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# SINGLE CHANNEL E1 SHORT HAUL LINE INTERFACE UNIT

**IDT82V2051E**

## FEATURES

- **Single channel E1 short haul line interfaces**
- **Supports HPS (Hitless Protection Switching) for 1+1 protection without external relays**
- **Single 3.3 V power supply with 5 V tolerance on digital interfaces**
- **Meets or exceeds specifications in**
  - ANSI T1.102
  - ITU I.431, G.703, G.736, G.775 and G.823
  - ETSI 300-166, 300-233 and TBR12/13
- **Software programmable or hardware selectable on:**
  - Wave-shaping templates
  - Line terminating impedance (75 Ω/120 Ω)
  - Adjustment of arbitrary pulse shape
  - JA (Jitter Attenuator) position (receive path or transmit path)
  - Single rail/dual rail system interfaces
  - HDB3/AMI line encoding/decoding
  - Active edge of transmit clock (TCLK) and receive clock (RCLK)
  - Active level of transmit data (TDATA) and receive data (RDATA)
  - Receiver or transmitter power down
  - High impedance setting for line drivers
  - PRBS (Pseudo Random Bit Sequence) generation and detection with $2^{15}$-1 PRBS polynomials
  - 16-bit BPV (Bipolar Pulse Violation) /Excess Zero/PRBS error counter
  - Analog loopback, Digital loopback, Remote loopback
- **Short circuit protection and internal protection diode for line drivers**
- **AIS (Alarm Indication Signal) detection**
- **Supports serial control interface, Motorola and Intel Multiplexed interfaces and hardware control mode**
- **Pin compatibe to 82V2081 T1/E1/J1 Long Haul/Short Haul LIU and 82V2041E T1/E1/J1 Short Haul LIU**
- **Package:**
  **Available in 44-pin TQFP packages**
  **Green package options available**

## DESCRIPTION

The IDT82V2051E is a single channel E1 Line Interface Unit. The IDT82V2051E performs clock/data recovery, AMI/HDB3 line decoding and detects and reports the LOS conditions. An integrated Adaptive Equalizer is available to increase the receive sensitivity and enable programming of LOS levels. In transmit path, there is an AMI/HDB3 encoder and Waveform Shaper. There is one Jitter Attenuator, which can be placed in either the receive path or the transmit path. The Jitter Attenuator can also be disabled. The IDT82V2051E supports both Single Rail and Dual Rail system interfaces. To facilitate the network maintenance, a PRBS generation/detection circuit is integrated in the chip, and different types of loopbacks can be set according to the applications. Two different kinds of line terminating impedance, 75 Ω and 120 Ω are selectable. The chip also provides driver short-circuit protection and internal protection diode. The chip can be controlled by either software or hardware.

The IDT82V2051E can be used in LAN, WAN, Routers, Wireless Base Stations, IADs, IMAs, IMAPs, Gateways, Frame Relay Access Devices, CSU/DSU equipment, etc.

# FUNCTIONAL BLOCK DIAGRAM

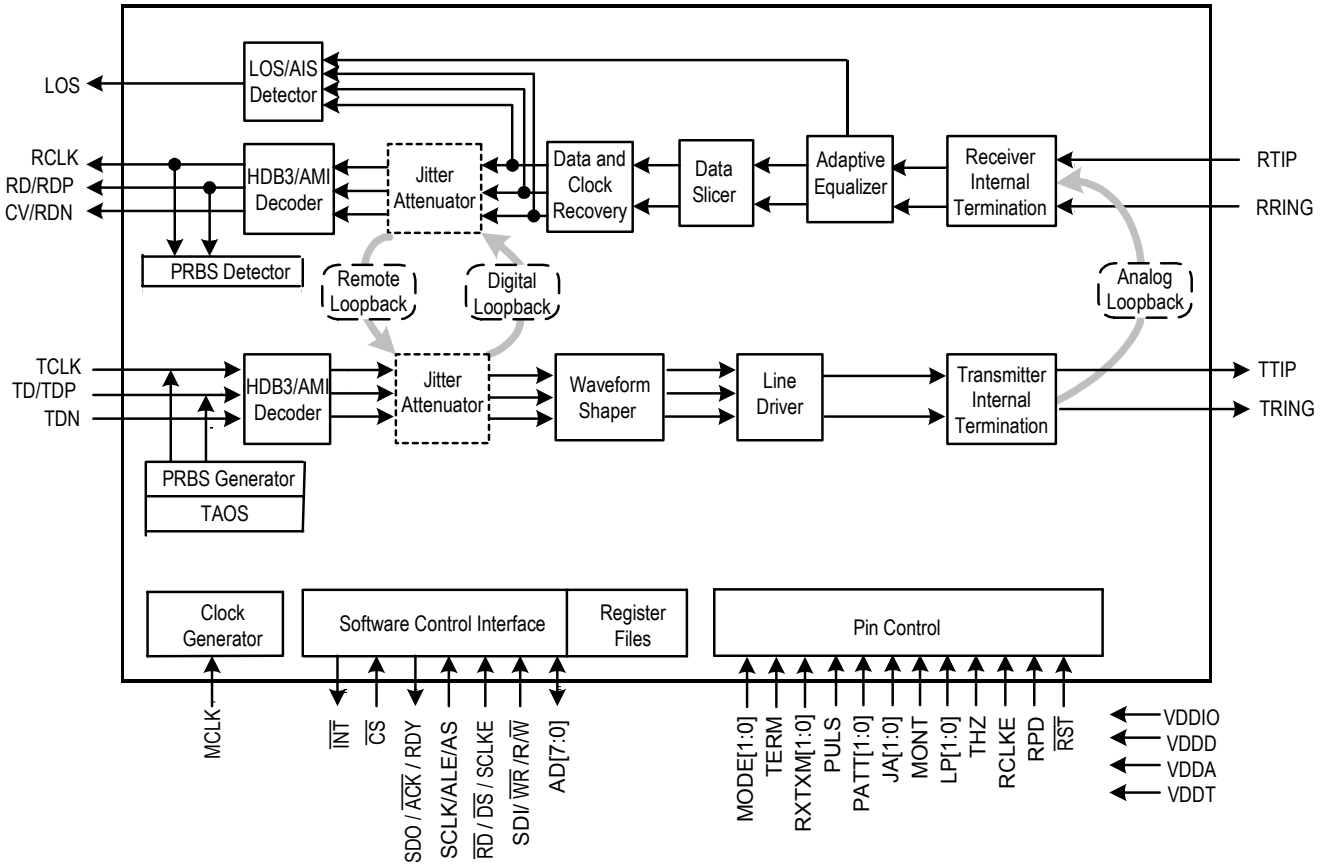


***Figure-1 Block Diagram***

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# 1 IDT82V2051E PIN CONFIGURATIONS

