

## FEATURES

- 6312/8448/34368 kbit/s line interface
- AGC and equalizer
- Line quality monitor ( $10^{-6}$  error rate threshold)
- Receive loss of signal and transmit loss of clock alarms
- Selectable HDB3 encoder/decoder
- Two loopbacks:
  - Receive to transmit
  - Transmit to receive
- Receive and Transmit AIS generators
- Rail or NRZ terminal side I/O
- Coding violation monitor
- Meets ITU-T Rec. G.703 pulse masks
- Meets ITU-T Rec. G.823 and JT-670,3 jitter requirements
- 44-pin plastic leaded chip carrier

## DESCRIPTION

The TranSwitch Multi-rate Receive/Transmit (MRT) Line Interface is a CMOS VLSI device that provides the functions needed for terminating two ITU-T line rates, 8448 and 34368 kbit/s, or a 6312 kbit/s rate which is specified in the Japanese NTT Technical Reference for High Speed Digital Leased Circuits. For 8448 and 34368 kbit/s operation, the MRT provides a selectable HDB3 codec.

The MRT is equipped with a receive equalizer circuit and AGC. The MRT also provides a rail or NRZ interface, HDB3 error rate monitor, alarm detection, and AIS generators. Testing capability is provided by transmit and receive loopbacks.

## APPLICATIONS

- Digital cross-connect equipment
- Remote terminals
- Terminal interface for multiplexers/demultiplexers
- Switching systems
- CSU/DSU

