

## ICs for Communications

Memory Time Switch Large  
MTSL

PEB 2047  
PEB 2047-16

Version 2.1

Data Sheet 03.95

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|                               |                             |                                                                     |
|-------------------------------|-----------------------------|---------------------------------------------------------------------|
| <b>PEB 2047</b>               |                             |                                                                     |
| <b>PEB 2047-16</b>            |                             |                                                                     |
| <b>Revision History:</b>      |                             | <b>Current Version: 03.95</b>                                       |
| Previous Version:             |                             | Data Book 01.94                                                     |
| Page<br>(in Version<br>01.94) | Page<br>(in new<br>Version) | Subjects (changes since last revision)                              |
| 124                           | 5                           | Version 2.1                                                         |
| 127                           | 8                           | Pin No. 6: INT open drain output                                    |
| 135                           | 16                          | Figure 8: Improved                                                  |
| 142                           | 23                          | STAR: FSAD(2:1) position                                            |
| 143                           | 25                          | MASK: Write address                                                 |
| 148                           | 31                          | Figure 12: $2 \times$ Data Rate, Figure 13: $1 \times$ Data Rate    |
| 153                           | 36                          | Abs. Max. Ratings: $V_S$ definition                                 |
| 154                           | 37                          | $t_{LA}$ min. = 15 ns, $t_{AH}$ min. = 15 ns, $t_{RWD}$ min. = 0 ns |
| 157                           | 40                          | Figure 23: $t_{RWD}$                                                |
| 158                           | 41                          | $t_S$ min. = 15 ns                                                  |
| 159                           | 42                          | Sequence of 1., 2. and 3. bit of frame                              |

## Data Classification

## Maximum Ratings

Maximum ratings are absolute ratings; exceeding only one of these values may cause irreversible damage to the integrated circuit.

## Characteristics

The listed characteristics are ensured over the operating range of the integrated circuit. Typical characteristics specify mean values expected over the production spread. If not otherwise specified, typical characteristics apply at  $T_A = 25^\circ\text{C}$  and the given supply voltage.

## Operating Range

In the operating range the functions given in the circuit description are fulfilled.

For detailed technical information about **"Processing Guidelines"** and **"Quality Assurance"** for ICs, see our **"Product Overview"**.

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## Memory Time Switch Large (MTSL)

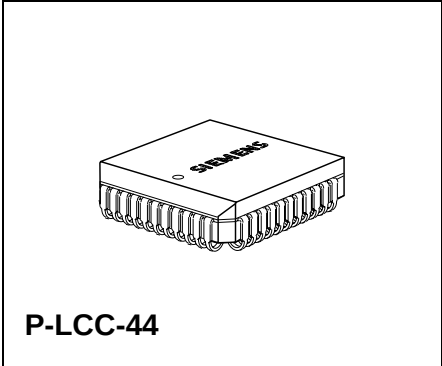
PEB 2047  
PEB 2047-16

### Preliminary Data

CMOS IC

#### 1 Features

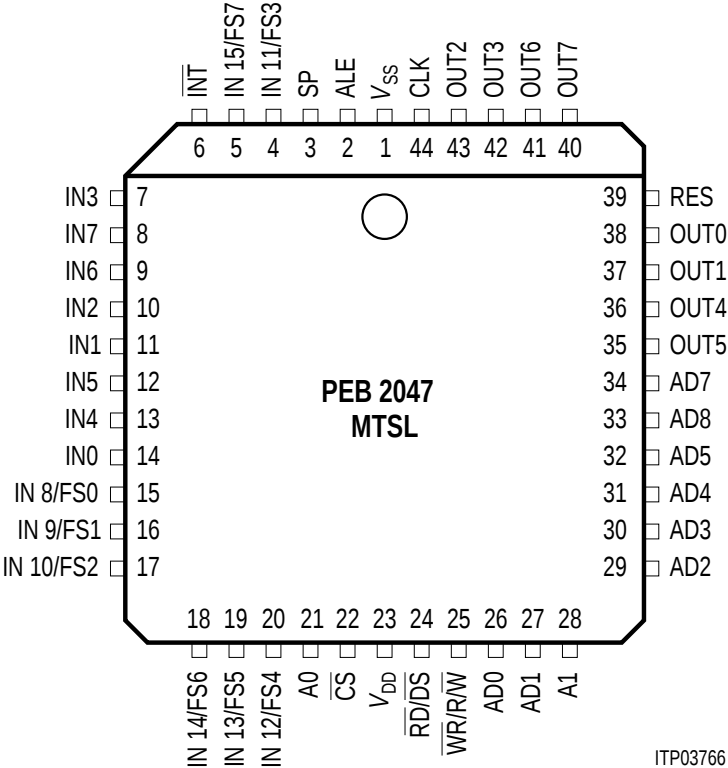
- Non-blocking time/space switch for 2048-, 4096-, 8192- or 16 384-kbit/s PCM systems
- Different modes programmable for input and output separately
- Configurable for a 4096-kHz, 8192-kHz or 16 384-kHz device clock
- Switching of up to 1024 incoming PCM channels to up to 1024 outgoing PCM channels
- 16 input and 8 output PCM lines
- Tristate function for further expansion and tandem operation
- $\mu$ P read-access to PCM data
- Programmable clock shift with half clock step resolution for input and output
- Individual line delay measurement and clock shift mechanism for 8 PCM inputs
- Built-in selftest
- 8-bit Motorola or Intel type  $\mu$ P interface
- Constant or minimal channel-delay programmable on a per time-slot basis
- In-operation adjustment of bit-sampling without bit errors
- Low power consumption
- Single 5 V power supply



**Important Note:** All 16 384-MHz features described in this data sheet are only available with the PEB 2047-16!

| Type               | Ordering Code | Package        |
|--------------------|---------------|----------------|
| PEB 2047-N V2.1    | Q67100-H6238  | P-LCC-44 (SMD) |
| PEF 2047-N-16 V2.1 | Q67100-H6301  | P-LCC-44 (SMD) |

Pin Configuration  
(top view)



ITP03766

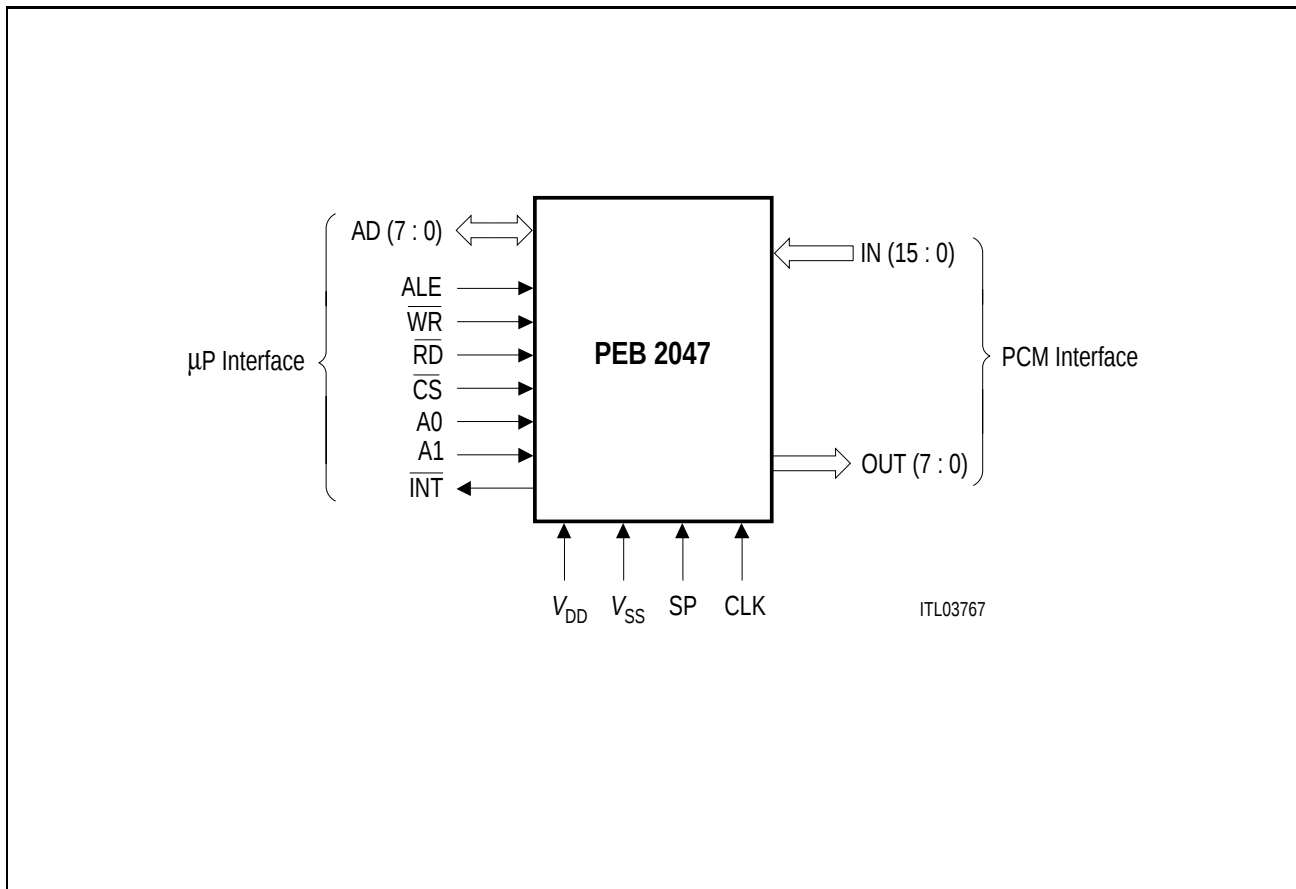
1.1 Pin Definitions and Functions

| Pin No.                                    | Symbol                                                                                     | Input (I)<br>Output (O)              | Function                                                                                                                                                                                                                                                           |
|--------------------------------------------|--------------------------------------------------------------------------------------------|--------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1                                          | V <sub>SS</sub>                                                                            | I                                    | Ground (0 V)                                                                                                                                                                                                                                                       |
| 3                                          | SP                                                                                         | I                                    | <b>Synchronization Pulse:</b> The MTSL is synchronized to the PCM system via this line.                                                                                                                                                                            |
| 14<br>11<br>10<br>7<br>13<br>12<br>9<br>8  | IN0<br>IN1<br>IN2<br>IN3<br>IN4<br>IN5<br>IN6<br>IN7                                       | I<br>I<br>I<br>I<br>I<br>I<br>I<br>I | <b>PCM-Input Ports:</b> Serial data is received at standard TTL levels.                                                                                                                                                                                            |
| 15<br>16<br>17<br>4<br>20<br>19<br>18<br>5 | IN8/FS0<br>IN9/FS1<br>IN10/FS2<br>IN11/FS3<br>IN12/FS4<br>IN13/FS5<br>IN14/FS6<br>IN15/FS7 | I<br>I<br>I<br>I<br>I<br>I<br>I<br>I |                                                                                                                                                                                                                                                                    |
| 21<br>28                                   | A0<br>A1                                                                                   | I<br>I                               |                                                                                                                                                                                                                                                                    |
| 22                                         | $\overline{CS}$                                                                            | I                                    |                                                                                                                                                                                                                                                                    |
| 23                                         | V <sub>DD</sub>                                                                            | I                                    |                                                                                                                                                                                                                                                                    |
| 39                                         | RES                                                                                        | I                                    |                                                                                                                                                                                                                                                                    |
| 25                                         | R/ $\overline{W}$<br><br>$\overline{WR}$                                                   | I<br><br>I                           |                                                                                                                                                                                                                                                                    |
| 24                                         | $\overline{DS}$<br><br>$\overline{RD}$                                                     | I<br><br>I                           |                                                                                                                                                                                                                                                                    |
|                                            |                                                                                            |                                      | <b>Address Bus Bit 0, 1:</b> These inputs interface to the systems address bus to select an internal register for a read or write access. These pins are only active if a demultiplexed $\mu$ P interface mode is selected.                                        |
|                                            |                                                                                            |                                      | <b>Chip Select:</b> A low level selects the MTSL for a register access operation.                                                                                                                                                                                  |
|                                            |                                                                                            |                                      | <b>Supply Voltage:</b> 5 V $\pm$ 5 %.                                                                                                                                                                                                                              |
|                                            |                                                                                            |                                      | <b>Reset:</b> A high signal on this input forces the MTSL into reset state.                                                                                                                                                                                        |
|                                            |                                                                                            |                                      | <b>Read/Write:</b> When “high”, identifies a valid $\mu$ P access as a read operation. When “low”, identifies a valid $\mu$ P access as a write operation (Motorola bus mode).<br><b>Write:</b> This signal indicates a write operation (Siemens/ Intel bus mode). |
|                                            |                                                                                            |                                      | <b>Data Strobe:</b> The rising edge marks the end of a valid read or write operation (Motorola bus mode).<br><b>Read:</b> This signal indicates a read operation (Siemens/ Intel bus mode).                                                                        |

## Pin Definitions and Functions (cont'd)

| Pin No. | Symbol                  | Input (I)<br>Output (O) | Function                                                                                                                                                                                                                                                                                                                                                                                     |
|---------|-------------------------|-------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 26      | AD0                     | I/O                     | <b>Address Data Bus:</b> If the multiplexed address/data $\mu$ P-interface bus mode is selected these pins transfer data and addresses between the $\mu$ P and the MTSL.<br><br>If a demultiplexed mode is used, these bits interface with the system data bus.                                                                                                                              |
| 27      | AD1                     | I/O                     |                                                                                                                                                                                                                                                                                                                                                                                              |
| 29      | AD2                     | I/O                     |                                                                                                                                                                                                                                                                                                                                                                                              |
| 30      | AD3                     | I/O                     |                                                                                                                                                                                                                                                                                                                                                                                              |
| 31      | AD4                     | I/O                     |                                                                                                                                                                                                                                                                                                                                                                                              |
| 32      | AD5                     | I/O                     |                                                                                                                                                                                                                                                                                                                                                                                              |
| 33      | AD6                     | I/O                     |                                                                                                                                                                                                                                                                                                                                                                                              |
| 34      | AD7                     | I/O                     |                                                                                                                                                                                                                                                                                                                                                                                              |
| 38      | OUT0                    | O                       | <b>PCM-Output Port:</b> Serial data is sent by these lines at standard CMOS- or TTL levels. These pins can be tristated.                                                                                                                                                                                                                                                                     |
| 37      | OUT1                    | O                       |                                                                                                                                                                                                                                                                                                                                                                                              |
| 43      | OUT2                    | O                       |                                                                                                                                                                                                                                                                                                                                                                                              |
| 42      | OUT3                    | O                       |                                                                                                                                                                                                                                                                                                                                                                                              |
| 36      | OUT4                    | O                       |                                                                                                                                                                                                                                                                                                                                                                                              |
| 35      | OUT5                    | O                       |                                                                                                                                                                                                                                                                                                                                                                                              |
| 41      | OUT6                    | O                       |                                                                                                                                                                                                                                                                                                                                                                                              |
| 40      | OUT7                    | O                       |                                                                                                                                                                                                                                                                                                                                                                                              |
| 44      | CLK                     | I                       | <b>Clock:</b> 4096-kHz, 8192-kHz or 16 384-kHz device clock.                                                                                                                                                                                                                                                                                                                                 |
| 2       | ALE                     | I                       | <b>Address Latch Enable:</b> In the Intel type multiplexed $\mu$ P-interface mode a logical high on this line indicates an address of an MTSL internal register on the external address/data bus. In the Intel type demultiplexed $\mu$ P-interface mode this line is hardwired to $V_{SS}$ , in the demultiplexed Motorola type $\mu$ P-interface mode it should be connected to $V_{DD}$ . |
| 6       | $\overline{\text{INT}}$ | (OD)                    | <b>Interrupt Line:</b> Active low open drain output.                                                                                                                                                                                                                                                                                                                                         |

## 1.2 Logic Symbol



**Figure 1**  
**Functional Symbol**

## 1.3 General Device Overview

The Siemens Memory Time Switch Large MTSL (PEB 2047) is an expansion of the MTSC (PEB 2045) regarding capacity and/or functionality. It is a monolithic CMOS switching device capable of connecting maximally 1024 PCM-input time-slots to 1024 output time-slots. A constant frame delay of one frame can be selected for wideband applications (e.g. ISDN H-Channels), whereas for example for voice channels a minimal frame delay is programmable. In order to manage the problem of different line delays, eight of the PCM inputs can be used as frame measurement inputs and eight different input offsets are allowed. Thus a frame wander can be compensated by adjusting the input offset during operation. A special circuitry guarantees that no bit error will occur, when reprogramming the input offsets.

The MTSL on-chip connection memory and data-memory are accessed via the 8-bit standard  $\mu$ P-interface (Motorola or Intel type).

A built-in selftest mechanism – also activated by the  $\mu$ P – ensures proper device operation in the system.

The PEB 2047 is fabricated using the advanced CMOS technology from Siemens and is mounted in a P-LCC-44 package. Inputs and outputs are TTL-compatible.

1.4 System Integration

The main application field for the MTSL (PEB 2047) are central switches with high switching capacity. Two possibilities exist to implement a non-blocking switch for 1024 input and 1024 output channels.

With a 16 384-kHz device clock only one MTSL is needed (figure 2), with a 8192-kHz device clock two chips in parallel realize the same functionality (figure 3).