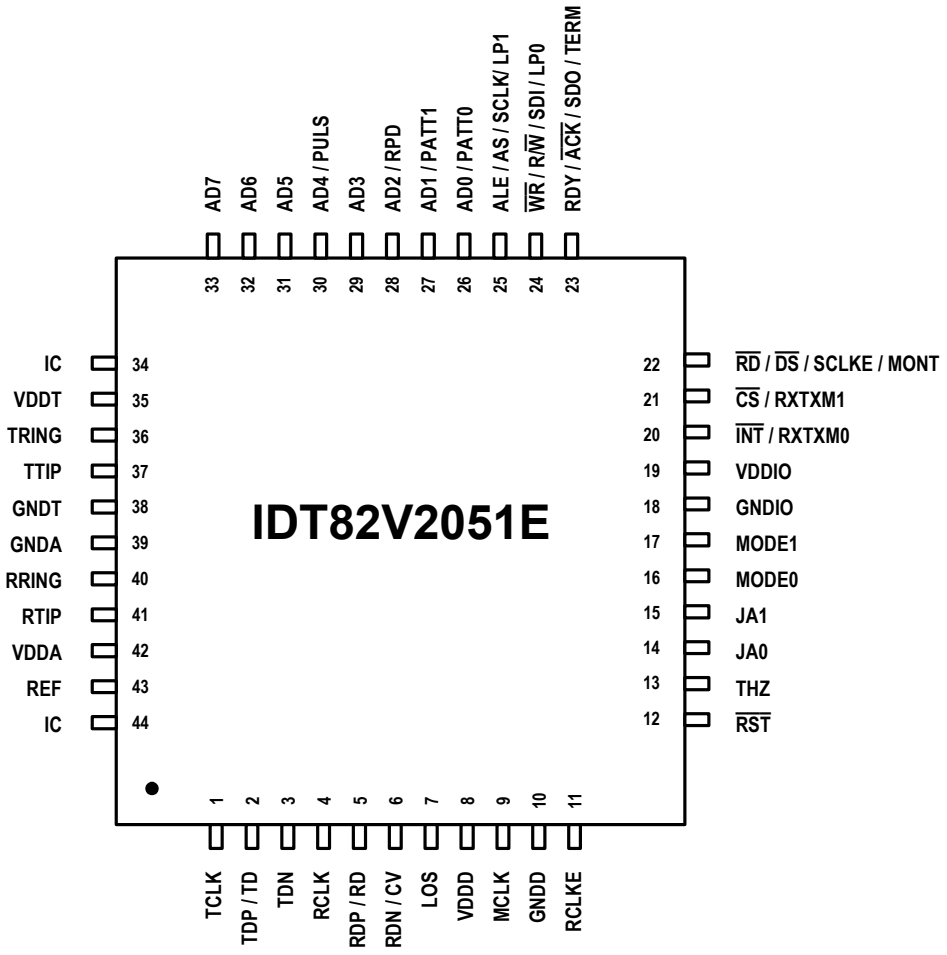



*Figure-2 IDT82V2051E TQFP44 Package Pin Assignment*

# 2 PIN DESCRIPTION

**Table-1 Pin Description**

<table>
<tr><th>Name</th><th>Type</th><th>Pin No.</th><th>Description</th></tr>
<tr><td>TTIP<br>TRING</td><td>Analog output</td><td>37<br>36</td><td>TTIP/TRING: Transmit Bipolar Tip/Ring<br>These pins are the differential line driver outputs. They will be in high impedance state under the following conditions:<br>• THZ pin is high;<br>• THZ bit is set to 1;<br>• Loss of MCLK;<br>• Loss of TCLK (exceptions: Remote Loopback; transmit internal pattern by MCLK);<br>• Transmit path power down;<br>• After software reset; pin reset and power on.</td></tr>
<tr><td>RTIP<br>RRING</td><td>Analog input</td><td>41<br>40</td><td>RTIP/RRING: Receive Bipolar Tip/Ring<br>These signals are the differential receiver inputs.</td></tr>
<tr><td>TD/TDP<br>TDN</td><td>I</td><td>2<br>3</td><td>TD: Transmit Data<br>When the device is in single rail mode, the NRZ data to be transmitted is input on this pin. Data on TD pin is sampled into the device on the active edge of TCLK and is encoded by AMI or HDB3 line code rules before being transmitted. In this mode, TDN should be connected to ground.<br><br>TDP/TDN: Positive/Negative Transmit Data<br>When the device is in dual rail mode, the NRZ data to be transmitted for positive/negative pulse is input on these pins. Data on TDP/TDN pin is sampled into the device on the active edge of TCLK. The line code in dual rail mode is as follows:<br><br>
<table>
<tr><th>TDP</th><th>TDN</th><th>Output Pulse</th></tr>
<tr><td>0</td><td>0</td><td>Space</td></tr>
<tr><td>0</td><td>1</td><td>Positive Pulse</td></tr>
<tr><td>1</td><td>0</td><td>Negative Pulse</td></tr>
<tr><td>1</td><td>1</td><td>Space</td></tr>
</table>
</td></tr>
<tr><td>TCLK</td><td>I</td><td>1</td><td>TCLK: Transmit Clock input<br>This pin inputs a 2.048 MHz transmit clock. The transmit data at TD/TDP or TDN is sampled into the device on the active edge of TCLK. If TCLK is missing[1] and the TCLK missing interrupt is not masked, an interrupt will be generated.</td></tr>
<tr><td>RD/RDP<br>CV/RDN</td><td>O</td><td>5<br>6</td><td>RD: Receive Data output<br>In single rail mode, this pin outputs NRZ data. The data is decoded according to AMI or HDB3 line code rules.<br><br>CV: Code Violation indication<br>In single rail mode, the BPV/CV code violation will be reported by driving the CV pin to high level for a full clock cycle. HDB3 line code violation can be indicated if the HDB3 decoder is enabled. When AMI decoder is selected, bipolar violation will be indicated.<br>In hardware control mode, the EXZ, BPV/CV errors in received data stream are always monitored by the CV pin if single rail mode is chosen.<br><br>RDP/RDN: Positive/Negative Receive Data output<br>In dual rail mode, this pin outputs the re-timed NRZ data when CDR is enabled, or directly outputs the raw RZ slicer data if CDR is bypassed.<br><br>Active edge and level select:<br>Data on RDP/RDN or RD is clocked with either the rising or the falling edge of RCLK. The active polarity is also selectable.</td></tr>
<tr><td>RCLK</td><td>O</td><td>4</td><td>RCLK: Receive Clock output<br>This pin outputs a 2.048 MHz receive clock. Under LOS condition with AIS enabled (bit AISE=1), RCLK is derived from MCLK. In clock recovery mode, this signal provides the clock recovered from the RTIP/RRING signal. The receive data (RD in single rail mode or RDP and RDN in dual rail mode) is clocked out of the device on the active edge of RCLK. If clock recovery is bypassed, RCLK is the exclusive OR (XOR) output of the dual rail slicer data RDP and RDN. This signal can be used in applications with external clock recovery circuitry.</td></tr>
</table>

**Notes:**

1. TCLK missing: the state of TCLK continues to be high level or low level over 70 MCLK cycles.

## Table-1 Pin Description (Continued)

<table>
<tr><th>Name</th><th>Type</th><th>Pin No.</th><th>Description</th></tr>
<tr><td>MCLK</td><td>I</td><td>9</td><td>MCLK: Master Clock input<br>A built-in clock system that accepts a 2.048MHz reference clock. This reference clock is used to generate several internal reference signals:<br>• Timing reference for the integrated clock recovery unit.<br>• Timing reference for the integrated digital jitter attenuator.<br>• Timing reference for microcontroller interface.<br>• Generation of RCLK signal during a loss of signal condition.<br>• Reference clock to transmit All Ones, all zeros and PRBS pattern. Note that for ATAO and AIS, MCLK is always used as the reference clock.<br>• Reference clock during the Transmit All Ones (TAO) condition or sending PRBS in hardware control mode.<br>The loss of MCLK will turn TTIP/TRING into high impedance status.</td></tr>
<tr><td>LOS</td><td>O</td><td>7</td><td>LOS: Loss of Signal Output<br>This is an active high signal used to indicate the loss of received signal. When LOS pin becomes high, it indicates the loss of received signal. The LOS pin will become low automatically when valid received signal is detected again. The criteria of loss of signal are described in 3.5 Los And AIS Detection.</td></tr>
<tr><td>REF</td><td>I</td><td>43</td><td>REF: reference resister<br>An external resistor (3 KΩ, 1%) is used to connect this pin to ground to provide a standard reference current for internal circuit.</td></tr>
<tr><td>MODE1<br>MODE0</td><td>I</td><td>17<br>16</td><td>MODE[1:0]: operation mode of Control interface select<br>The level on this pin determines which control mode is used to control the device as follows:<br><table><tr><th>MODE[1:0]</th><th>Control Interface mode</th></tr><tr><td>00</td><td>Hardware interface</td></tr><tr><td>01</td><td>Serial Microcontroller Interface</td></tr><tr><td>10</td><td>Parallel –Multiplexed -Motorola Interface</td></tr><tr><td>11</td><td>Parallel –Multiplexed -Intel Interface</td></tr></table>• The serial microcontroller Interface consists of $\overline{CS}$, SCLK, SCLKE, SDI, SDO and $\overline{INT}$ pins. SCLKE is used for the selection of the active edge of SCLK.<br>• The parallel multiplexed microcontroller interface consists of $\overline{CS}$, AD[7:0], $\overline{DS}$/$\overline{RD}$, R/$\overline{W}$/$\overline{WR}$, ALE/AS, $\overline{ACK}$/RDY and $\overline{INT}$ pins. (refer to 3.11 Microcontroller Interfaces for details)<br>• Hardware interface consists of PULS, THZ, RCLKE, LP[1:0], PATT[1:0], JA[1:0], MONT, TERM, RPD, MODE[1:0] and RXTXM[1:0]</td></tr>
<tr><td>RCLKE</td><td>I</td><td>11</td><td>RCLKE: the active edge of RCLK select<br>In hardware control mode, this pin selects the active edge of RCLK<br>• L= select the rising edge as the active edge of RCLK<br>• H= select the falling edge as the active edge of RCLK<br>In software control mode, this pin should be connected to GNDIO.</td></tr>
<tr><td>$\overline{CS}$<br><br><br>RXTXM1</td><td>I</td><td>21</td><td>$\overline{CS}$: Chip Select<br>In serial or parallel microcontroller interface mode, this is the active low enable signal. A low level on this pin enables serial or parallel microcontroller interface.<br><br>RXTXM[1:0]: Receive and transmit path operation mode select<br>In hardware control mode, these pins are used to select the single rail or dual rail operation modes as well as AMI or HDB3 line coding:<br>• 00= single rail with HDB3 coding<br>• 01= single rail with AMI coding<br>• 10= dual rail interface with CDR enabled<br>• 11= slicer mode (dual rail interface with CDR disabled)</td></tr>
</table>

