

# DATA SHEET

## **OQ2535HP** **SDH/SONET STM16/OC48** **multiplexer**

Product specification  
Supersedes data of 1997 Nov 27  
File under Integrated Circuits, IC19

1999 Oct 04

# SDH/SONET STM16/OC48 multiplexer

# OQ2535HP

## FEATURES

- Normal and loop (test) modes
- 3.3 V TTL compatible data inputs
- Differential Current-Mode Logic (CML) clock and data outputs
- 5 V TTL clock output (low speed interface)
- High input sensitivity (100 mV for the high speed clock input)
- Boundary Scan Test (BST) at low speed interface, in accordance with "IEEE Std 1149.1-1990"
- Low power dissipation (typically 1.65 W).

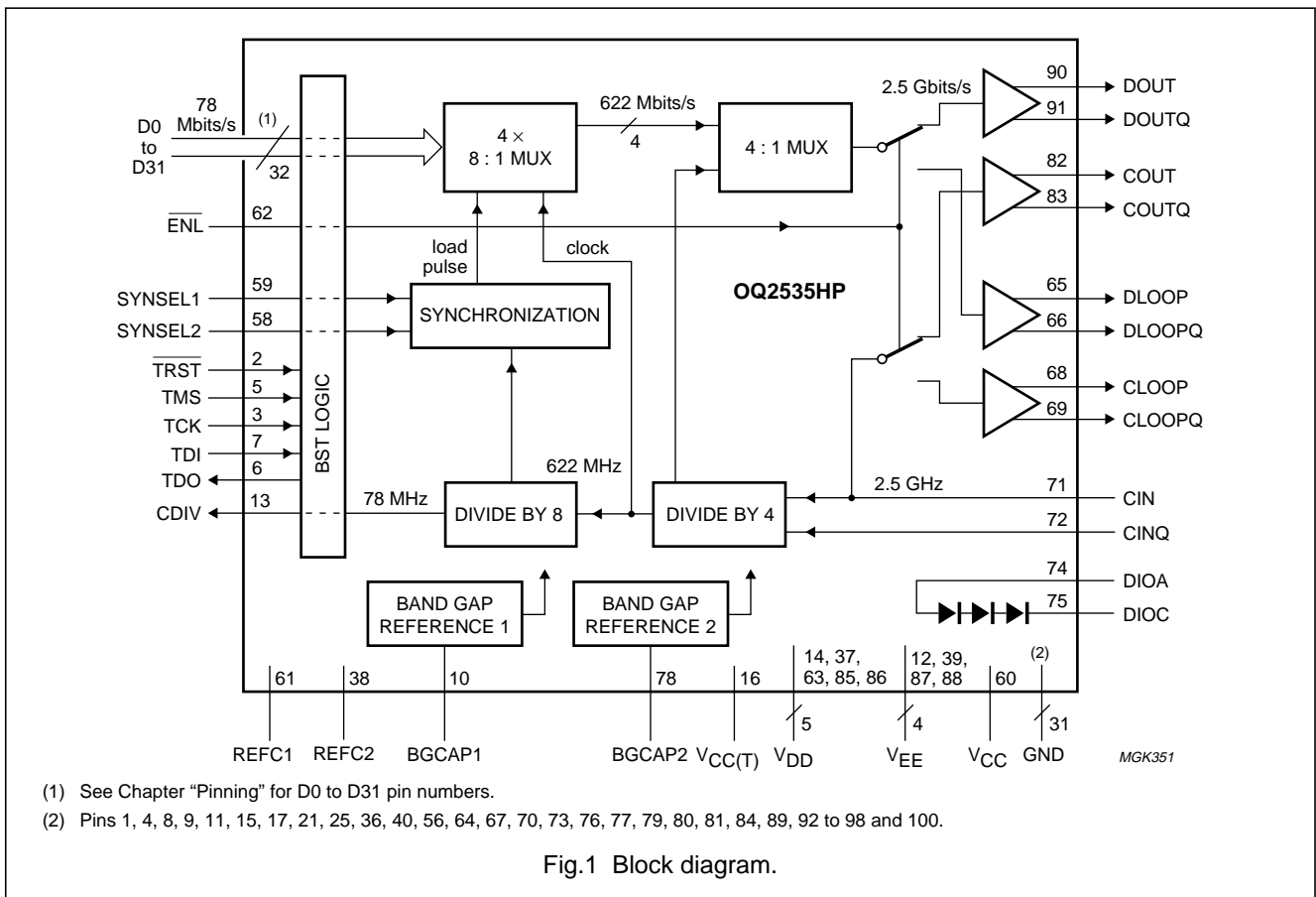
## GENERAL DESCRIPTION

The OQ2535HP is a 32-channel multiplexer intended for use in STM16/OC48 applications. It combines data from a total of  $32 \times 78$  Mbits/s input channels onto a single 2.5 Gbits/s output channel. It features 3.3 V TTL data inputs and a 5 V TTL clock output at the low speed interface, and CML compatible inputs and outputs at the high speed interface.

## ORDERING INFORMATION

| TYPE NUMBER | PACKAGE  |                                                                                                      |          |
|-------------|----------|------------------------------------------------------------------------------------------------------|----------|
|             | NAME     | DESCRIPTION                                                                                          | VERSION  |
| OQ2535HP    | HLQFP100 | plastic heat-dissipating low profile quad flat package; 100 leads; body $14 \times 14 \times 1.4$ mm | SOT470-1 |

## BLOCK DIAGRAM



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## PINNING

| SYMBOL             | PIN | TYPE <sup>(1)</sup> | DESCRIPTION                                                                         |
|--------------------|-----|---------------------|-------------------------------------------------------------------------------------|
| GND                | 1   | S                   | ground                                                                              |
| TRS                | 2   | I                   | test reset input for BST mode (active LOW)                                          |
| TCK                | 3   | I                   | test clock input for BST mode                                                       |
| GND                | 4   | S                   | ground                                                                              |
| TMS                | 5   | I                   | test mode select input for BST mode                                                 |
| TDO                | 6   | O                   | serial test data output for BST mode                                                |
| TDI                | 7   | I                   | serial test data input for BST mode                                                 |
| GND                | 8   | S                   | ground                                                                              |
| GND                | 9   | S                   | ground                                                                              |
| BGCAP1             | 10  | A                   | pin for connecting external band gap decoupling capacitor (4 × 8 : 1 MUX)           |
| GND                | 11  | S                   | ground                                                                              |
| V <sub>EE</sub>    | 12  | S                   | supply voltage (−4.5 V)                                                             |
| CDIV               | 13  | O                   | 78 MHz clock output                                                                 |
| V <sub>DD</sub>    | 14  | S                   | supply voltage (+3.3 V)                                                             |
| GND                | 15  | S                   | ground                                                                              |
| V <sub>CC(T)</sub> | 16  | S                   | supply voltage for TTL buffer (+5.0 V); not connected internally to V <sub>CC</sub> |
| GND                | 17  | S                   | ground                                                                              |
| D31                | 18  | I                   | 78 Mb/s data input channel for D31                                                  |
| D27                | 19  | I                   | 78 Mb/s data input channel for D27                                                  |
| D23                | 20  | I                   | 78 Mb/s data input channel for D23                                                  |
| GND                | 21  | S                   | ground                                                                              |
| D19                | 22  | I                   | 78 Mb/s data input channel for D19                                                  |
| D15                | 23  | I                   | 78 Mb/s data input channel for D15                                                  |
| D11                | 24  | I                   | 78 Mb/s data input channel for D11                                                  |
| GND                | 25  | S                   | ground                                                                              |
| D7                 | 26  | I                   | 78 Mb/s data input channel for D7                                                   |
| D3                 | 27  | I                   | 78 Mb/s data input channel for D3                                                   |
| D30                | 28  | I                   | 78 Mb/s data input channel for D30                                                  |
| D26                | 29  | I                   | 78 Mb/s data input channel for D26                                                  |
| D22                | 30  | I                   | 78 Mb/s data input channel for D22                                                  |
| D18                | 31  | I                   | 78 Mb/s data input channel for D18                                                  |
| D14                | 32  | I                   | 78 Mb/s data input channel for D14                                                  |
| D10                | 33  | I                   | 78 Mb/s data input channel for D10                                                  |
| D6                 | 34  | I                   | 78 Mb/s data input channel for D6                                                   |
| D2                 | 35  | I                   | 78 Mb/s data input channel for D2                                                   |
| GND                | 36  | S                   | ground                                                                              |
| V <sub>DD</sub>    | 37  | S                   | supply voltage (+3.3 V)                                                             |
| REFC2              | 38  | A                   | pin for connecting external reference decoupling capacitor (3.3 V CMOS reference)   |
| V <sub>EE</sub>    | 39  | S                   | supply voltage (−4.5 V)                                                             |