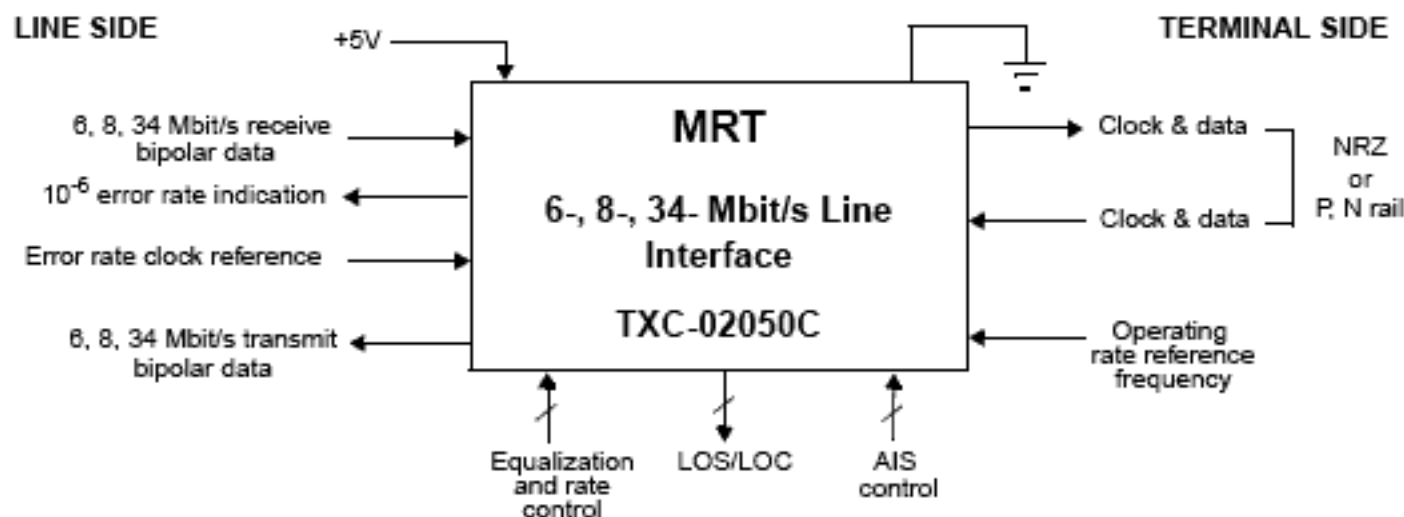




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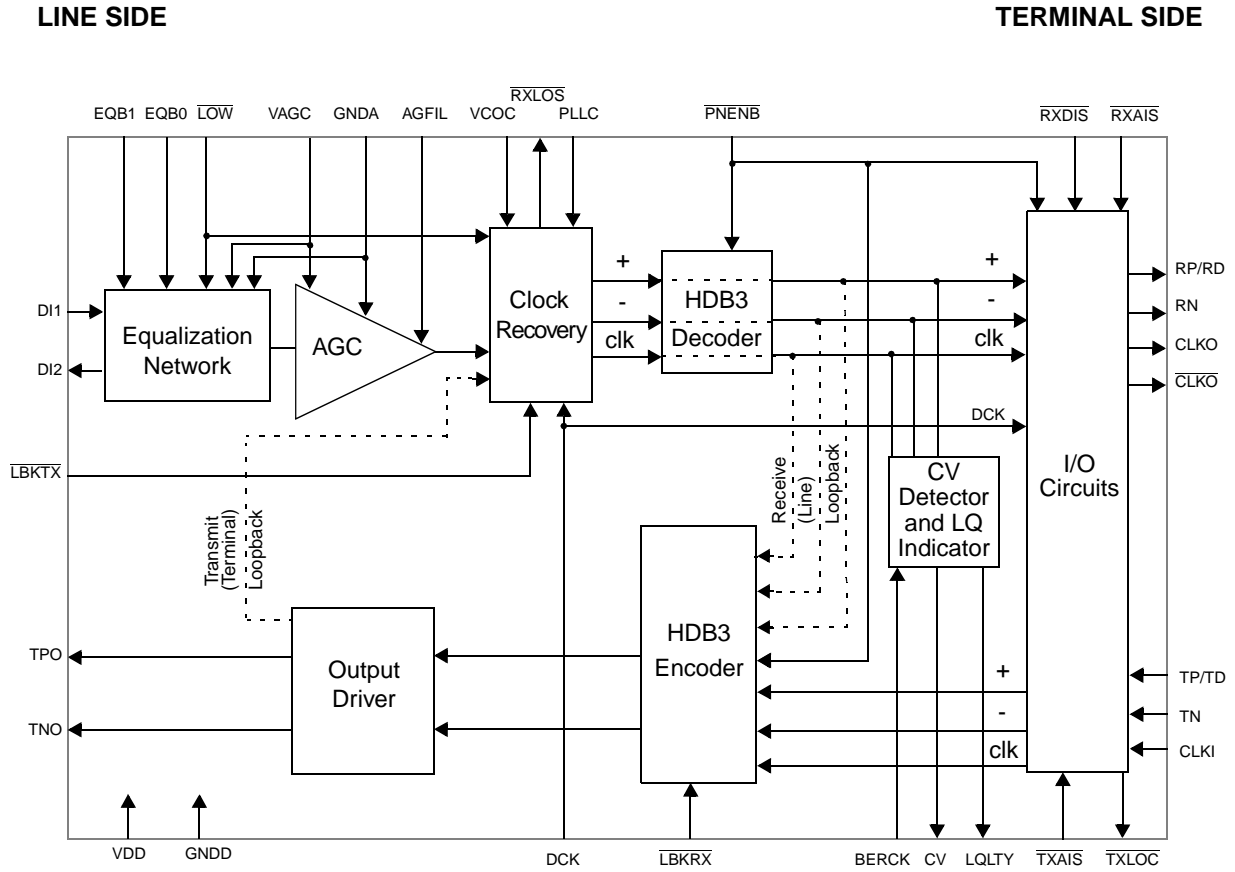
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\* Please note that TranSwitch provides documentation for all of its products. Current editions of many documents are available from the Products page of the TranSwitch Web site at [www.transwitch.com](http://www.transwitch.com). Customers who are using a TranSwitch Product, or planning to do so, should register with the TranSwitch Marketing Department to receive relevant updated and supplemental documentation as it is issued. They should also contact the Applications Engineering Department to ensure that they are provided with the latest available information about the product, especially before undertaking development of new designs incorporating the product.

