses 15H to 17H); see Tables 175 to 177
23	0	0	
24 to 309	0	0	
310	0	0	
311 and 312	0	1	
313 to 335	1	1	
336	1	0	
337 to 622	1	0	
623	1	0	
624 and 625	1	1	

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## 10.4.2 X PORT CONFIGURED AS INPUT

If data input mode is selected at the expansion port, then the scaler can choose its input data stream from the on-chip video decoder, or from the expansion port (controlled by bit SCSRC[1:0] 91H[5:4]). Byte serial Y-C<sub>B</sub>-C<sub>R</sub> 4 : 2 : 2, or subsets for other sampling schemes, or raw samples from an external ADC may be input (see also bits FSC[2:0] 91H[2:0]). The input data stream must be accompanied by an external clock XCLK, qualifier XDQ and reference signals XRH and XRV. Instead of the reference signal, embedded SAV and EAV codes, according to ITU 656, can also be accepted. The protection bits are not evaluated.

XRH and XRV carry the horizontal and vertical synchronization signals for the digital video stream through the expansion port. The field ID of the input video stream is carried in the phase (edge) of XRV and state of XRH, or directly as FS (frame sync, odd/even signal) on the XRV pin (controlled by XFDV[92H[7]], XFDH[92H[6]] and XDV[1:0] 92H[5:4]).

The trigger events on XRH (rising/falling edge) and XRV (rising/falling both edges) for the scalers acquisition window are defined by XDV[1:0] 92H[5:4] and XDH[92H[2]]. The signal polarity of the qualifier can also be defined by bit XDQ[92H[1]]. As an alternative to the qualifier, the input clock can be applied to a gated clock (clock gated with a data qualifier, controlled by bit XCKS[92H[0]]). In this event, all input data will be qualified.

## 10.5 Image port (I port)

The image port transfers data from the scaler as well as from the VBI data slicer, if selected (maximum 33 MHz). The reference clock is available at the ICLK pin as an output or as an input (maximum 33 MHz). As an output, the ICLK is derived from the line-locked decoder or expansion port input clock. The data stream from the scaler output is normally discontinuous. Therefore valid data during a clock cycle is accompanied by a data qualifying (data valid) flag on pin IDQ. For pin constrained applications the IDQ pin can be programmed to function as a gated clock output (bit ICKS2[80H[2]]).

The data formats at the image port are defined in Dwords of 32 bits (4 bytes), such as the related FIFO structures. However, the physical data stream at the image port is only 16-bit or 8-bit wide; in 16-bit mode data pins HPD7 to HPD0 are used for chrominance data. The four bytes of the Dwords are serialized in words or bytes.

The available formats are as follows:

- Y-C<sub>B</sub>-C<sub>R</sub> 4 : 2 : 2
- Y-C<sub>B</sub>-C<sub>R</sub> 4 : 1 : 1
- Raw samples
- Decoded VBI data.

For handshaking with the receiving VGA controller, or other memory or bus interface circuitry, F, H and V reference signals and programmable FIFO flags are provided. The information is provided on pins IGP0, IGP1, IGPH and IGPV. The function on these pins is controlled via subaddresses 84H and 85H.

VBI data is collected over an entire line in its own FIFO and transferred as an uninterrupted block of bytes. Decoded VBI data can be signed by the VBI flag on pins IGP0 and IGP1.

Because scaled video data and decoded VBI data may come from different and asynchronous sources, an arbitration scheme is needed. Normally the VBI data slicer has priority.

The image port consists of the pins and/or signals, as given in Table 46.

For pin constrained applications, or interfaces, the relevant timing and data reference signals can also be encoded into the data stream. Therefore the corresponding pins do not need to be connected. The minimum image port configuration requires 9 pins only, i.e. 8 pins for data including codes, and 1 pin for clock or gated clock. The inserted codes are defined in close relationship to the ITU-R BT.656 (D1) recommendation, where possible.

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The following deviations from "ITU 656 recommendation" are implemented at the SAA7108AE; SAA7109AEs image port interface:

- SAV and EAV codes are only present in those lines, where data is to be transferred, i.e. active video lines, or VBI raw samples, no codes for empty lines
- There may be more or less than 720 pixels between SAV and EAV
- The data content and number of clock cycles during horizontal and vertical blanking is undefined, and may be not constant
- The data stream may be interleaved with not-valid data codes, 00H, but SAV and EAV 4-byte codes are not interleaved with not-valid data codes
- There may be an irregular pattern of not-valid data, or IDQ, and as a result, ' $C_B - Y - C_R - Y'$  is not in a fixed phase to a regular clock divider

- VBI raw sample streams are enveloped with SAV and EAV, like normal video
- Decoded VBI data is transported as Ancillary (ANC) data, two modes:
  - direct decoded VBI data bytes (8-bit) are directly placed in the ANC data field, 00H and FFH codes may appear in the data block (violation to ITU-R BT.656)
  - recoded VBI data bytes (8-bit) directly placed in ANC data field, 00H and FFH codes will be recoded to even parity codes 03H and FCH to suppress invalid ITU-R BT.656 codes.

There are no empty cycles in the ancillary code or its data field. The data codes 00H and FFH are suppressed (changed to 01H or FEH respectively) in the active video stream, as well as in the VBI raw sample stream (VBI pass-through). As an option the number range can be limited further.

**Table 46** Signals dedicated to the image port

SYMBOL	PIN	I/O	DESCRIPTION	BIT
IPD7 to IPD0	E14, D14, C14, B14, E13, D13, C13 and B13	I/O	I port data	ICODE[93H[7]], ISWP[1:0] 85H[7:6] and IPE[1:0] 87H[1:0]
ICLK	H12	I/O	continuous reference clock at image port, can be input or output, as output decoder LLC or XCLK from X port	ICKS[1:0] 80H[1:0] and IPE[1:0] 87H[1:0]
IDQ	H14	O	data valid flag at image port, qualifier, with programmable polarity; secondary function: gated clock	ICKS2[80H[2]], IDQP[85H[0]] and IPE[1:0] 87H[1:0]
IGPH	G12	O	horizontal reference output signal, copy of the horizontal gate signal of the scaler, with programmable polarity; alternative function: HRESET pulse	IDH[1:0] 84H[1:0], IRHP[85H[1]] and IPE[1:0] 87H[1:0]
IGPV	F13	O	vertical reference output signal, copy of the vertical gate signal of the scaler, with programmable polarity; alternative function: VRESET pulse	IDV[1:0] 84H[3:2], IRVP[85H[2]] and IPE[1:0] 87H[1:0]
IGP1	G13	O	general purpose output signal for I port	IDG12[86H[4]], IDG1[1:0] 84H[5:4], IG1P[85H[3]] and IPE[1:0] 87H[1:0]
IGP0	F14	O	general purpose output signal for I port	IDG02[86H[5]], IDG0[1:0] 84H[7:6], IG0P[85H[4]] and IPE[1:0] 87H[1:0]
ITRDY	J14	I	target ready input signals	–
ITRI	G14	I	port control, switches I port into 3-state	IPE[1:0] 87H[1:0]

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**10.6 Host port for 16-bit extension of video data I/O (H port)**

The H port, pins HPD, can be used to extend the data I/O paths to 16-bit.

The I port has functional priority. If I8\_16[93H[6]] is set to logic 1 the output drivers of the H port are enabled and are dependent on the I port enable control. When I8\_16 = 0, the HPD output is disabled.

**Table 47** Signals dedicated to the host port

SYMBOL	PIN	I/O	DESCRIPTION	BIT
HPD7 to HPD0	A13, D12, C12, B12, A12, C11, B11 and A11	I/O	16-bit extension for digital I/O (chrominance component)	IPE[1:0] 87H[1:0], ITRI[8FH[6]] and I8_16[93H[6]]

**10.7 Basic input and output timing diagrams for the I and X ports**

## 10.7.1 I PORT OUTPUT TIMING

The following diagrams (Figs 40 to 46) illustrate the output timing via the I port. IGPH and IGPV are indicated as logic 1 active gate signals. If reference pulses are programmed, these pulses are generated on the rising edge of the logic 1 active gates. Valid data is accompanied by the output data qualifier on pin IDQ. In addition, invalid cycles are marked with output code 00H.

The IDQ output pin may be defined to be a gated clock output signal (ICLK AND internal IDQ).

## 10.7.2 X PORT INPUT TIMING

The input timing requirements at the X port are the same as those for the I port output. However, the following differences should be noted:

- It is not necessary to mark invalid cycles with a 00H code
- No constraints on the input qualifier (can be a random pattern)
- XCLK may be a gated clock (XCLK AND external XDQ).

**Remark:** All timings illustrated are given for an uninterrupted output stream (no handshake with the external hardware).

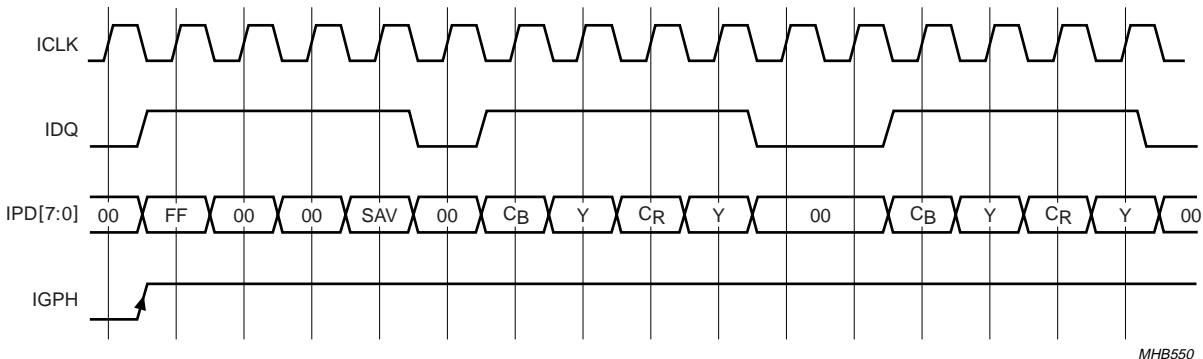


Fig.40 Output timing at the I port for serial 8-bit data at start of a line (ICODE = 1).

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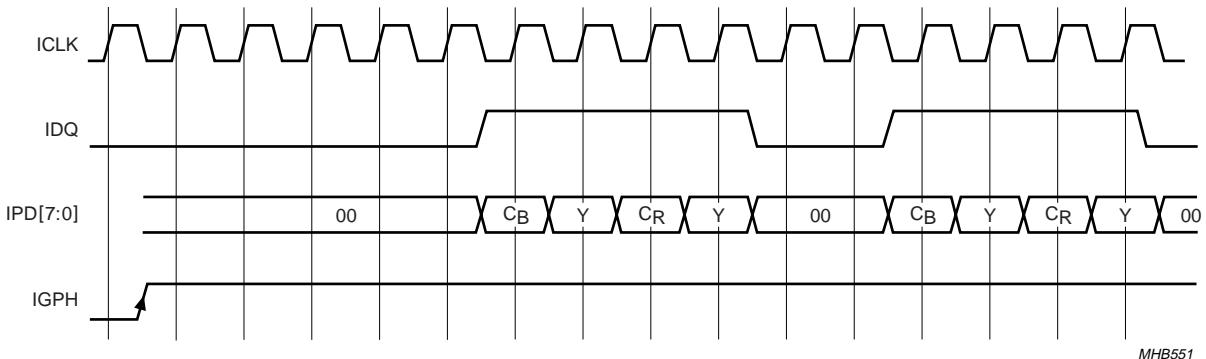


Fig.41 Output timing at the I port for serial 8-bit data at start of a line (ICODE = 0).

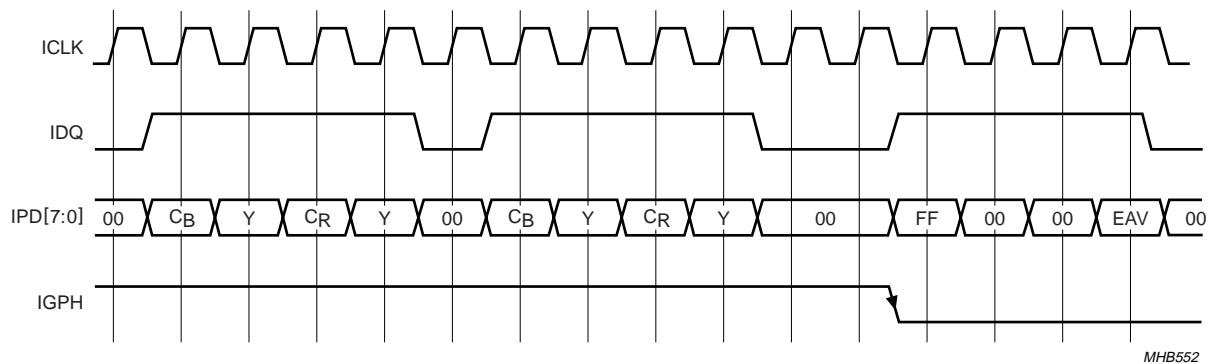


Fig.42 Output timing at the I port for serial 8-bit data at end of a line (ICODE = 1).

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## SAA7108AE; SAA7109AE

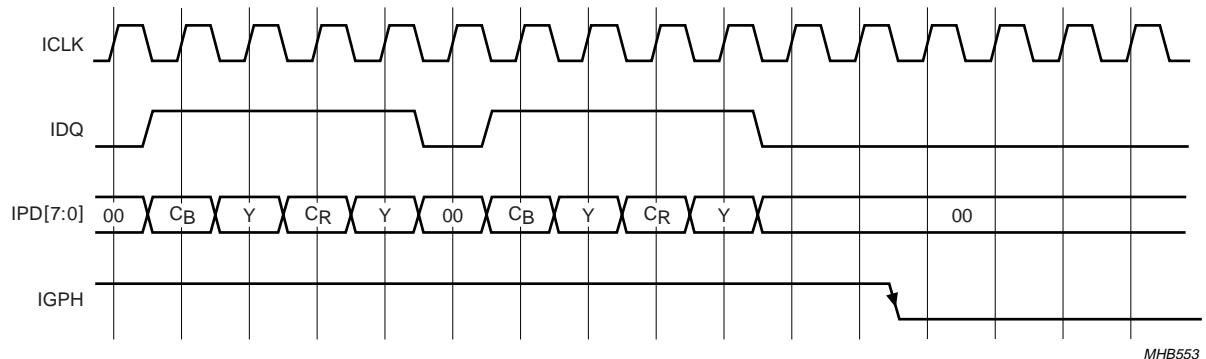


Fig.43 Output timing at the I port for serial 8-bit data at end of a line (ICODE = 0).

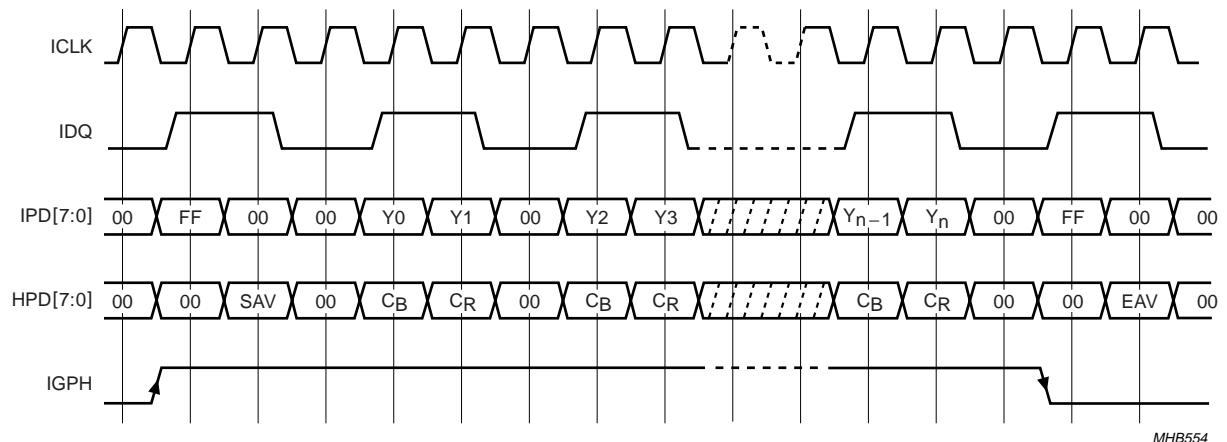


Fig.44 Output timing for 16-bit data output via the I and H port with codes (ICODE = 1), timing is like 8-bit output, but packages of 2 bytes per valid cycle.

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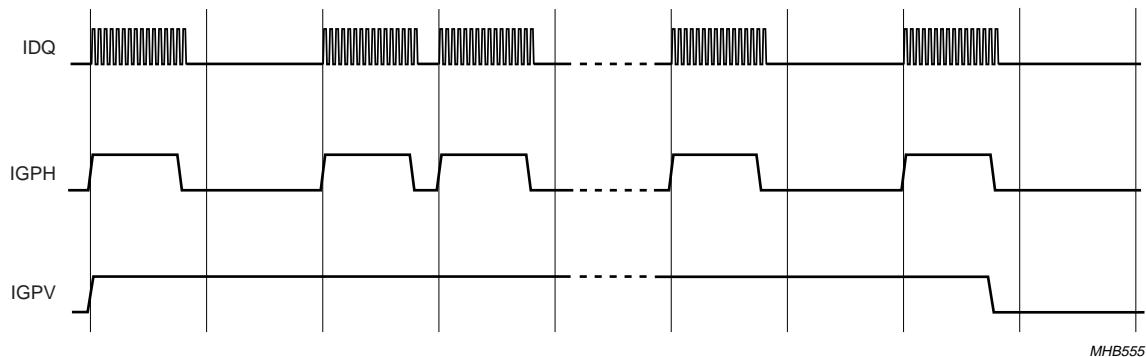


Fig.45 Horizontal and vertical gate output timing.

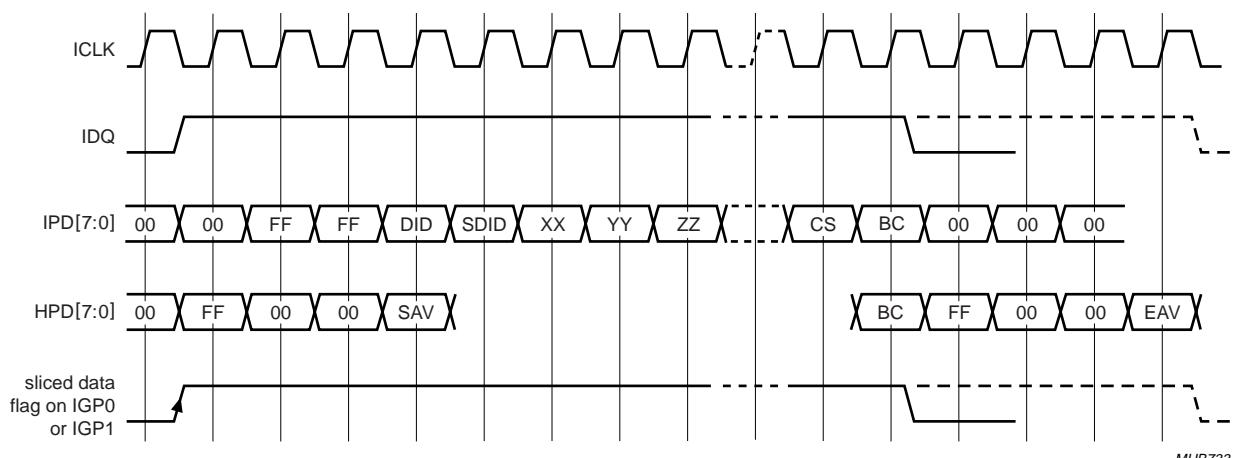


Fig.46 Output timing for sliced VBI data in 8-bit serial output mode (dotted graphs for SAV/EAV mode).

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## SAA7108AE; SAA7109AE

**11 BOUNDARY SCAN TEST**

The SAA7108AE; SAA7109AE has built-in logic and 2 times 5 dedicated pins to support boundary scan testing, separately for the encoder and decoder part, which allows board testing without special hardware (nails). The SAA7108AE; SAA7109AE follows the "*IEEE Std. 1149.1 - Standard Test Access Port and Boundary-Scan Architecture*" set by the Joint Test Action Group (JTAG) chaired by Philips.

The 10 special pins are Test Mode Select (TMS<sub>e</sub> and TMS<sub>d</sub>), Test Clock (TCK<sub>e</sub> and TCK<sub>d</sub>), Test Reset (TRST<sub>e</sub> and TRST<sub>d</sub>), Test Data Input (TD<sub>le</sub> and TD<sub>ld</sub>) and Test Data Output (TDO<sub>e</sub> and TDO<sub>d</sub>), where extension 'e' refers to the encoder part and extension 'd' refers to the decoder part.

The Boundary Scan Test (BST) functions BYPASS, EXTEST, INTEST, SAMPLE, CLAMP and IDCODE are all supported; see Table 48. Details about the JTAG BST-TEST can be found in the specification "*IEEE Std. 1149.1*". Two files containing the detailed Boundary Scan Description Language (BSDL) of the SAA7108AE; SAA7109AE are available on request.

**Table 48** BST instructions supported by the SAA7108AE; SAA7109AE

INSTRUCTION	DESCRIPTION
BYPASS	This mandatory instruction provides a minimum length serial path (1 bit) between TD <sub>le</sub> (or TD <sub>ld</sub> ) and TDO <sub>e</sub> (or TDO <sub>d</sub> ) when no test operation of the component is required.
EXTEST	This mandatory instruction allows testing of off-chip circuitry and board level interconnections.
SAMPLE	This mandatory instruction can be used to take a sample of the inputs during normal operation of the component. It can also be used to preload data values into the latched outputs of the boundary scan register.
CLAMP	This optional instruction is useful for testing when not all ICs have BST. This instruction addresses the bypass register while the boundary scan register is in external test mode.
IDCODE	This optional instruction will provide information on the components manufacturer, part number and version number.
INTEST	This optional instruction allows testing of the internal logic (no support for customers available).
USER1	This private instruction allows testing by the manufacturer (no support for customers available).

**11.1 Initialization of boundary scan circuit**

The Test Access Port (TAP) controller of an IC should be in the reset state (TEST\_LOGIC\_RESET) when the IC is in functional mode. This reset state also forces the instruction register into a functional instruction such as IDCODE or BYPASS.

To solve the power-up reset, the standard specifies that the TAP controller will be forced asynchronously to the TEST\_LOGIC\_RESET state by setting the TRST<sub>e</sub> or TRST<sub>d</sub> pin LOW.

**11.2 Device identification codes**

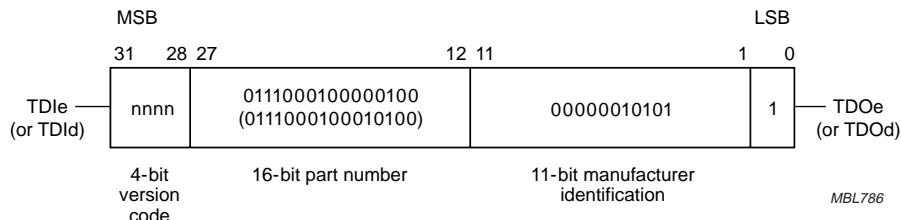
A device identification register is specified in "*IEEE Std. 1149.1b-1994*". It is a 32-bit register which contains fields for the specification of the IC manufacturer, the IC part number and the IC version number. Its biggest advantage

is the possibility to check for the correct ICs mounted after production and to determine the version number of the ICs during field service.

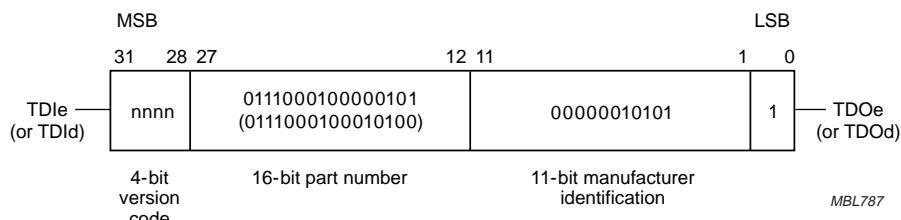
When the IDCODE instruction is loaded into the BST instruction register, the identification register will be connected between TD<sub>le</sub> (or TD<sub>ld</sub>) and TDO<sub>e</sub> (or TDO<sub>d</sub>) of the IC. The identification register will load a component specific code during the CAPTURE\_DATA\_REGISTER state of the TAP controller, this code can subsequently be shifted out. At board level this code can be used to verify component manufacturer, type and version number. The device identification register contains 32 bits, numbered 31 to 0, where bit 31 is the most significant bit (nearest to TD<sub>le</sub> or TD<sub>ld</sub>) and bit 0 is the least significant bit (nearest to TDO<sub>e</sub> or TDO<sub>d</sub>); see Fig.47.

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## SAA7108AE; SAA7109AE



a. SAA7108AE.



b. SAA7109AE.

Fig.47 32 bits of identification code.

## 12 LIMITING VALUES

In accordance with the Absolute Maximum Rating System (IEC 60134); all ground pins connected together and grounded (0 V); all supply pins connected together.

SYMBOL	PARAMETER	CONDITIONS	MIN.	MAX.	UNIT
$V_{DDD}$	digital supply voltage		-0.5	+4.6	V
$V_{DDA}$	analog supply voltage		-0.5	+4.6	V
$V_{i(A)}$	input voltage at analog inputs		-0.5	+4.6	V
$V_{i(n)}$	input voltage at pins XTAL1, SDA and SCL		-0.5	$V_{DDD} + 0.5$	V
$V_{i(D)}$	input voltage at digital inputs or I/O pins	outputs in 3-state	-0.5	+4.6	V
		outputs in 3-state; note 1	-0.5	+5.5	V
$\Delta V_{SS}$	voltage difference between $V_{SSA(n)}$ and $V_{SSD(n)}$		-	100	mV
$T_{stg}$	storage temperature		-65	+150	°C
$T_{amb}$	ambient temperature		0	70	°C
$V_{esd}$	electrostatic discharge voltage	human body model; note 2	-	$\pm 2000$	V
		machine model; note 3	-	$\pm 150$	V

## Notes

1. Condition for maximum voltage at digital inputs or I/O pins:  $3.0 \text{ V} < V_{DDD} < 3.6 \text{ V}$ .
2. Class 2 according to EIA/JESD22-114-B.
3. Class A according to EIA/JESD22-115-A.

## HD-CODEC

## SAA7108AE; SAA7109AE

## 13 THERMAL CHARACTERISTICS

SYMBOL	PARAMETER	CONDITIONS	VALUE	UNIT
$R_{th(j-a)}$	thermal resistance from junction to ambient	in free air	32 <sup>(1)</sup>	K/W

## Note

1. The overall  $R_{th(j-a)}$  value can vary depending on the board layout. To minimize the effective  $R_{th(j-a)}$  all power and ground pins must be connected to the power and ground layers directly. An ample copper area direct under the SAA7108AE; SAA7109AE with a number of through-hole plating, which connect to the ground layer (four-layer board: second layer), can also reduce the effective  $R_{th(j-a)}$ . Please do not use any solder-stop varnish under the chip. In addition the usage of soldering glue with a high thermal conductance after curing is recommended.

## 14 CHARACTERISTICS OF THE DIGITAL VIDEO ENCODER PART

$T_{amb}$  = 0 to 70 °C (typical values measured at  $T_{amb}$  = 25 °C); unless otherwise specified.

SYMBOL	PARAMETER	CONDITIONS	MIN.	TYP.	MAX.	UNIT
<b>Supplies</b>						
$V_{DDA}$	analog supply voltage		3.15	3.3	3.45	V
$V_{DDle}$	digital supply voltage		3.15	3.3	3.45	V
$V_{DD(DVO)}$	digital supply voltage (DVO)		1.045	1.1	1.155	V
			1.425	1.5	1.575	V
			1.71	1.8	1.89	V
			2.375	2.5	2.625	V
			3.135	3.3	3.465	V
$I_{DDA}$	analog supply current	note 1	1	110	115	mA
$I_{DDD}$	digital supply current	note 2	1	175	200	mA
<b>Inputs</b>						
$V_{IL}$	LOW-level input voltage	$V_{DD(DVO)} = 1.1$ V, 1.5 V, 1.8 V or 2.5 V; note 3	-0.1	-	+0.2	V
		$V_{DD(DVO)} = 3.3$ V; note 3	-0.5	-	+0.8	V
		pins $\overline{RESe}$ , $\overline{TMSe}$ , $\overline{TCKe}$ , $\overline{TRSTe}$ and $\overline{TDle}$	-0.5	-	+0.8	V
$V_{IH}$	HIGH-level input voltage	$V_{DD(DVO)} = 1.1$ V, 1.5 V, 1.8 V or 2.5 V; note 3	$V_{DD(DVO)} - 0.2$	-	$V_{DD(DVO)} + 0.1$	V
		$V_{DD(DVO)} = 3.3$ V; note 3	2	-	$V_{DD(DVO)} + 0.3$	V
		pins $\overline{RESe}$ , $\overline{TMSe}$ , $\overline{TCKe}$ , $\overline{TRSTe}$ and $\overline{TDle}$	2	-	$V_{DDle} + 0.3$	V
$I_{LI}$	input leakage current		-	-	10	$\mu$ A
$C_i$	input capacitance	clocks	-	-	10	pF
		data	-	-	10	pF
		I/Os at high-impedance	-	-	10	pF

## HD-CODEC

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SYMBOL	PARAMETER	CONDITIONS	MIN.	TYP.	MAX.	UNIT
<b>Outputs</b>						
V <sub>OL</sub>	LOW-level output voltage	V <sub>DD(DVO)</sub> = 1.1 V, 1.5 V, 1.8 V or 2.5 V; note 3	0	—	0.1	V
		V <sub>DD(DVO)</sub> = 3.3 V; note 3	0	—	0.4	V
		pins TDOe, TTXRQ_XCLKO2, VSM and HSM_CS <sub>YNC</sub>	0	—	0.4	V
V <sub>OH</sub>	HIGH-level output voltage	V <sub>DD(DVO)</sub> = 1.1 V, 1.5 V, 1.8 V or 2.5 V; note 3	V <sub>DD(DVO)</sub> – 0.1	—	V <sub>DD(DVO)</sub>	V
		V <sub>DD(DVO)</sub> = 3.3 V; note 3	2.4	—	V <sub>DD(DVO)</sub>	V
		pins TDOe, TTXRQ_XCLKO2, VSM and HSM_CS <sub>YNC</sub>	2.4	—	V <sub>DDle</sub>	V
<b>I<sup>2</sup>C-bus; pins SDA<sub>e</sub> and SC<sub>Le</sub></b>						
V <sub>IL</sub>	LOW-level input voltage		–0.5	—	0.3V <sub>DDle</sub>	V
V <sub>IH</sub>	HIGH-level input voltage		0.7V <sub>DDle</sub>	—	V <sub>DDle</sub> + 0.3	V
I <sub>i</sub>	input current	V <sub>i</sub> = LOW or HIGH	–10	—	+10	μA
V <sub>OL</sub>	LOW-level output voltage (pin SDA <sub>e</sub> )	I <sub>OL</sub> = 3 mA	—	—	0.4	V
I <sub>o</sub>	output current	during acknowledge	3	—	—	mA
<b>Clock timing; pins PIXCLKI and PIXCLKO</b>						
T <sub>PIXCLK</sub>	cycle time	note 4	12	—	—	ns
t <sub>d(CLKD)</sub>	delay from PIXCLKO to PIXCLKI	note 5	—	—	—	ns
δ	duty factor t <sub>HIGH</sub> /T <sub>PIXCLK</sub>	note 4	40	50	60	%
	duty factor t <sub>HIGH</sub> /T <sub>CLKO2</sub>	output	40	50	60	%
t <sub>r</sub>	rise time	note 4	—	—	1.5	ns
t <sub>f</sub>	fall time	note 4	—	—	1.5	ns
<b>Input timing</b>						
t <sub>SU;DAT</sub>	input data set-up time	pins PD11 to PD0	2	—	—	ns
t <sub>HD;DAT</sub>	input data hold time	pins PD11 to PD0	0.9	—	—	ns
t <sub>SU;DAT</sub>	input data set-up time	pins HSVGC, VSVGC and FSVGC; note 6	2	—	—	ns
t <sub>HD;DAT</sub>	input data hold time	pins HSVGC, VSVGC and FSVGC; note 6	1.5	—	—	ns
<b>Crystal oscillator</b>						
f <sub>nom</sub>	nominal frequency		—	27	—	MHz
Δf/f <sub>nom</sub>	permissible deviation of nominal frequency	note 7	–50	—	+50	10 <sup>–6</sup>

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SYMBOL	PARAMETER	CONDITIONS	MIN.	TYP.	MAX.	UNIT
CRYSTAL SPECIFICATION						
$T_{amb}$	ambient temperature		0	–	70	°C
$C_L$	load capacitance		8	–	–	pF
$R_S$	series resistance		–	–	80	Ω
$C_1$	motional capacitance (typical)		1.2	1.5	1.8	fF
$C_0$	parallel capacitance (typical)		2.8	3.5	4.2	pF
Data and reference signal output timing						
$C_L$	output load capacitance		8	–	40	pF
$t_{o(h)}(g_{fx})$	output hold time to graphics controller	pins HSVGC, VSVGC, FSVGC and $\overline{CBO}$	1.5	–	–	ns
$t_{o(d)}(g_{fx})$	output delay time to graphics controller	pins HSVGC, VSVGC, FSVGC and $\overline{CBO}$	–	–	10	ns
$t_{o(h)}$	output hold time	pins TDOe, TTXRQ_XCLK02, VSM and HSM_CS <sub>YNC</sub>	3	–	–	ns
$t_{o(d)}$	output delay time	pins TDOe, TTXRQ_XCLK02, VSM and HSM_CS <sub>YNC</sub>	–	–	25	ns
CVBS and RGB outputs						
$V_{o(CVBS)(p-p)}$	output voltage CVBS (peak-to-peak value)	see Table 49	–	1.23	–	V
$V_{o(VBS)(p-p)}$	output voltage VBS (S-video) (peak-to-peak value)	see Table 49	–	1	–	V
$V_{o(C)(p-p)}$	output voltage C (S-video) (peak-to-peak value)	see Table 49	–	0.89	–	V
$V_{o(RGB)(p-p)}$	output voltage R, G, B (peak-to-peak value)	see Table 49	–	0.7	–	V
$\Delta V_o$	inequality of output signal voltages		–	2	–	%
$R_L$	output load resistance		–	37.5	–	Ω
$B_{DAC}$	output signal bandwidth of DACs	–3 dB; note 8	–	170	–	MHz
$ILE_{lf(DAC)}$	low frequency integral linearity error of DACs		–	–	±3	LSB
$DLE_{lf(DAC)}$	low frequency differential linearity error of DACs		–	–	±1	LSB

## HD-CODEC

## SAA7108AE; SAA7109AE

## Notes

1. Minimum value for I<sup>2</sup>C-bus bit DOWNA = 1.
2. Minimum value for I<sup>2</sup>C-bus bit DOWND = 1.
3. Levels refer to pins PD11 to PD0, FSVGC, PIXCLKI, VSVGC, PIXCLKO,  $\overline{CBO}$ , TVD, and HSVGC, being inputs or outputs directly connected to a graphics controller.  
Input sensitivity is  $1/2V_{DD(DVO)} + 100$  mV for HIGH and  $1/2V_{DD(DVO)} - 100$  mV for LOW.  
The reference voltage  $1/2V_{DD(DVO)}$  is generated on chip.
4. The data is for both input and output direction.
5. This parameter is arbitrary, if PIXCLKI is looped through the VGC.
6. Tested with programming IFBP = 1.
7. If an internal oscillator is used, crystal deviation of nominal frequency is directly proportional to the deviation of subcarrier frequency and line/field frequency.
8.  $B_{-3\text{ dB}} = \frac{1}{2\pi(R_{o(L)}(C_{ext} + 5\text{ pF}))}$  with  $C_{ext} = 20\text{ pF}$  (typical).