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| SYMBOL          | PIN | TYPE <sup>(1)</sup> | DESCRIPTION                                                                             |
|-----------------|-----|---------------------|-----------------------------------------------------------------------------------------|
| GND             | 40  | S                   | ground                                                                                  |
| D29             | 41  | I                   | 78 Mbits/s data input channel for D29                                                   |
| D25             | 42  | I                   | 78 Mbits/s data input channel for D25                                                   |
| D21             | 43  | I                   | 78 Mbits/s data input channel for D21                                                   |
| D17             | 44  | I                   | 78 Mbits/s data input channel for D17                                                   |
| D13             | 45  | I                   | 78 Mbits/s data input channel for D13                                                   |
| D9              | 46  | I                   | 78 Mbits/s data input channel for D9                                                    |
| D5              | 47  | I                   | 78 Mbits/s data input channel for D5                                                    |
| D1              | 48  | I                   | 78 Mbits/s data input channel for D1                                                    |
| D28             | 49  | I                   | 78 Mbits/s data input channel for D28                                                   |
| D24             | 50  | I                   | 78 Mbits/s data input channel for D24                                                   |
| D20             | 51  | I                   | 78 Mbits/s data input channel for D20                                                   |
| D16             | 52  | I                   | 78 Mbits/s data input channel for D16                                                   |
| D12             | 53  | I                   | 78 Mbits/s data input channel for D12                                                   |
| D8              | 54  | I                   | 78 Mbits/s data input channel for D8                                                    |
| D4              | 55  | I                   | 78 Mbits/s data input channel for D4                                                    |
| GND             | 56  | S                   | ground                                                                                  |
| D0              | 57  | I                   | 78 Mbits/s data input channel for D0                                                    |
| SYNSEL2         | 58  | I                   | selection input 2 for synchronization pulse timing                                      |
| SYNSEL1         | 59  | I                   | selection input 1 for synchronization pulse timing                                      |
| V <sub>CC</sub> | 60  | S                   | supply voltage (+5.0 V)                                                                 |
| REFC1           | 61  | A                   | pin for connecting external reference decoupling capacitor (for standard TTL reference) |
| ENL             | 62  | I                   | loop mode enable (active LOW)                                                           |
| V <sub>DD</sub> | 63  | S                   | supply voltage (+3.3 V)                                                                 |
| GND             | 64  | S                   | ground                                                                                  |
| DLOOP           | 65  | O                   | data output to demultiplexer IC OQ2536 (loop mode)                                      |
| DLOOPQ          | 66  | O                   | inverted data output to demultiplexer IC OQ2536 (loop mode)                             |
| GND             | 67  | S                   | ground                                                                                  |
| CLOOP           | 68  | O                   | clock output to demultiplexer IC OQ2536 (loop mode)                                     |
| CLOOPQ          | 69  | O                   | inverted clock output to demultiplexer IC OQ2536 (loop mode)                            |
| GND             | 70  | S                   | ground                                                                                  |
| CIN             | 71  | I                   | clock input from VCO IC                                                                 |
| CINQ            | 72  | I                   | inverted clock input from VCO IC                                                        |
| GND             | 73  | S                   | ground                                                                                  |
| DIOA            | 74  | A                   | anode of temperature diode array                                                        |
| DIOC            | 75  | A                   | cathode of temperature diode array                                                      |
| GND             | 76  | S                   | ground                                                                                  |
| GND             | 77  | S                   | ground                                                                                  |
| BGCAP2          | 78  | A                   | pin for connecting external band gap decoupling capacitor (4 : 1 MUX)                   |
| GND             | 79  | S                   | ground                                                                                  |

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| SYMBOL          | PIN | TYPE <sup>(1)</sup> | DESCRIPTION                                   |
|-----------------|-----|---------------------|-----------------------------------------------|
| GND             | 80  | S                   | ground                                        |
| GND             | 81  | S                   | ground                                        |
| COUT            | 82  | O                   | clock output to laser driver IC               |
| COUTQ           | 83  | O                   | inverted clock output to laser driver IC      |
| GND             | 84  | S                   | ground                                        |
| V <sub>DD</sub> | 85  | S                   | supply voltage (+3.3 V)                       |
| V <sub>DD</sub> | 86  | S                   | supply voltage (+3.3 V)                       |
| V <sub>EE</sub> | 87  | S                   | supply voltage (-4.5 V)                       |
| V <sub>EE</sub> | 88  | S                   | supply voltage (-4.5 V)                       |
| GND             | 89  | S                   | ground                                        |
| DOUT            | 90  | O                   | data output to laser driver IC                |
| DOUTQ           | 91  | O                   | inverted data output to laser driver IC       |
| GND             | 92  | S                   | ground                                        |
| GND             | 93  | S                   | ground                                        |
| GND             | 94  | S                   | ground                                        |
| GND             | 95  | S                   | ground                                        |
| GND             | 96  | S                   | ground                                        |
| GND             | 97  | S                   | ground                                        |
| GND             | 98  | S                   | ground                                        |
| i.c.            | 99  | –                   | internally connected, to be left open-circuit |
| GND             | 100 | S                   | ground                                        |