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**BLOCK DIAGRAM**



**Figure 1. MRT TXC-02050C Block Diagram**

## BLOCK DIAGRAM DESCRIPTION

On the Line Side, a symmetrical bipolar signal is applied to the input signal pin (DI1), which requires an external 75Ω termination. DI2 is a DC reference voltage output which serves as an AC ground.

Equalization for various lengths of cable having a  $\sqrt{f}$  attenuation characteristic is compensated by setting the states of the EQB0 and EQB1 signal leads. The Equalization Network Block is connected to an AGC Block which has approximately a 20 dB dynamic range. The AGC has separate voltage and ground leads for noise immunity, and uses an external capacitor as part of an AGC filter. The AGC output is connected to the Clock Recovery Block.

The Clock Recovery Block contains a phase-locked loop and supporting logic to generate a clock signal from the line signal. The signal lead  $\overline{LOW}$  selects the appropriate circuit in the Clock Recovery Block for the operating frequency and provides input attenuation for the receive line signal. The line input is monitored for loss of signal, with an alarm indication provided on the RXLOS signal lead. The Clock Recovery Block requires an external reference clock at the operating frequency (DCK). The reference clock is also used for generating and sending a receive Alarm Indication Signal (AIS). The generation and sending of AIS for recovered data is controlled by the  $\overline{RXAIS}$  signal lead.

The output of the Clock Recovery Block is connected to the HDB3 Decoder Block, when enabled, or directly to the I/O Circuits Block. When the decoder is enabled, indications of coding violation errors, other than the normal HDB3 zero substitution codes, are provided as pulses on the signal lead labeled CV by the CV Detector and LQ Indicator Block. Examples of HDB3 coding and violations are shown in Figure 19. An external clock (BERCK) is used to generate a 10-second sampling window for detecting a  $10^{-6}$  or greater error rate. The resulting line quality indication is provided on the output signal lead LQLTY.

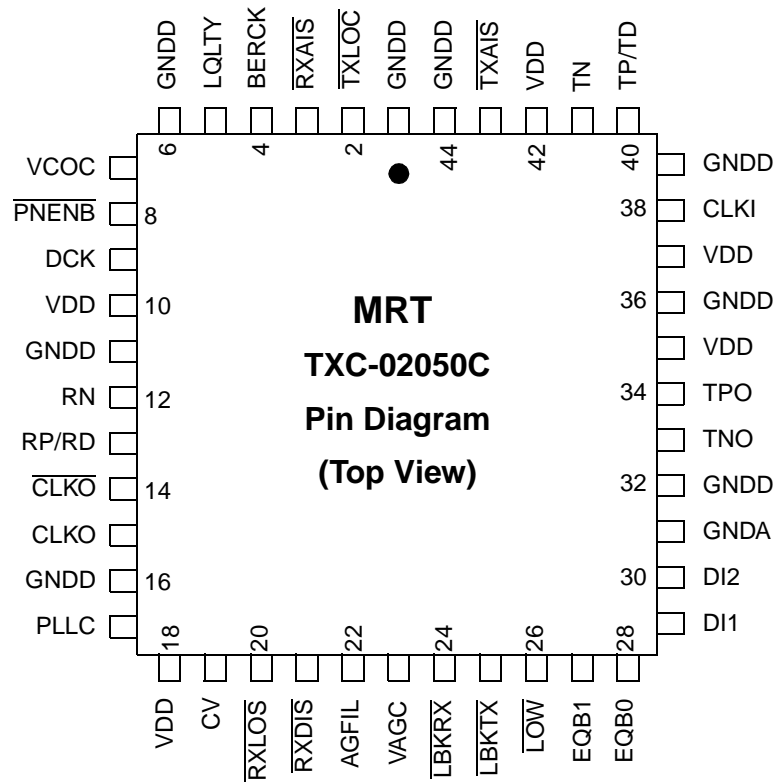
Two Terminal Side interfaces are provided, a positive and negative rail (RP and RN) or NRZ (RD) interface. The selection is determined by the state placed on the input signal lead  $\overline{PNENB}$ . When a low is applied to this signal lead, the HDB3 Decoder and HDB3 Encoder Blocks are bypassed, and the terminal side I/O is a positive and negative rail interface. When a high is applied to the signal lead, an NRZ interface is provided. Data is clocked out of the MRT on negative edges of the clock output signal (CLKO). Receive data and the clock signals are disabled, and forced to a high impedance state, by placing a low on the receive disable input lead ( $\overline{RXDIS}$ ). For a receive positive and negative rail interface, an inverted clock output signal ( $\overline{CLKO}$ ) is also provided.

