



# TDA7590

## Digital signal processing IC for speech and audio applications

### Features

- 24-bit, fixed point, 120 MIPS DSP core
- Large on-board memory (128KW-24 bit)
- Host access to internal RAM through expansion port
- Access to external RAM (16Mw) through expansion port
- Integrated stereo, 18-bit Sigma-DELTA A/D and 20-bit D/A converters
- Programmable CODEC sample rate up to 48 kHz
- On-board PLL for core clock and converters
- External Flash/SRAM memory bank management
- I<sup>2</sup>C and SCI serial interface for external control
- 2 enhanced synchronous serial interface (ESSI)
- JTAG interface
- Host interface
- 144-pin TQFP, 0.50 mm pitch
- Automotive temperature range (from -40 °C to +85 °C)

### Applications

- Real time digital speech and audio processing:
  - speech recognition
  - speech synthesis
  - speech compression
  - echo canceling
  - noise canceling
  - MP3 decoding



### Description

The TDA7590 is a high performances, fully programmable 24-bit, 120 MIPS. Digital signal processor (DSP), designed to support several speech and audio applications, as automatic speech recognition, speech synthesis, MP3 decoding, echo and noise cancellation.

Nevertheless, the embedded CODECs bandwidth and the generic processing engine allow to proceed also full-band audio signals. The large amount of on-chip memory (128 Kwords), together with the 16 Mwords external memory addressable and the 32 general purpose I/O pins permit to build a DSP-system avoiding the usage of an additional microcontroller.

The presence of serial and parallel interfaces allows easy connection with external devices including CODECs, DSPs, microprocessors and personal computers.

In particular, the debug/JTAG interface permits the on-chip emulation of the firmware developed. Further, the presence of the timers and watchdog block makes TDA7590 suitable for PWM processing and allows the integration of a system watchdog.

**Table 1. Device summary**

| Order code  | Package                                             | Packing       |
|-------------|-----------------------------------------------------|---------------|
| E-TDA7590   | TQFP144 (20x20x1.0 exposed pad down) <sup>(1)</sup> | Tray          |
| E-TDA7590TR |                                                     | Tape and reel |

1. In ECOPACK® package (see [Section 9: Package information on page 40](#)).

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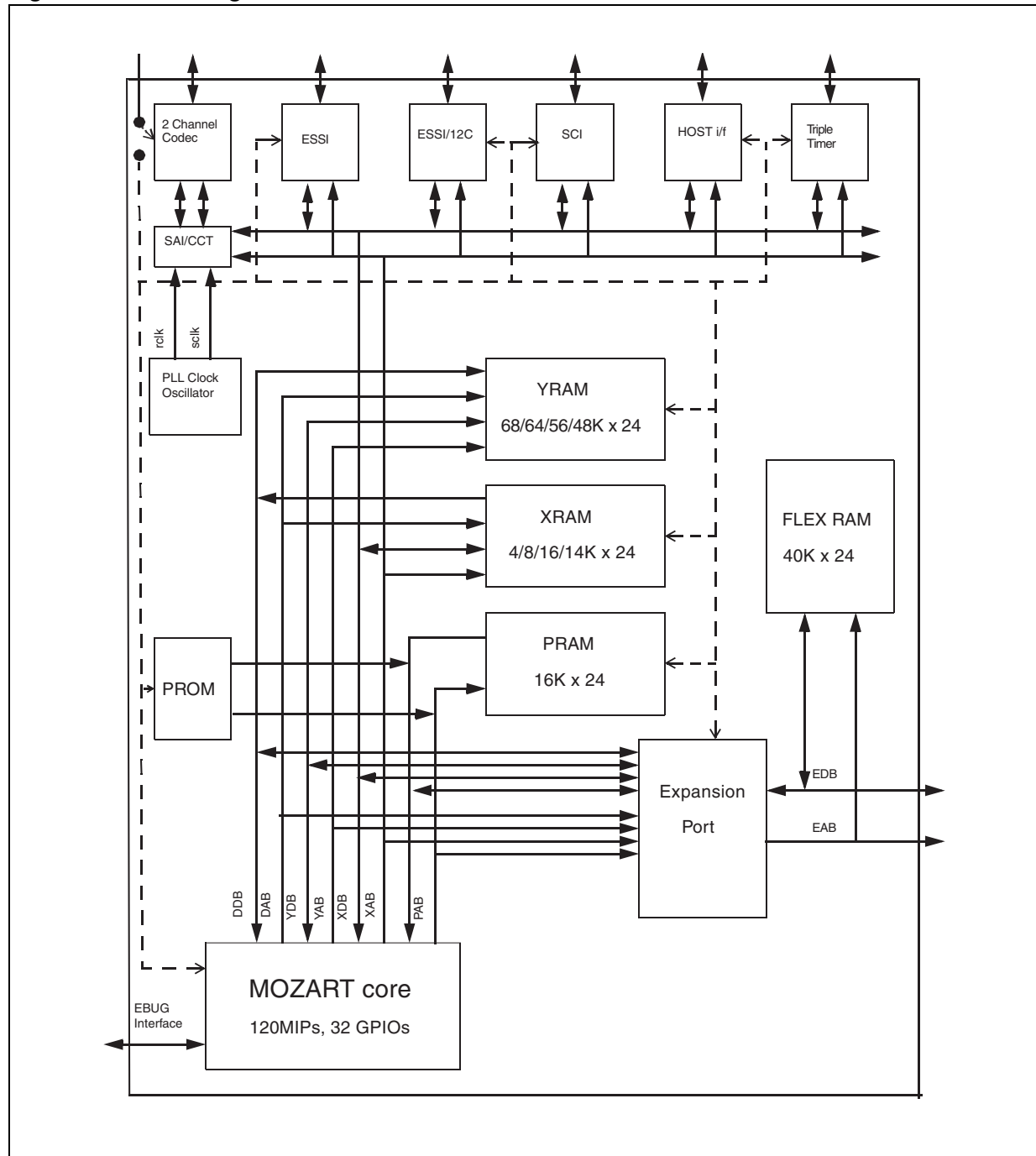
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# 1 Block diagram

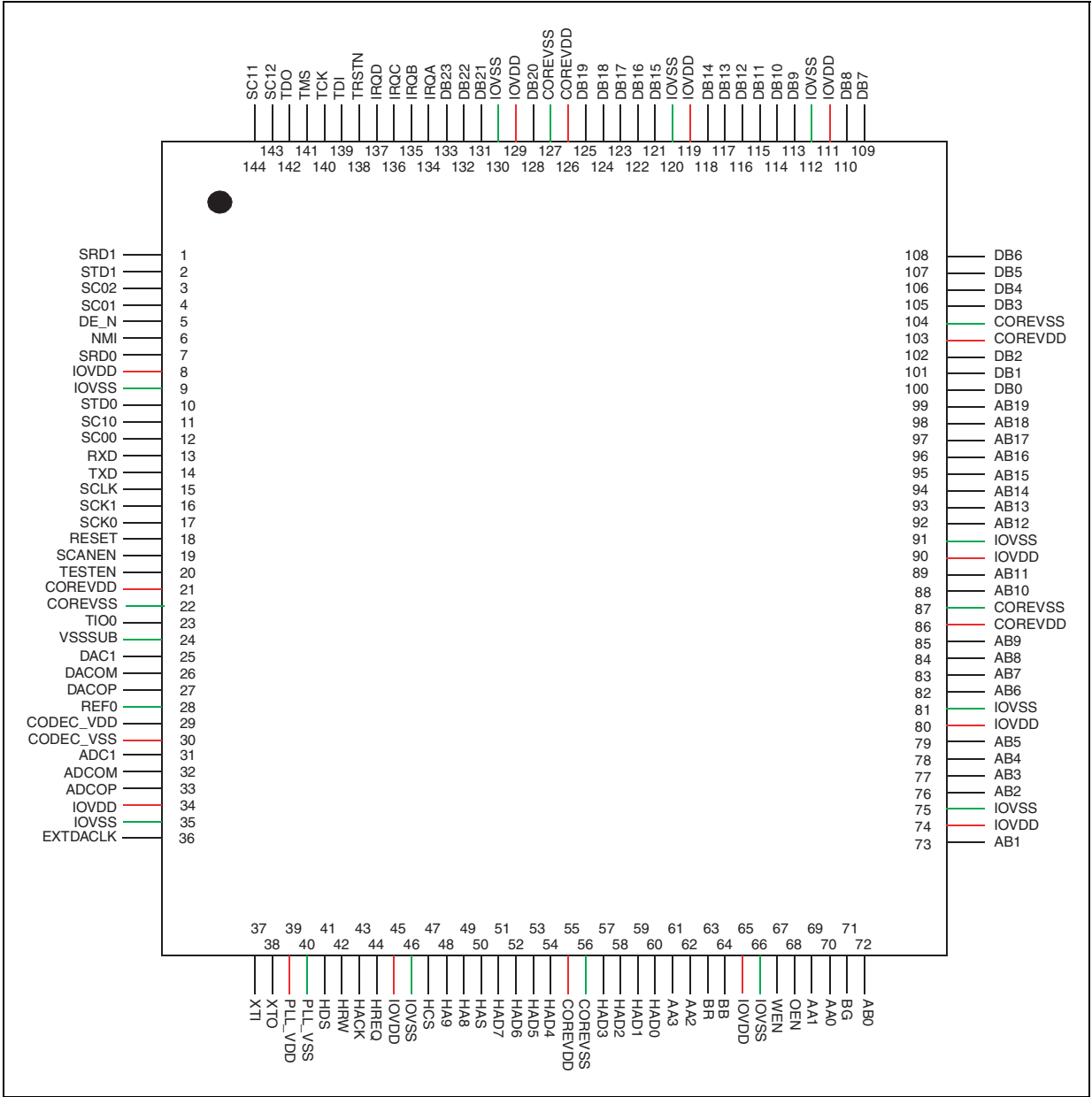
Figure 1. Block diagram



# 2 Pin description

## 2.1 Pin connection

Figure 2. Pin connection (top view)