**Note**

1. Pin type abbreviations: O = Output, I = Input, S = power Supply, A = Analog function.

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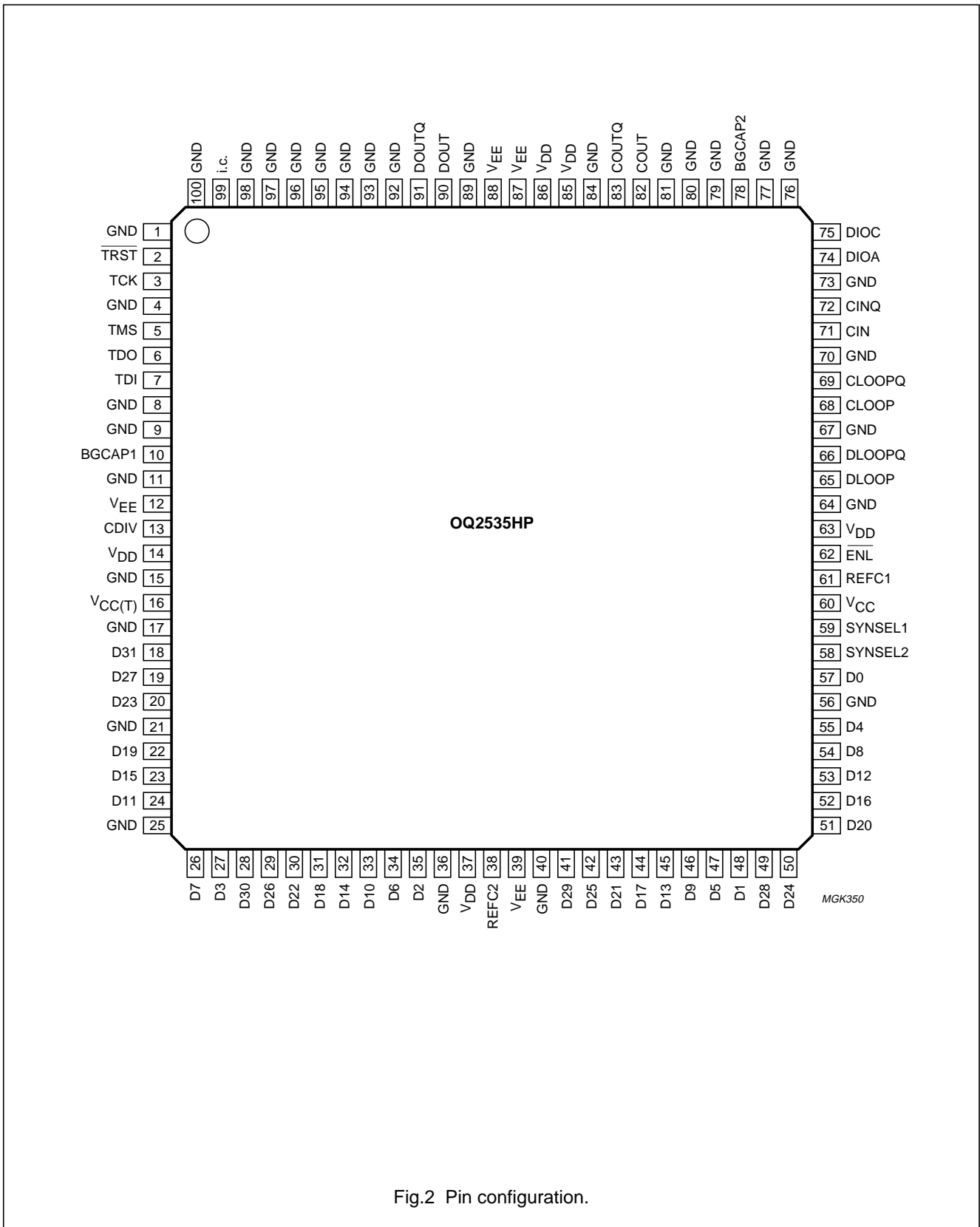


Fig.2 Pin configuration.

## SDH/SONET STM16/OC48 multiplexer

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**FUNCTIONAL DESCRIPTION**

The OQ2535HP is a 32-channel multiplexer intended for use in STM16/OC48 applications. It multiplexes  $32 \times 78$  Mbits/s input channels onto a single 2.5 Gbits/s output channel.

The multiplexing is performed in two stages. The 32 input channels are fed into four 8 : 1 multiplexers to generate four 622 Mbits/s channels. These four channels are then combined into a single 2.5 Gbits/s data stream.

The  $\overline{\text{ENL}}$  control input is used for switching between normal and loop modes. When loop mode is enabled, ( $\overline{\text{ENL}} = \text{LOW}$ ), the output signal is switched to DLOOP and DLOOPQ (these outputs could be connected to the DLOOP and DLOOPQ inputs on the OQ2536HP demultiplexer to form part of a test loop).

The 2.5 GHz clock at CIN and CINQ is used as the system reference. It is divided down to 78 MHz and made available on the CDIV TTL output for timing the input data (D0 to D31).

**Low bit rate stage: 4 × 8 : 1 MUX**

This part of the circuit consists of four 8-bit shift registers, each acting as an 8 : 1 multiplexer, together with a synchronization block.

The 32 data input signals are loaded into the shift registers before being shifted out on a 622 MHz clock.

The load pulse for the shift registers is generated in the synchronization block. The inputs SYNSEL1 and SYNSEL2 can be used to adjust the phase of the load pulse with respect to the input data (see Table 3) to synchronize the data and clock signals.

**High bit rate stage: 4 : 1 MUX**

The four 622 Mbits/s data outputs from the low bit rate stage are combined into a single 2.5 Gbits/s data stream in two stages: two 2 : 1 multiplexers are used to generate two 1244 Mbits/s data streams; these signals are then fed into a third 2 : 1 multiplexer to generate the 2.5 Gbits/s data stream.

The 2.5 Gbits/s serial data stream is passed either to the DOUT and DOUTQ outputs (normal mode), or to the DLOOP and DLOOPQ outputs (loop mode). The output sequence is D31 (MSB) to D0 (LSB). Data and clock output buffers are terminated internally with 100  $\Omega$  resistors to GND and are capable of driving 50  $\Omega$  loads. The unused output buffers are switched off to help minimize power dissipation.

The outputs CLOOP, CLOOPQ, DLOOP and DLOOPQ are terminated internally with 100  $\Omega$  resistors to GND and are specifically designed to drive 50  $\Omega$  printed-circuit board transmission lines.

The 2.5 GHz clock connected to CIN and CINQ is terminated internally with 50  $\Omega$  to GND.

**Power supply connections**

The power supply pins need to be individually decoupled using chip capacitors mounted as close as possible to the IC. If multiple decoupling capacitors are used for a single supply node, they must be placed close to each other to avoid RF resonance.

To minimize low frequency switching noise in the vicinity of the OQ2535HP, all power supply lines should be filtered once by an LC-circuit with a low cut-off frequency (as shown in the application diagram, Fig.6).  $V_{CC(T)}$  needs to be filtered separately via an LC-circuit because of the high switching currents present at the CDIV TTL output. As this current contains only 78 MHz harmonics, filtering can be achieved with relatively small values of L and C.

**Ground connection**

The ground connection on the printed-circuit board needs to be a large copper area fill connected to a common ground plane with low inductance.

**RF connections**

A coupled stripline or microstrip with an odd mode characteristic impedance of 50  $\Omega$  (nominal value) should be used for the RF connections on the printed-circuit board. The connections should be kept as short as possible. This applies to the CML differential line pairs CIN and CINQ, DOUT and DOUTQ, COUT and COUTQ, DLOOP and DLOOPQ, and CLOOP and CLOOPQ. In addition, the following lines should not vary in length by more than 5 mm:

- CIN and CINQ
- DOUT, DOUTQ, COUT and COUTQ
- DLOOP, DLOOPQ, CLOOP and CLOOPQ.

**Interface to transmit logic**

The 78 Mbits/s interface lines, CDIV and D0 to D31, should not vary in length by more than 20 mm. The parasitic capacitance of these lines should be as small as possible.

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**ESD protection**

All pads are protected by ESD protection diodes with the exception of the high frequency outputs DOUT, DOUTQ, DLOOP, DLOOPQ, COUT, COUTQ, CLOOP and CLOOPQ and clock inputs CIN and CINQ.

**Cooling**

In many cases it is necessary to mount a special cooling device on the package. The thermal resistance from junction to case,  $R_{th\ j-c}$  and from junction to ambient,  $R_{th\ j-a}$ , are given in Chapter "Thermal characteristics". Since the heat-slug in the package is connected to the die, the cooling device should be electrically isolated.

To calculate if a heatsink is necessary, the maximum allowed total thermal resistance  $R_{th}$  is calculated as:

$$R_{th} = \frac{T_j - T_{amb}}{P_{tot}} \tag{1}$$

where:

$R_{th}$  = total thermal resistance from junction to ambient in the application

$T_j$  = junction temperature

$T_{amb}$  = ambient temperature.

As long as  $R_{th}$  is greater than  $R_{th\ j-a}$  of the OQ2536HP including environmental conditions such as air flow and board layout, no heatsink is necessary.