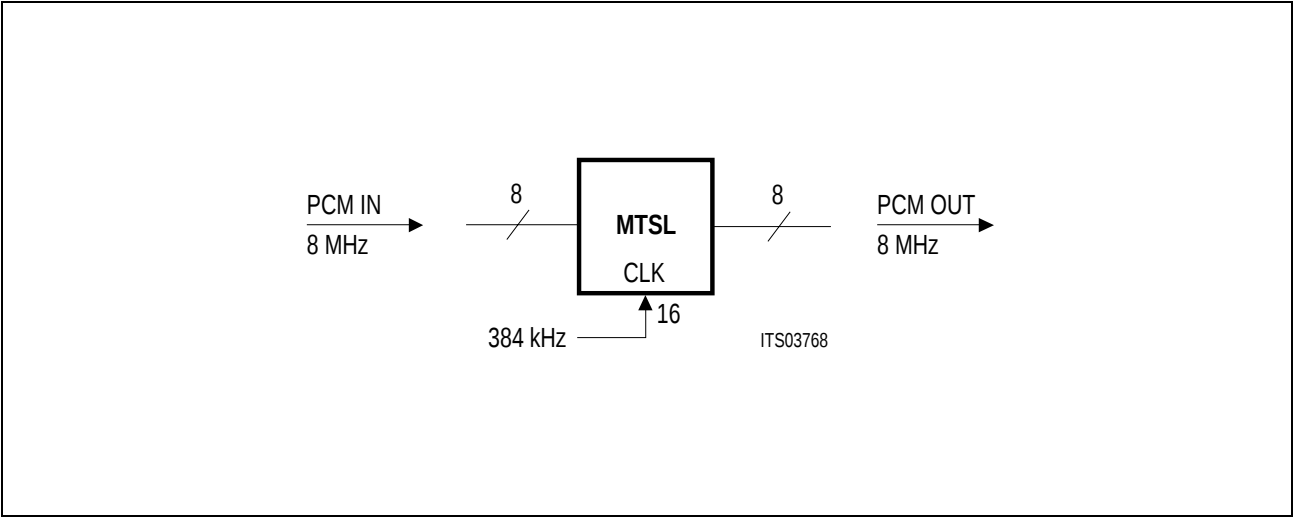


Figure 2  
Memory Time Switch for a Non-Blocking 1024-Channel Switch (16 MHz)

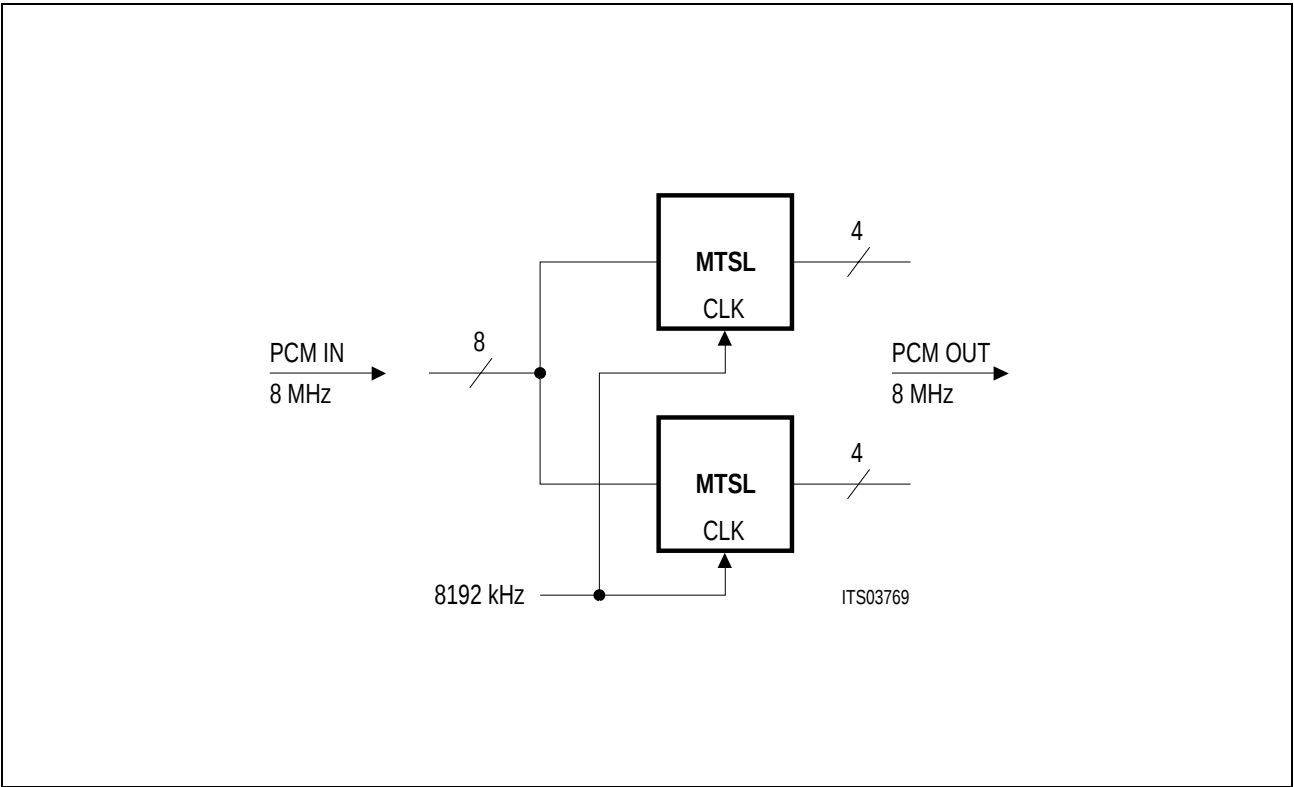
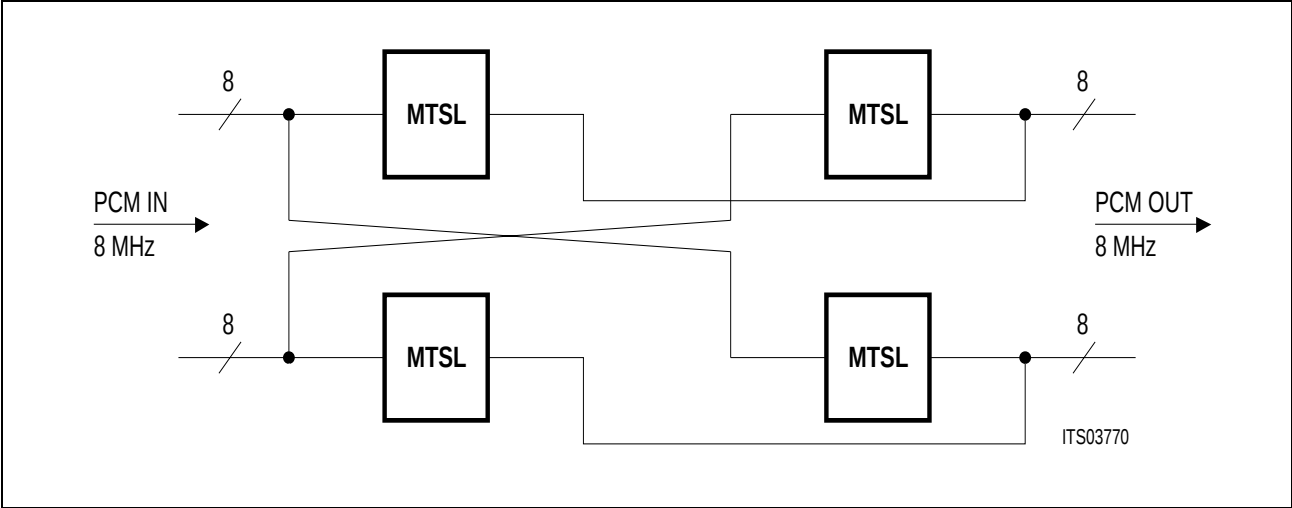


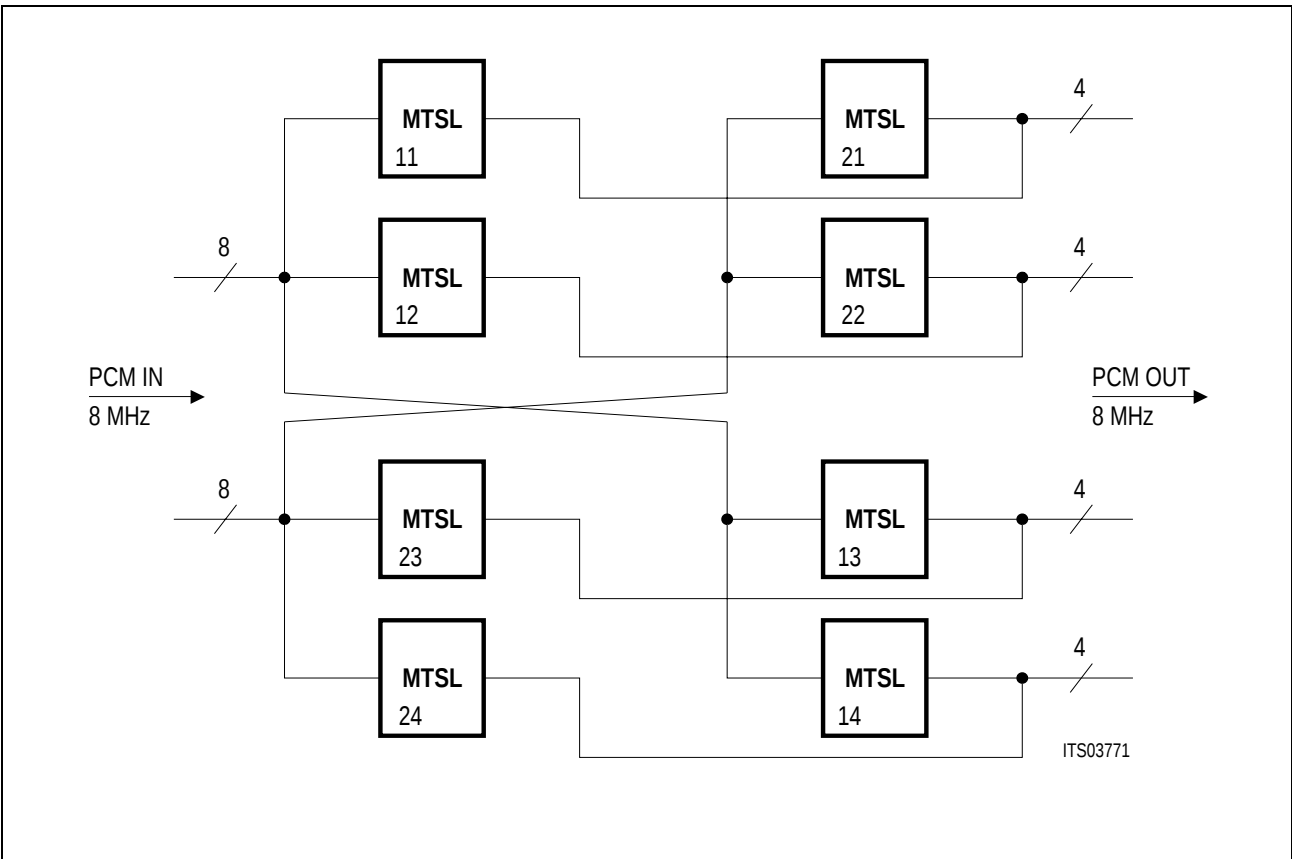
Figure 3  
Memory Time Switch for a Non-Blocking 1024-Channel Switch (8 MHz)

Due to the tristate capability of the MTSL larger switches can be easily formed.

**Figure 4** and **5** show how 4 devices operating with a 16 384-kHz clock or 8 devices operating with a 8192-kHz clock can be arranged to form non-blocking 2048-channel switches.



**Figure 4**  
**Memory Time Switch for a Non-Blocking 2048-Channel Switch with Four Devices (16-MHz device clock)**



**Figure 5**  
**Memory Time Switch for a Non-Blocking 2048-Channel Switch with Eight Devices (8-MHz device clock)**

2      Functional Description

The MTSL is a memory time switch device. Operating with a device clock of 8192 kHz it can connect any of 1024 PCM-input channels to any of 512 output channels. With a device clock of 16 384 kHz all 1024 PCM channels can be switched to the output. Additionally a 2048-kbit/s mode with a capacity of 512 × 256 time-slots and a clock frequency of 4096 kHz is possible for systems, which need the frame integrity feature.

A general block-diagram of the MTSL is shown in **figure 7**.

The input information of a complete frame is stored in one of the two on-chip 8-Kbit data memories DM0 and DM1. The incoming 1024 channels of 8 bits each are written in sequence into fixed positions of DM0 or DM1. This is controlled by the input counter in the timing control block with a 8-kHz repetition rate. If MTSL-A1 compatible operation (i.e. no frame integrity guaranteed) is wished, only one of the two data memories is used. Otherwise DM0 and DM1 are filled alternating with input frames.

For outputting, the connection memory (CM) is read in sequence. Each location in the CM points to a location in the data memory. The byte in this data memory location is transferred into the current output time-slot. The read access to the CM is controlled by an output counter. An additional bit (D12) in each location of the CM controls the access to the data memories DM0 and DM1. Three address pointers – two switching aligned to the input frame (DMI, IADP), one switching aligned to the output frame (DMO) – are working in conjunction with D12 implementing the constant/minimal delay function (**see figure 6**).

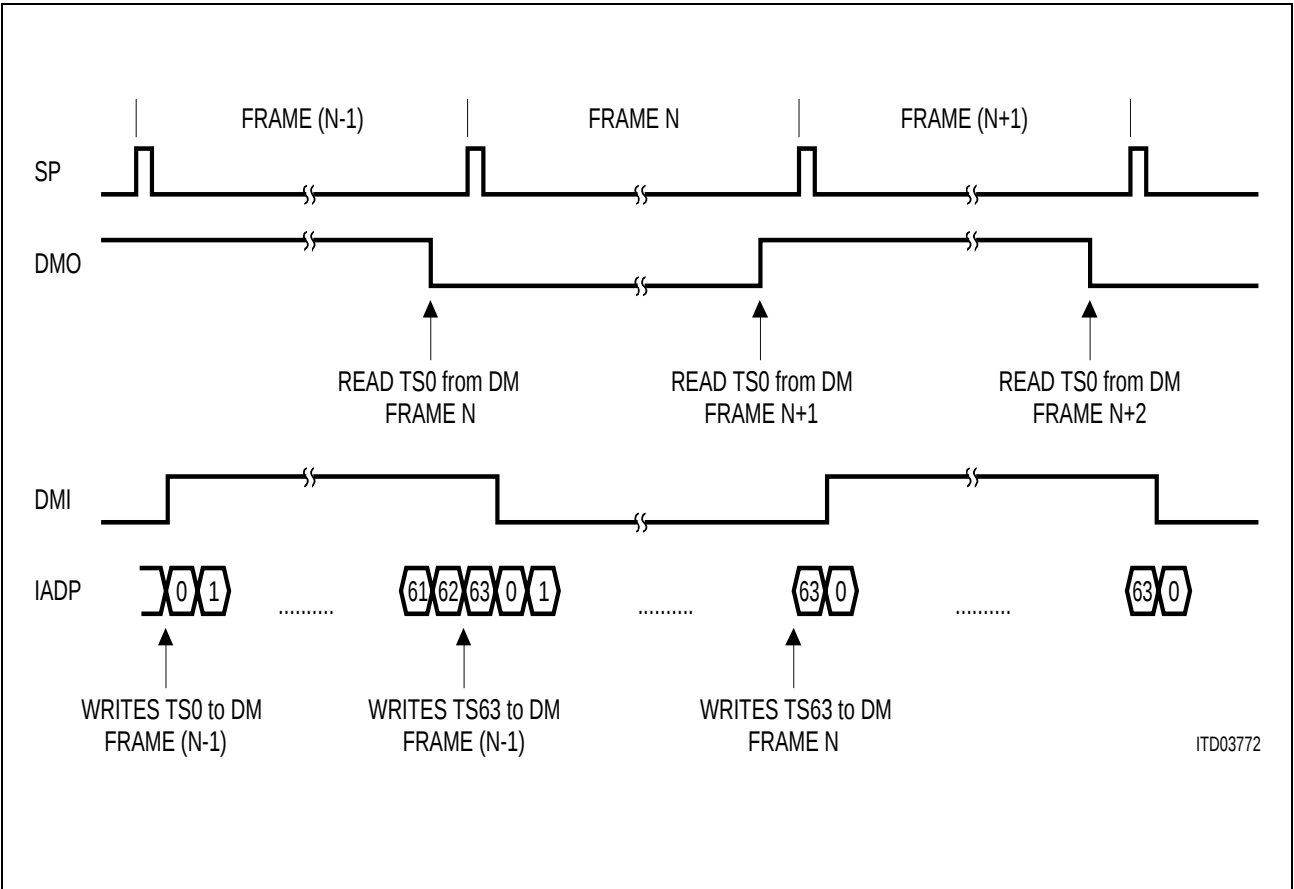


Figure 6

Constant delay (D12 = 0):      read output time-slot from data memory (not DMO)

Minimal delay (D12 = 1):      if number of input time-slot to be switched to current output  $\leq$  IADP  
                                          then  
                                          read output time-slot from data memory DMI  
                                          else  
                                          read output time-slot from data memory (not DMI)

The synchronization of this procedure will be achieved by a rising edge of the synchron pulse SP, which is always sampled with the falling edge of the device clock.

