

# DATA SHEET

## **TDA8784**

**18 Msps, 10-bit analog-to-digital  
interface for CCD cameras**

Product specification  
Supersedes data of 1999 Sep 21

2002 Oct 23

## 18 Msps, 10-bit analog-to-digital interface for CCD cameras

**TDA8784**

### FEATURES

- Correlated Double Sampling (CDS), AGC, 10-bit ADC and reference regulator included, adjustable bandwidth (CDS and AGC)
- Fully programmable via a 3-wire serial interface
- Sampling frequency up to 18 MHz
- AGC gain from 4.5 to 34.5 dB (in 0.1 dB steps)
- CDS programmable bandwidth from 4 to 120 MHz
- AGC programmable bandwidth from 4 to 54 MHz
- Standby mode available for each block for power saving applications 20 mW (typ)
- 6 dB fixed gain analog output for analog iris control
- 8-bit and 10-bit DAC included for analog settings
- Low power consumption of only 483 mW (typ)
- 5 V operation and 2.5 to 5.25 V operation for the digital outputs
- TTL compatible inputs, TTL and CMOS compatible outputs.

### APPLICATIONS

- CCD camera systems.

### GENERAL DESCRIPTION

The TDA8784 is a 10-bit analog-to-digital interface for CCD cameras. The device includes a correlated double sampling circuit, AGC and a low-power 10-bit Analog-to-Digital Converter (ADC) together with its reference voltage regulator.

The AGC and CDS have a bandwidth circuit controlled by on-chip DACs via a serial interface.

A 10-bit DAC controls the ADC input clamp level.

An additional 8-bit DAC is provided for additional system controls; its output voltage range is 1.4 V (p-p) which is available at pin OFDOUT.

### ORDERING INFORMATION

| TYPE<br>NUMBER | PACKAGE |                                                                                  |          |
|----------------|---------|----------------------------------------------------------------------------------|----------|
|                | NAME    | DESCRIPTION                                                                      | VERSION  |
| TDA8784HL      | LQFP48  | plastic low profile quad flat package; 48 leads; body $7 \times 7 \times 1.4$ mm | SOT313-2 |

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## QUICK REFERENCE DATA

| SYMBOL            | PARAMETER                                                   | CONDITIONS                                                             | MIN. | TYP.  | MAX. | UNIT    |
|-------------------|-------------------------------------------------------------|------------------------------------------------------------------------|------|-------|------|---------|
| $V_{CCA}$         | analog supply voltage                                       |                                                                        | 4.75 | 5     | 5.25 | V       |
| $V_{CCD}$         | digital supply voltage                                      |                                                                        | 4.75 | 5     | 5.25 | V       |
| $V_{CCO}$         | digital outputs supply voltage                              |                                                                        | 2.5  | 3     | 5.25 | V       |
| $I_{CCA}$         | analog supply current                                       |                                                                        | –    | 78    | 95   | mA      |
| $I_{CCD}$         | digital supply current                                      |                                                                        | –    | 18    | 20   | mA      |
| $I_{CCO}$         | digital outputs supply current                              | $f_{CLK} = 18$ MHz;<br>$C_L = 20$ pF; ramp input                       | –    | 1     | –    | mA      |
| $ADC_{res}$       | ADC resolution                                              |                                                                        | –    | 10    | –    | bits    |
| $V_{i(CDS)(p-p)}$ | CDS input voltage (peak-to-peak value)                      |                                                                        | –    | 400   | 1200 | mV      |
| $G_{CDS}$         | CDS output amplifier gain                                   |                                                                        | –    | 6     | –    | dB      |
| $f_{CLK(max)}$    | maximum clock frequency                                     | $f_{cut(CDS)} = 120$ MHz;<br>$f_{cut(AGC)} = 54$ MHz                   | 18   | –     | –    | MHz     |
| $AGC_{dyn}$       | AGC dynamic range                                           |                                                                        | –    | 30    | –    | dB      |
| $N_{tot(rms)}$    | total output noise from CDS input to ADC output (RMS value) | gain = 4.5 dB;<br>$f_{cut(CDS)} = 120$ MHz;<br>$f_{cut(AGC)} = 40$ MHz | –    | 0.125 | –    | LSB     |
| $E_{in(rms)}$     | equivalent input noise (RMS value)                          | gain = 34.5 dB                                                         | –    | 125   | –    | $\mu$ V |
| $P_{tot}$         | total power consumption                                     |                                                                        | –    | 483   | –    | mW      |

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## BLOCK DIAGRAM

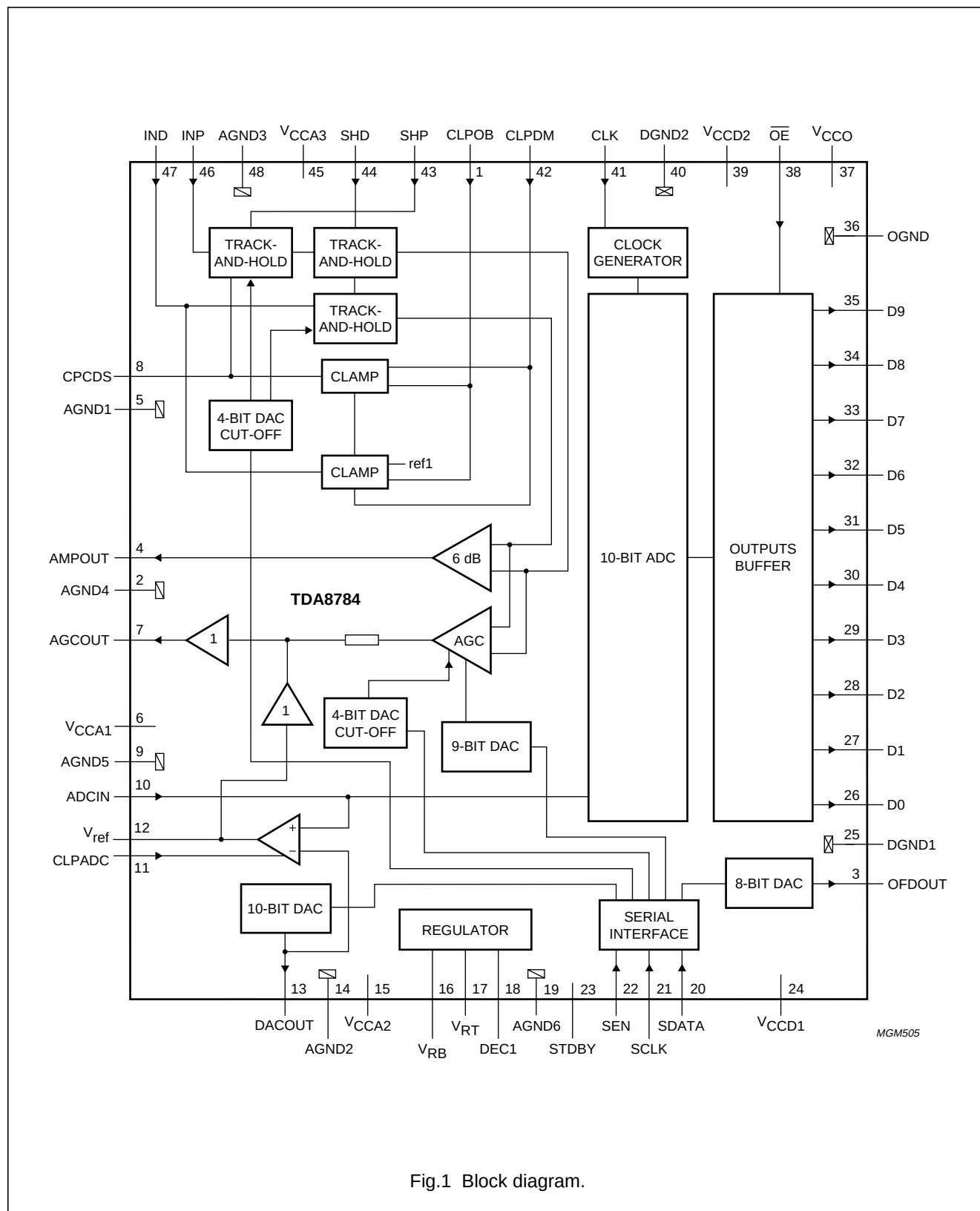


Fig.1 Block diagram.