For example if  $T_j = 120\text{ }^\circ\text{C}$ ,  $T_{amb} = 55\text{ }^\circ\text{C}$  and  $P_{tot} = 1.65\text{ W}$ , then:

$$R_{th} = \frac{(120 - 55)}{1.65} = 39.4\text{ K/W} \tag{2}$$

which is more than the worst case  $R_{th\ j-a} = 33\text{ K/W}$ , so no heatsink is necessary.

Another example; if for safety reasons  $T_j$  should stay as low as  $110\text{ }^\circ\text{C}$ , while  $T_{amb} = 85\text{ }^\circ\text{C}$  and  $P_{tot} = 2\text{ W}$ , then:

$$R_{th} = \frac{(110 - 85)}{2.0} = 12.5\text{ K/W} \tag{3}$$

In this case extra cooling is needed. The thermal resistance of the heatsink is calculated as follows:

$$R_{th\ h-a} \leq \left( \frac{1}{R_{th}} - \frac{1}{R_{th\ j-a}} \right)^{-1} - R_{th\ j-c} - R_{th\ c-h} \tag{4}$$

where:

$R_{th\ h-a}$  = thermal resistance from heatsink to ambient

$R_{th\ c-h}$  = thermal resistance from case to heatsink

$R_{th\ j-c}$  = thermal resistance from junction to case, see Chapter "Thermal characteristics".

If for instance  $R_{th\ c-h} = 0.5\text{ K/W}$  and  $R_{th\ j-a} = 33\text{ K/W}$  then:

$$R_{th\ h-a} \leq \left( \frac{1}{12.5} - \frac{1}{33} \right)^{-1} - 3.1 \tag{5}$$

$$\leq 17.0\text{ K/W}$$

**Built in temperature sensor**

Three series-connected diodes have been integrated for measuring junction temperature. The diode array, accessed by means of the DIOA (anode) and DIOC (cathode) pins, has a temperature dependency of approximately  $-6\text{ mV}/^\circ\text{C}$ . With a diode current of  $1\text{ mA}$ , the voltage will be somewhere in the range of  $1.7$  to  $2.5\text{ V}$ , depending on temperature.

**Boundary Scan Test (BST) interface**

Boundary scan test logic has been implemented for all digital inputs and outputs on the low frequency interface, in accordance with "IEEE Std 1149.1-1990". All scan tests other than SAMPLE mode are available. The boundary scan test logic consists of a TAP controller, a BYPASS register, a 2-bit instruction register, a 32-bit identification register and a 36-bit boundary scan register (the last two are combined). The architecture of the TAP controller and the BYPASS register is in accordance with IEEE recommendations. The four command modes, selected by means of the instruction register, are: EXTEST (00), PRELOAD (01), IDCODE (10) and BYPASS (11). All boundary scan test inputs, TDI, TMS, TCK and  $\overline{\text{TRST}}$ , have internal pull-up resistors. The maximum test clock frequency at TCK is  $12\text{ MHz}$ .

**Table 1** BST identifier code

| VERSION | OQ | 2535 (BINARY)     | PHILIPS SEMICONDUCTORS | LSB <sup>(1)</sup> |
|---------|----|-------------------|------------------------|--------------------|
| 0001    | 01 | 00 1001 1110 0111 | 0000 0010 101          | 1                  |

**Note**

1. LSB is shifted out first on the TDO pin.



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**Table 2** BST bit order

| BIT NUMBER             | SYMBOL  | PIN |
|------------------------|---------|-----|
| 35 (MSB)               | CDIV    | 13  |
| 34                     | ENL     | 62  |
| 33                     | SYNSEL2 | 58  |
| 32                     | SYNSEL1 | 59  |
| 31                     | D31     | 18  |
| 30                     | D30     | 28  |
| 29                     | D29     | 41  |
| 28                     | D28     | 49  |
| 27                     | D27     | 19  |
| 26                     | D26     | 29  |
| 25                     | D25     | 42  |
| 24                     | D24     | 50  |
| 23                     | D23     | 20  |
| 22                     | D22     | 30  |
| 21                     | D21     | 43  |
| 20                     | D20     | 51  |
| 19                     | D19     | 22  |
| 18                     | D18     | 31  |
| 17                     | D17     | 44  |
| 16                     | D16     | 52  |
| 15                     | D15     | 23  |
| 14                     | D14     | 32  |
| 13                     | D13     | 45  |
| 12                     | D12     | 53  |
| 11                     | D11     | 24  |
| 10                     | D10     | 33  |
| 9                      | D9      | 46  |
| 8                      | D8      | 54  |
| 7                      | D7      | 26  |
| 6                      | D6      | 34  |
| 5                      | D5      | 47  |
| 4                      | D4      | 55  |
| 3                      | D3      | 27  |
| 2                      | D2      | 35  |
| 1                      | D1      | 48  |
| 0 (LSB) <sup>(1)</sup> | D0      | 57  |

**Note**

1. LSB is shifted out first on the TDO pin.

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**LIMITING VALUES**

In accordance with the Absolute Maximum Rating System (IEC 134).

| SYMBOL              | PARAMETER                                          | MIN.           | MAX.           | UNIT |
|---------------------|----------------------------------------------------|----------------|----------------|------|
| $V_{CC}, V_{CC(T)}$ | supply voltage                                     | -0.5           | +6.0           | V    |
| $V_{EE}$            | supply voltage                                     | -6.0           | +0.5           | V    |
| $V_{DD}$            | supply voltage                                     | -0.5           | +5.0           | V    |
| $V_n$               | DC voltage                                         |                |                |      |
|                     | pins 18 to 20, 22 to 24, 26 to 35, 41 to 55 and 57 | -0.5           | $V_{DD} + 0.5$ | V    |
|                     | pins 2, 3, 5, 7, 38, 61 and 62                     | -0.5           | $V_{CC} + 0.5$ | V    |
|                     | pins 65, 66, 68, 69, 71, 72, 82, 83, 90 and 91     | -1.0           | +0.5           | V    |
|                     | pins 10 and 78                                     | $V_{EE} - 0.5$ | 0.5            | V    |
|                     | pins 74 and 75                                     | $V_{EE} - 0.5$ | $V_{CC} + 0.5$ | V    |
| $I_n$               | DC current                                         |                |                |      |
|                     | pins 6 and 13                                      | -              | 50             | mA   |
|                     | pins 74 and 75                                     | -              | 10             | mA   |
| $P_{tot}$           | total power dissipation                            | -              | 2.35           | W    |
| $T_j$               | junction temperature                               | -              | 120            | °C   |
| $T_{stg}$           | storage temperature                                | -65            | +150           | °C   |

**THERMAL CHARACTERISTICS**

| SYMBOL        | PARAMETER                                   | CONDITIONS           | VALUE | UNIT |
|---------------|---------------------------------------------|----------------------|-------|------|
| $R_{th\ j-c}$ | thermal resistance from junction to case    |                      | 2.6   | K/W  |
| $R_{th\ j-a}$ | thermal resistance from junction to ambient | see note 1           |       |      |
|               |                                             | airflow = 0 ft/min   | 33    | K/W  |
|               |                                             | airflow = 100 ft/min | 28    | K/W  |
|               |                                             | airflow = 200 ft/min | 25    | K/W  |
|               |                                             | airflow = 400 ft/min | 22    | K/W  |
|               |                                             | airflow = 600 ft/min | 20    | K/W  |

**Note**

1. The thermal resistance from junction to ambient is strongly depending on the board design and airflow. The values given in the table are typical values and are measured on a single sided test board with dimensions of  $76 \times 114 \times 1.6$  mm. Better values can be obtained when mounted on multilayer boards with large ground planes.