**Table-1 Pin Description (Continued)**

| Name | Type | Pin No. | Description |
|---|---|---|---|
| $\overline{\text{INT}}$ | O | 20 | **$\overline{\text{INT}}$: Interrupt Request**<br>In software control mode, this pin outputs the general interrupt request for all interrupt sources. These interrupt sources can be masked individually via registers (**INTM0, 14H**) and (**INTM1, 15H**). The interrupt status is reported via the registers (**INTS0, 19H**) and (**INTS1, 1AH**).<br>Output characteristics of this pin can be defined to be push-pull (active high or active low) or open-drain (active low) by setting INT_PIN[1:0] (**GCF, 02H**). |
| RXTXM0 | I | | **RXTXM0**<br>See RXTXM1 above. |
| SCLK | I | 25 | **SCLK: Shift Clock**<br>In serial microcontroller interface mode, this signal is the shift clock for the serial interface. Configuration data on SDI pin is sampled on the rising edge of SCLK. Configuration and status data on SDO pin is clocked out of the device on the falling edge of SCLK if SCLKE pin is high, or on the rising edge of SCLK if SCLKE pin is low. |
| ALE | | | **ALE: Address Latch Enable**<br>In parallel microcontroller interface mode with multiplexed Intel interface, the address on AD[7:0] is sampled into the device on the falling edge of ALE. |
| AS | | | **AS: Address Strobe**<br>In parallel microcontroller interface mode with multiplexed Motorola interface, the address on AD[7:0] is latched into the device on the falling edge of AS. |
| LP1 | | | **LP[1:0]: Loopback mode select**<br>When the chip is configured by hardware, this pin is used to select loopback operation modes:<br>• 00= no loopback<br>• 01= analog loopback<br>• 10= digital loopback<br>• 11= remote loopback |
| SDI | I | 24 | **SDI: Serial Data Input**<br>In serial microcontroller interface mode, this signal is the input data to the serial interface. Configuration data at SDI pin is sampled by the device on the rising edge of SCLK. |
| $\overline{\text{WR}}$ | | | **$\overline{\text{WR}}$: Write Strobe**<br>In Intel parallel multiplexed interface mode, this pin is asserted low by the microcontroller to initiate a write cycle. The data on AD[7:0] is sampled into the device in a write operation. |
| R/$\overline{\text{W}}$ | | | **R/$\overline{\text{W}}$: Read/Write Select**<br>In Motorola parallel multiplexed interface mode, this pin is low for write operation and high for read operation. |
| LP0 | | | **LP0**<br>See LP1 above. |

**Table-1 Pin Description (Continued)**

<table>
<tr><th>Name</th><th>Type</th><th>Pin No.</th><th>Description</th></tr>
<tr><td>SDO</td><td>O</td><td>23</td><td>SDO: Serial Data Output<br>In serial microcontroller interface mode, this signal is the output data of the serial interface. Configuration or Status data at SDO pin is clocked out of the device on the falling edge of SCLK if SCLKE pin is high, or on the rising edge of SCLK if SCLKE pin is low.</td></tr>
<tr><td>$\overline{ACK}$</td><td></td><td></td><td>$\overline{ACK}$: Acknowledge Output<br>In Motorola parallel mode interface, the low level on this pin means:<br>• The valid information is on the data bus during a read operation.<br>• The write data has been accepted during a write cycle.</td></tr>
<tr><td>RDY</td><td></td><td></td><td>RDY: Ready signal output<br>In Intel parallel mode interface, the low level on this pin means a read or write operation is in progress; a high acknowledges a read or write operation has been completed.</td></tr>
<tr><td>TERM</td><td>I</td><td></td><td>TERM: Internal or external termination select in hardware mode<br>This pin selects internal or external impedance matching for both receiver and transmitter.<br>• 0 = ternary interface with external impedance matching network<br>• 1 = ternary interface with internal impedance matching network</td></tr>
<tr><td>SCLKE</td><td>I</td><td>22</td><td>SCLKE: Serial Clock Edge Select<br>In serial microcontroller interface mode, this signal selects the active edge of SCLK for outputting SDO. The output data is valid after some delay from the active clock edge. It can be sampled on the opposite edge of the clock. The active clock edge which clocks the data out of the device is selected as shown below:<br><table><tr><th>SCLKE</th><th>SCLK</th></tr><tr><td>Low</td><td>Rising edge is the active edge.</td></tr><tr><td>High</td><td>Falling edge is the active edge.</td></tr></table></td></tr>
<tr><td>$\overline{RD}$</td><td></td><td></td><td>$\overline{RD}$: Read Strobe<br>In Intel parallel multiplexed interface mode, the data is driven to AD[7:0] by the device during low level of $\overline{RD}$ in a read operation.</td></tr>
<tr><td>$\overline{DS}$</td><td></td><td></td><td>$\overline{DS}$: Data Strobe<br>In Motorola parallel multiplexed interface mode, this signal is the data strobe of the parallel interface. In a write operation (R/$\overline{W}$ = 0), the data on AD[7:0] is sampled into the device. In a read operation (R/$\overline{W}$ = 1), the data is driven to AD[7:0] by the device.</td></tr>
<tr><td>MONT</td><td></td><td></td><td>MONT: Receive Monitor gain select<br>In hardware control mode with ternary interface, this pin selects the receive monitor gain of receiver:<br>0= 0 dB<br>1= 26 dB</td></tr>
<tr><td>AD7</td><td>I/O</td><td>33</td><td>AD7: Address/Data Bus bit7<br>In Intel/Motorola multiplexed interface mode, this signal is the multiplexed bi-directional address/data bus of the microcontroller interface.<br>In serial microcontroller interface mode, this pin should be connected to ground through a 10 kΩ resistor.<br><br>In Hardware mode, this pin has to be tied to GND.</td></tr>
<tr><td>AD6</td><td>I/O</td><td>32</td><td>AD6: Address/Data Bus bit6<br>In Intel/Motorola multiplexed interface mode, this signal is the multiplexed bi-directional address/data bus of the microcontroller interface.<br>In serial microcontroller interface mode, this pin should be connected to ground through a 10 kΩ resistor.<br><br>In Hardware mode, this pin has to be tied to GND.</td></tr>
</table>

## Table-1 Pin Description (Continued)

| Name | Type | Pin No. | Description |
|---|---|---|---|
| AD5 | I/O | 31 | **AD5: Address/Data Bus bit5**<br>In Intel/Motorola multiplexed interface mode, this signal is the multiplexed bi-directional address/data bus of the microcontroller interface.<br>In serial microcontroller interface mode, this pin should be connected to ground through a 10 kΩ resistor.<br><br>In Hardware mode, this pin has to be tied to GND. |
| AD4 | I/O | 30 | **AD4: Address/Data Bus bit4**<br>In Intel/Motorola multiplexed interface mode, this signal is the multiplexed bi-directional address/data bus of the microcontroller interface.<br>In serial microcontroller interface mode, this pin should be connected to ground through a 10 kΩ resistor.<br><br>**PULS: this pin is used to select the following functions in hardware control mode:**<br>• Transmit pulse template<br>• Internal termination impedance (75 Ω / 120 Ω)<br>Refer to 5 Hardware Control Pin Summary for details. |
| AD3 | I/O | 29 | **AD3: Address/Data Bus bit3**<br>In Intel/Motorola multiplexed interface mode, this signal is the multiplexed bi-directional address/data bus of the microcontroller interface.<br>In serial microcontroller interface mode, this pin should be connected to ground through a 10 kΩ resistor. |
| AD2<br><br>RPD | I/O<br><br>I | 28 | **AD2: Address/Data Bus bit2**<br>In Intel/Motorola multiplexed interface mode, this signal is the multiplexed bi-directional address/data bus of the microcontroller interface.<br>In serial microcontroller interface mode, this pin should be connected to ground through a 10 kΩ resistor.<br><br>**RPD: Receiver power down control in hardware control mode**<br>• 0= normal operation<br>• 1= receiver power down |
| AD1<br><br>PATT1 | I/O<br><br>I | 27 | **AD1: Address/Data Bus bit1**<br>In Intel/Motorola multiplexed interface mode, this signal is the multiplexed bi-directional address/data bus of the microcontroller interface.<br>In serial microcontroller interface mode, this pin should be connected to ground through a 10 kΩ resistor.<br><br>**PATT[1:0]: Transmit pattern select**<br>In hardware control mode, this pin selects the transmit pattern<br>• 00 = normal<br>• 01= All Ones<br>• 10= PRBS<br>• 11= transmitter power down |
| AD0<br><br>PATT0 | I/O<br><br>I | 26 | **AD0: Address/Data Bus bit0**<br>In Intel/Motorola multiplexed interface mode, this signal is the multiplexed bi-directional address/data bus of the microcontroller interface.<br>In serial microcontroller interface mode, this pin should be connected to ground through a 10 kΩ resistor.<br><br>See above. |
| JA1 | I | 15 | **JA[1:0]: Jitter attenuation position, bandwidth and the depth of FIFO select (only used for hardware control mode)**<br>• 00 = JA is disabled<br>• 01 = JA in receiver, broad bandwidth, FIFO=64 bits<br>• 10 = JA in receiver, narrow bandwidth, FIFO=128 bits<br>• 11 = JA in transmitter, narrow bandwidth, FIFO=128 bits<br>In software control mode, this pin should be connected to ground. |
| JA0 | I | 14 | See above. |