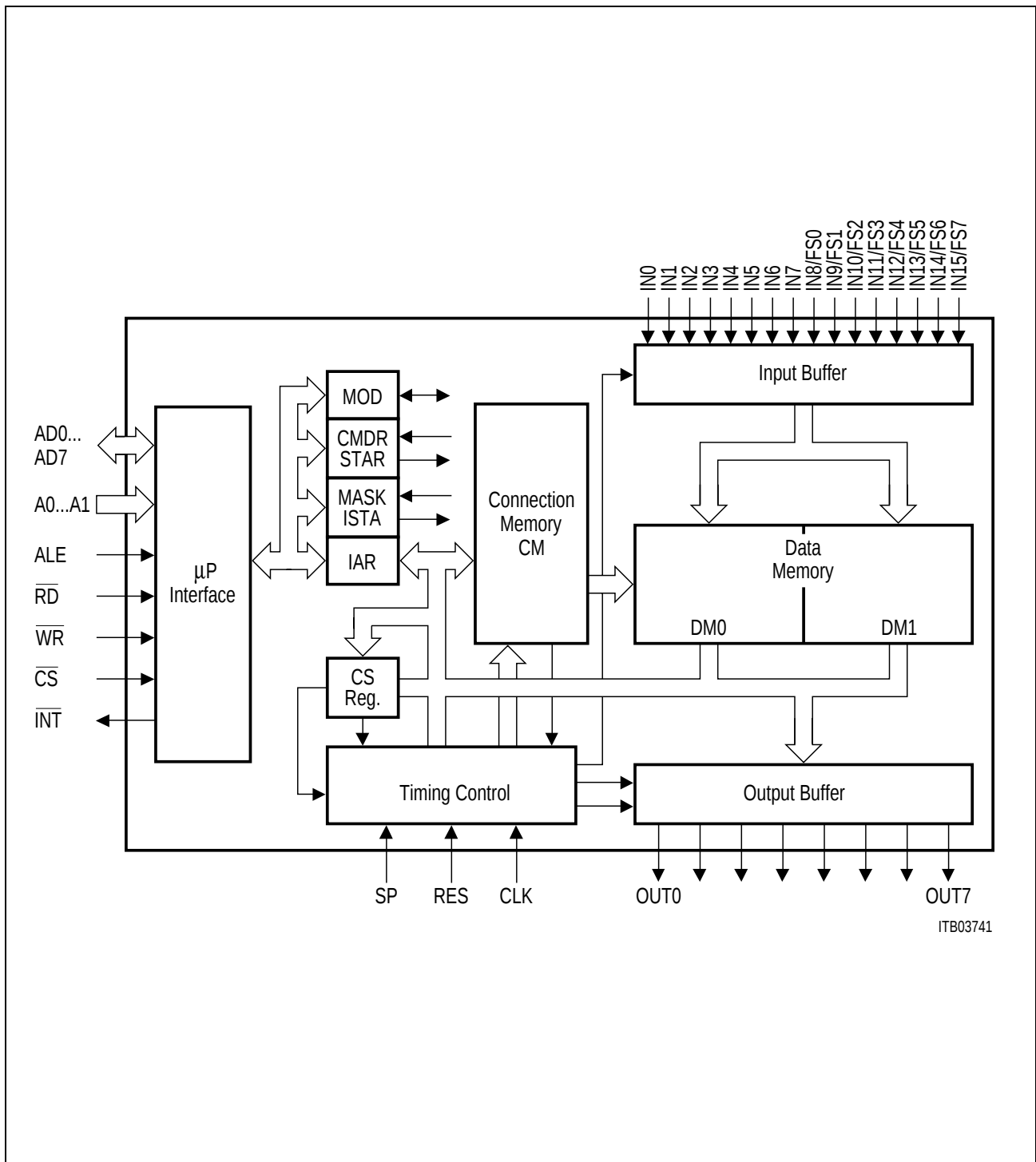
Different modes of operation are configurable at the PCM-input interface (**see table 3**). Furthermore, 8 PCM-input lines can be aligned with individual clock shift values to compensate different line delays. If more than 8 inputs are used one clock shift value controls up to two ports at the same time.

The input lines IN8 to IN15 can be used as additional frame-measurement inputs (FS(0:7)). After synchronizing the device by the SP pulse the FS inputs can be evaluated on a per port basis. This evaluation procedure is started by a microprocessor command. As a result the input counter value on the rising edge of the FS signal can be read from an internal register. Thus delay compensation is easily managed by programming appropriate clock shift values and/or a possible software offset.

During operation of the chip a frame length check is also supplied, which controls correct synchronization by the SP pulse and generates an interrupt in case of lost or achieved synchronization.

The output buffer operation is controlled by mode selection and the chosen clock-rate (4096 kHz, 8192 kHz or 16 384 kHz) (**see table 2**). Shifting of the output frame is also possible, but all output-lines are affected the same way.

The unused output ports are tristated by mode selection, whereas unused time-slots are tristated by an additional bit in the control memory. By using this tristate capability the MTSL can be easily expanded to a time switch of any size (**see figure 2 to 5**).



**Figure 7**  
**Block Diagram MTSL**

The standard 8-bit  $\mu$ P interface can communicate with Intel multiplexed/demultiplexed microprocessors as well as with Motorola demultiplexed processors. It gives access to the internal registers and to the control- and data memory. Five directly addressable registers are provided. All other registers and the memories are accessed by a simple three byte indirect access method (similar to the MTSC PEB 2045).

## 2.1 MTSL Internal Timing and Channel Delay

**Figure 7** shows the chip internal timing of writing and reading the data memory for all possible operation modes.

### Control Memory Reset

Initialization of the device after a hardware reset (RES) is easily done with a  $\mu$ P-command “control memory reset”. After finishing this procedure all control memory channels contain the information “tristated”.

### Evaluate Frame Measurement Signal

A command and an address (0 ... 7) will be given by the  $\mu$ P. The rising edge of the corresponding frame measurement signal (FS0 ... FS7) will be evaluated. The exact timing of the FS edge can then be read from an internal 12-bit register (resolution of a complete 8-kHz frame in half 16-MHz clock periods).

### MTSL-Selftest

The switching path of the MTSL including input buffer, data memory, control memory, output buffer and timing control can be tested in the system by a built-in selftest. The two data memories DM0 and DM1 require two test procedures. Activating this mechanism takes  $(2 \times 2.5)$  ms (4096 kHz),  $(2 \times 1.25)$  ms (8192 kHz) or  $(2 \times 0.625)$  ms (16 384 kHz). Finally the result “selftest ok/selftest not ok” can be read from the internal status register.

After test completion the control-memory is also reset.

## 2.2 Special Functions

The activity of all special functions can be read in the status register. Completion of these functions is indicated by interrupts.

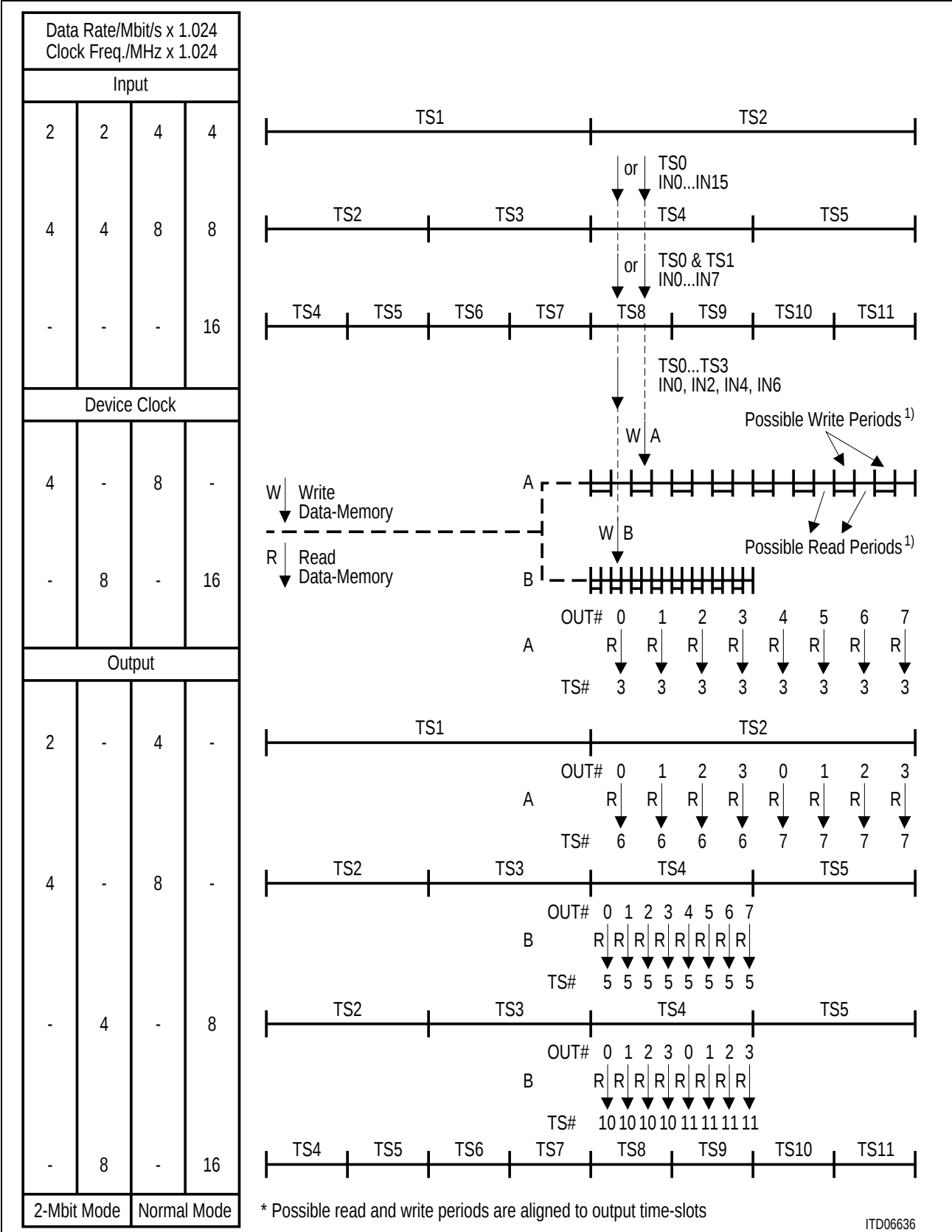


Figure 8  
Data Memory Timing

For a system operating with 8192-kHz device clock and 8192-Mbit/s/8192 Mbit/s input/output data rate the following frame delay table can be deduced from the timing diagram:

**Table 1**

| Input Time-Slot              |                | Switched to Output Time-Slot |         |       |
|------------------------------|----------------|------------------------------|---------|-------|
| Switched<br>to<br>OUT1, 2, 3 | 0 – 1          | 6 – 127                      | 0 – 5   | –     |
|                              | 2 – 3          | 8 – 127                      | 0 – 7   | –     |
|                              | 4 – 5          | 10 – 127                     | 0 – 9   | –     |
|                              | .              | .                            | .       | .     |
|                              | .              | .                            | .       | .     |
|                              | .              | .                            | .       | .     |
|                              | 118 – 119      | 124 – 127                    | 0 – 123 | –     |
|                              | 120 – 121      | 126 – 127                    | 0 – 125 | –     |
|                              | 122 – 123      | –                            | 0 – 127 | –     |
|                              | 124 – 125      | –                            | 2 – 127 | 0 – 1 |
|                              | 126 – 127      | –                            | 4 – 127 | 0 – 3 |
| Switched<br>to<br>OUT0       | 0 – 1          | 7 – 127                      | 0 – 6   | –     |
|                              | 2 – 3          | 9 – 127                      | 0 – 8   | –     |
|                              | 4 – 5          | 11 – 127                     | 0 – 10  | –     |
|                              | .              | .                            | .       | .     |
|                              | .              | .                            | .       | .     |
|                              | .              | .                            | .       | .     |
|                              | 118 – 119      | 125 – 127                    | 0 – 124 | –     |
|                              | 120 – 121      | 127                          | 0 – 126 | –     |
|                              | 122 – 123      | –                            | 1 – 127 | 0     |
|                              | 124 – 125      | –                            | 3 – 127 | 0 – 2 |
|                              | 126 – 127      | –                            | 5 – 127 | 0 – 4 |
| Delay/number of<br>frames    | minimal delay  | 0                            | 1       | 2     |
|                              | constant delay | 1                            | 1       | 3     |

From this table it can be seen, that it is not possible to achieve the constant delay of one frame for all switching paths. Those input time-slots, which are written to the data memory later than they should have been read (for example in the above configuration TS124 – TS127 switched to TS0 or TS1, OUT1, 2, 3), will be delayed by three frames!

## 3 Operational Description

### 3.1 Initialization Procedure

For a proper initialization of the MTSL the following procedure is recommended:

First a reset pulse (RES) of at least two CLK clock-periods has to be applied. All registers contain now their reset values. In the next step the connection-memory CM is initialized by the commands CMDR:STP (1:0) = 01 (CM reset) or CMDR:STP (1:0) = 11 (MTSL selftest).

After having programmed a CM-reset command, it takes 4096-clock periods until all tristate-control entries in the CM contain the value "1" (tristated).

If a selftest-command was given, it takes 10 240-clock periods to achieve the same effect. Furthermore the register bit STAR:STOK (selftest o.k.) should still be set to "1" in this case, in order to prove that there is no fault on the chip. From version V2.1 up, the selftest command must be given for each data memory (DM0, DM1) separately. DM1 is tested, when register OPCR contains the reset value FF<sub>H</sub>, DM0 is tested by programming OPCR to FB<sub>H</sub>.

The activity of the procedures can be monitored in STAR:PACT and an interrupt will indicate their completion.

In all cases it is important, that the outputs are tristated by MOD:PSB = 0.

### 3.2 Operation Mode

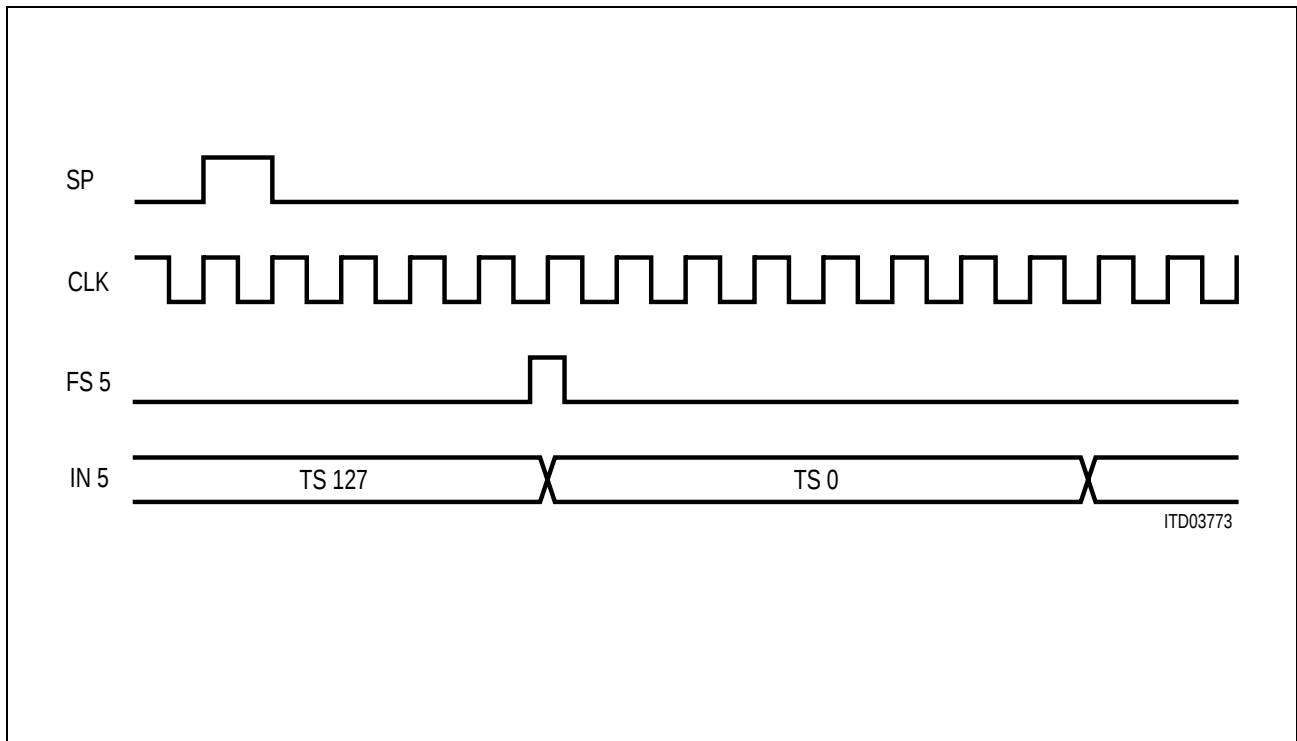
The operation mode of the device is fixed by programming MOD:OMD (1:0) and MOD:IMD (2:0) and by the device clock used at pin CLK (see table 2 and 3).

### 3.3 Indirect Access Register

The connection-memory, data-memory and indirect registers are accessible through the indirect access register (IAR). An indirect access is performed by reading and/or writing three consecutive bytes to/from IAR. An incomplete three-byte access is indicated by STAR:Z = 1. After having read and/or written the third byte the operation selected by IAR:C (1:0), WR/RDQ is started and the bit STAR:B is set to 1. It takes at most 4.5 clock periods (8.5 clock periods for a "read data memory") until the operation is performed and STAR:B is reset.

## 3.4 Frame Evaluation

Suppose the following timing at PCM input IN5 (mode 2):



**Figure 9**

If the device is in synchronized state (STAR:PSS = 1) and the command “frame evaluation at FS5” (CMDR = 58<sub>H</sub>) is programmed, the second following rising edge of FS5 is evaluated and creates the following result in register FER:

D (11) = 0  
D (10:1) = 3E7<sub>H</sub>  
D (0) = 0

D0 is fixed to 0 and doesn't have a meaning in 8-MHz clock operation modes.

The actual offset of the incoming frame can now be calculated according to the formulas given in **table 9**.

3.5 Input Offset and Output Offset

Based on the results of the frame evaluation procedures the input offsets can be adjusted by programming ICSR (7:0) corresponding to inputs IN (7:0). If data oversampling is used, the values of ICSR (7:0) can be adjusted within some limits during operation without producing bit errors:

- a) clockrate = 2 × datarate  
possible adjustment is one half clockperiod forward or backward.