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**DC CHARACTERISTICS**

All typical values are at  $T_{amb} = 25\text{ °C}$  and at typical supply voltages; minimum and maximum values are valid over the entire ambient temperature range and supply voltage range.

| SYMBOL                                                                 | PARAMETER                              | CONDITIONS                                                 | MIN.  | TYP. | MAX.  | UNIT |
|------------------------------------------------------------------------|----------------------------------------|------------------------------------------------------------|-------|------|-------|------|
| <b>General</b>                                                         |                                        |                                                            |       |      |       |      |
| $V_{CC}, V_{CC(T)}$                                                    | supply voltage                         | note 1                                                     | 4.75  | 5.0  | 5.25  | V    |
| $V_{EE}$                                                               | supply voltage                         |                                                            | -4.75 | -4.5 | -4.25 | V    |
| $V_{DD}$                                                               | supply voltage                         |                                                            | 3.14  | 3.3  | 3.47  | V    |
| $I_{CC}$                                                               | supply current                         |                                                            | -     | 2.3  | 4     | mA   |
| $I_{CC(T)}$                                                            | supply current                         |                                                            | -     | 20   | 40    | mA   |
| $I_{EE}$                                                               | supply current                         |                                                            | -     | 265  | 400   | mA   |
| $I_{DD}$                                                               | supply current                         |                                                            | -     | 20   | 28    | mA   |
| $P_{tot}$                                                              | total power dissipation                |                                                            | -     | 1.65 | 2.35  | W    |
| $T_j$                                                                  | junction temperature                   |                                                            | -     | -    | 120   | °C   |
| $T_{amb}$                                                              | ambient temperature                    |                                                            | -40   | -    | +85   | °C   |
| <b>TTL 3.3 V inputs: D0 to D31; note 2</b>                             |                                        |                                                            |       |      |       |      |
| $V_{IL}$                                                               | LOW-level input voltage                |                                                            | -     | -    | 0.8   | V    |
| $V_{IH}$                                                               | HIGH-level input voltage               |                                                            | 2.0   | -    | -     | V    |
| $I_{IL}$                                                               | LOW-level input current                |                                                            | -65   | -    | 0     | μA   |
| $I_{IH}$                                                               | HIGH-level input current               |                                                            | 0     | -    | 110   | μA   |
| <b>TTL inputs: ENL, SYNSEL1, SYNSEL2, TDI, TCK, TMS and TRST</b>       |                                        |                                                            |       |      |       |      |
| $V_{IL}$                                                               | LOW-level input voltage                |                                                            | -     | -    | 0.8   | V    |
| $V_{IH}$                                                               | HIGH-level input voltage               |                                                            | 2.0   | -    | -     | V    |
| $I_{IL}$                                                               | LOW-level input current                | note 3                                                     | -100  | -    | 0     | μA   |
| $I_{IH}$                                                               | HIGH-level input current               | note 3                                                     | 0     | -    | 210   | μA   |
| <b>CML clock inputs: CIN and CINQ; note 4</b>                          |                                        |                                                            |       |      |       |      |
| $V_{i(p-p)}$                                                           | input voltage (peak-to-peak value)     | 50 Ω<br>measurement<br>system                              | 100   | 250  | 500   | mV   |
| $V_{IO}$                                                               | permitted input offset voltage         |                                                            | -25   | -    | +25   | mV   |
| $V_I, V_{IQ}$                                                          | input voltages                         |                                                            | -600  | -    | +250  | mV   |
| $Z_i$                                                                  | single ended input impedance           | for DC signal                                              | -     | 50   | -     | Ω    |
| <b>TTL outputs: CDIV and TDO; note 5</b>                               |                                        |                                                            |       |      |       |      |
| $V_{OL}$                                                               | LOW-level output voltage               | $I_{OL} = 4\text{ mA}$                                     | -     | 0.3  | 0.5   | V    |
| $V_{OH}$                                                               | HIGH-level output voltage              | $I_{OH} = -400\text{ μA}$                                  | 2.4   | 4.0  | -     | V    |
| $I_{OZ}$                                                               | output current in high-impedance state |                                                            | -     | -    | 1     | μA   |
| <b>CML outputs in normal mode: COUT, COUTQ, DOUT and DOUTQ; note 4</b> |                                        |                                                            |       |      |       |      |
| $V_{o(p-p)}$                                                           | output voltage (peak-to-peak value)    | outputs<br>terminated<br>externally with<br>50 Ω resistors | 230   | 300  | 500   | mV   |
| $V_{OO}$                                                               | output offset voltage                  |                                                            | -25   | 0    | +25   | mV   |
| $V_O, V_{OQ}$                                                          | output voltages                        |                                                            | -600  | -    | 0     | mV   |
| $Z_o$                                                                  | output impedance                       | for DC signal                                              | -     | 100  | -     | Ω    |

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| SYMBOL                                                                   | PARAMETER                           | CONDITIONS                                     | MIN. | TYP. | MAX. | UNIT     |
|--------------------------------------------------------------------------|-------------------------------------|------------------------------------------------|------|------|------|----------|
| <b>CML outputs in loop mode: CLOOP, CLOOPQ, DLOOP and DLOOPQ; note 4</b> |                                     |                                                |      |      |      |          |
| $V_{o(p-p)}$                                                             | output voltage (peak-to-peak value) | outputs terminated externally with $50 \Omega$ | 230  | 300  | 500  | mV       |
| $V_{OO}$                                                                 | output offset voltage               |                                                | -25  | 0    | +25  | mV       |
| $V_O, V_{OQ}$                                                            | output voltages                     |                                                | -600 | -    | 0    | mV       |
| $Z_o$                                                                    | output impedance                    | for DC signal                                  | -    | 100  | -    | $\Omega$ |
| <b>Temperature diode array</b>                                           |                                     |                                                |      |      |      |          |
| $\Delta V_{DIOA-DIOC}$                                                   | diode voltage range; note 6         | $I_{I(d)} = 1 \text{ mA}$                      | -    | 2.1  | -    | V        |

Notes

1.  $V_{CC}$  and  $V_{CC(T)}$  require the same power supply voltage. However, a filter is needed to isolate  $V_{CC(T)}$  because of the high peak currents that occur at 78 MHz.
2. The output sequence is D31 (MSB) to D0 (LSB).
3. Only for inputs  $\overline{ENL}$ , SYNSEL1 and SYNSEL2. TDI, TMS, TCK and  $\overline{TRST}$  are connected to  $V_{CC}$  through 90 k $\Omega$  resistors.
4. See Fig.3 for symbol definitions.
5. TDO is switched to high impedance state if BST is inactive.
6. The temperature diode array can be used to measure the temperature of the die. The temperature dependency of this voltage is approximately -6 mV/K.