The terminal side interface for the transmitter can either be positive and negative rail (TP and TN) or NRZ (TD) data depending on the state of the common control input lead  $\overline{PNENB}$  (see Figure 20 for examples). Data is clocked into the MRT on positive transitions of the clock signal (CLKI). The input clock is monitored for the loss of clock. When the input clock remains high or low,  $\overline{TXLOC}$  will be set low. The MRT also provides the capability to generate and insert AIS (all ones signal), independent of the transmit data. A low placed on the  $\overline{TXAIS}$  input lead enables the transmit AIS generator.

Two loopbacks are provided, transmit loopback and receive loopback. Transmit loopback connects the data path from the transmitter Output Driver Block to the Clock Recovery Block, and disables the external receiver input. Transmit loopback is activated by placing a low on the  $\overline{LBKTX}$  input signal lead. Receive loopback connects the receive data path to the transmit output circuits and disables the transmit input. Receive loopback is activated by placing a low on the  $\overline{LBKRX}$  input signal lead.

For 6 Mbit/s operation, the MRT should be operated in the P and N rail mode, bypassing the HDB3 Decoder/Encoder. When the MRT is used with the TranSwitch JT2F device at this bit rate, the JT2F can provide either B6ZS or B8ZS encoding and decoding.

**PIN DIAGRAM**



**Figure 2. MRT TXC-02050C Pin Diagram**



## PIN DESCRIPTIONS

## Power Supply and Ground

Symbol	Pin No.	I/O/P*	Type	Name/Function
VDD	10,18,35, 37,42	P		<b>VDD:</b> $V_{DD}$ , +5 volt supply, $\pm 5\%$ .
GNDD	1,6,11,16,32, 36,39,44	P		<b>Digital Ground:</b> 0 volts reference.
VAGC	23	P		<b>AGC VDD:</b> +4.3 volt supply, derived from $V_{DD}$ using 1N914 or 1N4148 diode (see Figure 10).
GNDA	31	P		<b>Analog Ground:</b> 0 volts reference.

\*Note: I = Input; O = Output; P = Power.

## Line Side I/O

Symbol	Pin No.	I/O/P	Type *	Name/Function
DI1	29	I	Analog	<b>Data In 1:</b> HDB3 or B8ZS encoded bipolar receive data input.
DI2	30	O	Analog	<b>Data In 2:</b> DC Voltage Reference for Data Input DI1. The MRT uses an internally generated voltage reference as an AC ground for the received data input. An external 0.1 $\mu\text{F}$ capacitor, in parallel with a 10 $\mu\text{F}/6.3\text{ V}$ tantalum capacitor, is connected between this pin and ground. No other connection should be made to this pin.
TNO	33	O	TTL24mA	<b>Transmit Negative Out:</b> Line transmit negative; output is active high.
TPO	34	O	TTL24mA	<b>Transmit Positive Out:</b> Line transmit positive; output is active high.