## 15 CHARACTERISTICS OF THE DIGITAL VIDEO DECODER PART

$V_{DDD} = 3.0$  to  $3.6$  V;  $V_{DDA} = 3.1$  to  $3.5$  V;  $T_{amb} = 0$  to  $70$  °C (typical values measured at  $T_{amb} = 25$  °C); timings and levels refer to drawings and conditions illustrated in Fig.52; unless otherwise specified.

SYMBOL	PARAMETER	CONDITIONS	MIN.	TYP.	MAX.	UNIT
<b>Supplies</b>						
$V_{DDD}$	digital supply voltage		3.15	3.3	3.45	V
$I_{DDD}$	digital supply current	X port 3-state; 8-bit I port	–	90	–	mA
$P_D$	power dissipation digital part		–	300	–	mW
$V_{DDA}$	analog supply voltage		3.15	3.3	3.45	V
$I_{DDA}$	analog supply current	AOSL1 and AOSL0 = 0 CVBS mode Y/C mode	– –	47 72	– –	mA mA
$P_A$	power dissipation analog part	CVBS mode	–	150	–	mW
		Y/C mode	–	240	–	mW
$P_{tot(A+D)}$	total power dissipation analog and digital part	CVBS mode	–	450	–	mW
		Y/C mode	–	540	–	mW
$P_{tot(A+D)(pd)}$	total power dissipation analog and digital part in Power-down mode	CE pulled down to ground	–	5	–	mW
$P_{tot(A+D)(ps)}$	total power dissipation analog and digital part in power-save mode	I <sup>2</sup> C-bus controlled via address 88H = 0FH	–	75	–	mW
<b>Analog part</b>						
$I_{clamp}$	clamping current	$V_I = 0.9$ V DC	–	±8	–	µA

## HD-CODEC

## SAA7108AE; SAA7109AE

SYMBOL	PARAMETER	CONDITIONS	MIN.	TYP.	MAX.	UNIT
$V_{i(p-p)}$	input voltage (peak-to-peak value)	for normal video levels 1 V (p-p), -3 dB termination 27/47 $\Omega$ and AC coupling required; coupling capacitor = 22 nF	—	0.7	—	V
$ Z_i $	input impedance	clamping current off	200	—	—	$k\Omega$
$C_i$	input capacitance		—	—	10	pF
$\alpha_{cs}$	channel crosstalk	$f_i < 5$ MHz	—	—	-50	dB
<b>9-bit analog-to-digital converters</b>						
B	analog bandwidth	at -3 dB	—	7	—	MHz
$\phi_{diff}$	differential phase (amplifier plus anti-alias filter bypassed)		—	2	—	deg
$G_{diff}$	differential gain (amplifier plus anti-alias filter bypassed)		—	2	—	%
$f_{clk(ADC)}$	ADC clock frequency		12.8	—	14.3	MHz
$DLE_{dc(d)}$	DC differential linearity error		—	0.7	—	LSB
$ILE_{dc(i)}$	DC integral linearity error		—	1	—	LSB
<b>Digital inputs</b>						
$V_{IL(SDAd, SCLd)}$	LOW-level input voltage pins SDAd and SCLd		-0.5	—	$+0.3V_{DDD}$	V
$V_{IH(SDAd, SCLd)}$	HIGH-level input voltage pins SDAd and SCLd		$0.7V_{DDD}$	—	$V_{DDD} + 0.5$	V
$V_{IL(XTALd)}$	LOW-level CMOS input voltage pin XTALId		-0.3	—	+0.8	V
$V_{IH(XTALd)}$	HIGH-level CMOS input voltage pin XTALId		2.0	—	$V_{DDD} + 0.3$	V
$V_{IL(n)}$	LOW-level input voltage all other inputs		-0.3	—	+0.8	V
$V_{IH(n)}$	HIGH-level input voltage all other inputs		2.0	—	5.5	V
$I_{LI}$	input leakage current		—	—	1	$\mu A$
$I_{LI/O}$	I/O leakage current		—	—	10	$\mu A$
$C_i$	input capacitance	I/O at high-impedance	—	—	8	pF
<b>Digital outputs; note 1</b>						
$V_{OL(SDAd)}$	LOW-level output voltage pin SDAd	SDAd at 3 mA sink current	—	—	0.4	V
$V_{OL(clk)}$	LOW-level output voltage for clocks		-0.5	—	+0.6	V
$V_{OH(clk)}$	HIGH-level output voltage for clocks		2.4	—	$V_{DDD} + 0.5$	V

## HD-CODEC

## SAA7108AE; SAA7109AE

SYMBOL	PARAMETER	CONDITIONS	MIN.	TYP.	MAX.	UNIT
$V_{OL}$	LOW-level output voltage all other digital outputs		0	—	0.4	V
$V_{OH}$	HIGH-level output voltage all other digital outputs		2.4	—	$V_{DDD} + 0.5$	V

**Clock output timing (LLC and LLC2); note 2**

$C_{L(LLC)}$	output load capacitance		15	—	50	pF
$T_{cy}$	cycle time	pin LLC	35	—	39	ns
		pin LLC2	70	—	78	ns
$\delta$	duty factors for $t_{LLCH}/t_{LLC}$ and $t_{LLC2H}/t_{LLC2}$	$C_L = 40$ pF	40	—	60	%
$t_r$	rise time LLC and LLC2	0.2 V to $V_{DDD} - 0.2$ V	—	—	5	ns
$t_f$	fall time LLC and LLC2	$V_{DDD} - 0.2$ V to 0.2 V	—	—	5	ns
$t_d(LLC-LLC2)$	delay time between LLC and LLC2 output	measured at 1.5 V; $C_L = 25$ pF	-4	—	+8	ns

**Horizontal PLL**

$f_{H(nom)}$	nominal line frequency	50 Hz field	—	15625	—	Hz
		60 Hz field	—	15734	—	Hz
$\Delta f_H/f_{H(nom)}$	permissible static deviation		—	—	5.7	%

**Subcarrier PLL**

$f_{sc(nom)}$	nominal subcarrier frequency	PAL BGHI	—	4433619	—	Hz
		NTSC M	—	3579545	—	Hz
		PAL M	—	3575612	—	Hz
		PAL N	—	3582056	—	Hz
$\Delta f_{sc}$	lock-in range		$\pm 400$	—	—	Hz

**Crystal oscillator for 32.11 MHz; note 3**

$f_{xtal(nom)}$	nominal frequency	3rd-harmonic	—	32.11	—	MHz
$\Delta f_{xtal(nom)}$	permissible nominal frequency deviation		—	—	$\pm 70 \times 10^{-6}$	
$\Delta f_{xtal(nom)(T)}$	permissible nominal frequency deviation with temperature		—	—	$\pm 30 \times 10^{-6}$	

**CRYSTAL SPECIFICATION (X1)**

$T_{amb(X1)}$	ambient temperature		0	—	70	°C
$C_L$	load capacitance		8	—	—	pF
$R_s$	series resonance resistor		—	40	80	Ω
$C_1$	motional capacitance		—	$1.5 \pm 20$ %	—	fF
$C_0$	parallel capacitance		—	$4.3 \pm 20$ %	—	pF

**Crystal oscillator for 24.576 MHz; note 3**

$f_{xtal(nom)}$	nominal frequency	3rd-harmonic	—	24.576	—	MHz
$\Delta f_{xtal(nom)}$	permissible nominal frequency deviation		—	—	$\pm 50 \times 10^{-6}$	

## HD-CODEC

## SAA7108AE; SAA7109AE

SYMBOL	PARAMETER	CONDITIONS	MIN.	TYP.	MAX.	UNIT
$\Delta f_{xtal(nom)(T)}$	permissible nominal frequency deviation with temperature		—	—	$\pm 20 \times 10^{-6}$	
<b>CRYSTAL SPECIFICATION (X1)</b>						
$T_{amb}(X1)$	ambient temperature		0	—	70	°C
$C_L$	load capacitance		8	—	—	pF
$R_s$	series resonance resistor		—	40	80	Ω
$C_1$	motional capacitance		—	$1.5 \pm 20 \%$	—	fF
$C_0$	parallel capacitance		—	$3.5 \pm 20 \%$	—	pF
<b>Clock input timing (XCLK)</b>						
$T_{cy}$	cycle time		31	—	45	ns
$\delta$	duty factors for $t_{LLCH}/t_{LLC}$		40	50	60	%
$t_r$	rise time		—	—	5	ns
$t_f$	fall time		—	—	5	ns
<b>Data and control signal input timing X port, related to XCLK input</b>						
$t_{SU;DAT}$	input data set-up time		—	10	—	ns
$t_{HD;DAT}$	input data hold time		—	3	—	ns
<b>Clock output timing</b>						
$C_L$	output load capacitance		15	—	50	pF
$T_{cy}$	cycle time		35	—	39	ns
$\delta$	duty factors for $t_{XCLKH}/t_{XCLKL}$		35	—	65	%
$t_r$	rise time	0.6 to 2.6 V	—	—	5	ns
$t_f$	fall time	2.6 to 0.6 V	—	—	5	ns
<b>Data and control signal output timing X port, related to XCLK output (for <math>XPCK[1:0] 83H[5:4] = 00</math> is default); note 2</b>						
$C_L$	output load capacitance		15	—	50	pF
$t_{OHD;DAT}$	output hold time	$C_L = 15 \text{ pF}$	—	14	—	ns
$t_{PD}$	propagation delay from positive edge of XCLK output	$C_L = 15 \text{ pF}$	—	24	—	ns
<b>Control signal output timing RT port, related to LLC output</b>						
$C_L$	output load capacitance		15	—	50	pF
$t_{OHD;DAT}$	output hold time	$C_L = 15 \text{ pF}$	—	14	—	ns
$t_{PD}$	propagation delay from positive edge of LLC output	$C_L = 15 \text{ pF}$	—	24	—	ns
<b>ICLK output timing</b>						
$C_L$	output load capacitance		15	—	50	pF
$T_{cy}$	cycle time		31	—	45	ns
$\delta$	duty factors for $t_{ICLKH}/t_{ICLKL}$		35	—	65	%

## HD-CODEC

## SAA7108AE; SAA7109AE

SYMBOL	PARAMETER	CONDITIONS	MIN.	TYP.	MAX.	UNIT
$t_r$	rise time	0.6 to 2.6 V	—	—	5	ns
$t_f$	fall time	2.6 to 0.6 V	—	—	5	ns
<b>Data and control signal output timing I port, related to ICLK output (for IPCK[1:0] 87H[5:4] = 00 is default)</b>						
$C_L$	output load capacitance at all outputs		15	—	50	pF
$t_{OHD;DAT}$	output data hold time	$C_L = 15 \text{ pF}$	—	12	—	ns
$t_{o(d)}$	output delay time	$C_L = 15 \text{ pF}$	—	22	—	ns
<b>ICLK input timing</b>						
$T_{cy}$	cycle time		31	—	100	ns

## Notes

1. The levels must be measured with load circuits; 1.2 k $\Omega$  at 3 V (TTL load);  $C_L = 50 \text{ pF}$ .
2. The effects of rise and fall times are included in the calculation of  $t_{OHD;DAT}$  and  $t_{PD}$ . Timings and levels refer to drawings and conditions illustrated in Fig.52.
3. The crystal oscillator drive level is 0.28 mW (typ.).

## 16 TIMING

## 16.1 Digital video encoder part

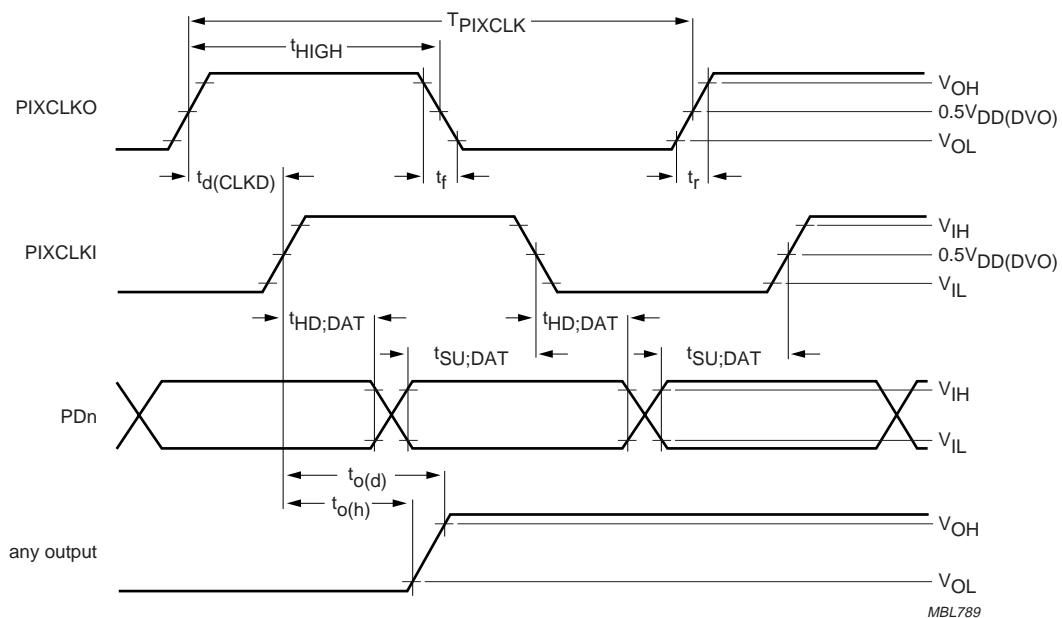


Fig.48 Input/output timing specification.

## HD-CODEC

## SAA7108AE; SAA7109AE

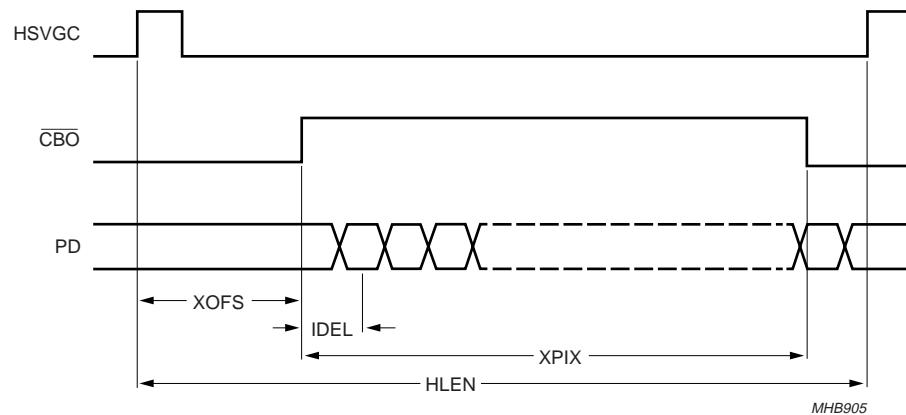


Fig.49 Horizontal input timing.

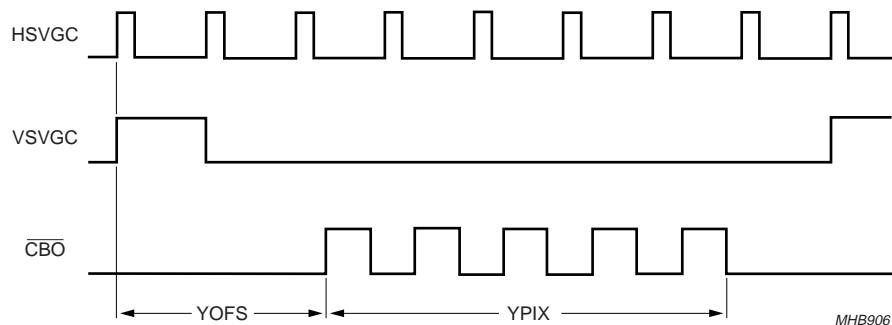


Fig.50 Vertical input timing.

## HD-CODEC

## SAA7108AE; SAA7109AE

## 16.1.1 TELETEXT TIMING

Time  $t_{FD}$  is the time needed to interpolate input data TTX and insert it into the CVBS and VBS output signal, such that it appears at  $t_{TTX} = 9.78 \mu s$  (PAL) or  $t_{TTX} = 10.5 \mu s$  (NTSC) after the leading edge of the horizontal synchronization pulse.

Time  $t_{PD}$  is the pipeline delay time introduced by the source that is gated by TTXRQ\_XCLKO2 in order to deliver TTX data. This delay is programmable by register TTXHD. For every active HIGH state at output pin TTXRQ\_XCLKO2, a new teletext bit must be provided by the source.

Since the beginning of the pulses representing the TTXRQ signal and the delay between the rising edge of TTXRQ and valid teletext input data are fully programmable (TTXHS and TTXHD), the TTX data is always inserted at the correct position after the leading edge of the outgoing horizontal synchronization pulse.

Time  $t_{i(TTXW)}$  is the internally used insertion window for TTX data; it has a constant length that allows insertion of 360 teletext bits at a text data rate of 6.9375 Mbit/s (PAL), 296 teletext bits at a text data rate of 5.7272 Mbit/s (world standard TTX) or 288 teletext bits at a text data rate of 5.7272 Mbit/s (NABTS). The insertion window is not opened if the control bit TTXEN is zero.

Using appropriate programming, all suitable lines of the odd field (TTXOVS and TTXOVE) plus all suitable lines of the even field (TTXEVS and TTXEVE) can be used for teletext insertion.

**It is essential to note that the two pins used for teletext insertion must be configured for this purpose by the correct I<sup>2</sup>C-bus register settings.**

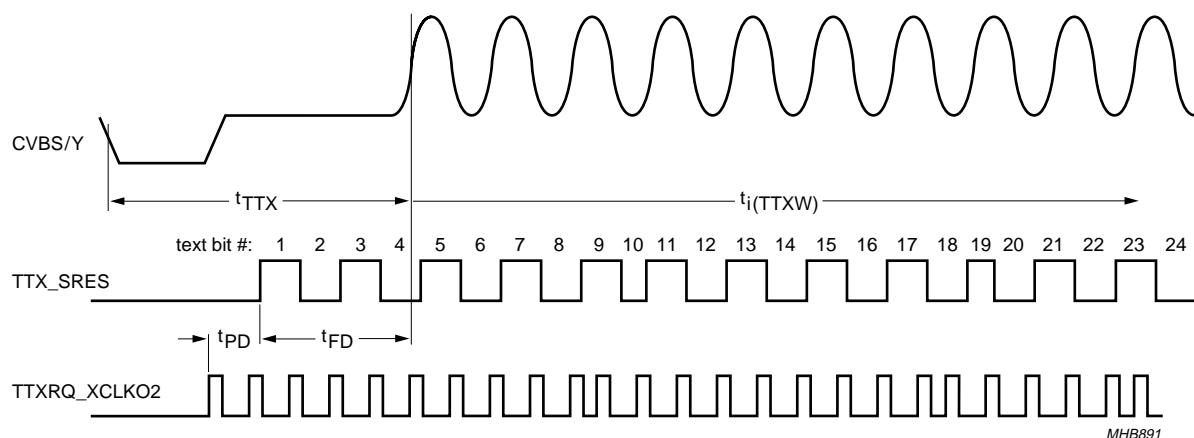


Fig.51 Teletext timing.

## HD-CODEC

## SAA7108AE; SAA7109AE

## 16.2 Digital video decoder part

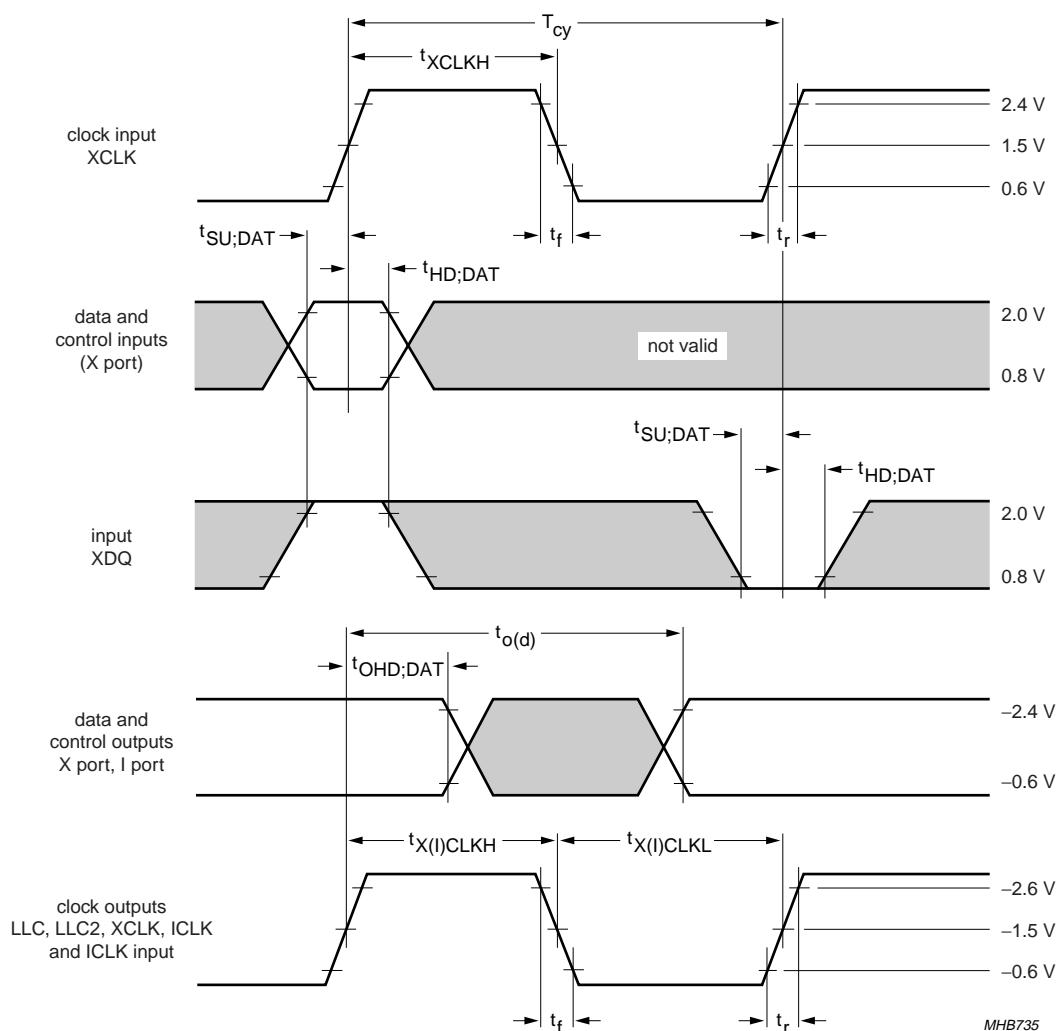


Fig.52 Data input/output timing diagram (X port, RT port and I port).

## HD-CODEC

## SAA7108AE; SAA7109AE

## 17 APPLICATION INFORMATION

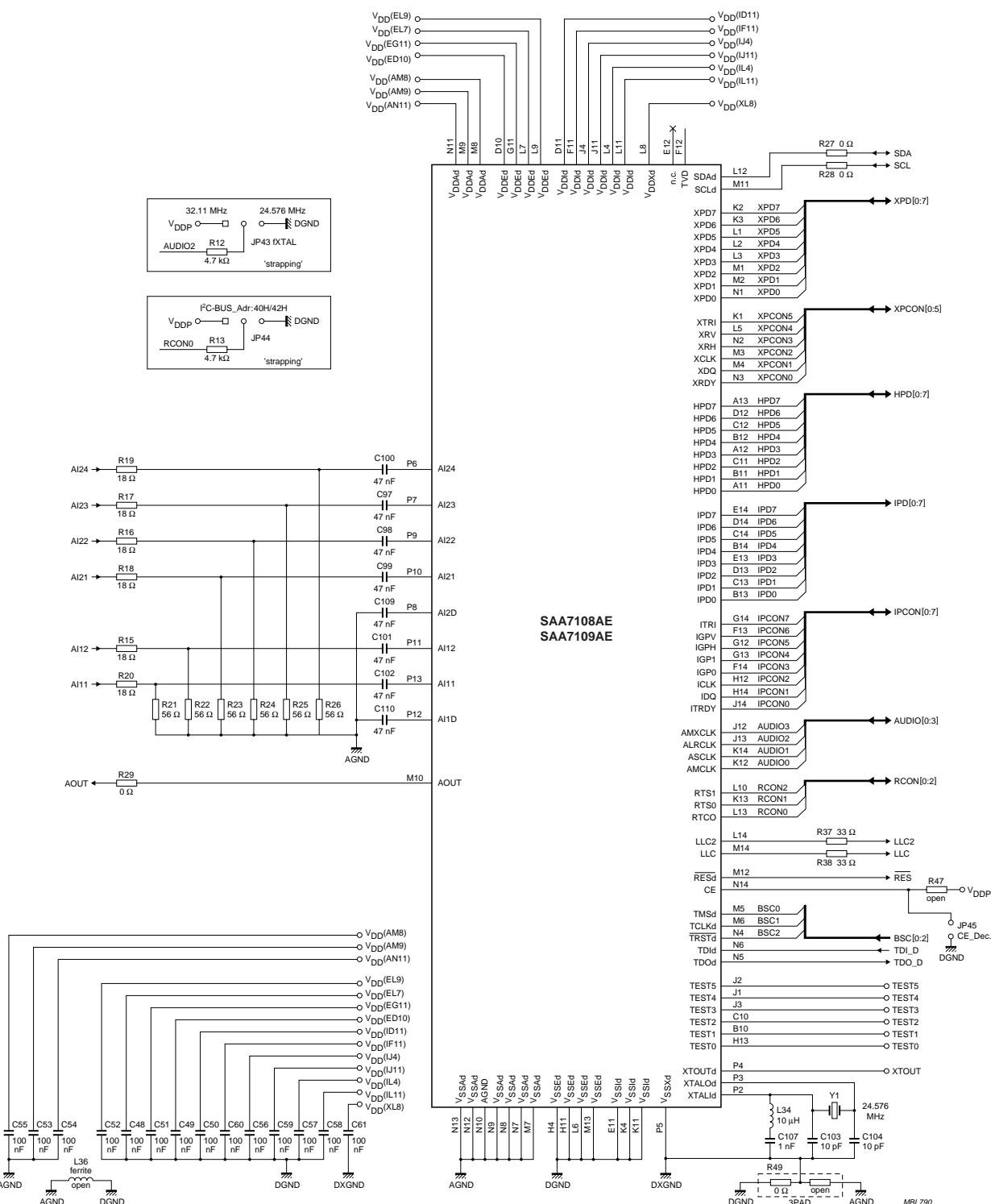


Fig.53 Application circuit (decoder part).

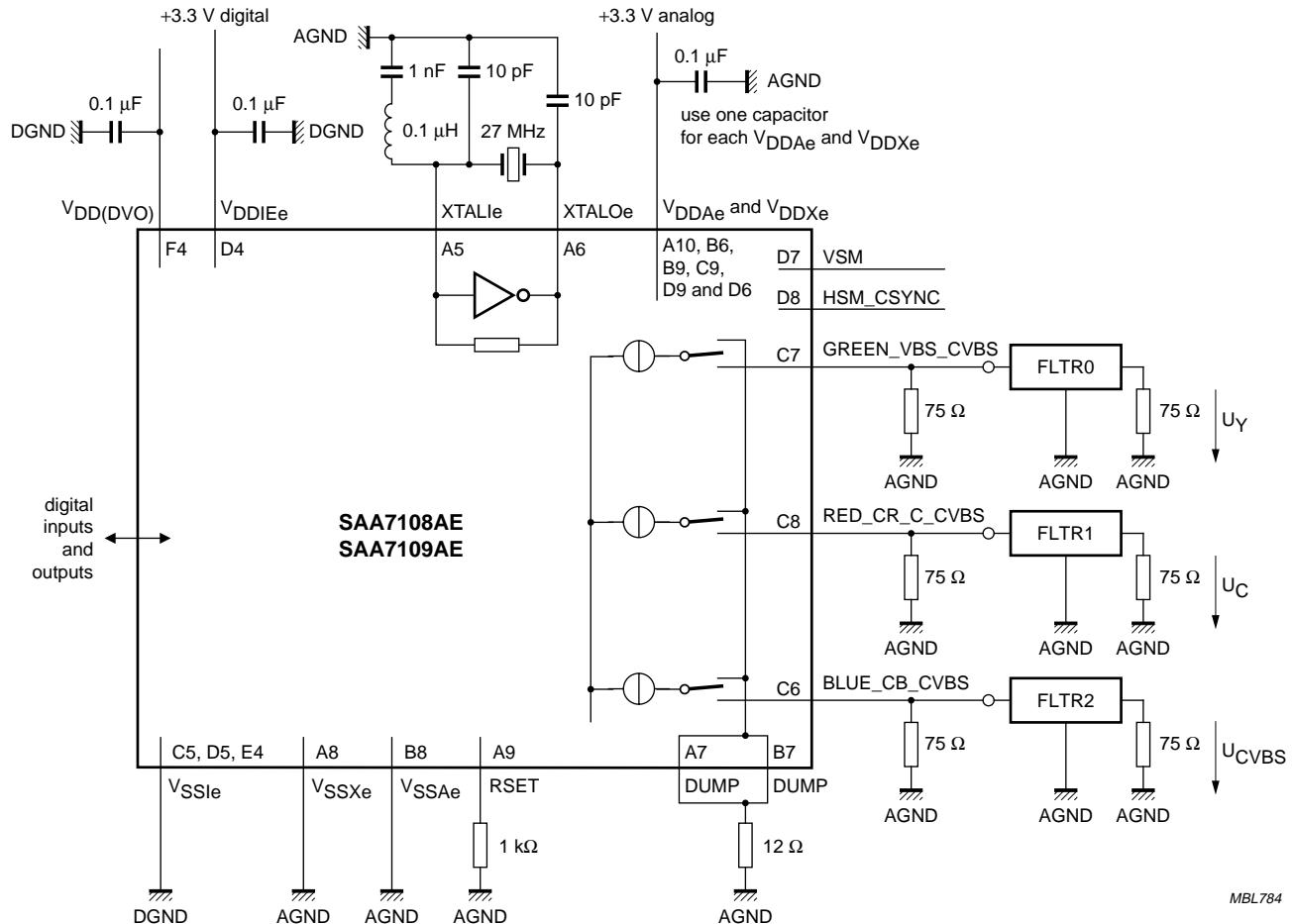


Fig.54 Application circuit (encoder part).

## HD-CODEC

## SAA7108AE; SAA7109AE

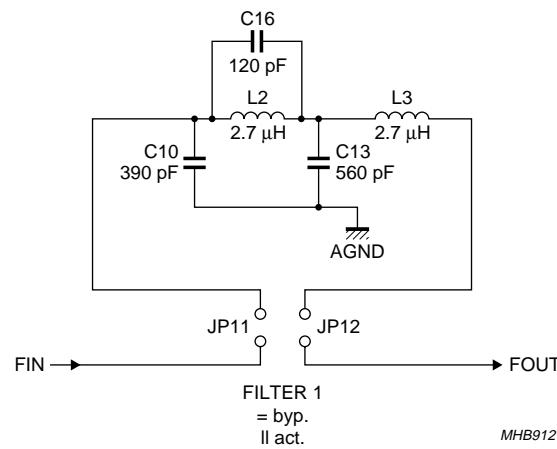
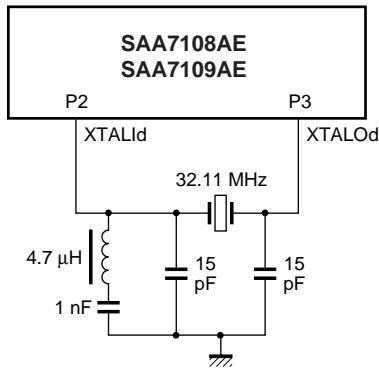


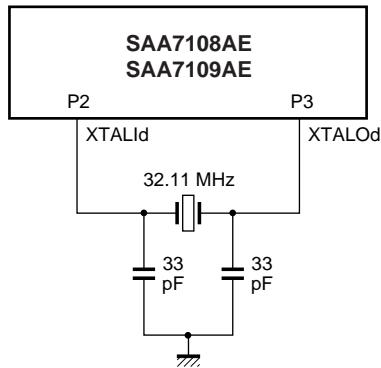
Fig.55 FLTR0, FLTR1 and FLTR2 as shown in Fig.54.