## 2.2 Pin function

**Table 2. Pin function**

| N° | Name      | Type | Description                                                                                                                                                                      |
|----|-----------|------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1  | SRD1/TI02 | I/O  | Serial receive data. Serial input data for receiver. Timer 2 input/output.                                                                                                       |
| 2  | STD1      | I/O  | Serial transmit data. Serial output data from transmitter.                                                                                                                       |
| 3  | SC02      | I/O  | Serial control 2. Transmitter frame sync only in asynchronous mode, transmitter and receiver frame sync in synchronous mode.                                                     |
| 4  | SC01      | I/O  | Serial control 1. Receive frame sync in asynchronous mode, output from transmitter 2 or serial flag 1 in synchronous mode.                                                       |
| 5  | DE_N      | I/O  | Test data output (input/output). Debug request input and acknowledge output.                                                                                                     |
| 6  | NMI_N     | I    | Non-maskable interrupt/ PINIT. Used to enable the PLL during RESET and as a non-maskable interrupt at all other times.                                                           |
| 7  | SRD0      | I/O  | Serial receive data. Serial input data for receiver.                                                                                                                             |
| 8  | IOVDD     | I    | IO power supply.                                                                                                                                                                 |
| 9  | IOVSS     | I    | IO ground.                                                                                                                                                                       |
| 10 | STD0      | I/O  | Serial Transmit Data. Serial output data from transmitter.                                                                                                                       |
| 11 | SC10/SCL  | I/O  | ESSI1 serial control 0. Receive clock in asynchronous mode, output from transmitter or serial flag in synchronous mode.<br>I <sup>2</sup> C SCL serial clock line.               |
| 12 | SC00      | I/O  | Serial control 0. Receive clock in asynchronous mode, output from transmitter 1 or serial flag 0 in synchronous mode.                                                            |
| 13 | RXD       | I/O  | SCI receive data. Receives byte-oriented serial data.                                                                                                                            |
| 14 | TXD       | I/O  | SCI read enable. Transmits serial data from SCI transmit shift register.                                                                                                         |
| 15 | SCLK      | I/O  | SCI serial clock. Input or output clock from which data is transferred in synchronous mode and from which the transmit and/or receive baud rate is derived in asynchronous mode. |
| 16 | SCK1/TI01 | I/O  | Serial clock. Serial bit clock for transmitter only in asynchronous mode, serial bit clock for both receiver and transmitter in synchronous mode.<br>Timer 1 input/output.       |
| 17 | SCK0      | I/O  | Serial clock. Serial bit clock for transmitter only in asynchronous mode, serial bit clock for both receiver and transmitter in synchronous mode.                                |
| 18 | RESETN    | I    | System reset. A low level applied to RESET_N input initializes the IC.                                                                                                           |
| 19 | SCANEN    | I    | SCAN enable. When active with TESTEN also active, controls the shifting of the internal scan chains.                                                                             |
| 20 | TESTEN    | I    | Test enable. When active, puts the chip into test mode and muxes the XTI clock to all flip-flops. When SCANEN is also active, the scan chain shifting is enabled.                |
| 21 | COREVSS   | I    | Core ground.                                                                                                                                                                     |
| 22 | COREVDD   | I    | Core power supply.                                                                                                                                                               |
| 23 | TIO0      | I/O  | Timer 0 input/output.                                                                                                                                                            |
| 24 | VSSSUB    | I    | Analog substrate isolation.                                                                                                                                                      |

Table 2. Pin function (continued)

| N° | Name      | Type | Description                                                                                                                                                                         |
|----|-----------|------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 25 | DAC1      | O    | DAC1 left single analog output.                                                                                                                                                     |
| 26 | DAC0M     | O    | DAC0 negative right differential analog output.                                                                                                                                     |
| 27 | DAC0P     | O    | DAC0 positive right differential analog output.                                                                                                                                     |
| 28 | CODEC_VSS | I    | Voltage ground.                                                                                                                                                                     |
| 29 | REF0      | I    | Codec power supply.                                                                                                                                                                 |
| 30 | CODEC_VDD | I    | Codec reference.                                                                                                                                                                    |
| 31 | ADC1      | I    | ADC1 left single analog input.                                                                                                                                                      |
| 32 | ADC0M     | I    | DAC0 negative right differential analog inputs.                                                                                                                                     |
| 33 | ADC0P     | I    | DAC0 positive right differential analog inputs.                                                                                                                                     |
| 36 | EXTDACLK  | I    | External DAC clock. Optional external clock source from which LRCLK and SCLK can be generated.                                                                                      |
| 37 | XTI       | I    | Crystal oscillator input. External clock input or crystal connection.                                                                                                               |
| 38 | XTO       | O    | Crystal oscillator output. Crystal oscillator output drive.                                                                                                                         |
| 39 | PLL_VDD   | I    | PLL power supply.                                                                                                                                                                   |
| 40 | PLL_VSS   | I    | PLL ground input.                                                                                                                                                                   |
| 41 | HDS       | I/O  | Host data strobe. Polarity programmable Host data strobe input for single strobe mode. Polarity programmable Host write strobe input for double strobe mode.                        |
| 42 | HRW       | I/O  | Host read/write. Host read/write for single strobe bus mode. Polarity programmable Host read data strobe for double strobe mode.                                                    |
| 43 | HACK      | I/O  | Host acknowledge. Polarity programmable host interrupt acknowledge for single host request mode. Polarity programmable host receive request interrupt for double host request mode. |
| 44 | HREQ      | I/O  | Host request. Polarity programmable host request interrupt for single host request mode. Polarity programmable host transfer request interrupt for double host request mode.        |
| 45 | IOVDD     | I    | IO power supply.                                                                                                                                                                    |
| 46 | IOVSS     | I    | IO ground.                                                                                                                                                                          |
| 47 | HCS       | I/O  | Host chip select. Polarity programmable host chip select for non-multiplexed mode.<br>Host address Line 10 for multiplexed mode.                                                    |
| 48 | HA9       | I/O  | Host address 9. Address line 9 in multiplexed mode otherwise address line 2 in non-multiplexed mode.                                                                                |
| 49 | HA8       | I/O  | Host address 8. Address line 8 in multiplexed mode otherwise address line 1 in non-multiplexed mode.                                                                                |
| 50 | HAS       | I/O  | Host address strobe. Address strobe for multiplexed bus or Address 0 for non multiplexed.                                                                                           |
| 51 | HAD[7]    | I/O  | Host 8-bit data line 7. Host data bus and/or address lines when in multiplexed mode.                                                                                                |

Table 2. Pin function (continued)

| N° | Name    | Type | Description                                                                                                                                   |
|----|---------|------|-----------------------------------------------------------------------------------------------------------------------------------------------|
| 52 | HAD[6]  | I/O  | Host 8-bit data line 6. Host data bus and/or address lines when in multiplexed mode.                                                          |
| 53 | HAD[5]  | I/O  | Host 8-bit data line 5. Host data bus and/or address lines when in multiplexed mode.                                                          |
| 54 | HAD[4]  | I/O  | Host 8-bit data line 4. Host data bus and/or address lines when in multiplexed mode.                                                          |
| 55 | COREVDD | I    | Core power supply.                                                                                                                            |
| 56 | COREVSS | I    | Core ground.                                                                                                                                  |
| 57 | HAD[3]  | I/O  | Host 8-bit data line 3. Host data bus and/or address lines when in multiplexed mode.                                                          |
| 58 | HAD[2]  | I/O  | Host 8-bit data line 2. Host data bus and/or address lines when in multiplexed mode.                                                          |
| 59 | HAD[1]  | I/O  | Host 8-bit data line 1. Host data bus and/or address lines when in multiplexed mode.                                                          |
| 60 | HAD[0]  | I/O  | Host 8-bit data line 0. Host data bus and/or address lines when in multiplexed mode.                                                          |
| 61 | AA[3]   | O    | Address attributes line 3.Port A address attributes/chip select pins with programmable polarity.                                              |
| 62 | AA[2]   | O    | Address attributes line 2.Port A address attributes/chip select pins with programmable polarity.                                              |
| 63 | BR_N    | O    | Bus request. Asserted when port A requires bus mastership to perform off-chip accesses.                                                       |
| 64 | BB_N    | I/O  | Bus busy. Asserted by port A when bus_busy_in_n is negated and BG_N is asserted.                                                              |
| 65 | IOVDD   | I    | IO power supply.                                                                                                                              |
| 66 | IOVSS   | I    | IO ground.                                                                                                                                    |
| 67 | WEN_N   | O    | Write enable.                                                                                                                                 |
| 68 | OEN_N   | O    | Output enable.                                                                                                                                |
| 69 | AA[1]   | O    | Address attributes line 1.Port A address attributes/chip select pins with programmable polarity.                                              |
| 70 | AA[0]   | O    | Address attributes line 0.Port A address attributes/chip select pins with programmable polarity.                                              |
| 71 | BG_N    | I    | Bus grant. When asserted, Port A becomes the bus master elect. Bus mastership is attained when bus busy is negated by the current bus master. |
| 72 | AB[0]   | O    | Address bus line 0. Port A external address bus.                                                                                              |
| 73 | AB[1]   | O    | Address bus line 1. Port A external address bus.                                                                                              |
| 74 | IOVDD   | I    | IO power supply.                                                                                                                              |
| 75 | IOVSS   | I    | IO ground.                                                                                                                                    |
| 76 | AB[2]   | O    | Address bus line 2. Port A external address bus.                                                                                              |

Table 2. Pin function (continued)

| N°  | Name    | Type | Description                                       |
|-----|---------|------|---------------------------------------------------|
| 77  | AB[3]   | O    | Address bus line 3. Port A external address bus.  |
| 78  | AB[4]   | O    | Address bus line 4. Port A external address bus.  |
| 79  | AB[5]   | O    | Address bus line 5. Port A external address bus.  |
| 80  | IOVDD   | I    | IO power supply.                                  |
| 81  | IOVSS   | I    | IO ground.                                        |
| 82  | AB[6]   | O    | Address bus line 6. Port A external address bus.  |
| 83  | AB[7]   | O    | Address bus line 7. Port A external address bus.  |
| 84  | AB[8]   | O    | Address bus line 8. Port A external address bus.  |
| 85  | AB[9]   | O    | Address bus line 9. Port A external address bus.  |
| 86  | COREVDD | I    | Core power supply.                                |
| 87  | COREVSS | I    | Core ground.                                      |
| 88  | AB[10]  | O    | Address bus line 10. Port A external address bus. |
| 89  | AB[11]  | O    | Address bus line 11. Port A external address bus. |
| 90  | IOVDD   | I    | IO power supply.                                  |
| 91  | IOVSS   | I    | IO ground.                                        |
| 92  | AB[12]  | O    | Address bus line 12. Port A external address bus. |
| 93  | AB[13]  | O    | Address bus line 13. Port A external address bus. |
| 94  | AB[14]  | O    | Address bus line 14. Port A external address bus. |
| 95  | AB[15]  | O    | Address bus line 15. Port A external address bus. |
| 96  | AB[16]  | O    | Address bus line 16. Port A external address bus. |
| 97  | AB[17]  | O    | Address bus line 17. Port A external address bus. |
| 98  | AB[18]  | O    | Address bus line 18. Port A external address bus. |
| 99  | AB[19]  | O    | Address bus line 19. Port A external address bus. |
| 100 | DB[0]   | I/O  | Address bus 0. Port A external data bus.          |
| 101 | DB[1]   | I/O  | Address bus 1. Port A external data bus.          |
| 102 | DB[2]   | I/O  | Address bus 2. Port A external data bus.          |
| 103 | COREVDD | I    | Core power supply.                                |
| 104 | COREVSS | I    | Core ground.                                      |
| 105 | DB[3]   | I/O  | Data bus line 3. Port A external data bus.        |
| 106 | DB[4]   | I/O  | Data bus line 4. Port A external data bus.        |
| 107 | DB[5]   | I/O  | Data bus line 5. Port A external data bus.        |
| 108 | DB[6]   | I/O  | Data bus line 6. Port A external data bus.        |
| 109 | DB[7]   | I/O  | Data bus line 7. Port A external data bus.        |
| 110 | DB[8]   | I/O  | Data bus line 8. Port A external data bus.        |
| 111 | IOVDD   | I    | IO Power Supply.                                  |