\* See Input and Output Parameters section for digital Type definitions.

## Terminal Side I/O

Symbol	Pin No.	I/O/P	Type	Name/Function
RN	12	O	TTL4mA (Tristate)	<b>Receive Negative:</b> When $\overline{\text{PNENB}}$ is low, the HDB3 codec is bypassed and N-rail (RN) data is provided on this pin. When $\overline{\text{PNENB}}$ is high or $\overline{\text{RXDIS}}$ is low, this pin is forced to a high impedance state (disabled).
RP/RD	13	O	TTL4mA (Tristate)	<b>Receive Positive/Receive Data:</b> When $\overline{\text{PNENB}}$ is low, the HDB3 codec is bypassed and P-Rail (RP) data is provided on this pin. When $\overline{\text{PNENB}}$ is high, NRZ data (RD) is provided. When $\overline{\text{RXDIS}}$ is low, this pin is forced to a high impedance state (disabled).

Symbol	Pin No.	I/O/P	Type	Name/Function
$\overline{\text{CLKO}}$	14	O	CMOS8mA (Tristate)	<b>Clock Out Inverted:</b> Receive inverted clock output. Positive and negative rail receive data is clocked out on the rising edge. When $\overline{\text{PNENB}}$ is high or $\overline{\text{RXDIS}}$ is low, this pin is forced to a high impedance state (disabled).
CLKO	15	O	CMOS8mA (Tristate)	<b>Clock Out:</b> Receive clock output. Receive positive and negative rail and NRZ data is clocked out on the falling edge. When $\overline{\text{RXDIS}}$ is low, this pin is forced to a high impedance state (disabled).
CLKI	38	I	TTLr	<b>Clock In:</b> Transmit clock input for P and N rail and NRZ data. Transmit data is clocked into the MRT on the rising edge. This clock must have a frequency accuracy of $\pm 20$ ppm for the 34368 kbit/s operation and $\pm 30$ ppm for the 6312/8448 kbit/s operation (ref: ITU-T recommendation G.703). The duty cycle requirement for this clock signal is $(50 \pm 5)\%$ , measured at the 1.4V TTL threshold level.
TP/TD	40	I	TTL	<b>Transmit Positive/Transmit Data:</b> When $\overline{\text{PNENB}}$ is low, the HDB3 codec is bypassed and transmit P-rail (TP) data is applied to this pin. When $\overline{\text{PNENB}}$ is high, NRZ transmit data (TD) is applied.
TN	41	I	TTL	<b>Transmit Negative:</b> When $\overline{\text{PNENB}}$ is low, the HDB3 codec is bypassed and transmit N-Rail (TN) is applied to this pin. When $\overline{\text{PNENB}}$ is high, this input is disabled.

**Alarm Signal Outputs**

Symbol	Pin No.	I/O/P	Type	Name/Function
$\overline{\text{TXLOC}}$	2	O	TTL2mA	<b>Transmit Loss Of Clock:</b> Active low output. A transmit loss of clock alarm occurs when the transmit clock input (CLKI) is stuck high or low for about 500 clock cycles. Recovery occurs on the first input clock transition. DCK is required for proper operation.
LQLTY	5	O	TTL2mA	<b>Line Quality:</b> This signal represents an estimate of the line quality which is determined by counting coding violations for 34 (8) Mbit/s operation. If the line error rate exceeds a $10^{-6}$ threshold during a 10 (40) second interval, LQLTY goes active high. LQLTY is active low when coding violations do not exceed the $10^{-6}$ threshold in a 10 (40) second interval. The output on this pin is only valid when the appropriate clock signal is applied to BERCK. It should be disregarded in the P and N mode of operation or in 6 Mbit/s operation.