## HD-CODEC

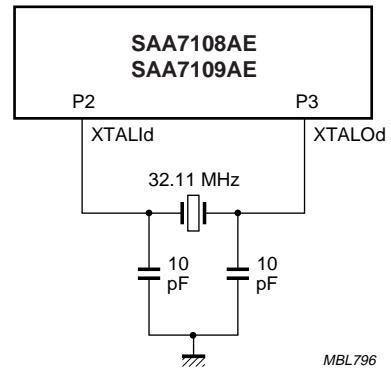
## SAA7108AE; SAA7109AE



(1a) With 3rd-harmonic quartz.  
Crystal load = 8 pF.

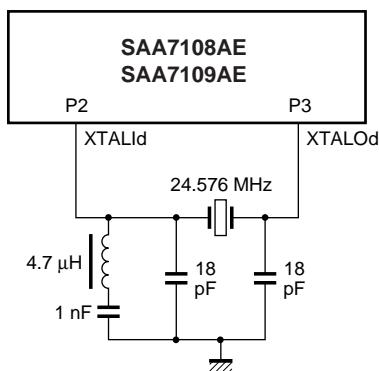


(1b) With fundamental quartz.  
Crystal load = 20 pF.

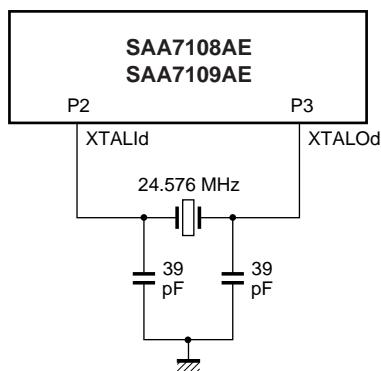


(1c) With fundamental quartz.  
Crystal load = 8 pF

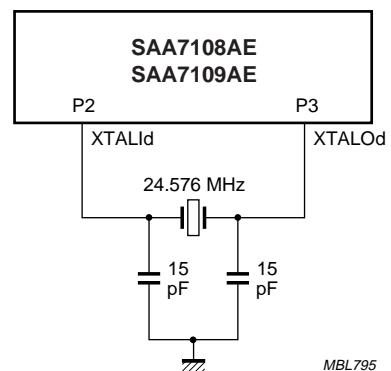
MBL796



(2a) With 3rd-harmonic quartz.  
Crystal load = 8 pF.

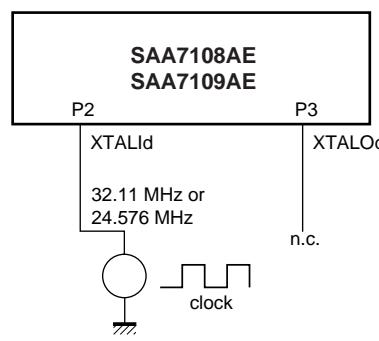


(2b) With fundamental quartz.  
Crystal load = 20 pF.

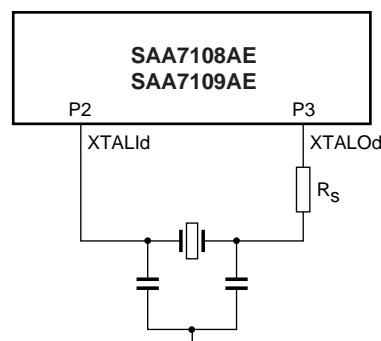


(2c) With fundamental quartz.  
Crystal load = 8 pF

MBL795



(3a) With direct clock.



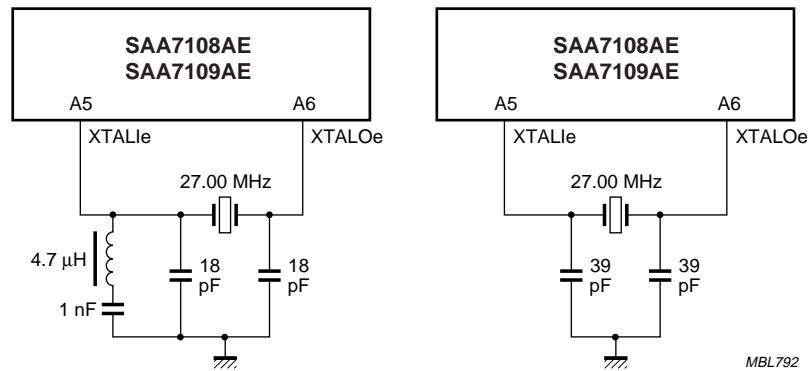
(3b) With fundamental quartz and restricted drive level. When  $P_{drive}$  of the internal oscillator is too high, a resistance  $R_s$  can be placed in series with the oscillator output XTALOd.

Note: The decreased crystal amplitude results in a lower drive level but on the other hand the jitter performance will decrease.

Fig.56 Oscillator application for decoder part.

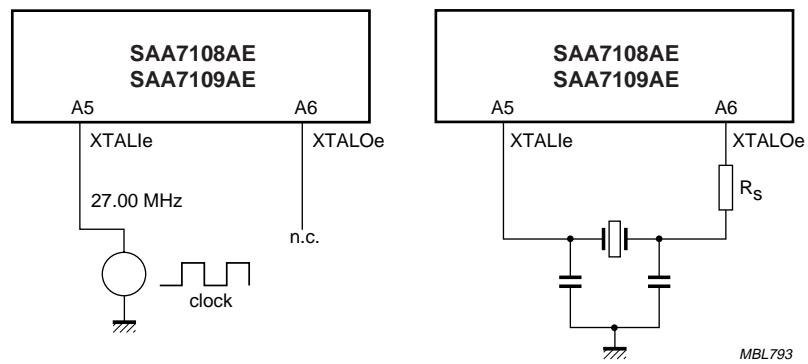
## HD-CODEC

## SAA7108AE; SAA7109AE



(1a) With 3rd-harmonic quartz.  
Crystal load = 8 pF.

(1b) With fundamental quartz.  
Crystal load = 20 pF.



(2a) With direct clock.

(2b) With fundamental quartz and restricted drive level. When  $P_{drive}$  of the internal oscillator is too high, a resistance  $R_s$  can be placed in series with the oscillator output XTALOe.

Note: The decreased crystal amplitude results in a lower drive level but on the other hand the jitter performance will decrease.

Fig.57 Oscillator application for encoder part.

## HD-CODEC

## SAA7108AE; SAA7109AE

**17.1 Reconstruction filter**

Figure 55 shows a possible reconstruction filter for the digital-to-analog converters. Due to its cut-off frequency of ~6 MHz, it is not suitable for HDTV applications.

**17.2 Analog output voltages**

The analog output voltages are dependent on the total load (typical value  $37.5 \Omega$ ), the digital gain parameters and the I<sup>2</sup>C-bus settings of the DAC reference currents (analog settings).

The digital output signals in front of the DACs under nominal (nominal here stands for the settings given in Tables 75 to 82 for example a standard PAL or NTSC signal) conditions occupy different conversion ranges, as indicated in Table 49 for a 100/100 colour bar signal.

By setting the reference currents of the DACs as shown in Table 49, standard compliant amplitudes can be achieved for all signal combinations; it is assumed that in subaddress 16H, parameter DACF = 0000b, that means the fine adjustment for all DACs in common is set to 0 %.

If S-video output is desired, the adjustment for the C (chrominance subcarrier) output should be identical to the one for VBS (luminance plus sync) output.

**Table 49** Digital output signals conversion range

SET/OUT	CVBS, SYNC TIP-TO-WHITE	VBS, SYNC TIP-TO-WHITE	RGB, BLACK-TO-WHITE
Digital settings	see Tables 75 to 82	see Tables 75 to 82	see Table 70
Digital output	1014	881	876
Analog settings	e.g. B DAC = 1FH	e.g. G DAC = 1BH	e.g. R DAC = G DAC = B DAC = 0BH
Analog output	1.23 V (p-p)	1.00 V (p-p)	0.70 V (p-p)

**17.3 Suggestions for a board layout**

Use separate ground planes for analog and digital ground. Connect these planes only at one point directly under the device, by using a  $0 \Omega$  resistor directly at the supply stage. Use separate supply lines for the analog and digital supply. Place the supply decoupling capacitors close to the supply pins.

Use  $L_{\text{bead}}$  (ferrite coil) in each digital supply line close to the decoupling capacitors to minimize radiation energy (EMC).

Place the analog coupling (clamp) capacitors close to the analog input pins. Place the analog termination resistors close to the coupling capacitors.

Be careful of hidden layout capacitors around the crystal application.

Use serial resistors in clock, sync and data lines, to avoid clock or data reflection effects and to soften data energy.

The SAA7108AE; SAA7109AE crystal temperature depends on the PCB it is soldered on. For normal airflow conditions at a maximum ambient temperature of 70 °C it will be sufficient to provide:

- PCB dimensions at least 2000 mm<sup>2</sup>
- PCB at least 4 layers
- At least 50 vias (connecting PCB layers) close to the chip
- Metal coverage at least 60 % on at least 2 PCB layers near the chip.

## 18 I<sup>2</sup>C-BUS DESCRIPTION

### 18.1 Digital video encoder part

**Table 50** Slave receiver bit allocation map (slave address 88H)

REGISTER FUNCTION	SUB ADDR. (HEX)	D7	D6	D5	D4	D3	D2	D1	D0
Status byte (read only)	00	VER2	VER1	VER0	CCRDO	CCRDE	(1)	FSEQ	O_E
Null	01 to 15	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)
Common DAC adjust fine	16	(1)	(1)	(1)	(1)	DACF3	DACF2	DACF1	DACF0
R DAC adjust coarse	17	(1)	(1)	(1)	RDACC4	RDACC3	RDACC2	RDACC1	RDACC0
G DAC adjust coarse	18	(1)	(1)	(1)	GDACC4	GDACC3	GDACC2	GDACC1	GDACC0
B DAC adjust coarse	19	(1)	(1)	(1)	BDACC4	BDACC3	BDACC2	BDACC1	BDACC0
MSM threshold	1A	MSMT7	MSMT6	MSMT5	MSMT4	MSMT3	MSMT2	MSMT1	MSMT0
Monitor sense mode	1B	MSM	MSA	MSOE	(1)	(1)	RCOMP	GCOMP	BCOMP
Chip ID (02B or 03B, read only)	1C	CID7	CID6	CID5	CID4	CID3	CID2	CID1	CID0
Wide screen signal	26	WSS7	WSS6	WSS5	WSS4	WSS3	WSS2	WSS1	WSS0
Wide screen signal	27	WSSON	(1)	WSS13	WSS12	WSS11	WSS10	WSS9	WSS8
Real-time control, burst start	28	(1)	(1)	BS5	BS4	BS3	BS2	BS1	BS0
Sync reset enable, burst end	29	SRES	(1)	BE5	BE4	BE3	BE2	BE1	BE0
Copy generation 0	2A	CG07	CG06	CG05	CG04	CG03	CG02	CG01	CG00
Copy generation 1	2B	CG15	CG14	CG13	CG12	CG11	CG10	CG09	CG08
CG enable, copy generation 2	2C	CGEN	(1)	(1)	(1)	CG19	CG18	CG17	CG16
Output port control	2D	VBSEN	CVBSEN1	CVBSEN0	CEN	ENCOFF	CLK2EN	CVBSEN2	(1)
Null	2E to 36	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)
Input path control	37	(1)	YUPSC	YFIL1	YFIL0	(1)	CZOOM	IGAIN	XINT
Gain luminance for RGB	38	(1)	(1)	(1)	GY4	GY3	GY2	GY1	GY0
Gain colour difference for RGB	39	(1)	(1)	(1)	GCD4	GCD3	GCD2	GCD1	GCD0
Input port control 1	3A	CBENB	(1)	SYNTV	SYMP	DEMOFF	CSYNC	Y2C	UV2C
VPS enable, input control 2	54	VPSEN	(1)	GPVAL	GOPEN	(1)	(1)	EDGE	SLOT
VPS byte 5	55	VPS57	VPS56	VPS55	VPS54	VPS53	VPS52	VPS51	VPS50
VPS byte 11	56	VPS117	VPS116	VPS115	VPS114	VPS113	VPS112	VPS111	VPS110
VPS byte 12	57	VPS127	VPS126	VPS125	VPS124	VPS123	VPS122	VPS121	VPS120
VPS byte 13	58	VPS137	VPS136	VPS135	VPS134	VPS133	VPS132	VPS131	VPS130
VPS byte 14	59	VPS147	VPS146	VPS145	VPS144	VPS143	VPS142	VPS141	VPS140

REGISTER FUNCTION	SUB ADDR. (HEX)	D7	D6	D5	D4	D3	D2	D1	D0
Chrominance phase	5A	CHPS7	CHPS6	CHPS5	CHPS4	CHPS3	CHPS2	CHPS1	CHPS0
Gain U	5B	GAINU7	GAINU6	GAINU5	GAINU4	GAINU3	GAINU2	GAINU1	GAINU0
Gain V	5C	GAINV7	GAINV6	GAINV5	GAINV4	GAINV3	GAINV2	GAINV1	GAINV0
Gain U MSB, black level	5D	GAINU8	(1)	BLCKL5	BLCKL4	BLCKL3	BLCKL2	BLCKL1	BLCKL0
Gain V MSB, blanking level	5E	GAINV8	(1)	BLNNL5	BLNNL4	BLNNL3	BLNNL2	BLNNL1	BLNNL0
CCR, blanking level VBI	5F	CCRS1	CCRS0	BLNVB5	BLNVB4	BLNVB3	BLNVB2	BLNVB1	BLNVB0
Null	60	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)
Standard control	61	DOWND	DOWNA	INPI	YGS	(1)	SCBW	PAL	FISE
Burst amplitude	62	RTCE	BSTA6	BSTA5	BSTA4	BSTA3	BSTA2	BSTA1	BSTA0
Subcarrier 0	63	FSC07	FSC06	FSC05	FSC04	FSC03	FSC02	FSC01	FSC00
Subcarrier 1	64	FSC15	FSC14	FSC13	FSC12	FSC11	FSC10	FSC09	FSC08
Subcarrier 2	65	FSC23	FSC22	FSC21	FSC20	FSC19	FSC18	FSC17	FSC16
Subcarrier 3	66	FSC31	FSC30	FSC29	FSC28	FSC27	FSC26	FSC25	FSC24
Line 21 odd 0	67	L21O07	L21O06	L21O05	L21O04	L21O03	L21O02	L21O01	L21O00
Line 21 odd 1	68	L21O17	L21O16	L21O15	L21O14	L21O13	L21O12	L21O11	L21O10
Line 21 even 0	69	L21E07	L21E06	L21E05	L21E04	L21E03	L21E02	L21E01	L21E00
Line 21 even 1	6A	L21E17	L21E16	L21E15	L21E14	L21E13	L21E12	L21E11	L21E10
Null	6B	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)
Trigger control	6C	HTRIG7	HTRIG6	HTRIG5	HTRIG4	HTRIG3	HTRIG2	HTRIG1	HTRIG0
Trigger control	6D	HTRIG10	HTRIG9	HTRIG8	VTRIG4	VTRIG3	VTRIG2	VTRIG1	VTRIG0
Multi control	6E	NVTRIG	BLCKON	PHRES1	PHRES0	LDEL1	LDEL0	FLC1	FLC0
Closed Caption, teletext enable	6F	CCEN1	CCEN0	TTXEN	SCCLN4	SCCLN3	SCCLN2	SCCLN1	SCCLN0
Active display window horizontal start	70	ADWHS7	ADWHS6	ADWHS5	ADWHS4	ADWHS3	ADWHS2	ADWHS1	ADWHS0
Active display window horizontal end	71	ADWHE7	ADWHE6	ADWHE5	ADWHE4	ADWHE3	ADWHE2	ADWHE1	ADWHE0
MSBs ADWH	72	(1)	ADWHE10	ADWHE9	ADWHE8	(1)	ADWHS10	ADWHS9	ADWHS8
TTX request horizontal start	73	TTXHS7	TTXHS6	TTXHS5	TTXHS4	TTXHS3	TTXHS2	TTXHS1	TTXHS0
TTX request horizontal delay	74	(1)	(1)	(1)	(1)	TTXHD3	TTXHD2	TTXHD1	TTXHD0
CSYNC advance	75	CSYNCA4	CSYNCA3	CSYNCA2	CSYNCA1	CSYNCA0	(1)	(1)	(1)
TTX odd request vertical start	76	TTXOVS7	TTXOVS6	TTXOVS5	TTXOVS4	TTXOVS3	TTXOVS2	TTXOVS1	TTXOVS0
TTX odd request vertical end	77	TTXOVE7	TTXOVE6	TTXOVE5	TTXOVE4	TTXOVE3	TTXOVE2	TTXOVE1	TTXOVE0

REGISTER FUNCTION	SUB ADDR. (HEX)	D7	D6	D5	D4	D3	D2	D1	D0
TTX even request vertical start	78	TTXEVS7	TTXEVS6	TTXEVS5	TTXEVS4	TTXEVS3	TTXEVS2	TTXEVS1	TTXEVS0
TTX even request vertical end	79	TTXEVE7	TTXEVE6	TTXEVE5	TTXEVE4	TTXEVE3	TTXEVE2	TTXEVE1	TTXEVE0
First active line	7A	FAL7	FAL6	FAL5	FAL4	FAL3	FAL2	FAL1	FAL0
Last active line	7B	LAL7	LAL6	LAL5	LAL4	LAL3	LAL2	LAL1	LAL0
TTX mode, MSB vertical	7C	TTX60	LAL8	TTXO	FAL8	TTXEVE8	TTXOVE8	TTXEVS8	TTXOVS8
Null	7D	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)
Disable TTX line	7E	LINE12	LINE11	LINE10	LINE9	LINE8	LINE7	LINE6	LINE5
Disable TTX line	7F	LINE20	LINE19	LINE18	LINE17	LINE16	LINE15	LINE14	LINE13
FIFO status (read only)	80	(1)	(1)	(1)	(1)	IFERR	BFERR	OVFL	UDFL
Pixel clock 0	81	PCL07	PCL06	PCL05	PCL04	PCL03	PCL02	PCL01	PCL00
Pixel clock 1	82	PCL15	PCL14	PCL13	PCL12	PCL11	PCL10	PCL09	PCL08
Pixel clock 2	83	PCL23	PCL22	PCL21	PCL20	PCL19	PCL18	PCL17	PCL16
Pixel clock control	84	DCLK	PCLSY	IFRA	IFBP	PCLE1	PCLE0	PCLI1	PCLI0
FIFO control	85	EIDIV	(1)	(1)	(1)	FILI3	FILI2	FILI1	FILI0
Null	86 to 8F	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)
Horizontal offset	90	XOFS7	XOFS6	XOFS5	XOFS4	XOFS3	XOFS2	XOFS1	XOFS0
Pixel number	91	XPIX7	XPIX6	XPIX5	XPIX4	XPIX3	XPIX2	XPIX1	XPIX0
Vertical offset odd	92	YOFSO7	YOFSO6	YOFSO5	YOFSO4	YOFSO3	YOFSO2	YOFSO1	YOFSO0
Vertical offset even	93	YOFSE7	YOFSE6	YOFSE5	YOFSE4	YOFSE3	YOFSE2	YOFSE1	YOFSE0
MSBs	94	YOFSE9	YOFSE8	YOFSO9	YOFSO8	XPIX9	XPIX8	XOFS9	XOFS8
Line number	95	YPIX7	YPIX6	YPIX5	YPIX4	YPIX3	YPIX2	YPIX1	YPIX0
Scaler CTRL, MCB YPIX	96	EFS	PCBN	SLAVE	ILC	YFIL	(1)	YPIX9	YPIX8
Sync control	97	HFS	VFS	OFS	PFS	OVS	PVS	OHS	PHS
Line length	98	HLEN7	HLEN6	HLEN5	HLEN4	HLEN3	HLEN2	HLEN1	HLEN0
Input delay, MSB line length	99	IDEL3	IDEL2	IDEL1	IDEL0	HLEN11	HLEN10	HLEN9	HLEN8
Horizontal increment	9A	XINC7	XINC6	XINC5	XINC4	XINC3	XINC2	XINC1	XINC0
Vertical increment	9B	YINC7	YINC6	YINC5	YINC4	YINC3	YINC2	YINC1	YINC0
MSBs vertical and horizontal increment	9C	YINC11	YINC10	YINC9	YINC8	XINC11	XINC10	XINC9	XINC8
Weighting factor odd	9D	YIWGTO7	YIWGTO6	YIWGTO5	YIWGTO4	YIWGTO3	YIWGTO2	YIWGTO1	YIWGTO0
Weighting factor even	9E	YIWGTE7	YIWGTE6	YIWGTE5	YIWGTE4	YIWGTE3	YIWGTE2	YIWGTE1	YIWGTE0
Weighting factor MSB	9F	YIWGTE11	YIWGTE10	YIWGTE9	YIWGTE8	YIWGTE11	YIWGTO10	YIWGTO9	YIWGTO8

REGISTER FUNCTION	SUB ADDR. (HEX)	D7	D6	D5	D4	D3	D2	D1	D0
Vertical line skip	A0	YSKIP7	YSKIP6	YSKIP5	YSKIP4	YSKIP3	YSKIP2	YSKIP1	YSKIP0
Blank enable for NI-bypass, vertical line skip MSB	A1	BLEN	(1)	(1)	(1)	YSKIP11	YSKIP10	YSKIP9	YSKIP8
Border colour Y	A2	BCY7	BCY6	BCY5	BCY4	BCY3	BCY2	BCY1	BCY0
Border colour U	A3	BCU7	BCU6	BCU5	BCU4	BCU3	BCU2	BCU1	BCU0
Border colour V	A4	BCV7	BCV6	BCV5	BCV4	BCV3	BCV2	BCV1	BCV0
HD sync line count array	D0	RAM address (see Table 123)							
HD sync line type array	D1	RAM address (see Table 125)							
HD sync line pattern array	D2	RAM address (see Table 127)							
HD sync value array	D3	RAM address (see Table 129)							
HD sync trigger state 1	D4	HLCT7	HLCT6	HLCT5	HLCT4	HLCT3	HLCT2	HLCT1	HLCT0
HD sync trigger state 2	D5	HLCPT3	HLCPT2	HLCPT1	HLCPT0	HLPPT1	HLPPT0	HLCT9	HLCT8
HD sync trigger state 3	D6	HDCT7	HDCT6	HDCT5	HDCT4	HDCT3	HDCT2	HDCT1	HDCT0
HD sync trigger state 4	D7	(1)	HEPT2	HEPT1	HEPT0	(1)	(1)	HDCT9	HDCT8
HD sync trigger phase x	D8	HTX7	HTX6	HTX5	HTX4	HTX3	HTX2	HTX1	HTX0
	D9	(1)	(1)	(1)	(1)	HTX11	HTX10	HTX9	HTX8
HD sync trigger phase y	DA	HTY7	HTY6	HTY5	HTY4	HTY3	HTY2	HTY1	HTY0
	DB	(1)	(1)	(1)	(1)	(1)	(1)	HTY9	HTY8
HD output control	DC	(1)	(1)	(1)	(1)	HDSYE	HDTc	HDGY	HDIP
Cursor colour 1 R	F0	CC1R7	CC1R6	CC1R5	CC1R4	CC1R3	CC1R2	CC1R1	CC1R0
Cursor colour 1 G	F1	CC1G7	CC1G6	CC1G5	CC1G4	CC1G3	CC1G2	CC1G1	CC1G0
Cursor colour 1 B	F2	CC1B7	CC1B6	CC1B5	CC1B4	CC1B3	CC1B2	CC1B1	CC1B0
Cursor colour 2 R	F3	CC2R7	CC2R6	CC2R5	CC2R4	CC2R3	CC2R2	CC2R1	CC2R0
Cursor colour 2 G	F4	CC2G7	CC2G6	CC2G5	CC2G4	CC2G3	CC2G2	CC2G1	CC2G0
Cursor colour 2 B	F5	CC2B7	CC2B6	CC2B5	CC2B4	CC2B3	CC2B2	CC2B1	CC2B0
Auxiliary cursor colour R	F6	AUXR7	AUXR6	AUXR5	AUXR4	AUXR3	AUXR2	AUXR1	AUXR0
Auxiliary cursor colour G	F7	AUXG7	AUXG6	AUXG5	AUXG4	AUXG3	AUXG2	AUXG1	AUXG0
Auxiliary cursor colour B	F8	AUXB7	AUXB6	AUXB5	AUXB4	AUXB3	AUXB2	AUXB1	AUXB0
Horizontal cursor position	F9	XCP7	XCP6	XCP5	XCP4	XCP3	XCP2	XCP1	XCP0
Horizontal hot spot, MSB XCP	FA	XHS4	XHS3	XHS2	XHS1	XHS0	XCP10	XCP9	XCP8
Vertical cursor position	FB	YCP7	YCP6	YCP5	YCP4	YCP3	YCP2	YCP1	YCP0
Vertical hot spot, MSB YCP	FC	YHS4	YHS3	YHS2	YHS1	YHS0	(1)	YCP9	YCP8

REGISTER FUNCTION	SUB ADDR. (HEX)	D7	D6	D5	D4	D3	D2	D1	D0
Input path control	FD	LUTOFF	CMODE	LUTL	IF2	IF1	IF0	MATOFF	DFOFF
Cursor bit map	FE								RAM address (see Table 144)
Colour look-up table	FF								RAM address (see Table 145)

**Note**

1. All unused control bits must be programmed with logic 0 to ensure compatibility to future enhancements.

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18.1.1 I<sup>2</sup>C-BUS FORMAT**Table 51** I<sup>2</sup>C-bus write access to control registers; see Table 57

S	1	0	0	0	1	0	0	A	SUBADDRESS	A	DATA 0	A	-----	DATA n	A	P
---	---	---	---	---	---	---	---	---	------------	---	--------	---	-------	--------	---	---

**Table 52** I<sup>2</sup>C-bus write access to the HD line count array (subaddress D0H); see Table 57

S	1	0	0	0	1	0	0	A	D0H	A	RAM ADDRESS	A	DATA 00	A	DATA 01	A	-----	DATA n	A	P
---	---	---	---	---	---	---	---	---	-----	---	-------------	---	---------	---	---------	---	-------	--------	---	---

**Table 53** I<sup>2</sup>C-bus write access to cursor bit map (subaddress FEH); see Table 57

S	1	0	0	0	1	0	0	A	FEH	A	RAM ADDRESS	A	DATA 0	A	-----	DATA n	A	P
---	---	---	---	---	---	---	---	---	-----	---	-------------	---	--------	---	-------	--------	---	---

**Table 54** I<sup>2</sup>C-bus write access to colour look-up table (subaddress FFH); see Table 57

S	1	0	0	0	1	0	0	A	FFH	A	RAM ADDRESS	A	DATA 0R	A	DATA 0G	A	DATA 0B	A	-----	P
---	---	---	---	---	---	---	---	---	-----	---	-------------	---	---------	---	---------	---	---------	---	-------	---

**Table 55** I<sup>2</sup>C-bus read access to control registers; see Table 57

S	1	0	0	0	1	0	0	A	SUBADDRESS	A	Sr	1	0	0	1	0	0	A	DATA 0	Am	-----	DATA n	Am	P
---	---	---	---	---	---	---	---	---	------------	---	----	---	---	---	---	---	---	---	--------	----	-------	--------	----	---

**Table 56** I<sup>2</sup>C-bus read access to cursor bit map or colour LUT; see Table 57

S	1	0	0	0	1	0	0	A	FEH	A	RAM ADDRESS	A	Sr	1	0	0	1	0	0	A	DATA 0	Am	-----	DATA n	Am	P
---	---	---	---	---	---	---	---	---	-----	---	-------------	---	----	---	---	---	---	---	---	---	--------	----	-------	--------	----	---

**Table 57** Explanations of Tables 51 to 56

CODE	DESCRIPTION
S	START condition
Sr	repeated START condition
1 0 0 0 1 0 0 X; note 1	slave address
A	acknowledge generated by the slave
Am	acknowledge generated by the master
SUBADDRESS; note 2	subaddress byte
DATA	data byte
-----	continued data bytes and acknowledges
P	STOP condition
RAM ADDRESS	start address for RAM access

**Notes**

1. X is the read/write control bit; X = logic 0 is order to write; X = logic 1 is order to read.
2. If more than 1 byte of DATA is transmitted, then auto-increment of the subaddress is performed.

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## 18.1.2 SLAVE RECEIVER

**Table 58** Subaddress 16H

DATA BYTE	DESCRIPTION
DACF	output level adjustment fine in 1 % steps for all DACs; default after reset is 00H; see Table 59

**Table 59** Fine adjustment of DAC output voltage

BINARY	GAIN (%)
0111	7
0110	6
0101	5
0100	4
0011	3
0010	2
0001	1
0000	0
1000	0
1001	-1
1010	-2
1011	-3
1100	-4
1101	-5
1110	-6
1111	-7

**Table 60** Subaddresses 17H to 19H

DATA BYTE	DESCRIPTION
RDACC	output level coarse adjustment for RED DAC; default after reset is 1BH for output of C signal 00000b = 0.585 V to 11111b = 1.240 V at 37.5 $\Omega$ nominal for full-scale conversion
GDACC	output level coarse adjustment for GREEN DAC; default after reset is 1BH for output of VBS signal 00000b = 0.585 V to 11111b = 1.240 V at 37.5 $\Omega$ nominal for full-scale conversion
BDACC	output level coarse adjustment for BLUE DAC; default after reset is 1FH for output of CVBS signal 00000b = 0.585 V to 11111b = 1.240 V at 37.5 $\Omega$ nominal for full-scale conversion

**Table 61** Subaddress 1AH

DATA BYTE	DESCRIPTION
MSMT	monitor sense mode threshold for DAC output voltage, should be set to 70

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**Table 62** Subaddress 1BH

DATA BYTE	LOGIC LEVEL	DESCRIPTION
MSM	0	monitor sense mode off; RCOMP, GCOMP and BCOMP bits are not valid; default after reset
	1	monitor sense mode on
MSA	0	automatic monitor sense mode off; RCOMP, GCOMP and BCOMP bits are not valid; default after reset
	1	automatic monitor sense mode on if MSM = 0
MSOE	0	pin TVD is active
	1	pin TVD is 3-state; default after reset
RCOMP (read only)	0	check comparator at DAC on pin RED_CR_C_CVBS is active, output is loaded
	1	check comparator at DAC on pin RED_CR_C_CVBS is inactive, output is not loaded
GCOMP (read only)	0	check comparator at DAC on pin GREEN_VBS_CVBS is active, output is loaded
	1	check comparator at DAC on pin GREEN_VBS_CVBS is inactive, output is not loaded
BCOMP (read only)	0	check comparator at DAC on pin BLUE_CB_CVBS is active, output is loaded
	1	check comparator at DAC on pin BLUE_CB_CVBS is inactive, output is not loaded

**Table 63** Subaddresses 26H and 27H

DATA BYTE	LOGIC LEVEL	DESCRIPTION
WSS	–	wide screen signalling bits 3 to 0 = aspect ratio 7 to 4 = enhanced services 10 to 8 = subtitles 13 to 11 = reserved
WSSON	0	wide screen signalling output is disabled; default after reset
	1	wide screen signalling output is enabled

**Table 64** Subaddress 28H

DATA BYTE	LOGIC LEVEL	DESCRIPTION	REMARKS
BS	–	starting point of burst in clock cycles	PAL: BS = 33 (21H); default after reset if strapping pin FSVG tied to HIGH
			NTSC: BS = 25 (19H); default after reset if strapping pin FSVG tied to LOW

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**Table 65** Subaddress 29H

DATA BYTE	LOGIC LEVEL	DESCRIPTION	REMARKS
SRES	0	pin TTX_SRES accepts a teletext bit stream (TTX)	default after reset
	1	pin TTX_SRES accepts a sync reset input (SRES)	a HIGH impulse resets synchronization of the encoder (first field, first line)
BE	–	ending point of burst in clock cycles	PAL: BE = 29 (1DH); default after reset if strapping pin FSVGC tied to HIGH
			NTSC: BE = 29 (1DH); default after reset if strapping pin FSVGC tied to LOW

**Table 66** Subaddresses 2AH to 2CH

DATA BYTE	LOGIC LEVEL	DESCRIPTION
CG	–	LSB of the respective bytes are encoded immediately after run-in, the MSBs of the respective bytes have to carry the CRCC bits, in accordance with the definition of copy generation management system encoding format.
CGEN	0	copy generation data output is disabled; default after reset
	1	copy generation data output is enabled

**Table 67** Subaddress 2DH

DATA BYTE	LOGIC LEVEL	DESCRIPTION
VBSEN	0	pin GREEN_VBS_CVBS provides a component GREEN signal (CVBSEN1 = 0) or CVBS signal (CVBSEN1 = 1)
	1	pin GREEN_VBS_CVBS provides a luminance (VBS) signal; default after reset
CVBSEN1	0	pin GREEN_VBS_CVBS provides a component GREEN (G) or luminance (VBS) signal; default after reset
	1	pin GREEN_VBS_CVBS provides a CVBS signal
CVBSEN0	0	pin BLUE_CB_CVBS provides a component BLUE (B) or colour difference BLUE (C <sub>B</sub> ) signal
	1	pin BLUE_CB_CVBS provides a CVBS signal; default after reset
CEN	0	pin RED_CR_C_CVBS provides a component RED (R) or colour difference RED (C <sub>R</sub> ) signal
	1	pin RED_CR_C_CVBS provides a chrominance signal (C) as modulated subcarrier for S-video; default after reset
ENCOFF	0	encoder is active; default after reset
	1	encoder bypass, DACs are provided with RGB signal after cursor insertion block
CLK2EN	0	pin TTXRQ_XCLKO2 provides a teletext request signal (TTXRQ)
	1	pin TTXRQ_XCLKO2 provides the buffered crystal clock divided by two (13.5 MHz); default after reset
CVBSEN2	0	pin RED_CR_C_CVBS provides a signal according to CEN; default after reset
	1	pin RED_CR_C_CVBS provides a CVBS signal

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**Table 68** Subaddress 37H

DATA BYTE	LOGIC LEVEL	DESCRIPTION
YUPSC	0	normal operation of the vertical scaler; default after reset
	1	vertical upscaling is enabled
YFIL	–	controls the vertical interpolation filter, see Table 69; the filter is not available if YUPSC = 1
CZOOM	0	normal operation of the cursor generator; default after reset
	1	the cursor will be zoomed by a factor of 2 in both directions
IGAIN	0	expected input level swing is 16 to 235 (8-bit RGB); default after reset
	1	expected input level swing is 0 to 255 (8-bit RGB)
XINT	0	no horizontal interpolation filter; default after reset
	1	interpolation filter for horizontal upscaling is active

**Table 69** Logic levels and function of YFIL

DATA BYTE		DESCRIPTION
YFIL1	YFIL0	
0	0	no filter active; default after reset
0	1	filter is inserted before vertical scaling
1	0	filter is inserted after vertical scaling; YSKIP should be logic 0
1	1	reserved

**Table 70** Subaddresses 38H and 39H

DATA BYTE	DESCRIPTION
GY4 to GY0	Gain luminance of RGB ( $C_R$ , Y and $C_B$ ) output, ranging from $(1 - 16/32)$ to $(1 + 15/32)$ . Suggested nominal value = 0, depending on external application.
GCD4 to GCD0	Gain colour difference of RGB ( $C_R$ , Y and $C_B$ ) output, ranging from $(1 - 16/32)$ to $(1 + 15/32)$ . Suggested nominal value = 0, depending on external application.