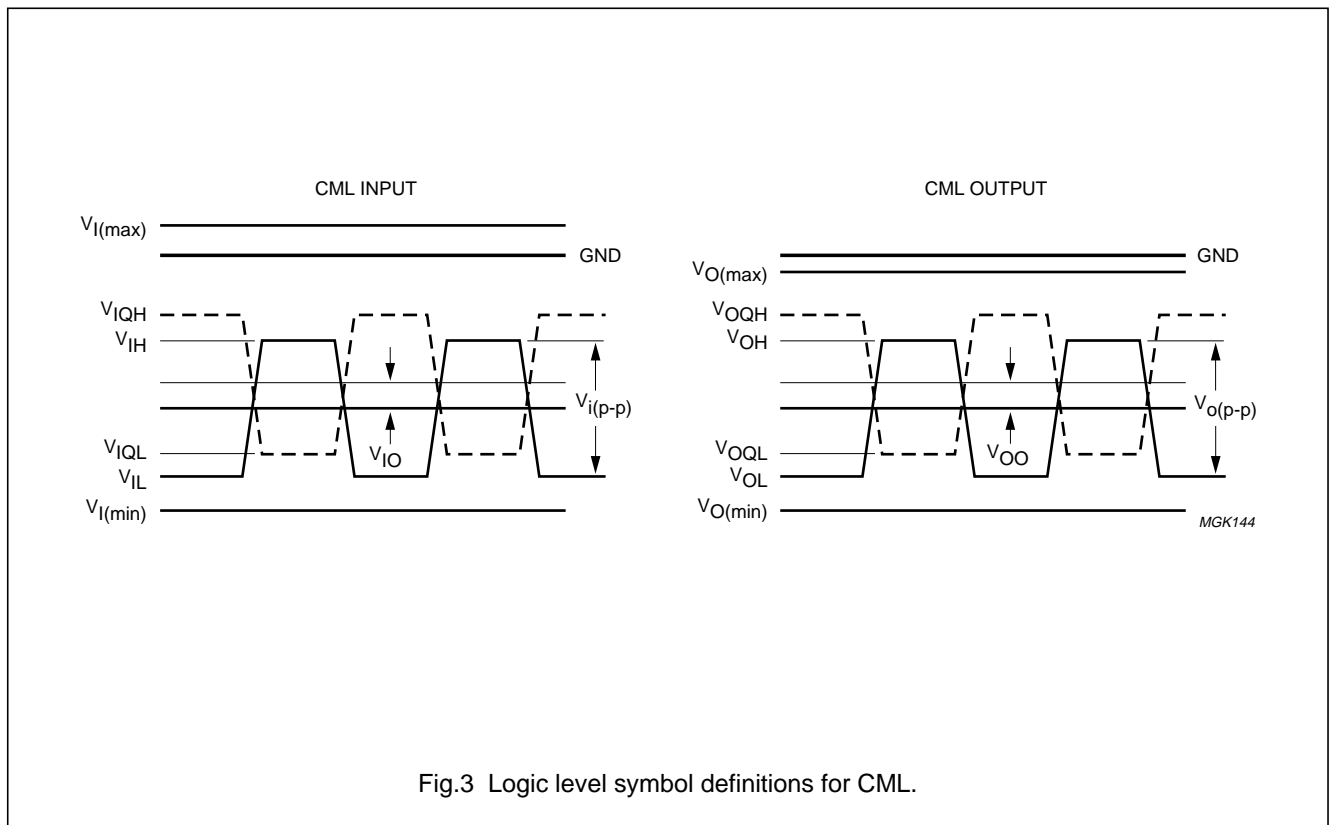


Fig.3 Logic level symbol definitions for CML.

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**TIMING**

Typical values at  $T_{amb} = 25\text{ }^{\circ}\text{C}$  and at typical supply voltages; minimum and maximum values are valid over the entire ambient temperature range and supply voltage range.

| SYMBOL                           | PARAMETER                        | CONDITIONS                        | MIN. | TYP.  | MAX. | UNIT |
|----------------------------------|----------------------------------|-----------------------------------|------|-------|------|------|
| <b>TTL input timing</b>          |                                  |                                   |      |       |      |      |
| $f_{clk(CDIV)}$                  | low speed output clock frequency | $f_{clk(CIN)} = 2.488\text{ GHz}$ | –    | 77.76 | –    | MHz  |
| $t_{r(CDIV)}, t_{f(CDIV)}$       | CDIV rise/fall time              | capacitive load of 15 pF          | –    | –     | 2600 | ps   |
| $t_{su}$                         | input data set-up time           | note 1                            | 1200 | –     | –    | ps   |
| $t_h$                            | input data hold time             | note 1                            | 2600 | –     | –    | ps   |
| <b>CML output timing; note 2</b> |                                  |                                   |      |       |      |      |
| $f_{clk(COUT)}$                  | output clock frequency           | $f_{clk(CIN)} = 2.488\text{ GHz}$ | –    | 2.488 | –    | GHz  |
| $t_{CDV}$                        | clock edge to data valid time    |                                   | –    | –     | 250  | ps   |
| $t_{DI}$                         | data invalid time                |                                   | –    | –     | 120  | ps   |
| $t_{r(CML)}, t_{f(CML)}$         | CML output rise/fall time        |                                   | –    | –     | 150  | ps   |
| $\delta_{COUT}$                  | output clock duty factor         |                                   | 45   | 50    | 55   | %    |

**Notes**

1. The set-up and hold times given are valid for SYNSEL1 = SYNSEL2 = HIGH. Different SYNSEL1, SYNSEL2 combinations will produce different set-up and hold times (see Table 3).
2. All CML outputs must be terminated externally with 50  $\Omega$  to GND. The specified timing characteristics are applicable in both normal and loop modes.

**Table 3** Timing relationship between the clock edge and the data valid region (minimum values)

| SYNSEL2 | SYNSEL1 | $t_{su}$ | $t_h$ | UNIT |
|---------|---------|----------|-------|------|
| HIGH    | HIGH    | 1200     | 2600  | ps   |
| HIGH    | LOW     | 2800     | 1000  | ps   |
| LOW     | HIGH    | 1700     | 2100  | ps   |
| LOW     | LOW     | 3300     | 500   | ps   |

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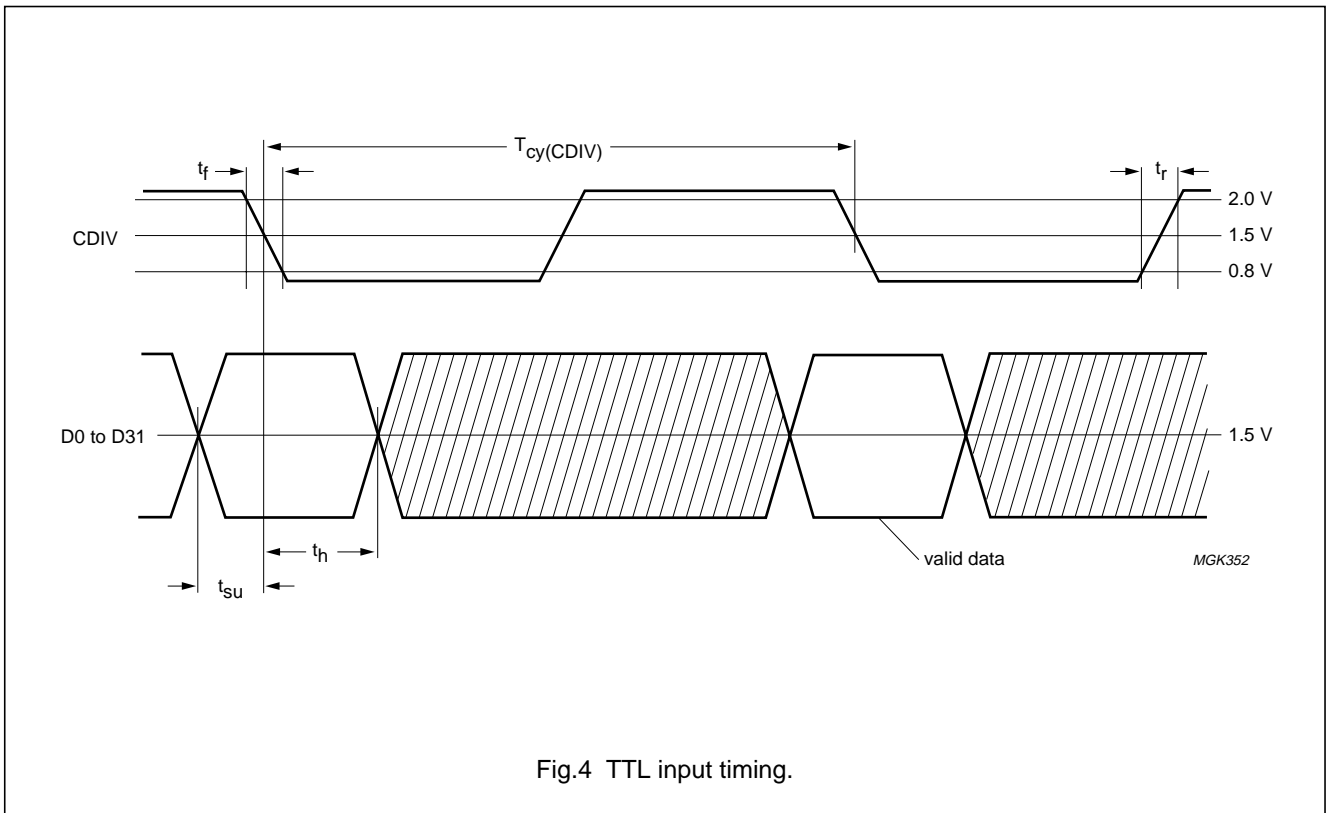


Fig.4 TTL input timing.