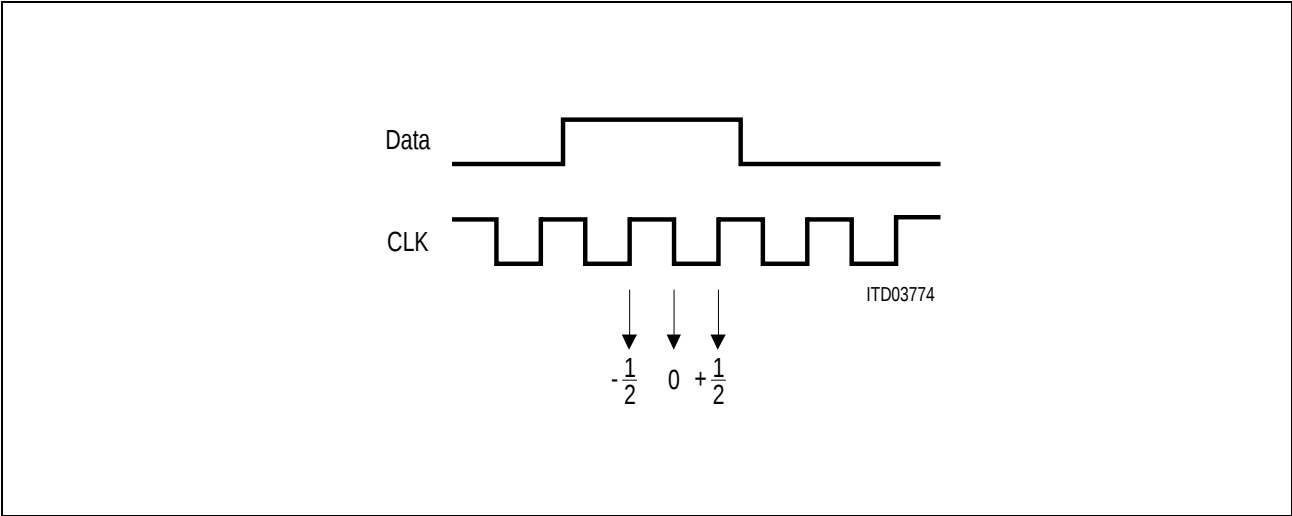


Figure 10

- b) clockrate = 4 × datarate  
possible adjustment is one clockperiod backward or two clockperiods forward.

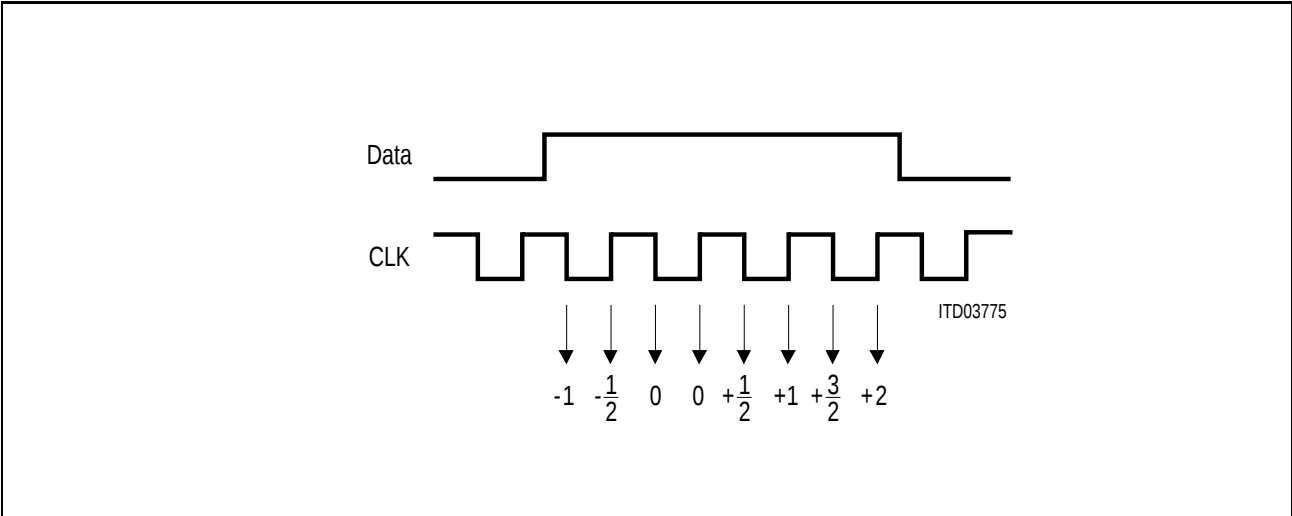


Figure 11

The output offset is the same for all output lines and is fixed in register OCSR.

4 Detailed Register Description

4.1 Mode Register (MOD)

Access in the multiplexed  $\mu$ P-interface mode: Read/write, address: 0<sub>H</sub>  
Access in a demultiplexed  $\mu$ P-interface mode: Read/write, address: 0<sub>H</sub>  
Reset value: 00<sub>H</sub>

|       |     |   |      |       |      |      |      |
|-------|-----|---|------|-------|------|------|------|
| Bit 7 |     |   |      | Bit 0 |      |      |      |
| PSB   | MD2 | 0 | OMD1 | OMD0  | IMD2 | IMD1 | IMD0 |

- PSB** **PCM Stand By**; a logical 0 switches the PCM-interface outputs to high impedance.
- MD2** If set to “1”, the PEB 2047 is able to switch channels with 2048-kHz data rate, when operating with 8.192 MHz (switching capacity 512 × 512 time-slots) or 4.096 MHz (switching capacity 512 × 256 time-slots).
- OMD1 ... OMD0** **Output Mode 1 and 0**; these bits define the PCM-output mode according to the following table.

Table 2  
Output Modes

| Device Clock [kHz] | Output Mode OMD (1:0) <sup>1)</sup> | Port Numbers                       | Number of Ports × Data Rate/kbit/s |
|--------------------|-------------------------------------|------------------------------------|------------------------------------|
| 4.096              | 0                                   | OUT (7:0)                          | 8 × 2048                           |
|                    | 1                                   | OUT7, OUT5, OUT3, OUT1, OUT2, OUT0 | 4 × 2048 / 2 × 4096                |
|                    | 3                                   | OUT (3:0)                          | 4 × 4096                           |
| 8.192              | 0                                   | OUT (7:0)                          | 8 × 4096                           |
|                    | 1                                   | OUT7, OUT5, OUT3, OUT1, OUT2, OUT0 | 4 × 4096 / 2 × 8192                |
|                    | 3                                   | OUT (3:0)                          | 4 × 8192                           |
| 16.384             | 0                                   | OUT (7:0)                          | 8 × 8192                           |
|                    | 1                                   | OUT7, OUT5, OUT3, OUT1, OUT2, OUT0 | 4 × 8192 / 2 × 16384               |
|                    | 3                                   | OUT (3:0)                          | 4 × 16384                          |

<sup>1)</sup> Input and output mode combinations which use the same device clock frequency have to be selected.

**IMD2 ... IMD0:** **Input Mode 2, 1 and 0;** these bits define the PCM-input mode according to the following table.

**Table 3**  
**Input Modes**

| Device Clock [kHz] | MD2 | Input Mode IMD (2:0) <sup>1)</sup> | Port Numbers                    | Number of Ports × Data Rate/kbit/s |
|--------------------|-----|------------------------------------|---------------------------------|------------------------------------|
| 4.096              | 1   | 0                                  | IN (15:0)                       | 16 × 2048                          |
|                    | 1   | 1                                  | IN (15:12), IN (7:4) / IN (3:0) | 8 × 2048 / 4 × 4096                |
|                    | 1   | 2                                  | IN (7:0)                        | 8 × 4096                           |
| 8.192              | 0   | 0                                  | IN (15:0)                       | 16 × 4096                          |
|                    | 0   | 1                                  | IN (15:12), IN (7:4) / IN (3:0) | 8 × 4096 / 4 × 8192                |
|                    | 0   | 2                                  | IN (7:0)                        | 8 × 8192                           |
|                    | 1   | 4                                  | IN (15:0)                       | 16 × 2048                          |
|                    | 1   | 5                                  | IN (15:12), IN (7:4) / IN (3:0) | 8 × 2048 / 4 × 4096                |
|                    | 1   | 6                                  | IN (7:0)                        | 8 × 4096                           |
| 16.384             | 0   | 4                                  | IN (15:0)                       | 16 × 4096                          |
|                    | 0   | 5                                  | IN (15:12), IN (7:4) / IN (3:0) | 8 × 4096 / 4 × 8192                |
|                    | 0   | 6                                  | IN (7:0)                        | 8 × 8192                           |
|                    | 0   | 3                                  | IN6, IN4 / IN (3:0)             | 2 × 16384 / 4 × 8192               |
|                    | 0   | 7                                  | IN6, IN4, IN2, IN0              | 4 × 16984                          |

<sup>1)</sup> Input and output mode combinations which use the same device clock frequency have to be selected.

4.2 Command Register (CMDR)

Access in the multiplexed  $\mu$ P-interface mode:

Access in a demultiplexed  $\mu$ P-interface mode:

Address:01<sub>H</sub>

Write, address 2<sub>H</sub>

Write, address 1<sub>H</sub>

|       |       |       |       |       |    |      |      |
|-------|-------|-------|-------|-------|----|------|------|
| Bit 7 |       |       |       | Bit 0 |    |      |      |
| 0     | FSAD2 | FSAD1 | FSAD0 | SFE   | RI | STP1 | STP0 |

- FSAD (2:0)

Frame Synchronization signal Address 2 to 0; Address of the chosen FS signal 0 to 7 to be evaluated by the procedure started by SFE.
- SFE

Start Frame Evaluation; a one in this bit position starts the frame evaluation procedure. A read operation on register FER will stop an unfinished frame evaluation procedure.
- RI

Reset Incomplete instruction; if a three byte indirect register access is not completed the internal logic must be initialized again before a new three byte access is possible.
- STP0 ... STP1

Start Procedure 1 and 0.  
The following procedures can be activated by these bits:

Table 4  
STP Commands

| STP1 | STP0 | Function                             |
|------|------|--------------------------------------|
| X    | 0    | No operation                         |
| 0    | 1    | Start control memory reset procedure |
| 1    | 1    | Start selftest procedure             |

**Note:** Before activating one of these procedures MOD:PSB has to be set to 0. During selftest or CM reset the device will ignore the external synchronization pulse and the user has no access to the internal data memory.

4.3 Status Register (STAR)

Access in the multiplexed  $\mu$ P-interface mode:

Access in a demultiplexed  $\mu$ P-interface mode:

Reset value:

01<sub>H</sub>

Read, address: 2<sub>H</sub>

Read, address: 1<sub>H</sub>

|       |       |       |       |       |      |     |      |
|-------|-------|-------|-------|-------|------|-----|------|
| Bit 7 |       |       |       | Bit 0 |      |     |      |
| Z     | FSAD2 | FSAD1 | FSAD0 | B     | PACT | PSS | STOK |

- Z

Incomplete instruction; a three byte indirect instruction is not completed (Z = 1).
- FSAD (2:0)

Frame Synchronization signal Address 2 to 0: see CMDR.
- B

Busy; an indirect access is active (memories or indirect registers); the three byte indirect access register is not accessible.
- PACT

Procedure Active; one of the procedures started by the  $\mu$ P (selftest, CM reset or frame evaluation) is active.
- PSS

PCM Synchronization Status; the PCM interface is synchronized (logical 1) or not synchronized (logical 0).
- STOK

Selftest O.K.; after a selftest procedure this bit is set to 1, if no faults are detected.
- Note:

This bit is only valid, if no power failure or inappropriate clocking occurred during the test (see ISTA:IR); this bit is set to 1 by a start selftest command or by hardware reset.

4.4 Interrupt Status Register (ISTA)

Access in the multiplexed  $\mu$ P-interface mode:

Access in a demultiplexed  $\mu$ P-interface mode:

Reset value:

00<sub>H</sub>

Read, address: 4<sub>H</sub>

Read, address: 2<sub>H</sub>

|       |   |   |   |     |    |    |       |
|-------|---|---|---|-----|----|----|-------|
| Bit 7 |   |   |   |     |    |    | Bit 0 |
| 0     | 0 | 0 | 0 | FEC | PC | IR | PFI   |

- FEC

**Frame Evaluation Completed**; the indirect register FER contains a valid offset and can be read; this bit is reset by reading ISTA.
- PC

**Procedure Completed**; the procedure started from the command register (CM reset or MTSL selftest) is finished; this bit is reset by reading ISTA.
- IR

**Initialization Request**. The connection memory has to be programmed due to a loss of data (IR = 1). The IR bit is set after power failure or inappropriate clocking. This bit is reset by reading ISTA. It can only be retriggered again after a selftest or CM-reset procedure.
- PFI

**PCM-Framing Interrupt**; this bit being logical 1 indicates the loss or gain of synchronization. Synchronization is considered lost by the MTSL if the SP signal is not repeated within the correct period. Synchronization is considered achieved, if two consecutive SP pulses with the correct period have been received. PFI is reset by reading ISTA.

4.5 Mask Register (MASK)

Access in the multiplexed  $\mu$ P-interface mode:

Access in a demultiplexed  $\mu$ P-interface mode:

Reset value:

00<sub>H</sub>

Write, address: 4<sub>H</sub>

Write, address: 2<sub>H</sub>

|       |   |   |   |     |    |    |       |
|-------|---|---|---|-----|----|----|-------|
| Bit 7 |   |   |   |     |    |    | Bit 0 |
| 0     | 0 | 0 | 0 | FEC | PC | IR | PFI   |

A logical 1 disables the corresponding interrupt as described in ISTA. A masked interrupt is stored internally and reported in ISTA immediately, if the mask is released.

4.6 Indirect Access Register (IAR)

Access in the multiplexed  $\mu$ P-interface mode: Read/write, address: 6<sub>H</sub>  
Access in a demultiplexed  $\mu$ P-interface mode: Read/write, address: 3<sub>H</sub>  
Reset value: Only the control bits C (1:0) and WR/RDQ are initialized to 0.

An indirect access is performed by reading/writing three consecutive bytes (first byte = extended control byte, second byte = data byte, third byte = address byte) to/from IAR.

|       |             |            |     |              |     |    |    |
|-------|-------------|------------|-----|--------------|-----|----|----|
| Bit 7 |             |            |     | Bit 0        |     |    |    |
| C1    | C0 /<br>D12 | WR/<br>RDQ | IA9 | IA8 /<br>D11 | D10 | D9 | D8 |

|              |    |    |    |    |    |    |    |
|--------------|----|----|----|----|----|----|----|
| control byte |    |    |    |    |    |    |    |
| D7           | D6 | D5 | D4 | D3 | D2 | D1 | D0 |

|           |     |     |     |     |     |     |     |
|-----------|-----|-----|-----|-----|-----|-----|-----|
| data byte |     |     |     |     |     |     |     |
| IA7       | IA6 | IA5 | IA4 | IA3 | IA2 | IA1 | IA0 |

address byte

**C (1:0)**            **Code** values to determine the type of access.  
**WR/RDQ**            If set to 1 a write access is performed; otherwise a read access is activated.

Table 5  
Indirect Access Codes

| C1 | C0 | WR/RDQ | Function                     | Max. Access Time<br>Clock Periods |
|----|----|--------|------------------------------|-----------------------------------|
| 0  | 0  | 0      | No operation                 | —                                 |
| 0  | 0  | 1      | Write control memory D12 = 0 | 4.5                               |
| 0  | 1  | 1      | Write control memory D12 = 1 | 4.5                               |
| 0  | 1  | 0      | Read control memory          | 4.5                               |
| 1  | 0  | 0      | Read data memory             | 8.5                               |
| 1  | 1  | 0      | Read indirect register       | 4.5                               |
| 1  | 1  | 1      | Write indirect register      | 4.5                               |

- D12

This bit is only used as a data bit in a read or write control memory operation. Dependent on the contents of register OPCR D12 is interpreted as absolute address for data memories DM0 and DM1 (OPCR = FF<sub>H</sub>) or as a switch for constant (D12 = 0) and minimal (D12 = 1) delay (OPCR = FC<sub>H</sub>).
- D11

This bit is only used as data bit in a read operation of the FER register.
- D (10:0)

Data value for read/write access; if the control-memory is accessed D10 is used as a tristate control bit (0 = active, 1 = high impedance).

The incoming PCM data are transformed onto the data-memory (control memory data D12, D (10:0)) in the following way:

- TSN

Time-Slot Number
- PN

Port Number
- TSC

Tristate Control Value (0 = active, 1 = high impedance)
- MD

Minimal Delay (1 = minimal, 0 = constant frame delay), if OPCR:OC (1:0) = 00<sub>B</sub>. Absolute address of data memories DM0, DM1 if OPCR:OC (1:0) = 11<sub>B</sub>.