Table 2. Pin function (continued)

| N°  | Name    | Type | Description                                                                                                               |
|-----|---------|------|---------------------------------------------------------------------------------------------------------------------------|
| 112 | IOVSS   | I    | IO Ground.                                                                                                                |
| 113 | DB[9]   | I/O  | Data Bus line 9. Port A external data bus.                                                                                |
| 114 | DB[10]  | I/O  | Data bus line 10. Port A external data bus.                                                                               |
| 115 | DB[11]  | I/O  | Data bus line 11. Port A external data bus.                                                                               |
| 116 | DB[12]  | I/O  | Data bus line 12. Port A external data bus.                                                                               |
| 117 | DB[13]  | I/O  | Data bus line 13. Port A external data bus.                                                                               |
| 118 | DB[14]  | I/O  | Data bus line 14. Port A external data bus.                                                                               |
| 119 | IOVDD   | I    | IO power supply.                                                                                                          |
| 120 | IOVSS   | I    | IO Ground.                                                                                                                |
| 121 | DB[15]  | I/O  | Data bus line 15. port a external data bus.                                                                               |
| 122 | DB[16]  | I/O  | Data bus line 16. Port A external data bus.                                                                               |
| 123 | DB[17]  | I/O  | Data bus line 17. Port A external data bus.                                                                               |
| 124 | DB[18]  | I/O  | Data bus line 18. Port A external data bus.                                                                               |
| 125 | DB[19]  | I/O  | Data bus line 19. Port A external data bus.                                                                               |
| 126 | COREVDD | I    | Core power supply.                                                                                                        |
| 127 | COREVSS | I    | Core ground.                                                                                                              |
| 128 | DB[20]  | I/O  | Data bus line 20. Port A external data bus.                                                                               |
| 129 | IOVDD   | I    | IO power supply.                                                                                                          |
| 130 | IOVSS   | I    | IO ground.                                                                                                                |
| 131 | DB[21]  | I/O  | Data bus line 21. Port A external data bus.                                                                               |
| 132 | DB[22]  | I/O  | Data bus line 22. Port A external data bus.                                                                               |
| 133 | DB[23]  | I/O  | Data bus line 23. Port A external data bus.                                                                               |
| 134 | IRQA    | I    | Interrupt request line/ Mode control. Used as mode control during RESET and as interrupt request line at all other times. |
| 135 | IRQB    | I    | Interrupt request line/ Mode control. Used as mode control during RESET and as interrupt request line at all other times. |
| 136 | IRQC    | I    | Interrupt request line/ Mode control. Used as mode control during RESET and as interrupt request line at all other times. |
| 137 | IRQD    | I    | Interrupt request line/ Mode control. Used as mode control during RESET and as interrupt request line at all other times. |
| 138 | TRSTN   | I    | Test reset. JTAG output pin for serial data out from debug interface.                                                     |
| 139 | TDI     | I    | Test data input. JTAG input pin for serial data input for debug interface.                                                |
| 140 | TCK     | I    | Test clock. JTAG input pin for clocking debug interface.                                                                  |
| 141 | TMS     | I    | Test mode select. JTAG input pin for control of TAP Controller of debug interface.                                        |
| 142 | TDO     | O    | Test data output. JTAG output pin for serial data out from debug interface.                                               |

**Table 2. Pin function (continued)**

| N°  | Name     | Type | Description                                                                                                                                                           |
|-----|----------|------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 143 | SC12     | I/O  | Serial control 2. Transmitter frame sync only in asynchronous mode, transmitter and receiver frame sync in synchronous mode.                                          |
| 144 | SC11/SDA | I/O  | Serial control 1. Receive frame sync in asynchronous mode, output from transmitter 2 or serial flag 1 in synchronous mode.<br>I <sup>2</sup> C SDA. Serial data line. |

## 2.3 Thermal data

**Table 3. Thermal data**

| Symbol                 | Parameter                           | Value | Unit |
|------------------------|-------------------------------------|-------|------|
| R <sub>th-j-pins</sub> | Thermal resistance junction to pins | 32    | °C/W |

## 3 Key parameters

### 3.1 Power consumption

Power consumption depends on application running and DSP clock frequency.

Supply current values are measured and guaranteed at testing level by adopting the benchmarking program reported in Appendix 1.

**Table 4. Key parameters**

| Symbol                  | Parameter                            | Min. | Typ. | Max. | Unit |
|-------------------------|--------------------------------------|------|------|------|------|
| <b>General</b>          |                                      |      |      |      |      |
| fosc                    | Crystal frequency                    |      |      | 16   | MHz  |
| CORE_VDD                | Operating voltage                    | 1.62 | 1.8  | 1.98 | V    |
| CODEC_VDD               | Operating voltage                    | 3.0  | 3.3  | 3.6  | V    |
| IOVDD                   | Operating voltage                    | 3.0  | 3.3  | 3.6  | V    |
| PLL_VDD                 | Operating voltage                    | 3.0  | 3.3  | 3.6  | V    |
| IDD_1.8V                | Supply current                       |      |      | 150  | mA   |
| IDD_3.3V                | Supply current                       |      |      | 50   | mA   |
| Tamb                    | Operating temperature                | -40  |      | 85   | °C   |
| <b>DSP core</b>         |                                      |      |      |      |      |
| fdsp                    | DSP clock frequency                  |      |      | 120  | MHz  |
| <b>ADC single ended</b> |                                      |      |      |      |      |
| Vpp                     | Maximum input range at ADC1          |      |      | 1.4  | V    |
| THD/S                   | Total harmonics distortion to signal |      | -71  |      | dB   |
| (THD+N)/S               | (THD + Noise) to signal              |      | -70  |      | dB   |
| DR                      | Dynamic range                        |      | 75   |      | dB   |
| ICL                     | Interchannel Isolation               |      | -100 |      | dB   |
| <b>ADC differential</b> |                                      |      |      |      |      |
| Vpp                     | Maximum input range at ADC0M-ADC0P   |      |      | 2.8  | V    |
| THD/S                   | Total harmonics distortion to signal |      | -65  |      | dB   |
| (THD+N)/S               | (THD + Noise) to signal              |      | -65  |      | dB   |
| DR                      | Dynamic range                        |      | 84   |      | dB   |
| ICL                     | Interchannel isolation               |      | -100 |      | dB   |
| <b>DAC single ended</b> |                                      |      |      |      |      |
| Vpp                     | Maximum input range at ADC1          |      |      | 1.4  | V    |
| THD/S                   | Total harmonics distortion to signal |      | -64  |      | dB   |
| (THD+N)                 | (THD + Noise) to signal              |      | -60  |      | dB   |

**Table 4. Key parameters (continued)**

| Symbol                  | Parameter                            | Min. | Typ. | Max. | Unit |
|-------------------------|--------------------------------------|------|------|------|------|
| DR                      | Dynamic range                        |      | 89   |      | dB   |
| ICL                     | Interchannel isolation               |      | -100 |      | dB   |
| <b>DAC differential</b> |                                      |      |      |      |      |
| V <sub>pp</sub>         | Maximum input range at ADC1          |      |      | 2.8  | V    |
| THD/S                   | Total harmonics distortion to signal |      | -58  |      | dB   |
| (THD+N)/S               | (THD + Noise) to signal              |      | -57  |      | dB   |
| DR                      | Dynamic range                        |      | 90   |      | dB   |
| ICL                     | Interchannel Isolation               |      | -85  |      | dB   |

### 3.1.1 CODEC (ADC/DAC) test description

Reported typical values (table 3. - ADC and DAC sections) have been measured at Lab level during product evaluation phase. General definitions and procedures are separately defined in following dedicated paragraphs.

#### Total harmonic distortion with noise to signal (THD+N)/S

THD+N is defined as the ratio of the total power of the second power and higher harmonic with noise components to the power of the fundamental for that signal. For THD+N measurement, choose the DSP analyzer in digital analyzer with THD ratio as measurement option. Measure the THD+N value at -3 dB amplitude of the input signal. First measure the THD+N value at 1V<sub>rms</sub> which is 0 dB reference and then measure the value at -3 dB reference.

#### Dynamic range (DR)

DR is defined as the level of THD+N measured when the input sine wave amplitude is so small that no harmonics apart from the fundamental tone are present in the output signal. This way THD+N becomes practically the ratio between the whole signal and noise floor, being a different way to express SNR. As a convention, at which no harmonics should be present in the output signal, it is fixed at -40dB of the full scale amplitude.

#### Crosstalk or interchannel isolation

A disturbance, caused by electromagnetic interference, along a circuit or a cable pair. An electric signal disrupts another signal in an adjacent circuit and can cause it to become confused and cross over each other. Crosstalk is measured by applying a signal -3dB amplitude of input signal at one channel (A) and no signal at an other channel (B), measuring the effect on this channel (B) because of the channel (A).

#### Total harmonic distortion to signal (THD)/S

THD is defined as the ratio of the sum of only those components of the output signal which are harmonic of system input, after having removed the fundamental tone corresponding to the pure sine wave as input and the input signal. This measurement is done by using the Harmonic analyzer which can isolate up to 15th harmonic components on the acquired signal and report the sum of all of them, centering the fundamental tone on the frequency provided by the input signal generator. These measurements are performed at -3dB reference amplitude of input signal.