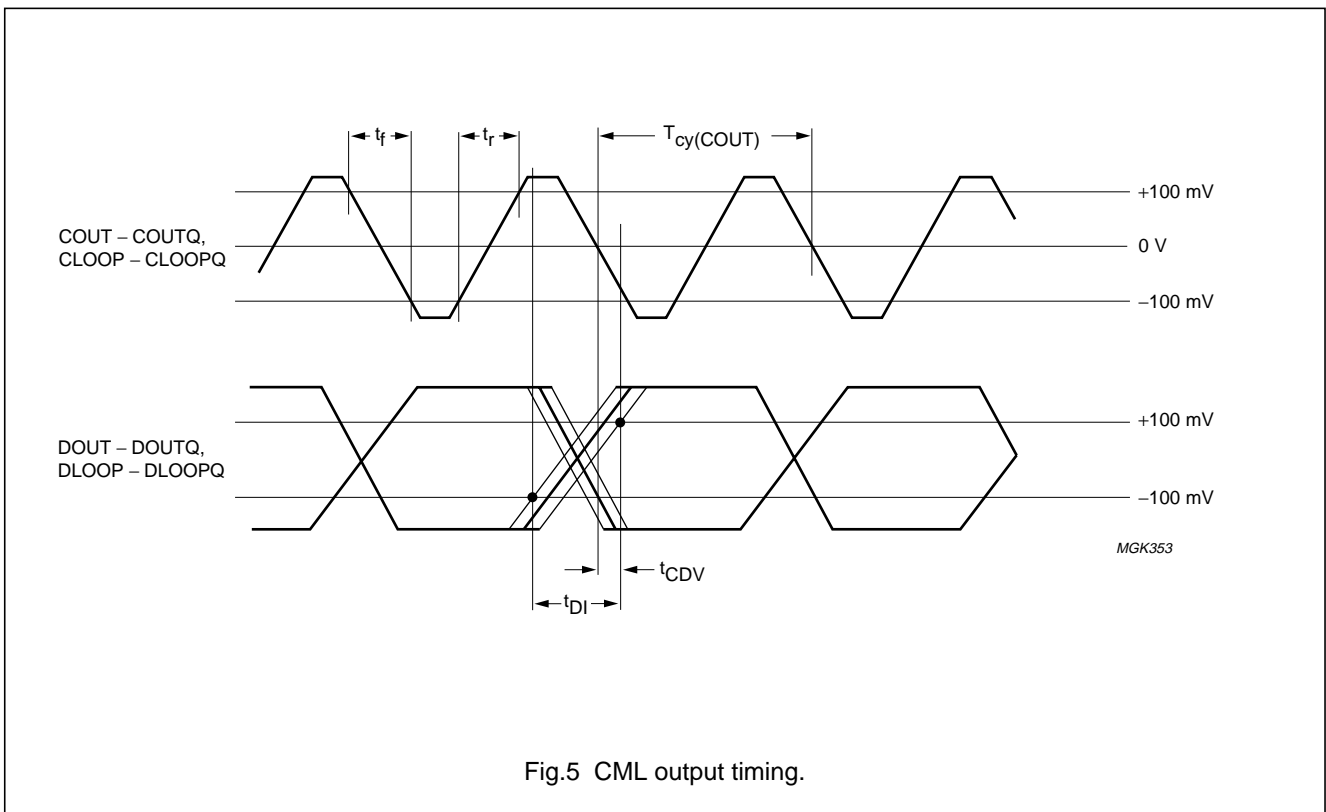


Fig.5 CML output timing.

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APPLICATION INFORMATION

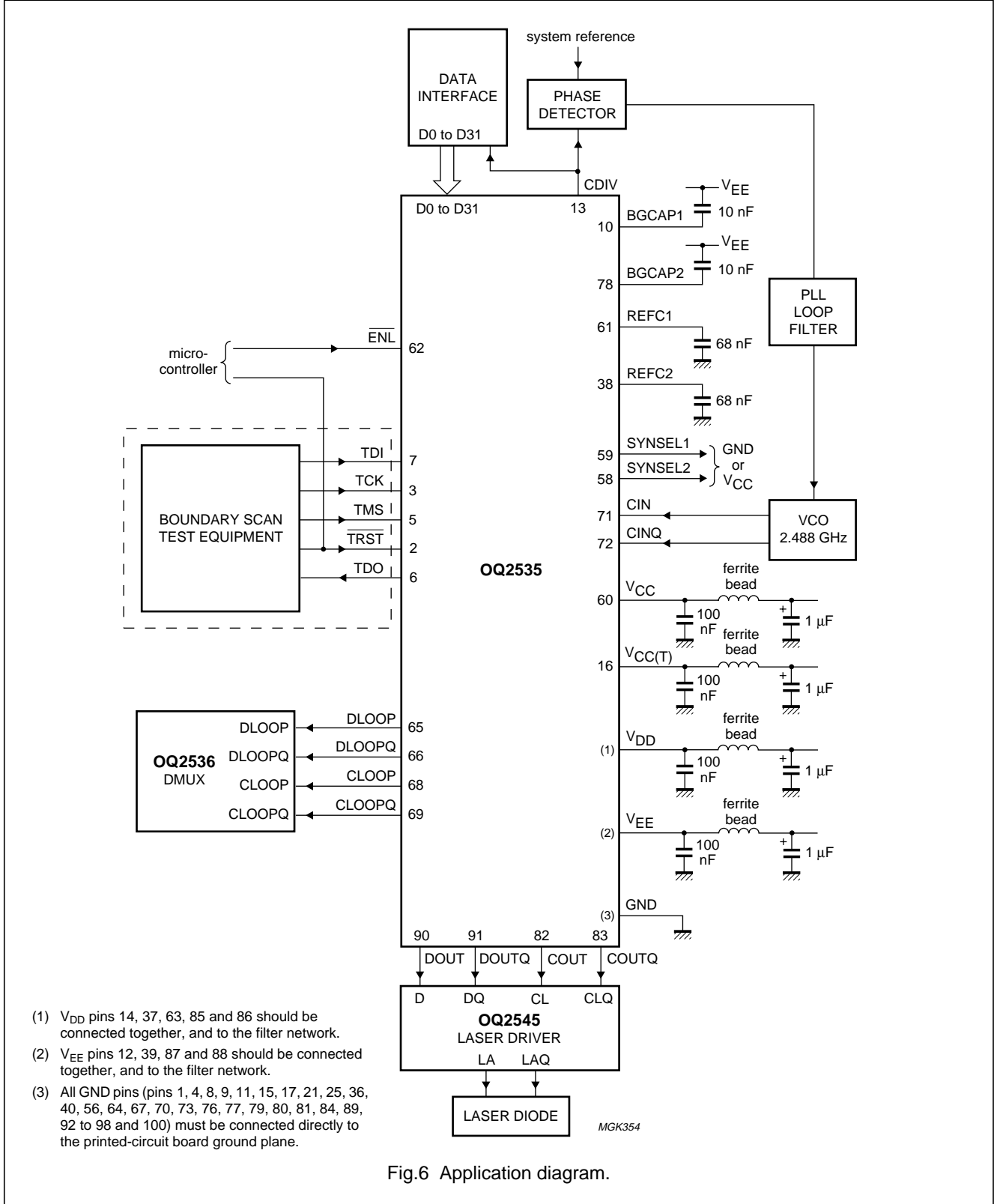


Fig.6 Application diagram.