**Table 71** Subaddress 3AH

DATA BYTE	LOGIC LEVEL	DESCRIPTION
CBENB	0	data from input ports is encoded
	1	colour bar with fixed colours is encoded
SYNTV	0	in slave mode, the encoder is only synchronized at the beginning of an odd field; default after reset
	1	in slave mode, the encoder receives a vertical sync signal
SYMP	0	horizontal and vertical trigger is taken from FSVGc or both VSVGc and HSVGc; default after reset
	1	horizontal and vertical trigger is decoded out of "ITU-R BT.656" compatible data at PD port

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DATA BYTE	LOGIC LEVEL	DESCRIPTION
DEMOFF	0	Y-C <sub>B</sub> -C <sub>R</sub> to RGB dematrix is active; default after reset
	1	Y-C <sub>B</sub> -C <sub>R</sub> to RGB dematrix is bypassed
CSYNC	0	pin HSM_CSYNC provides a horizontal sync for non-interlaced VGA components output (at PIXCLK)
	1	pin HSM_CSYNC provides a composite sync for interlaced components output (at XTAL clock)
Y2C	0	input luminance data is twos complement from PD input port
	1	input luminance data is straight binary from PD input port; default after reset
UV2C	0	input colour difference data is twos complement from PD input port
	1	input colour difference data is straight binary from PD input port; default after reset

**Table 72** Subaddress 54H

DATA BYTE	LOGIC LEVEL	DESCRIPTION
VPSEN	0	video programming system data insertion is disabled; default after reset
	1	video programming system data insertion in line 16 is enabled
GPVAL	0	pin VSM provides a LOW level if GPEN = 1
	1	pin VSM provides a HIGH level if GPEN = 1
GPEN	0	pin VSM provides a vertical sync for a monitor; default after reset
	1	pin VSM provides a constant signal according to GPVAL
EDGE	0	input data is sampled with inverse clock edges
	1	input data is sampled with the clock edges specified in Tables 9 to 14; default after reset
SLOT	0	normal assignment of the input data to the clock edge; default after reset
	1	correct time misalignment due to inverted assignment of input data to the clock edge

**Table 73** Subaddresses 55H to 59H

DATA BYTE	DESCRIPTION	REMARKS
VPS5	fifth byte of video programming system data	in line 16; LSB first; all other bytes are not relevant for VPS
VPS11	eleventh byte of video programming system data	
VPS12	twelfth byte of video programming system data	
VPS13	thirteenth byte of video programming system data	
VPS14	fourteenth byte of video programming system data	

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**Table 74** Subaddress 5AH; note 1

DATA BYTE	DESCRIPTION	VALUE	RESULT
CHPS	phase of encoded colour subcarrier (including burst) relative to horizontal sync; can be adjusted in steps of 360/256 degrees	6BH	PAL B/G and data from input ports in master mode
		16H	PAL B/G and data from look-up table
		25H	NTSC M and data from input ports in master mode
		46H	NTSC M and data from look-up table

**Note**

1. The default value after reset is 00H.

**Table 75** Subaddresses 5BH and 5DH

DATA BYTE	DESCRIPTION	CONDITIONS	REMARKS
GAINU	variable gain for $C_B$ signal; input representation in accordance with "ITU-R BT.601"	white-to-black = 92.5 IRE	GAINU = $-2.17 \times \text{nominal}$ to $+2.16 \times \text{nominal}$
		GAINU = 0	output subcarrier of U contribution = 0
		GAINU = 118 (76H)	output subcarrier of U contribution = nominal
		white-to-black = 100 IRE	GAINU = $-2.05 \times \text{nominal}$ to $+2.04 \times \text{nominal}$
		GAINU = 0	output subcarrier of U contribution = 0
		GAINU = 125 (7DH)	output subcarrier of U contribution = nominal

**Table 76** Subaddresses 5CH and 5EH

DATA BYTE	DESCRIPTION	CONDITIONS	REMARKS
GAINV	variable gain for $C_R$ signal; input representation in accordance with "ITU-R BT.601"	white-to-black = 92.5 IRE	GAINV = $-1.55 \times \text{nominal}$ to $+1.55 \times \text{nominal}$
		GAINV = 0	output subcarrier of V contribution = 0
		GAINV = 165 (A5H)	output subcarrier of V contribution = nominal
		white-to-black = 100 IRE	GAINV = $-1.46 \times \text{nominal}$ to $+1.46 \times \text{nominal}$
		GAINV = 0	output subcarrier of V contribution = 0
		GAINV = 175 (AFH)	output subcarrier of V contribution = nominal

**Table 77** Subaddress 5DH

DATA BYTE	DESCRIPTION	CONDITIONS	REMARKS
BLCKL	variable black level; input representation in accordance with "ITU-R BT.601"	white-to-sync = 140 IRE; note 1	recommended value: BLCKL = 58 (3AH)
		BLCKL = 0; note 1	output black level = 29 IRE
		BLCKL = 63 (3FH); note 1	output black level = 49 IRE
		white-to-sync = 143 IRE; note 2	recommended value: BLCKL = 51 (33H)
		BLCKL = 0; note 2	output black level = 27 IRE
		BLCKL = 63 (3FH); note 2	output black level = 47 IRE

**Notes**

1. Output black level/IRE =  $BLCKL \times 2/6.29 + 28.9$ .
2. Output black level/IRE =  $BLCKL \times 2/6.18 + 26.5$ .

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**Table 78** Subaddress 5EH

DATA BYTE	DESCRIPTION	CONDITIONS	REMARKS
BLNNL	variable blanking level	white-to-sync = 140 IRE; note 1	recommended value: BLNNL = 46 (2EH)
		BLNNL = 0; note 1	output blanking level = 25 IRE
		BLNNL = 63 (3FH); note 1	output blanking level = 45 IRE
		white-to-sync = 143 IRE; note 2	recommended value: BLNNL = 53 (35H)
		BLNNL = 0; note 2	output blanking level = 26 IRE
		BLNNL = 63 (3FH); note 2	output blanking level = 46 IRE

**Notes**

1. Output black level/IRE =  $BLNNL \times 2/6.29 + 25.4$ .
2. Output black level/IRE =  $BLNNL \times 2/6.18 + 25.9$ ; default after reset: 35H.

**Table 79** Subaddress 5FH

DATA BYTE	DESCRIPTION
CCRS	select cross-colour reduction filter in luminance; see Table 80
BLNVA	variable blanking level during vertical blanking interval is typically identical to value of BLNNL

**Table 80** Logic levels and function of CCRS

CCRS1	CCRS0	DESCRIPTION
0	0	no cross-colour reduction; for overall transfer characteristic of luminance see Fig.7
0	1	cross-colour reduction #1 active; for overall transfer characteristic see Fig.7
1	0	cross-colour reduction #2 active; for overall transfer characteristic see Fig.7
1	1	cross-colour reduction #3 active; for overall transfer characteristic see Fig.7

**Table 81** Subaddress 61H

DATA BYTE	LOGIC LEVEL	DESCRIPTION
DOWND	0	digital core in normal operational mode; default after reset
	1	digital core in sleep mode and is reactivated with an I <sup>2</sup> C-bus address
DOWNA	0	DACs in normal operational mode; default after reset
	1	DACs in Power-down mode
INPI	0	PAL switch phase is nominal; default after reset
	1	PAL switch is inverted compared to nominal if RTCE = 1
YGS	0	luminance gain for white – black 100 IRE
	1	luminance gain for white – black 92.5 IRE including 7.5 IRE set-up of black
SCBW	0	enlarged bandwidth for chrominance encoding (for overall transfer characteristic of chrominance in baseband representation see Figs 5 and 6)
	1	standard bandwidth for chrominance encoding (for overall transfer characteristic of chrominance in baseband representation see Figs 5 and 6); default after reset

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DATA BYTE	LOGIC LEVEL	DESCRIPTION
PAL	0	NTSC encoding (non-alternating V component)
	1	PAL encoding (alternating V component)
FISE	0	864 total pixel clocks per line
	1	858 total pixel clocks per line

**Table 82** Subaddress 62H

DATA BYTE	LOGIC LEVEL	DESCRIPTION	CONDITIONS	REMARKS
RTCE	0	no real-time control of generated subcarrier frequency; default after reset		
	1			
BSTA	–	amplitude of colour burst; input representation in accordance with "ITU-R BT.601"	white-to-black = 92.5 IRE; burst = 40 IRE; NTSC encoding BSTA = 0 to 2.02 × nominal	recommended value: BSTA = 63 (3FH)
			white-to-black = 92.5 IRE; burst = 40 IRE; PAL encoding BSTA = 0 to 2.82 × nominal	recommended value: BSTA = 45 (2DH)
			white-to-black = 100 IRE; burst = 43 IRE; NTSC encoding BSTA = 0 to 1.90 × nominal	recommended value: BSTA = 67 (43H)
			white-to-black = 100 IRE; burst = 43 IRE; PAL encoding BSTA = 0 to 3.02 × nominal	recommended value: BSTA = 47 (2FH); default after reset

**Table 83** Subaddresses 63H to 66H (four bytes to program subcarrier frequency)

DATA BYTE	DESCRIPTION	CONDITIONS	REMARKS
FSC0 to FSC3	$f_{fsc}$ = subcarrier frequency (in multiples of line frequency); $f_{llc}$ = clock frequency (in multiples of line frequency)	$FSC = \text{round}\left(\frac{f_{fsc}}{f_{llc}} \times 2^{32}\right)$ ; note 1	FSC3 = most significant byte; FSC0 = least significant byte

**Note**

1. Examples:
  - a) NTSC M:  $f_{fsc} = 227.5$ ,  $f_{llc} = 1716 \rightarrow FSC = 569408543$  (21F07C1FH).
  - b) PAL B/G:  $f_{fsc} = 283.7516$ ,  $f_{llc} = 1728 \rightarrow FSC = 705268427$  (2A098ACBH).

**Table 84** Subaddresses 67H to 6AH

DATA BYTE	DESCRIPTION	REMARKS
L21O0	first byte of captioning data, odd field	LSBs of the respective bytes are encoded immediately after run-in and framing code, the MSBs of the respective bytes have to carry the parity bit, in accordance with the definition of line 21 encoding format.
L21O1	second byte of captioning data, odd field	
L21E0	first byte of extended data, even field	
L21E1	second byte of extended data, even field	

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**Table 85** Subaddresses 6CH and 6DH

DATA BYTE	DESCRIPTION
HTRIG	sets the horizontal trigger phase related to chip-internal horizontal input values above 1715 (FISE = 1) or 1727 (FISE = 0) are not allowed; increasing HTRIG decreases delays of all internally generated timing signals; the default value is 0

**Table 86** Subaddress 6DH

DATA BYTE	DESCRIPTION
VTRIG	sets the vertical trigger phase related to chip-internal vertical input increasing VTRIG decreases delays of all internally generated timing signals, measured in half lines; variation range of VTRIG = 0 to 31 (1FH); the default value is 0

**Table 87** Subaddress 6EH

DATA BYTE	LOGIC LEVEL	DESCRIPTION
NVTRIG	0	values of the VTRIG register are positive
	1	values of the VTRIG register are negative
BLCKON	0	encoder in normal operation mode; default after reset
	1	output signal is forced to blanking level
PHRES	–	selects the phase reset mode of the colour subcarrier generator; see Table 88
LDEL	–	selects the delay on luminance path with reference to chrominance path; see Table 89
FLC	–	field length control; see Table 90

**Table 88** Logic levels and function of PHRES

DATA BYTE		DESCRIPTION
PHRES1	PHRES0	
0	0	no subcarrier reset
0	1	subcarrier reset every two lines
1	0	subcarrier reset every eight fields
1	1	subcarrier reset every four fields

**Table 89** Logic levels and function of LDEL

DATA BYTE		DESCRIPTION
LDEL1	LDEL0	
0	0	no luminance delay; default after reset
0	1	1 LLC luminance delay
1	0	2 LLC luminance delay
1	1	3 LLC luminance delay

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**Table 90** Logic levels and function of FLC

DATA BYTE		DESCRIPTION
FLC1	FLC0	
0	0	interlaced 312.5 lines/field at 50 Hz, 262.5 lines/field at 60 Hz; default after reset
0	1	non-interlaced 312 lines/field at 50 Hz, 262 lines/field at 60 Hz
1	0	non-interlaced 313 lines/field at 50 Hz, 263 lines/field at 60 Hz
1	1	non-interlaced 313 lines/field at 50 Hz, 263 lines/field at 60 Hz

**Table 91** Subaddress 6FH

DATA BYTE	LOGIC LEVEL	DESCRIPTION
CCEN	–	enables individual line 21 encoding; see Table 92
TTXEN	0	disables teletext insertion; default after reset
	1	enables teletext insertion
SCCLN	–	selects the actual line, where Closed Caption or extended data are encoded; line = (SCCLN + 4) for M-systems; line = (SCCLN + 1) for other systems

**Table 92** Logic levels and function of CCEN

DATA BYTE		DESCRIPTION
CCEN1	CCEN0	
0	0	line 21 encoding off; default after reset
0	1	enables encoding in field 1 (odd)
1	0	enables encoding in field 2 (even)
1	1	enables encoding in both fields

**Table 93** Subaddresses 70H to 72H

DATA BYTE	DESCRIPTION
ADWHS	active display window horizontal start; defines the start of the active TV display portion after the border colour values above 1715 (FISE = 1) or 1727 (FISE = 0) are not allowed
ADWHE	active display window horizontal end; defines the end of the active TV display portion before the border colour values above 1715 (FISE = 1) or 1727 (FISE = 0) are not allowed

**Table 94** Subaddress 73H

DATA BYTE	DESCRIPTION	REMARKS
TTXHS	start of signal TTXRQ on pin TTXRQ_XCLK02 (CLK2EN = 0); see Fig.51	TTXHS = 42H; is default after reset if strapped to PAL
		TTXHS = 54H; is default after reset if strapped to NTSC

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**Table 95** Subaddress 74H

DATA BYTE	DESCRIPTION	REMARKS
TTXHD	indicates the delay in clock cycles between rising edge of TTXRQ output signal on pin TTXRQ_XCLK02 (CLK2EN = 0) and valid data at pin TTX_SRES	minimum value: TTXHD = 2; is default after reset

**Table 96** Subaddress 75H

DATA BYTE	DESCRIPTION
CSYNCA	advanced composite sync against RGB output from 0 XTAL clocks to 31 XTAL clocks

**Table 97** Subaddresses 76H, 77H and 7CH

DATA BYTE	DESCRIPTION	REMARKS
TTXOVS	first line of occurrence of signal TTXRQ on pin TTXRQ_XCLK02 (CLK2EN = 0) in odd field line = (TTXOVS + 4) for M-systems line = (TTXOVS + 1) for other systems	TTXOVS = 05H; is default after reset if strapped to PAL TTXOVS = 06H; is default after reset if strapped to NTSC
TTXOVE	last line of occurrence of signal TTXRQ on pin TTXRQ_XCLK02 (CLK2EN = 0) in odd field line = (TTXOVE + 3) for M-systems line = TTXOVE for other systems	TTXOVE = 16H; is default after reset if strapped to PAL TTXOVE = 10H; is default after reset if strapped to NTSC

**Table 98** Subaddresses 78H, 79H and 7CH

DATA BYTE	DESCRIPTION	REMARKS
TTXEVS	first line of occurrence of signal TTXRQ on pin TTXRQ_XCLK02 (CLK2EN = 0) in even field line = (TTXEVS + 4) for M-systems line = (TTXEVS + 1) for other systems	TTXEVS = 04H; is default after reset if strapped to PAL TTXEVS = 05H; is default after reset if strapped to NTSC
TTXEVE	last line of occurrence of signal TTXRQ on pin TTXRQ_XCLK02 (CLK2EN = 0) in even field line = (TTXEVE + 3) for M-systems line = TTXEVE for other systems	TTXEVE = 16H; is default after reset if strapped to PAL TTXEVE = 10H; is default after reset if strapped to NTSC

**Table 99** Subaddresses 7AH to 7CH

DATA BYTE	DESCRIPTION
FAL	first active line = FAL + 4 for M-systems and FAL + 1 for other systems, measured in lines FAL = 0 coincides with the first field synchronization pulse
LAL	last active line = LAL + 3 for M-systems and LAL for other system, measured in lines LAL = 0 coincides with the first field synchronization pulse

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**Table 100** Subaddress 7CH

DATA BYTE	LOGIC LEVEL	DESCRIPTION
TTX60	0	enables NABTS (FISE = 1) or European TTX (FISE = 0); default after reset
	1	enables world standard teletext 60 Hz (FISE = 1)
TTXO	0	new teletext protocol selected; at each rising edge of TTXRQ a single teletext bit is requested (see Fig.51); default after reset
	1	old teletext protocol selected; the encoder provides a window of TTXRQ going HIGH; the length of the window depends on the chosen teletext standard (see Fig.51)

**Table 101** Subaddresses 7EH and 7FH

DATA BYTE	DESCRIPTION
LINE	individual lines in both fields (PAL counting) can be disabled for insertion of teletext by the respective bits, disabled line = LINExx (50 Hz field rate) this bit mask is effective only if the lines are enabled by TTXOVS/TTXOVE and TTXEVS/TTXEVE

**Table 102** Subaddresses 81H to 83H

DATA BYTE	DESCRIPTION
PCL	defines the frequency of the synthesized pixel clock PIXCLKO; $f_{PIXCLK} = \left( \frac{PCL}{2^{24}} \times f_{XTAL} \right) \times 8$ ; $f_{XTAL} = 27$ MHz nominal, e.g. 640 × 480 to NTSC M: PCL = 20F63BH; 640 × 480 to PAL B/G: PCL = 1B5A73H (as by strapping pins)

**Table 103** Subaddress 84H

DATA BYTE	LOGIC LEVEL	DESCRIPTION
DCLK	0	pixel clock input is differential, pin $\bar{PIXCLKI}$ receives the inverted clock; default after reset
	1	pixel clock input is single ended, pin $\bar{PIXCLKI}$ has no function
PCLSY	0	pixel clock generator runs free; default after reset
	1	pixel clock generator gets synchronized with the vertical sync
IFRA	0	input FIFO gets reset explicitly at falling edge
	1	input FIFO gets reset every field; default after reset
IFBP	0	input FIFO is active
	1	input FIFO is bypassed; default after reset
PCLE	–	controls the divider for the external pixel clock; see Table 104
PCLI	–	controls the divider for the internal pixel clock; see Table 105

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**Table 104** Logic levels and function of PCLE

DATA BYTE		DESCRIPTION
PCLE1	PCLE0	
0	0	divider ratio for PIXCLK output is 1
0	1	divider ratio for PIXCLK output is 2; default after reset
1	0	divider ratio for PIXCLK output is 4
1	1	divider ratio for PIXCLK output is 8

**Table 105** Logic levels and function of PCLI

DATA BYTE		DESCRIPTION
PCLI1	PCLI0	
0	0	divider ratio for internal PIXCLK is 1
0	1	divider ratio for internal PIXCLK is 2; default after reset
1	0	divider ratio for internal PIXCLK is 4
1	1	not allowed

**Table 106** Subaddress 85H

DATA BYTE	LOGIC LEVEL	DESCRIPTION
EIDIV	0	input dividers are off; inputs are high-impedance; default after reset
	1	input dividers are on; inputs have lower impedance
FILI	–	threshold for FIFO internal transfers; nominal value is 8; default after reset

**Table 107** Subaddresses 90H and 94H

DATA BYTE	DESCRIPTION
XOFS	horizontal offset; defines the number of PIXCLKs from horizontal sync (HSVGC) output to composite blanking ( $\overline{CBO}$ ) output

**Table 108** Subaddresses 91H and 94H

DATA BYTE	DESCRIPTION
XPIX	pixel in X direction; defines half the number of active pixels per input line (identical to the length of $\overline{CBO}$ pulses)

**Table 109** Subaddresses 92H and 94H

DATA BYTE	DESCRIPTION
YOFSO	vertical offset in odd field; defines (in the odd field) the number of lines from VSVG to first line with active $\overline{CBO}$ ; if no LUT data is requested, the first active $\overline{CBO}$ will be output at YOFSO + 2; usually, YOFSO = YOFSE with the exception of extreme vertical downscaling and interlacing

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**Table 110** Subaddresses 93H and 94H

DATA BYTE	DESCRIPTION
YOFSE	vertical offset in even field; defines (in the even field) the number of lines from VSVG to first line with active CBO; if no LUT data is requested, the first active CBO will be output at YOFSE + 2; usually, YOFSE = YOFSO with the exception of extreme vertical downscaling and interlacing

**Table 111** Subaddresses 95H and 96H

DATA BYTE	DESCRIPTION
YPIX	defines the number of requested input lines from the feeding device; number of requested lines = YPIX + YOFSE - YOFSO

**Table 112** Subaddress 96H

DATA BYTE	LOGIC LEVEL	DESCRIPTION
EFS	0	frame sync signal at pin FSVG ignored in slave mode
	1	frame sync signal at pin FSVG accepted in slave mode
PCBN	0	normal polarity of CBO signal (HIGH during active video)
	1	inverted polarity of CBO signal (LOW during active video)
SLAVE	0	the SAA7108AE; SAA7109AE is timing master to the graphics controller
	1	the SAA7108AE; SAA7109AE is timing slave to the graphics controller
ILC	0	if hardware cursor insertion is active, set LOW for non-interlaced input signals
	1	if hardware cursor insertion is active, set HIGH for interlaced input signals
YFIL	0	luminance sharpness booster disabled
	1	luminance sharpness booster enabled

**Table 113** Subaddress 97H

DATA BYTE	LOGIC LEVEL	DESCRIPTION
HFS	0	horizontal sync is directly derived from input signal (slave mode) at pin HSVGC
	1	horizontal sync is derived from a frame sync signal (slave mode) at pin FSVG (only if EFS is set HIGH)
VFS	0	vertical sync (field sync) is directly derived from input signal (slave mode) at pin VSVG
	1	vertical sync (field sync) is derived from a frame sync signal (slave mode) at pin FSVG (only if EFS is set HIGH)
OFS	0	pin FSVG is switched to input
	1	pin FSVG is switched to active output
PFS	0	polarity of signal at pin FSVG in output mode (master mode) is active HIGH; rising edge of the input signal is used in slave mode
	1	polarity of signal at pin FSVG in output mode (master mode) is active LOW; falling edge of the input signal is used in slave mode
OVS	0	pin VSVG is switched to input
	1	pin VSVG is switched to active output

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DATA BYTE	LOGIC LEVEL	DESCRIPTION
PVS	0	polarity of signal at pin VSVG in output mode (master mode) is active HIGH; rising edge of the input signal is used in slave mode
	1	polarity of signal at pin VSVG in output mode (master mode) is active LOW; falling edge of the input signal is used in slave mode
OHS	0	pin HSVG is switched to input
	1	pin HSVG is switched to active output
PHS	0	polarity of signal at pin HSVG in output mode (master mode) is active HIGH; rising edge of the input signal is used in slave mode
	1	polarity of signal at pin HSVG in output mode (master mode) is active LOW; falling edge of the input signal is used in slave mode

**Table 114** Subaddresses 98H and 99H

DATA BYTE	DESCRIPTION
HLEN	horizontal length; HLEN = $\frac{\text{number of PIXCLKs}}{\text{line}} - 1$

**Table 115** Subaddress 99H

DATA BYTE	DESCRIPTION
IDEL	input delay; defines the distance in PIXCLKs between the active edge of CBO and the first received valid pixel

**Table 116** Subaddresses 9AH and 9CH

DATA BYTE	DESCRIPTION
XINC	incremental fraction of the horizontal scaling engine; $XINC = \frac{\text{number of output pixels}}{\text{line}} \times 4096$ $\frac{\text{number of input pixels}}{\text{line}}$

**Table 117** Subaddresses 9BH and 9CH

DATA BYTE	DESCRIPTION
YINC	incremental fraction of the vertical scaling engine; $YINC = \frac{\text{number of active output lines}}{\text{number of active input lines}} \times 4096$

**Table 118** Subaddresses 9DH and 9FH

DATA BYTE	DESCRIPTION
YIWGTO	weighting factor for the first line of the odd field; $YIWGTO = \frac{YINC}{2} + 2048$

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**Table 119** Subaddresses 9EH and 9FH

DATA BYTE	DESCRIPTION
YIWGTE	weighting factor for the first line of the even field; $YIWGTE = \frac{YINC - YSKIP}{2}$

**Table 120** Subaddresses A0H and A1H

DATA BYTE	DESCRIPTION
YSKIP	vertical line skip; defines the effectiveness of the anti-flicker filter; YSKIP = 0: most effective; YSKIP = 4095: anti-flicker filter switched off

**Table 121** Subaddress A1H

DATA BYTE	LOGIC LEVEL	DESCRIPTION
BLEN	0	no internal blanking for non-interlaced graphics in bypass mode; default after reset
	1	forced internal blanking for non-interlaced graphics in bypass mode

**Table 122** Subaddresses A2H to A4H

DATA BYTE	DESCRIPTION
BCY, BCU and BCV	luminance and colour difference portion of border colour in underscan area

**Table 123** Subaddress D0H

DATA BYTE	DESCRIPTION
HLCA	RAM start address for the HD sync line count array; the byte following subaddress D0 points to the first cell to be loaded with the next transmitted byte; succeeding cells are loaded by auto-incrementing until stop condition. Each line count array entry consists of 2 bytes; see Table 124. The array has 15 entries.
HLC	HD line counter. The system will repeat the pattern described in 'HLT' HLC times and then start with the next entry in line count array.
HLT	HD line type pointer. If not 0, the value points into the line type array, index HLT – 1 with the description of the current line. 0 means the entry is not used.

**Table 124** Layout of the data bytes in the line count array

BYTE	DESCRIPTION								
0	HLC7	HLC6	HLC5	HLC4	HLC3	HLC2	HLC1	HLC0	
1	HLT3	HLT2	HLT1	HLT0	0	0	HLC9	HLC8	

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**Table 125** Subaddress D1H

DATA BYTE	DESCRIPTION
HLTA	RAM start address for the HD sync line type array; the byte following subaddress D1 points to the first cell to be loaded with the next transmitted byte; succeeding cells are loaded by auto-incrementing until stop condition. Each line type array entry consists of 4 bytes; see Table 126. The array has 15 entries.
HLP	HD line type; if not 0, the value points into the line pattern array. The index used is HLP – 1. It consists of value-duration pairs. Each entry consists of 8 pointers, used from index 0 to 7. The value 0 means that the entry is not used.

**Table 126** Layout of the data bytes in the line type array

BYTE	DESCRIPTION								
0	0	HLP12	HLP11	HLP10	0	HLP02	HLP01	HLP00	
1	0	HLP32	HLP31	HLP30	0	HLP22	HLP21	HLP20	
2	0	HLP52	HLP51	HLP50	0	HLP42	HLP41	HLP40	
3	0	HLP72	HLP71	HLP70	0	HLP62	HLP61	HLP60	

**Table 127** Subaddress D2H

DATA BYTE	DESCRIPTION
HLPA	RAM start address for the HD sync line pattern array; the byte following subaddress D2 points to the first cell to be loaded with the next transmitted byte; succeeding cells are loaded by auto-incrementing until stop condition. Each line pattern array entry consists of 4 value-duration pairs occupying 2 bytes; see Table 128. The array has 7 entries.
HPD	HD pattern duration. The value defines the time in pixel clocks (HPD + 1) the corresponding value HPV is added to the HD output signal. If 0, this entry will be skipped.
HPV	HD pattern value pointer. This gives the index in the HD value array containing the level to be inserted into the HD output path. If the MSB of HPV is logic 1, the value will only be inserted into the y/green channel of the HD data path, the other channels remain unchanged.

**Table 128** Layout of the data bytes in the line pattern array

BYTE	DESCRIPTION								
0	HPD07	HPD06	HPD05	HPD04	HPD03	HPD02	HPD01	HPD00	
1	HPV03	HPV02	HPV01	HPV00	0	0	HPD09	HPD08	
2	HPD17	HPD16	HPD14	HPD14	HPD13	HPD12	HPD11	HPD10	
3	HPV13	HPV12	HPV11	HPV10	0	0	HPD19	HPD18	
4	HPD27	HPD26	HPD25	HPD24	HPD23	HPD22	HPD21	HPD20	
5	HPV23	HPV22	HPV21	HPV20	0	0	HPD29	HPD28	
6	HPD37	HPD36	HPD35	HPD34	HPD33	HPD32	HPD31	HPD30	
7	HPV33	HPV32	HPV31	HPV30	0	0	HPD39	HPD38	

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**Table 129** Subaddress D3H

DATA BYTE	DESCRIPTION
HPVA	RAM start address for the HD sync value array; the byte following subaddress D3 points to the first cell to be loaded with the next transmitted byte; succeeding cells are loaded by auto-incrementing until stop condition. Each line pattern array entry consists of 2 bytes. The array has 8 entries.
HPVE	HD pattern value entry. The HD path will insert a level of $(HPV + 52) \times 0.66$ IRE into the data path. The value is signed 8-bits wide; see Table 130.
HHS	HD horizontal sync. If the HD engine is active, this value will be provided at pin HSM; see Table 130.
HVS	HD vertical sync. If the HD engine is active, this value will be provided at pin VSM; see Table 130.

**Table 130** Layout of the data bytes in the value array

BYTE	DESCRIPTION								
0	HPVE7	HPVE6	HPVE5	HPVE4	HPVE3	HPVE2	HPVE1	HPVE0	
1	0	0	0	0	0	0	HVS	HHS	

**Table 131** Subaddresses D4H and D5H

DATA BYTE	DESCRIPTION
HLCT	state of the HD line counter after trigger, note that it counts backwards
HLCPT	state of the HD line type pointer after trigger
HLPPPT	state of the HD pattern pointer after trigger

**Table 132** Subaddresses D6H and D7H

DATA BYTE	DESCRIPTION
HDCT	state of the HD duration counter after trigger, note that it counts backwards
HEPT	state of the HD event type pointer in the line type array after trigger

**Table 133** Subaddresses D8H and D9H

DATA BYTE	DESCRIPTION
HTX	horizontal trigger phase for the HD sync engine in pixel clocks

**Table 134** Subaddresses DAH and DBH

DATA BYTE	DESCRIPTION
HTY	vertical trigger phase for the HD sync engine in input lines

**Table 135** Subaddress DCH

DATA BYTE	LOGIC LEVEL	DESCRIPTION
HDSYE	0	the HD sync engine is off; default after reset
	1	the HD sync engine is active
HDTCT	0	HD output path processes RGB; default after reset
	1	HD output path processes YUV

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DATA BYTE	LOGIC LEVEL	DESCRIPTION
HDGY	0	gain in the HD output path is reduced, insertion of sync pulses is possible; default after reset
	1	full level swing at the input causes full level swing at the DACs in HD mode
HDIP	0	interpolator for the colour difference signal in the HD output path is active; default after reset
	1	interpolator for the colour difference signals in the HD output path is off

**Table 136** Subaddresses F0H to F2H

DATA BYTE	DESCRIPTION
CC1R, CC1G and CC1B	RED, GREEN and BLUE portion of first cursor colour

**Table 137** Subaddresses F3H to F5H

DATA BYTE	DESCRIPTION
CC2R, CC2G and CC2B	RED, GREEN and BLUE portion of second cursor colour

**Table 138** Subaddresses F6H to F8H

DATA BYTE	DESCRIPTION
AUXR, AUXG and AUXB	RED, GREEN and BLUE portion of auxiliary cursor colour

**Table 139** Subaddresses F9H and FAH

DATA BYTE	DESCRIPTION
XCP	horizontal cursor position

**Table 140** Subaddress FAH

DATA BYTE	DESCRIPTION
XHS	horizontal hot spot of cursor

**Table 141** Subaddresses FBH and FCH

DATA BYTE	DESCRIPTION
YCP	vertical cursor position

**Table 142** Subaddress FCH

DATA BYTE	DESCRIPTION
YHS	vertical hot spot of cursor

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**Table 143** Subaddress FDH

DATA BYTE	LOGIC LEVEL	DESCRIPTION
LUTOFF	0	colour look-up table is active
	1	colour look-up table is bypassed
CMODE	0	cursor mode; input colour will be inverted
	1	auxiliary cursor colour will be inserted
LUTL	0	LUT loading via input data stream is inactive
	1	colour and cursor LUTs are loaded via input data stream
IF	0	input format is 8 + 8 + 8-bit 4 : 4 : 4 non-interlaced RGB or C <sub>B</sub> -Y-C <sub>R</sub>
	1	input format is 5 + 5 + 5-bit 4 : 4 : 4 non-interlaced RGB
	2	input format is 5 + 6 + 5-bit 4 : 4 : 4 non-interlaced RGB
	3	input format is 8 + 8 + 8-bit 4 : 2 : 2 non-interlaced C <sub>B</sub> -Y-C <sub>R</sub>
	4	input format is 8 + 8 + 8-bit 4 : 2 : 2 interlaced C <sub>B</sub> -Y-C <sub>R</sub> (ITU-R BT.656, 27 MHz clock) (in subaddresses 91H and 94H set XPIX = number of active pixels/line)
	5	input format is 8-bit non-interlaced index colour
	6	input format is 8 + 8 + 8-bit 4 : 4 : 4 non-interlaced RGB or C <sub>B</sub> -Y-C <sub>R</sub> (special bit ordering)
MATOFF	0	RGB to C <sub>R</sub> -Y-C <sub>B</sub> matrix is active
	1	RGB to C <sub>R</sub> -Y-C <sub>B</sub> matrix is bypassed
DFOFF	0	down formatter (4 : 4 : 4 to 4 : 2 : 2) in input path is active
	1	down formatter is bypassed

**Table 144** Subaddress FEH

DATA BYTE	DESCRIPTION
CURSA	RAM start address for cursor bit map; the byte following subaddress FEH points to the first cell to be loaded with the next transmitted byte; succeeding cells are loaded by auto-incrementing until stop condition

**Table 145** Subaddress FFH

DATA BYTE	DESCRIPTION
COLSA	RAM start address for colour LUT; the byte following subaddress FFH points to the first cell to be loaded with the next transmitted byte; succeeding cells are loaded by auto-incrementing until stop condition

In subaddresses 5BH, 5CH, 5DH, 5EH, 62H and D3H all IRE values are rounded up.