## 4 Electrical specification

### 4.1 Absolute maximum ratings

**Table 5. Absolute maximum ratings**

| Symbol    | Parameter                      | Value                | Unit |
|-----------|--------------------------------|----------------------|------|
| PLL_VDD   | 3.3V PLL power supply voltage  | -0.5 to 4            | V    |
| CODEC_VDD | 3.3V CODEC analog power supply | -0.5 to 4            | V    |
| IOVDD     | 3.3V IO power supply           | -0.5 to 4            | V    |
| CORE_VDD  | 1.8V CORE power supply         | -0.5 to 2.2          | V    |
| IO_MAX    | Input or output voltage        | -0.5 to (IOVDD +0.5) | V    |

### 4.2 Electrical characteristics for I/O pins

**Table 6. Recommended DC operating conditions**

| Symbol         | Parameter                      | Value                   | Unit |
|----------------|--------------------------------|-------------------------|------|
| IOVDD          | IO power supply voltage        | 3 to 3.6 <sup>(1)</sup> | V    |
| T <sub>j</sub> | Operating junction temperature | -40 to 105              | °C   |

1. All the specification are valid only within these recommended operating conditions.

**Table 7. General interface electrical characteristics**

| Symbol            | Parameter                                                               | Test condition              | Min.         | Typ. | Max. | Unit |
|-------------------|-------------------------------------------------------------------------|-----------------------------|--------------|------|------|------|
| I <sub>il</sub>   | Low level input current without pull-up device                          |                             |              |      | 1    | μA   |
| I <sub>ih</sub>   | High level input current without pull-down device                       |                             |              |      | 1    | μA   |
| I <sub>oz</sub>   | Tri-state output leakage without pull up/down device                    |                             |              |      | 1    | μA   |
| I <sub>ozFT</sub> | Five Volt tolerant tri-state output leakage without pull up/down device |                             |              |      | 1    | μA   |
| I latch-up        | I/O latch-up current                                                    | V < 0V, V < V <sub>dd</sub> | 200          |      |      | mA   |
| V <sub>esd</sub>  | Electrostatic protection (HBM)                                          | leakage < 1mA               | 2000         |      |      | V    |
| V <sub>il</sub>   | Low level input voltage <sup>(1)</sup>                                  |                             |              |      | 0.8  | V    |
| V <sub>ih</sub>   | High level input voltage <sup>(1)</sup>                                 |                             | 2            |      |      | V    |
| V <sub>hyst</sub> | Schmitt trigger hysteresis <sup>(1)</sup>                               |                             | 0.4          |      |      | V    |
| V <sub>ol</sub>   | Low level output voltage <sup>(1) (2) (3)</sup>                         | I <sub>ol</sub> = XmA       |              |      | 0.15 | V    |
| V <sub>oh</sub>   | High level output voltage <sup>(1) (2) (3)</sup>                        | I <sub>oh</sub> = -XmA      | IOVDD - 0.15 |      |      | V    |

1. TTL specifications only apply to the supply voltage range V<sub>dd</sub> = 3.15V to 3.6V.

2. Takes into account 200mV voltage drop in both supply lines.

3. X is the source/sink current under worst case conditions and is reflected in the name of the I/O cell according to the drive capability.

## 5 24 bit DSP core

The DSP core is a general purpose 24-bit DSP. The main feature of the DSP core are listed below:

- 120 MHz operating frequency (120 MIPS)
- Fully pipelined 24 x 24 bit parallel multiplier-accumulator
- Saturation/limiting logic
- 56-bit parallel barrel shifter
- Linear, reverse carry and modulo addressing modes
- 24-bit address buses for program, X and Y data spaces and DMA
- Memory-expandible hardware stack
- Nested zero-overhead DO loops
- Fast interrupts
- Powerful JTAG emulation port
- Software wait and stop low power standby modes
- Program address tracing support
- Two 24-bit data moves in parallel with arithmetic operations
- External interrupts including non-maskable interrupt
- Interrupts may be independently masked and prioritized
- Bit-manipulation instructions can access any register or memory location
- On board support for DMA controller

## 6 Memories

128 K x 24-bit RAM divided into 4 areas, program RAM(PRAM), X data RAM(XRAM), Y data RAM(YRAM) and flexible allocation RAM(FLEX) as follows:

- 16 kB PRAM
- 40 kB FLEX RAM. FLEX RAM is accessed through the expansion port by the DSP core.
- External access to the FLEX RAM is also supported.
- 72 kB RAM is allocated as XRAM and YRAM. Four configurations are supported:
  - 4 kB XRAM and 68 kB YRAM
  - 8 kB XRAM and 64 kB YRAM
  - 16 kB XRAM and 56 kB YRAM
  - 24 kB XRAM and 48 kB YRAM

## 7 DSP peripherals

### 7.1 Serial audio interface (SAI)

The SAI is used to communicate between the CODEC and the DSPs.

In addition, digital audio can be directly input for processing. There is only one SAI found on the chip that can be accessed by either the DSP or the DMA controller. The main features of this block are listed below:

- Slave operating modes, all clock lines can be inputs or outputs
- Transmit and receive interrupt logic triggers on left/right data pairs
- Receive and transmit data registers have two locations to hold left and right data

### 7.2 Serial communication interface (SCI)

The serial communication interface provides a full duplex port for serial communication to other DSPs, microprocessors, and peripherals like modems.

The interface supports the following features:

- No additional logic for connection to other TTL level peripherals
- Asynchronous bit rates and protocols "High speed" synchronous data transmission.
- Asynchronous protocol includes Multidrop mode for master/slave operation with wake-up on Idle line and wake-up on address bit capability, permitting the SCI to share a single line with multiple peripherals
- Transmit and receive logic can operate asynchronously from each other.
- A programmable baud-rate generator which provide the transmit and receive clocks or functions as a general purpose timer.

### 7.3 I<sup>2</sup>C interface

The inter integrated-circuit bus is a simple bi-directional two-wire bus used for efficient inter IC control. All I<sup>2</sup>C bus compatible devices incorporate an on-chip interface which allows them to communicate directly with each other via the I<sup>2</sup>C bus.

Every component connected to the I<sup>2</sup>C bus has its own unique address whether it is a CPU, memory or some other complex function chip. Each of these chips can act as a receiver and/or transmitter depending on its functionality.

### 7.4 Host interface (HI)

The host interface is a system-on-chip module that permits connection to the data bus of a host processor. The HI is capable of driving 16 programmable external pins which can be configured as an 8 bit parallel port for direct connection to a host processor.

The key features of the host interface are:

- 8 bit parallel port "Full-duplex" dedicated host register bank
- Dedicated Mozart™ core DSP register core bank.
- Register banks map directly into Mozart X memory space
- 3 transfer modes:
  - host command
  - Host to Mozart core DSP
  - Mozart core DSP to host
- Access protocols:
  - Software polled
  - Interrupt
  - DMA access by the Mozart core DSP core
- 2+ wait states clock cycles per transfer
- Supported instructions:
  - Data transfer between Mozart core and external host using Mozart MOVE instruction
  - Simple I/O service routine with bit addressing instructions
  - IO service using fast interrupts with MOVEP instructions.

## 7.5 ESSI

The ESSI peripheral enables serial-port communication between the DSP core and external devices including Codecs, DSP, microprocessors. The ESSI is capable of driving 12 programmable external pins which can be configured as GPIO ports C and D or ESSI pins.

The key features of the ESSI are:

- Independent receiver and transmitter
- Synchronous or asynchronous channel modes synchronous. Receiver and transmitter use same clock/sync asynchronous. Receiver and transmitter may use separate clock/sync up to one transmitter enabled in asynchronous channel mode.
- Up to three transmitters enabled in synchronous channel mode.
- Normal mode. One word per period.
- Network mode. Up to 32 words per period.

## 7.6 EOC

The Salieri extended on-chip memory interface provides access to 40 kB of on-chip memory. The Mozart core will treat this memory as if it were external. Access by off-chip expansion bus masters is permitted. All accesses to the extended on-chip RAM are controlled by the extended on-chip memory control register. This register determines which combinations of the Address attribute pins should be interpreted as accesses to the 40 kB of RAM.

## 7.7 Timers and watchdog block

The timers and watchdog block consists of a common 21-bit prescaler and three independent and identical general-purpose 24-bit timer/event counters, each with its own register set.

Each timer has the following capabilities:

- Uses internal or external clocking.
- Interrupts the Mozart after a specified number of events (clocks).
- Signals an external device after counting internal events.
- Triggers DMA transfers after a specified number of events (clocks) occurs.
- Connects to the external world through designated pins TIO[0-2] for timers 0-2.

When TIO is configured as an

- Input: timer functions as an external event counter. Timer measures external pulse width/signal period.
- Output: timer functions as a:
  - Timer
  - Watchdog timer
  - Pulse-width modulator.

## 7.8 PLL

The PLL generates the following clocks:

- DCLK: DSP core clock
- DACLK: ADC and DAC clock
- LRCLK: left/right clock for the SAI and the CODEC
- SCLK: shift serial clock for the SAI and the CODEC

## 7.9 CODEC cell

The main features of the CODEC cell are listed below:

- 20 bits stereo DAC, and 18 bits ADC
- I<sup>2</sup>S format
- Oversampling ratio: 512
- Sampling rates of 8 kHz to 48 kHz

The analog interface is in the form of differential signals for each channel. The interface on the digital side has the form of an SAI interface and can interface directly to an SAI channel and then to the DSP core.

DCLK can be supplied either by the internal PLL or by external, to allow synchronization with external anal digital sources.

## 8.1 Benchmarking program

```

;***** FILE HEADER *****
;
;Title:      Salieri CODEC/SAI Functionality Test
;
;File Name:  full_func.asm
;
;Author:     --
;
;Language:   DSP2420 Core Assembler
;
;Project:    Salieri
;
;Description:      CODEC + TIMER + HI gpios + ESSI + SCI
;
;
;
;
;
;
;
;
;
;
;***** Equates *****
;*****
Npts      equ      20
Ntaps     equ      4

;-----
;      EQUATES for I/O Port Programming
;-----

;      Register Addresses
M_HDR     EQU      $FFFFC9      ; PS- Host port GPIO data Register
M_HDDR    EQU      $FFFFC8      ; PS- Host port GPIO direction Register
M_PCRC    EQU      $FFFFBF      ; Port C Control Register
M_PSRC    EQU      $FFFFBE      ; Port C Direction Register
M_PDRC    EQU      $FFFFBD      ; Port C GPIO Data Register
M_PCRD    EQU      $FFFFBA      ; Port D Control register
M_PSRD    EQU      $FFFFAE      ; Port D Direction Data Register
M_PDRD    EQU      $FFFFAD      ; Port D GPIO Data Register
M_PCRE    EQU      $FFFF9F      ; Port E Control register
M_PPRE    EQU      $FFFF9E      ; Port E Direction Register
M_PDRE    EQU      $FFFF9D      ; Port E Data Register
M_OGDB    EQU      $FFFFFC      ; OnCE GDB Register

;-----
;      EQUATES for Exception Processing
;-----

; Register Addresses
IPR_C     EQU      $FFFFFF      ; Interrupt Priority Register Core