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## PINNING

| SYMBOL            | PIN | DESCRIPTION                                                                                                                                                                                                                                                         |
|-------------------|-----|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| CLPOB             | 1   | clamp pulse input at optical black                                                                                                                                                                                                                                  |
| AGND4             | 2   | analog ground 4                                                                                                                                                                                                                                                     |
| OFDOUT            | 3   | analog output of the additional 8-bit control DAC (controlled via the serial interface)                                                                                                                                                                             |
| AMPOUT            | 4   | CDS amplifier output (fixed gain = 6 dB)                                                                                                                                                                                                                            |
| AGND1             | 5   | analog ground 1                                                                                                                                                                                                                                                     |
| V <sub>CCA1</sub> | 6   | analog supply voltage 1                                                                                                                                                                                                                                             |
| AGCOUT            | 7   | AGC amplifier signal output                                                                                                                                                                                                                                         |
| CPCDS             | 8   | clamp storage capacitor pin                                                                                                                                                                                                                                         |
| AGND5             | 9   | analog ground 5                                                                                                                                                                                                                                                     |
| ADCIN             | 10  | ADC analog signal input from AGCOUT via a short circuit                                                                                                                                                                                                             |
| CLPADC            | 11  | clamp control input for ADC analog input signal clamp (used with a capacitor from V <sub>ref</sub> to ground)                                                                                                                                                       |
| V <sub>ref</sub>  | 12  | ADC input clamp reference voltage (normally connected to pin V <sub>RB</sub> or DACOUT, or connected to ground via a capacitor)                                                                                                                                     |
| DACOUT            | 13  | DAC output for ADC clamp level                                                                                                                                                                                                                                      |
| AGND2             | 14  | analog ground 2                                                                                                                                                                                                                                                     |
| V <sub>CCA2</sub> | 15  | analog supply voltage 2                                                                                                                                                                                                                                             |
| V <sub>RB</sub>   | 16  | ADC reference voltage (BOTTOM) code 0                                                                                                                                                                                                                               |
| V <sub>RT</sub>   | 17  | ADC reference voltage (TOP) code 1023                                                                                                                                                                                                                               |
| DEC1              | 18  | decoupling 1 (decoupled to ground via a capacitor)                                                                                                                                                                                                                  |
| AGND6             | 19  | analog ground 6                                                                                                                                                                                                                                                     |
| SDATA             | 20  | serial data input for the 4 control DACs (9-bit DAC for AGC gain, 8-bit DAC for frequency cut-off; additional 8-bit DAC for OFD output voltage; 10-bit DAC for ADC clamp level and the standby mode per block and edge pulse control); see Fig.3, Fig.4 and Table 1 |
| SCLK              | 21  | serial clock input for the control DACs and their serial interface; see Fig.3, Fig.4 and Table 1                                                                                                                                                                    |
| SEN               | 22  | enable input for the serial interface shift register (active when SEN = logic 0); see Fig.3, Fig.4 and Table 1                                                                                                                                                      |
| STDBY             | 23  | standby control (active HIGH); all the output bits are logic 0 when standby is enabled                                                                                                                                                                              |
| V <sub>CCD1</sub> | 24  | digital supply voltage 1                                                                                                                                                                                                                                            |
| DGND1             | 25  | digital ground 1                                                                                                                                                                                                                                                    |
| D0                | 26  | ADC digital output 0 (LSB)                                                                                                                                                                                                                                          |
| D1                | 27  | ADC digital output 1                                                                                                                                                                                                                                                |
| D2                | 28  | ADC digital output 2                                                                                                                                                                                                                                                |
| D3                | 29  | ADC digital output 3                                                                                                                                                                                                                                                |
| D4                | 30  | ADC digital output 4                                                                                                                                                                                                                                                |
| D5                | 31  | ADC digital output 5                                                                                                                                                                                                                                                |
| D6                | 32  | ADC digital output 6                                                                                                                                                                                                                                                |
| D7                | 33  | ADC digital output 7                                                                                                                                                                                                                                                |
| D8                | 34  | ADC digital output 8                                                                                                                                                                                                                                                |
| D9                | 35  | ADC digital output 9 (MSB)                                                                                                                                                                                                                                          |
| OGND              | 36  | digital output ground                                                                                                                                                                                                                                               |

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| SYMBOL                 | PIN | DESCRIPTION                                                                                     |
|------------------------|-----|-------------------------------------------------------------------------------------------------|
| V <sub>CCO</sub>       | 37  | digital output supply voltage                                                                   |
| $\overline{\text{OE}}$ | 38  | output enable (active LOW: digital outputs active; active HIGH: digital outputs high impedance) |
| V <sub>CCD2</sub>      | 39  | digital supply voltage 2                                                                        |
| DGND2                  | 40  | digital ground 2                                                                                |
| CLK                    | 41  | ADC clock input                                                                                 |
| CLPDM                  | 42  | clamp pulse input at dummy pixel                                                                |
| SHP                    | 43  | pre-set sample-and-hold pulse input                                                             |
| SHD                    | 44  | data sample-and-hold pulse input                                                                |
| V <sub>CCA3</sub>      | 45  | analog supply voltage 3                                                                         |
| INP                    | 46  | pre-set input signal from CCD                                                                   |
| IND                    | 47  | data input signal from CCD                                                                      |
| AGND3                  | 48  | analog ground 3                                                                                 |

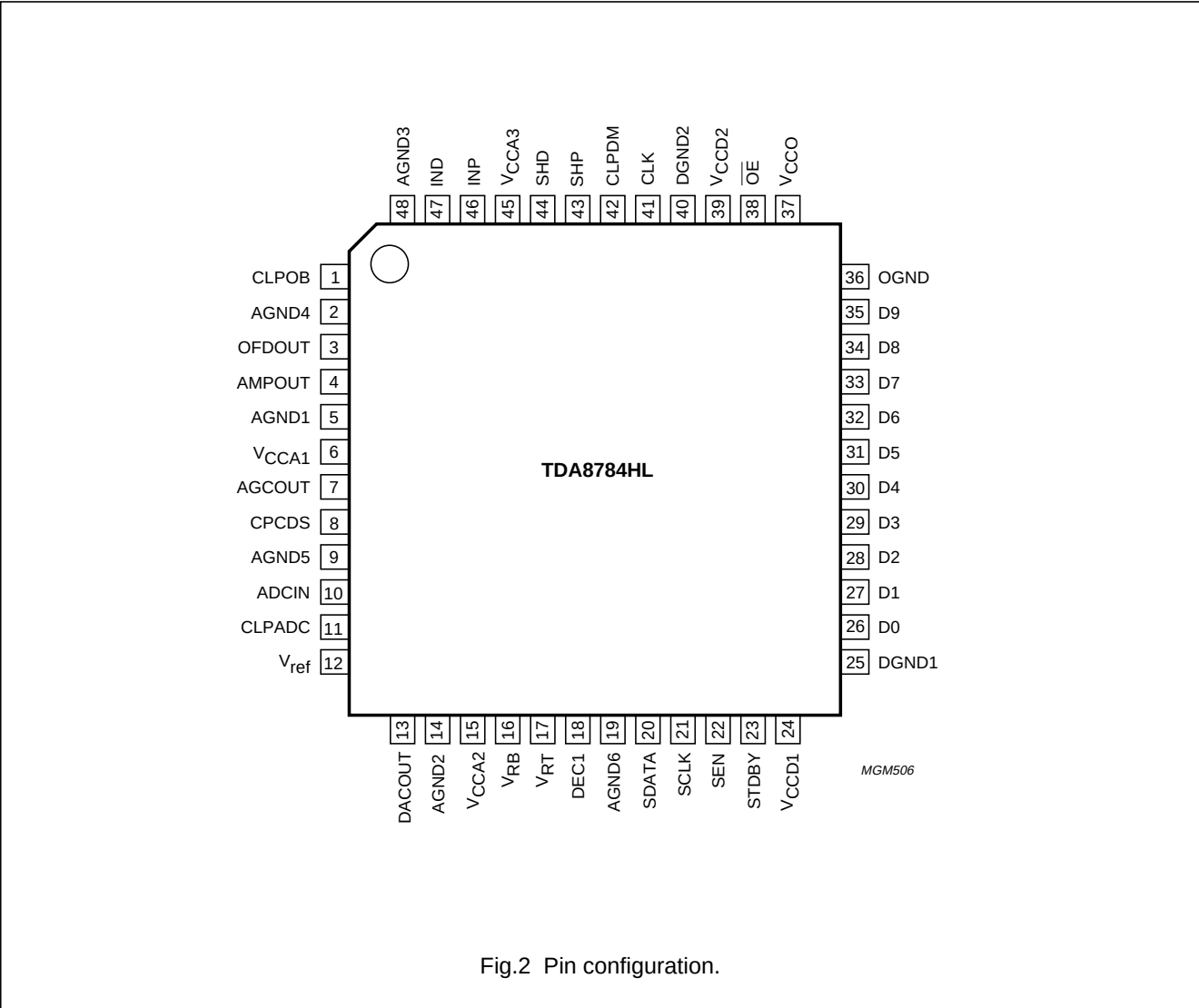


Fig.2 Pin configuration.

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## LIMITING VALUES

In accordance with the Absolute Maximum Rating System (IEC 60134).

| SYMBOL          | PARAMETER                                                    | CONDITIONS         | MIN. | MAX.      | UNIT |
|-----------------|--------------------------------------------------------------|--------------------|------|-----------|------|
| $V_{CCA}$       | analog supply voltage                                        | note 1             | −0.3 | +7.0      | V    |
| $V_{CCD}$       | digital supply voltage                                       | note 1             | −0.3 | +7.0      | V    |
| $V_{CCO}$       | output stages supply voltage                                 | note 1             | −0.3 | +7.0      | V    |
| $\Delta V_{CC}$ | supply voltage difference<br>between $V_{CCA}$ and $V_{CCD}$ |                    | −1.0 | +1.0      | V    |
|                 | between $V_{CCA}$ and $V_{CCO}$                              |                    | −1.0 | +4.0      | V    |
|                 | between $V_{CCD}$ and $V_{CCO}$                              |                    | −1.0 | +4.0      | V    |
| $V_i$           | input voltage                                                | referenced to AGND | −0.3 | +7.0      | V    |
| $V_{CLK(p-p)}$  | AC input voltage for switching<br>(peak-to-peak value)       | referenced to DGND | −    | $V_{CCD}$ | V    |
| $I_o$           | output current                                               |                    | −    | 10        | mA   |
| $T_{stg}$       | storage temperature                                          |                    | −55  | +150      | °C   |
| $T_{amb}$       | ambient temperature                                          |                    | −20  | +75       | °C   |
| $T_j$           | junction temperature                                         |                    | −    | 150       | °C   |

### Note

1. The supply voltages  $V_{CCA}$ ,  $V_{CCD}$  and  $V_{CCO}$  may have any value between −0.3 and +7.0 V provided that the supply voltage difference  $\Delta V_{CC}$  remains as indicated.

## HANDLING

Inputs and outputs are protected against electrostatic discharges in normal handling. However, to be totally safe, it is desirable to take normal precautions appropriate to handling integrated circuits.