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## 18.1.3 SLAVE TRANSMITTER

**Table 146** Slave transmitter (slave address 89H)

REGISTER FUNCTION	SUBADDRESS	DATA BYTE							
		D7	D6	D5	D4	D3	D2	D1	D0
Status byte	00H	VER2	VER1	VER0	CCRDO	CCRDE	0	FSEQ	O_E
Chip ID	1CH	CID7	CID6	CID5	CID4	CID3	CID2	CID1	CID0
FIFO status	80H	0	0	0	0	0	0	OVFL	UDFL

**Table 147** Subaddress 00H

DATA BYTE	LOGIC LEVEL	DESCRIPTION
VER	–	version identification of the device: it will be changed with all versions of the IC that have different programming models; current version is 101 binary
CCRDO	1	Closed Caption bytes of the odd field have been encoded
	0	the bit is reset after information has been written to the subaddresses 67H and 68H; it is set immediately after the data has been encoded
CCRDE	1	Closed Caption bytes of the even field have been encoded
	0	the bit is reset after information has been written to the subaddresses 69H and 6AH; it is set immediately after the data has been encoded
FSEQ	1	during first field of a sequence (repetition rate: NTSC = 4 fields, PAL = 8 fields)
	0	not first field of a sequence
O_E	1	during even field
	0	during odd field

**Table 148** Subaddress 1CH

DATA BYTE	DESCRIPTION
CID	chip ID of SAA7108AE = 04H; chip ID of SAA7109AE = 05H

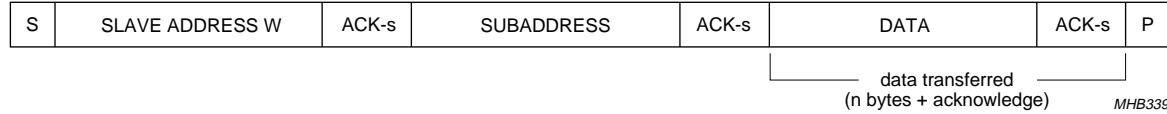
**Table 149** Subaddress 80H

DATA BYTE	LOGIC LEVEL	DESCRIPTION
IFERR	0	normal FIFO state
	1	input FIFO overflow/underflow has occurred
BFERR	0	normal FIFO state
	1	buffer FIFO overflow, only if YUPSC = 1
OVFL	0	no FIFO overflow
	1	FIFO overflow has occurred; this bit is reset after this subaddress has been read
UDFL	0	no FIFO underflow
	1	FIFO underflow has occurred; this bit is reset after this subaddress has been read

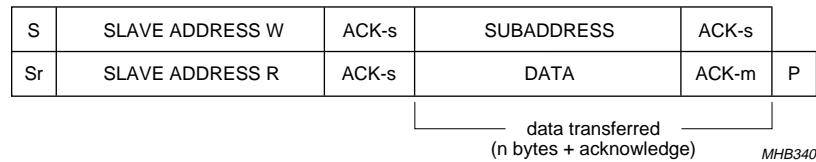
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## 18.2 Digital video decoder part

18.2.1 I<sup>2</sup>C-BUS FORMAT

a. Write procedure.



b. Read procedure (combined).

Fig.58 I<sup>2</sup>C-bus format.**Table 150** Description of I<sup>2</sup>C-bus format; note 1

CODE	DESCRIPTION
S	START condition
Sr	repeated START condition
SLAVE ADDRESS W	'0100 0010' (42H, default) or '0100 0000' (40H; note 2)
SLAVE ADDRESS R	'0100 0011' (43H, default) or '0100 0001' (41H; note 2)
ACK-s	acknowledge generated by the slave
ACK-m	acknowledge generated by the master
SUBADDRESS	subaddress byte; see Tables 151 and 152
DATA	data byte; see Table 152; if more than one byte DATA is transmitted the subaddress pointer is automatically incremented
P	STOP condition
X	read/write control bit (LSB slave address); X = 0, order to write (the circuit is slave receiver); X = 1, order to read (the circuit is slave transmitter)

**Notes**

1. The SAA7108AE; SAA7109AE supports the 'fast mode' I<sup>2</sup>C-bus specification extension (data rate up to 400 kbit/s).
2. If pin RTCO is strapped to V<sub>DDD</sub> via a 3.3 kΩ resistor.

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**Table 151** Subaddress description and access

SUBADDRESS	DESCRIPTION	ACCESS (READ/WRITE)
00H	chip version	read only
F0H to FFH	reserved	—
<b>Video decoder: 01H to 2FH</b>		
01H to 05H	front-end part	read and write
06H to 19H	decoder part	read and write
1AH to 1EH	reserved	—
1FH	video decoder status byte	read only
20H to 2FH	reserved	—
<b>Audio clock generation: 30H to 3FH</b>		
30H to 3AH	audio clock generator	read and write
3BH to 3FH	reserved	—
<b>General purpose VBI data slicer: 40H to 7FH</b>		
40H to 5EH	VBI data slicer	read and write
5FH	reserved	—
60H to 62H	VBI data slicer status	read only
63H to 7FH	reserved	—
<b>X port, I port and the scaler: 80H to EFH</b>		
80H to 8FH	task independent global settings	read and write
90H to BFH	task A definition	read and write
C0H to EFH	task B definition	read and write

**Table 152** I<sup>2</sup>C-bus receiver/transmitter overview

REGISTER FUNCTION	SUB ADDR. (HEX)	D7	D6	D5	D4	D3	D2	D1	D0
<b>Chip version: register 00H</b>									
Chip version (read only)	00	ID7	ID6	ID5	ID4	-	-	-	-
<b>Video decoder: registers 01H to 2FH</b>									
FRONT-END PART: REGISTERS 01H TO 05H									
Increment delay	01	(1)	(1)	(1)	(1)	IDEL3	IDEL2	IDEL1	IDEL0
Analog input control 1	02	FUSE1	FUSE0	GUDL1	GUDL0	MODE3	MODE2	MODE1	MODE0
Analog input control 2	03	(1)	HLNRS	VBSL	WPOFF	HOLDG	GAFIX	GAI28	GAI18
Analog input control 3	04	GAI17	GAI16	GAI15	GAI14	GAI13	GAI12	GAI11	GAI10
Analog input control 4	05	GAI27	GAI26	GAI25	GAI24	GAI23	GAI22	GAI21	GAI20
DECODER PART: REGISTERS 06H TO 2FH									
Horizontal sync start	06	HSB7	HSB6	HSB5	HSB4	HSB3	HSB2	HSB1	HSB0
Horizontal sync stop	07	HSS7	HSS6	HSS5	HSS4	HSS3	HSS2	HSS1	HSS0
Sync control	08	AUFD	FSEL	FOET	HTC1	HTC0	HPLL	VNOI1	VNOI0
Luminance control	09	BYPS	YCOMB	LDEL	LUBW	LUF13	LUF12	LUF11	LUF10
Luminance brightness control	0A	DBRI7	DBRI6	DBRI5	DBRI4	DBRI3	DBRI2	DBRI1	DBRI0
Luminance contrast control	0B	DCON7	DCON6	DCON5	DCON4	DCON3	DCON2	DCON1	DCON0
Chrominance saturation control	0C	DSAT7	DSAT6	DSAT5	DSAT4	DSAT3	DSAT2	DSAT1	DSAT0
Chrominance hue control	0D	HUEC7	HUEC6	HUEC5	HUEC4	HUEC3	HUEC2	HUEC1	HUEC0
Chrominance control 1	0E	CDTO	CSTD2	CSTD1	CSTD0	DCVF	FCTC	(1)	CCOMB
Chrominance gain control	0F	ACGC	CGAIN6	CGAIN5	CGAIN4	CGAIN3	CGAIN2	CGAIN1	CGAIN0
Chrominance control 2	10	OFFU1	OFFU0	OFFV1	OFFV0	CHBW	LCBW2	LCBW1	LCBW0
Mode/delay control	11	COLO	RTP1	HDEL1	HDEL0	RTP0	YDEL2	YDEL1	YDEL0
RT signal control	12	RTSE13	RTSE12	RTSE11	RTSE10	RTSE03	RTSE02	RTSE01	RTSE00
RT/X port output control	13	RTCE	XRHS	XRVS1	XRVS0	HLSEL	OFTS2	OFTS1	OFTS0
Analog/ADC/compatibility control	14	CM99	UPTCV	AOSL1	AOSL0	XTOUTE	OLDSB	APCK1	APCK0
VGATE start, FID change	15	VSTA7	VSTA6	VSTA5	VSTA4	VSTA3	VSTA2	VSTA1	VSTA0
VGATE stop	16	VSTO7	VSTO6	VSTO5	VSTO4	VSTO3	VSTO2	VSTO1	VSTO0

REGISTER FUNCTION	SUB ADDR. (HEX)	D7	D6	D5	D4	D3	D2	D1	D0
Miscellaneous, VGATE configuration and MSBs	17	LLCE	LLC2E	(1)	(1)	(1)	VGPS	VSTO8	VSTA8
Raw data gain control	18	RAWG7	RAWG6	RAWG5	RAWG4	RAWG3	RAWG2	RAWG1	RAWG0
Raw data offset control	19	RAWO7	RAWO6	RAWO5	RAWO4	RAWO3	RAWO2	RAWO1	RAWO0
Reserved	1A to 1E	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)
Status byte video decoder (read only, OLDSB = 0)	1F	INTL	HLVLN	FIDT	GLIMT	GLIMB	WIPA	COPRO	RDCAP
Status byte video decoder (read only, OLDSB = 1)	1F	INTL	HLCK	FIDT	GLIMT	GLIMB	WIPA	SLTCA	CODE
Reserved	20 to 2F	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)
<b>Audio clock generator part: registers 30H to 3FH</b>									
Audio master clock cycles per field	30	ACPF7	ACPF6	ACPF5	ACPF4	ACPF3	ACPF2	ACPF1	ACPF0
	31	ACPF15	ACPF14	ACPF13	ACPF12	ACPF11	ACPF10	ACPF9	ACPF8
	32	(1)	(1)	(1)	(1)	(1)	(1)	ACPF17	ACPF16
Reserved	33	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)
Audio master clock nominal increment	34	ACNI7	ACNI6	ACNI5	ACNI4	ACNI3	ACNI2	ACNI1	ACNI0
	35	ACNI15	ACNI14	ACNI13	ACNI12	ACNI11	ACNI10	ACNI9	ACNI8
	36	(1)	(1)	ACNI21	ACNI20	ACNI19	ACNI18	ACNI17	ACNI16
Reserved	37	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)
Clock ratio AMXCLK to ASCLK	38	(1)	(1)	SDIV5	SDIV4	SDIV3	SDIV2	SDIV1	SDIV0
Clock ratio ASCLK to ALRCLK	39	(1)	(1)	LRDIV5	LRDIV4	LRDIV3	LRDIV2	LRDIV1	LRDIV0
Audio clock generator basic set-up	3A	(1)	(1)	(1)	(1)	APLL	AMVR	LRPH	SCPH
Reserved	3B to 3F	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)
<b>General purpose VBI data slicer part: registers 40H to 7FH</b>									
Slicer control 1	40	(1)	HAM_N	FCE	HUNT_N	(1)	(1)	(1)	(1)
LCR2 to LCR24 (n = 2 to 24)	41 to 57	LCRn_7	LCRn_6	LCRn_5	LCRn_4	LCRn_3	LCRn_2	LCRn_1	LCRn_0
Programmable framing code	58	FC7	FC6	FC5	FC4	FC3	FC2	FC1	FC0
Horizontal offset for slicer	59	HOFF7	HOFF6	HOFF5	HOFF4	HOFF3	HOFF2	HOFF1	HOFF0
Vertical offset for slicer	5A	VOFF7	VOFF6	VOFF5	VOFF4	VOFF3	VOFF2	VOFF1	VOFF0

REGISTER FUNCTION	SUB ADDR. (HEX)	D7	D6	D5	D4	D3	D2	D1	D0
Field offset and MSBs for horizontal and vertical offset	5B	FOFF	RECODE	(1)	VOFF8	(1)	HOFF10	HOFF9	HOFF8
Reserved (for testing)	5C	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)
Header and data identification (DID) code control	5D	FVREF	(1)	DID5	DID4	DID3	DID2	DID1	DID0
Sliced data identification (SDID) code	5E	(1)	(1)	SDID5	SDID4	SDID3	SDID2	SDID1	SDID0
Reserved	5F	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)
Slicer status byte 0 (read only)	60	—	FC8V	FC7V	VPSV	PPV	CCV	—	—
Slicer status byte 1 (read only)	61	—	—	F21_N	LN8	LN7	LN6	LN5	LN4
Slicer status byte 2 (read only)	62	LN3	LN2	LN1	LN0	DT3	DT2	DT1	DT0
Reserved	63 to 7F	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)
<b>X port, I port and the scaler part: registers 80H to EFH</b>									
TASK INDEPENDENT GLOBAL SETTINGS: 80H TO 8FH									
Global control 1	80	(1)	SMOD	TEB	TEA	ICKS3	ICKS2	ICKS1	ICKS0
Reserved	81 and 82	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)
X port I/O enable and output clock phase control	83	(1)	(1)	XPCK1	XPCK0	(1)	XRQT	XPE1	XPE0
I port signal definitions	84	IDG01	IDG00	IDG11	IDG10	IDV1	IDV0	IDH1	IDH0
I port signal polarities	85	ISWP1	ISWP0	ILLV	IG0P	IG1P	IRVP	IRHP	IDQP
I port FIFO flag control and arbitration	86	VITX1	VITX0	IDG02	IDG12	FFL1	FFL0	FEL1	FEL0
I port I/O enable, output clock and gated clock phase control	87	IPCK3	IPCK2	IPCK1	IPCK0	(1)	(1)	IPE1	IPE0
Power save control	88	CH4EN	CH2EN	SWRST	DPROG	SLM3	(1)	SLM1	SLM0
Reserved	89 to 8E	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)
Status information scaler part	8F	XTRI	ITRI	FFIL	FFOV	PRDON	ERROF	FIDSCI	FIDSCO

REGISTER FUNCTION	SUB ADDR. (HEX)	D7	D6	D5	D4	D3	D2	D1	D0
TASK A DEFINITION: REGISTERS 90H TO BFH									
<i>Basic settings and acquisition window definition</i>									
Task handling control	90	CONLH	OFIDC	FSKP2	FSKP1	FSKP0	RPTSK	STRC1	STRC0
X port formats and configuration	91	CONLV	HLDFV	SCSRC1	SCSRC0	SCRQE	FSC2	FSC1	FSC0
X port input reference signal definitions	92	XFDV	XFDH	XDV1	XDV0	XCODE	XDH	XDQ	XCKS
I port output formats and configuration	93	ICODE	I8_16	FYSK	FOI1	FOI0	FSI2	FSI1	FSI0
Horizontal input window start	94	XO7	XO6	XO5	XO4	XO3	XO2	XO1	XO0
	95	(1)	(1)	(1)	(1)	XO11	XO10	XO9	XO8
Horizontal input window length	96	XS7	XS6	XS5	XS4	XS3	XS2	XS1	XS0
	97	(1)	(1)	(1)	(1)	XS11	XS10	XS9	XS8
Vertical input window start	98	YO7	YO6	YO5	YO4	YO3	YO2	YO1	YO0
	99	(1)	(1)	(1)	(1)	YO11	YO10	YO9	YO8
Vertical input window length	9A	YS7	YS6	YS5	YS4	YS3	YS2	YS1	YS0
	9B	(1)	(1)	(1)	(1)	YS11	YS10	YS9	YS8
Horizontal output window length	9C	XD7	XD6	XD5	XD4	XD3	XD2	XD1	XD0
	9D	(1)	(1)	(1)	(1)	XD11	XD10	XD9	XD8
Vertical output window length	9E	YD7	YD6	YD5	YD4	YD3	YD2	YD1	YD0
	9F	(1)	(1)	(1)	(1)	YD11	YD10	YD9	YD8
<i>FIR filtering and prescaling</i>									
Horizontal prescaling	A0	(1)	(1)	XPSC5	XPSC4	XPSC3	XPSC2	XPSC1	XPSC0
Accumulation length	A1	(1)	(1)	XACL5	XACL4	XACL3	XACL2	XACL1	XACL0
Prescaler DC gain and FIR prefilter control	A2	PFUV1	PFUV0	PFY1	PFY0	XC2_1	XDCG2	XDCG1	XDCG0
Reserved	A3	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)
Luminance brightness control	A4	BRIG7	BRIG6	BRIG5	BRIG4	BRIG3	BRIG2	BRIG1	BRIG0
Luminance contrast control	A5	CONT7	CONT6	CONT5	CONT4	CONT3	CONT2	CONT1	CONT0
Chrominance saturation control	A6	SATN7	SATN6	SATN5	SATN4	SATN3	SATN2	SATN1	SATN0
Reserved	A7	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)

REGISTER FUNCTION	SUB ADDR. (HEX)	D7	D6	D5	D4	D3	D2	D1	D0
<i>Horizontal phase scaling</i>									
Horizontal luminance scaling increment	A8	XSCY7	XSCY6	XSCY5	XSCY4	XSCY3	XSCY2	XSCY1	XSCY0
	A9	(1)	(1)	(1)	XSCY12	XSCY11	XSCY10	XSCY9	XSCY8
Horizontal luminance phase offset	AA	XPHY7	XPHY6	XPHY5	XPHY4	XPHY3	XPHY2	XPHY1	XPHY0
Reserved	AB	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)
Horizontal chrominance scaling increment	AC	XSCC7	XSCC6	XSCC5	XSCC4	XSCC3	XSCC2	XSCC1	XSCC0
	AD	(1)	(1)	(1)	XSCC12	XSCC11	XSCC10	XSCC9	XSCC8
Horizontal chrominance phase offset	AE	XPHC7	XPHC6	XPHC5	XPHC4	XPHC3	XPHC2	XPHC1	XPHC0
Reserved	AF	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)
<i>Vertical scaling</i>									
Vertical luminance scaling increment	B0	YSCY7	YSCY6	YSCY5	YSCY4	YSCY3	YSCY2	YSCY1	YSCY0
	B1	YSCY15	YSCY14	YSCY13	YSCY12	YSCY11	YSCY10	YSCY9	YSCY8
Vertical chrominance scaling increment	B2	YSCC7	YSCC6	YSCC5	YSCC4	YSCC3	YSCC2	YSCC1	YSCC0
	B3	YSCC15	YSCC14	YSCC13	YSCC12	YSCC11	YSCC10	YSCC9	YSCC8
Vertical scaling mode control	B4	(1)	(1)	(1)	YMIR	(1)	(1)	(1)	YMODE
Reserved	B5 to B7	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)
Vertical chrominance phase offset '00'	B8	YPC07	YPC06	YPC05	YPC04	YPC03	YPC02	YPC01	YPC00
Vertical chrominance phase offset '01'	B9	YPC17	YPC16	YPC15	YPC14	YPC13	YPC12	YPC11	YPC10
Vertical chrominance phase offset '10'	BA	YPC27	YPC26	YPC25	YPC24	YPC23	YPC22	YPC21	YPC20
Vertical chrominance phase offset '11'	BB	YPC37	YPC36	YPC35	YPC34	YPC33	YPC32	YPC31	YPC30
Vertical luminance phase offset '00'	BC	YPY07	YPY06	YPY05	YPY04	YPY03	YPY02	YPY01	YPY00
Vertical luminance phase offset '01'	BD	YPY17	YPY16	YPY15	YPY14	YPY13	YPY12	YPY11	YPY10
Vertical luminance phase offset '10'	BE	YPY27	YPY26	YPY25	YPY24	YPY23	YPY22	YPY21	YPY20

REGISTER FUNCTION	SUB ADDR. (HEX)	D7	D6	D5	D4	D3	D2	D1	D0
Vertical luminance phase offset '11'	BF	YPY37	YPY36	YPY35	YPY34	YPY33	YPY32	YPY31	YPY30
TASK B DEFINITION REGISTERS C0H TO EFH									
<i>Basic settings and acquisition window definition</i>									
Task handling control	C0	CONLH	OFIDC	FSKP2	FSKP1	FSKP0	RPTSK	STR1C1	STR0C0
X port formats and configuration	C1	CONLV	HLDFV	SCSRC1	SCSRC0	SCRQE	FSC2	FSC1	FSC0
Input reference signal definition	C2	XFDV	XFDH	XDV1	XDV0	XCODE	XDH	XDQ	XCKS
I port formats and configuration	C3	ICODE	I8_16	FYSK	FOI1	FOI0	FSI2	FSI1	FSI0
Horizontal input window start	C4	XO7	XO6	XO5	XO4	XO3	XO2	XO1	XO0
	C5	(1)	(1)	(1)	(1)	XO11	XO10	XO9	XO8
Horizontal input window length	C6	XS7	XS6	XS5	XS4	XS3	XS2	XS1	XS0
	C7	(1)	(1)	(1)	(1)	XS11	XS10	XS9	XS8
Vertical input window start	C8	YO7	YO6	YO5	YO4	YO3	YO2	YO1	YO0
	C9	(1)	(1)	(1)	(1)	YO11	YO10	YO9	YO8
Vertical input window length	CA	YS7	YS6	YS5	YS4	YS3	YS2	YS1	YS0
	CB	(1)	(1)	(1)	(1)	YS11	YS10	YS9	YS8
Horizontal output window length	CC	XD7	XD6	XD5	XD4	XD3	XD2	XD1	XD0
	CD	(1)	(1)	(1)	(1)	XD11	XD10	XD9	XD8
Vertical output window length	CE	YD7	YD6	YD5	YD4	YD3	YD2	YD1	YD0
	CF	(1)	(1)	(1)	(1)	YD11	YD10	YD9	YD8
<i>FIR filtering and prescaling</i>									
Horizontal prescaling	D0	(1)	(1)	XPSC5	XPSC4	XPSC3	XPSC2	XPSC1	XPSC0
Accumulation length	D1	(1)	(1)	XACL5	XACL4	XACL3	XACL2	XACL1	XACL0
Prescaler DC gain and FIR prefilter control	D2	PFUV1	PFUV0	PFY1	PFY0	XC2_1	XDCG2	XDCG1	XDCG0
Reserved	D3	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)
Luminance brightness control	D4	BRIG7	BRIG6	BRIG5	BRIG4	BRIG3	BRIG2	BRIG1	BRIG0
Luminance contrast control	D5	CONT7	CONT6	CONT5	CONT4	CONT3	CONT2	CONT1	CONT0
Chrominance saturation control	D6	SATN7	SATN6	SATN5	SATN4	SATN3	SATN2	SATN1	SATN0
Reserved	D7	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)

REGISTER FUNCTION	SUB ADDR. (HEX)	D7	D6	D5	D4	D3	D2	D1	D0
<i>Horizontal phase scaling</i>									
Horizontal luminance scaling increment	D8	XSCY7	XSCY6	XSCY5	XSCY4	XSCY3	XSCY2	XSCY1	XSCY0
	D9	(1)	(1)	(1)	XSCY12	XSCY11	XSCY10	XSCY9	XSCY8
Horizontal luminance phase offset	DA	XPHY7	XPHY6	XPHY5	XPHY4	XPHY3	XPHY2	XPHY1	XPHY0
Reserved	DB	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)
Horizontal chrominance scaling increment	DC	XSCC7	XSCC6	XSCC5	XSCC4	XSCC3	XSCC2	XSCC1	XSCC0
	DD	(1)	(1)	(1)	XSCC12	XSCC11	XSCC10	XSCC9	XSCC8
Horizontal chrominance phase offset	DE	XPHC7	XPHC6	XPHC5	XPHC4	XPHC3	XPHC2	XPHC1	XPHC0
Reserved	DF	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)
<i>Vertical scaling</i>									
Vertical luminance scaling increment	E0	YSCY7	YSCY6	YSCY5	YSCY4	YSCY3	YSCY2	YSCY1	YSCY0
	E1	YSCY15	YSCY14	YSCY13	YSCY12	YSCY11	YSCY10	YSCY9	YSCY8
Vertical chrominance scaling increment	E2	YSCC7	YSCC6	YSCC5	YSCC4	YSCC3	YSCC2	YSCC1	YSCC0
	E3	YSCC15	YSCC14	YSCC13	YSCC12	YSCC11	YSCC10	YSCC9	YSCC8
Vertical scaling mode control	E4	(1)	(1)	(1)	YMIR	(1)	(1)	(1)	YMODE
Reserved	E5 to E7	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)
Vertical chrominance phase offset '00'	E8	YPC07	YPC06	YPC05	YPC04	YPC03	YPC02	YPC01	YPC00
Vertical chrominance phase offset '01'	E9	YPC17	YPC16	YPC15	YPC14	YPC13	YPC12	YPC11	YPC10
Vertical chrominance phase offset '10'	EA	YPC27	YPC26	YPC25	YPC24	YPC23	YPC22	YPC21	YPC20
Vertical chrominance phase offset '11'	EB	YPC37	YPC36	YPC35	YPC34	YPC33	YPC32	YPC31	YPC30
Vertical luminance phase offset '00'	EC	YPY07	YPY06	YPY05	YPY04	YPY03	YPY02	YPY01	YPY00

REGISTER FUNCTION	SUB ADDR. (HEX)	D7	D6	D5	D4	D3	D2	D1	D0
Vertical luminance phase offset '01'	ED	YPY17	YPY16	YPY15	YPY14	YPY13	YPY12	YPY11	YPY10
Vertical luminance phase offset '10'	EE	YPY27	YPY26	YPY25	YPY24	YPY23	YPY22	YPY21	YPY20
Vertical luminance phase offset '11'	EF	YPY37	YPY36	YPY35	YPY34	YPY33	YPY32	YPY31	YPY30

**Note**

1. All unused control bits must be programmed with logic 0 to ensure compatibility to future enhancements.

#### 18.2.2 I<sup>2</sup>C-BUS DETAIL

##### 18.2.2.1 Subaddress 00H

**Table 153** Chip version (CV) identification; 00H[7:4]; read only register

FUNCTION	LOGIC LEVELS			
	ID7	ID6	ID5	ID4
Chip Version (CV)	CV3	CV2	CV1	CV0

##### 18.2.2.2 Subaddress 01H

The programming of the horizontal increment delay is used to match internal processing delays to the delay of the ADC. Use recommended position only.

**Table 154** Horizontal increment delay; 01H[3:0]

FUNCTION	IDEL3	IDEL2	IDEL1	IDEL0
No update	1	1	1	1
Minimum delay	1	1	1	0
<b>Recommended position</b>	<b>1</b>	<b>0</b>	<b>0</b>	<b>0</b>
Maximum delay	0	0	0	0

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## 18.2.2.3 Subaddress 02H

**Table 155** Analog input control 1 (AICO1); 02H[7:0]

BIT	DESCRIPTION	SYMBOL	VALUE	FUNCTION
7 and 6	analog function select; see Fig.15	FUSE[1:0]	00	amplifier plus anti-alias filter bypassed
			01	
			10	amplifier active
			11	amplifier plus anti-alias filter active
5 and 4	update hysteresis for 9-bit gain; see Fig.16	GUDL[1:0]	00	off
			01	$\pm 1$ LSB
			10	$\pm 2$ LSB
			11	$\pm 3$ LSB
3 to 0	mode selection	MODE[3:0]	0000	<b>Mode 0:</b> CVBS (automatic gain) from AI11 (pin P13); see Fig.59
			0001	<b>Mode 1:</b> CVBS (automatic gain) from AI12 (pin P11); see Fig.60
			0010	<b>Mode 2:</b> CVBS (automatic gain) from AI21 (pin P10); see Fig.61
			0011	<b>Mode 3:</b> CVBS (automatic gain) from AI22 (pin P9); see Fig.62
			0100	<b>Mode 4:</b> CVBS (automatic gain) from AI23 (pin P7); see Fig.63
			0101	<b>Mode 5:</b> CVBS (automatic gain) from AI24 (pin P6); see Fig.64
			0110	<b>Mode 6:</b> Y (automatic gain) from AI11 (pin P13) + C (gain adjustable via GAI28 to GAI20) from AI21 (pin P10); note 1; see Fig.65
			0111	<b>Mode 7:</b> Y (automatic gain) from AI12 (pin P11) + C (gain adjustable via GAI28 to GAI20) from AI22 (pin P9); note 1; see Fig.66
			1000	<b>Mode 8:</b> Y (automatic gain) from AI11 (pin P13) + C (gain adapted to Y gain) from AI21 (pin P10); note 1; see Fig.67
			1001	<b>Mode 9:</b> Y (automatic gain) from AI12 (pin P11) + C (gain adapted to Y gain) from AI22 (pin P9); note 1; see Fig.68
			1010 to 1111	<b>Modes 10 to 15:</b> reserved

**Note**

1. To take full advantage of the Y/C modes 6 to 9 the I<sup>2</sup>C-bus bit BYPS (subaddress 09H, bit 7) should be set to logic 1 (full luminance bandwidth).

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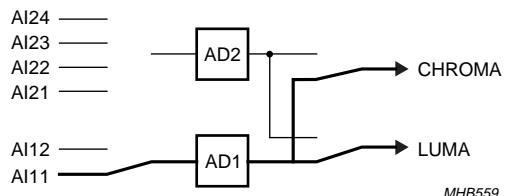


Fig.59 Mode 0; CVBS (automatic gain).

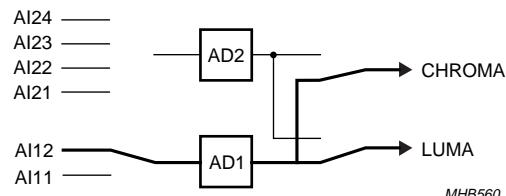


Fig.60 Mode 1; CVBS (automatic gain).

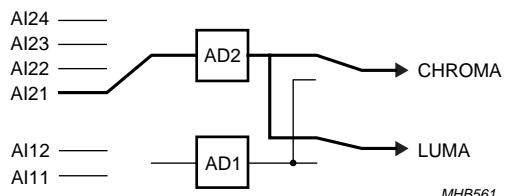


Fig.61 Mode 2; CVBS (automatic gain).

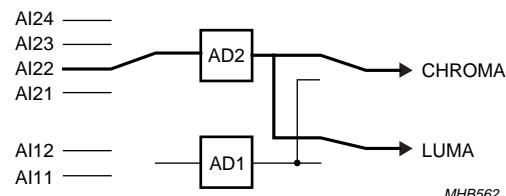


Fig.62 Mode 3; CVBS (automatic gain).

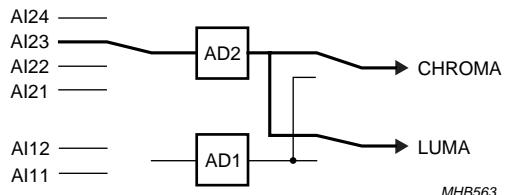


Fig.63 Mode 4; CVBS (automatic gain).

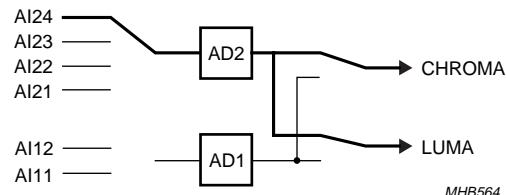
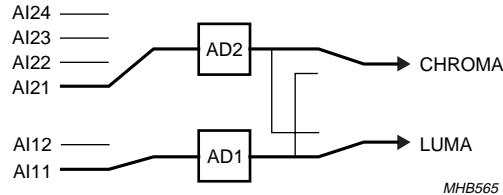


Fig.64 Mode 5; CVBS (automatic gain).

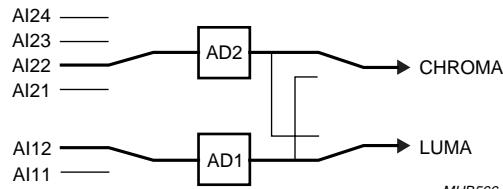
## HD-CODEC

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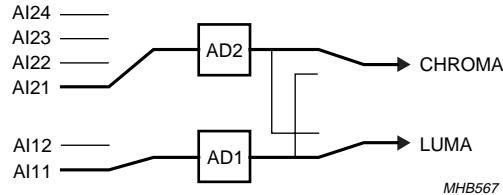
I<sup>2</sup>C-bus bit BYPS (subaddress 09H, bit 7) should be set to logic 1 (full luminance bandwidth).