**Table-1 Pin Description (Continued)**

| Name | Type | Pin No. | Description |
|---|---|---|---|
| $\overline{RST}$ | I | 12 | **$\overline{RST}$: Hardware reset**<br>The chip is forced to reset state if a low signal is input on this pin for more than 100 ns. MCLK must be active during reset. |
| THZ | I | 13 | **THZ: Transmitter Driver High Impedance Enable**<br>This signal enables or disables transmitter driver. A low level on this pin enables the driver while a high level on this pin places driver in high impedance state. Note that the functionality of the internal circuits is not affected by this signal. |
| **Power Supplies and Grounds** | | | |
| VDDIO | - | 19 | **3.3 V I/O power supply** |
| GNDIO | - | 18 | **I/O ground** |
| VDDT | - | 35 | **3.3 V power supply for transmitter driver** |
| GNDT | - | 38 | **Analog ground for transmitter driver** |
| VDDA | - | 42 | **3.3 V analog core power supply** |
| GNDA | - | 39 | **Analog core ground** |
| VDDD | - | 8 | **Digital core power supply** |
| GNDD | - | 10 | **Digital core ground** |
| **Others** | | | |
| IC | - | 34 | **IC: Internal connection**<br>Internal Use. This pin should be left open when in normal operation. |
| IC | - | 44 | **IC: Internal connection**<br>Internal Use. This pin should be connected to ground when in normal operation. |

# 3 FUNCTIONAL DESCRIPTION

## 3.1 CONTROL MODE SELECTION

The IDT82V2051E can be configured by software or by hardware. The software control mode supports Serial Control Interface, Motorola Multiplexed Control Interface and Intel Multiplexed Control Interface. The Control mode is selected by MODE1 and MODE0 pins as follows:

| | Control Interface mode |
|---|---|
| 00 | Hardware interface |
| 01 | Serial Microcontroller Interface. |
| 10 | Parallel –Multiplexed -Motorola Interface |
| 11 | Parallel –Multiplexed -Intel Interface |

- The serial microcontroller Interface consists of $\overline{CS}$, SCLK, SCLKE, SDI, SDO and $\overline{INT}$ pins. SCLKE is used for the selection of active edge of SCLK.
- The parallel Multiplexed microcontroller Interface consists of $\overline{CS}$, AD[7:0], $\overline{DS}$/$\overline{RD}$, R/$\overline{W}$/$\overline{WR}$, ALE/AS, $\overline{ACK}$/RDY and $\overline{INT}$ pins.
- Hardware interface consists of PULS, THZ, RCLKE, LP[1:0], PATT[1:0], JA[1:0], MONT, TERM, RPD, MODE[1:0] and RXTXM[1:0]. Refer to 5 Hardware Control Pin Summary for details about hardware control.

## 3.2 TRANSMIT PATH

The transmit path of IDT82V2051E consists of an Encoder, an optional Jitter Attenuator, a Waveform Shaper, a Line Driver and a Programmable Transmit Termination.

### 3.2.1 TRANSMIT PATH SYSTEM INTERFACE

The transmit path system interface consists of TCLK pin, TD/TDP pin and TDN pin. TCLK is a 2.048 MHz clock. If TCLK is missing for more than 70 MCLK cycles, an interrupt will be generated if it is not masked.

Transmit data is sampled on the TD/TDP and TDN pins by the active edge of TCLK. The active edge of TCLK can be selected by the TCLK_SEL bit (**TCF0, 05H**). And the active level of the data on TD/TDP and TDN can be selected by the TD_INV bit (**TCF0, 05H**). In hardware control mode, the falling edge of TCLK and the active high of transmit data are always used.

The transmit data from the system side can be provided in two different ways: Single Rail and Dual Rail. In Single Rail mode, only TD pin is used for transmitting data and the T_MD[1] bit (**TCF0, 05H**) should be set to '0'. In Dual Rail Mode, both TDP pin and TDN pin are used for transmitting data, the T_MD[1] bit (**TCF0, 05H**) should be set to '1'.

### 3.2.2 ENCODER

In Single Rail mode, the Encoder can be configured to be a HDB3 encoder or an AMI encoder by setting T_MD[0] bit (**TCF0, 05H**).

In Dual Rail mode, the Encoder is by-passed. In Dual Rail mode, a logic '1' on the TDP pin and a logic '0' on the TDN pin results in a negative pulse on the TTIP/TRING; a logic '0' on TDP pin and a logic '1' on TDN pin results in a positive pulse on the TTIP/TRING. If both TDP and TDN are high or low, the TTIP/TRING outputs a space (Refer to TD/TDP, TDN Pin Description).

In hardware control mode, the operation mode of receive and transmit path can be selected by setting RXTXM1 and RXTXM0 pins. Refer to 5 Hardware Control Pin Summary for details.

### 3.2.3 PULSE SHAPER

The IDT82V2051E provides two ways of manipulating the pulse shape before sending it. One is to use preset pulse templates, the other is to use user-programmable arbitrary waveform template.

In software control mode, the pulse shape can be selected by setting the related registers.

In hardware control mode, the pulse shape can be selected by setting PULS pin. Refer to 5 Hardware Control Pin Summary for details.

#### 3.2.3.1 PRESET PULSE TEMPLATES

The pulse shape is shown in Figure-3 according to the G.703 and the measuring diagram is shown in Figure-4. In internal impedance matching mode, if the cable impedance is 75 Ω, the PULS[3:0] bits (**TCF1, 06H**) should be set to '0000'; if the cable impedance is 120 Ω, the PULS[3:0] bits (**TCF1, 06H**) should be set to '0001'. In external impedance matching mode, for both E1/75 Ω and E1/120 Ω cable impedance, PULS[3:0] should be set to '0001'.

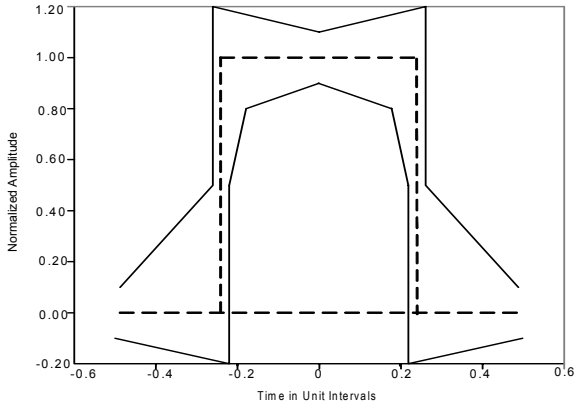



***Figure-3 E1 Waveform Template Diagram***

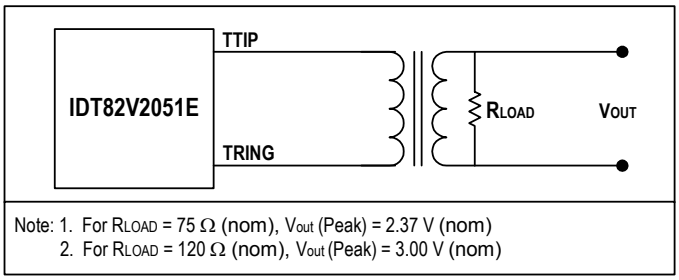



***Figure-4 E1 Pulse Template Test Circuit***

#### 3.2.3.2 USER-PROGRAMMABLE ARBITRARY WAVEFORM

When the PULS[3:0] bits are set to '11xx', user-programmable arbitrary waveform generator mode can be used. This allows the transmitter performance to be tuned for a wide variety of line condition or special application.

Each pulse shape can extend up to 4 UIs (Unit Interval), addressed by UI[1:0] bits (**TCF3, 08H**) and each UI is divided into 16 sub-phases, addressed by the SAMP[3:0] bits (**TCF3, 08H**). The pulse amplitude of each phase is represented by a binary byte, within the range from +63 to -63, stored in WDAT[6:0] bits (**TCF4, 09H**) in signed magnitude form. The most positive number +63 (D) represents the positive maximum amplitude of the transmit pulse while the most negative number -63 (D) represents the maximum negative amplitude of the transmit pulse. Therefore, up to 64 bytes are used.

There are two standard templates which are stored in an on-chip ROM. User can select one of them as reference and make some changes to get the desired waveform.

User can change the wave shape and the amplitude to get the desired pulse shape. In order to do this, firstly, users can choose a set of waveform value from the following two tables, which is the most similar to the desired pulse shape. Table-2 and Table-3 list the sample data and scaling data of each of the two templates. Then modify the corresponding sample data to get the desired transmit pulse shape.

Secondly, through the value of SCAL[5:0] bits increased or decreased by 1, the pulse amplitude can be scaled up or down at the percentage ratio against the standard pulse amplitude if needed. For different pulse shapes, the value of SCAL[5:0] bits and the scaling percentage ratio are different. The following two tables list these values.

Do the followings step by step, the desired waveform can be programmed, based on the selected waveform template:

(1).Select the UI by UI[1:0] bits (**TCF3, 08H**)

(2).Specify the sample address in the selected UI by SAMP [3:0] bits (**TCF3, 08H**)

(3).Write sample data to WDAT[6:0] bits (**TCF4, 09H**). It contains the data to be stored in the RAM, addressed by the selected UI and the corresponding sample address.

(4).Set the RW bit (**TCF3, 08H**) to '0' to implement writing data to RAM, or to '1' to implement read data from RAM

(5).Implement the Read from RAM/Write to RAM by setting the DONE bit (**TCF3, 08H**)

Repeat the above steps until all the sample data are written to or read from the internal RAM.

(6).Write the scaling data to SCAL[5:0] bits (**TCF2, 07H**) to scale the amplitude of the waveform based on the selected standard pulse amplitude

When more than one UI is used to compose the pulse template, the overlap of two consecutive pulses could make the pulse amplitude overflow (exceed the maximum limitation) if the pulse amplitude is not set properly. This overflow is captured by DAC_OV_IS bit (**INTS1, 1AH**), and, if enabled by the DAC_OV_IM bit (**INTM1, 15H**), an interrupt will be generated.