Table 6  
Input Time-Slot Mapping

| Input Mode | D (10:0) |     |                   |    |    |    |    |    |                               |        |                   |                   | Valid for Inputs |
|------------|----------|-----|-------------------|----|----|----|----|----|-------------------------------|--------|-------------------|-------------------|------------------|
| 0,4        | D12      | D10 | D9                | D8 | D7 | D6 | D5 | D4 | $\overline{D3}^{1)}$ D2 D1 D0 |        |                   |                   |                  |
|            | MD       | TSC | TSN               |    |    |    |    |    | PN                            |        |                   |                   |                  |
| 1,5        | D12      | D10 | D9 D8 D7 D6 D5 D4 |    |    |    |    |    | $\overline{D3}^{1)}$ 1 D1 D0  |        |                   |                   |                  |
|            | MD       | TSC | TSN               |    |    |    |    |    | PN                            |        |                   |                   |                  |
|            | D12      | D10 | D9 D8 D7 D6 D5 D3 |    |    |    |    |    | 0                             | D1     | D0                |                   |                  |
|            | MD       | TSC | TSN               |    |    |    |    |    | PN                            |        |                   |                   |                  |
| 2,6        | D12      | D10 | D9 D8 D7 D6 D5 D3 |    |    |    |    |    | D2                            | D1     | D0                |                   |                  |
|            | MD       | TSC | TSN               |    |    |    |    |    | PN                            |        |                   |                   |                  |
| 7          | D12      | D10 | D9                | D8 | D7 | D6 | D5 | D4 | D3                            | D2     | D1                | $\overline{D0}^*$ |                  |
|            | MD       | TSC | TSN (7:2)         |    |    |    |    |    | TSN0                          | PN ÷ 2 |                   | TSN1              |                  |
| 3          | D12      | D10 | D9 D8 D7 D6 D5 D3 |    |    |    |    |    | 0                             | D1     | D0                |                   |                  |
|            | MD       | TSC | TSN               |    |    |    |    |    | PN                            |        |                   |                   |                  |
|            | D12      | D10 | D9 D8 D7 D6 D4 D3 |    |    |    |    |    | 1                             | D1     | $\overline{D0}^*$ |                   |                  |
|            | MD       | TSC | TSN (7:2)         |    |    |    |    |    | TSN0                          | PN ÷ 2 |                   | TSN1              |                  |

1) D3 and D0 contain the inverted values in these cases.

**Note:** D9 must be set to “0”, if MOD = MD2 is set, i.e. in 2-Mbit applications.

PN ÷ 2 means, you have to multiply D (2:1) by two to generate the correct input numbers.

**IA9 ... IA0**      **Indirect Address** for a read/write access

If a indirect register is accessed only IA (3:0) are interpreted as address bits.

The control memory address is transformed to the output time-slots:

Table 7  
Output Time-Slot Mapping

| Output Mode |                                                                                                                                                          | Valid for Outputs                                                                                                                                                                                                                                                                             |     |     |     |     |     |     |     |    |    |    |           |           |     |     |     |     |   |  |     |  |  |    |  |  |
|-------------|----------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----|-----|-----|-----|-----|-----|-----|----|----|----|-----------|-----------|-----|-----|-----|-----|---|--|-----|--|--|----|--|--|
| 0           | <table><tr><td>IA9</td><td>IA8</td><td>IA3</td><td>IA2</td><td>IA1</td><td>IA0</td></tr><tr><td colspan="3">TSN</td><td colspan="3">PN</td></tr></table> | IA9                                                                                                                                                                                                                                                                                           | IA8 | IA3 | IA2 | IA1 | IA0 | TSN |     |    | PN |    |           | OUT (7:0) |     |     |     |     |   |  |     |  |  |    |  |  |
|             | IA9                                                                                                                                                      | IA8                                                                                                                                                                                                                                                                                           | IA3 | IA2 | IA1 | IA0 |     |     |     |    |    |    |           |           |     |     |     |     |   |  |     |  |  |    |  |  |
|             | TSN                                                                                                                                                      |                                                                                                                                                                                                                                                                                               |     | PN  |     |     |     |     |     |    |    |    |           |           |     |     |     |     |   |  |     |  |  |    |  |  |
|             | 1                                                                                                                                                        | <table><tr><td>IA9</td><td>IA8</td><td>IA3</td><td>IA2</td><td>IA1</td><td>1</td></tr><tr><td colspan="3">TSN</td><td colspan="3">PN</td></tr><tr><td>IA9</td><td>IA8</td><td>IA2</td><td>IA1</td><td colspan="2">0</td></tr><tr><td colspan="3">TSN</td><td colspan="3">PN</td></tr></table> | IA9 | IA8 | IA3 | IA2 | IA1 | 1   | TSN |    |    | PN |           |           | IA9 | IA8 | IA2 | IA1 | 0 |  | TSN |  |  | PN |  |  |
| IA9         |                                                                                                                                                          | IA8                                                                                                                                                                                                                                                                                           | IA3 | IA2 | IA1 | 1   |     |     |     |    |    |    |           |           |     |     |     |     |   |  |     |  |  |    |  |  |
| TSN         |                                                                                                                                                          |                                                                                                                                                                                                                                                                                               | PN  |     |     |     |     |     |     |    |    |    |           |           |     |     |     |     |   |  |     |  |  |    |  |  |
| IA9         |                                                                                                                                                          | IA8                                                                                                                                                                                                                                                                                           | IA2 | IA1 | 0   |     |     |     |     |    |    |    |           |           |     |     |     |     |   |  |     |  |  |    |  |  |
| TSN         |                                                                                                                                                          |                                                                                                                                                                                                                                                                                               | PN  |     |     |     |     |     |     |    |    |    |           |           |     |     |     |     |   |  |     |  |  |    |  |  |
| 3           | <table><tr><td>IA9</td><td>IA8</td><td>IA2</td><td>IA1</td><td>IA0</td></tr><tr><td colspan="3">TSN</td><td colspan="3">PN</td></tr></table>             | IA9                                                                                                                                                                                                                                                                                           | IA8 | IA2 | IA1 | IA0 | TSN |     |     | PN |    |    | OUT (3:0) |           |     |     |     |     |   |  |     |  |  |    |  |  |
|             | IA9                                                                                                                                                      | IA8                                                                                                                                                                                                                                                                                           | IA2 | IA1 | IA0 |     |     |     |     |    |    |    |           |           |     |     |     |     |   |  |     |  |  |    |  |  |
| TSN         |                                                                                                                                                          |                                                                                                                                                                                                                                                                                               | PN  |     |     |     |     |     |     |    |    |    |           |           |     |     |     |     |   |  |     |  |  |    |  |  |

**Note:** IA9 is only valid within applications with a 16.384-MHz device clock. If a 8.192 or 4.096-MHz clock is used, it is internally fixed to 0.

IA8 must be set to “0”, if MOD:MD2 is set, i.e. in 2-Mbit applications.

4.7 Indirect Registers

Input Clock Shift Registers ICSR (7:0)

Read/write at indirect address IA (3:0) = 0<sub>H</sub> ... 7<sub>H</sub>

Reset value: 40<sub>H</sub>

|       |   |      |      |      |      |      |       |
|-------|---|------|------|------|------|------|-------|
| Bit 7 |   |      |      |      |      |      | Bit 0 |
| ADSR  | 1 | ICS4 | ICS3 | ICS2 | ICS1 | ICS0 | RRE   |

**ADSR**            **Add Shift Register**; a three bit shift register is inserted into the corresponding input(s).

**ICS4 ... ICS0**   **Input Clock Shift**; the value of ICS (4:0) determines the number of clock cycles by which the bit sampling point is shifted forward in all input modes.

**Note:** ICS4 has to be set to “0” in input modes 0, 1 and 2.

**RRE**            **Receive on Rising Edge**

These eight registers determine the individual clock shift of inputs IN0 to IN7.

If more than eight inputs are used, two inputs are controlled by one ICSR register:

|       |          |           |
|-------|----------|-----------|
| ICSR0 | controls | IN0, IN8  |
| ICSR1 | ”        | IN1, IN9  |
| ICSR2 | ”        | IN2, IN10 |
| .     |          | .         |
| .     |          | .         |
| .     |          | .         |
| ICSR7 | ”        | IN7, IN15 |



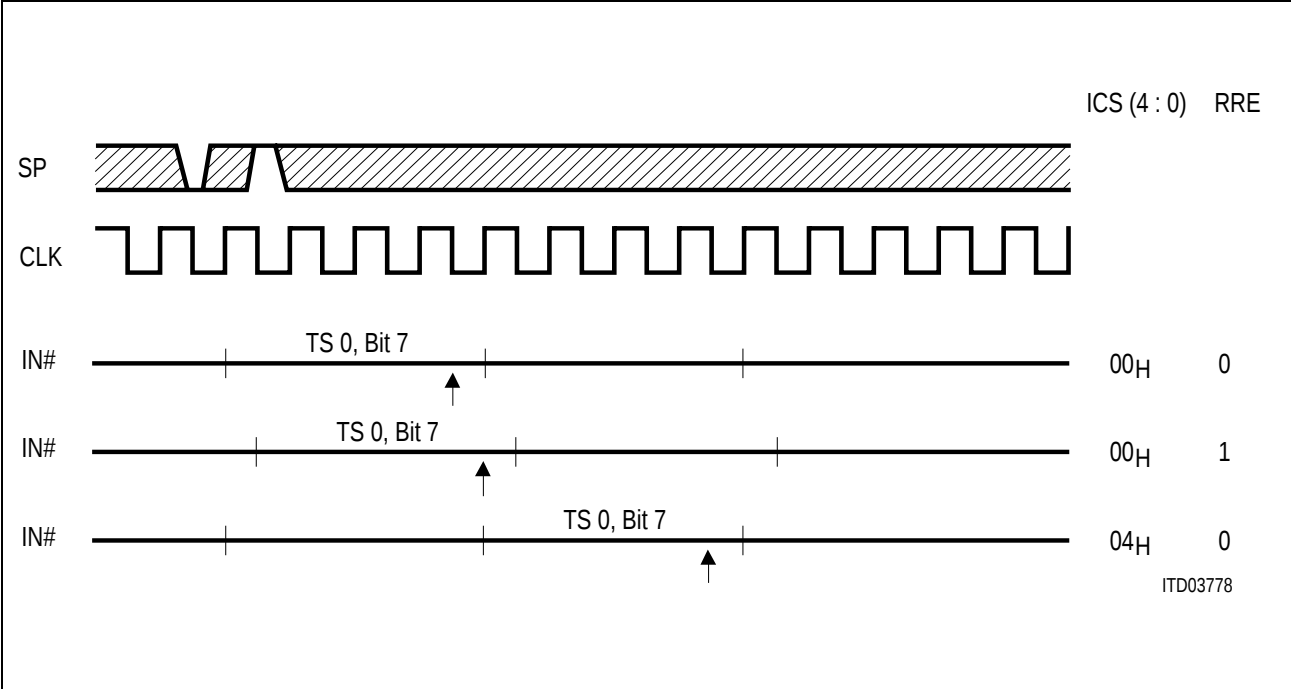


Figure 14  
Device Clock = 4 × Data Rate

Operation Control Register (OPCR)

Read/write at indirect address IA (3:0) = D<sub>H</sub>

Reset value: FF<sub>H</sub>

| Bit 7 |   |   |   |   | Bit 0 |     |     |
|-------|---|---|---|---|-------|-----|-----|
| 1     | 1 | 1 | 1 | 1 | SDM   | OC1 | OC0 |

- SDM** Select Data Memory; only used in configuration with OC (1:0) = 11<sub>B</sub>
- OC (1:0)** Operation Control; OC (1:0) determine the usage of the two data memory blocks according to the table below.

Table 8

| OC1 | OC0 | Function                                                                                                                                         |
|-----|-----|--------------------------------------------------------------------------------------------------------------------------------------------------|
| 1   | 1   | Only one data memory block is used; the absolute address is given by SDM; bit D12 in the control memory is also interpreted as absolute address. |
| 0   | 0   | Both data memory blocks are used; bit D12 in the control memory controls the constant or minimal frame delay function.                           |
| 0   | 1   | Reserved                                                                                                                                         |
| 1   | 0   | Reserved                                                                                                                                         |

Output Clock Shift Register (OSCR)

Read/write at indirect address IA (3:0) = E<sub>H</sub>

Reset value: 20<sub>H</sub>

This register determines the clock shift for all outputs.

| Bit 7 |     |     |      |      |      |      |     | Bit 0 |
|-------|-----|-----|------|------|------|------|-----|-------|
| VN2   | VN1 | VN0 | OCS3 | OCS2 | OCS1 | OCS0 | XFE |       |

OCS (3:0)      Output Clock Shift  
XFE              Transmit on Falling Edge

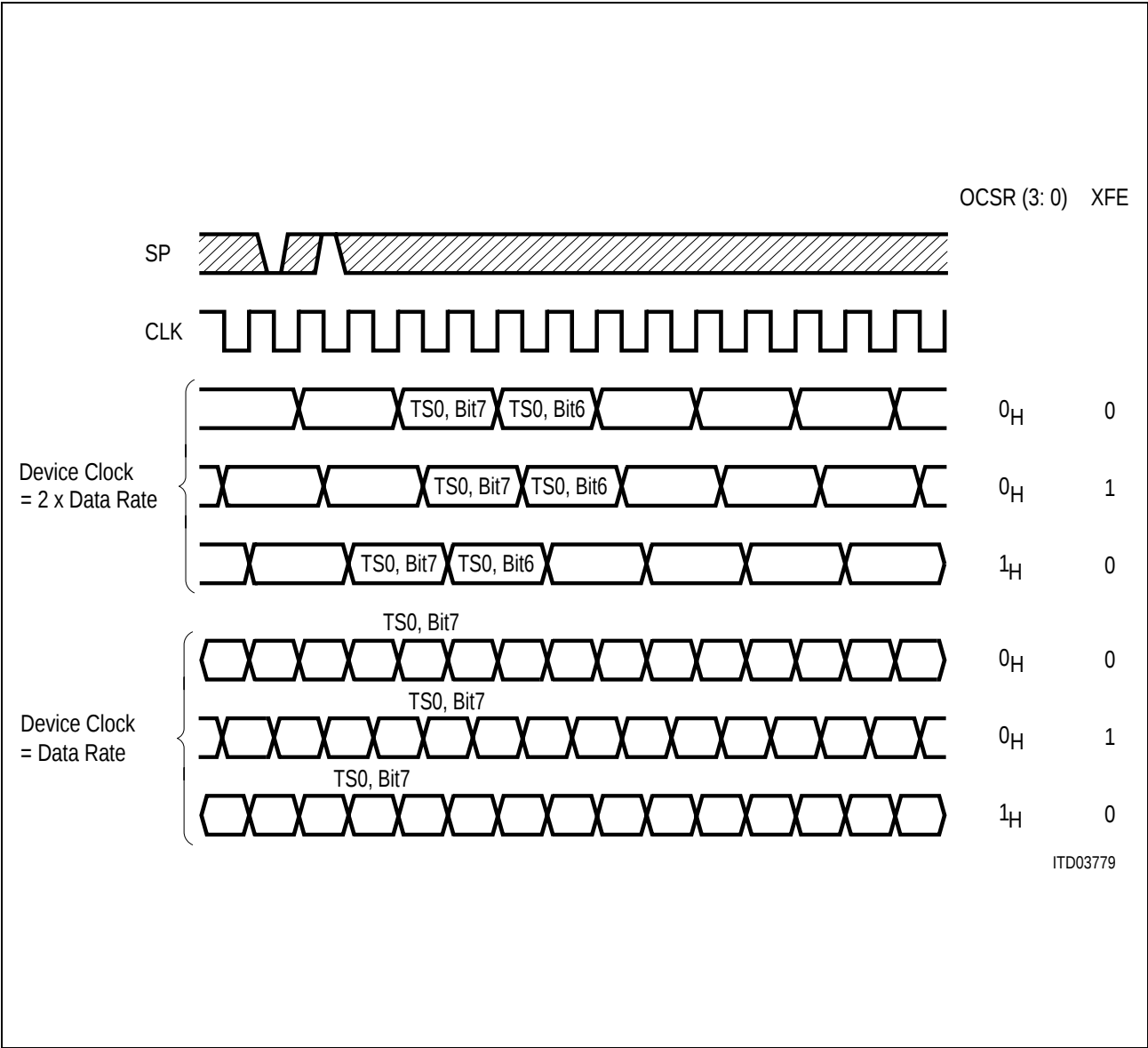


Figure 15  
Output Timing and Clock Shift

VN (2:0)            **Version Number** according to the table below:

Table 9  
Version Number

| VN2 | VN1 | VN0 | Device Versions |
|-----|-----|-----|-----------------|
| 0   | 0   | 0   | A1              |
| 0   | 0   | 1   | V2.1 (B1)       |

**Frame Evaluation Register (FER)**

Read at indirect address IA (3:0) = F<sub>H</sub>

Reset value = XXX

After a frame evaluation procedure this 12-bit register contains the input counter offset between the SP frame and an evaluated FS0 ... FS7 frame. The evaluation is performed at the second following rising edge of FS after the command CMDR:SFE = 1 was programmed.

|       |    |    |    |       |     |    |    |
|-------|----|----|----|-------|-----|----|----|
| Bit 7 |    |    |    | Bit 0 |     |    |    |
|       |    |    |    | D11   | D10 | D9 | D8 |
| D7    | D6 | D5 | D4 | D3    | D2  | D1 | D0 |

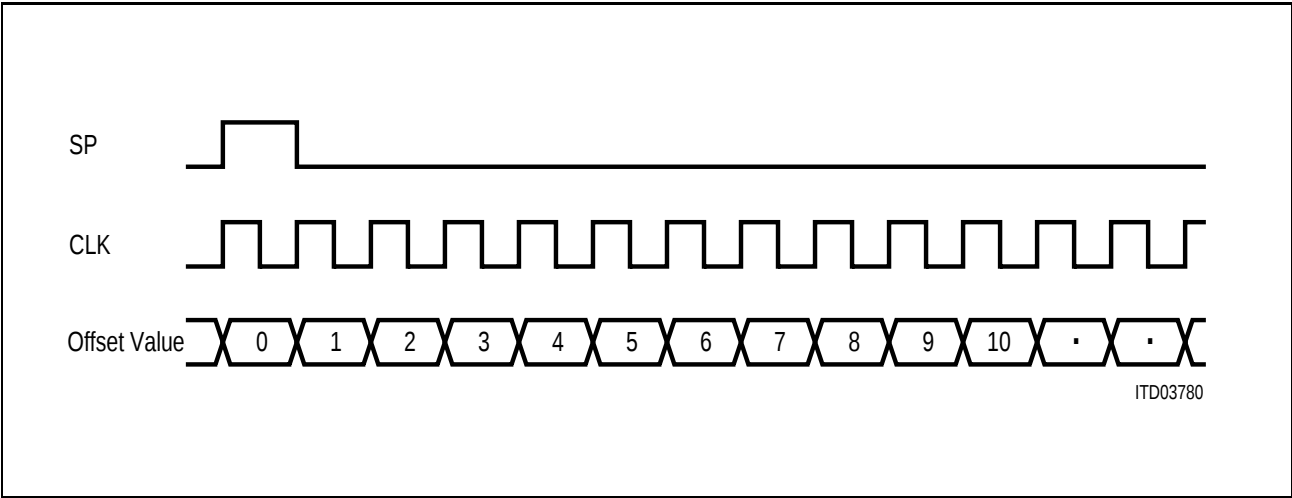
**D11**            The FS-rising edge was sampled during the clock-high phase (D11 = 1), or during the clock-low phase (D11 = 0).