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Symbol	Pin No.	I/O/P	Type	Name/Function
CV	19	O	TTL2mA	<b>Coding Violation:</b> Active high output. A coding violation pulse occurs when an HDB3 coding violation is detected in the received line data input. A coding violation is not part of the HDB3 zero-substitution code. A coding violation occurs because of noise or other impairments affecting the line signal. The output of this pin should be disregarded in the P and N mode.
$\overline{\text{RXLOS}}$	20	O	TTL2mA	<b>Receive Loss Of Signal:</b> Active low output. A receive loss of signal occurs when the input data is zero for 40-50 $\mu\text{s}$ . Recovery occurs when the receive signal returns.

## MRT Control Leads

Symbol	Pin No.	I/O/P	Type	Name/Function
$\overline{\text{RXAIS}}$	3	I	CMOSr	<b>Receive Alarm Indication Signal:</b> When $\overline{\text{RXAIS}}$ is low, the MRT generates AIS (all ones signal) for the terminal side receive output data. The line side receive data path is disabled. The reference clock (DCK) provides the clock source required for generating AIS.
BERCK	4	I	TTLr	<b>Bit Error Rate Clock:</b> This clock establishes the time base for estimating the coding violation error rate. For 34 Mbit/s operation the clock frequency must be 6 kHz, and for 8 Mbit/s operation the clock frequency must be 1.5 kHz. This pin should be left open for P and N mode operation.
$\overline{\text{PNENB}}$	8	I	CMOSr	<b>P And N Enable:</b> When $\overline{\text{PNENB}}$ is low, the P and N rail interface is enabled, and the HDB3 codec is bypassed. When $\overline{\text{PNENB}}$ is high, the terminal side I/O data is NRZ and the HDB3 codec is enabled. This pin must be held low for 6 Mbit/s operation.
DCK	9	I	TTL	<b>Reference Clock:</b> Operating frequency reference clock. For receive signal clock recovery, $\pm 200$ ppm frequency accuracy is adequate. If the transmit and receive AIS features are used, the frequency accuracy must be $\pm 20$ ppm for 34368 kbit/s and $\pm 30$ ppm for 8448 and 6312 kbit/s operation. The duty cycle requirement for this clock signal is $(50 \pm 5) \%$ as measured at the 1.4V TTL threshold level.
$\overline{\text{RXDIS}}$	21	I	CMOSr	<b>Receive Disable:</b> When $\overline{\text{RXDIS}}$ is low, the receive side of the MRT is disabled and the RN, RP/RD, CLKO and $\overline{\text{CLKO}}$ output leads are forced to a high impedance state.





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Symbol	Pin No.	I/O/P	Type	Name/Function
$\overline{\text{LBKR}}\overline{\text{X}}$	24	I	CMOSr	<b>Loopback Receive:</b> When $\overline{\text{LBKR}}\overline{\text{X}}$ is low, the MRT loops back receive data as transmit data. The receive data is also sent to the terminal side, but the transmit data input on the terminal side is disabled (see Note 1).
$\overline{\text{LBKT}}\overline{\text{X}}$	25	I	CMOSr	<b>Loopback Transmit:</b> When $\overline{\text{LBKT}}\overline{\text{X}}$ is low, the MRT loops back transmit data as receive data. The transmit data is sent on the line side, but the receive data input on the line side is disabled (see Note 1).

Note 1: Setting  $\overline{\text{LBKT}}\overline{\text{X}}$  and  $\overline{\text{LBKR}}\overline{\text{X}}$  low simultaneously will cause invalid outputs at the receive terminal and transmit line ports.