## THERMAL CHARACTERISTICS

| SYMBOL        | PARAMETER                                   | CONDITIONS  | VALUE | UNIT |
|---------------|---------------------------------------------|-------------|-------|------|
| $R_{th(j-a)}$ | thermal resistance from junction to ambient | in free air | 76    | K/W  |

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## CHARACTERISTICS

$V_{CCA} = V_{CCD} = 5\text{ V}$ ;  $V_{CCO} = 3\text{ V}$ ;  $f_{CLK} = 18\text{ MHz}$ ;  $T_{amb} = 25\text{ °C}$ ; unless otherwise specified.

| SYMBOL                                                                            | PARAMETER                                          | CONDITIONS                                                                                                                                                                                                                                                                    | MIN. | TYP. | MAX.      | UNIT             |
|-----------------------------------------------------------------------------------|----------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|------|-----------|------------------|
| <b>Supplies</b>                                                                   |                                                    |                                                                                                                                                                                                                                                                               |      |      |           |                  |
| $V_{CCA}$                                                                         | analog supply voltage                              |                                                                                                                                                                                                                                                                               | 4.75 | 5    | 5.25      | V                |
| $V_{CCD}$                                                                         | digital supply voltage                             |                                                                                                                                                                                                                                                                               | 4.75 | 5    | 5.25      | V                |
| $V_{CCO}$                                                                         | digital outputs supply voltage                     |                                                                                                                                                                                                                                                                               | 2.5  | 3    | 5.25      | V                |
| $I_{CCA}$                                                                         | analog supply current                              |                                                                                                                                                                                                                                                                               | –    | 78   | 95        | mA               |
| $I_{CCD}$                                                                         | digital supply current                             |                                                                                                                                                                                                                                                                               | –    | 18   | 20        | mA               |
| $I_{CCO}$                                                                         | digital outputs supply current                     | $C_L = 20\text{ pF}$ on all data outputs;<br>ramp input                                                                                                                                                                                                                       | –    | 1    | –         | mA               |
| <b>Digital inputs</b>                                                             |                                                    |                                                                                                                                                                                                                                                                               |      |      |           |                  |
| CLOCK INPUT: CLK (REFERENCED TO DGND)                                             |                                                    |                                                                                                                                                                                                                                                                               |      |      |           |                  |
| $V_{IL}$                                                                          | LOW-level input voltage                            |                                                                                                                                                                                                                                                                               | 0    | –    | 0.8       | V                |
| $V_{IH}$                                                                          | HIGH-level input voltage                           |                                                                                                                                                                                                                                                                               | 2.0  | –    | $V_{CCD}$ | V                |
| $I_{IL}$                                                                          | LOW-level input current                            | $V_{CLK} = 0.8\text{ V}$                                                                                                                                                                                                                                                      | –1   | –    | +1        | $\mu\text{A}$    |
| $I_{IH}$                                                                          | HIGH-level input current                           | $V_{CLK} = 2.0\text{ V}$                                                                                                                                                                                                                                                      | –    | –    | 20        | $\mu\text{A}$    |
| $Z_i$                                                                             | input impedance                                    | $f_{CLK} = 18\text{ MHz}$                                                                                                                                                                                                                                                     | –    | 46   | –         | $\text{k}\Omega$ |
| $C_i$                                                                             | input capacitance                                  | $f_{CLK} = 18\text{ MHz}$                                                                                                                                                                                                                                                     | –    | 1    | –         | pF               |
| INPUTS: SHP AND SHD                                                               |                                                    |                                                                                                                                                                                                                                                                               |      |      |           |                  |
| $V_{IL}$                                                                          | LOW-level input voltage                            |                                                                                                                                                                                                                                                                               | 0    | –    | 0.8       | V                |
| $V_{IH}$                                                                          | HIGH-level input voltage                           |                                                                                                                                                                                                                                                                               | 2.0  | –    | $V_{CCD}$ | V                |
| $I_{IL}$                                                                          | LOW-level input current                            | $V_{IL} = 0.8\text{ V}$                                                                                                                                                                                                                                                       | –    | –6   | –         | $\mu\text{A}$    |
| $I_{IH}$                                                                          | HIGH-level input current                           | $V_{IH} = 2.0\text{ V}$                                                                                                                                                                                                                                                       | –    | 0    | –         | $\mu\text{A}$    |
| INPUTS: SEN, SCLK, SDATA, $\overline{\text{OE}}$ , STDBY, CLPDM, CLPOB AND CLPADC |                                                    |                                                                                                                                                                                                                                                                               |      |      |           |                  |
| $V_{IL}$                                                                          | LOW-level input voltage                            |                                                                                                                                                                                                                                                                               | 0    | –    | 0.8       | V                |
| $V_{IH}$                                                                          | HIGH-level input voltage                           |                                                                                                                                                                                                                                                                               | 2.0  | –    | $V_{CCD}$ | V                |
| $I_i$                                                                             | input current                                      |                                                                                                                                                                                                                                                                               | –2   | –    | +2        | $\mu\text{A}$    |
| <b>Correlated Double Sampling (CDS); note 1</b>                                   |                                                    |                                                                                                                                                                                                                                                                               |      |      |           |                  |
| $V_{i(\text{CDS})(\text{p-p})}$                                                   | CDS input amplitude pin 47<br>(peak-to-peak value) |                                                                                                                                                                                                                                                                               | –    | 400  | 1200      | mV               |
| $I_{\text{CPCDS}}, I_{\text{INP}}, I_{\text{IND}}$                                | input current pins 8, 46 and 47                    |                                                                                                                                                                                                                                                                               | –2   | –    | +2        | $\mu\text{A}$    |
| $t_{\text{CDS}(\text{min})}$                                                      | CDS control pulses minimum<br>active time          | $f_{i(\text{CDS}1,2)} = f_{\text{CLK}(\text{pix})}$ ;<br>$V_{i(\text{CDS})} = 1200\text{ mV (p-p)}$<br>black-to-white transition in<br>1 pixel ( $\pm 1\text{ LSB typ.}$ );<br>$f_{\text{cut}(\text{CDS})} = 40\text{ MHz}$ ;<br>$f_{\text{cut}(\text{AGC})} = 40\text{ MHz}$ | 12   | –    | –         | ns               |
| $t_{\text{hd1}}$                                                                  | hold time INP compared to<br>control pulse SHP     | see Fig.5                                                                                                                                                                                                                                                                     | –    | 1    | –         | ns               |



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| SYMBOL                   | PARAMETER                                                       | CONDITIONS                                                                                                                                                                         | MIN.        | TYP.          | MAX.        | UNIT              |
|--------------------------|-----------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------|---------------|-------------|-------------------|
| $t_{hd2}$                | hold time of IND compared to control pulse SHD                  | see Fig.5                                                                                                                                                                          | –           | 1             | –           | ns                |
| $t_{set(CDS)}$           | CDS settling time                                               | see Fig.12; control DAC 4 bits<br>input code; AGC gain = 0 dB;<br>$f_{cut(AGC)} = 54$ MHz;<br>$V_{i(CDS)} = 1200$ mV (p-p)<br>black-to-white transition in<br>1 pixel (1 LSB typ.) |             |               |             |                   |
|                          |                                                                 | 0000                                                                                                                                                                               | –           | 12            | –           | ns                |
|                          |                                                                 | 0001                                                                                                                                                                               | –           | 25            | –           | ns                |
|                          |                                                                 | 0010                                                                                                                                                                               | –           | 45            | –           | ns                |
|                          |                                                                 | 0011                                                                                                                                                                               | –           | 55            | –           | ns                |
|                          |                                                                 | 0100                                                                                                                                                                               | –           | 105           | –           | ns                |
|                          |                                                                 | 0111                                                                                                                                                                               | –           | 140           | –           | ns                |
|                          |                                                                 | 1000                                                                                                                                                                               | –           | 270           | –           | ns                |
|                          |                                                                 | 1011                                                                                                                                                                               | –           | 300           | –           | ns                |
|                          |                                                                 | 1111                                                                                                                                                                               | –           | 365           | –           | ns                |
| <b>Amplifier outputs</b> |                                                                 |                                                                                                                                                                                    |             |               |             |                   |
| $G_{AMPOUT}$             | output amplifier gain                                           |                                                                                                                                                                                    | –           | 6             | –           | dB                |
| $Z_{AMPOUT}$             | output amplifier impedance                                      |                                                                                                                                                                                    | –           | 300           | –           | $\Omega$          |
| $V_{AMPOUT(p-p)}$        | output amplifier dynamic voltage (peak-to-peak value)           |                                                                                                                                                                                    | –           | 2.4           | –           | V                 |
| $V_{AMPOUT(bl)}$         | output amplifier black level voltage                            |                                                                                                                                                                                    | –           | 1.5           | –           | V                 |
| $V_{AGCOUT(p-p)}$        | AGC output amplifier dynamic voltage level (peak-to-peak value) |                                                                                                                                                                                    | –           | 2000          | –           | mV                |
| $V_{AGCOUT(bl)}$         | AGC output amplifier black level voltage                        | $V_{ref}$ connected to DACOUT                                                                                                                                                      | –           | $V_{ref}$     | –           | V                 |
| $Z_{AGCOUT}$             | AGC output amplifier output impedance                           | at 10 kHz                                                                                                                                                                          | –           | 5             | –           | $\Omega$          |
| $I_{AGCOUT}$             | AGC output static drive current                                 | static                                                                                                                                                                             | –           | –             | 1           | mA                |
| $G_{AGC(min)}$           | minimum gain of AGC circuit                                     | AGC DAC input code = 00<br>(9-bit control); see Fig.7                                                                                                                              | –           | 4.5           | –           | dB                |
| $G_{AGC(max)}$           | maximum gain of AGC circuit                                     | AGC DAC input code $\geq 319$<br>(9-bit control); see Fig.7                                                                                                                        | –           | 34.5          | –           | dB                |
| $f_{cut(AGC)}$           | cut-off frequency AGC                                           | 4-bit control DAC<br>input code = 00<br>input code = 01<br>input code = 15<br>other codes see Fig.13                                                                               | –<br>–<br>– | 54<br>40<br>4 | –<br>–<br>– | MHz<br>MHz<br>MHz |