**D (10:0)**        The FS-rising edge was sampled at:  
input counter value + 1 if D11 = 1  
input counter value + 2 if D11 = 0  
With a device clock of 8 MHz D0 is fixed to 0 and D (10:1) contain the input counter value.

The actual offset between the SP frame and an evaluated FS frame can be calculated by the following formulas:

| CLK × 1.024 MHz | Offset Value/Number of Clock Periods                           | D11 | FS-Rising Edge at |
|-----------------|----------------------------------------------------------------|-----|-------------------|
| 8               | (D (10:1) <sub>H</sub> + 01D <sub>H</sub> ) <sub>MOD1024</sub> | 0   | CLK low           |
|                 | (D (10:1) <sub>H</sub> + 01E <sub>H</sub> ) <sub>MOD1024</sub> | 1   | CLK high          |
| 16              | (D (10:0) <sub>H</sub> + 03D <sub>H</sub> ) <sub>MOD2048</sub> | 0   | CLK low           |
|                 | (D (10:0) <sub>H</sub> + 03E <sub>H</sub> ) <sub>MOD2048</sub> | 1   | CLK high          |
| 4               | (D (9:1) <sub>H</sub> + 01D <sub>H</sub> ) <sub>MOD512</sub>   | 0   | CLK low           |
|                 | (D (9:1) <sub>H</sub> + 01E <sub>H</sub> ) <sub>MOD512</sub>   | 1   | CLK high          |

Definition of the calculated offset value:



**Figure 16**  
**Formulas for Offset Calculation**

**Note:** The device must be synchronized to SP (STAR: PSS = 1) in order to generate a correct result in FER.

5 Electrical Characteristics

Absolute Maximum Ratings

| Parameter                                 | Symbol           | Limit Values                   | Unit |
|-------------------------------------------|------------------|--------------------------------|------|
| Ambient temperature under bias            | $T_A$            | 0 to 70                        | °C   |
| Storage temperature                       | $T_{\text{stg}}$ | – 65 to 125                    | °C   |
| Voltage at any pin with respect to ground | $V_S$            | – 0.4 to $V_{\text{DD}} + 0.4$ | V    |
| Maximum voltage on any pin                | $V_{\text{max}}$ | 7                              | V    |

**Note:** Stresses above those listed here may cause permanent damage to the device. Exposure to absolute maximum ratings conditions for extended periods may affect device reliability.

DC Characteristics

Ambient temperature under bias range;  $V_{\text{DD}} = 5 \text{ V} \pm 5 \%$ ,  $V_{\text{SS}} = 0 \text{ V}$ .

| Parameter                                                                                                       | Symbol                             | Limit Values          |                       | Unit          | Test Condition                                                                           |
|-----------------------------------------------------------------------------------------------------------------|------------------------------------|-----------------------|-----------------------|---------------|------------------------------------------------------------------------------------------|
|                                                                                                                 |                                    | min.                  | max.                  |               |                                                                                          |
| L-input voltage                                                                                                 | $V_{\text{IL}}$                    | – 0.4                 | 0.8                   | V             |                                                                                          |
| H-input voltage                                                                                                 | $V_{\text{IH}}$                    | 2.2                   | $V_{\text{DD}} + 0.4$ | V             |                                                                                          |
| L-output voltage                                                                                                | $V_{\text{OL}}$                    |                       | 0.45                  | V             | $I_{\text{OL}} = 2 \text{ mA}$                                                           |
| H-output voltage                                                                                                | $V_{\text{OH}}$                    | 2.4                   |                       | V             | $I_{\text{OH}} = - 400 \text{ }\mu\text{A}$                                              |
| H-output voltage                                                                                                | $V_{\text{OH}}$                    | $V_{\text{DD}} - 0.5$ |                       | V             | $I_{\text{OH}} = - 100 \text{ }\mu\text{A}$                                              |
| Operational power supply current<br>$f_{\text{CLK}} = 8192 \text{ kHz}$<br>$f_{\text{CLK}} = 16384 \text{ kHz}$ | $I_{\text{CC}}$<br>$I_{\text{CC}}$ |                       | 20<br>34              | mA<br>mA      | $V_{\text{DD}} = 5 \text{ V}$ ,<br>inputs at 0 V or $V_{\text{DD}}$ , no<br>output loads |
| Input leakage current                                                                                           | $I_{\text{LI}}$                    |                       | 10                    | $\mu\text{A}$ | $0 \text{ V} < V_{\text{IN}} < V_{\text{DD}}$ to 0 V                                     |
| Output leakage current                                                                                          | $I_{\text{LO}}$                    |                       | 10                    | $\mu\text{A}$ | $0 \text{ V} < V_{\text{OUT}} < V_{\text{DD}}$ to 0 V                                    |

Capacitances

$T_A = 25 \text{ }^\circ\text{C}$ ,  $V_{\text{DD}} = 5 \text{ V} \pm 5 \%$ ,  $V_{\text{SS}} = 0 \text{ V}$ .

| Parameter          | Symbol           | Limit Values |      | Unit |
|--------------------|------------------|--------------|------|------|
|                    |                  | min.         | max. |      |
| Input capacitance  | $C_{\text{IN}}$  |              | 10   | pF   |
| Output capacitance | $C_{\text{OUT}}$ |              | 15   | pF   |
| I/O capacitance    | $C_{\text{IO}}$  |              | 20   | pF   |

AC Characteristics

Ambient temperature under bias range,  $V_{DD} = 5\text{ V} \pm 5\%$ .  
Inputs are driven at 2.4 V for a logical 1 and at 0.4 V for a logical 0. Timing measurements are made at 2.0 V for a logical 1 and at 0.8 V for a logical 0. The AC testing input/output waveforms are shown below.

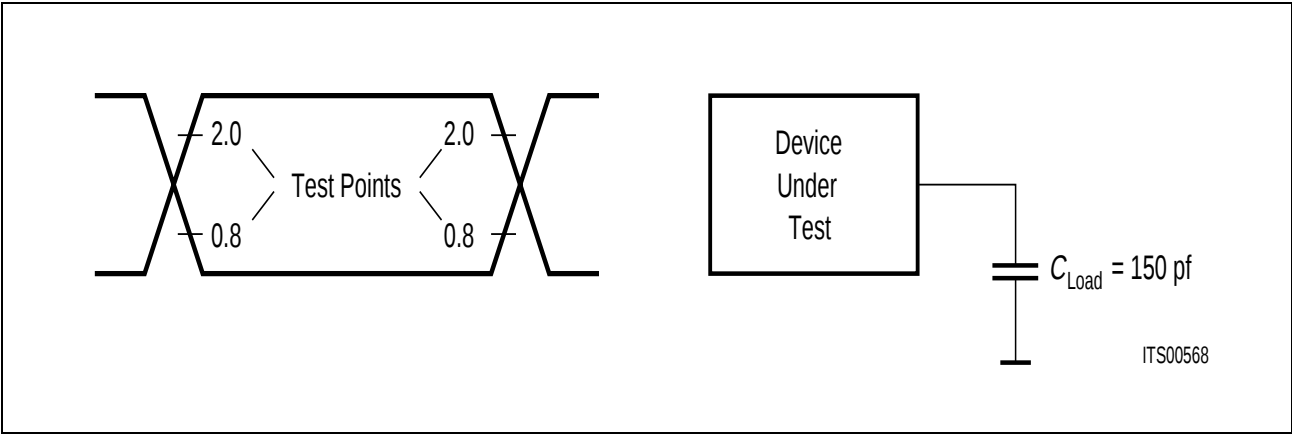


Figure 17  
I/O Waveform for AC Tests

$\mu$ P-Interface Timing Parameters

| Parameter                                                     | Symbol    | Limit Values |      | Unit |
|---------------------------------------------------------------|-----------|--------------|------|------|
|                                                               |           | min.         | max. |      |
| ALE pulse width                                               | $t_{AA}$  | 30           |      | ns   |
| Address setup time to ALE                                     | $t_{AL}$  | 10           |      | ns   |
| Address hold time from ALE                                    | $t_{LA}$  | 15           |      | ns   |
| Address latch setup time to $\overline{WR}$ , $\overline{RD}$ | $t_{ALS}$ | 0            |      | ns   |
| Address setup time to $\overline{WR}$ , $\overline{RD}$       | $t_{AS}$  | 10           |      | ns   |
| Address hold time from $\overline{WR}$ , $\overline{RD}$      | $t_{AH}$  | 15           |      | ns   |
| $\overline{RD}$ delay after $\overline{WR}$ setup             | $t_{DSD}$ | 0            |      | ns   |
| $\overline{RD}$ pulse width                                   | $t_{RR}$  | 120          |      | ns   |
| Data output delay from $\overline{RD}$                        | $t_{RD}$  |              | 100  | ns   |
| Data float from $\overline{RD}$                               | $t_{DF}$  |              | 25   | ns   |
| $\overline{RD}$ control interval                              | $t_{RI}$  | 70           |      | ns   |
| $\overline{WR}$ pulse width                                   | $t_{WW}$  | 60           |      | ns   |
| Data setup time to $\overline{WR} + \overline{CS}$            | $t_{DW}$  | 30           |      | ns   |
| Data hold time from $\overline{WR} + \overline{CS}$           | $t_{WD}$  | 10           |      | ns   |
| $\overline{WR}$ control interval                              | $t_{WI}$  | 70           |      | ns   |
| R/ $\overline{W}$ delay after $\overline{RD}$ setup           | $t_{RWD}$ | 0            |      | ns   |

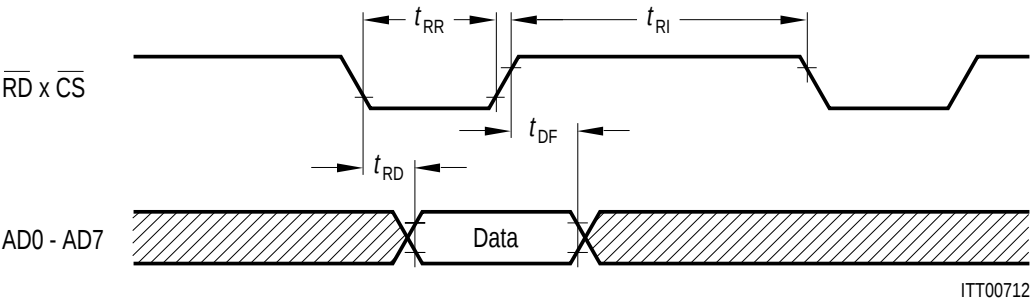


Figure 18  
 $\mu$ P-Read Cycle

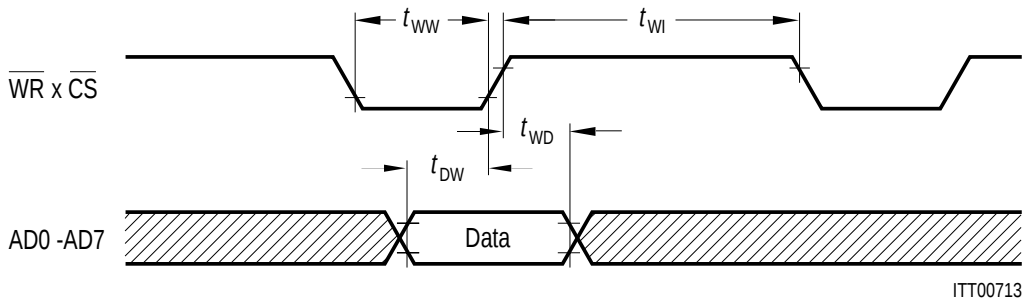
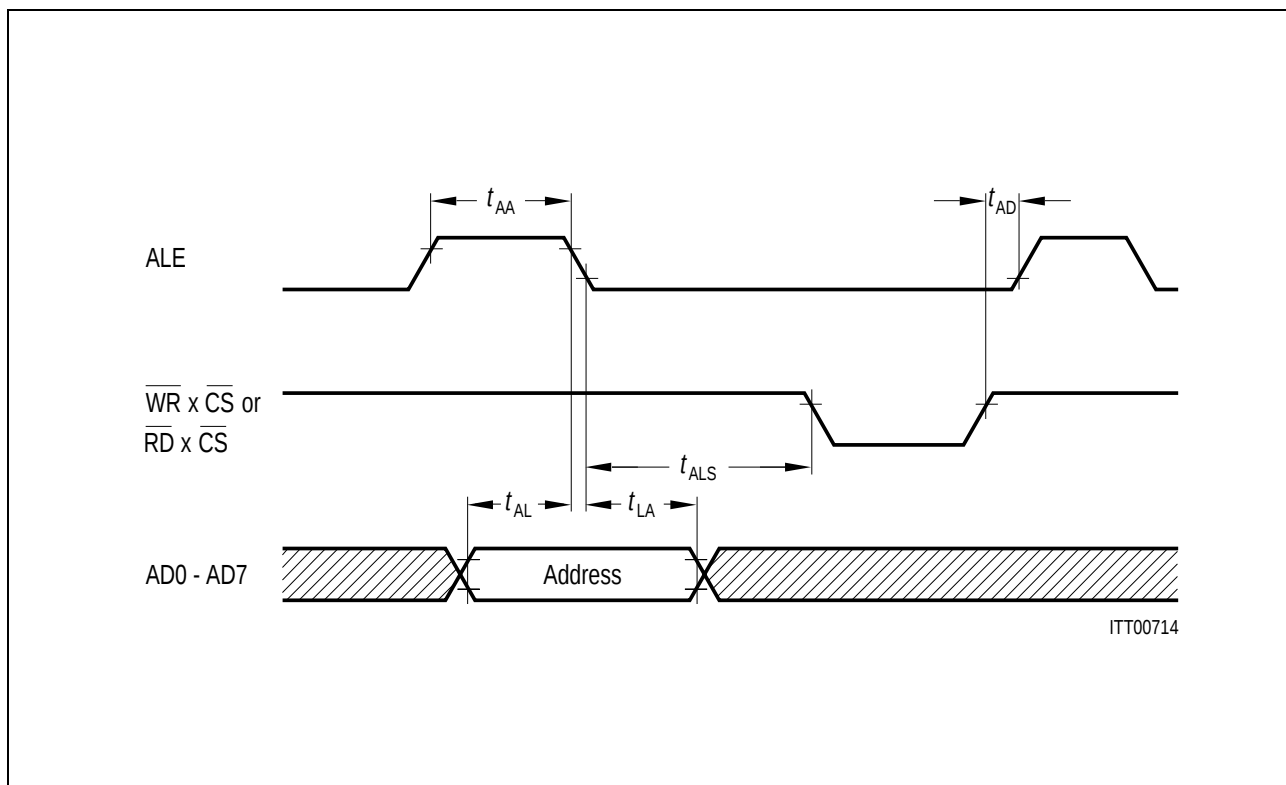
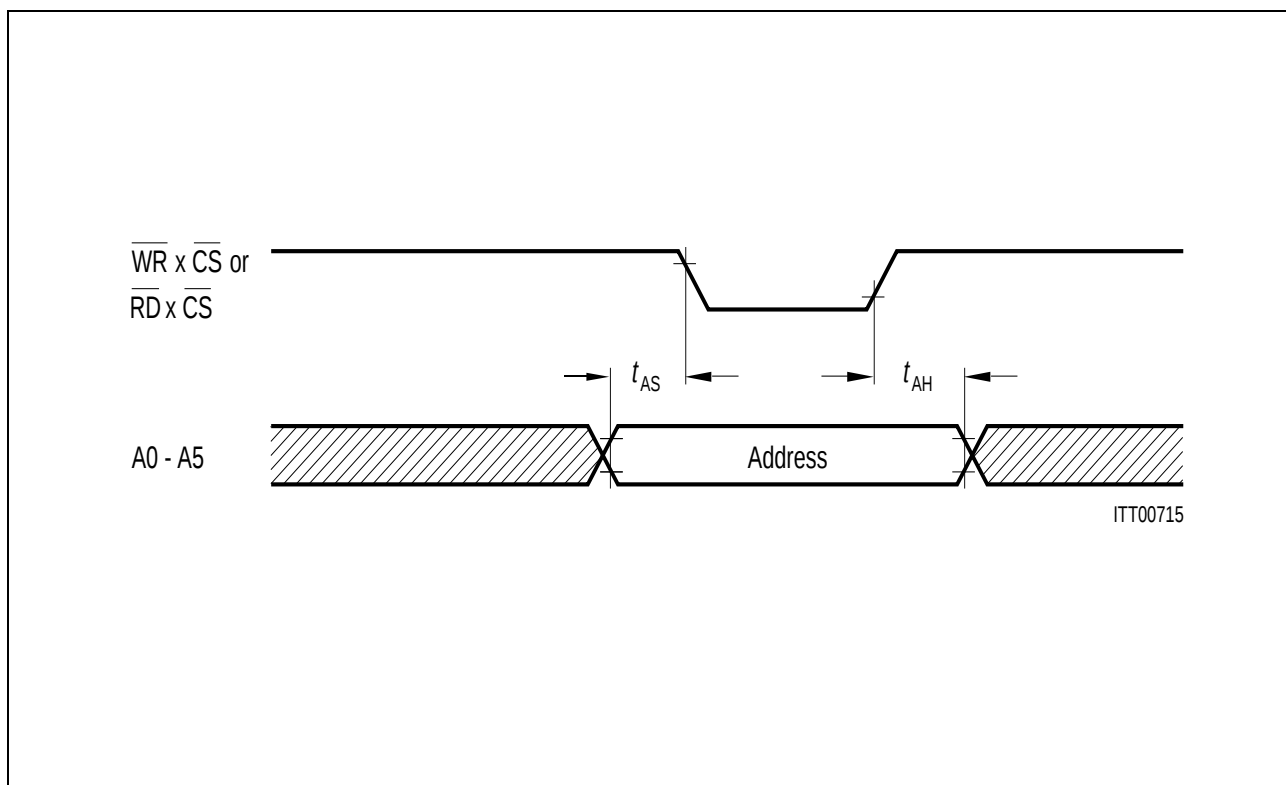