Fig.65 Mode 6; Y + C (gain channel 2 adjusted via GAI2).



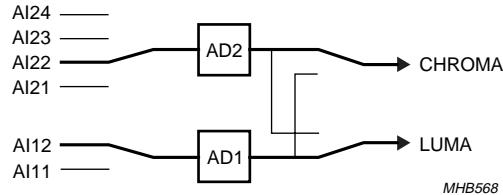
I<sup>2</sup>C-bus bit BYPS (subaddress 09H, bit 7) should be set to logic 1 (full luminance bandwidth).

Fig.66 Mode 7; Y + C (gain channel 2 adjusted via GAI2).



I<sup>2</sup>C-bus bit BYPS (subaddress 09H, bit 7) should be set to logic 1 (full luminance bandwidth).

Fig.67 Mode 8; Y + C (gain channel 2 adapted to Y gain).



I<sup>2</sup>C-bus bit BYPS (subaddress 09H, bit 7) should be set to logic 1 (full luminance bandwidth).

Fig.68 Mode 9; Y + C (gain channel 2 adapted to Y gain).

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## 18.2.2.4 Subaddress 03H

**Table 156** Analog input control 2 (AICO2); 03H[6:0]

BIT	DESCRIPTION	SYMBOL	VALUE	FUNCTION		
6	HL not reference select	HLNRS	0	normal clamping if decoder is in unlocked state		
			1 <sup>(1)</sup>	reference select if decoder is in unlocked state		
5	AGC hold during vertical blanking period	VBSL	0	short vertical blanking (AGC disabled during equalization and serration pulses)		
			1	long vertical blanking (AGC disabled from start of pre-equalization pulses until start of active video (line 22 for 60 Hz, line 24 for 50 Hz)		
4	white peak control off	WPOFF	0 <sup>(1)</sup>	white peak control active		
			1	white peak control off		
3	automatic gain control integration	HOLDG	0	AGC active		
			1	AGC integration hold (freeze)		
2	gain control fix	GAFIX	0	automatic gain controlled by MODE3 to MODE0		
			1	gain is user programmable via GAI[17:10] and GAI[27:20]		
1	static gain control channel 2 sign bit	GAI28	see Table 158			
0	static gain control channel 1 sign bit	GAI18	see Table 157			

**Note**

1. HLNRS = 1 should not be used in combination with WPOFF = 0.

## 18.2.2.5 Subaddress 04H

**Table 157** Analog input control 3 (AICO3); static gain control channel 1; 03H[0] and 04H[7:0]

DECIMAL VALUE	GAIN (dB)	SIGN BIT 03H[0]	CONTROL BITS 7 TO 0								
			GAI18	GAI17	GAI16	GAI15	GAI14	GAI13	GAI12	GAI11	GAI10
0...	-3	0	0	0	0	0	0	0	0	0	0
...144	0	0	1	0	0	1	0	0	0	0	0
145...	0	0	1	0	0	1	0	0	0	0	1
...511	+6	1	1	1	1	1	1	1	1	1	1

## 18.2.2.6 Subaddress 05H

**Table 158** Analog input control 4 (AICO4); static gain control channel 2; 03H[1] and 05H[7:0]

DECIMAL VALUE	GAIN (dB)	SIGN BIT 03H[1]	CONTROL BITS 7 TO 0								
			GAI28	GAI27	GAI26	GAI25	GAI24	GAI23	GAI22	GAI21	GAI20
0...	-3	0	0	0	0	0	0	0	0	0	0
...144	0	0	1	0	0	1	0	0	0	0	0
145...	0	0	1	0	0	1	0	0	0	0	1
...511	+6	1	1	1	1	1	1	1	1	1	1

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## 18.2.2.7 Subaddress 06H

**Table 159** Horizontal sync start; 06H[7:0]

DELAY TIME (STEP SIZE = 8/LLC)	CONTROL BITS 7 TO 0							
	HSB7	HSB6	HSB5	HSB4	HSB3	HSB2	HSB1	HSB0
-128...-109 (50 Hz)	forbidden (outside available central counter range)							
-128...-108 (60 Hz)	forbidden (outside available central counter range)							
-108 (50 Hz)...	1	0	0	1	0	1	0	0
-107 (60 Hz)...	1	0	0	1	0	1	0	1
...108 (50 Hz)	0	1	1	0	1	1	0	0
...107 (60 Hz)	0	1	1	0	1	0	1	1
109...127 (50 Hz)	forbidden (outside available central counter range)							
108...127 (60 Hz)	forbidden (outside available central counter range)							

## 18.2.2.8 Subaddress 07H

**Table 160** Horizontal sync stop; 07H[7:0]

DELAY TIME (STEP SIZE = 8/LLC)	CONTROL BITS 7 TO 0							
	HSS7	HSS6	HSS5	HSS4	HSS3	HSS2	HSS1	HSS0
-128...-109 (50 Hz)	forbidden (outside available central counter range)							
-128...-108 (60 Hz)	forbidden (outside available central counter range)							
-108 (50 Hz)...	1	0	0	1	0	1	0	0
-107 (60 Hz)...	1	0	0	1	0	1	0	1
...108 (50 Hz)	0	1	1	0	1	1	0	0
...107 (60 Hz)	0	1	1	0	1	0	1	1
109...127 (50 Hz)	forbidden (outside available central counter range)							
108...127 (60 Hz)	forbidden (outside available central counter range)							

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## 18.2.2.9 Subaddress 08H

**Table 161** Sync control; 08H[7:0]

BIT	DESCRIPTION	SYMBOL	VALUE	FUNCTION
7	automatic field detection	AUFD	0	field state directly controlled via FSEL
			1	automatic field detection; <b>recommended setting</b>
6	field selection	FSEL	0	50 Hz, 625 lines
			1	60 Hz, 525 lines
5	forced ODD/EVEN toggle	FOET	0	ODD/EVEN signal toggles only with interlaced source
			1	ODD/EVEN signal toggles fieldwise even if source is non-interlaced
4 and 3	horizontal time constant selection	HTC[1:0]	00	TV mode, recommended for poor quality TV signals only; do not use for new applications
			01	VTR mode, recommended if a deflection control circuit is directly connected to the SAA7108AE; SAA7109AE
			10	reserved
			11	fast locking mode; <b>recommended setting</b>
2	horizontal PLL	HPLL	0	PLL closed
			1	PLL open; horizontal frequency fixed
1 and 0	vertical noise reduction	VNOI[1:0]	00	normal mode; <b>recommended setting</b>
			01	fast mode, applicable for stable sources only; automatic field detection (AUFD) <b>must</b> be disabled
			10	free running mode
			11	vertical noise reduction bypassed

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## 18.2.2.10 Subaddress 09H

**Table 162** Luminance control; 09H[7:0]

BIT	DESCRIPTION	SYMBOL	VALUE	FUNCTION	
7	chrominance trap/comb filter bypass	BYPS	0	chrominance trap or luminance comb filter active; default for CVBS mode	
			1	chrominance trap or luminance comb filter bypassed; default for S-video mode	
6	adaptive luminance comb filter	YCOMB	0	disabled (= chrominance trap enabled, if BYPS = 0)	
			1	active, if BYPS = 0	
5	processing delay in non comb filter mode	LDEL	0	processing delay is equal to internal pipelining delay	
			1	one (NTSC standards) or two (PAL standards) video lines additional processing delay	
4	remodulation bandwidth for luminance; see Figs 21 to 24	LUBW	0	small remodulation bandwidth (narrow chrominance notch $\Rightarrow$ higher luminance bandwidth)	
			1	large remodulation bandwidth (wider chrominance notch $\Rightarrow$ smaller luminance bandwidth)	
3 to 0	sharpness control, luminance filter characteristic; see Fig.25	LUF1[3:0]	0001	resolution enhancement filter; 8.0 dB at 4.1 MHz	
			0010	resolution enhancement filter; 6.8 dB at 4.1 MHz	
			0011	resolution enhancement filter; 5.1 dB at 4.1 MHz	
			0100	resolution enhancement filter; 4.1 dB at 4.1 MHz	
			0101	resolution enhancement filter; 3.0 dB at 4.1 MHz	
			0110	resolution enhancement filter; 2.3 dB at 4.1 MHz	
			0111	resolution enhancement filter; 1.6 dB at 4.1 MHz	
			0000	plain	
			1000	low-pass filter; 2 dB at 4.1 MHz	
			1001	low-pass filter; 3 dB at 4.1 MHz	
			1010	low-pass filter; 3 dB at 3.3 MHz; 4 dB at 4.1 MHz	
			1011	low-pass filter; 3 dB at 2.6 MHz; 8 dB at 4.1 MHz	
			1100	low-pass filter; 3 dB at 2.4 MHz; 14 dB at 4.1 MHz	
			1101	low-pass filter; 3 dB at 2.2 MHz; notch at 3.4 MHz	
			1110	low-pass filter; 3 dB at 1.9 MHz; notch at 3.0 MHz	
			1111	low-pass filter; 3 dB at 1.7 MHz; notch at 2.5 MHz	

## 18.2.2.11 Subaddress 0AH

**Table 163** Luminance brightness control: decoder part; 0AH[7:0]

OFFSET	CONTROL BITS 7 TO 0							
	DBRI7	DBRI6	DBRI5	DBRI4	DBRI3	DBRI2	DBRI1	DBRI0
255 (bright)	1	1	1	1	1	1	1	1
128 (ITU level)	1	0	0	0	0	0	0	0
0 (dark)	0	0	0	0	0	0	0	0

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## 18.2.2.12 Subaddress 0BH

**Table 164** Luminance contrast control: decoder part; 0BH[7:0]

GAIN	CONTROL BITS 7 TO 0							
	DCON7	DCON6	DCON5	DCON4	DCON3	DCON2	DCON1	DCON0
1.984 (maximum)	0	1	1	1	1	1	1	1
1.063 (ITU level)	0	1	0	0	0	1	0	0
1.0	0	1	0	0	0	0	0	0
0 (luminance off)	0	0	0	0	0	0	0	0
-1 (inverse luminance)	1	1	0	0	0	0	0	0
-2 (inverse luminance)	1	0	0	0	0	0	0	0

## 18.2.2.13 Subaddress 0CH

**Table 165** Chrominance saturation control: decoder part; 0CH[7:0]

GAIN	CONTROL BITS 7 TO 0							
	DSAT7	DSAT6	DSAT5	DSAT4	DSAT3	DSAT2	DSAT1	DSAT0
1.984 (maximum)	0	1	1	1	1	1	1	1
1.0 (ITU level)	0	1	0	0	0	0	0	0
0 (colour off)	0	0	0	0	0	0	0	0
-1 (inverse chrominance)	1	1	0	0	0	0	0	0
-2 (inverse chrominance)	1	0	0	0	0	0	0	0

## 18.2.2.14 Subaddress 0DH

**Table 166** Chrominance hue control: 0DH[7:0]

HUE PHASE (DEG)	CONTROL BITS 7 TO 0							
	HUEC7	HUEC6	HUEC5	HUEC4	HUEC3	HUEC2	HUEC1	HUEC0
+178.6...	0	1	1	1	1	1	1	1
...0...	0	0	0	0	0	0	0	0
...-180	1	0	0	0	0	0	0	0

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## 18.2.2.15 Subaddress 0EH

**Table 167** Chrominance control 1; 0EH[7:0]

BIT	DESCRIPTION	SYMBOL	VALUE	FUNCTION	
				50 Hz/625 LINES	60 Hz/525 LINES
7	clear DTO	CDTO	0	disabled	
			1	Every time CDTO is set, the internal subcarrier DTO phase is reset to 0° and the RTCO output generates a logic 0 at time slot 68 (see document "RTC Functional Description", available on request). So an identical subcarrier phase can be generated by an external device (e.g. an encoder).	
6 to 4	colour standard selection	CSTD[2:0]	000	PAL BGDHI (4.43 MHz)	NTSC M (3.58 MHz)
			001	NTSC 4.43 (50 Hz)	PAL 4.43 (60 Hz)
			010	Combination-PAL N (3.58 MHz)	NTSC 4.43 (60 Hz)
			011	NTSC N (3.58 MHz)	PAL M (3.58 MHz)
			100	reserved	NTSC-Japan (3.58 MHz)
			101	SECAM	reserved
			110	reserved; <b>do not use</b>	
			111	reserved; <b>do not use</b>	
3	disable chrominance vertical filter and PAL phase error correction	DCVF	0	chrominance vertical filter and PAL phase error correction on (during active video lines)	
			1	chrominance vertical filter and PAL phase error correction permanently off	
2	fast colour time constant	FCTC	0	nominal time constant	
			1	fast time constant for special applications	
0	adaptive chrominance comb filter	CCOMB	0	disabled	
			1	active	

## 18.2.2.16 Subaddress 0FH

**Table 168** Chrominance gain control; 0FH[7:0]

BIT	DESCRIPTION	SYMBOL	VALUE	FUNCTION	
7	automatic chrominance gain control	ACGC	0	on	
			1	programmable gain via CGAIN6 to CGAIN0; need to be set for SECAM standard	
6 to 0	chrominance gain value (if ACGC is set to logic 1)	CGAIN[6:0]	000 0000	minimum gain (0.5)	
			010 0100	nominal gain (1.125)	
			111 1111	maximum gain (7.5)	

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## 18.2.2.17 Subaddress 10H

**Table 169** Chrominance control 2; 10H[7:0]

BIT	DESCRIPTION	SYMBOL	VALUE	FUNCTION
7 and 6	fine offset adjustment B – Y component	OFFU[1:0]	00	0 LSB
			01	1/4 LSB
			10	1/2 LSB
			11	3/4 LSB
5 and 4	fine offset adjustment R – Y component	OFFV[1:0]	00	0 LSB
			01	1/4 LSB
			10	1/2 LSB
			11	3/4 LSB
3	chrominance bandwidth; see Figs 19 and 20	CHBW	0	small
			1	wide
2 to 0	combined luminance/chrominance bandwidth adjustment; see Figs 19 to 25	LCBW[2:0]	000	smallest chrominance bandwidth or largest luminance bandwidth
			...	... to ...
			111	largest chrominance bandwidth or smallest luminance bandwidth

## 18.2.2.18 Subaddress 11H

**Table 170** Mode/delay control; 11H[7:0]

BIT	DESCRIPTION	SYMBOL	VALUE	FUNCTION
7	colour on	COLO	0	automatic colour killer enabled
			1	colour forced on
6	polarity of RTS1 output signal	RTP1	0	non inverted
			1	inverted
5 and 4	fine position of HS (steps in 2/LLC)	HDEL[1:0]	00	0
			01	1
			10	2
			11	3
3	polarity of RTS0 output signal	RTP0	0	non inverted
			1	inverted
2 to 0	luminance delay compensation (steps in 2/LLC)	YDEL[2:0]	100	-4...
			000	...0...
			011	...3

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## 18.2.2.19 Subaddress 12H

**Table 171** RT signal control: RTS0 output; 12H[3:0]

The polarity of any signal on RTS0 can be inverted via RTP0[11H[3]].

RTS0 OUTPUT	RTSE03	RTSE02	RTSE01	RTSE00
3-state	0	0	0	0
Constant LOW	0	0	0	1
CREF (13.5 MHz toggling pulse; see Fig.32)	0	0	1	0
CREF2 (6.75 MHz toggling pulse; see Fig.32)	0	0	1	1
HL; horizontal lock indicator (note 1): HL = 0: unlocked HL = 1: locked	0	1	0	0
VL; vertical and horizontal lock: VL = 0: unlocked VL = 1: locked	0	1	0	1
DL; vertical and horizontal lock and colour detected: DL = 0: unlocked DL = 1: locked	0	1	1	0
Reserved	0	1	1	1
HREF, horizontal reference signal; indicates 720 pixels valid data on the expansion port. The positive slope marks the beginning of a new active line. HREF is also generated during the vertical blanking interval; see Fig.32.	1	0	0	0
HS: programmable width in LLC8 steps via HSB[7:0] 06H[7:0] and HSS[7:0] 07H[7:0] fine position adjustment in LLC2 steps via HDEL[1:0] 11H[5:4]; see Fig.32	1	0	0	1
HQ; HREF gated with VGATE	1	0	1	0
Reserved	1	0	1	1
V123; vertical sync; see vertical timing diagrams Figs 30 and 31	1	1	0	0
VGATE; programmable via VSTA[8:0] 17H[0] 15H[7:0], VSTO[8:0] 17H[1] 16H[7:0] and VGPS[17H[2]]	1	1	0	1
LSBs of the 9-bit ADC's	1	1	1	0
FID; position programmable via VSTA[8:0] 17H[0] 15H[7:0]; see vertical timing diagrams Figs 30 and 31	1	1	1	1

**Note**

1. Function of HL is selectable via HLSEL[13H[3]]:
  - a) HLSEL = 0: HL is standard horizontal lock indicator.
  - b) HLSEL = 1: HL is fast horizontal lock indicator (use is not recommended for sources with unstable timebase e.g. VCRs).

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**Table 172** RT signal control: RTS1 output; 12H[7:4]

The polarity of any signal on RTS1 can be inverted via RTP1[11H[6]].

RTS1 OUTPUT CONTROL	RTSE13	RTSE12	RTSE11	RTSE10
3-state	0	0	0	0
Constant LOW	0	0	0	1
CREF (13.5 MHz toggling pulse; see Fig.32)	0	0	1	0
CREF2 (6.75 MHz toggling pulse; see Fig.32)	0	0	1	1
HL; horizontal lock indicator (note 1):	0	1	0	0
HL = 0: unlocked				
HL = 1: locked				
VL; vertical and horizontal lock:	0	1	0	1
VL = 0: unlocked				
VL = 1: locked				
DL; vertical and horizontal lock and colour detected:	0	1	1	0
DL = 0: unlocked				
DL = 1: locked				
Reserved	0	1	1	1
HREF; horizontal reference signal: indicates 720 pixels valid data on the expansion port. The positive slope marks the beginning of a new active line. HREF is also generated during the vertical blanking interval; see Fig.32.	1	0	0	0
HS:	1	0	0	1
programmable width in LLC8 steps via HSB[7:0] 06H[7:0] and HSS[7:0] 07H[7:0]				
fine position adjustment in LLC2 steps via HDEL[1:0] 11H[5:4]; see Fig.32				
HQ; HREF gated with VGATE	1	0	1	0
Reserved	1	0	1	1
V123; vertical sync; see vertical timing diagrams Figs 30 and 31	1	1	0	0
VGATE; programmable via VSTA[8:0] 17H[0] 15H[7:0], VSTO[8:0] 17H[1] 16H[7:0] and VGPS[17H[2]]	1	1	0	1
Reserved	1	1	1	0
FID; position programmable via VSTA[8:0] 17H[0] 15H[7:0]; see vertical timing diagrams Figs 30 and 31	1	1	1	1

**Note**

1. Function of HL is selectable via HLSEL[13H[3]]:
  - a) HLSEL = 0: HL is standard horizontal lock indicator.
  - b) HLSEL = 1: HL is fast horizontal lock indicator (use is not recommended for sources with unstable timebase e.g. VCRs).

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18.2.2.20 Subaddress 13H

**Table 173** RT/X port output control; 13H[7:0]

BIT	DESCRIPTION	SYMBOL	VALUE	FUNCTION
7	RTCO output enable	RTCE	0	3-state
			1	enabled
6	X port XRH output selection	XRHS	0	HREF; see Fig.32
			1	HS: programmable width in LLC8 steps via HSB[7:0] 06H[7:0] and HSS[7:0] 07H[7:0] fine position adjustment in LLC2 steps via HDEL[1:0] 11H[5:4]; see Fig.32
5 and 4	X port XRV output selection	XRVS[1:0]	00	V123; see Figs 30 and 31
			01	ITU 656 related field ID; see Figs 30 and 31
			10	inverted V123
			11	inverted ITU 656 related field ID
3	horizontal lock indicator selection	HLSEL	0	copy of inverted HLCK status bit (default)
			1	fast horizontal lock indicator (for special applications only)
2 to 0	XPD7 to XPD0 (port output format selection); see Section 10.4	OFTS[2:0]	000	ITU 656
			001	ITU 656 like format with modified field blanking according to VGATE position (programmable via VSTA[8:0] 17H[0] 15H[7:0], VSTO[8:0] 17H[1] 16H[7:0] and VGPS[17H[2]])
			010	Y-C <sub>B</sub> -C <sub>R</sub> 4 : 2 : 2 8-bit format (no SAV/EAV codes inserted)
			011	reserved
			100	multiplexed AD2/AD1 bypass (bits 8 to 1) dependent on mode settings; if both ADCs are selected AD2 is output at CREF = 1 and AD1 is output at CREF = 0
			101	multiplexed AD2/AD1 bypass (bits 7 to 0) dependent on mode settings; if both ADCs are selected AD2 is output at CREF = 1 and AD1 is output at CREF = 0
			110	reserved
			111	multiplexed ADC MSB/LSB bypass dependent on mode settings; only one ADC should be selected at a time; ADx8 to ADx1 are outputs at CREF = 1 and ADx7 to ADx0 are outputs at CREF = 0

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18.2.2.21 Subaddress 14H

**Table 174** Analog/ADC/compatibility control; 14H[7:0]

BIT	DESCRIPTION	SYMBOL	VALUE	FUNCTION
7	compatibility bit for SAA7199	CM99	0	off (default)
			1	on (to be set <b>only</b> if SAA7199 is used for re-encoding <b>in conjunction with RTCO active</b> )
6	update time interval for AGC value	UPTCV	0	horizontal update (once per line)
			1	vertical update (once per field)
5 and 4	analog test select	AOSL[1:0]	00	AOUT connected to internal test point 1
			01	AOUT connected to input AD1
			10	AOUT connected to input AD2
			11	AOUT connected to internal test point 2
3	XTOUTd output enable	XTOUTE	0	pin P4 (XTOUTd) 3-stated
			1	pin P4 (XTOUTd) enabled
2	decoder status byte selection; see Table 180	OLDSB	0	standard
			1	backward compatibility to SAA7112
1 and 0	ADC sample clock phase delay	APCK[1:0]	00	application dependent
			01	
			10	
			11	

## 18.2.2.22 Subaddress 15H

**Table 175** VGATE start; FID polarity change; 17H[0] and 15H[7:0]

Start of VGATE pulse (LOW-to-HIGH transition) and polarity change of FID pulse, VGPS = 0; see Figs 30 and 31.

FIELD		FRAME LINE COUNTING	DECIMAL VALUE	MSB 17H[0]	CONTROL BITS 7 TO 0								
					VSTA8	VSTA7	VSTA6	VSTA5	VSTA4	VSTA3	VSTA2	VSTA1	VSTA0
50 Hz	1st	1	312	1	0	0	1	1	1	0	0	0	0
	2nd	314											
	1st	2	0...	0	0	0	0	0	0	0	0	0	0
	2nd	315											
	1st	312	...310	1	0	0	1	1	0	1	1	1	1
	2nd	625											
60 Hz	1st	4	262	1	0	0	0	0	0	1	1	0	0
	2nd	267											
	1st	5	0...	0	0	0	0	0	0	0	0	0	0
	2nd	268											
	1st	265	...260	1	0	0	0	0	0	1	0	1	0
	2nd	3											

## 18.2.2.23 Subaddress 16H

**Table 176** VGATE stop; 17H[1] and 16H[7:0]

Stop of VGATE pulse (HIGH-to-LOW transition), VGPS = 0; see Figs 30 and 31.

FIELD		FRAME LINE COUNTING	DECIMAL VALUE	MSB 17H[1]	CONTROL BITS 7 TO 0								
					VSTO8	VSTO7	VSTO6	VSTO5	VSTO4	VSTO3	VSTO2	VSTO1	VSTO0
50 Hz	1st	1	312	1	0	0	1	1	1	0	0	0	0
	2nd	314											
	1st	2	0...	0	0	0	0	0	0	0	0	0	0
	2nd	315											
	1st	312	..310	1	0	0	1	1	0	1	1	1	1
	2nd	625											
60 Hz	1st	4	262	1	0	0	0	0	0	1	1	0	0
	2nd	267											
	1st	5	0...	0	0	0	0	0	0	0	0	0	0
	2nd	268											
	1st	265	..260	1	0	0	0	0	0	1	0	1	1
	2nd	3											

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## 18.2.2.24 Subaddress 17H

**Table 177** Miscellaneous/VGATE MSBs; 17H[7:6] and 17H[2:0]

BIT	DESCRIPTION	SYMBOL	VALUE	FUNCTION
7	LLC output enable	LLCE	0	enable
			1	3-state
6	LLC2 output enable	LLC2E	0	enable
			1	3-state
2	alternative VGATE position	VGPS	0	VGATE position according to Tables 175 and 176
			1	VGATE occurs one line earlier during field 2
1	MSB VGATE stop	VSTO8	see Table 176	
0	MSB VGATE start	VSTA8	see Table 175	

## 18.2.2.25 Subaddress 18H

**Table 178** Raw data gain control; RAWG[7:0] 18H[7:0]; see Fig.27

GAIN	CONTROL BITS 7 TO 0							
	RAWG7	RAWG6	RAWG5	RAWG4	RAWG3	RAWG2	RAWG1	RAWG0
255 (double amplitude)	0	1	1	1	1	1	1	1
128 (nominal level)	0	1	0	0	0	0	0	0
0 (off)	0	0	0	0	0	0	0	0

## 18.2.2.26 Subaddress 19H

**Table 179** Raw data offset control; RAWO[7:0] 19H[7:0]; see Fig.27

OFFSET	CONTROL BITS 7 TO 0							
	RAWO7	RAWO6	RAWO5	RAWO4	RAWO3	RAWO2	RAWO1	RAWO0
-128 LSB	0	0	0	0	0	0	0	0
0 LSB	1	0	0	0	0	0	0	0
+128 LSB	1	1	1	1	1	1	1	1

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## 18.2.2.27 Subaddress 1FH

**Table 180** Status byte video decoder; 1FH[7:0]; read only register

BIT	DESCRIPTION	I <sup>2</sup> C-BUS CONTROL BIT	OLDSB 14H[2]	VALUE	FUNCTION
7	status bit for interlace detection	INTL	–	0	non-interlaced
				1	interlaced
6	status bit for horizontal and vertical loop	HLVLN	0	0	both loops locked
				1	unlocked
5	status bit for locked horizontal frequency	HLCK	1	0	locked
				1	unlocked
4	identification bit for detected field frequency	FIDT	–	0	50 Hz
				1	60 Hz
3	gain value for active luminance channel is limited; maximum (top)	GLIMT	–	0	not active
				1	active
2	gain value for active luminance channel is limited; minimum (bottom)	GLIMB	–	0	not active
				1	active
1	white peak loop is activated	WIPA	–	0	not active
				1	active
0	copy protected source detected according to Macrovision version up to 7.01	COPRO	0	0	not active
				1	active
	slow time constant active in WIPA mode	SLTCA	1	0	not active
				1	active
	ready for capture (all internal loops locked)	RDCAP	0	0	not active
				1	active
	colour signal in accordance with selected standard has been detected	CODE	1	0	not active
				1	active

## 18.2.3 PROGRAMMING REGISTER AUDIO CLOCK GENERATION

See equations in Section 9.6 and examples in Tables 35 and 36.

## 18.2.3.1 Subaddresses 30H to 32H

**Table 181** Audio master clock (AMCLK) cycles per field

SUBADDRESS	CONTROL BITS 7 TO 0								
30H	ACPF7	ACPF6	ACPF5	ACPF4	ACPF3	ACPF2	ACPF1	ACPF0	
31H	ACPF15	ACPF14	ACPF13	ACPF12	ACPF11	ACPF10	ACPF9	ACPF8	
32H	–	–	–	–	–	–	ACPF17	ACPF16	

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## 18.2.3.2 Subaddresses 34H to 36H

**Table 182** Audio master clock (AMCLK) nominal increment

SUBADDRESS	CONTROL BITS 7 TO 0							
34H	ACNI7	ACNI	ACNI5	ACNI4	ACNI3	ACNI2	ACNI1	ACNI0
35H	ACNI15	ACNI14	ACNI13	ACNI12	ACNI11	ACNI10	ACNI9	ACNI8
36H	—	—	ACNI21	ACNI20	ACNI19	ACNI18	ACNI17	ACNI16

## 18.2.3.3 Subaddress 38H

**Table 183** Clock ratio audio master clock (AMXCLK) to serial bit clock (ASCLK)

SUBADDRESS	CONTROL BITS 7 TO 0							
38H	—	—	SDIV5	SDIV4	SDIV3	SDIV2	SDIV1	SDIV0

## 18.2.3.4 Subaddress 39H

**Table 184** Clock ratio serial bit clock (ASCLK) to channel select clock (ALRCLK)

SUBADDRESS	CONTROL BITS 7 TO 0							
39H	—	—	LRDIV5	LRDIV4	LRDIV3	LRDIV2	LRDIV1	LRDIV0

## 18.2.3.5 Subaddress 3AH

**Table 185** Audio clock control; 3AH[3:0]

BIT	DESCRIPTION	SYMBOL	VALUE	FUNCTION
3	audio PLL modes	APLL	0	PLL active, AMCLK is field-locked
			1	PLL open, AMCLK is free-running
2	audio master clock vertical reference	AMVR	0	vertical reference pulse is taken from internal decoder
			1	vertical reference is taken from XRV input (expansion port)
1	ALRCLK phase	LRPH	0	ALRCLK edges triggered by falling edges of ASCLK
			1	ALRCLK edges triggered by rising edges of ASCLK
0	ASCLK phase	SCPH	0	ASCLK edges triggered by falling edges of AMCLK
			1	ASCLK edges triggered by rising edges of AMCLK

## 18.2.4 PROGRAMMING REGISTER VBI DATA SLICER

## 18.2.4.1 Subaddress 40H

**Table 186** Slicer control 1; 40H[6:4]

BIT	DESCRIPTION	SYMBOL	VALUE	FUNCTION
6	Hamming check	HAM_N	0	Hamming check for 2 bytes after framing code, dependent on data type (default)
			1	no Hamming check
5	framing code error	FCE	0	one framing code error allowed
			1	no framing code errors allowed
4	amplitude searching	HUNT_N	0	amplitude searching active (default)
			1	amplitude searching stopped

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## 18.2.4.2 Subaddresses 41H to 57H

**Table 187** Line control register; LCR2 to LCR24 (41H to 57H); see Sections 9.2 and 9.4

NAME	DESCRIPTION	FRAMING CODE	BITS 7 TO 4 (41H TO 57H)	BITS 3 TO 0 (41H TO 57H)
			DT[3:0] 62H[3:0] (FIELD 1)	DT[3:0] 62H[3:0] (FIELD 2)
WST625	teletext EuroWST, CCST	27H	0000	0000
CC625	European Closed Caption	001	0001	0001
VPS	video programming service	9951H	0010	0010
WSS	wide screen signalling bits	1E3C1FH	0011	0011
WST525	US teletext (WST)	27H	0100	0100
CC525	US Closed Caption (line 21)	001	0101	0101
Test line	video component signal, VBI region	–	0110	0110
Intercast	raw data	–	0111	0111
General text	teletext	programmable	1000	1000
VITC625	VITC/EBU time codes (Europe)	programmable	1001	1001
VITC525	VITC/SMPTE time codes (USA)	programmable	1010	1010
Reserved	reserved	–	1011	1011
NABTS	US NABTS	–	1100	1100
Japtext	MOJI (Japanese)	programmable (A7H)	1101	1101
JFS	Japanese format switch (L20/22)	programmable	1110	1110
Active video	<b>video component signal, active video region (default)</b>	–	1111	1111

## 18.2.4.3 Subaddress 58H

**Table 188** Programmable framing code; slicer set 58H[7:0]; see Tables 28 and 187

FRAMING CODE FOR PROGRAMMABLE DATA TYPES	CONTROL BITS 7 TO 0
Default value	FC[7:0] = 40H

## 18.2.4.4 Subaddress 59H

**Table 189** Horizontal offset for slicer; slicer set 59H and 5BH

HORIZONTAL OFFSET	CONTROL BITS 5BH[2:0]	CONTROL BITS 59H[7:0]
Recommended value	HOFF[10:8] = 3H	HOFF[7:0] = 47H

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## SAA7108AE; SAA7109AE

## 18.2.4.5 Subaddress 5AH

**Table 190** Vertical offset for slicer; slicer set 5AH and 5BH

VERTICAL OFFSET	CONTROL BIT 5BH[4] VOFF8	CONTROL BITS 5AH[7:0] VOFF[7:0]
Minimum value 0	0	00H
Maximum value 312	1	38H
Value for 50 Hz 625 lines input	0	03H
Value for 60 Hz 525 lines input	0	06H

## 18.2.4.6 Subaddress 5BH

**Table 191** Field offset, and MSBs for horizontal and vertical offsets; slicer set 5BH[7:6]

See Sections 18.2.4.4 and 18.2.4.5 for HOFF[10:8] 5BH[2:0] and VOFF8[5BH[4]].