The following tables give all the sample data based on the preset pulse templates in detail for reference. For preset pulse templates, scaling up/down against the pulse amplitude is not supported.

1.Table-2 Transmit Waveform Value For E1 75 Ω

2.Table-3 Transmit Waveform Value For E1 120 Ω

**Table-2 Transmit Waveform Value For E1 75 ohm**

| Sample | UI 1 | UI 2 | UI 3 | UI 4 |
|---|---|---|---|---|
| 1 | 0000000 | 0000000 | 0000000 | 0000000 |
| 2 | 0000000 | 0000000 | 0000000 | 0000000 |
| 3 | 0000000 | 0000000 | 0000000 | 0000000 |
| 4 | 0001100 | 0000000 | 0000000 | 0000000 |
| 5 | 0110000 | 0000000 | 0000000 | 0000000 |
| 6 | 0110000 | 0000000 | 0000000 | 0000000 |
| 7 | 0110000 | 0000000 | 0000000 | 0000000 |
| 8 | 0110000 | 0000000 | 0000000 | 0000000 |
| 9 | 0110000 | 0000000 | 0000000 | 0000000 |
| 10 | 0110000 | 0000000 | 0000000 | 0000000 |
| 11 | 0110000 | 0000000 | 0000000 | 0000000 |
| 12 | 0110000 | 0000000 | 0000000 | 0000000 |
| 13 | 0000000 | 0000000 | 0000000 | 0000000 |
| 14 | 0000000 | 0000000 | 0000000 | 0000000 |
| 15 | 0000000 | 0000000 | 0000000 | 0000000 |
| 16 | 0000000 | 0000000 | 0000000 | 0000000 |
| SCAL[5:0] = 100001 (default), One step change of this value of SCAL[5:0] results in 3% scaling up/down against the pulse amplitude. | | | | |

**Table-3 Transmit Waveform Value For E1 120 ohm**

| Sample | UI 1 | UI 2 | UI 3 | UI 4 |
|---|---|---|---|---|
| 1 | 0000000 | 0000000 | 0000000 | 0000000 |
| 2 | 0000000 | 0000000 | 0000000 | 0000000 |
| 3 | 0000000 | 0000000 | 0000000 | 0000000 |
| 4 | 0001111 | 0000000 | 0000000 | 0000000 |
| 5 | 0111100 | 0000000 | 0000000 | 0000000 |
| 6 | 0111100 | 0000000 | 0000000 | 0000000 |
| 7 | 0111100 | 0000000 | 0000000 | 0000000 |
| 8 | 0111100 | 0000000 | 0000000 | 0000000 |
| 9 | 0111100 | 0000000 | 0000000 | 0000000 |
| 10 | 0111100 | 0000000 | 0000000 | 0000000 |
| 11 | 0111100 | 0000000 | 0000000 | 0000000 |
| 12 | 0111100 | 0000000 | 0000000 | 0000000 |
| 13 | 0000000 | 0000000 | 0000000 | 0000000 |
| 14 | 0000000 | 0000000 | 0000000 | 0000000 |
| 15 | 0000000 | 0000000 | 0000000 | 0000000 |
| 16 | 0000000 | 0000000 | 0000000 | 0000000 |
| SCAL[5:0] = 100001 (default), One step change of this value of SCAL[5:0] results in 3% scaling up/down against the pulse amplitude. | | | | |

### 3.2.4 TRANSMIT PATH LINE INTERFACE

The transmit line interface consists of TTIP pin and TRING pin. The impedance matching can be realized by the internal impedance matching circuit or the external impedance matching circuit. If T_TERM[2] is set to '0', the internal impedance matching circuit will be selected. In this case, the T_TERM[1:0] bits (**TERM, 03H**) can be set to choose 75 Ω or 120 Ω internal impedance of TTIP/TRING. If T_TERM[2] is set to '1', the internal impedance matching circuit will be disabled. In this case, the external impedance matching circuit will be used to realize the impedance matching. Figure-6 shows the appropriate external components to connect with the cable. Table-4 is the list of the recommended impedance matching for transmitter.

In hardware control mode, TERM pin can be used to select impedance matching for both receiver and transmitter. If TERM pin is low, external impedance network will be used for impedance matching. If TERM pin is high, internal impedance will be used for impedance matching and PULS pin will be set to select the specific internal impedance. Refer to 5 Hardware Control Pin Summary for details.

The TTIP/TRING pins can also be turned into high impedance by setting the THZ bit (**TCF1, 06H**) to '1'. In this state, the internal transmit circuits are still active.

In hardware control mode, TTIP/TRING can be turned into high impedance by pulling THZ pin to high. Refer to 5 Hardware Control Pin Summary for details.

Besides, in the following cases, both TTIP/TRING pins will also become high impedance:

- Loss of MCLK;
- Loss of TCLK (exceptions: Remote Loopback; Transmit internal pattern by MCLK);
- Transmit path power down;
- After software reset; pin reset and power on.

**Table-4 Impedance Matching for Transmitter**

| Cable Configuration | Internal Termination | | | External Termination | | |
|---|---|---|---|---|---|---|
| | T_TERM[2:0] | PULS[3:0] | $R_T$ | T_TERM[2:0] | PULS[3:0] | $R_T$ |
| E1 / 75 Ω | 000 | 0000 | 0 Ω | 1XX | 0001 | 9.4 Ω |
| E1 / 120 Ω | 001 | 0001 | | | | |

**Note**: The precision of the resistors should be better than ± 1%

### 3.2.5 TRANSMIT PATH POWER DOWN

The transmit path can be powered down by setting the T_OFF bit (**TCF0, 05H**) to '1'. In this case, the TTIP/TRING pins are turned into high impedance.

In hardware control mode, the transmit path can be powered down by pulling both PATT1 and PATT0 pins to high. Refer to 5 Hardware Control Pin Summary for details.

## 3.3 RECEIVE PATH

The receive path consists of Receive Internal Termination, Monitor Gain, Amplitude/Wave Shape Detector, Digital Tuning Controller, Adaptive Equalizer, Data Slicer, CDR (Clock & Data Recovery), Optional Jitter Attenuator, Decoder and LOS/AIS Detector. Refer to Figure-5.

### 3.3.1 RECEIVE INTERNAL TERMINATION

The impedance matching can be realized by the internal impedance matching circuit or the external impedance matching circuit. If R_TERM[2] is set to '0', the internal impedance matching circuit will be selected. In this case, the R_TERM[1:0] bits (**TERM, 03H**) can be set to choose 75 Ω or 120 Ω internal impedance of RTIP/RRING. If R_TERM[2] is set to '1', the internal impedance matching circuit will be disabled. In this case, the external impedance matching circuit will be used to realize the impedance matching. Figure-6 shows the appropriate external components to connect with the cable. Table-5 is the list of the recommended impedance matching for receiver.

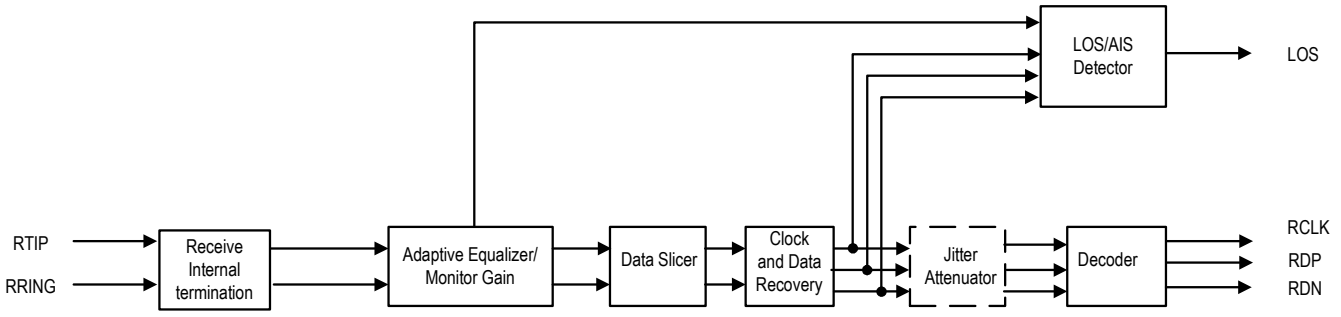
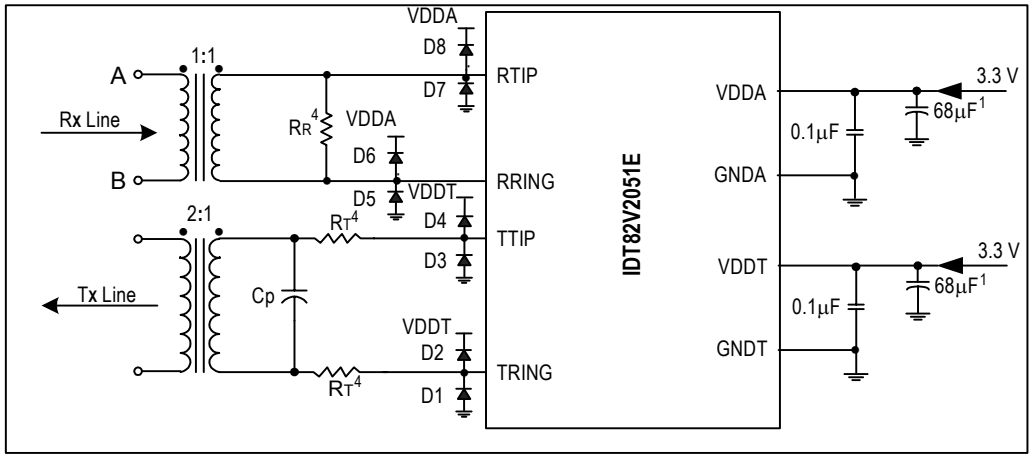