```

```

IPR_P      EQU      $FFFFFF      ; Interrupt Priority Register Peripheral

; SAI interrupt Vectors
SAI_ROF     EQU      $070         ; Receiver Overflow
SAI_TUF     EQU      $072         ; Transmitter Underflow
SAI_RDR     EQU      $074         ; Receiver Data Ready
SAI_TDE     EQU      $076         ; Transmitter Data Empty

; Timer interrupt Vector
Timer0_tcf  equ      $24          ; Timer0 Compare
Timer0_tof  equ      $26          ; Timer0 Overflow
Timer1_tcf  equ      $28          ; Timer1 Compare
Timer1_tof  equ      $2A          ; Timer1 Overflow
Timer2_tcf  equ      $2C          ; Timer2 Compare
Timer2_tof  equ      $2E          ; Timer2 Overflow

; SCI Interrupt Vectors
SCI_REC     EQU      $000050      ; SCI receive data
SCI_REC_E   EQU      $000052      ; SCI receive data with exception status
SCI_TRANS   EQU      $000054      ; SCI transmit data
SCI_IDLE    EQU      $000056      ; SCI idle line
SCI_TIMER   EQU      $000058      ; SCI timer

;; Bit Definition for SCI_SSR
FRAMING     EQU      6

RESET       EQU      $000000      ; Reset address location

;-----
;          EQUATES for SAI (y memory)
;-----
SAI_RCS     EQU      $FFFFFF      ; SAI Receive Control/Status Register
SAI_RX2     EQU      $FFFFFFE     ; SAI Channel 2 Receiver Data
SAI_RX1     EQU      $FFFFFFD     ; SAI Channel 1 Receiver Data
SAI_RX0     EQU      $FFFFFFC     ; SAI Channel 0 Receiver Data
SAI_TCS     EQU      $FFFFFFB     ; SAI Transmit Control/Status Register
SAI_TX2     EQU      $FFFFFFA     ; SAI Channel 2 Transmitter Data
SAI_TX1     EQU      $FFFFFF9     ; SAI Channel 1 Transmitter Data
SAI_TX0     EQU      $FFFFFF8     ; SAI Channel 0 Transmitter Data

;; Bit Definitions for M_RCS
ROFCL       EQU      16           ; Receiver Data Overflow Clear
RDR         EQU      15           ; Receiver Data Ready
ROFL        EQU      14           ; Receiver Data Overflow
;Reserved
RXIE        EQU      12           ; Receiver Interrupt Enable
RDWJ        EQU      11           ; Receiver Data Word Justification
RREL        EQU      10           ; Receiver Relative Timing
RCKP        EQU      9           ; Receiver Clock Polarity
RLRS        EQU      8           ; Receiver Left Right Selection
RDIR        EQU      7           ; Receiver Data Shift Direction
RWL1        EQU      6           ; Receiver Word Length Control 1
RWL0        EQU      5           ; Receiver Word Length Control 0
;Reserved
RMME        EQU      3           ; Receiver Master Mode Enable
R2EN        EQU      2           ; Receiver 2 enable
R1EN        EQU      1           ; Receiver 1 enable
R0EN        EQU      0           ; Receiver 0 enable

```

```

;;; Bit Definitions for M_TCS
TUFCL      EQU    16      ; Transmitter Data Overflow Clear
TDE        EQU    15      ; Transmitter Data Ready
TUFL       EQU    14      ; Transmitter Data Overflow
;Reserved
TXIE       EQU    12      ; Transmitter Interrupt Enable
TDWE       EQU    11      ; Transmitter Data Word Justification
TREL       EQU    10      ; Transmitter Relative Timing
TCKP       EQU    9       ; Transmitter Clock Polarity
TLRS       EQU    8       ; Transmitter Left Right Selection
TDIR       EQU    7       ; Transmitter Data Shift Direction
TWL1       EQU    6       ; Transmitter Word Length Control 1
TWL0       EQU    5       ; Transmitter Word Length Control 0
;Reserved
TMME       EQU    3       ; Transmitter Master Mode Enable
T2EN       EQU    2       ; Transmitter 2 enable
T1EN       EQU    1       ; Transmitter 1 enable
TOEN       EQU    0       ; Transmitter 0 enable

;-----
;          EQUATES for CODEC
;-----
CODEC_CSR  EQU    $FFFFCB  ; CODEC Control Register Address

;;; Bit Definitions for CODEC
GADCL_0    EQU    0       ; ADC Left Gain Bit 0
GADCL_1    EQU    1       ; ADC Left Gain Bit 1
GADCL_2    EQU    2       ; ADC Left Gain Bit 2
GADCR_0    EQU    3       ; ADC Right Gain Bit 0
GADCR_1    EQU    4       ; ADC Right Gain Bit 1
GADCR_2    EQU    5       ; ADC Right Gain Bit 2
GDACL_0    EQU    6       ; DAC Left Gain Bit 0
GDACL_1    EQU    7       ; DAC Left Gain Bit 1
GDACL_2    EQU    8       ; DAC Left Gain Bit 2
GDACR_0    EQU    9       ; DAC Right Gain Bit 0
GDACR_1    EQU    10      ; DAC Right Gain Bit 1
GDACR_2    EQU    11      ; DAC Right Gain Bit 2
MUTEDAC    EQU    12      ; Mute DAC - Active Hi, Reset Val = 1
PDNDAC     EQU    13      ; Power down DAC - Active Hi, Reset Val = 0
PDNADC     EQU    14      ; Power down ADC - Active Hi, Reset Val = 0
N_RST      EQU    15      ; Asynchronous Reset - Active Lo, Reset Val = 1

;-----
;          EQUATES for PLL
;-----
PLL_CSR    EQU    $FFFFD7  ; PLL Control/Status Register
PLL_FCR    EQU    $FFFFD6  ; PLL Fractional Register
PLL_CLKCTL EQU    $FFFFD5  ; PLL Clock Control Register

;;; Bit Definitions for PLL_CSR
IDF0       EQU    0       ; Input Divide Factor 0
IDF1       EQU    1       ; Input Divide Factor 1
IDF2       EQU    2       ; Input Divide Factor 2
IDF3       EQU    3       ; Input Divide Factor 3
IDF4       EQU    4       ; Input Divide Factor 4
; Reserved

```

```

LOCK      EQU      6      ; PLL Lock Indication bit
OUTLOCK   EQU      7      ; PLL Lost Lock bit
MF0       EQU      8      ; Multiplication bit 0
MF1       EQU      9      ; Multiplication bit 1
MF2       EQU      10     ; Multiplication bit 2
MF3       EQU      11     ; Multiplication bit 3
MF4       EQU      12     ; Multiplication bit 4
MF5       EQU      13     ; Multiplication bit 5
MF6       EQU      14     ; Multiplication bit 6
PLLIE     EQU      15     ; PLL interrupt enable
PWRDN     EQU      16     ; PLL power down
DITEN     EQU      17     ; Dither Enable
FRACEN    EQU      18     ; PLL Fractional-N function enable
PEN       EQU      19     ; PLL Enable

;; Bit Definitions for PLL_CLKCNTL
DSPDF0    EQU      0      ; DSP clock divider factor 0
DSPDF1    EQU      1      ; DSP clock divider factor 1
DSPDF2    EQU      2      ; DSP clock divider factor 2
DSPDF3    EQU      3      ; DSP clock divider factor 3
; Reserved
DCKSRC    EQU      6      ; DSP clock source 0->XTI/(DSPDF3:0 + 1)
                        ; 1->VCO/(DSPDF3:0 + 1)
DACLKEN   EQU      7      ; Enable bit for oversampling clock
MFSDf0    EQU      8      ; Oversampling multiple bit 0
MFSDf1    EQU      9      ; Oversampling multiple bit 1
MFSDf2    EQU      10     ; Oversampling multiple bit 2
MFSDf3    EQU      11     ; Oversampling multiple bit 3
MFSDf4    EQU      12     ; Oversampling multiple bit 4
MFSDf5    EQU      13     ; Oversampling multiple bit 5
MFSDf6    EQU      14     ; Oversampling multiple bit 6
SEL0      EQU      15     ; Sampling multiple select bit 0
SEL1      EQU      16     ; Sampling multiple select bit 1
SEL2      EQU      17     ; Sampling multiple select bit 2
DSP_XTI   EQU      18     ; DSP_XTI =0 -> Use VCO/DSPDF for DCLK
                        ; DSP_XTI =1 -> Use XTI for DCLK
DAC_SEL   EQU      19     ; Selects between VCO and ext_dac_clk
XTLD      EQU      20     ; Disables the external crystal when set

;-----
;          EQUATES for I/O Port Programming
;-----
;          Register Addresses
HDR        EQU      $FFFFC9 ; PS- Host port GPIO data Register
HDDR      EQU      $FFFFC8 ; PS- Host port GPIO direction Register
PCRC      EQU      $FFFFBF ; Port C Control Register
PRRC      EQU      $FFFFBE ; Port C Direction Register
PDRC      EQU      $FFFFBD ; Port C GPIO Data Register
PCRD      EQU      $FFFFAF ; Port D Control register
PRRD      EQU      $FFFFAE ; Port D Direction Data Register
PDRD      EQU      $FFFFAD ; Port D GPIO Data Register
PCRE      EQU      $FFFF9F ; Port E Control register
PRRE      EQU      $FFFF9E ; Port E Direction Register
PDRE      EQU      $FFFF9D ; Port E Data Register
OGDB      EQU      $FFFFFC ; OnCE GDB Register

```

```

;-----
;           EQUATES for GPIOs
;-----

;;; Register Addresses
GPIOCTRL    EQU    $FFFFc4      ; Host Port Control Register
GPIODIR     EQU    $FFFFc8      ; GPIODIR register.(HI - HDDR)
GPIODAT     EQU    $FFFFc9      ; GPIODAT register.(HI - HDR)

;;; Bit Definitions for GPIO Direction Register
GPIO0_DIR   EQU    $0
GPIO1_DIR   EQU    $1
GPIO2_DIR   EQU    $2
GPIO3_DIR   EQU    $3
GPIO4_DIR   EQU    $4
GPIO5_DIR   EQU    $5
GPIO6_DIR   EQU    $6
GPIO7_DIR   EQU    $7
GPIO8_DIR   EQU    $8

;;; Bit Definitions for GPIO Data Register
GPIO0_DAT   EQU    $0
GPIO1_DAT   EQU    $1
GPIO2_DAT   EQU    $2
GPIO3_DAT   EQU    $3
GPIO4_DAT   EQU    $4
GPIO5_DAT   EQU    $5
GPIO6_DAT   EQU    $6
GPIO7_DAT   EQU    $7
GPIO8_DAT   EQU    $8

;-----
;           EQUATES for Timer
;-----

M_TCSR0     EQU    $FFFF8F      ;Timer 0 Control/Status Register (TCSR0)
M_TLR0      EQU    $FFFF8E      ;Timer 0 Load Register (TLR0)
M_TCPR0     EQU    $FFFF8D      ;Timer 0 Compare Register (TCPR0)
M_TCR0      EQU    $FFFF8C      ;Timer 0 Count Register (TCR0)
M_TCSR1     EQU    $FFFF8B      ;Timer 1 Control/Status Register (TCSR1)
M_TLR1      EQU    $FFFF8A      ;Timer 1 Load Register (TLR1)
M_TCPR1     EQU    $FFFF89      ;Timer 1 Compare Register (TCPR1)
M_TCR1      EQU    $FFFF88      ;Timer 1 Count Register (TCR1)
M_TCSR2     EQU    $FFFF87      ;Timer 2 Control/Status Register (TCSR2)
M_TLR2      EQU    $FFFF86      ;Timer 2 Load Register (TLR2)
M_TCPR2     EQU    $FFFF85      ;Timer 2 Compare Register (TCPR2)
M_TCR2      EQU    $FFFF84      ;Timer 2 Count Register (TCR2)
M_TPLR      EQU    $FFFF83      ;Timer Prescaler Load Register (TPLR)
M_TPCR      EQU    $FFFF82      ;Timer Prescaler Count Register (TPCR)

;-----
;
;           EQUATES for Enhanced Synchronous Serial Interface (ESSI)
;
;-----
;ESSI 0 interrupt equates
essi0_rdf   equ    $30
essi0_roe   equ    $32
essi0_rls   equ    $34