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| SYMBOL                                        | PARAMETER                                                              | CONDITIONS                                                                                                                                                 | MIN.   | TYP.         | MAX.       | UNIT       |
|-----------------------------------------------|------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------|--------|--------------|------------|------------|
| Clamps                                        |                                                                        |                                                                                                                                                            |        |              |            |            |
| $g_{m(ADC)}$                                  | ADC clamp transconductance                                             | at clamp level                                                                                                                                             | –      | 7            | –          | mS         |
| $g_{m(CDS)}$                                  | CDS clamp transconductance                                             | at clamp level                                                                                                                                             | –      | 1.5          | –          | mS         |
| Analog-to-Digital Converter (ADC)             |                                                                        |                                                                                                                                                            |        |              |            |            |
| $f_{CLK(max)}$                                | maximum clock frequency                                                |                                                                                                                                                            | 18     | –            | –          | MHz        |
| $t_{CPH}$                                     | clock pulse width HIGH                                                 |                                                                                                                                                            | 15     | –            | –          | ns         |
| $t_{CPL}$                                     | clock pulse width LOW                                                  |                                                                                                                                                            | 15     | –            | –          | ns         |
| $SR_{CLK}$                                    | clock input slew rate (rising and falling edge)                        | 10% to 90%                                                                                                                                                 | 0.5    | –            | –          | V/ns       |
| $V_{i(ADC)(p-p)}$                             | ADC input voltage level (peak-to-peak value)                           |                                                                                                                                                            | –      | 2            | –          | V          |
| $V_{RB}$                                      | ADC reference voltage output code 0                                    |                                                                                                                                                            | –      | 1.5          | –          | V          |
| $V_{RT}$                                      | ADC reference voltage output code 1023                                 |                                                                                                                                                            | –      | 3.5          | –          | V          |
| $I_{ADCIN}$                                   | input current pin 10                                                   |                                                                                                                                                            | –2     | –            | +120       | $\mu$ A    |
| INL                                           | integral non-linearity                                                 | ramp input                                                                                                                                                 | –      | $\pm 0.6$    | $\pm 1.5$  | LSB        |
| DNL                                           | differential non-linearity                                             | ramp input                                                                                                                                                 | –      | $\pm 0.2$    | $\pm 0.75$ | LSB        |
| $t_{d(s)}$                                    | sampling delay time                                                    |                                                                                                                                                            | –      | –            | 5          | ns         |
| Total chain characteristics (CDS + AGC + ADC) |                                                                        |                                                                                                                                                            |        |              |            |            |
| $t_d$                                         | delay between SHD and CLK                                              | see Fig.5; 50% at rising edges CLK and SHP: transition full scale code 0 to 1023; $f_{cut(CDS)} = 40$ MHz; $f_{cut(AGC)} = 40$ MHz; $V_{i(CDS)} = 1200$ mV | –      | 40           | –          | ns         |
| $N_{tot(rms)}$                                | total output noise (RMS value)                                         | $f_{cut(CDS)} = 120$ MHz; $f_{cut(AGC)} = 40$ MHz; note 2<br>$G_{AGC} = 4.5$ dB<br>$G_{AGC} = 34.5$ dB                                                     | –<br>– | 0.125<br>1.6 | –<br>–     | LSB<br>LSB |
| $V_{offset(fl-d)}$                            | maximum offset between CCD floating level and CCD dark pixel level     |                                                                                                                                                            | –200   | –            | +200       | mV         |
| $V_{n(i)(eq)(rms)}$                           | equivalent input noise voltage (RMS value)                             | AGC gain = 34.5 dB                                                                                                                                         | –      | 125          | –          | $\mu$ V    |
|                                               |                                                                        | AGC gain = 4.5 dB                                                                                                                                          | –      | 150          | –          | $\mu$ V    |
| Digital-to-analog converter (OFDOUT)          |                                                                        |                                                                                                                                                            |        |              |            |            |
| $V_{OFDOUT(p-p)}$                             | additional 8-bit control DAC (OFD) output voltage (peak-to-peak value) |                                                                                                                                                            | –      | 1.4          | –          | V          |
| $V_{OFDOUT(0)}$                               | DC output voltage for code 0                                           |                                                                                                                                                            | –      | 2.3          | –          | V          |
| $V_{OFDOUT(255)}$                             | DC output voltage for code 255                                         |                                                                                                                                                            | –      | 3.7          | –          | V          |