Figure 19  
 $\mu$ P-Write Cycle



**Figure 20**  
**Multiplexed Address Timing**



**Figure 21**  
**Demultiplexed Address Timing**

Motorola Bus Mode

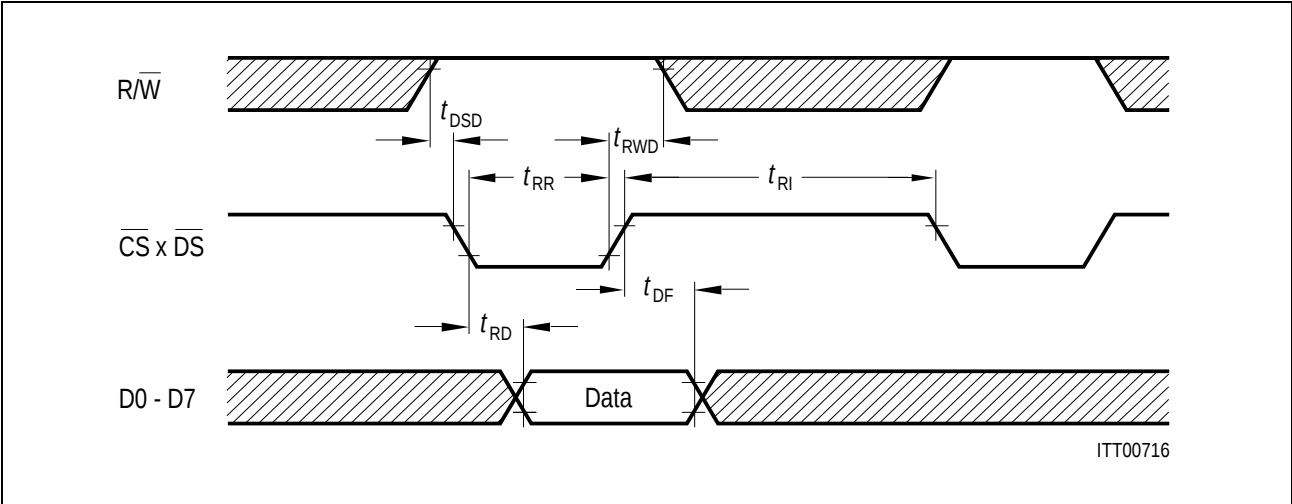


Figure 22  
 $\mu$ P-Read Cycle

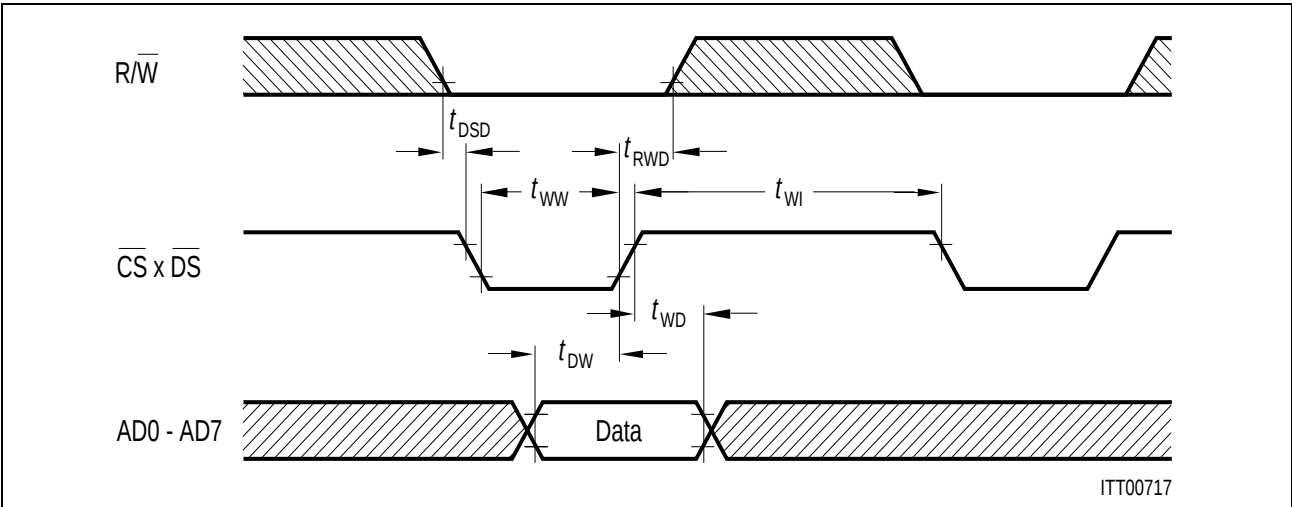


Figure 23  
 $\mu$ P-Write Cycle

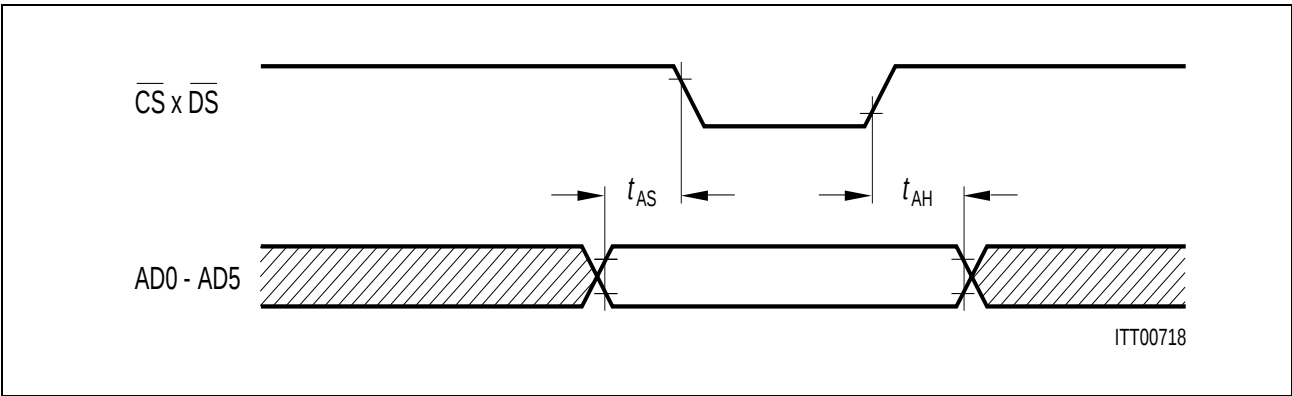
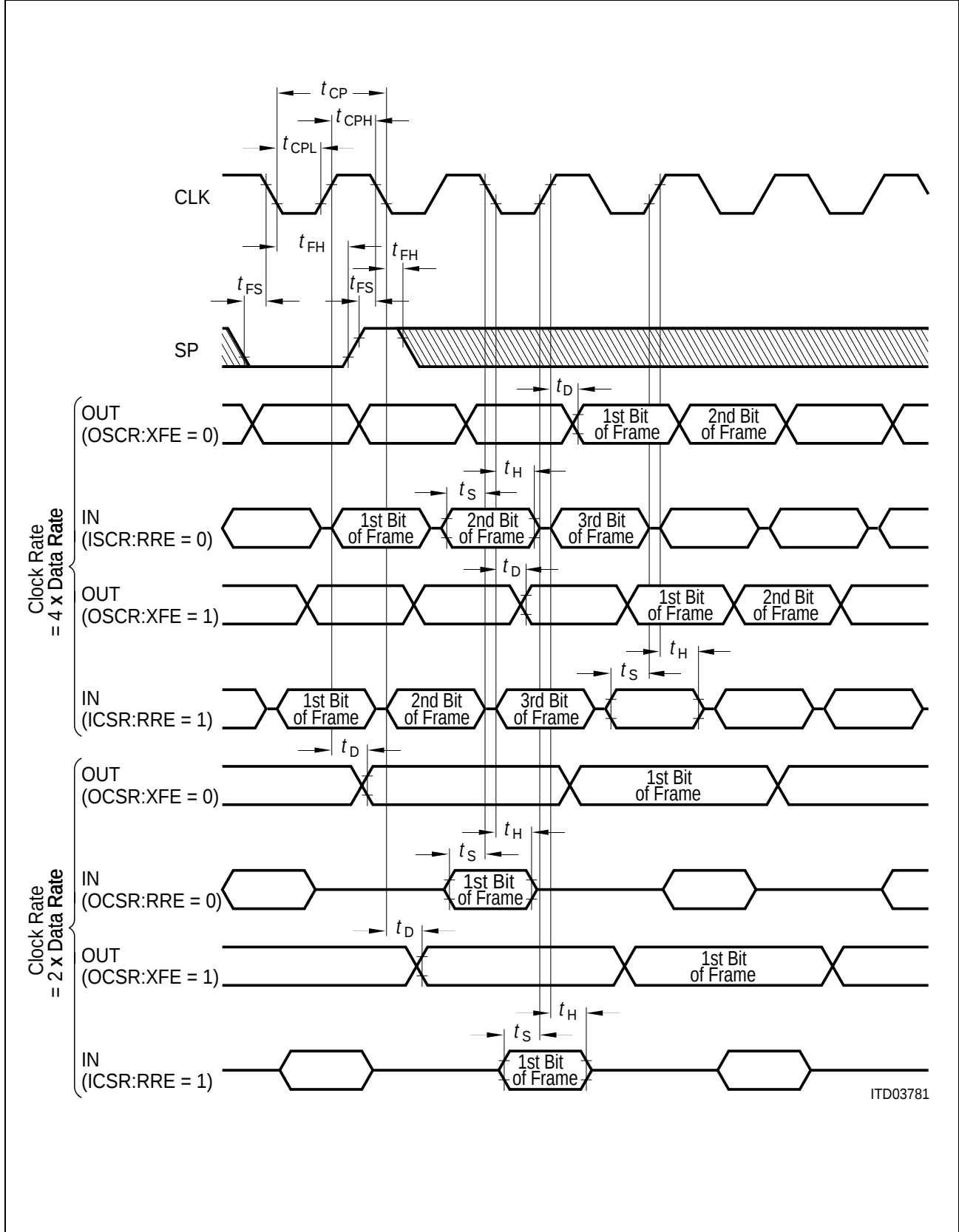


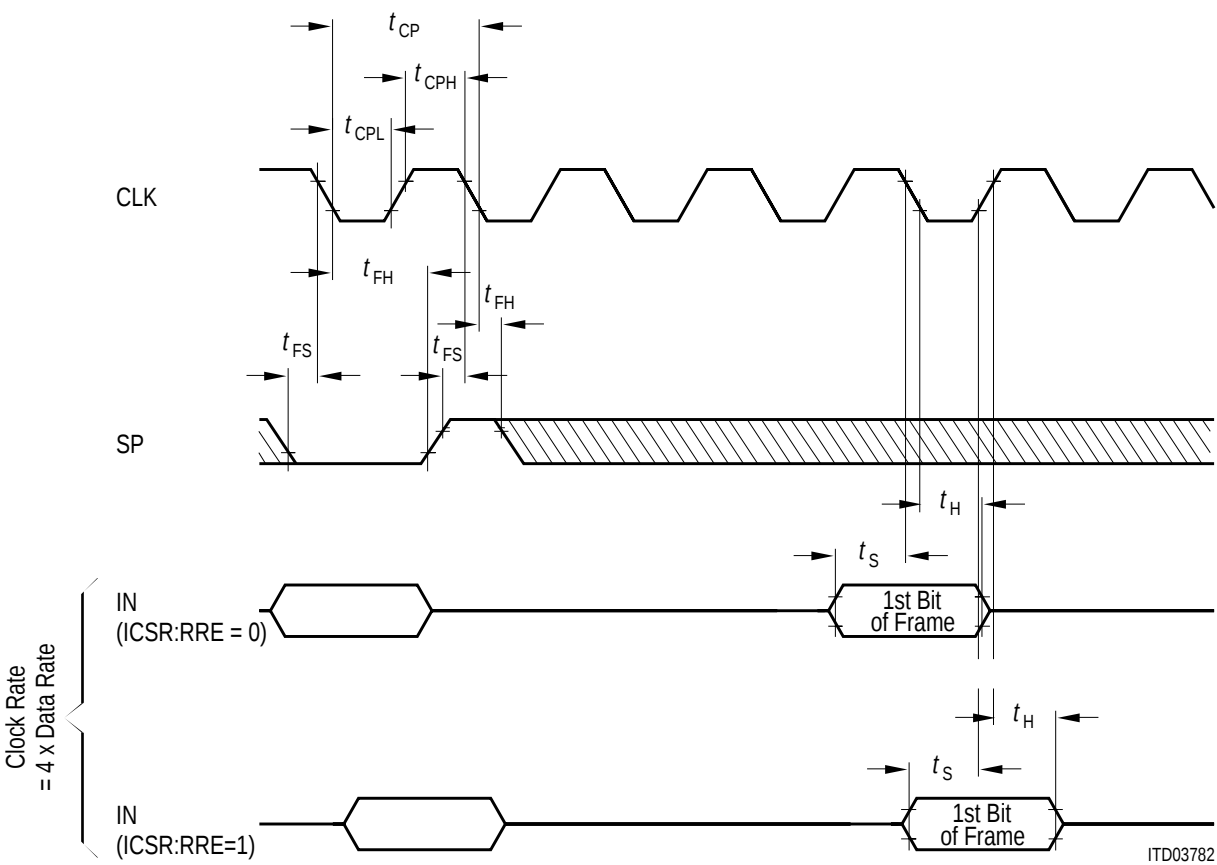
Figure 24  
Address Timing

PCM-Interface Characteristics

| Parameter                            | Symbol    | Limit Values |      | Unit | Condition                                                 |
|--------------------------------------|-----------|--------------|------|------|-----------------------------------------------------------|
|                                      |           | min.         | max. |      |                                                           |
| Clock period                         | $t_{CP}$  | 120          |      | ns   | PEB 2047                                                  |
| Clock period low                     | $t_{CPL}$ | 50           |      | ns   |                                                           |
| Clock period high                    | $t_{CPH}$ | 50           |      | ns   |                                                           |
| Clock period                         | $t_{CP}$  | 60           |      | ns   | PEB 2047-16                                               |
| Clock period low                     | $t_{CPL}$ | 27           |      | ns   |                                                           |
| Clock period high                    | $t_{CPH}$ | 23           |      | ns   |                                                           |
| Frame setup time                     | $t_{FS}$  | 15           |      | ns   |                                                           |
| Frame hold time                      | $t_{FH}$  | 20           |      | ns   |                                                           |
| Serial data input setup time         | $t_S$     | 15           |      | ns   | PCM-input data<br>frequency 8192 kHz                      |
| Serial data input hold time          | $t_H$     | 20           |      | ns   |                                                           |
| Serial data input setup time         | $t_S$     | 15           |      | ns   | PCM-input data<br>frequency 16496 kHz<br>only PEB 2047-16 |
| Serial data input hold time          | $t_H$     | 20           |      | ns   |                                                           |
| PCM-serial data output delay<br>time | $t_D$     |              | 30   | ns   |                                                           |



**Figure 25**  
**AC Characteristics at the PCM Interface**



**Figure 26**  
**AC Characteristics at the PCM Interface**

## 6 Applications

### 6.1 Determination of MTSL Frame Delay

When switching time slots from the input of the MTSL to its output, the question often arises whether the incoming channel is transmitted in the same frame (0 frame delay), the next frame (1 frame delay), or even in the frame thereafter (2 frames delay).

Because framing delay is different depending on the selected output port, delay timings have to be calculated separately for all outputs.

The following text advises how to do this calculation and delivers a value for MINIMAL or CONSTANT delay. A CONSTANT delay may be programmed by the control byte bit D12 of IAR-register.

#### Instructions for Use

1. Determine the data rate for the input data stream and for the output data stream. e.g. 4 Mbit/s for input data stream; 4 Mbit/s for output data stream.
2. Select a device clock. Please note, that not all output ports are available for every choice of the device clock (refer to the following table) !! e.g. 8 MHz.
3. Determine the constant  $T_d$  for your special configuration by selecting the corresponding row in the table below (a, b, c or d):  
e.g. for a 4 Mbit/s input- /output- data stream with 8 MHz device clock row a) has to be selected.  
The table delivers a value  $T_d = 4$  for line OUT0 and  $T_d = 3$  for OUT1 ... 7.  
A big value for  $T_d$  also means a big internal switching delay.

|    | Input Data Rate [Mbit/s]       | Output Data Rate [Mbit/s] | Device CLK [MHz] | $T_d$ for OUT0 | $T_d$ for OUT1 | $T_d$ for OUT2 ... 3 | $T_d$ for OUT4 ... 7 |
|----|--------------------------------|---------------------------|------------------|----------------|----------------|----------------------|----------------------|
| a) | 2, 4 <sup>1)</sup><br>4, 8     | 2<br>4                    | 4<br>8           | 4              | 3              | 3                    | 3                    |
| b) | 2, 4 <sup>1)</sup><br>4, 8     | 4<br>8                    | 4<br>8           | 7              | 6              | 6                    | not available !!     |
| c) | 2<br>4, 8, 16                  | 4<br>8                    | 8<br>16          | 6              | 5              | 5                    | 5                    |
| d) | 2, 4 <sup>1)</sup><br>4, 8, 16 | 8<br>16                   | 8<br>16          | 11             | 10             | 10                   | not available !!     |

<sup>1)</sup> 2, 4 has the meaning 2,048 Mbit/s or 4,096 Mbit/s

4. Determine the constant M.
- The value for M can be determined by selecting the corresponding row in the table below (a, b or c) for your configuration.
- e.g. for a 4 Mbit/s input- /output- data stream with 8 MHz device clock row a) has to be selected.
- The table delivers the value M = 1.