```

```

essi0_tde    equ    $36
essi0_tue    equ    $38
essi0_tls    equ    $3a

;ESSI 1 interrupt equates
essi1_rdf    equ    $40
essi1_roe    equ    $42
essi1_rls    equ    $44
essi1_tde    equ    $46
essi1_tue    equ    $48
essi1_tls    equ    $4a

;Register Addresses of ESSI0
M_TX00      EQU    $FFFFBC    ; SSI0 Transmit Data Register 0
M_TX01      EQU    $FFFFBB    ; SSI0 Transmit Data Register 1
M_TX02      EQU    $FFFFBA    ; SSI0 Transmit Data Register 2
M_TSR0      EQU    $FFFFB9    ; SSI0 Time Slot Register
M_RX0       EQU    $FFFFB8    ; SSI0 Receive Data Register
M_SISR0     EQU    $FFFFB7    ; SSI0 Status Register
M_CRB0      EQU    $FFFFB6    ; SSI0 Control Register B
M_CRA0      EQU    $FFFFB5    ; SSI0 Control Register A
M_TSMA0     EQU    $FFFFB4    ; SSI0 Transmit Slot Mask Register A
M_TSMB0     EQU    $FFFFB3    ; SSI0 Transmit Slot Mask Register B
M_RSMA0     EQU    $FFFFB2    ; SSI0 Receive Slot Mask Register A
M_RSMB0     EQU    $FFFFB1    ; SSI0 Receive Slot Mask Register B

;Register Addresses of ESSI1
M_TX10      EQU    $FFFFAC    ; SSI1 Transmit Data Register 0
M_TX11      EQU    $FFFFAB    ; SSI1 Transmit Data Register 1
M_TX12      EQU    $FFFFAA    ; SSI1 Transmit Data Register 2
M_TSR1      EQU    $FFFFA9    ; SSI1 Time Slot Register
M_RX1       EQU    $FFFFA8    ; SSI1 Receive Data Register
M_SISR1     EQU    $FFFFA7    ; SSI1 Status Register
M_CRB1      EQU    $FFFFA6    ; SSI1 Control Register B
M_CRA1      EQU    $FFFFA5    ; SSI1 Control Register A
M_TSMA1     EQU    $FFFFA4    ; SSI1 Transmit Slot Mask Register A
M_TSMB1     EQU    $FFFFA3    ; SSI1 Transmit Slot Mask Register B
M_RSMA1     EQU    $FFFFA2    ; SSI1 Receive Slot Mask Register A
M_RSMB1     EQU    $FFFFA1    ; SSI1 Receive Slot Mask Register B

;-----
;          EQUATES for SCI
;-----
PCRE_ADR    EQU    $FFFF9F    ; Serial Port Control Register
PRRE_ADR    EQU    $FFFF9E    ; Serial Port Direction Register
PDRE_ADR    EQU    $FFFF9D    ; Serial Port Direction Register
SCR_ADR     EQU    $FFFF9C    ; SCI Control Register
SCCR_ADR    EQU    $FFFF9B    ; SCI Clock Control Register
SRXH_ADR    EQU    $FFFF9A    ; Serial Recieve Register high
SRXM_ADR    EQU    $FFFF99    ; Serial Recieve Register mid
SRXL_ADR    EQU    $FFFF98    ; Serial Recieve Register low
STXH_ADR    EQU    $FFFF97    ; Serial Transmit Register high
STXM_ADR    EQU    $FFFF96    ; Serial Transmit Register mid
STXL_ADR    EQU    $FFFF95    ; Serial Transmit Register low
STXA_ADR    EQU    $FFFF94    ; Serial Transmit Adress Register
SSR_ADR     EQU    $FFFF93    ; Serial Status Register

```

```

;-----
;          EQUATES for Expansion Port
;-----
EXP_BCR      EQU    $FFFFFFB      ; Bus Control Register address
EXP_AAR0     EQU    $FFFFFF9      ; Address Attribute Register (AAR0) address
EXP_AAR1     EQU    $FFFFFF8      ; Address Attribute Register (AAR1) address
EXP_AAR2     EQU    $FFFFFF7      ; Address Attribute Register (AAR2) address
EXP_AAR3     EQU    $FFFFFF6      ; Address Attribute Register (AAR3) address
EXT_RAM_START EQU    $C00000

;-----
;          EQUATES for Extended Memory
;-----
EOC_ADR      EQU    $FFFFFFCA

;*****
;***** Initialisation Values *****
;*****

;-----
;          CODEC Initialisation values
;-----
; --- INIT_CCR -----
; settings fro the CODEC Control Register
;
;          321098765432109876543210
INIT_CODEC_CSR EQU    %000000001110011011011011    ; $00E6DB DACgain = 0dB - ADCgain = +0dBdB
;
;          011 --- GADCL[0:2]
;
;          011 ----- GADCR[0:2]
;
;          011 ----- GDACL[0:2]
;
;          011 ----- GDACR[0:2]
;
;          0 ----- MUTEDAC (1=Mute)
;
;          1 ----- PDNDAC (1=pwrdown)
;
;          1 ----- PDNADC (1=pwrdown)
;
;          1 ----- NRST (0=reset)

;-----
;          SAI Initialisation values
;-----

;--- INIT_RCS -----
; settings for the Receiver Control/Status Register
;
;          321098765432109876543210
INIT_SAI_RCS  EQU    %000000000001000101001001    ; $000149
;
;          1 --- R0EN (0:Disbaled; 1:Enabled)
;
;          0 --- R1EN (0:Disbaled; 1:Enabled)
;
;          0 --- R2EN (0:Disbaled; 1:Enabled)
;
;          1 ----- RMME (1:Master mode; 0:Slave mode)
;
;          0 ----- Reserved
;
;          10 ----- RWL[0:1] (00:16; 01:24; 10:32)
;
;          0 ----- RDIR (0:MSB 1st; 1:LSB 1st)
;
;          1 ----- RLRS (0:LRCKR=0-LW; 1:LRCKR=0-RW)
;
;          0 ----- RCKP (0:-ve ; 1:+ve)
;
;          0 ----- RREL (0:trans-1st; 1:I2S)
;
;          0 ----- RDWJ
;
;          1 ----- RXIE (0:Disabled; 1:Enabled)
;
;          0 ----- Reserved
;
;          0 ----- ROFL

```

```

;                                0 ----- RDR
;                                0 ----- ROFCL

;--- INIT_TCS -----
; settings for the Transmitter Control/Status Register
;                                321098765432109876543210
INIT_SAI_TCS    EQU    %000000000001010101001001    ; $000549 - non incrociato
;                                1 --- T0EN (0:Disbaled; 1:Enabled)
;                                0 --- T1EN (0:Disbaled; 1:Enabled)
;                                0 ---- T2EN (0:Disbaled; 1:Enabled)
;                                1 ----- TMME (1:Master mode; 0:Slave mode)
;                                0 ----- reserved
;                                10 ----- TWL[0:1] (00:16; 01:24; 10:32)
;                                0 ----- TDIR (0:MSB 1st; 1:LSB 1st)
;                                1 ----- TLRS (0:LRCKR=0-LW; 1:LRCKR=0-RW)
;                                0 ----- TCKP (0:-ve ; 1:+ve)
;                                1 ----- TREL (0:trans-1st; 1:I2S)
;                                0 ----- TDWE
;                                1 ----- TXIE (0:Disabled; 1:Enabled)
;                                0 ----- Reserved
;                                0 ----- TUFL
;                                0 ----- TDE
;                                0 ----- TUFCL

;-----
;                                PLL Intitilisation values
;-----
IF 1    ; Settings per sci 115200
;--- PLL_CSR -----
; settings for the PLL control register
;                                321098765432109876543210
; settings for the PLL control register
;                                321098765432109876543210
;INIT_PLL_CSR    EQU    $0E0C00
INIT_PLL_CSR    EQU    %000011100000110000000000    ; $0E0C00
;                                00000 --- IDF = 0 (actual = IDF+1=1)
;                                0 ----- RESERVED
;                                0 ----- LOCK (read only; 0:out of lock)
;                                0 ----- OUTLOCK (read only; 0:in lock)
;                                0001100 ----- MF =12 (actual = MF + 1 = 13)
;                                0 ----- PLLIE (0:intr disable)
;                                0 ----- PWRDN (1:power down mode)
;                                1 ----- DITEN (0:disable)
;                                1 ----- FRACTN (0:disable)
;                                1 ----- PEN (1:PLL enable)

;--- FRACT -----
; settings for the Fractional N part of the PLL
;                                321098765432109876543210
;INIT_PLL_FCR    EQU    $0034bd
INIT_PLL_FCR    EQU    %000000000011010010111101    ; $0034bd

;                                01110000101001 --- FRACT = 13501

;--- CLKCTL -----