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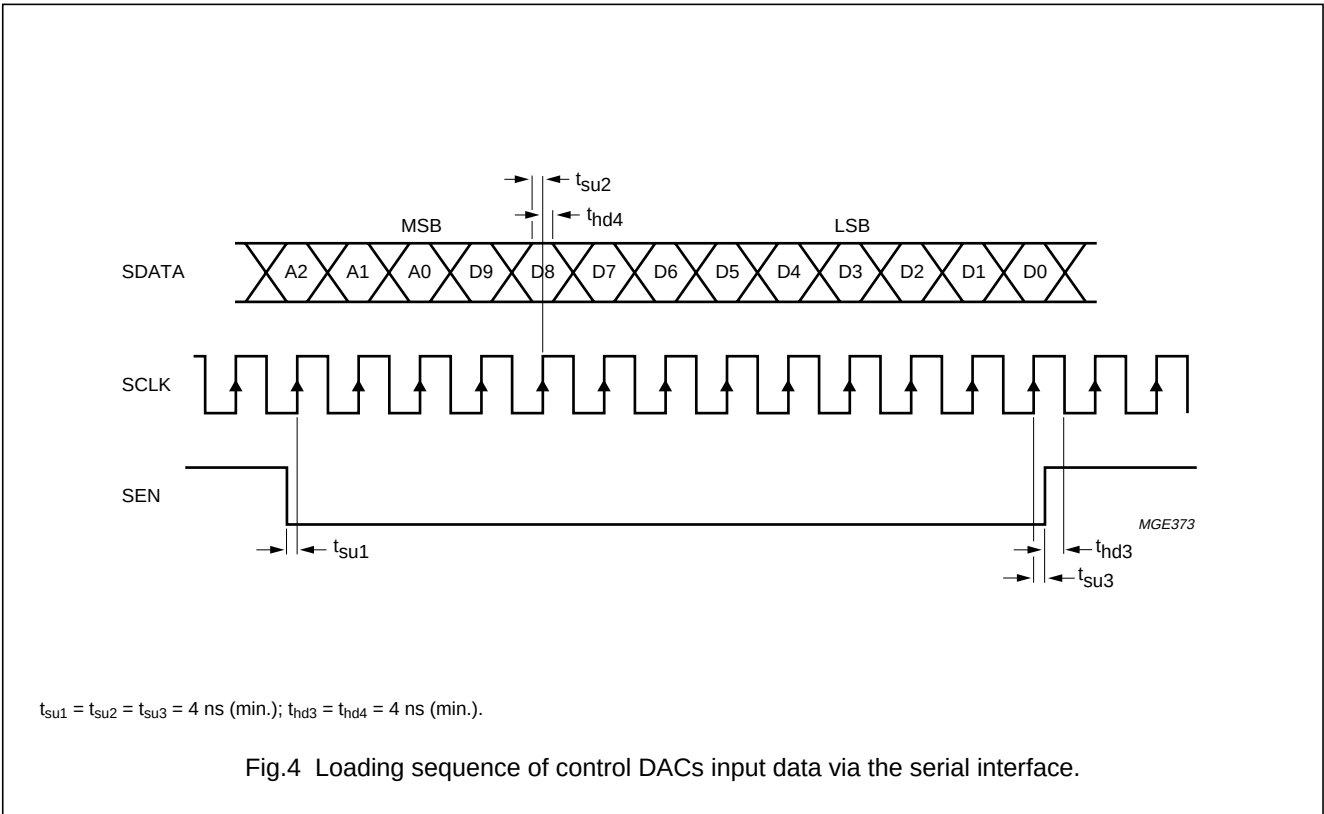
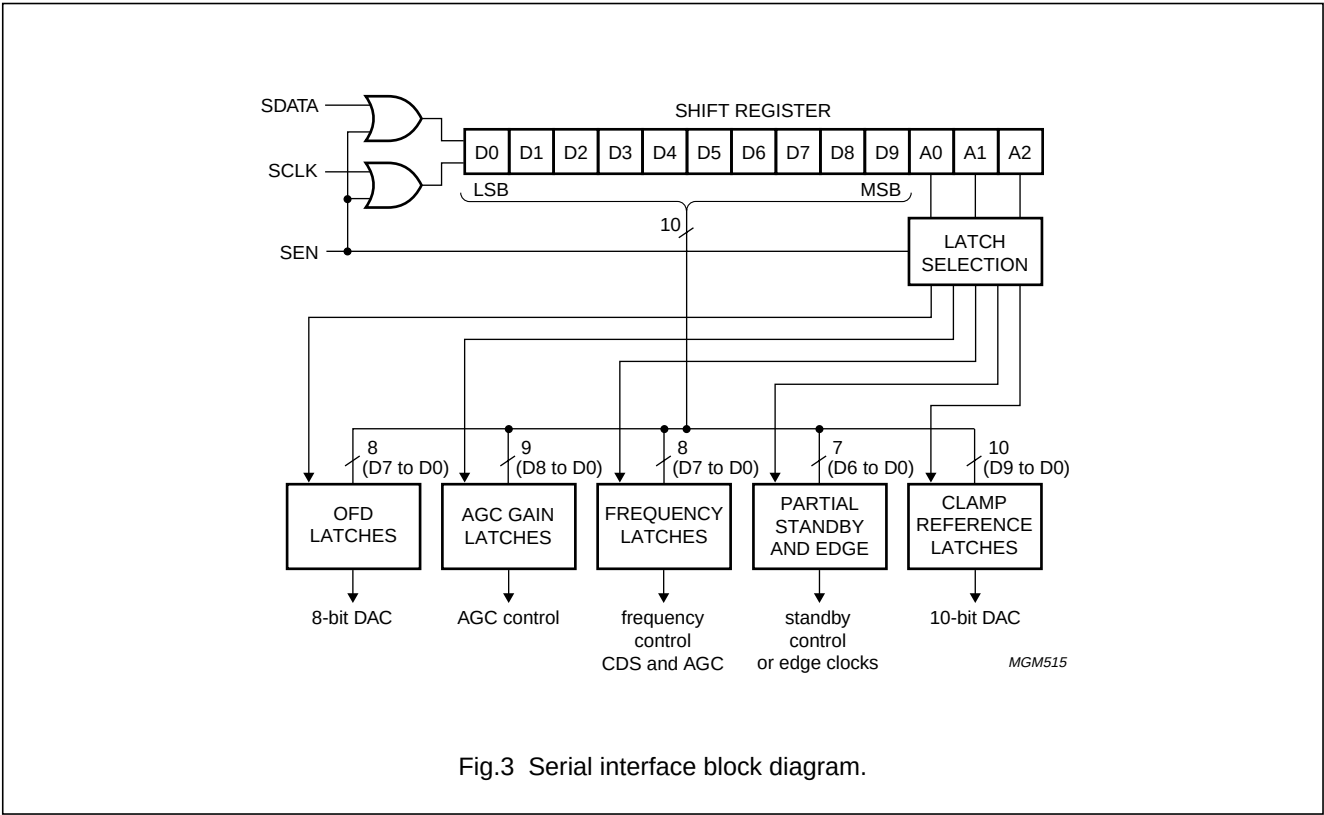
| SYMBOL                                                              | PARAMETER                                                        | CONDITIONS                                       | MIN.                   | TYP. | MAX.             | UNIT |
|---------------------------------------------------------------------|------------------------------------------------------------------|--------------------------------------------------|------------------------|------|------------------|------|
| Z <sub>OFDOUT</sub>                                                 | additional 8-bit control DAC (OFD) output impedance              |                                                  | –                      | 2000 | –                | Ω    |
| I <sub>OFDOUT</sub>                                                 | OFD output current drive                                         | static                                           | –                      | –    | 50               | μA   |
| ADC clamp control DAC (see Fig.8)                                   |                                                                  |                                                  |                        |      |                  |      |
| V <sub>DACOUT(p-p)</sub>                                            | ADC clamp 10-bit control DAC output voltage (peak-to-peak value) |                                                  | –                      | 1    | –                | V    |
| V <sub>DACOUT</sub>                                                 | DC output voltage                                                | code 0                                           | –                      | 1.5  | –                | V    |
|                                                                     |                                                                  | code 1023                                        | –                      | 2.5  | –                | V    |
| Z <sub>DACOUT</sub>                                                 | ADC clamp control DAC output impedance                           |                                                  | –                      | –    | 250              | Ω    |
| I <sub>DACOUT</sub>                                                 | DAC output current drive                                         | static                                           | –                      | –    | 50               | μA   |
| OFE <sub>LOOP</sub>                                                 | maximum offset error of DAC + ADC clamp loop                     | code 0                                           | –                      | ±5   | –                | LSB  |
|                                                                     |                                                                  | code 1023                                        | –                      | ±5   | –                | LSB  |
| Digital outputs (f <sub>CLK</sub> = 18 MHz; C <sub>L</sub> = 20 pF) |                                                                  |                                                  |                        |      |                  |      |
| V <sub>OH</sub>                                                     | HIGH-level output voltage                                        | I <sub>OH</sub> = –1 mA                          | V <sub>CCO</sub> – 0.5 | –    | V <sub>CCO</sub> | V    |
| V <sub>OL</sub>                                                     | LOW-level output voltage                                         | I <sub>OL</sub> = 1 mA                           | 0                      | –    | 0.5              | V    |
| I <sub>OZ</sub>                                                     | output current in 3-state mode                                   | 0 V < V <sub>o</sub> < V <sub>CCO</sub>          | –20                    | –    | +20              | μA   |
| t <sub>o(h)</sub>                                                   | output hold time                                                 | see Fig.5                                        | 8                      | –    | –                | ns   |
| t <sub>o(d)</sub>                                                   | output delay time                                                | C <sub>L</sub> = 20 pF; V <sub>CCO</sub> = 5 V   | –                      | 17   | 23               | ns   |
|                                                                     |                                                                  | C <sub>L</sub> = 10 pF; V <sub>CCO</sub> = 5 V   | –                      | 15   | 21               | ns   |
|                                                                     |                                                                  | C <sub>L</sub> = 20 pF; V <sub>CCO</sub> = 3 V   | –                      | 20   | 29               | ns   |
|                                                                     |                                                                  | C <sub>L</sub> = 10 pF; V <sub>CCO</sub> = 3 V   | –                      | 17   | 25               | ns   |
|                                                                     |                                                                  | C <sub>L</sub> = 20 pF; V <sub>CCO</sub> = 2.5 V | –                      | 22   | 33               | ns   |
|                                                                     |                                                                  | C <sub>L</sub> = 10 pF; V <sub>CCO</sub> = 2.5 V | –                      | 18   | 28               | ns   |
| Serial interface                                                    |                                                                  |                                                  |                        |      |                  |      |
| f <sub>SCLK(max)</sub>                                              | maximum frequency of serial interface                            |                                                  | 5                      | –    | –                | MHz  |

## Notes

- More information about CDS related signals is available in the following figures: The clamp current for pin CPCDS is given in Fig. 9, clamp current for pins IND and INP in Fig 10 and for clamp current for pin  $V_{\text{ref}}$  in Fig 11. The CDS output amplitude is shown in Fig. 14
- Noise measurement at ADC outputs: the coupling capacitor at the input is connected to ground, so that only the noise contribution of the front-end is evaluated. The front-end operates at 18 Mpix with a line of 1024 pixels. The first 40 are used to run CLPOB and the last 40 to run CLPDM. Data at the ADC outputs is measured during the other pixels. The differences between the types of codes statistic is then computed; the result is the noise. No quantization noise is taken into account as no signal is input. Figure 15 gives noise figure graphs with signal input.

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**Table 1** Serial interface programming

| ADDRESS BITS |    |    | DATA BITS D9 to D0                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
|--------------|----|----|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| A2           | A1 | A0 |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |
| 0            | 0  | 0  | OFD output control (D7 to D0).                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
| 0            | 0  | 1  | Cut-off frequency of CDS and AGC. Only the 4 LSBs (D3 to D0) are used for CDS. D4 to D7 are used for AGC. D8 and D9 should be set to logic 0.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
| 0            | 1  | 0  | AGC gain control (D8 to D0).                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
| 0            | 1  | 1  | Partial standby controls for power consumption optimization. Only the 4 LSBs (D3 to D0) are used. Edge control for pulses SHP, SHD, CLAMP and clock ADC:<br>D0 = 1: CDS + AGC in standby; $I_{CCA} + I_{CCD} = 35 \text{ mA}$<br>D1 = 1: OFD DAC in standby; $I_{CCA} + I_{CCD} = 95 \text{ mA}$<br>D2 = 1: 6 dB amplifier (output on AMPOUT pin) in standby;<br>$I_{CCA} + I_{CCD} = 95.5 \text{ mA}$<br>D3 = 1: SHP and SHD activated with falling edge (for positive pulse)<br>D4 = 1: CLPDM, CLPOB and CLPADC activated on HIGH level; note 1<br>D5 = 0: CLKADC activated with falling edge<br>D6 must be set to logic 0. |
| 1            | 0  | 0  | Clamp reference DAC (D9 to D0).                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |

**Note**

- When CLPADC is HIGH (D4 = 1: serial interface), the ADC input is clamped to voltage level  $V_{ref}$ .  $V_{ref}$  is connected to ground via a capacitance.

**Table 2** Standby selection

| STDBY | DATA BITS D9 to D0 | $I_{CCA} + I_{CCD}$ (TYP.) |
|-------|--------------------|----------------------------|
| 1     | LOW                | 4 mA                       |
| 0     | active             | 96 mA                      |