$\overline{\text{LOW}}$	26	I	CMOSr	<b>Low Frequency:</b> When $\overline{\text{LOW}}$ is low, the MRT enables equalization and input attenuator settings for 6312 or 8448 kbit/s operation. When $\overline{\text{LOW}}$ is high, the settings for 34368 kbit/s operation are enabled. This lead also controls the clock recovery high/low frequency range circuit.																																																												
EQB1 EQB0	27 28	I I	CMOSr	<p><b>Equalizer Bit 1:</b> MSB of equalizer setting. <b>Equalizer Bit 0:</b> LSB of equalizer setting.</p> <p>The equalizer setting depends on cable length (attenuation) as shown in the following tables.</p> <table border="0"> <tr> <td colspan="3">For 34 Mbit/s operation:</td> <td>Equivalent</td> </tr> <tr> <td><u>EQB1</u></td> <td><u>EQB0</u></td> <td><u>Cable Attenuation @ f *</u></td> <td><u>ATT 734A Cable</u></td> </tr> <tr> <td>1</td> <td>1</td> <td>0dB &lt; cable &lt; 5.7dB</td> <td>0 - 550 ft.</td> </tr> <tr> <td>1</td> <td>0</td> <td>4.1dB &lt; cable &lt; 12dB</td> <td>400 - 1150 ft.</td> </tr> <tr> <td>0</td> <td>0</td> <td>5.7dB &lt; cable &lt; 14dB</td> <td>550 - 1350 ft.</td> </tr> <tr> <td>0</td> <td>1</td> <td>6.8dB &lt; cable &lt; 14 dB</td> <td>650 - 1350 ft.</td> </tr> <tr> <td colspan="3">For 8 Mbit/s operation:</td> <td></td> </tr> <tr> <td>1</td> <td>1</td> <td>0dB &lt; cable &lt; 3.5dB</td> <td>0 - 550 ft.</td> </tr> <tr> <td>1</td> <td>0</td> <td>3.0dB &lt; cable &lt; 6.5dB</td> <td>500 - 1100 ft.</td> </tr> <tr> <td>0</td> <td>0</td> <td>3.6dB &lt; cable &lt; 6.8dB</td> <td>700 - 1350 ft.</td> </tr> <tr> <td colspan="3">For 6 Mbit/s operation (see Note 2):</td> <td>Equivalent</td> </tr> <tr> <td></td> <td></td> <td></td> <td><u>ATT 734A Cable</u></td> </tr> <tr> <td>1</td> <td>1</td> <td>0dB &lt; cable &lt; 2.4dB</td> <td>0 - 550 ft.</td> </tr> <tr> <td>1</td> <td>0</td> <td>2.4dB &lt; cable &lt; 5.1dB</td> <td>500 - 1100 ft.</td> </tr> <tr> <td>0</td> <td>0</td> <td>3.1dB &lt; cable &lt; 6.0dB</td> <td>700 - 1350 ft.</td> </tr> </table> <p>* f = 1/2 the bit rate</p>	For 34 Mbit/s operation:			Equivalent	<u>EQB1</u>	<u>EQB0</u>	<u>Cable Attenuation @ f *</u>	<u>ATT 734A Cable</u>	1	1	0dB < cable < 5.7dB	0 - 550 ft.	1	0	4.1dB < cable < 12dB	400 - 1150 ft.	0	0	5.7dB < cable < 14dB	550 - 1350 ft.	0	1	6.8dB < cable < 14 dB	650 - 1350 ft.	For 8 Mbit/s operation:				1	1	0dB < cable < 3.5dB	0 - 550 ft.	1	0	3.0dB < cable < 6.5dB	500 - 1100 ft.	0	0	3.6dB < cable < 6.8dB	700 - 1350 ft.	For 6 Mbit/s operation (see Note 2):			Equivalent				<u>ATT 734A Cable</u>	1	1	0dB < cable < 2.4dB	0 - 550 ft.	1	0	2.4dB < cable < 5.1dB	500 - 1100 ft.	0	0	3.1dB < cable < 6.0dB	700 - 1350 ft.
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$\overline{\text{TXAIS}}$	43	I	CMOSr	<b>Transmit AIS:</b> When $\overline{\text{TXAIS}}$ is low, the MRT sends an AIS (all ones signal) for the line side transmit output data. The terminal side transmit data path is disabled. The reference clock (DCK) provides the clock required for generating AIS. equivalent																																																												

Note 2: For 6 Mbit/s operation, setting the equalizer for long cable length while having a short cable will cause an error in the recovered clock frequency. The recovered clock frequency will not be 6.312 MHz.