```

```

; settings for the clock control register
;
; 321098765432109876543210
; INIT_PLL_CLKCTL EQU    $018cc1
INIT_PLL_CLKCTL EQU    %0000000110000001011000001    ; $018cc1
;
; 0001 --- DSPDF =1 (actual = DSPDF+1=3)
;
; 00 ----- TESTSEL
;
; 1 ----- DCKSRC (0:XTI; 1:FVCO)
;
; 1 ----- DACLKEN (1: enable CODEC clocks)
;
; 0000010 ----- MFSDF =2 (actual =MFSDF+1 = 3 )
;
; 011 ----- SEL (000:128,001:256, 010:384, etc)
;
; 0 ----- DSP_XTI (0:vco/DSPDF; 1:xti)
;
; 0 ----- DAC_SEL (0:vco/MFSDF; 1:ext_dac_clk)
;
; 0 ----- XTLD (0:Enabled; 1:Disabled)

ENDIF    ; Settings per sci 115200

;-----
;
; Timer Intitilisation values
;-----
;--- TCSR0 -----
; settings for the Timer Control/Status Register
;
; 321098765432109876543210
INIT_TCSR0 EQU %0000000010001010000000100    ; $8A04    mode0 / trm=1 / tce=1 / pce=1/ dir=out
INIT_TCSR1 EQU %0000000010001010000000100    ; $8A04    mode0 / trm=1 / tce=1 / pce=1/ dir=out
INIT_TCSR2 EQU %0000000010001010000000100    ; $8A04    mode0 / trm=1 / tce=1 / pce=1/ dir=out
;
; xx ----->[23-22]; unused
;
; 0 ----->[21]    TCF    ; Timer Compare Flag
;
; 0 ----->[20]    TOF    ; Timer Overflow Flag
;
; xxxx ----->[19-16]    ; unused
;
; 0 ----->[15]    PCE    ; Prescaler Clock Enable
;
; x ----->[14]    ; unused
;
; 0 ----->[13]    DO     ; Data Output
;
; 0 ----->[12]    DI     ; Data Input
;
; 1 ----->[11]    DIR    ; Direction
;
; x ----->[10]    ; unused
;
; 1 ----->[ 9]    TRM    ; Timer Reload Mode
;
; 0 ----->[ 8]    INV    ; Inverter
;
; 0000 ----->[7-4]    Tc[3-0] ; Timer Control = Mode0
;
; x ---->[ 3]    ; unused
;
; 1 --->[ 2]    TCIE    ; Timer Compare Interrupt Enable
;
; 0 -->[ 1]    TOIE    ; Timer Overflow Enable
;
; 0 ->[ 0]    TE       ; Timer Enable

;--- TLR0 -----
; settings for the Timer Load Register
INIT_TLR0 EQU    $000000
INIT_TLR1 EQU    $000000
INIT_TLR2 EQU    $000000

;--- TCPR0 -----
; settings for the Timer Compare Register
; INIT_TCPR0 EQU    $000002
; INIT_TCPR1 EQU    $000004
; INIT_TCPR2 EQU    $000008
INIT_TCPR0 EQU    $000000
INIT_TCPR1 EQU    $000000

```

```

INIT_T CPR2 EQU $000000

;--- TPLR -----
; settings for the clock control register
;
; 321098765432109876543210
; INIT_TPLR EQU %001000000000001111100111 ; $2003E7 source TIO0 / divider = 999+1
INIT_TPLR EQU %000000000000001111100111 ; $0003E7 source internal / prescaler 999
;
; X-----> ; Reserved. Write to zero for future compatibility.
;
; 01-----> PS[1-0] ; Prescaler Source [00 internal / 01 external TIO0 /
;
; ; 10 external TIO0 / 11 external TIO0]
;
; 00000000001000000000-> PL[20-0] ; Prescaler Preload Value200400

;-----
;
; Interrupt Initialisation Values
;-----
; settings for the Interrupt priority register - Core
;
; 321098765432109876543210
INIT_IPR_C EQU %000000000000000000000000 ; $000000

; settings for the Interrupt priority register - peripherals
;
; 321098765432109876543210
INIT_IPR_P EQU %000000000011111001000100 ; $29C4 glitch sull'uscita del dac
;
; 00---- HI
;
; 11----- ESSIO
;
; 00----- ESSII
;
; 11----- SCI
;
; 11----- TIMER
;
; 11 ----- SAI
;
; 11 ----- CODEC
;
; 00 ----- PLL
;
; 00 ----- Unknow
;
; 00 ----- I2C
;
; 00 ----- SPI
;
; 00 ----- EMI

;-----
;
; Expansion Port Initialisation values
;-----
;--- INIT_AAR0 -----
; settings for the Address Attribute Register1
;
; 321098765432109876543210
INIT_AAR0 EQU %11000000000010000010000 ; C00410
;
; 00 --- BAT (00: Synchronous SRAM; 01: SRAM; 10: DRAM; 11: Reserved)
;
; 0 ---- BAAP (0:AA1 active low; 1: AA1 active high)
;
; 0 ----- BPEN (0: P space disabled; 1: P space enabled)
;
; 1 ----- BXEN (0: X data space disabled; 1: X data space enabled)
;
; 0 ----- BYEN (0: Y data space disabled; 1: Y data space enabled)
;
; 0 ----- BAM (0: 8 LSB of address will appear on A0-A7;
;
; 1: 8 LSB of address will appear on A16-A23)
;
; 0 ----- BPAC (0: packing disabled; 1: packing enabled)
;
; 0100 ----- BNC (Number of bits to compare; 1111, 1110, 1101 reserved)
;
; 110000000000 ----- BAC (Address to compare; BNC most significant)
;--- INIT_BCR -----

```

```

; settings for the Bus Control Register
;
; 321098765432109876543210
INIT_BCR      EQU    %001100000010010000100001 ; 306E10
;INIT_BCR      EQU    %000001111111110011100111 ; 30FE07
;
; 00111 --- BA0W (Area 0 wait states)
;
; 00000 ----- BA1W (Area 1 wait states)
;
; 111 ----- BA2W (Area 2 wait states)
;
; 111 ----- BA3W (Area 3 wait states)
;
; 00000 ----- BDFW (Default area wait states)
;
; 0 ----- BBS (0: ; 1: DSP is bus master READ ONLY)
;
; 0 ----- BLH (0: ; 1: BLN always asserted)
;
; 0 ----- BRH (0: ; 1: BRN always asserted)

;*****

; definitions added by Paul Cassidy for salieri testbench
TRIGGER_TUBE  EQU    $12002
M_BCR         EQU    $FFFFFFB ; Bus Control Register
M_AAR0        EQU    $FFFFFF9 ; Address Attribute 0
M_AAR1        EQU    $FFFFFF8 ; Address Attribute 1
M_AAR2        EQU    $FFFFFF7 ; Address Attribute 2
M_AAR3        EQU    $FFFFFF6 ; Address Attribute 3

;*****
;***** Main Prog Starts Here *****
;*****

startp
    org p:$0
    jmp start

sci_int
    org p:SCI_REC ; Interrupt SCI receive
    jsr INT_SCIR
    org p:SCI_TRANS ; Interrupt SCI transmit
    jsr INT_SCIT
    org p:SCI_REC_E ; Interrupt SCI framing error
    jsr INT_SCIE

sai_int
    org p:SAI_RDR
    jsr INT_RDR
    org p:SAI_TDE
    jsr INT_TDE
    org p:SAI_ROF
    jsr INT_ROF
    org p:SAI_TUF
    jsr INT_TUF

essi_int
    org p:essi0_rdf
    jsr Comp_0
    nop
    org p:essi0_roe

```

```

        movep x:M_SSISR0,a0
        movep x:M_RX0,y:(r0)+
        org p:essi0_rls
        nop
        nop
        org p:essi0_tde
        jsr clr_tde0
        nop
        org p:essi0_tue
        jsr clr_tue0
        nop
        org p:essi0_tls
        nop
        nop

timer_int
        org p:Timer0_tcf
        jsr INT_TMR0_tcf
        org p:Timer0_tof
        jsr INT_TMR0_tof
        org p:Timer1_tcf
        jsr INT_TMR1_tcf
        org p:Timer1_tof
        jsr INT_TMR1_tof
        org p:Timer2_tcf
        jsr INT_TMR2_tcf
        org p:Timer2_tof
        jsr INT_TMR2_tof

        org x:0
states   dsm ntaps

        org y:0
coef     dc  .1,.3,-.1,.2

        org p:$100
start
        ; setup external memory for sync with testbench
;-----
;   Initialise Core
;-----

        clr     a
        clr     b
        move    #$0,r0
        move    #$ffff,m0
        ori     #$3,mr          ; mask interrupts
        movep   #INIT_IPR_C,x:IPR_C      ; set CORE interrupt priorities
        movep   #INIT_IPR_P,x:IPR_P      ; set PERIPHERAL interrupt priorities

;-----
;   Initialise PLL
;-----

init_pll
        movep   #INIT_PLL_CSR,x:PLL_CSR      ; enable the pll.
        jclr    #LOCK,x:<<PLL_CSR,*          ; wait for lock.

```

```

        movep    #INIT_PLL_FCR,x:PLL_FCR        ; set fract value.
        bset     #FRACEN,x:<<PLL_CSR            ; enable fractional-n operation.
        movep    #INIT_PLL_CLKCTL,x:PLL_CLKCTL   ; setup the clock generation.

        IF 1
;-----
;   Initialise CODEC
;-----
init_codec
        movep    #INIT_CODEC_CSR,x:CODEC_CSR     ; initialise CODEC control/status reg

;-----
;   Initialise SAI
;-----
; The receiver and transmitter control/status register are configured the same for simplicity only.
; Master mode , 24-bit word-size , MSB first , Low word clock = left word , Neg bit-clk polarity ,
; Non i2s format , (For 32-bit words) First bit x 8 , Interrupts enabled.
init_sai
        movep    #INIT_SAI_TCS,y:SAI_TCS         ; initialise transmit control/status reg
        movep    #INIT_SAI_RCS,y:SAI_RCS         ; initialise receiver control/status reg

;-----
; Enable gpios for HI
;-----
        bset     #GPIO0_DIR,x:GPIOCTRL          ; Setup HI pin for GPIO mode
        bset     #GPIO0_DIR,x:GPIODIR           ; Setup GPIO as output
        bset     #GPIO1_DIR,x:GPIOCTRL          ; Setup HI pin for GPIO mode
        bset     #GPIO1_DIR,x:GPIODIR           ; Setup GPIO as output
        ENDIF

;-----
; Initialize ESSIO
;-----
        IF 1
init_essi
        movep    #$181801,x:M_CRA0 ; cra0_addr, 24'b010110000001100000011110
                                ; The divider control is set to 1 (2 words per frame)
                                ; for Normal mode, bits are left aligned to bit 23. Word
                                ; length is set to 24 bits.PM = 1 -> Fcore/4.

        movep    #$fc113e,x:M_CRB0 ; crb0_addr, 24'b111111000001010100111110
                                ; The receive exception and transmit exception interrupts
                                ; are enabled as are receive last slot and transmit last
                                ; slot. It is set in the synchronous normal mode. Data and
                                ; frame sync are clocked out on the rising edge of the clock.
                                ; Frame sync polarity is positive and occurs together with the
                                ; the first bit of data from the first slot. MSB is shifted
                                ; first. SC2 o/p SC1 o/p SC0 o/p

Enable_pins
;-----
        move     #$01c000,x0          ;
        movep    x:M_CRB0,b1          ;
        or       x0,b1                ; // Enable TX2/TX1/TX0 (ESSI 0)
        movep    #$00003f,x:M_PCRC ; // ALL Pins are ESSI.
                                ; check that all pins are enabled

        rep     #5
        nop