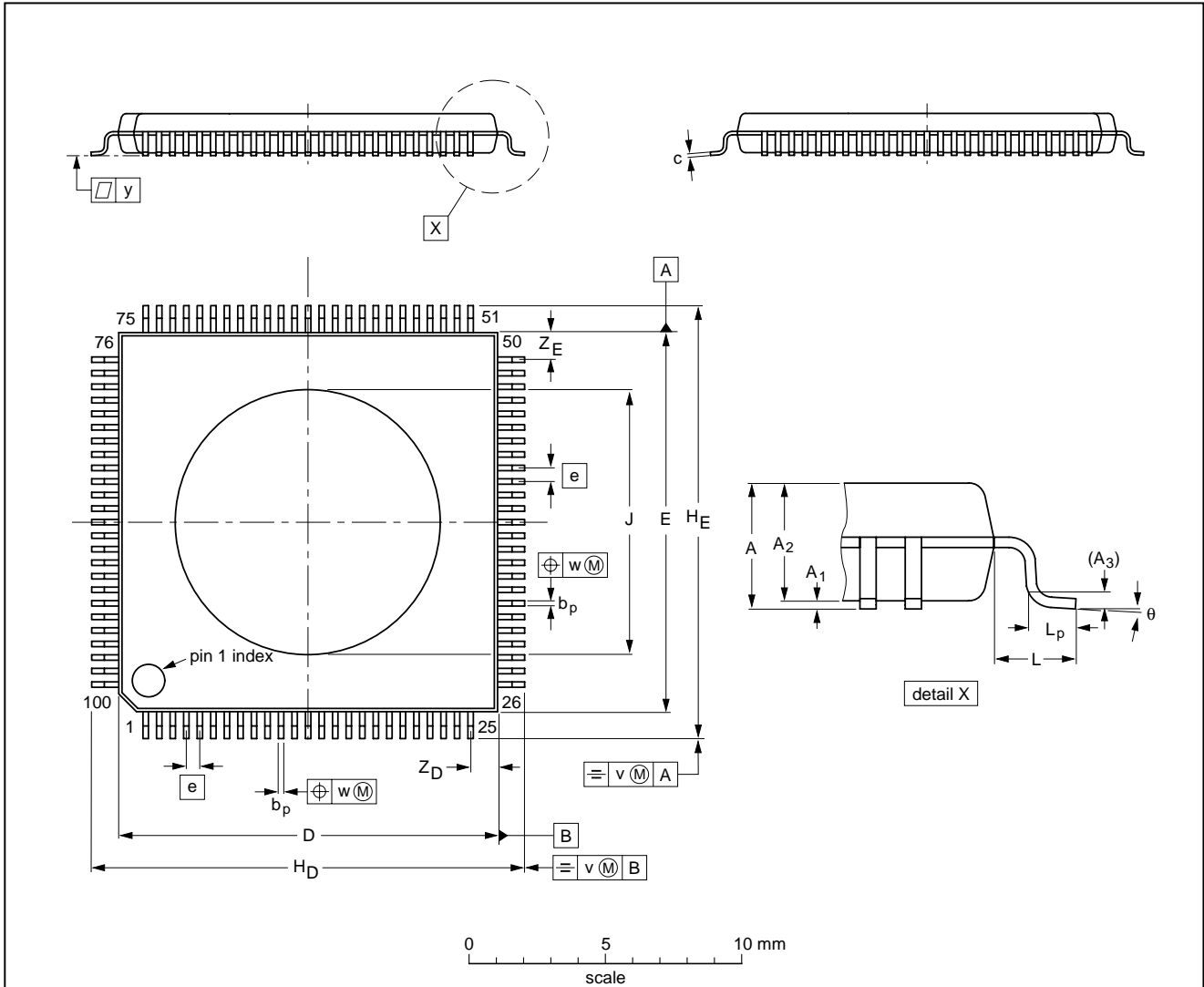
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PACKAGE OUTLINE

HLQFP100: plastic heat-dissipating low profile quad flat package;  
100 leads; body 14 x 14 x 1.4 mm

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DIMENSIONS (mm are the original dimensions)

| UNIT | A max. | A <sub>1</sub> | A <sub>2</sub> | A <sub>3</sub> | b <sub>p</sub> | c            | D <sup>(1)</sup> | E <sup>(1)</sup> | e   | H <sub>D</sub> | H <sub>E</sub> | J <sup>(2)</sup> | L   | L <sub>p</sub> | v   | w    | y   | Z <sub>D</sub> <sup>(1)</sup> | Z <sub>E</sub> <sup>(1)</sup> | θ        |
|------|--------|----------------|----------------|----------------|----------------|--------------|------------------|------------------|-----|----------------|----------------|------------------|-----|----------------|-----|------|-----|-------------------------------|-------------------------------|----------|
| mm   | 1.6    | 0.20<br>0.05   | 1.5<br>1.3     | 0.25           | 0.28<br>0.16   | 0.18<br>0.12 | 14.1<br>13.9     | 14.1<br>13.9     | 0.5 | 16.25<br>15.75 | 16.25<br>15.75 | 10.15<br>9.15    | 1.0 | 0.75<br>0.45   | 0.2 | 0.12 | 0.1 | 1.15<br>0.85                  | 1.15<br>0.85                  | 7°<br>0° |

Notes

1. Plastic or metal protrusions of 0.25 mm maximum per side are not included.
2. Heatsink intrusion 0.0127 maximum.

| OUTLINE VERSION | REFERENCES |       |      |  | EUROPEAN PROJECTION | ISSUE DATE |
|-----------------|------------|-------|------|--|---------------------|------------|
|                 | IEC        | JEDEC | EIAJ |  |                     |            |
| SOT470-1        |            |       |      |  |                     | 97-01-13   |



## SDH/SONET STM16/OC48 multiplexer

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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 is not always suitable for surface mount ICs, or for printed-circuit boards with high population densities. In these situations reflow soldering is often used.

**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, infrared/convection 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 230 °C.

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

Notes

1. 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".
2. These packages are not suitable for wave soldering as a solder joint between the printed-circuit board and heatsink (at bottom version) can not be achieved, and as solder may stick to the heatsink (on top version).
3. 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.
4. Wave soldering is only suitable for LQFP, TQFP and QFP packages with a pitch (e) equal to or larger than 0.8 mm; it is definitely not suitable for packages with a pitch (e) equal to or smaller than 0.65 mm.
5. Wave soldering is only 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.

DEFINITIONS

|                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                                                                       |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------|
| <b>Data sheet status</b>                                                                                                                                                                                                                                                                                                                                                                                                                                  |                                                                                       |
| Objective specification                                                                                                                                                                                                                                                                                                                                                                                                                                   | This data sheet contains target or goal specifications for product development.       |
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| Product specification                                                                                                                                                                                                                                                                                                                                                                                                                                     | This data sheet contains final product specifications.                                |
| <b>Limiting values</b>                                                                                                                                                                                                                                                                                                                                                                                                                                    |                                                                                       |
| Limiting values given are in accordance with the Absolute Maximum Rating System (IEC 134). 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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