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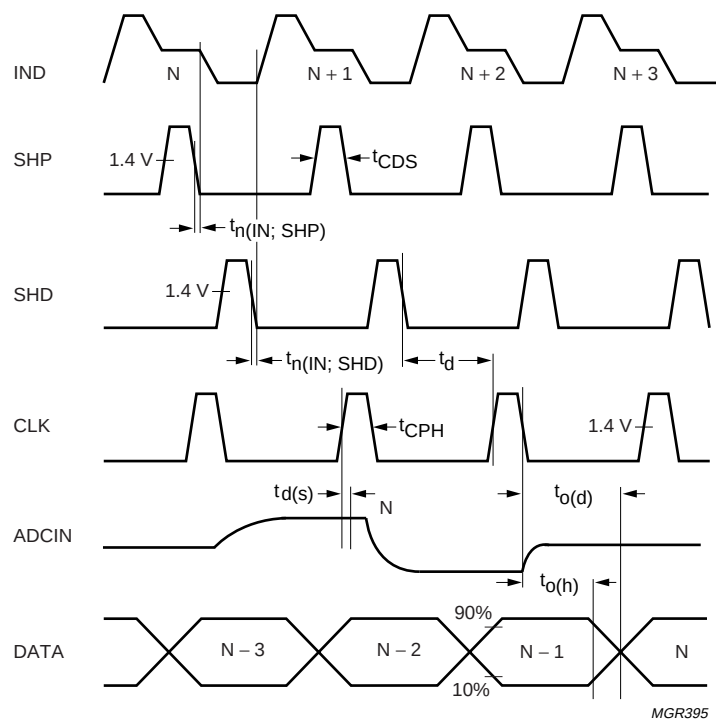
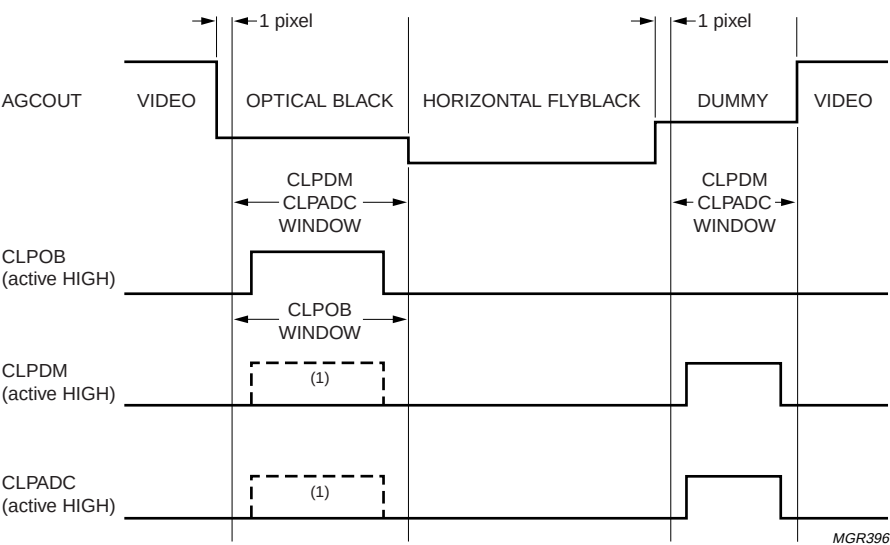


Fig.5 Pixel frequency timing diagram.

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(1) When dummy pixels are not available.

Fig.6 Line frequency timing diagram.

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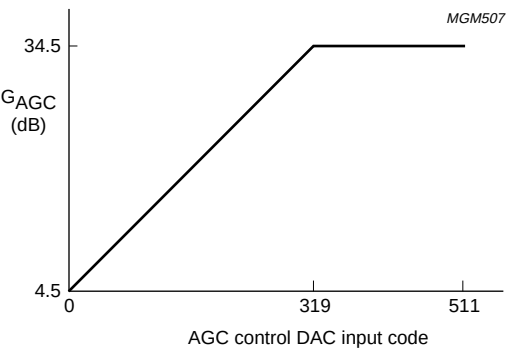


Fig.7 AGC gain as a function of DAC input code.

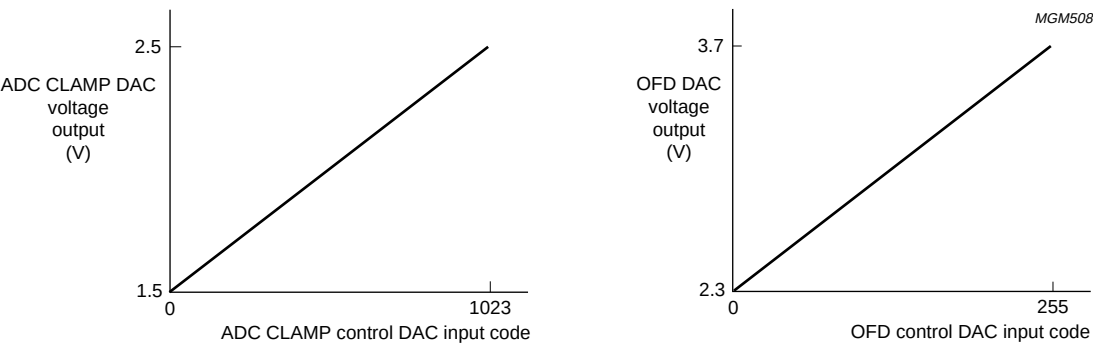


Fig.8 DAC voltage output as a function of DAC input code.



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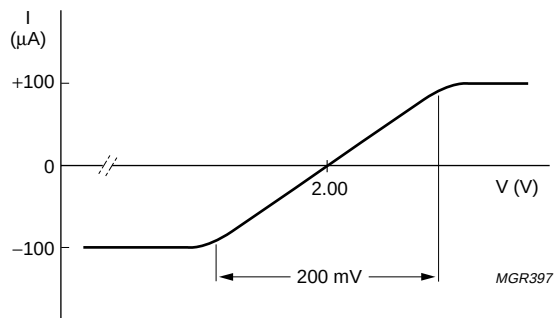


Fig.9 Typical clamp current for pin CPCDS.

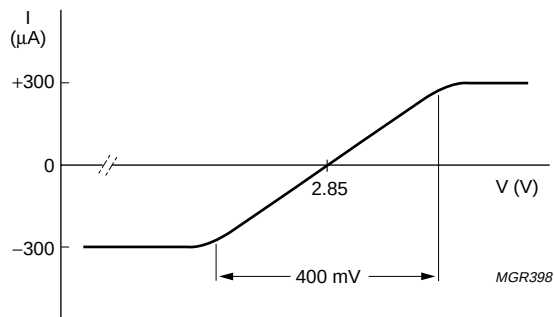


Fig.10 Typical clamp current for pins IND and INP.

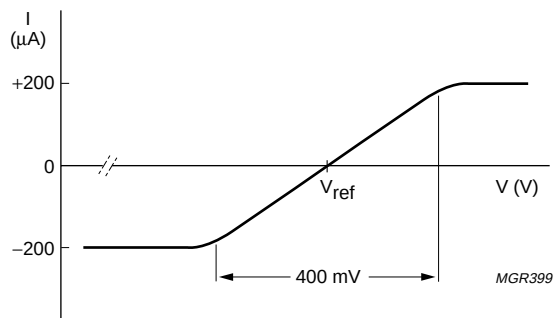
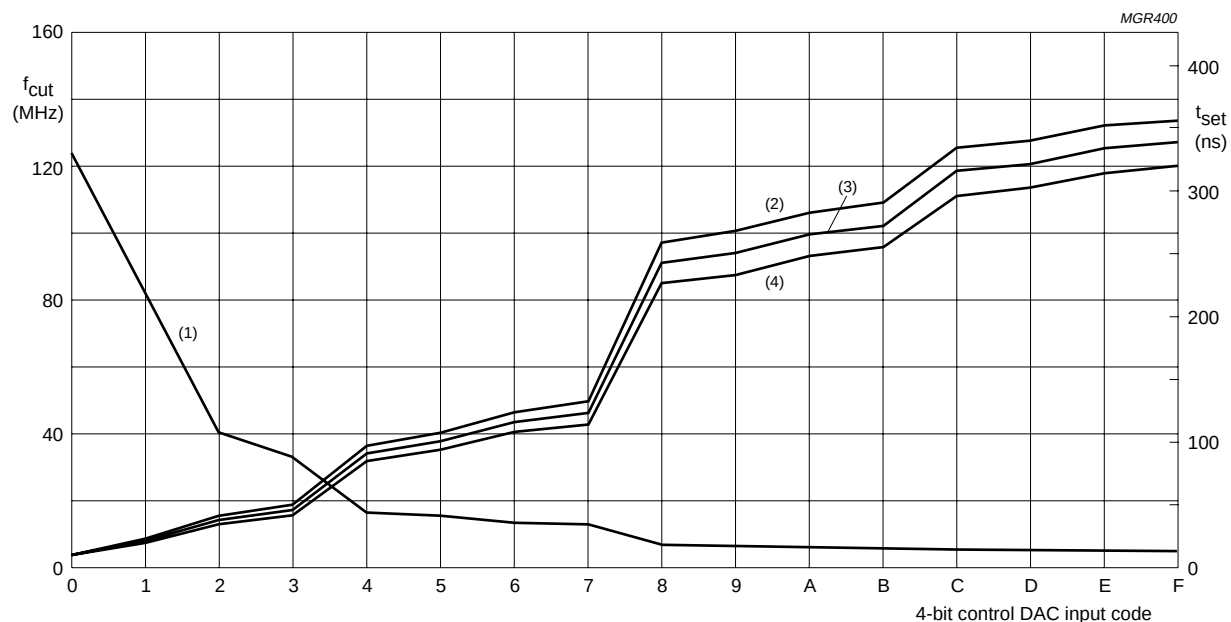


Fig.11 Typical clamp current for pin  $V_{\text{ref}}$ .

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- (1)  $f_{cut}$ .
- (2)  $t_{set}$  (10 bits accuracy).
- (3)  $t_{set}$  (9 bits accuracy).
- (4)  $t_{set}$  (8 bits accuracy).

Fig.12 CDS settling time and bandwidth.