BIT	DESCRIPTION	SYMBOL	VALUE	FUNCTION
7	field offset	FOFF	0	no modification of internal field indicator (default for 50 Hz 625 lines input sources)
			1	invert field indicator (default for 60 Hz 525 lines input sources)
6	recode	RECODE	0	<b>let data unchanged (default)</b>
			1	convert 00H and FFH data bytes into 03H and FCH

## 18.2.4.7 Subaddress 5DH

**Table 192** Header and data identification (DID; ITU 656) code control; slicer set 5DH[7:0]

BIT	DESCRIPTION	SYMBOL	VALUE	FUNCTION	
7	field ID and V-blank selection for text output (F and V reference selection)	FVREF	0	F and V output of slicer is LCR table dependent	
			1	F and V output is taken from decoder real time signals EVEN_ITU and VBLNK_ITU	
5 to 0	<b>default; DID[5:0] = 00H</b>	DID[5:0]	00 0000	<b>ANC header framing</b> ; see Fig.39 and Table 34	
	special cases of DID programming		11 1110	DID[5:0] = 3EH SAV/EAV framing, with FVREF = 1	
			11 1111	DID[5:0] = 3FH SAV/EAV framing, with FVREF = 0	

## 18.2.4.8 Subaddress 5EH

**Table 193** Sliced data identification (SDID) code; slicer set 5EH[5:0]

BIT	DESCRIPTION	SYMBOL	VALUE	FUNCTION
5 to 0	SDID codes	SDID[5:0]	00H	<b>default</b>

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## 18.2.4.9 Subaddress 60H

**Table 194** Slicer status byte 0; 60H[6:2]; read only register

BIT	DESCRIPTION	SYMBOL	VALUE	FUNCTION
6	framing code valid	FC8V	0	no framing code (0 error) in the last frame detected
			1	framing code with 0 error detected
5	framing code valid	FC7V	0	no framing code (1 error) in the last frame detected
			1	framing code with 1 error detected
4	VPS valid	VPSV	0	no VPS in the last frame
			1	VPS detected
3	PALplus valid	PPV	0	no PALplus in the last frame
			1	PALplus detected
2	Closed Caption valid	CCV	0	no Closed Caption in the last frame
			1	Closed Caption detected

## 18.2.4.10 Subaddresses 61H and 62H

**Table 195** Slicer status byte 1; 61H[5:0] and slicer status byte 2; 62H[7:0]; read only registers

SUBADDRESS	BIT	SYMBOL	DESCRIPTION
61H	5	F21_N	field ID as seen by the VBI slicer; for field 1: bit 5 = 0
	4 to 0	LN[8:4]	line number
62H	7 to 4	LN[3:0]	data type; according to Table 28
	3 to 0	DT[3:0]	

## 18.2.5 PROGRAMMING REGISTER INTERFACES AND SCALER PART

## 18.2.5.1 Subaddress 80H

**Table 196** Global control 1; global set 80H[6:4]

SWRST moved to subaddress 88H[5]; note 1.

TASK ENABLE CONTROL	CONTROL BITS 6 TO 4		
	SMOD	TEB	TEA
Task of register set A is disabled	X	X	0
Task of register set A is enabled	X	X	1
Task of register set B is disabled	X	0	X
Task of register set B is enabled	X	1	X
The scaler window defines the F and V timing of the scaler output	0	X	X
VBI data slicer defines the F and V timing of the scaler output	1	X	X

**Note**

1. X = don't care.

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## SAA7108AE; SAA7109AE

**Table 197** Global control 1; global set 80H[3:0]; note 1

I PORT AND SCALER BACK-END CLOCK SELECTION	CONTROL BITS 3 TO 0			
	ICKS3	ICKS2	ICKS1	ICKS0
ICLK output and back-end clock is line-locked clock LLC from decoder	X	X	0	0
ICLK output and back-end clock is XCLK from X port	X	X	0	1
ICLK output is LLC and back-end clock is LLC2 clock	X	X <sup>(2)</sup>	1	0
Back-end clock is the ICLK input	X	X	1	1
IDQ pin carries the data qualifier	X	0	X	X
IDQ pin carries a gated back-end clock (IDQ AND CLK)	X	1	X	X
IDQ generation only for valid data	0	X	X	X
IDQ qualifies valid data inside the scaling region and all data outside the scaling region	1	X	X	X

**Notes**

1. Although the ICLKO I/O is independent of ICKS2 and ICKS3, this selection can only be used if ICKS2 = 1.
2. X = don't care.

## 18.2.5.2 Subaddresses 83H to 87H

**Table 198** X port I/O enable and output clock phase control; global set 83H[5:4]

OUTPUT CLOCK PHASE CONTROL	CONTROL BITS 5 AND 4	
	XPCK1	XPCK0
<b>XCLK default output phase, recommended value</b>	0	0
XCLK output inverted	0	1
XCLK phase shifted by about 3 ns	1	0
XCLK output inverted and shifted by about 3 ns	1	1

**Table 199** X port I/O enable and output clock phase control; global set 83H[2:0]

X PORT I/O ENABLE	CONTROL BITS 2 TO 0		
	XRQT	XPE1	XPE0
X port output is disabled by software	X <sup>(1)</sup>	0	0
X port output is enabled by software	X	0	1
X port output is enabled by pin XTRI at logic 0	X	1	0
X port output is enabled by pin XTRI at logic 1	X	1	1
XRDY output signal is A/B task flag from event handler (A = 1)	0	X	X
XRDY output signal is ready signal from scaler path (XRDY = 1 means SAA7108AE; SAA7109AE is ready to receive data)	1	X	X

**Note**

1. X = don't care

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## SAA7108AE; SAA7109AE

**Table 200** I port signal definitions; global set 84H[7:6] and 86H[5]

I PORT SIGNAL DEFINITIONS	CONTROL BITS		
	86H[5]	84H[7:6]	
	IDG02	IDG01	IDG00
IGP0 is output field ID, as defined by OFIDC[90H[6]]	0	0	0
IGP0 is A/B task flag, as defined by CONLH[90H[7]]	0	0	1
IGP0 is sliced data flag, framing the sliced VBI data at the I port	0	1	0
<b>IGP0 is set to logic 0 (default polarity)</b>	0	1	1
IGP0 is the output FIFO almost filled flag	1	0	0
IGP0 is the output FIFO overflow flag	1	0	1
IGP0 is the output FIFO almost full flag, level to be programmed in subaddress 86H	1	1	0
IGP0 is the output FIFO almost empty flag, level to be programmed in subaddress 86H	1	1	1

**Table 201** I port signal definitions; global set 84H[5:4] and 86H[4]

I PORT SIGNAL DEFINITIONS	CONTROL BITS		
	86H[4]	84H[5:4]	
	IDG12	IDG11	IDG10
IGP1 is output field ID, as defined by OFIDC[90H[6]]	0	0	0
IGP1 is A/B task flag, as defined by CONLH[90H[7]]	0	0	1
IGP1 is sliced data flag, framing the sliced VBI data at the I port	0	1	0
<b>IGP1 is set to logic 0 (default polarity)</b>	0	1	1
IGP1 is the output FIFO almost filled flag	1	0	0
IGP1 is the output FIFO overflow flag	1	0	1
IGP1 is the output FIFO almost full flag, level to be programmed in subaddress 86H	1	1	0
IGP1 is the output FIFO almost empty flag, level to be programmed in subaddress 86H	1	1	1

**Table 202** I port output signal definitions; global set 84H[3:0]; note 1

I PORT OUTPUT SIGNAL DEFINITIONS	CONTROL BITS 3 TO 0			
	IDV1	IDV0	IDH1	IDH0
IGPH is a H gate signal, framing the scaler output	X	X	0	0
IGPH is an extended H gate (framing H gate during scaler output and scaler input H reference outside the scaler window)	X	X	0	1
IGPH is a horizontal trigger pulse, on active going edge of H gate	X	X	1	0
IGPH is a horizontal trigger pulse, on active going edge of extended H gate	X	X	1	1
IGPV is a V gate signal, framing scaled output lines	0	0	X	X
IGPV is the V reference signal from scaler input	0	1	X	X
IGPV is a vertical trigger pulse, derived from V gate	1	0	X	X
IGPV is a vertical trigger pulse derived from input V reference	1	1	X	X

**Note**

1. X = don't care.

## HD-CODEC

## SAA7108AE; SAA7109AE

**Table 203** X port signal definitions text slicer; global set 85H[7:5]; note 1

X PORT SIGNAL DEFINITIONS TEXT SLICER	CONTROL BITS 7 TO 5		
	ISWP1	ISWP0	ILLV
Video data limited to range 1 to 254	X	X	0
Video data limited to range 8 to 247	X	X	1
Dword byte swap, influences serial output timing D0 D1 D2 D3 $\Rightarrow$ FF 00 00 SAV C <sub>B</sub> 0 Y0 C <sub>R</sub> 0 Y1	0	0	X
D1 D0 D3 D2 $\Rightarrow$ 00 FF SAV 00 Y0 C <sub>B</sub> 0 Y1 C <sub>R</sub> 0	0	1	X
D2 D3 D0 D1 $\Rightarrow$ 00 SAV FF 00 C <sub>R</sub> 0 Y1 C <sub>B</sub> 0 Y0	1	0	X
D3 D2 D1 D0 $\Rightarrow$ SAV 00 00 FF Y1 C <sub>R</sub> 0 Y0 C <sub>B</sub> 0	1	1	X

**Note**

1. X = don't care.

**Table 204** I port reference signal polarities; global set 85H[4:0]; note 1

I PORT REFERENCE SIGNAL POLARITIES	CONTROL BITS 4 TO 0				
	IG0P	IG1P	IRVP	IRHP	IDQP
IDQ at default polarity (1 = active)	X	X	X	X	0
IDQ is inverted	X	X	X	X	1
IGPH at default polarity (1 = active)	X	X	X	0	X
IGPH is inverted	X	X	X	1	X
IGPV at default polarity (1 = active)	X	X	0	X	X
IGPV is inverted	X	X	1	X	X
IGP1 at default polarity	X	0	X	X	X
IGP1 is inverted	X	1	X	X	X
IGP0 at default polarity	0	X	X	X	X
IGP0 is inverted	1	X	X	X	X

**Note**

1. X = don't care.

## HD-CODEC

## SAA7108AE; SAA7109AE

**Table 205** I port FIFO flag control and arbitration; global set 86H[7:4]; note 1

FUNCTION	CONTROL BITS 7 TO 4			
	VITX1	VITX0	IDG02	IDG12
See subaddress 84H: IDG11 and IDG10	X	X	X	0
	X	X	X	1
See subaddress 84H: IDG01 and IDG00	X	X	0	X
	X	X	1	X
<b>I port signal definitions</b>				
I port data output inhibited	0	0	X	X
Only video data are transferred	0	1	X	X
Only text data are transferred (no EAV, SAV will occur)	1	0	X	X
Text and video data are transferred, text has priority	1	1	X	X

**Note**

1. X = don't care.

**Table 206** I port FIFO flag control and arbitration; global set 86H[3:0]; note 1

I PORT FIFO FLAG CONTROL AND ARBITRATION	CONTROL BITS 3 TO 0			
	FFL1	FFL0	FEL1	FEL0
FAE FIFO flag almost empty level				
	X	X	0	0
	X	X	0	1
	X	X	1	0
FAF FIFO flag almost full level				
	0	0	X	X
	0	1	X	X
	1	0	X	X
32 Dwords	1	1	X	X

**Note**

1. X = don't care.

## HD-CODEC

## SAA7108AE; SAA7109AE

**Table 207** I port I/O enable, output clock and gated clock phase control; global set 87H[7:4]; note 1

OUTPUT CLOCK AND GATED CLOCK PHASE CONTROL	CONTROL BITS 7 TO 4			
	IPCK3 <sup>(2)</sup>	IPCK2 <sup>(2)</sup>	IPCK1	IPCK0
ICLK default output phase	X	X	0	0
ICLK phase shifted by $\frac{1}{2}$ clock cycle $\Rightarrow$ recommended for ICKS1 = 1 and ICKS0 = 0 (subaddress 80H)	X	X	0	1
ICLK phase shifted by about 3 ns	X	X	1	0
ICLK phase shifted by $\frac{1}{2}$ clock cycle + approximately 3 ns $\Rightarrow$ alternatively to setting '01'	X	X	1	1
IDQ = gated clock default output phase	0	0	X	X
IDQ = gated clock phase shifted by $\frac{1}{2}$ clock cycle $\Rightarrow$ recommended for gated clock output	0	1	X	X
IDQ = gated clock phase shifted by approximately 3 ns	1	0	X	X
IDQ = gated clock phase shifted by $\frac{1}{2}$ clock cycle + approximately 3 ns $\Rightarrow$ alternatively to setting '01'	1	1	X	X

**Notes**

1. X = don't care.
2. IPCK3 and IPCK2 only affects the gated clock (subaddress 80H, bit ICKS2 = 1).

**Table 208** I port I/O enable, output clock and gated clock phase control; global set 87H[1:0]

I PORT I/O ENABLE	CONTROL BITS 1 AND 0	
	IPE1	IPE0
I port output is disabled by software	0	0
I port output is enabled by software	0	1
I port output is enabled by pin ITRI at logic 0	1	0
I port output is enabled by pin ITRI at logic 1	1	1

## HD-CODEC

## SAA7108AE; SAA7109AE

## 18.2.5.3 Subaddress 88H

**Table 209** Power save control; global set 88H[7:4]; note 1

POWER SAVE CONTROL	CONTROL BITS 7 TO 4			
	CH4EN	CH2EN	SWRST <sup>(2)</sup>	DPROG
DPROG = 0 after reset	X	X	X	0
DPROG = 1 can be used to assign that the device has been programmed; this bit can be monitored in the scalers status byte, bit PRDON; if DPROG was set to logic 1 and PRDON status bit shows a logic 0, a power-up or start-up fail has occurred	X	X	X	1
Scaler path is reset to its idle state, software reset	X	X	0	X
Scaler is switched back to operation	X	X	1	X
AD1x analog channel is in Power-down mode	X	0	X	X
AD1x analog channel is active	X	1	X	X
AD2x analog channel is in Power-down mode	0	X	X	X
AD2x analog channel is active	1	X	X	X

**Notes**

1. X = don't care.
2. Bit SWRST is now located here.

**Table 210** Power save control; global set 88H[3] and 88H[1:0]; note 1

POWER SAVE CONTROL	CONTROL BITS 3, 1 AND 0		
	SLM3	SLM1	SLM0
Decoder and VBI slicer are in operational mode	X	X	0
Decoder and VBI slicer are in Power-down mode; scaler only operates, if scaler input and ICLK source is the X port (refer to subaddresses 80H and 91H/C1H)	X	X	1
Scaler is in operational mode	X	0	X
Scaler is in Power-down mode; scaler in power-down stops I port output	X	1	X
Audio clock generation active	0	X	X
Audio clock generation in power-down and output disabled	1	X	X

**Note**

1. X = don't care.

## HD-CODEC

## SAA7108AE; SAA7109AE

## 18.2.5.4 Subaddress 8FH

**Table 211** Status information scaler part; 8FH[7:0]; read only register

BIT	I <sup>2</sup> C-BUS STATUS BIT	FUNCTION <sup>(1)</sup>
7	XTRI	status on input pin XTRI, if not used for 3-state control, usable as hardware flag for software use
6	ITRI	status on input pin ITRI, if not used for 3-state control, usable as hardware flag for software use
5	FFIL	status of the internal 'FIFO almost filled' flag
4	FFOV	status of the internal 'FIFO overflow' flag
3	PRDON	copy of bit DPRG, can be used to detect power-up and start-up fails
2	ERROF	error flag of scalers output formatter, normally set, if the output processing needs to be interrupted, due to input/output data rate conflicts, e.g. if output data rate is much too low and all internal FIFO capacity used
1	FIDSCI	status of the field sequence ID at the scalers input
0	FIDSCO	status of the field sequence ID at the scalers output, scaler processing dependent

**Note**

1. Status information is unsynchronized and shows the actual status at the time of I<sup>2</sup>C-bus read.

## 18.2.5.5 Subaddresses 90H and C0H

**Table 212** Task handing control; register set A [90H[7:6]] and B [C0H[7:6]]; note 1

EVENT HANDLER CONTROL	CONTROL BITS 7 AND 6	
	CONLH	OFIDC
Output field ID is field ID from scaler input	X	0
Output field ID is task status flag, which changes every time an selected task is activated (not synchronized to input field ID)	X	1
<b>Scaler SAV/EAV byte bit 7 and task flag = 1, default</b>	0	X
Scaler SAV/EAV byte bit 7 and task flag = 0	1	X

**Note**

1. X = don't care.

**Table 213** Task handing control; register set A [90H[5:3]] and B [C0H[5:3]]

EVENT HANDLER CONTROL	CONTROL BITS 5 TO 3		
	FSKP2	FSKP1	FSKP0
Active task is carried out directly	0	0	0
1 field is skipped before active task is carried out	0	0	1
... fields are skipped before active task is carried out	...	...	...
6 fields are skipped before active task is carried out	1	1	0
7 fields are skipped before active task is carried out	1	1	1

## HD-CODEC

## SAA7108AE; SAA7109AE

**Table 214** Task handling control; register set A [90H[2:0]] and B [C0H[2:0]]; note 1

EVENT HANDLER CONTROL	CONTROL BITS 2 TO 0		
	RPTSK	STRC1	STRC0
Event handler triggers immediately after finishing a task	X	0	0
Event handler triggers with next V-sync	X	0	1
Event handler triggers with field ID = 0	X	1	0
Event handler triggers with field ID = 1	X	1	1
If active task is finished, handling is taken over by the next task	0	X	X
Active task is repeated once, before handling is taken over by the next task	1	X	X

**Note**

1. X = don't care.

## 18.2.5.6 Subaddresses 91H to 93H

**Table 215** X port formats and configuration; register set A [91H[7:3]] and B [C1H[7:3]]; note 1

SCALER INPUT FORMAT AND CONFIGURATION SOURCE SELECTION	CONTROL BITS 7 TO 3				
	CONLV	HLDFV	SCSRC1	SCSRC0	SCRQE
Only if XRQT[83H[2]] = 1: scaler input source reacts on SAA7108AE; SAA7109AE request	X	X	X	X	0
Scaler input source is a continuous data stream, which cannot be interrupted (must be logic 1 if SAA7108AE; SAA7109AE decoder part is source of scaler or XRQT[83H[2]] = 0)	X	X	X	X	1
Scaler input source is data from decoder, data type is provided according to Table 28	X	X	0	0	X
Scaler input source is Y-C <sub>B</sub> -C <sub>R</sub> data from X port	X	X	0	1	X
Scaler input source is raw digital CVBS from selected analog channel, for backward compatibility only, further use is not recommended	X	X	1	0	X
Scaler input source is raw digital CVBS (or 16-bit Y + C <sub>B</sub> -C <sub>R</sub> , if no 16-bit output are active) from X port	X	X	1	1	X
SAV/EAV code bits 6 and 5 (F and V) may change between SAV and EAV	X	0	X	X	X
SAV/EAV code bits 6 and 5 (F and V) are synchronized to scalers output line start	X	1	X	X	X
SAV/EAV code bit 5 (V) and V gate on pin IGPV as generated by the internal processing; see Fig.45	0	X	X	X	X
SAV/EAV code bit 5 (V) and V gate are inverted	1	X	X	X	X

**Note**

1. X = don't care.

## HD-CODEC

## SAA7108AE; SAA7109AE

**Table 216** X port formats and configuration; register set A [91H[2:0]] and B [C1H[2:0]]; note 1

SCALER INPUT FORMAT AND CONFIGURATION FORMAT CONTROL	CONTROL BITS 2 TO 0		
	FSC2 <sup>(2)</sup>	FSC1 <sup>(2)</sup>	FSC0
Input is Y-C <sub>B</sub> -C <sub>R</sub> 4 : 2 : 2 like sampling scheme	X	X	0
Input is Y-C <sub>B</sub> -C <sub>R</sub> 4 : 1 : 1 like sampling scheme	X	X	1
<b>Chroma is provided every line, default</b>	0	0	X
Chroma is provided every 2nd line	0	1	X
Chroma is provided every 3rd line	1	0	X
Chroma is provided every 4th line	1	1	X

**Notes**

1. X = don't care.
2. FSC2 and FSC1 only to be used, if X port input source don't provide chroma information for every input line. X port input stream must contain dummy chroma bytes.

**Table 217** X port input reference signal definitions; register set A [92H[7:4]] and B [C2H[7:4]]; note 1

X PORT INPUT REFERENCE SIGNAL DEFINITIONS	CONTROL BITS 7 TO 4			
	XFDV	XFDH	XDV1	XDV0
Rising edge of XRV input and decoder V123 is vertical reference	X	X	X	0
Falling edge of XRV input and decoder V123 is vertical reference	X	X	X	1
XRV is a V-sync or V gate signal	X	X	0	X
XRV is a frame sync, V pulses are generated internally on both edges of FS input	X	X	1	X
X port field ID is state of XRH at reference edge on XRV (defined by XFDV)	X	0	X	X
Field ID (decoder and X port field ID) is inverted	X	1	X	X
Reference edge for field detection is falling edge of XRV	0	X	X	X
Reference edge for field detection is rising edge of XRV	1	X	X	X

**Note**

1. X = don't care.

## HD-CODEC

## SAA7108AE; SAA7109AE

**Table 218** X port input reference signal definitions; register set A [92H[3:0]] and B [C2H[3:0]]; note 1

X PORT INPUT REFERENCE SIGNAL DEFINITIONS	CONTROL BITS 3 TO 0			
	XCODE	XDH	XDQ	XCKS
XCLK input clock and XDQ input qualifier are needed	X	X	X	0
Data rate is defined by XCLK only, no XDQ signal used	X	X	X	1
Data are qualified at XDQ input at logic 1	X	X	0	X
Data are qualified at XDQ input at logic 0	X	X	1	X
Rising edge of XRH input is horizontal reference	X	0	X	X
Falling edge of XRH input is horizontal reference	X	1	X	X
Reference signals are taken from XRH and XRV	0	X	X	X
Reference signals are decoded from EAV and SAV	1	X	X	X

**Note**

1. X = don't care.

**Table 219** I port output format and configuration; register set A [93H[7:5]] and B [C3H[7:5]]; note 1

I PORT OUTPUT FORMATS AND CONFIGURATION	CONTROL BITS 7 TO 5		
	ICODE	I8_16	FYSK
All lines will be output	X	X	0
Skip the number of leading Y only lines, as defined by FOI1 and FOI0	X	X	1
Dwords are transferred byte wise, see subaddress 85H bits ISWP1 and ISWP0	X	0	X
Dwords are transferred 16-bit word wise via IPD and HPD, see subaddress 85H bits ISWP1 and ISWP0	X	1	X
No ITU 656 like SAV/EAV codes are available	0	X	X
ITU 656 like SAV/EAV codes are inserted in the output data stream, framed by a qualifier	1	X	X

**Note**

1. X = don't care.

## HD-CODEC

## SAA7108AE; SAA7109AE

**Table 220** I port output format and configuration; register set A [93H[4:0]] and B [C3H[4:0]]; note 1

I PORT OUTPUT FORMATS AND CONFIGURATION	CONTROL BITS 4 TO 0				
	FOI1	FOI0	FSI2	FSI1	FSI0
4 : 2 : 2 Dword formatting	X	X	0	0	0
4 : 1 : 1 Dword formatting	X	X	0	0	1
4 : 2 : 0, only every 2nd line Y + C <sub>B</sub> -C <sub>R</sub> output, in between Y only output	X	X	0	1	0
4 : 1 : 0, only every 4th line Y + C <sub>B</sub> -C <sub>R</sub> output, in between Y only output	X	X	0	1	1
Y only	X	X	1	0	0
Not defined	X	X	1	0	1
Not defined	X	X	1	1	0
Not defined	X	X	1	1	1
No leading Y only line, before 1st Y + C <sub>B</sub> -C <sub>R</sub> line is output	0	0	X	X	X
1 leading Y only line, before 1st Y + C <sub>B</sub> -C <sub>R</sub> line is output	0	1	X	X	X
2 leading Y only lines, before 1st Y + C <sub>B</sub> -C <sub>R</sub> line is output	1	0	X	X	X
3 leading Y only lines, before 1st Y + C <sub>B</sub> -C <sub>R</sub> line is output	1	1	X	X	X

**Note**

1. X = don't care.

## 18.2.5.7 Subaddresses 94H to 9BH

**Table 221** Horizontal input window start; register set A [94H[7:0]; 95H[3:0]] and B [C4H[7:0]; C5H[3:0]]

HORIZONTAL INPUT ACQUISITION WINDOW DEFINITION OFFSET IN X (HORIZONTAL) DIRECTION <sup>(1)</sup>	CONTROL BITS												
	A [95H[3:0]] B [C5H[3:0]]				A [94H[7:0]] B [C4H[7:0]]								
	XO11	XO10	XO9	XO8	XO7	XO6	XO5	XO4	XO3	XO2	XO1	XO0	
A minimum of 2 should be kept, due to a line counting mismatch	0	0	0	0	0	0	0	0	0	0	1	0	
Odd offsets are changing the C <sub>B</sub> -C <sub>R</sub> sequence in the output stream to C <sub>R</sub> -C <sub>B</sub> sequence	0	0	0	0	0	0	0	0	0	0	1	1	
Maximum possible pixel offset = 4095	1	1	1	1	1	1	1	1	1	1	1	1	

**Note**

1. Reference for counting are luminance samples.

## HD-CODEC

## SAA7108AE; SAA7109AE

**Table 222** Horizontal input window length; register set A [96H[7:0]; 97H[3:0]] and B [C6H[7:0]; C7H[3:0]]

HORIZONTAL INPUT ACQUISITION WINDOW DEFINITION INPUT WINDOW LENGTH IN X (HORIZONTAL) DIRECTION <sup>(1)</sup>	CONTROL BITS											
	A [97H[3:0]] B [C7H[3:0]]				A [96H[7:0]] B [C6H[7:0]]							
	XS11	XS10	XS9	XS8	XS7	XS6	XS5	XS4	XS3	XS2	XS1	XS0
No output	0	0	0	0	0	0	0	0	0	0	0	0
Odd lengths are allowed, but will be rounded up to even lengths	0	0	0	0	0	0	0	0	0	0	0	1
Maximum possible number of input pixels = 4095	1	1	1	1	1	1	1	1	1	1	1	1

**Note**

1. Reference for counting are luminance samples.

**Table 223** Vertical input window start; register set A [98H[7:0]; 99H[3:0]] and B [C8H[7:0]; C9H[3:0]]

VERTICAL INPUT ACQUISITION WINDOW DEFINITION OFFSET IN Y (VERTICAL) DIRECTION <sup>(1)</sup>	CONTROL BITS											
	A [99H[3:0]] B [C9H[3:0]]				A [98H[7:0]] B [C8H[7:0]]							
	YO11	YO10	YO9	YO8	YO7	YO6	YO5	YO4	YO3	YO2	YO1	YO0
Line offset = 0	0	0	0	0	0	0	0	0	0	0	0	0
Line offset = 1	0	0	0	0	0	0	0	0	0	0	0	1
Maximum line offset = 4095	1	1	1	1	1	1	1	1	1	1	1	1

**Note**

1. For trigger condition: STRC[1:0] 90H[1:0] = 00; YO + YS > (number of input lines per field – 2), will result in field dropping. Other trigger conditions: YO > (number of input lines per field – 2), will result in field dropping.

**Table 224** Vertical input window length; register set A [9AH[7:0]; 9BH[3:0]] and B [CAH[7:0]; CBH[3:0]]

VERTICAL INPUT ACQUISITION WINDOW DEFINITION INPUT WINDOW LENGTH IN Y (VERTICAL) DIRECTION <sup>(1)</sup>	CONTROL BITS											
	A [9BH[3:0]] B [CBH[3:0]]				A [9AH[7:0]] B [CAH[7:0]]							
	YS11	YS10	YS9	YS8	YS7	YS6	YS5	YS4	YS3	YS2	YS1	YS0
No input lines	0	0	0	0	0	0	0	0	0	0	0	0
1 input line	0	0	0	0	0	0	0	0	0	0	0	1
Maximum possible number of input lines = 4095	1	1	1	1	1	1	1	1	1	1	1	1

**Note**

1. For trigger condition: STRC[1:0] 90H[1:0] = 00; YO + YS > (number of input lines per field – 2), will result in field dropping. Other trigger conditions: YS > (number of input lines per field – 2), will result in field dropping.

## HD-CODEC

## SAA7108AE; SAA7109AE

## 18.2.5.8 Subaddresses 9CH to 9FH

**Table 225** Horizontal output window length; register set A [9CH[7:0]; 9DH[3:0]] and B [CCH[7:0]; CDH[3:0]]

HORIZONTAL OUTPUT ACQUISITION WINDOW DEFINITION NUMBER OF DESIRED OUTPUT PIXEL IN X (HORIZONTAL) DIRECTION <sup>(1)</sup>	CONTROL BITS											
	A [9DH[3:0]] B [CDH[3:0]]				A [9CH[7:0]] B [CCH[7:0]]							
	XD11	XD10	XD9	XD8	XD7	XD6	XD5	XD4	XD3	XD2	XD1	XD0
No output	0	0	0	0	0	0	0	0	0	0	0	0
Odd lengths are allowed, but will be filled up to even lengths	0	0	0	0	0	0	0	0	0	0	0	1
Maximum possible number of input pixels = 4095; note 2	1	1	1	1	1	1	1	1	1	1	1	1

## Notes

1. Reference for counting are luminance samples.
2. If the desired output length is greater than the number of scaled output pixels, the last scaled pixel is repeated.

**Table 226** Vertical output window length; register set A [9EH[7:0]; 9FH[3:0]] and B [CEH[7:0]; CFH[3:0]]

VERTICAL OUTPUT ACQUISITION WINDOW DEFINITION NUMBER OF DESIRED OUTPUT LINES IN Y (VERTICAL) DIRECTION	CONTROL BITS											
	A [9FH[3:0]] B [CFH[3:0]]				A [9EH[7:0]] B [CEH[7:0]]							
	YD11	YD10	YD9	YD8	YD7	YD6	YD5	YD4	YD3	YD2	YD1	YD0
No output	0	0	0	0	0	0	0	0	0	0	0	0
1 pixel	0	0	0	0	0	0	0	0	0	0	0	1
Maximum possible number of output lines = 4095; note 1	1	1	1	1	1	1	1	1	1	1	1	1

## Note

1. If the desired output length is greater than the number of scaled output lines, the processing is cut.

## 18.2.5.9 Subaddresses A0H to A2H

**Table 227** Horizontal prescaling; register set A [A0H[5:0]] and B [D0H[5:0]]

HORIZONTAL INTEGER PRESCALING RATIO (XPSC)	CONTROL BITS 5 TO 0					
	XPSC5	XPSC4	XPSC3	XPSC2	XPSC1	XPSC0
Not allowed	0	0	0	0	0	0
Downscale = 1	0	0	0	0	0	1
Downscale = $1/2$	0	0	0	0	1	0
...	...	...	...	...	...	...
Downscale = $1/63$	1	1	1	1	1	1

## HD-CODEC

## SAA7108AE; SAA7109AE

**Table 228** Accumulation length; register set A [A1H[5:0]] and B [D1H[5:0]]

HORIZONTAL PRESCALER ACCUMULATION SEQUENCE LENGTH (XACL)	CONTROL BITS 5 TO 0					
	XACL5	XACL4	XACL3	XACL2	XACL1	XACL0
Accumulation length = 1	0	0	0	0	0	0
Accumulation length = 2	0	0	0	0	0	1
...	...	...	...	...	...	...
Accumulation length = 64	1	1	1	1	1	1

**Table 229** Prescaler DC gain and FIR prefilter control; register set A [A2H[7:4]] and B [D2H[7:4]]; note 1

FIR PREFILTER CONTROL	CONTROL BITS 7 TO 4			
	PFUV1	PFUV0	PFY1	PFY0
Luminance FIR filter bypassed	X	X	0	0
$H_y(z) = \frac{1}{4} (1 2 1)$	X	X	0	1
$H_y(z) = \frac{1}{8} (-1 1 1.75 4.5 1.75 1 -1)$	X	X	1	0
$H_y(z) = \frac{1}{8} (1 2 2 2 1)$	X	X	1	1
Chrominance FIR filter bypassed	0	0	X	X
$H_{uv}(z) = \frac{1}{4} (1 2 1)$	0	1	X	X
$H_{uv}(z) = \frac{1}{32} (3 8 10 8 3)$	1	0	X	X
$H_{uv}(z) = \frac{1}{8} (1 2 2 2 1)$	1	1	X	X

**Note**

1. X = don't care.

**Table 230** Prescaler DC gain and FIR prefilter control; register set A [A2H[3:0]] and B [D2H[3:0]]; note 1

PRESCALER DC GAIN	CONTROL BITS 3 TO 0			
	XC2_1	XDCG2	XDCG1	XDCG0
Prescaler output is renormalized by gain factor = 1	X	0	0	0
Prescaler output is renormalized by gain factor = $\frac{1}{2}$	X	0	0	1
Prescaler output is renormalized by gain factor = $\frac{1}{4}$	X	0	1	0
Prescaler output is renormalized by gain factor = $\frac{1}{8}$	X	0	1	1
Prescaler output is renormalized by gain factor = $\frac{1}{16}$	X	1	0	0
Prescaler output is renormalized by gain factor = $\frac{1}{32}$	X	1	0	1
Prescaler output is renormalized by gain factor = $\frac{1}{64}$	X	1	1	0
Prescaler output is renormalized by gain factor = $\frac{1}{128}$	X	1	1	1
Weighting of all accumulated samples is factor 1; e.g. XACL = 4 $\Rightarrow$ sequence 1 + 1 + 1 + 1 + 1 + 1	0	X	X	X
Weighting of samples inside sequence is factor 2; e.g. XACL = 4 $\Rightarrow$ sequence 1 + 2 + 2 + 2 + 1	1	X	X	X

**Note**

1. X = don't care.

## HD-CODEC

## SAA7108AE; SAA7109AE

## 18.2.5.10 Subaddresses A4H to A6H

**Table 231** Luminance brightness control; register set A [A4H[7:0]] and B [D4H[7:0]]

LUMINANCE BRIGHTNESS CONTROL	CONTROL BITS 7 TO 0							
	BRIG7	BRIG6	BRIG5	BRIG4	BRIG3	BRIG2	BRIG1	BRIG0
Value = 0	0	0	0	0	0	0	0	0
Nominal value = 128	1	0	0	0	0	0	0	0
Value = 255	1	1	1	1	1	1	1	1

**Table 232** Luminance contrast control; register set A [A5H[7:0]] and B [D5H[7:0]]

LUMINANCE CONTRAST CONTROL	CONTROL BITS 7 TO 0							
	CONT7	CONT6	CONT5	CONT4	CONT3	CONT2	CONT1	CONT0
Gain = 0	0	0	0	0	0	0	0	0
Gain = $1/64$	0	0	0	0	0	0	0	1
Nominal gain = 64	0	1	0	0	0	0	0	0
Gain = $127/64$	0	1	1	1	1	1	1	1