***Figure-5 Receive Monitor Gain Adaptive Equalizer***

**Table-5 Impedance Matching for Receiver**

| Cable Configuration | Internal Termination | | External Termination | |
|---|---|---|---|---|
| | R_TERM[2:0] | $R_R$ | R_TERM[2:0] | $R_R$ |
| E1/75 Ω | 000 | 120 Ω | 1XX | 75 Ω |
| E1/120 Ω | 001 | | | 120 Ω |




Note: 1. Common decoupling capacitor, one per chip
2. Cp 0-560 (pF)
3. D1 - D8, Motorola - MBR0540T1; International Rectifier - 11DQ04 or 10BQ060
4. $R_T$/ $R_R$: refer toTable-4 and Table-5 respecivley for $R_T$ and $R_R$ values

***Figure-6 Transmit/Receive Line Circuit***

In hardware control mode, TERM and PULS pins can be used to select impedance matching for both receiver and transmitter. If TERM pin is low, external impedance network will be used for impedance matching. If TERM pin is high, internal impedance will be used for impedance matching and PULS pins can be set to select the specific internal impedance. Refer to 5 Hardware Control Pin Summary for details.

### 3.3.2 LINE MONITOR

The non-intrusive monitoring on channels located in other chips can be performed by tapping the monitored channel through a high impedance bridging circuit. Refer to Figure-7 and Figure-9.

After a high resistance bridging circuit, the signal arriving at the RTIP/RRING is dramatically attenuated. To compensate this attenuation, the Monitor Gain can be used to boost the signal by 22 dB, 26 dB and 32 dB, selected by MG[1:0] bits (**RCF2, 0CH**). For normal operation, the Monitor Gain should be set to 0 dB.

In hardware control mode, MONT pin can be used to set the Monitor Gain. When MONT pin is low, the Monitor Gain is 0 dB. When MONT pin is high, the Monitor Gain is 26 dB. Refer to 5 Hardware Control Pin Summary for details.

Note that LOS indication is not supported if the device is operated in Line Monitor Mode

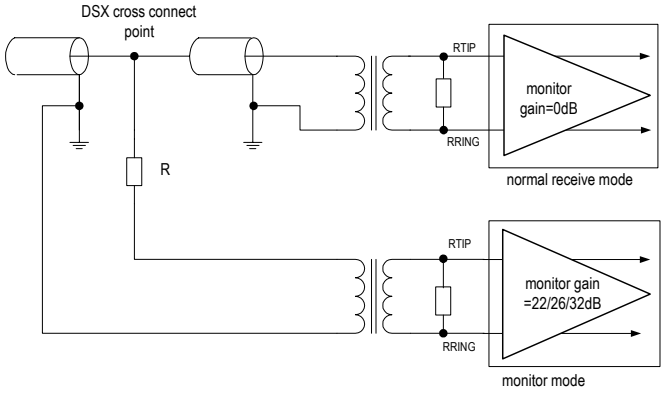



***Figure-7 Monitoring Receive Line in Another Chip***

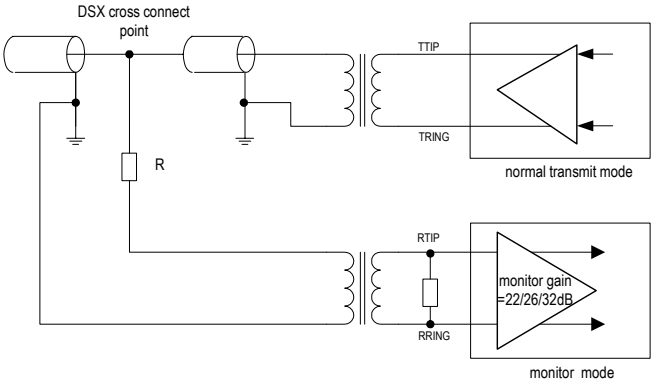



***Figure-8 Monitor Transmit Line in Another Chip***

### 3.3.3 ADAPTIVE EQUALIZER

The Adaptive Equalizer can be enabled to increase the receive sensitivity and to allow programming of the LOS level up to -24 dB. See3.5 Los And AIS Detection. It can be enabled or disabled by setting EQ_ON bit to '1' or '0' (**RCF1, 0BH**).

### 3.3.4 RECEIVE SENSITIVITY

The Receive Sensitivity is -10 dB. With the Adaptive Equalizer enabled, the receive sensitivity will be -20 dB.

In Hardware mode, the Adaptive Equalizer can not be enabled and the receive sensitivity is fixed at -10 dB. Refer to 5 Hardware Control Pin Summary for details.

### 3.3.5 DATA SLICER

The Data Slicer is used to generate a standard amplitude mark or a space according to the amplitude of the input signals. The threshold can be 40%, 50%, 60% or 70%, as selected by the SLICE[1:0] bits (**RCF2, 0CH**). The output of the Data Slicer is forwarded to the CDR (Clock & Data Recovery) unit or to the RDP/RDN pins directly if the CDR is disabled.

### 3.3.6 CDR (CLOCK & DATA RECOVERY)

The CDR is used to recover the clock and data from the received signal. The recovered clock tracks the jitter in the data output from the Data Slicer and keeps the phase relationship between data and clock during the absence of the incoming pulse. The CDR can also be by-passed in the Dual Rail mode. When CDR is by-passed, the data from the Data Slicer is output to the RDP/RDN pins directly.

### 3.3.7 DECODER

The R_MD[1:0] bits (**RCF0, 0AH**) are used to select the AMI decoder or HDB3 decoder.

When the chip is configured by hardware, the operation mode of receive and transmit path can be selected by setting RXTXM1 and RXTXM0 pins. Refer to 5 Hardware Control Pin Summary for details.

### 3.3.8 RECEIVE PATH SYSTEM INTERFACE

The receive path system interface consists of RCLK pin, RD/RDP pin and RDN pin. The RCLK outputs a recovered 2.048 MHz clock. The received data is updated on the RD/RDP and RDN pins on the active edge of RCLK. The active edge of RCLK can be selected by the RCLK_SEL bit (**RCF0, 0AH**). And the active level of the data on RD/RDP and RDN can be selected by the RD_INV bit (**RCF0, 0AH**).

In hardware control mode, only the active edge of RCLK can be selected. If RCLKE is set to high, the falling edge will be chosen as the active edge of RCLK. If RCLKE is set to low, the rising edge will be chosen as the active edge of RCLK. The active level of the data on RD/RDP and RDN is the same as that in software control mode.

The received data can be output to the system side in two different ways: Single Rail or Dual Rail, as selected by R_MD bit [1] (**RCF0, 0AH**). In Single Rail mode, only RD pin is used to output data and the RDN/CV pin is used to report the received errors. In Dual Rail Mode, both RDP pin and RDN pin are used for outputting data.

In the receive Dual Rail mode, the CDR unit can be by-passed by setting R_MD[1:0] to '11' (binary). In this situation, the output data from the Data Slicer will be output to the RDP/RDN pins directly, and the RCLK outputs the exclusive OR (XOR) of the RDP and RDN. This is called receiver slicer mode. In this case, the transmit path is still operating in Dual Rail mode.

### 3.3.9 RECEIVE PATH POWER DOWN

The receive path can be powered down by setting R_OFF bit (**RCF0, 0AH**) to '1'. In this case, the RCLK, RD/RDP, RDN and LOS will be logic low.

In hardware control mode, receiver power down can be selected by pulling RPD pin to high. Refer to 5 Hardware Control Pin Summary for more details.

## 3.4 JITTER ATTENUATOR

There is one Jitter Attenuator in the IDT82V2051E. The Jitter Attenuator can be deployed in the transmit path or the receive path, and can also be disabled. This is selected by the JACF[1:0] bits (**JACF, 04H**).

In hardware control mode, Jitter Attenuator position, bandwidth and the depth of FIFO can be selected by JA[1:0] pins. Refer to 5 Hardware Control Pin Summary for details.

### 3.4.1 JITTER ATTENUATION FUNCTION DESCRIPTON

The Jitter Attenuator is composed of a FIFO and a DPLL, as shown in Figure-9. The FIFO is used as a pool to buffer the jittered input data, then the data is clocked out of the FIFO by a de-jittered clock. The depth of the FIFO can be 32 bits, 64 bits or 128 bits, as selected by the JADP[1:0] bits (**JACF, 04H**). In hardware control mode, the depth of FIFO can be selected by JA[1:0] pins. Refer to 5 Hardware Control Pin Summary for details. Consequently, the constant delay of the Jitter Attenuator will be 16 bits, 32 bits or 64 bits. Deeper FIFO can tolerate larger jitter, but at the cost of increasing data latency time.