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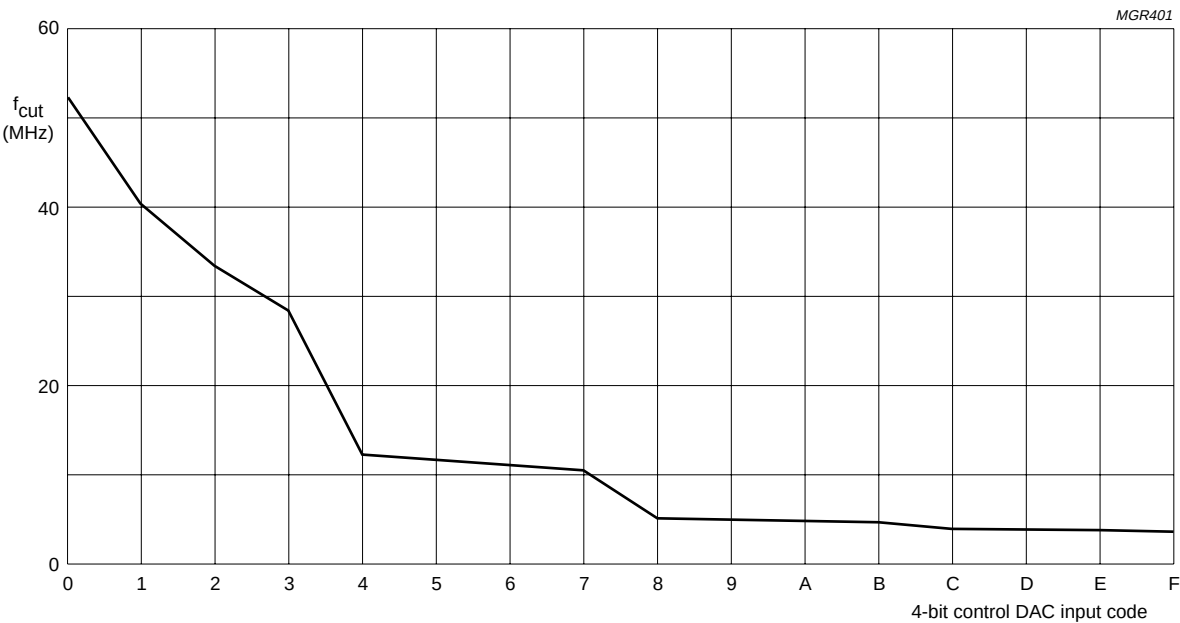


Fig.13 AGC bandwidth.

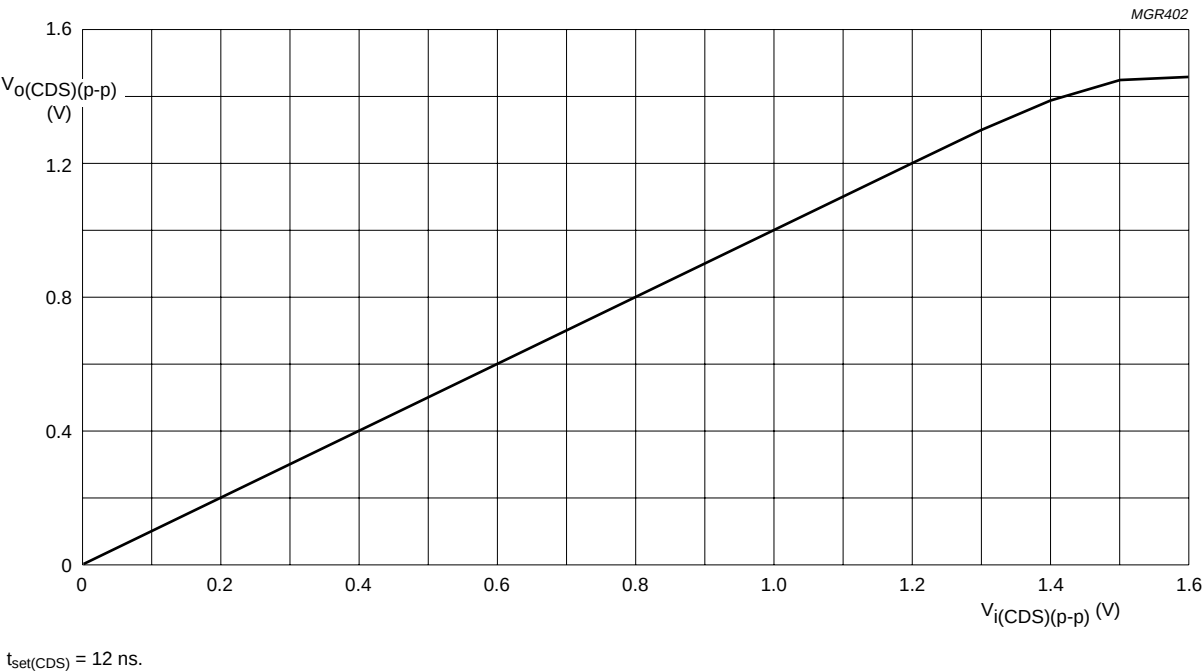
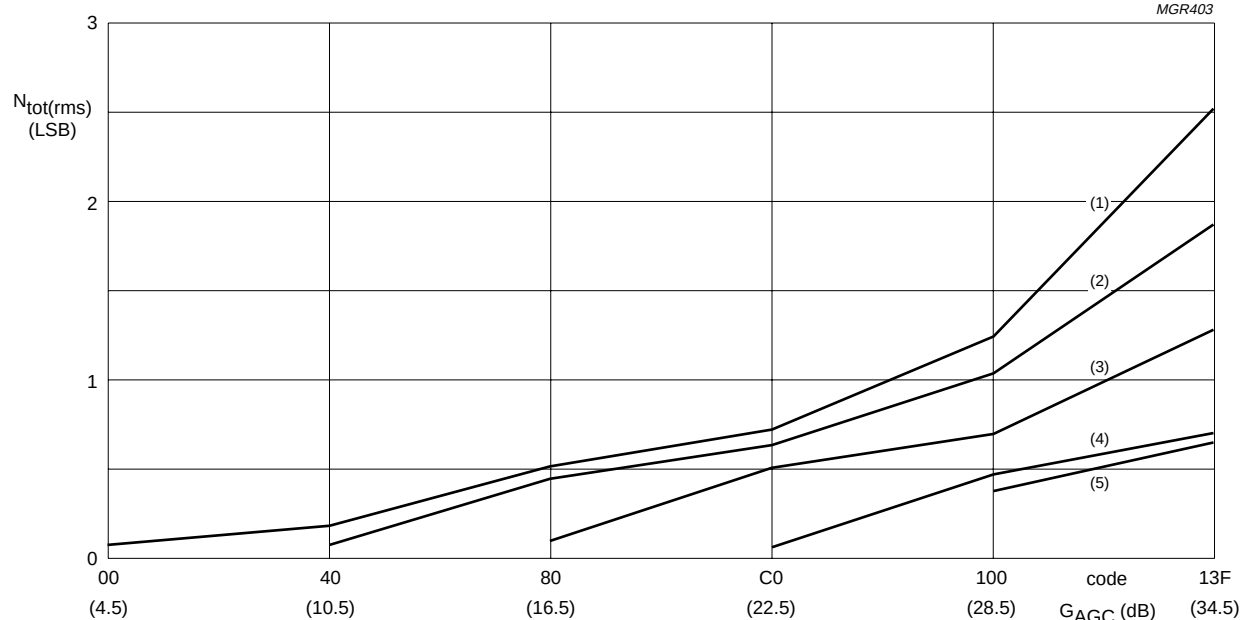


Fig.14 CDS output.

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MGR403



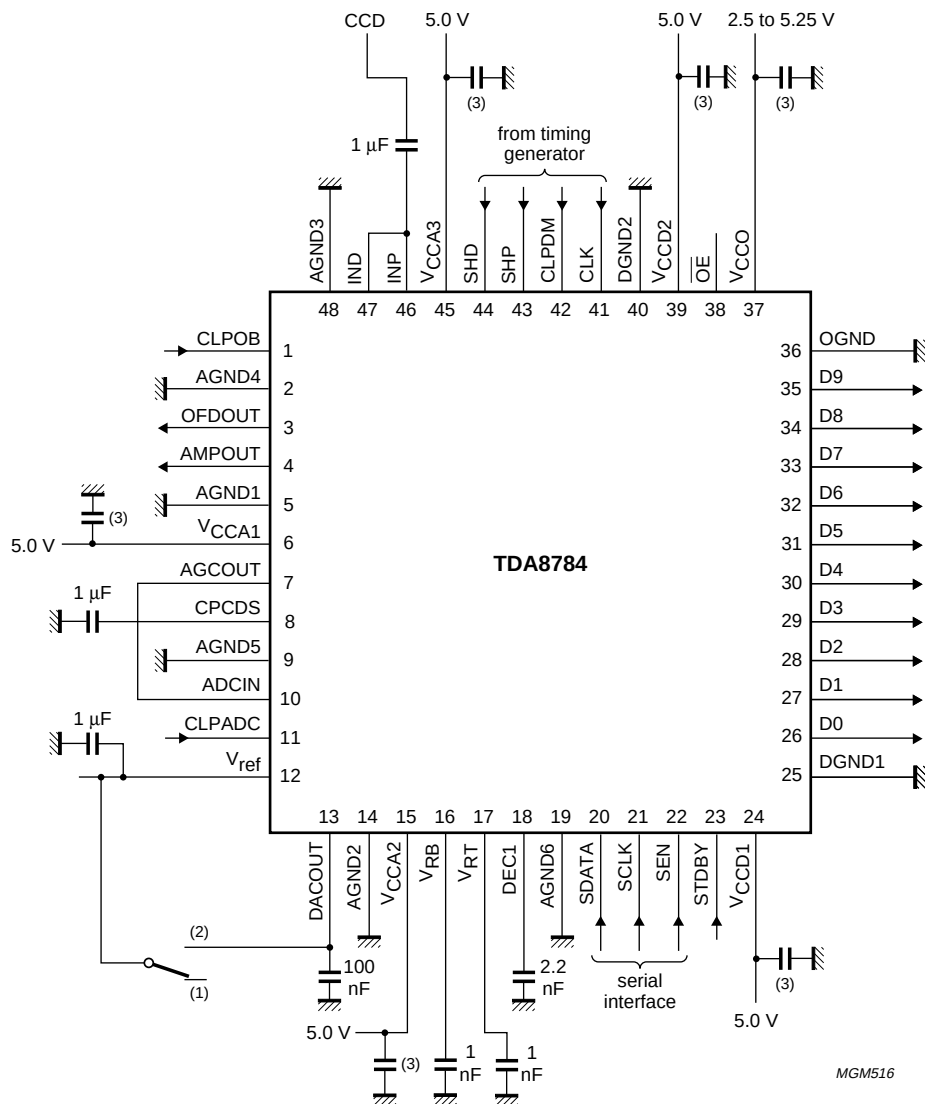
- (1)  $f_{pix} = 18$  MHz; control DAC = 10H;  $f_{cut(CDS)} = 120$  MHz;  $f_{cut(AGC)} = 40$  MHz.
- (2)  $f_{pix} = 10$  MHz; control DAC = 31H;  $f_{cut(CDS)} = 80$  MHz;  $f_{cut(AGC)} = 30$  MHz.
- (3)  $f_{pix} = 5$  MHz; control DAC = 43H;  $f_{cut(CDS)} = 35$  MHz;  $f_{cut(AGC)} = 12$  MHz.
- (4)  $f_{pix} = 1$  MHz; control DAC = F8H;  $f_{cut(CDS)} = 6$  MHz;  $f_{cut(AGC)} = 4$  MHz.
- (5)  $f_{pix} = 375$  kHz; control DAC = FFH;  $f_{cut(CDS)} = 4$  MHz;  $f_{cut(AGC)} = 4$  MHz.