**Table 233** Chrominance saturation control; register set A [A6H[7:0]] and B [D6H[7:0]]

CHROMINANCE SATURATION CONTROL	CONTROL BITS 7 TO 0							
	SATN7	SATN6	SATN5	SATN4	SATN3	SATN2	SATN1	SATN0
Gain = 0	0	0	0	0	0	0	0	0
Gain = $1/64$	0	0	0	0	0	0	0	1
Nominal gain = 64	0	1	0	0	0	0	0	0
Gain = $127/64$	0	1	1	1	1	1	1	1

## 18.2.5.11 Subaddresses A8H to AEH

**Table 234** Horizontal luminance scaling increment; register set A [A8H[7:0]; A9H[7:0]] and B [D8H[7:0]; D9H[7:0]]

HORIZONTAL LUMINANCE SCALING INCREMENT	CONTROL BITS				
	A [A9H[7:4]] B [D9H[7:4]]	A [A9H[3:0]] B [D9H[3:0]]	A [A8H[7:4]] B [D8H[7:4]]	A [A8H[3:0]] B [D8H[3:0]]	
	XSCY[15:12] <sup>(1)</sup>	XSCY[11:8]	XSCY[7:4]	XSCY[3:0]	
Scale = $1024/1$ (theoretical) zoom	0000	0000	0000	0000	
Scale = $1024/294$ , lower limit defined by data path structure	0000	0001	0010	0110	
Scale = $1024/1023$ zoom	0000	0011	1111	1111	
Scale = 1, equals 1024	0000	0100	0000	0000	
Scale = $1024/1025$ downscale	0000	0100	0000	0001	
Scale = $1024/8191$ downscale	0001	1111	1111	1111	

**Note**

1. Bits XSCY[15:13] are reserved and are set to logic 0.

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**Table 235** Horizontal luminance phase offset; register set A [AAH[7:0]] and B [DAH[7:0]]

HORIZONTAL LUMINANCE PHASE OFFSET	CONTROL BITS 7 TO 0							
	XPHY7	XPHY6	XPHY5	XPHY4	XPHY3	XPHY2	XPHY1	XPHY0
Offset = 0	0	0	0	0	0	0	0	0
Offset = $\frac{1}{32}$ pixel	0	0	0	0	0	0	0	1
Offset = $\frac{32}{32}$ = 1 pixel	0	0	1	0	0	0	0	0
Offset = $\frac{255}{32}$ pixel	1	1	1	1	1	1	1	1

**Table 236** Horizontal chrominance scaling increment; register set A [ACH[7:0]; ADH[7:0]] and B [DCH[7:0]; DDH[7:0]]

HORIZONTAL CHROMINANCE SCALING INCREMENT	CONTROL BITS			
	A [ADH[7:4]] B [DDH[7:4]]	A [ADH[3:0]] B [DDH[3:0]]	A [ACH[7:4]] B [DCH[7:4]]	A [ACH[3:0]] B [DCH[3:0]]
	XSCC[15:12] <sup>(1)</sup>	XSCC[11:8]	XSCC[7:4]	XSCC[3:0]
This value must be set to the luminance value $\frac{1}{2}XSCY[15:0]$	0000	0000	0000	0000
	0000	0000	0000	0001
	0001	1111	1111	1111

**Note**

1. Bits XSCC[15:13] are reserved and are set to logic 0.

**Table 237** Horizontal chrominance phase offset; register set A [AEH[7:0]] and B [DEH[7:0]]

HORIZONTAL CHROMINANCE PHASE OFFSET	CONTROL BITS 7 TO 0							
	XPHC7	XPHC6	XPHC5	XPHC4	XPHC3	XPHC2	XPHC1	XPHC0
This value must be set to $\frac{1}{2}XPHY[7:0]$	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	1
	1	1	1	1	1	1	1	1

## 18.2.5.12 Subaddresses B0H to BFH

**Table 238** Vertical luminance scaling increment; register set A [B0H[7:0]; B1H[7:0]] and B [E0H[7:0]; E1H[7:0]]

VERTICAL LUMINANCE SCALING INCREMENT	CONTROL BITS			
	A [B1H[7:4]] B [E1H[7:4]]	A [B1H[3:0]] B [E1H[3:0]]	A [B0H[7:4]] B [E0H[7:4]]	A [B0H[3:0]] B [E0H[3:0]]
	YSCY[15:12]	YSCY[11:8]	YSCY[7:4]	YSCY[3:0]
Scale = $1024/1$ (theoretical) zoom	0000	0000	0000	0001
Scale = $1024/1023$ zoom	0000	0011	1111	1111
Scale = 1, equals 1024	0000	0100	0000	0000
Scale = $1024/1025$ downscale	0000	0100	0000	0001
Scale = $1/63.999$ downscale	1111	1111	1111	1111

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**Table 239** Vertical chrominance scaling increment; register set A [B2H[7:0]; B3H[7:0]] and B [E2H[7:0]; E3H[7:0]]

VERTICAL CHROMINANCE SCALING INCREMENT	CONTROL BITS			
	A [B3H[7:4]] B [E3H[7:4]]	A [B3H[3:0]] B [E3H[3:0]]	A [B2H[7:4]] B [E2H[7:4]]	A [B2H[3:0]] B [E2H[3:0]]
	YSCC[15:12]	YSCC[11:8]	YSCC[7:4]	YSCC[3:0]
This value must be set to the luminance value YSCY[15:0]	0000	0000	0000	0001
	1111	1111	1111	1111

**Table 240** Vertical scaling mode control; register set A [B4H[4 and 0]] and B [E4H[4 and 0]]; note 1

VERTICAL SCALING MODE CONTROL	CONTROL BITS 4 AND 0	
	YMIR	YMODE
Vertical scaling performs linear interpolation between lines	X	0
Vertical scaling performs higher order accumulating interpolation, better alias suppression	X	1
No mirroring	0	X
Lines are mirrored	1	X

**Note**

1. X = don't care.

**Table 241** Vertical chrominance phase offset '00'; register set A [B8H[7:0]] and B [E8H[7:0]]

VERTICAL CHROMINANCE PHASE OFFSET	CONTROL BITS 7 TO 0							
	YPC07	YPC06	YPC05	YPC04	YPC03	YPC02	YPC01	YPC00
Offset = 0	0	0	0	0	0	0	0	0
Offset = $\frac{32}{32}$ = 1 line	0	0	1	0	0	0	0	0
Offset = $\frac{255}{32}$ lines	1	1	1	1	1	1	1	1

**Table 242** Vertical luminance phase offset '00'; register set A [BCH[7:0]] and B [ECH[7:0]]

VERTICAL LUMINANCE PHASE OFFSET	CONTROL BITS 7 TO 0							
	YPY07	YPY06	YPY05	YPY04	YPY03	YPY02	YPY01	YPY00
Offset = 0	0	0	0	0	0	0	0	0
Offset = $\frac{32}{32}$ = 1 line	0	0	1	0	0	0	0	0
Offset = $\frac{255}{32}$ lines	1	1	1	1	1	1	1	1

## HD-CODEC

## SAA7108AE; SAA7109AE

**19 PROGRAMMING START SET-UP OF DIGITAL VIDEO DECODER PART****19.1 Decoder part**

The given values force the following behaviour of the SAA7108AE; SAA7109AE decoder part:

- The analog input AI11 expects an NTSC M, PAL B, D, G, H and I or SECAM signal in CVBS format; analog anti-alias filter and AGC active
- Automatic field detection enabled
- Standard ITU 656 output format enabled on the expansion port
- Contrast, brightness and saturation control in accordance with ITU standards
- Adaptive comb filter for luminance and chrominance activated
- Pins LLC, LLC2, XTOUTd, RTS0, RTS1 and RTCO are set to 3-state.

**Table 243** Decoder part start set-up values for the three main standards

SUB ADDRESS (HEX)	REGISTER FUNCTION	BIT NAME <sup>(1)</sup>	VALUES (HEX)		
			NTSC M	PAL B, D, G, H AND I	SECAM
00	chip version	ID7 to ID4	read only		
01	increment delay	X, X, X, X, IDEL3 to IDEL0	08	08	08
02	analog input control 1	FUSE1, FUSE0, GUDL1, GUDL0 and MODE3 to MODE0	C0	C0	C0
03	analog input control 2	X, HLNRS, VBSL, WPOFF, HOLDG, GAFIX, GAI28 and GAI18	10	10	10
04	analog input control 3	GAI17 to GAI10	90	90	90
05	analog input control 4	GAI27 to GAI20	90	90	90
06	horizontal sync start	HSB7 to HSB0	EB	EB	EB
07	horizontal sync stop	HSS7 to HSS0	E0	E0	E0
08	sync control	AUFD, FSEL, FOET, HTC1, HTC0, HPLL, VNOI1 and VNOI0	98	98	98
09	luminance control	BYPS, YCOMB, LDEL, LUBW and LUF13 to LUF10	40	40	1B
0A	luminance brightness control	DBRI7 to DBRI0	80	80	80
0B	luminance contrast control	DCON7 to DCON0	44	44	44
0C	chrominance saturation control	DSAT7 to DSAT0	40	40	40
0D	chrominance hue control	HUEC7 to HUEC0	00	00	00
0E	chrominance control 1	CDTO, CSTD2 to CSTD0, DCVF, FCTC, X and CCOMB	89	81	D0
0F	chrominance gain control	ACGC and CGAIN6 to CGAIN0	2A	2A	80
10	chrominance control 2	OFFU1, OFFU0, OFFV1, OFFV0, CHBW and LCBW2 to LCBW0	0E	06	00
11	mode/delay control	COLO, RTP1, HDEL1, HDEL0, RTP0 and YDEL2 to YDEL0	00	00	00

## HD-CODEC

## SAA7108AE; SAA7109AE

SUB ADDRESS (HEX)	REGISTER FUNCTION	BIT NAME <sup>(1)</sup>	VALUES (HEX)		
			NTSC M	PAL B, D, G, H AND I	SECAM
12	RT signal control	RTSE13 to RTSE10 and RTSE03 to RTSE00	00	00	00
13	RT/X port output control	RTCE, XRHS, XRVS1, XRVS0, HLSEL and OFTS2 to OFTS0	00	00	00
14	analog/ADC/compatibility control	CM99, UPTCV, AOSL1, AOSL0, XTOUTE, OLDSB, APCK1 and APCK0	00	00	00
15	VGATE start, FID change	VSTA7 to VSTA0	11	11	11
16	VGATE stop	VSTO7 to VSTO0	FE	FE	FE
17	miscellaneous, VGATE configuration and MSBs	LLCE, LLC2E, X, X, X, VGPS, VSTO8 and VSTA8	40	40	40
18	raw data gain control	RAWG7 to RAWG0	40	40	40
19	raw data offset control	RAWO7 to RAWO0	80	80	80
1A to 1E	reserved	X, X, X, X, X, X, X, X	00	00	00
1F	status byte video decoder (OLDSB = 0)	INTL, HLVLN, FIDT, GLIMT, GLIMB, WIPA, COPRO and RDCAP	read only		

**Note**

1. All X values must be set to logic 0.

## HD-CODEC

## SAA7108AE; SAA7109AE

**19.2 Audio clock generation part**

The given values force the following behaviour of the SAA7108AE; SAA7109AE audio clock generation part:

- Used crystal is 24.576 MHz
- Expected field frequency is 59.94 Hz (e.g. NTSC M standard)
- Generated audio master clock frequency at pin AMCLK is  $256 \times 44.1 \text{ kHz} = 11.2896 \text{ MHz}$
- AMCLK is externally connected to AMXCLK (short-cut between pins K12 and J12)
- ASCLK =  $32 \times 44.1 \text{ kHz} = 1.4112 \text{ MHz}$
- ALRCLK is 44.1 kHz.

**Table 244** Audio clock part set-up values

SUB ADDRESS (HEX)	REGISTER FUNCTION	BIT NAME <sup>(1)</sup>	START VALUES								
			7	6	5	4	3	2	1	0	HEX
30	audio master clock cycles per field; bits 7 to 0	ACPF7 to ACPF0	1	0	1	1	1	1	0	0	BC
31	audio master clock cycles per field; bits 15 to 8	ACPF15 to ACPF8	1	1	0	1	1	1	1	1	DF
32	audio master clock cycles per field; bits 17 and 16	X, X, X, X, X, X, ACPF17 and ACPF16	0	0	0	0	0	0	1	0	02
33	reserved	X, X, X, X, X, X, X, X	0	0	0	0	0	0	0	0	00
34	audio master clock nominal increment; bits 7 to 0	ACNI7 to ACNI0	1	1	0	0	1	1	0	1	CD
35	audio master clock nominal increment; bits 15 to 8	ACNI15 to ACNI8	1	1	0	0	1	1	0	0	CC
36	audio master clock nominal increment; bits 21 to 16	X, X, ACNI21 to ACNI16	0	0	1	1	1	0	1	0	3A
37	reserved	X, X, X, X, X, X, X, X	0	0	0	0	0	0	0	0	00
38	clock ratio AMXCLK to ASCLK	X, X, SDIV5 to SDIV0	0	0	0	0	0	0	1	1	03
39	clock ratio ASCLK to ALRCLK	X, X, LRDIV5 to LRDIV0	0	0	0	1	0	0	0	0	10
3A	audio clock generator basic set-up	X, X, X, X, APLL, AMVR, LRPH, SCPH	0	0	0	0	0	0	0	0	00
3B to 3F	reserved	X, X, X, X, X, X, X, X	0	0	0	0	0	0	0	0	00

**Note**

1. All X values must be set to logic 0.

## HD-CODEC

## SAA7108AE; SAA7109AE

**19.3 Data slicer and data type control part**

The given values force the following behaviour of the SAA7108AE; SAA7109AE VBI data slicer part:

- Closed captioning data is expected at line 21 of field 1 (60 Hz/525 line system)
- All other lines are processed as active video
- Sliced data are framed by ITU 656 like SAV/EAV sequence (DID[5:0] = 3EH  $\Rightarrow$  MSB of SAV/EAV = 1).

**Table 245** Data slicer start set-up values

SUB ADDRESS (HEX)	REGISTER FUNCTION	BIT NAME <sup>(1)</sup>	START VALUES								
			7	6	5	4	3	2	1	0	HEX
40	slicer control 1	X, HAM_N, FCE, HUNT_N, X, X, X, X	0	1	0	0	0	0	0	0	40
41 to 53	line control register 2 to 20	LCRn_7 to LCRn_0 (n = 2 to 20)	1	1	1	1	1	1	1	1	FF
54	line control register 21	LCR21_7 to LCR21_0	0	1	0	1	1	1	1	1	5F
55 to 57	line control register 22 to 24	LCRn_7 to LCRn_0 (n = 22 to 24)	1	1	1	1	1	1	1	1	FF
58	programmable framing code	FC7 to FC0	0	0	0	0	0	0	0	0	00
59	horizontal offset for slicer	HOFF7 to HOFF0	0	1	0	0	0	1	1	1	47
5A	vertical offset for slicer	VOFF7 to VOFF0	0	0	0	0	0	1	1	0	06 <sup>(2)</sup>
5B	field offset and MSBs for horizontal and vertical offset	FOFF, RECODE, X, VOFF8, X, HOFF10 to HOFF8	1	0	0	0	0	0	1	1	83 <sup>(2)</sup>
5C	reserved	X, X, X, X, X, X, X, X	0	0	0	0	0	0	0	0	00
5D	header and data identification code control	FVREF, X, DID5 to DID0	0	0	1	1	1	1	1	0	3E
5E	sliced data identification code	X, X, SDID5 to SDID0	0	0	0	0	0	0	0	0	00
5F	reserved	X, X, X, X, X, X, X, X	0	0	0	0	0	0	0	0	00
60	slicer status byte 0	–, FC8V, FC7V, VPSV, PPV, CCV, –, –	read-only register								
61	slicer status byte 1	–, –, F21_N, LN8 to LN4	read-only register								
62	slicer status byte 2	LN3 to LN0, DT3 to DT0	read-only register								

**Notes**

1. All X values must be set to logic 0.
2. Changes for 50 Hz/625 line systems: subaddress 5AH = 03H and subaddress 5BH = 03H.

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## SAA7108AE; SAA7109AE

## 19.4 Scaler and interfaces

Table 246 shows some examples for the scaler programming where:

- prsc = prescale ratio
- fisc = fine scale ratio
- vsc = vertical scale ratio.

The ratio is defined as: 
$$\frac{\text{number of input pixel}}{\text{number of output pixel}}$$

In the following settings the VBI data slicer is inactive. To activate the VBI data slicer, VITX[1:0] 86H[7:6] has to be set to '11'. Depending on the VBI data slicer settings, the sliced VBI data is inserted after the end of the scaled video lines, if the regions of the VBI data slicer and scaler overlap.

To compensate for the running-in of the vertical scaler, the vertical input window lengths are extended by 2 to 290 lines, respectively 242 lines for XS, but the scaler increment calculations are done with 288, respectively 240 lines.

## 19.4.3 EXAMPLES

**Table 246** Example of configurations

EXAMPLE NUMBER	SCALER SOURCE AND REFERENCE EVENTS	INPUT WINDOW	OUTPUT WINDOW	SCALE RATIOS
1	analog input to 8-bit I port output, with SAV/EAV codes, 8-bit serial byte stream decoder output at X port; acquisition trigger at falling edge vertical and rising edge horizontal reference signal; H and V gates on IGPH and IGPV, IGP0 = VBI sliced data flag, IGP1 = FIFO almost full, level $\geq 24$ , IDQ qualifier logic 1 active	720 × 240	720 × 240	prsc = 1; fisc = 1; vsc = 1
2	analog input to 16-bit output, without SAV/EAV codes, Y on I port, C <sub>B</sub> -C <sub>R</sub> on H port and decoder output at X port; acquisition trigger at falling edge vertical and rising edge horizontal reference signal; H and V pulses on IGPH and IGPV, output FID on IGP0, IGP1 fixed to logic 1, IDQ qualifier logic 0 active	704 × 288	768 × 288	prsc = 1; fisc = 0.91667; vsc = 1
3	X port input 8 bit with SAV/EAV codes, no reference signals on XRH and XRV, XCLK as gated clock; field detection and acquisition trigger on different events; acquisition triggers at rising edge vertical and rising edge horizontal; I port output 8-bit with SAV/EAV codes like example number 1; see Table 247	720 × 240	352 × 288	prsc = 2; fisc = 1.022; vsc = 0.8333
4	X port and H port for 16-bit Y-C <sub>B</sub> -C <sub>R</sub> 4 : 2 : 2 input (if no 16-bit output selected); XRH and XRV as references; field detection and acquisition trigger at falling edge of vertical and rising edge of horizontal; I port output 8-bit with SAV/EAV codes, but Y only output	720 × 288	200 × 80	prsc = 2; fisc = 1.8; vsc = 3.6

## 19.4.1 TRIGGER CONDITION

For trigger condition STRC[1:0] 90H[1:0] not equal '00'.

If the value of (YO + YS) is  $\geq 262$  (NTSC), and 312 (PAL) the output field rate is reduced to 30 Hz and 25 Hz respectively.

Horizontal and vertical offsets (XO and YO) have to be used to adjust the displayed video in the display window. As this adjustment is application dependent, the listed values are only dummy values.

## 19.4.2 MAXIMUM ZOOM FACTOR

The maximum zoom factor is dependent on the back-end data rate and is therefore back-end clock and data format dependent (8 or 16-bit output). The maximum horizontal zoom is limited to approximately 3.5, due to internal data path restrictions.

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**Table 247** Scaler and interface configuration examples

I <sup>2</sup> C-BUS ADDRESS (HEX)	MAIN FUNCTION	EXAMPLE 1		EXAMPLE 2		EXAMPLE 3		EXAMPLE 4	
		HEX	DEC	HEX	DEC	HEX	DEC	HEX	DEC
<b>Global settings</b>									
80	task enable, IDQ and back-end clock definition	10	–	10	–	10	–	10	–
83	XCLK output phase and X port output enable	01	–	01	–	00	–	00	–
84	IGPH, IGPV, IGP0 and IGP1 output definition	A0	–	C5	–	A0	–	A0	–
85	signal polarity control and I port byte swapping	10	–	09	–	10	–	10	–
86	FIFO flag thresholds and video/text arbitration	45	–	40	–	45	–	45	–
87	ICLK and IDQ output phase and I port enable	01	–	01	–	01	–	01	–
88	power save control and software reset	F0	–	F0	–	F0	–	F0	–
<b>Task A: scaler input configuration and output format settings</b>									
90	task handling	00	–	00	–	00	–	00	–
91	scaler input source and format definition	08	–	08	–	18	–	38	–
92	reference signal definition at scaler input	10	–	10	–	10	–	10	–
93	I port output formats and configuration	80	–	40	–	80	–	84	–
<b>Input and output window definition</b>									
94	horizontal input offset (XO)	10	16	10	16	10	16	10	16
95		00	–	00	–	00	–	00	–
96	horizontal input (source) window length (XS)	D0	720	C0	704	D0	720	D0	720
97		02	–	02	–	02	–	02	–
98	vertical input offset (YO)	0A	10	0A	10	0A	10	0A	10
99		00	–	00	–	00	–	00	–
9A	vertical input (source) window length (YS)	F2	242	22	290	F2	242	22	290
9B		00	–	01	–	00	–	01	–
9C	horizontal output (destination) window length (XD)	D0	720	00	768	60	352	C8	200
9D		02	–	03	–	01	–	00	–
9E	vertical output (destination) window length (YD)	F0	240	20	288	20	288	50	80
9F		00	–	01	–	01	–	00	–
<b>Prefiltering and prescaling</b>									
A0	integer prescale (value '00' not allowed)	01	–	01	–	02	–	02	–
A1	accumulation length for prescaler	00	–	00	–	02	–	03	–
A2	FIR prefilter and prescaler DC normalization	00	–	00	–	AA	–	F2	–
A4	scaler brightness control	80	128	80	128	80	128	80	128
A5	scaler contrast control	40	64	40	64	40	64	11	17
A6	scaler saturation control	40	64	40	64	40	64	11	17

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I <sup>2</sup> C-BUS ADDRESS (HEX)	MAIN FUNCTION	EXAMPLE 1		EXAMPLE 2		EXAMPLE 3		EXAMPLE 4	
		HEX	DEC	HEX	DEC	HEX	DEC	HEX	DEC
<b>Horizontal phase scaling</b>									
A8	horizontal scaling increment for luminance	00	1024	AA	938	18	1048	34	1844
A9		04	–	03	–	04	–	07	–
AA	horizontal phase offset luminance	00	–	00	–	00	–	00	–
AC	horizontal scaling increment for chrominance	00	512	D5	469	0C	524	9A	922
AD		02	–	01	–	02	–	03	–
AE	horizontal phase offset chrominance	00	–	00	–	00	–	00	–
<b>Vertical scaling</b>									
B0	vertical scaling increment for luminance	00	1024	00	1024	55	853	66	3686
B1		04	–	04	–	03	–	0E	–
B2	vertical scaling increment for chrominance	00	1024	00	1024	55	853	66	3686
B3		04	–	04	–	03	–	0E	–
B4	vertical scaling mode control	00	–	00	–	00	–	01	–
B8 to BF	vertical phase offsets luminance and chrominance (needs to be used for interlace correct scaled output)	start with B8 to BF at 00H, if there are no problems with the interlaced scaled output optimize according to Section 9.3.3.2							

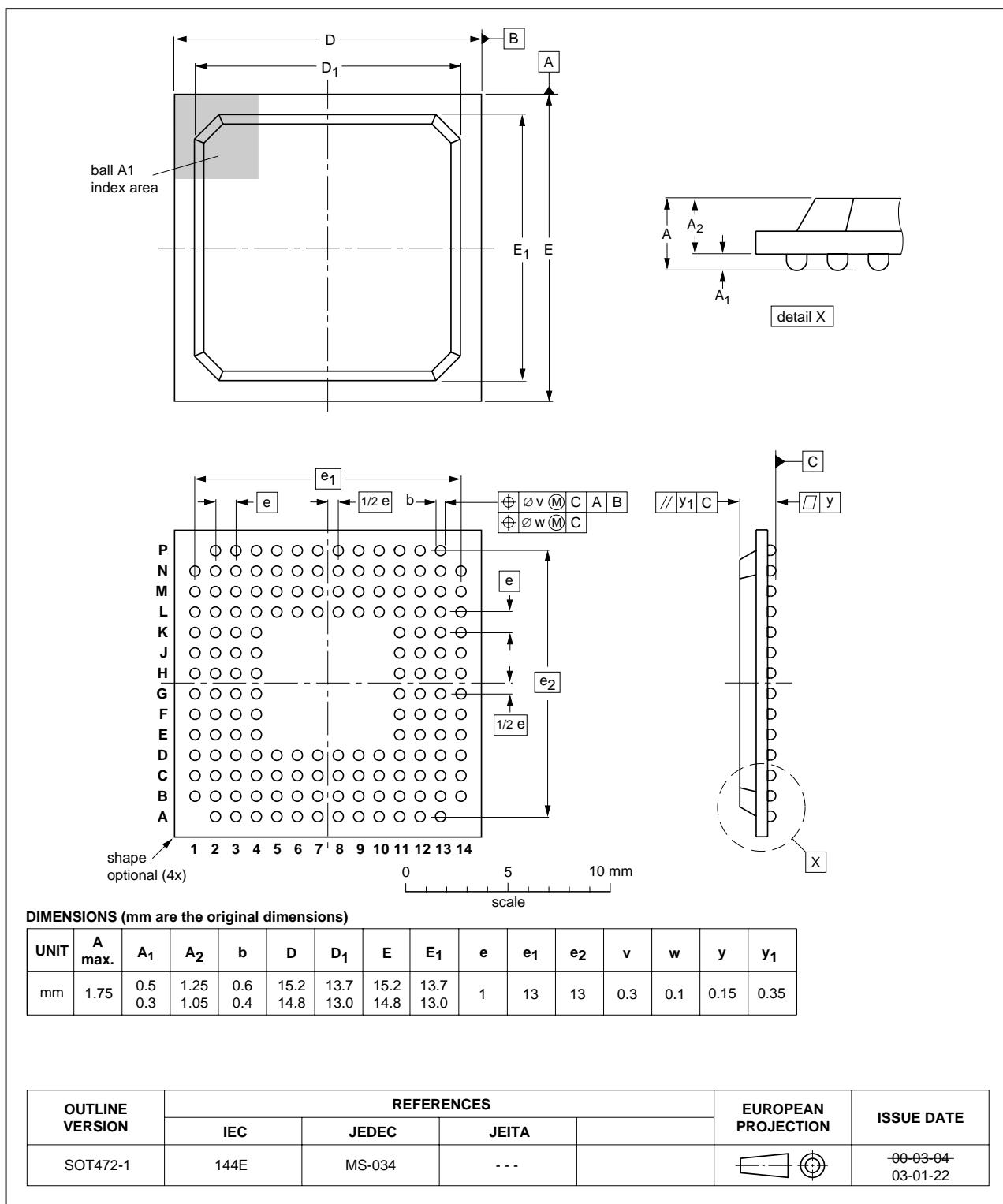
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## 20 PACKAGE OUTLINE

BGA156: plastic ball grid array package; 156 balls; body 15 x 15 x 1.15 mm

SOT472-1



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### 21 SOLDERING

#### 21.1 Introduction to soldering surface mount packages

This text gives a very brief insight to a complex technology. A more in-depth account of soldering ICs can be found in our "Data Handbook IC26; Integrated Circuit Packages" (document order number 9398 652 90011).

There is no soldering method that is ideal for all surface mount IC packages. Wave soldering can still be used for certain surface mount ICs, but it is not suitable for fine pitch SMDs. In these situations reflow soldering is recommended.

#### 21.2 Reflow soldering

Reflow soldering requires solder paste (a suspension of fine solder particles, flux and binding agent) to be applied to the printed-circuit board by screen printing, stencilling or pressure-syringe dispensing before package placement. Driven by legislation and environmental forces the worldwide use of lead-free solder pastes is increasing.

Several methods exist for reflowing; for example, convection or convection/infrared heating in a conveyor type oven. Throughput times (preheating, soldering and cooling) vary between 100 and 200 seconds depending on heating method.

Typical reflow peak temperatures range from 215 to 270 °C depending on solder paste material. The top-surface temperature of the packages should preferably be kept:

- below 225 °C (SnPb process) or below 245 °C (Pb-free process)
  - for all BGA, HTSSON-T and SSOP-T packages
  - for packages with a thickness  $\geq$  2.5 mm
  - for packages with a thickness  $<$  2.5 mm and a volume  $\geq$  350 mm<sup>3</sup> so called thick/large packages.
- below 240 °C (SnPb process) or below 260 °C (Pb-free process) for packages with a thickness  $<$  2.5 mm and a volume  $<$  350 mm<sup>3</sup> so called small/thin packages.

Moisture sensitivity precautions, as indicated on packing, must be respected at all times.

#### 21.3 Wave soldering

Conventional single wave soldering is not recommended for surface mount devices (SMDs) or printed-circuit boards with a high component density, as solder bridging and non-wetting can present major problems.

To overcome these problems the double-wave soldering method was specifically developed.

If wave soldering is used the following conditions must be observed for optimal results:

- Use a double-wave soldering method comprising a turbulent wave with high upward pressure followed by a smooth laminar wave.
- For packages with leads on two sides and a pitch (e):
  - larger than or equal to 1.27 mm, the footprint longitudinal axis is **preferred** to be parallel to the transport direction of the printed-circuit board;
  - smaller than 1.27 mm, the footprint longitudinal axis **must** be parallel to the transport direction of the printed-circuit board.

The footprint must incorporate solder thieves at the downstream end.

- For packages with leads on four sides, the footprint must be placed at a 45° angle to the transport direction of the printed-circuit board. The footprint must incorporate solder thieves downstream and at the side corners.

During placement and before soldering, the package must be fixed with a droplet of adhesive. The adhesive can be applied by screen printing, pin transfer or syringe dispensing. The package can be soldered after the adhesive is cured.

Typical dwell time of the leads in the wave ranges from 3 to 4 seconds at 250 °C or 265 °C, depending on solder material applied, SnPb or Pb-free respectively.

A mildly-activated flux will eliminate the need for removal of corrosive residues in most applications.

#### 21.4 Manual soldering

Fix the component by first soldering two diagonally-opposite end leads. Use a low voltage (24 V or less) soldering iron applied to the flat part of the lead. Contact time must be limited to 10 seconds at up to 300 °C.

When using a dedicated tool, all other leads can be soldered in one operation within 2 to 5 seconds between 270 and 320 °C.

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## 21.5 Suitability of surface mount IC packages for wave and reflow soldering methods

PACKAGE <sup>(1)</sup>	SOLDERING METHOD	
	WAVE	REFLOW <sup>(2)</sup>
BGA, HTSSON..T <sup>(3)</sup> , LBGA, LFBGA, SQFP, SSOP..T <sup>(3)</sup> , TFBGA, USON, VFBGA	not suitable	suitable
DHVQFN, HBCC, HBGA, HLQFP, HSO, HSOP, HSQFP, HSSON, HTQFP, HTSSOP, HVQFN, HVSON, SMS	not suitable <sup>(4)</sup>	suitable
PLCC <sup>(5)</sup> , SO, SOJ	suitable	suitable
LQFP, QFP, TQFP	not recommended <sup>(5)(6)</sup>	suitable
SSOP, TSSOP, VSO, VSSOP	not recommended <sup>(7)</sup>	suitable
CWQCCN..L <sup>(8)</sup> , PMFP <sup>(9)</sup> , WQCCN..L <sup>(8)</sup>	not suitable	not suitable

## Notes

1. For more detailed information on the BGA packages refer to the "(LF)BGA Application Note" (AN01026); order a copy from your Philips Semiconductors sales office.
2. All surface mount (SMD) packages are moisture sensitive. Depending upon the moisture content, the maximum temperature (with respect to time) and body size of the package, there is a risk that internal or external package cracks may occur due to vaporization of the moisture in them (the so called popcorn effect). For details, refer to the Drypack information in the "Data Handbook IC26; Integrated Circuit Packages; Section: Packing Methods".
3. These transparent plastic packages are extremely sensitive to reflow soldering conditions and must on no account be processed through more than one soldering cycle or subjected to infrared reflow soldering with peak temperature exceeding 217 °C ± 10 °C measured in the atmosphere of the reflow oven. The package body peak temperature must be kept as low as possible.
4. These packages are not suitable for wave soldering. On versions with the heatsink on the bottom side, the solder cannot penetrate between the printed-circuit board and the heatsink. On versions with the heatsink on the top side, the solder might be deposited on the heatsink surface.
5. If wave soldering is considered, then the package must be placed at a 45° angle to the solder wave direction. The package footprint must incorporate solder thieves downstream and at the side corners.
6. Wave soldering is suitable for LQFP, TQFP and QFP packages with a pitch (e) larger than 0.8 mm; it is definitely not suitable for packages with a pitch (e) equal to or smaller than 0.65 mm.
7. Wave soldering is suitable for SSOP, TSSOP, VSO and VSSOP packages with a pitch (e) equal to or larger than 0.65 mm; it is definitely not suitable for packages with a pitch (e) equal to or smaller than 0.5 mm.
8. Image sensor packages in principle should not be soldered. They are mounted in sockets or delivered pre-mounted on flex foil. However, the image sensor package can be mounted by the client on a flex foil by using a hot bar soldering process. The appropriate soldering profile can be provided on request.
9. Hot bar or manual soldering is suitable for PMFP packages.

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## 22 DATA SHEET STATUS

LEVEL	DATA SHEET STATUS <sup>(1)</sup>	PRODUCT STATUS <sup>(2)(3)</sup>	DEFINITION
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3. For data sheets describing multiple type numbers, the highest-level product status determines the data sheet status.

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## **Contact information**

For additional information please visit <http://www.semiconductors.philips.com>. Fax: +31 40 27 24825  
For sales offices addresses send e-mail to: [sales.addresses@www.semiconductors.philips.com](mailto:sales.addresses@www.semiconductors.philips.com).

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