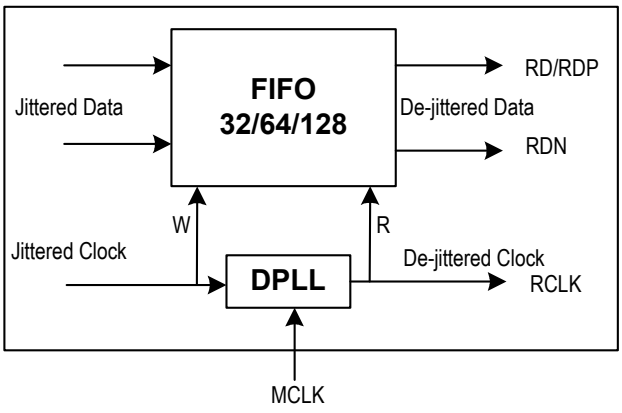



***Figure-9 Jitter Attenuator***

The Corner Frequency of the DPLL can be 0.9 Hz or 6.8 Hz, as selected by the JABW bit (**JACF, 04H**). The lower the Corner Frequency is, the longer time is needed to achieve synchronization.

When the incoming data moves faster than the outgoing data, the FIFO will overflow. This overflow is captured by the JAOV_IS bit (**INTS1, 1AH**). If the incoming data moves slower than the outgoing data, the FIFO will underflow. This underflow is captured by the JAUD_IS bit (**INTS1, 1AH**). For some applications that are sensitive to data corruption, the JA limit mode can be enabled by setting JA_LIMIT bit (**JACF, 04H**) to '1'. In the JA limit mode, the speed of the outgoing data will be adjusted automatically when the FIFO is close to its full or emptiness. The criteria of starting speed adjustment are shown in Table-6. The JA limit mode can reduce the possibility of FIFO overflow and underflow, but the quality of jitter attenuation is deteriorated.

**Table-6 Criteria of Starting Speed Adjustment**

| FIFO Depth | Criteria for Adjusting Data Outgoing Speed |
|---|---|
| 32 Bits | 2 bits close to its full or emptiness |
| 64 Bits | 3 bits close to its full or emptiness |
| 128 Bits | 4 bits close to its full or emptiness |

### 3.4.2 JITTER ATTENUATOR PERFORMANCE

The performance of the Jitter Attenuator in the IDT82V2051E meets the ITU-T I.431, G.703, G.736-739, G.823, G.824, ETSI 300011 and ETSI TBR12/13 specifications. Details of the Jitter Attenuator performance is shown in Table-47 Jitter Tolerance and Table-48 Jitter Attenuator Characteristics.

## 3.5 LOS AND AIS DETECTION

### 3.5.1 LOS DETECTION

The Loss of Signal Detector monitors the amplitude of the incoming signal level and pulse density of the received signal on RTIP and RRING.

- **LOS declare (LOS=1)**

A LOS is detected when the incoming signal has “no transitions”, i.e., when the signal level is less than Q dB below nominal for N consecutive pulse intervals. Here N is defined by LAC bit (**MAINT0, 0DH**). LOS will be declared by pulling LOS pin to high (LOS=1) and LOS interrupt will be generated if it is not masked.

Note that LOS indication is not supported if the device is operated in Line Monitor Mode. Refer to 3.3.2 Line Monitor.

- **LOS clear (LOS=0)**

The LOS is cleared when the incoming signal has “transitions”, i.e., when the signal level is greater than P dB below nominal and has an average pulse density of at least 12.5% for M consecutive pulse intervals, starting with the receipt of a pulse. Here M is defined by LAC bit (**MAINT0, 0DH**). LOS status is cleared by pulling LOS pin to low.

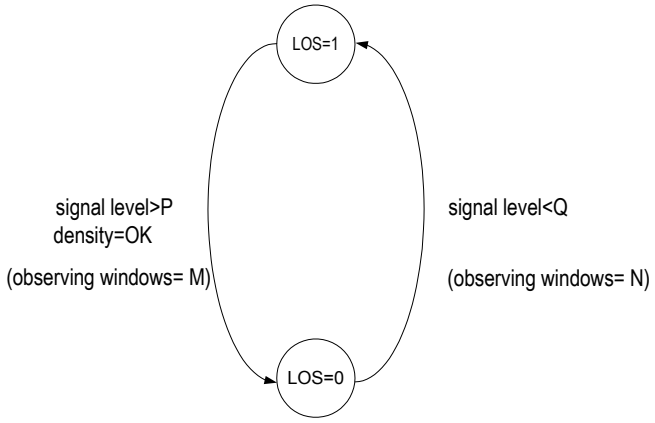



***Figure-10 LOS Declare and Clear***

- **LOS detect level threshold**

With the Adaptive Equalizer off, the amplitude threshold Q is fixed on 800 mVpp, while P=Q+200 mVpp (200 mVpp is the LOS level detect hysteresis).

With the Adaptive Equalizer on, the value of Q can be selected by LOS[4:0] bit (**RCF1, 0BH**), while P=Q+4 dB (4 dB is the LOS level detect hysteresis). Refer to Table-20 TCF1: Transmitter Configuration Register 1 for LOS[4:0] bit values available.

When the chip is configured by hardware, the Adaptive Equalizer can not be enabled and Programmable LOS levels are not available (pin 29 has to be set to ‘0’).

- **Criteria for declare and clear of a LOS detect**

The detection supports G.775 and ETSI 300233/I.431. The criteria can be selected by LAC bit (**MAINT0, 0DH**).

Table-7 and Table-8 summarize LOS declare and clear criteria for both with and without the Adaptive Equalizer enabled.

- **All Ones output during LOS**

On the system side, the RDP/RDN will reflect the input pulse “transition” at the RTIP/RRING side and output recovered clock (but the quality of the output clock can not be guaranteed when the input level is lower than the maximum receive sensitivity) when AISE bit (**MAINT0, 0DH**) is 0; or output All Ones as AIS when AISE bit (**MAINT0, 0DH**) is 1. In this case, RCLK output is replaced by MCLK.

On the line side, the TTIP/TRING will output All Ones as AIS when ATAO bit (**MAINT0, 0DH**) is 1. The All Ones pattern uses MCLK as the reference clock.

LOS indicator is always active for all kinds of loopback modes.

**Table-7 LOS Declare and Clear Criteria, Adaptive Equalizer Disabled**

| Control bit (LAC) | LOS declare threshold | LOS clear threshold |
|---|---|---|
| 0 = G.775 | Level < 800 mVpp; N=32 bits | Level > 1 Vpp; M=32 bits; 12.5% mark density; <16 consecutive zeroes |
| 1 = I.431/ETSI | Level < 800 mVpp; N=2048 bits | Level > 1 Vpp; M=32 bits; 12.5% mark density; <16 consecutive zeroes |

**Table-8 LOS Declare and Clear Criteria, Adaptive Equalizer Enabled**

| Control bit | | | | LOS declare threshold | LOS clear threshold | Note |
|---|---|---|---|---|---|---|
| LAC | | LOS[4:0] | Q (dB) | | | |
| 0 | - | 00000<br>…<br>00010 | -4<br>…<br>-8 | Level < Q<br>N=32 bits | Level > Q+ 4 dB<br>M=32 bits<br>12.5% mark density<br><16 consecutive zeroes | G.775 Level detect range is -9 to -35 dB. |
| | G.775 | 00011<br>…<br>01010<br>01011 - 11111 | -10<br>…<br>-24<br>Reserved | | | |
| 1 | - | 00000 | -4 | Level < Q<br>N=2048 bits | Level > Q+ 4 dB<br>M=32 bits<br>12.5% mark density<br><16 consecutive zeroes | I.431 Level detect range is -6 to -20 dB. |
| | I.431/ETSI | 00001<br>…<br>01010<br>01011 - 11111 | -6<br>…<br>-24<br>Reserved | | | |

### 3.5.2 AIS DETECTION

The Alarm Indication Signal can be detected by the IDT82V2051E when the Clock & Data Recovery unit is enabled. The status of AIS detection is reflected in the AIS_S bit (**STAT0, 17H)**. The criteria for declaring/clearing AIS detection comply with the ITU G.775 or the ETSI 300233, as selected by the LAC bit (**MAINT0, 0DH**). Table-9 summarizes different criteria for AIS detection Declaring/Clearing.

**Table-9 AIS Condition**

| | ITU G.775 (LAC bit is set to '0' by default) | ETSI 300233 (LAC bit is set to '1') |
|---|---|---|
| **AIS detected** | Less than 3 zeros contained in each of two consecutive 512-bit streams are received | Less than 3 zeros contained in a 512-bit stream are received |
| **AIS cleared** | 3 or more zeros contained in each of two consecutive 512-bit streams are received | 3 or more zeros contained in a 512-bit stream are received |

## 3.6 TRANSMIT AND DETECT INTERNAL PATTERNS

The internal patterns (All Ones, All Zeros and PRBS pattern) will be generated and detected by IDT82V2051E. TCLK is used as the reference clock by default. MCLK can also be used as the reference clock by setting the PATT_CLK bit (**MAINT0, 0DH**) to '1'.