The Constant M for Different Data Rates...

|    | Input Data Rate<br>[Mbit/s]   | Output Data Rate<br>[Mbit/s] | Device<br>CLK [MHz] | M |
|----|-------------------------------|------------------------------|---------------------|---|
| a) | 2, 4<br>4, 8                  | 2<br>4                       | 4<br>8              | 1 |
| b) | 2, 4<br>4, 8<br>2<br>4, 8, 16 | 4<br>8<br>4<br>8             | 4<br>8<br>8<br>16   | 2 |
| c) | 2, 4<br>4, 8, 16              | 8<br>16                      | 8<br>16             | 4 |

5. Determine the constant K.
- The value for K can be determined by selecting the corresponding row in the table below (a, b or c) for your configuration.
- e.g. for a 4 Mbit/s input- /output- data stream with 8 MHz device clock row a) has to be selected and the table delivers the value K = 1.

|    | Input<br>Data Rate<br>[Mbit/s] | Output<br>Data Rate<br>[Mbit/s] | Device CLK<br>[MHz] | Number of Input TS [K]<br>Sampled at the same Time |
|----|--------------------------------|---------------------------------|---------------------|----------------------------------------------------|
| a) | 2<br>2<br>4<br>4               | 2, 4<br>4, 8<br>4, 8<br>8, 16   | 4<br>8<br>8<br>16   | 1                                                  |
| b) | 4<br>8<br>8                    | 2, 4<br>4, 8<br>8, 16           | 4<br>8<br>16        | 2                                                  |
| c) | 16                             | 8, 16                           | 16                  | 4                                                  |

6. By inserting the obtained values for K, M and  $T_d$  in the table below, minimal and constant frame delays may be calculated for every timeslot (TS).

| Input TS                                                                                                                                                                                                                                                | Minimal Delay<br>= 0 Frame<br>for Output TS                                                                                                                                                                                                                 | Minimal Delay<br>= 1 frame<br>for Output TS                                                                                                                                                                           | Minimal Delay<br>= 2 Frames<br>for Output TS                                                                                     |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------|
| $0 \times K \dots (1 \times K - 1)$<br>$1 \times K \dots (2 \times K - 1)$<br>$2 \times K \dots (3 \times K - 1)$<br>$3 \times K \dots (4 \times K - 1)$<br>$\vdots$<br>$\vdots$<br>$\text{maxi} + 1 - (n + 1) \times K \dots \text{maxi} - n \times K$ | $T_d + (0 \times M) \dots \text{maxo}$<br>$T_d + (1 \times M) \dots \text{maxo}$<br>$T_d + (2 \times M) \dots \text{maxo}$<br>$T_d + (3 \times M) \dots \text{maxo}$<br>$\dots$<br>$\vdots$<br>$\text{maxo} + 1 - (n + 1) \times M + T_d \dots \text{maxo}$ | $0 \dots (T_d - 1 + 0 \times M)$<br>$0 \dots (T_d - 1 + 1 \times M)$<br>$0 \dots (T_d - 1 + 2 \times M)$<br>$0 \dots (T_d - 1 + 3 \times M)$<br>$\dots$<br>$\vdots$<br>$0 \dots \text{maxo} - (n + 1) \times M + T_d$ | –                                                                                                                                |
| $\text{maxi} + 1 - n \times K \dots \text{maxi} - (n - 1) \times K$<br>$\vdots$<br>$\vdots$<br>$\text{maxi} + 1 - 2 \times K \dots \text{maxi} - 1 \times K$<br>$\text{maxi} + 1 - 1 \times K \dots \text{maxi} - 0 \times K$                           | –                                                                                                                                                                                                                                                           | $T_d - n \times M \dots \text{maxo}$<br>$\vdots$<br>$\vdots$<br>$T_d - 2 \times M \dots \text{maxo}$<br>$T_d - 1 \times M \dots \text{maxo}$                                                                          | $0 \dots (T_d - n \times M - 1)$<br>$\vdots$<br>$\vdots$<br>$0 \dots (T_d - 2 \times M - 1)$<br>$0 \dots (T_d - 1 \times M - 1)$ |
| constant delay<br>in [frames]                                                                                                                                                                                                                           | 1                                                                                                                                                                                                                                                           | 1                                                                                                                                                                                                                     | 3                                                                                                                                |

The other constants inserted are:

**n:** This constant is a max. counter value that is obtained by integer division of  $T_d$  by M.

**maxi:** Is the maximal number of input time slots – 1

**maxo:** Is the maximal number of output time slots – 1

**Please note:** A negative value means no entry in the table!

## Example

The example below will demonstrate the usage for a system with 8 MHz device CLK and 4 Mbit/s input and output data streams.

Before starting the calculation the value n must be found by integer division of  $T_d$  by M. With the values  $T_d = 4$  and  $M = 1$  the value for  $n = 4$ . With  $T_d = 3$  and  $M = 1$  the value for  $n = 3$ .

The maximal number of input time slots :  $\text{maxi} = 64 - 1 = 63$

The maximal number of output time slots:  $\text{maxo} = 64 - 1 = 63$

Frame Delay for OUT0 with  $T_d = 4$ ,  $K = 1$ ,  $M = 1$ ,  $n = 4$ ,  $\text{maxo} = 63$ ,  $\text{maxi} = 63$ :

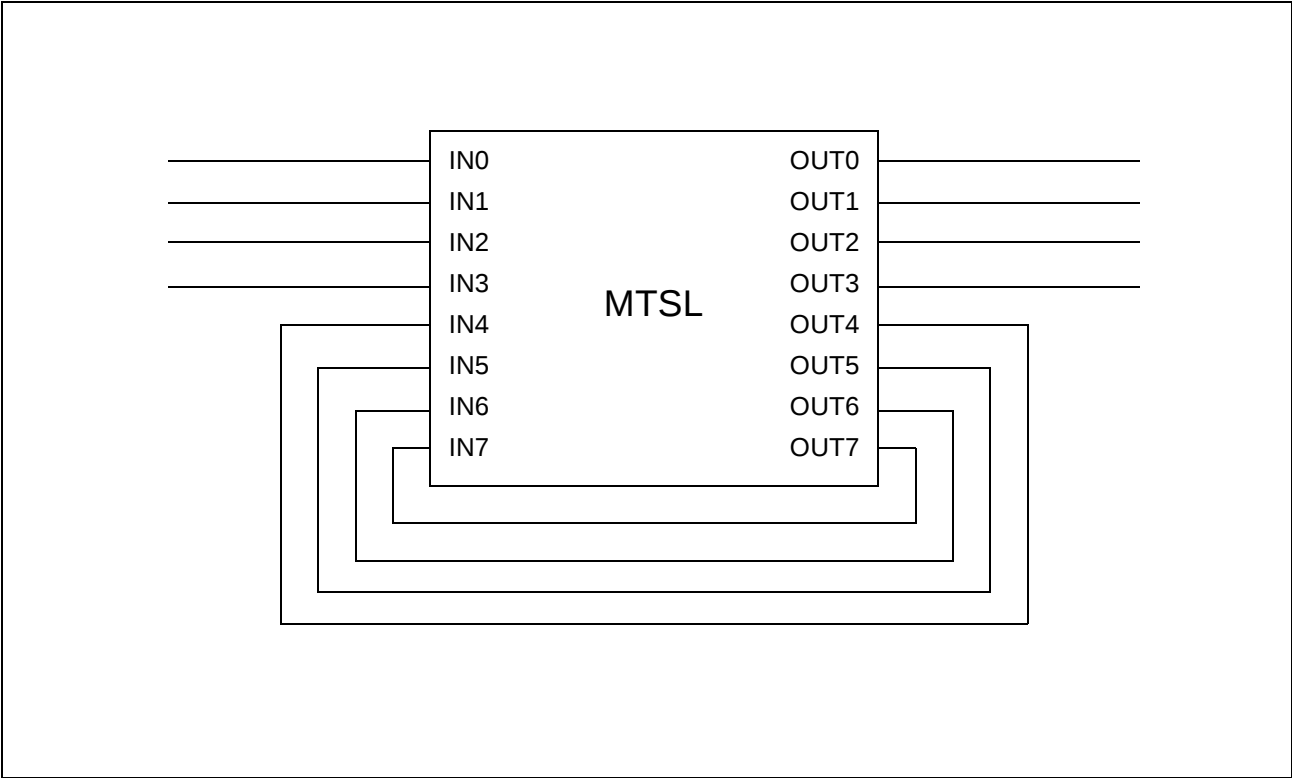
| Input TS                      | Minimal Delay<br>= 0 frame<br>for Output TS | Mminimal Delay<br>= 1 Frame<br>for Output TS | Minimal Delay<br>= 2 Frames<br>for Output TS |
|-------------------------------|---------------------------------------------|----------------------------------------------|----------------------------------------------|
| 0                             | 4 ... 63                                    | 0 ... 3                                      | —                                            |
| 1                             | 5 ... 63                                    | 0 ... 4                                      |                                              |
| 2                             | 6 ... 63                                    | 0 ... 5                                      |                                              |
| .                             | .                                           | .                                            |                                              |
| .                             | .                                           | .                                            |                                              |
| 59                            | 63                                          | 0 ... 62                                     |                                              |
| 60                            | —                                           | 0 ... 63                                     | —                                            |
| 61                            |                                             | 1 ... 63                                     | 0                                            |
| 62                            |                                             | 2 ... 63                                     | 0 ... 1                                      |
| 63                            |                                             | 3 ... 63                                     | 0 ... 2                                      |
| constant delay<br>in [frames] | 1                                           | 1                                            | 3                                            |

Frame Delay for OUT1 ... 7 with  $T_d = 3$ ,  $K = 1$ ,  $M = 1$ ,  $n = 4$ ,  $\text{maxo} = 63$ ,  $\text{maxi} = 63$ :

| Input TS                      | Minimal Delay<br>= 0 frame<br>for Output TS | Minimal Delay<br>= 1 Frame<br>for Output TS | Minimal Delay<br>= 2 Frames<br>for Output TS |
|-------------------------------|---------------------------------------------|---------------------------------------------|----------------------------------------------|
| 0                             | 3 ... 63                                    | 0 ... 2                                     | —                                            |
| 1                             | 4 ... 63                                    | 0 ... 3                                     |                                              |
| 2                             | 5 ... 63                                    | 0 ... 4                                     |                                              |
| .                             | .                                           | .                                           |                                              |
| .                             | 63                                          | .                                           |                                              |
| 60                            |                                             | 0 ... 62                                    |                                              |
| 61                            | —                                           | 0 ... 63                                    | — 0                                          |
| 62                            |                                             | 1 ... 63                                    | 0                                            |
| 63                            |                                             | 2 ... 63                                    | 0 ... 1                                      |
| constant delay<br>in [frames] | 1                                           | 1                                           | 3                                            |

6.2 Example for a MTSL Design guaranteeing Constant Frame Delay for all Time Slots

In order to achieve a constant frame delay of all PCM channels switched from input to output, the following work-around is suggested. The device is operated with a 16-MHz clock and  $8 \times 8$  MHz PCM lives for input and output respectively. The effective switch capacity is reduced to  $512 \times 512$ .



**Figure 27**  
**MTSL Operation Mode with Constant Frame Delay (frame delay = 1)**

The general idea in this configuration is to switch all input time-slots, which would be passed to the output in the same frame (input TS# + OFFSET < output TS#), to OUT [4:7] followed by a switch from IN [4:7] to the desired output time-slot at OUT [0:3]. Thus a constant frame delay of one frame can be achieved (refer to table 10).

For a 8 MHz/8 MHz-system for example the following frame delay table can be deduced from the timing diagram:

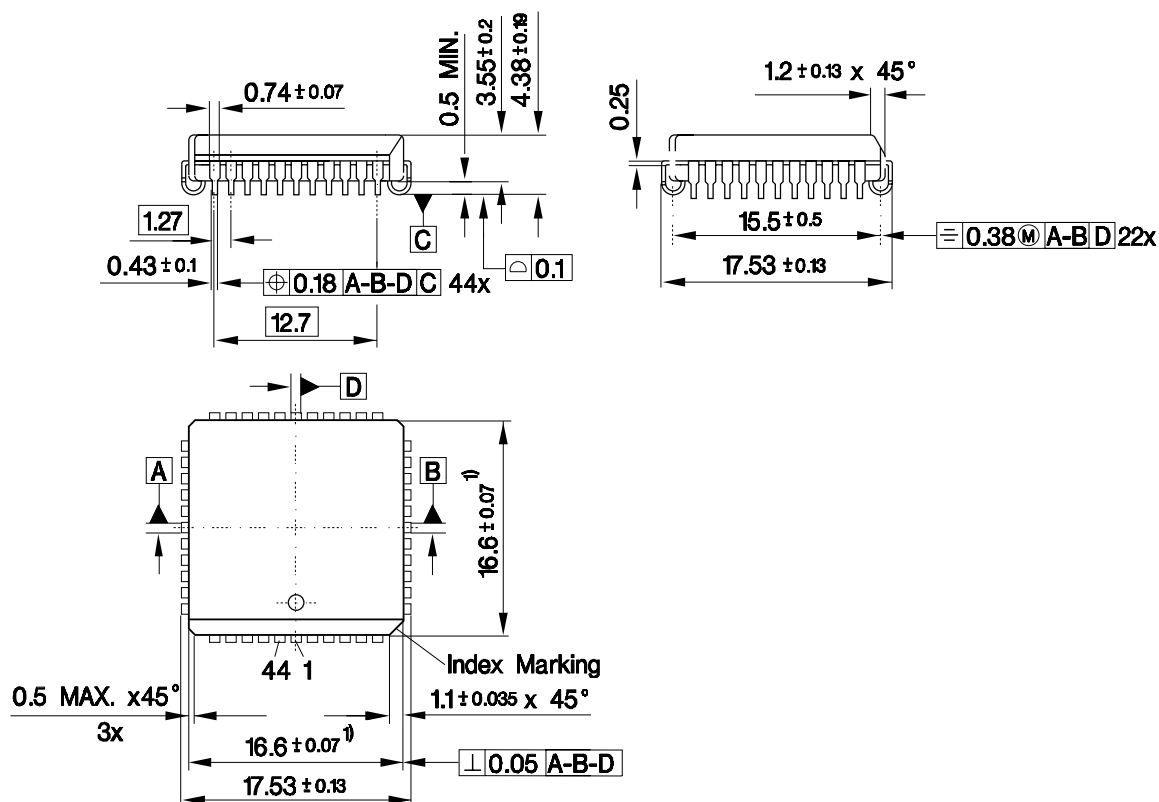
**Table 10**  
**Frame Delay**

|                                                                     | Input Time-Slot | Switched to Output Time-Slot |         |     |   |
|---------------------------------------------------------------------|-----------------|------------------------------|---------|-----|---|
| IN0 ... IN4 or<br><br>(IN4 ... IN7<br>switched to<br>OUT1 ... OUT3) | 0 – 1           | 6 – 127                      | 0 – 5   | –   |   |
|                                                                     | 2 – 3           | 8 – 127                      | 0 – 7   | –   |   |
|                                                                     | 4 – 5           | 10 – 127                     | 0 – 9   | –   |   |
|                                                                     | .               | .                            | .       | .   |   |
|                                                                     | .               | .                            | .       | .   |   |
|                                                                     | .               | .                            | .       | .   |   |
|                                                                     | 118 – 119       | 124 – 125                    | 0 – 123 | –   |   |
|                                                                     | 120 – 121       | 126 – 127                    | 0 – 125 | –   |   |
|                                                                     | 122 – 123       | –                            | 0 – 127 | –   |   |
|                                                                     | 124 – 125       | –                            | 2 – 127 | 0 – | 1 |
|                                                                     | 126 – 127       | –                            | 4 – 127 | 0 – | 3 |
|                                                                     |                 |                              |         |     |   |
| IN4 ... IN7<br>switched to<br>OUT0                                  | 0 – 1           | 7 – 127                      | 0 – 6   | –   |   |
|                                                                     | 2 – 3           | 9 – 127                      | 0 – 8   | –   |   |
|                                                                     | 4 – 5           | 11 – 127                     | 0 – 10  | –   |   |
|                                                                     | .               | .                            | .       | .   |   |
|                                                                     | .               | .                            | .       | .   |   |
|                                                                     | .               | .                            | .       | .   |   |
|                                                                     | 120             | 127                          | 0 – 126 | –   |   |
|                                                                     | 121             | –                            | 0 – 127 | –   |   |
|                                                                     | 122 – 123       | –                            | 1 – 127 | 0   |   |
|                                                                     | 124 – 125       | –                            | 3 – 127 | 0 – | 2 |
|                                                                     | 126 – 127       | –                            | 5 – 127 | 0 – | 4 |
|                                                                     |                 |                              |         |     |   |
| Delay/Number of frames                                              |                 | 0                            | 1       | 2   |   |

## 7 Package Outlines

### Plastic Package, P-LCC-44 (SMD)

(Plastic Leaded Chip Carrier)



1) Does not include plastic or metal protrusion of 0.15 max. per side

GPL05102

### Sorts of Packing

Package outlines for tubes, trays etc. are contained in our Data Book "Package Information".

SMD = Surface Mounted Device

Dimensions in mm