```

```

        movep b1,x:M_CRB0

    ENDIF

    IF 1
;-----
; Enable gpios for TIMER
;-----

init_gpio
;   movep   #$000000,x:<<PCRC           ; ESSIO port as GPIO
;   movep   #$0000ff,x:<<PRRC           ; ESSIO port as OUT
        Movep   #$000000,x:<<PCRD           ; ESSI1 port as GPIO
        Movep   #$000000,x:<<PRRD           ; ESSI1 port as TIMER (INPUT)

;-----
;   Initialise Timer
;-----

init_timer
        bclr #0,x:M_TCSR0           ; Disable Timer0
        bclr #0,x:M_TCSR1           ; Disable Timer1
        bclr #0,x:M_TCSR2           ; Disable Timer2

        movep #INIT_TCSR0,x:<<M_TCSR0           ; Timer0 enable at mode 0 + reload
        movep #INIT_TPLR,x:<<M_TPLR           ; Initial value of the timer counter
        movep #INIT_TLR0,x:<<M_TLR0           ; Initial value of the timer counter
        movep #INIT_TCPR0,x:<<M_TCPR0           ; Number of CLK/2 cycles until a trigger is generated

        movep #INIT_TCSR1,x:<<M_TCSR1           ; Timer1 enable at mode 0 + reload
        movep #INIT_TPLR,x:<<M_TPLR           ; Initial value of the timer counter
        movep #INIT_TLR1,x:<<M_TLR1           ; Initial value of the timer counter
        movep #INIT_TCPR1,x:<<M_TCPR1           ; Number of CLK/2 cycles until a trigger is generated

        movep #INIT_TCSR2,x:<<M_TCSR2           ; Timer2 enable at mode 0 + reload
        movep #INIT_TPLR,x:<<M_TPLR           ; Initial value of the timer counter
        movep #INIT_TLR2,x:<<M_TLR2           ; Initial value of the timer counter
        movep #INIT_TCPR2,x:<<M_TCPR2           ; Number of CLK/2 cycles until a trigger is generated

;-----
;   Initialise Expansion Port and Flex Memory
;-----

init_expport
        movep   #INIT_AAR0,x:EXP_AAR0           ; initialise AAR0 control/status reg
        movep   #INIT_BCR,x:EXP_BCR           ; initialise BCR reg

    ENDIF

;-----
;   Initialise SCI
;-----

    IF 1
init_sci
        movep   #$E,x:SCCR_ADR
        movep   #$7,x:PCRE_ADR
        movep   #$11b02,x:SCR_ADR

```

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```

        bset    #12,x:SCR_ADR                ; start SCI transmit
        mac     x0,y0,a      x:(r3)+,x0      y:(r4)+,y0  ; generates variations on mean value of DAC
        move    #$AAAAAA,x0
        move    x0,x:$CAAAAA                ; send data to expansion port
        move    x0,x:GPIODAT                ; move PORTB pins

        bset    #12,x:SCR_ADR                ; start SCI transmit
        mac     x0,y0,a      x:(r3)+,x0      y:(r4)+,y0  ; generates variations on mean value of DAC
        move    #$555555,x0
        move    x0,x:$C55555                ; send data to expansion port
        move    x0,x:GPIODAT                ; move PORTB pins

    jmp  LOOP

    ENDIF

;-----
;   Interrupt Service Routines
;-----

;SAI
;-----
INT_TDE                                ; The transmitter data empty flag is cleared as soon
                                      ; as the last move is performed
        Movep  a,y:<<SAI_TX0            ; Load LEFT transmit data register for channel 0
        nop
        nop
        movep  b,y:<<SAI_TX0            ; Load RIGHT transmit data register for channel 0
        rti

INT_RDR                                ; The receiver data ready flag is cleared as soon
                                      ; as the last move is performed
        movep  y:<<SAI_RX0,a            ; Move Channel 0 received LEFT data to x-memory.
        move   a,x:(r0)
        nop
        nop
        movep  y:<<SAI_RX0,b            ; Move channel 0 received RIGHT data to y-memory.
        move   b,y:(r0)+
        rti

INT_ROF
        bset   #16,y:SAI_RCS
        bclr   #16,y:SAI_RCS
        rti

INT_TUF
        bset   #16,y:SAI_TCS
        bclr   #16,y:SAI_RCS
        rti

;TIMER

```

```

;-----
INT_TMR0_tcf
;    bchg    #0,x:PDRC          ; toggle pin12 Fout=(XTI/2)/((TPLR+1)*(TCPR+1)*2)
    bchg    #13,x:M_TCSR0      ; toggle TIO0 Fout=(XTI/2)/((TPLR+1)*(TCPR+1)*2)
    nop
    rti

INT_TMR0_tof
    nop
    nop
    rti

INT_TMR1_tcf
;    bchg    #1,x:PDRC          ; toggle pin4 Fout=Fin/((TPLR+1)*(TCPR+1)*2)
    bchg    #13,x:M_TCSR1      ; toggle TIO1 Fout=(XTI/2)/((TPLR+1)*(TCPR+1)*2)
    nop
    rti

INT_TMR1_tof
    nop
    nop
    rti

INT_TMR2_tcf
;    bchg    #2,x:PDRC          ; toggle pin3 Fout=Fin/((TPLR+1)*(TCPR+1)*2)
    bchg    #13,x:M_TCSR2      ; toggle TIO2 Fout=(XTI/2)/((TPLR+1)*(TCPR+1)*2)
    nop
    rti

INT_TMR2_tof
    nop
    nop
    rti

;ESSI
;-----
clr_tde0
    movep    r1,x:M_TX00
    move     (r1)+
    movep    r1,x:M_TX01
    move     (r1)+
    movep    r1,x:M_TX02
    move     (r1)+
    rti

clr_tue0
    movep    x:M_SISR0,a0
    movep    r1,x:M_TX00
    move     (r1)+
    movep    r1,x:M_TX01
    move     (r1)+
    movep    r1,x:M_TX02
    move     (1)+
    rti

Comp_0
    rti

```

```

Clr_gpio
    bclr    #0,x:M_PDRE
    rti

Comp_1
    rti

;SCI
;-----
INT_SCIR
    move    x:SRXL_ADR,x0
    movep   #$3f02,x:SCR_ADR
;    move    x0,x:(r1)+
;    move    x0,x:$C00000
    rti

INT_SCIT
;    movep   x0,x:STXA_ADR
    movep   #$000041,x:STXA_ADR
;    movep   #$000061,x:STXA_ADR
L3
    jclr    #0,x:<<SSR_ADR,L3
    movep   #$12f02,x:SCR_ADR
    rti

INT_SCIE
    jclr    #FRAMING,x:SSR_ADR,NO_FRA
L2
    jclr    #0,x:<<SSR_ADR,L2
    movep   #$21,x:STXA_ADR
NO_FRA
    nop
    move    x:SRXL_ADR,x0
    rti

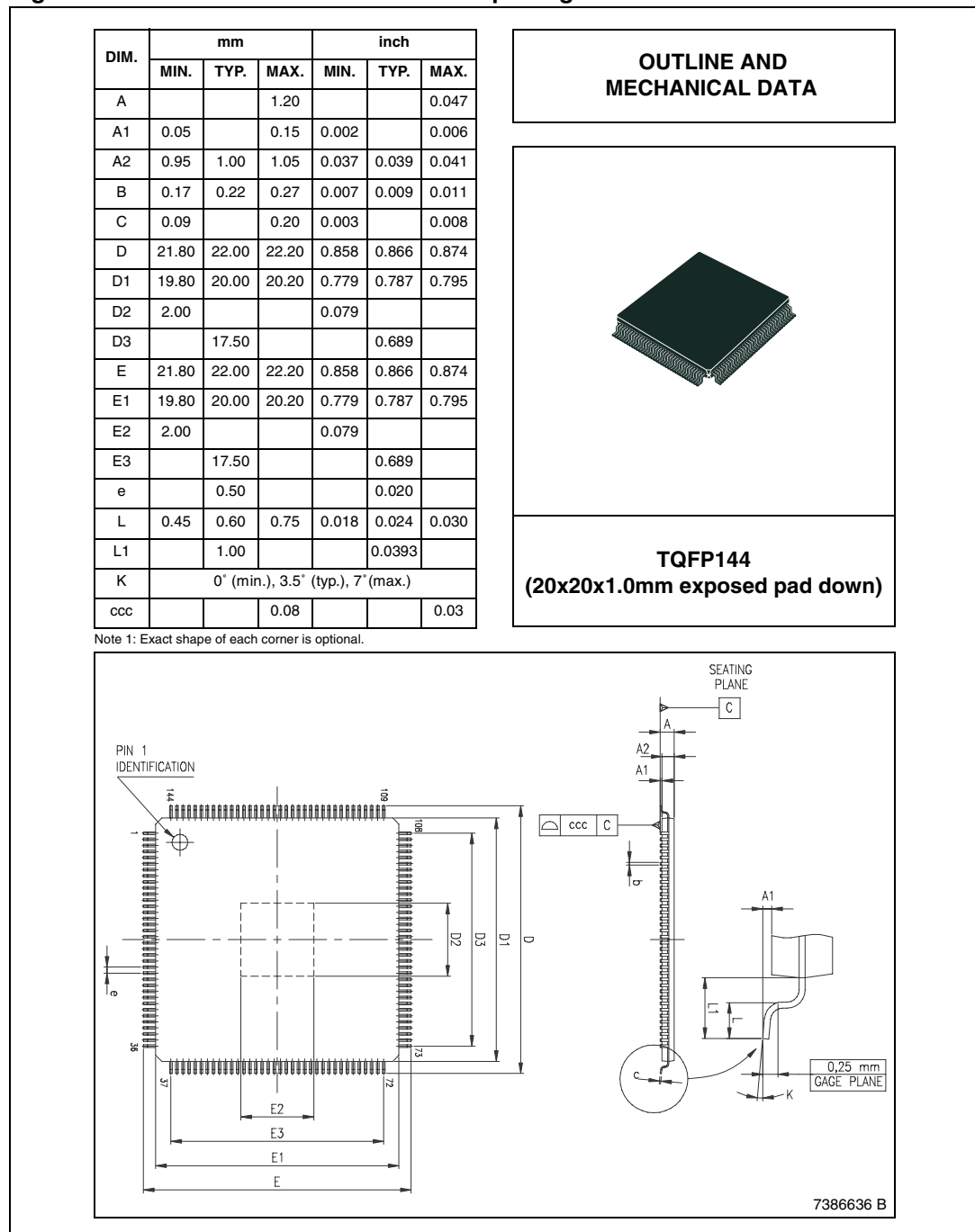
```

## 9 Package information

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**Figure 3. TQFP144 mechanical data and package dimensions**



## 10 Revision history

**Table 8. Document revision history**

| Date        | Revision | Changes                                                                                                                             |
|-------------|----------|-------------------------------------------------------------------------------------------------------------------------------------|
| 11-Apr-2006 | 1        | Initial release.                                                                                                                    |
| 26-Jan-2009 | 2        | Document status promoted from preliminary data to datasheet.<br>Updated <a href="#">Section 9: Package information on page 40</a> . |

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