Fig.15 Output noise (RMS value).

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## APPLICATION INFORMATION



Depending on the application, the following connections must be made:

- (1) The clamp level of the signal input at ADCIN can be tuned from code 00 to code 511 in 0.5 LSB steps of ADC via the serial interface (clamp ADC activated).
- (2) Clamp ADC not activated, direct connection from DACOUT to  $V_{ref}$ .
- (3) All supply pins must be decoupled with 100 nF capacitors as close as possible to the device.

Fig.16 Application diagram.

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### Power and grounding recommendations

Care must be taken to minimize noise when designing a printed-circuit board for applications such as PC cameras, surveillance cameras, camcorders and digital still cameras.

For the front-end integrated circuit, the basic rules of printed-circuit board design and implementation of analog components (such as classical operational amplifiers) must be taken into account, particularly with respect to power and ground connections.

The connections between CCD interface and CDS input should be as short as possible and a ground ring protection around these connections can be beneficial.

Decoupling capacitors are necessary on all supply pins as shown in Fig.16.

Separate analog and digital supplies provide the best performance. If it is not possible to do this on the board, then decouple the analog supply pins effectively from the digital supply pins. The decoupling capacitors must be placed as close as possible to the IC package.

In a two-ground system, in order to minimize the noise from package and die parasitics, the following recommendations must be implemented:

- The ground pin associated with the digital outputs must be connected to the digital ground plane and special care should be taken to avoid feedthrough in the analog ground plane. The analog and digital ground planes must be connected with an inductor as close as possible to the IC package, in order to have the same DC voltage on the ground planes.
- The digital output pins and their associated lines should be shielded by the digital ground plane, which can be used as return path for the digital signals.

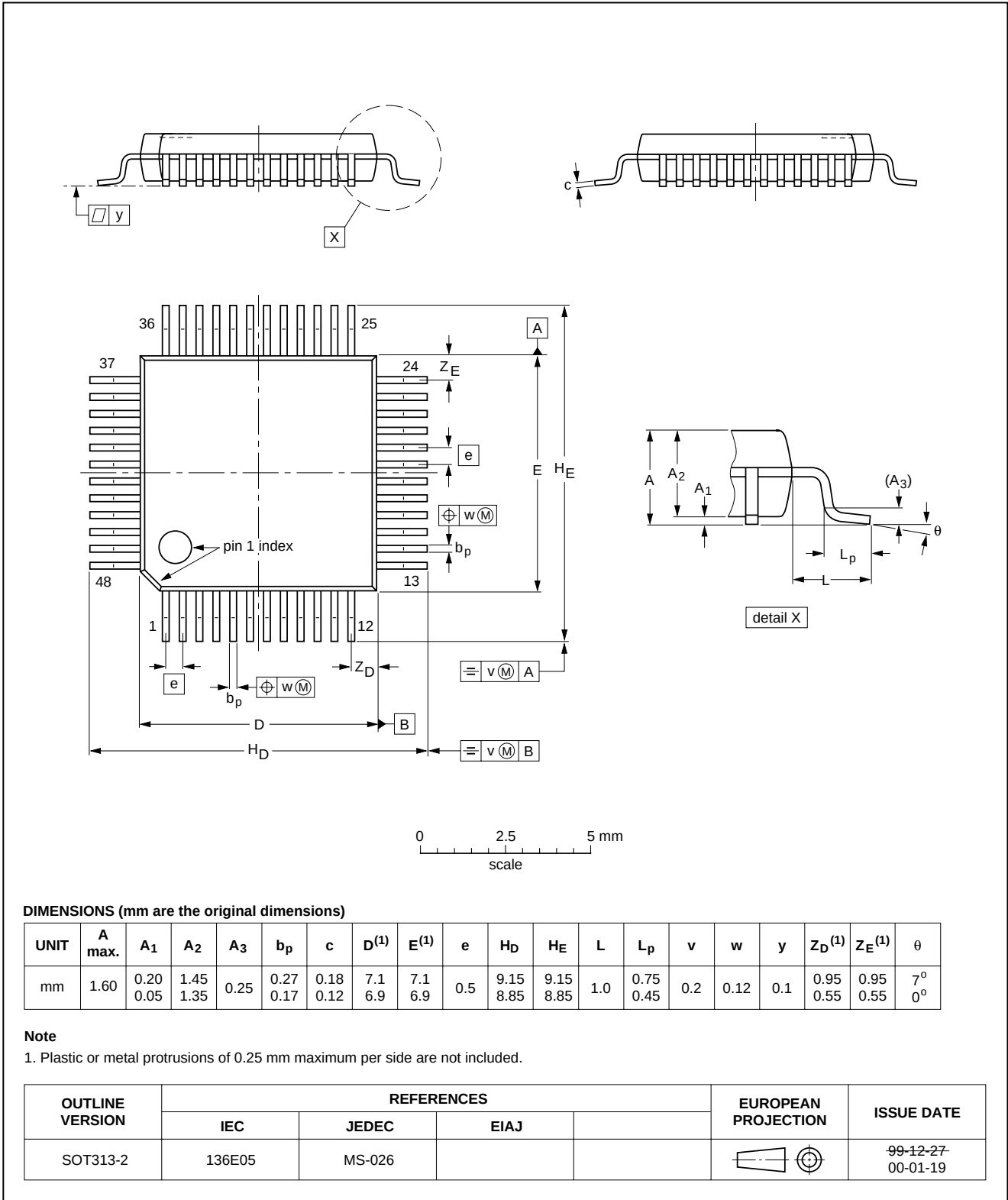
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PACKAGE OUTLINE

LQFP48: plastic low profile quad flat package; 48 leads; body 7 x 7 x 1.4 mm

SOT313-2



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## SOLDERING

### 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.

### 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.

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 250 °C. The top-surface temperature of the packages should preferably be kept below 220 °C for thick/large packages, and below 235 °C for small/thin packages.

### 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 is 4 seconds at 250 °C.

A mildly-activated flux will eliminate the need for removal of corrosive residues in most applications.

### 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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## Suitability of surface mount IC packages for wave and reflow soldering methods

| PACKAGE <sup>(1)</sup>                                           | SOLDERING METHOD                  |                       |
|------------------------------------------------------------------|-----------------------------------|-----------------------|
|                                                                  | WAVE                              | REFLOW <sup>(2)</sup> |
| BGA, LBGA, LFBGA, SQFP, TFBGA, VFBGA                             | not suitable                      | suitable              |
| HBCC, HBGA, HLQFP, HSQFP, HSOP, HTQFP, HTSSOP, HVQFN, HVSON, SMS | not suitable <sup>(3)</sup>       | suitable              |
| PLCC <sup>(4)</sup> , SO, SOJ                                    | suitable                          | suitable              |
| LQFP, QFP, TQFP                                                  | not recommended <sup>(4)(5)</sup> | suitable              |
| SSOP, TSSOP, VSO                                                 | not recommended <sup>(6)</sup>    | suitable              |

### Notes

- 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.
- 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”.
- 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.
- 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.
- 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.
- Wave soldering is suitable for SSOP and TSSOP 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.

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## DATA SHEET STATUS

| LEVEL | DATA SHEET STATUS <sup>(1)</sup> | PRODUCT STATUS <sup>(2)(3)</sup> | DEFINITION                                                                                                                                                                                                                                                                                     |
|-------|----------------------------------|----------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| I     | Objective data                   | Development                      | This data sheet contains data from the objective specification for product development. Philips Semiconductors reserves the right to change the specification in any manner without notice.                                                                                                    |
| II    | Preliminary data                 | Qualification                    | This data sheet contains data from the preliminary specification. Supplementary data will be published at a later date. Philips Semiconductors reserves the right to change the specification without notice, in order to improve the design and supply the best possible product.             |
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2. The product status of the device(s) described in this data sheet may have changed since this data sheet was published. The latest information is available on the Internet at URL <http://www.semiconductors.philips.com>.
3. For data sheets describing multiple type numbers, the highest-level product status determines the data sheet status.

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**Limiting values definition** — Limiting values given are in accordance with the Absolute Maximum Rating System (IEC 60134). Stress above one or more of the limiting values may cause permanent damage to the device. These are stress ratings only and operation of the device at these or at any other conditions above those given in the Characteristics sections of the specification is not implied. Exposure to limiting values for extended periods may affect device reliability.

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#### NOTES

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