If the PATT_CLK bit (**MAINT0, 0DH**) is set to '0' and the PATT[1:0] bits (**MAINT0, 0DH**) are set to '00', the transmit path will operate in normal mode.

When the chip is configured by hardware, the transmit path will operate in normal mode by setting PATT[1:0] pins to '00'. Refer to 5 Hardware Control Pin Summary for details.

### 3.6.1 TRANSMIT ALL ONES

In transmit direction, the All Ones data can be inserted into the data stream when the PATT[1:0] bits (**MAINT0, 0DH**) are set to '01'. The transmit data stream is output from TTIP/TRING. In this case, either TCLK or MCLK can be used as the transmit clock, as selected by the PATT_CLK bit (**MAINT0, 0DH**).

In hardware control mode, the All Ones data can be inserted into the data stream in transmit direction by setting PATT[1:0] pins to '01'. Refer to 5 Hardware Control Pin Summary for details.

### 3.6.2 TRANSMIT ALL ZEROS

If the PATT_CLK bit (**MAINT0, 0DH**) is set to '1', the All Zeros will be inserted into the transmit data stream when the PATT[1:0] bits (**MAINT0, 0DH**) are set to '00'.

### 3.6.3 PRBS GENERATION AND DETECTION

A PRBS will be generated in the transmit direction and detected in the receive direction by IDT82V2051E. The PRBS is $2^{15}$-1, with maximum zero restrictions according to ITU-T O.151.

When the PATT[1:0] bits (**MAINT0, 0DH**) are set to '10', the PRBS pattern will be inserted into the transmit data stream with the MSB first. The PRBS pattern will be transmitted directly or invertedly.

In hardware control mode, the PRBS data will be generated in the transmit direction and inserted into the transmit data stream by setting PATT[1:0] pins to '10'. Refer to 5 Hardware Control Pin Summary for details.

The PRBS in the received data stream will be monitored. If the PRBS has reached synchronization status, the PRBS_S bit (**STAT0, 17H**) will be set to '1', even in the presence of a logic error rate less than or equal to $10^{-1}$. The criteria for setting/clearing the PRBS_S bit are shown in Table-10.

**Table-10 Criteria for Setting/Clearing the PRBS_S Bit**

| | |
|---|---|
| **PRBS Detection** | 6 or less than 6 bit errors detected in a 64 bits hopping window. |
| **PRBS Missing** | More than 6 bit errors detected in a 64 bits hopping window. |

PRBS data can be inverted through setting the PRBS_INV bit (**MAINT0, 0DH)**.

Any change of PRBS_S bit will be captured by PRBS_IS bit (**INTS0, 19H**). The PRBS_IES bit (**INTES, 16H**) can be used to determine whether the '0' to '1' change of PRBS_S bit will be captured by the PRBS_IS bit or any changes of PRBS_S bit will be captured by the PRBS_IS bit. When the PRBS_IS bit is '1', an interrupt will be generated if the PRBS_IM bit (**INTM0, 14H**) is set to '1'.

The received PRBS logic errors can be counted in a 16-bit counter if the ERR_SEL [1:0] bits (**MAINT6, 13H**) are set to '00'. Refer to 3.8 Error Detection/Counting And Insertion for the operation of the error counter.

## 3.7 LOOPBACK

To facilitate testing and diagnosis, the IDT82V2051E provides three different loopback configurations: Analog Loopback, Digital Loopback and Remote Loopback.

### 3.7.1 ANALOG LOOPBACK

When the ALP bit (**MAINT1, 0EH**) is set to '1', the chip is configured in Analog Loopback mode. In this mode, the transmit signals are looped back to the Receiver Internal Termination in the receive path then output from RCLK, RD, RDP/RDN. At the same time, the transmit signals are still output to TTIP/TRING in transmit direction. The all-ones pattern can be generated during analog loopback. Figure-11 shows the process.

### 3.7.2 DIGITAL LOOPBACK

When the DLP bit (**MAINT1, 0EH**) is set to '1', the chip is configured in Digital Loopback mode. In this mode, the transmit signals are looped back to the jitter attenuator (if enabled) and decoder in receive path, then output from RCLK, RD, RDP/RDN. At the same time, the transmit signals are still output to TTIP/TRING in transmit direction. Figure-12 shows the process.

Both Analog Loopback mode and Digital Loopback mode allow the sending of the internal patterns (All Ones, All Zeros, PRBS, etc.) which will overwrite the transmit signals. In this case, either TCLK or MCLK can be used as the reference clock for internal patterns transmission.

In hardware control mode, Digital Loopback can be selected by setting LP[1:0] pins to '10'.

### 3.7.3 REMOTE LOOPBACK

When the RLP bit (**MAINT1, 0EH**) is set to '1', the chip is configured in Remote Loopback mode. In this mode, the recovered clock and data output from Clock and Data Recovery on the receive path is looped back to the jitter attenuator (if enabled) and Waveform Shaper in transmit path. Figure-13 shows the process.

In hardware control mode, Remote Loopback can be selected by setting LP[1:0] pins to '11'.

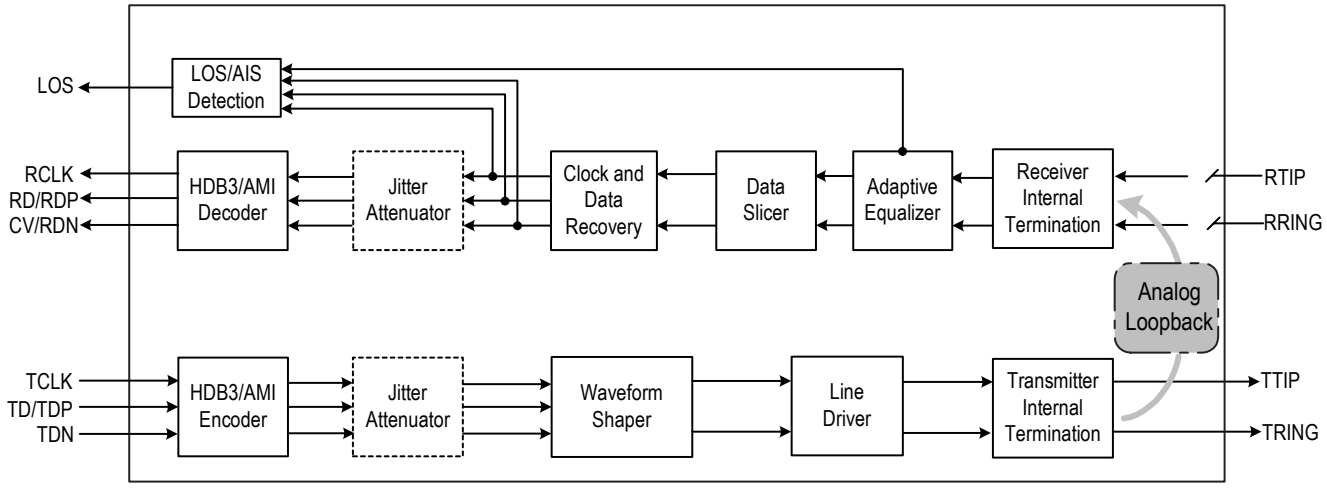



***Figure-11 Analog Loopback***

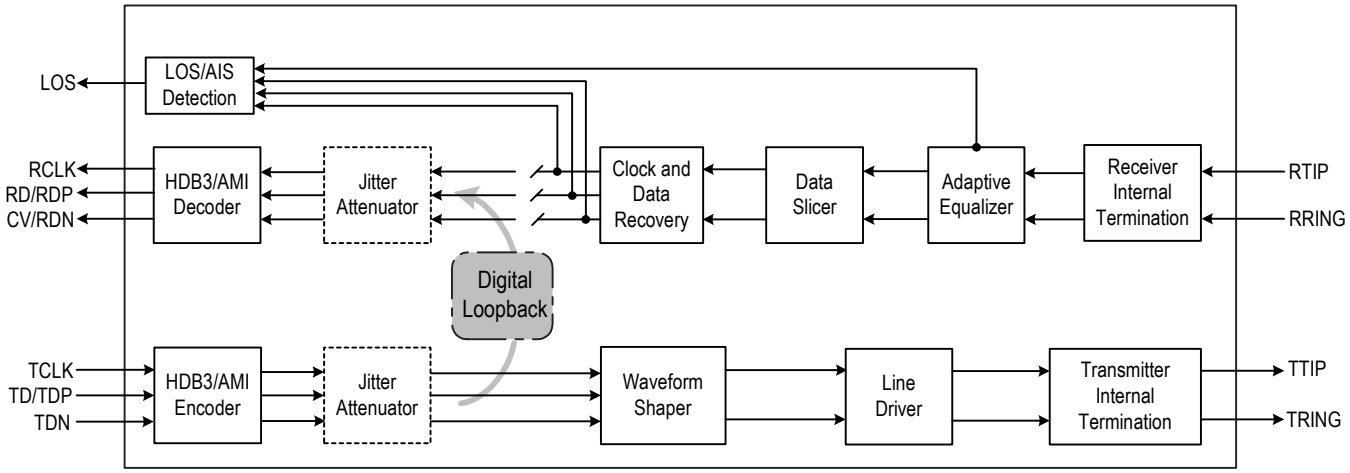



***Figure-12 Digital Loopback***