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## Pins With External Components

Symbol	Pin No.	I/O/P	Type	Name/Function
VCOC	7	I	Analog	<b>Voltage Controlled Oscillator Capacitor:</b> For 6, 8, and 34 Mbit/s operation, a 470 ohm $\pm$ 5% 1/8 watt resistor is connected in series with a 0.1 $\mu$ F $\pm$ 10% capacitor from this pin to ground. This component is used in the phase-locked loop filter.
PLL	17	I	Analog	<b>Phase-Locked Loop Capacitor:</b> 0.1 $\mu$ F $\pm$ 10% ceramic disk capacitor connected to ground.
AGFIL	22	I	Analog	<b>Automatic Gain Filter:</b> For 6, 8, and 34 Mbit/s operation, a 0.1 $\mu$ F $\pm$ 10% ceramic disk capacitor is connected from this pin to ground.



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**ABSOLUTE MAXIMUM RATINGS**

Parameter	Symbol	Min *	Max *	Unit
Supply voltage	$V_{DD}$	-0.3	+7.0	V
AGC Supply Voltage	$V_{AGC}$	-0.5	+6.5	V
DC input voltage	$V_{IN}$	-0.5	$V_{DD} + 0.5$	V
Continuous power dissipation	$P_C$		750	mW
Ambient operating temperature	$T_A$	-40	85	°C
Operating junction temperature	$T_J$		125	°C
Storage temperature range	$T_S$	-55	150	°C

\*Note: Operating conditions exceeding those listed in Absolute Maximum Ratings may cause permanent failure. Exposure to absolute maximum ratings for extended periods may impair device reliability.

**THERMAL CHARACTERISTICS**

Parameter	Min	Typ	Max	Unit	Test Conditions
Thermal Resistance: junction to ambient			46	°C/W	0 ft/min linear airflow

**POWER REQUIREMENTS**

Parameter	Min	Typ	Max	Unit	Test Conditions
$V_{DD}$	4.75	5.0	5.25	V	
$V_{AGC}$	$V_{DD} - 0.3$		$V_{DD} - 0.62$	V	Derived from $V_{DD}$ via a 1N914 or 1N4148 diode.
$I_{DD}$			100	mA	$V_{DD} = 5.25V$
$I_{AGC}$			20	mA	$V_{AGC} = 4.63V$
$P_{DD}$			525	mW	$V_{DD} = 5.25V$ *
$P_{AGC}$			93	mW	$V_{AGC} = 4.75V$ *

\* with inputs switching and outputs terminated.



**INPUT AND OUTPUT PARAMETERS**

**Input Parameters For TTL**

Parameter	Min	Typ	Max	Unit	Test Conditions
$V_{IH}$	2.0		$V_{DD}+0.3$	V	$4.75 \leq V_{DD} \leq 5.25$
$V_{IL}$	-0.3		0.8	V	$4.75 \leq V_{DD} \leq 5.25$
Input leakage current			10	$\mu A$	$V_{DD} = 5.25$
Input capacitance		5.5		pF	

**Input Parameters For TTLr**

Parameter	Min	Typ	Max	Unit	Test Conditions
$V_{IH}$	2.0		$V_{DD}+0.3$	V	$4.75 \leq V_{DD} \leq 5.25$
$V_{IL}$	-0.3		0.8	V	$4.75 \leq V_{DD} \leq 5.25$
Input leakage current		50	120	$\mu A$	$V_{DD} = 5.25$
Input capacitance		5.5		pF	

Note: Input has a 100K (nominal) internal pull-up resistor.

**Input Parameters For CMOSr**

Parameter	Min	Typ	Max	Unit	Test Conditions
$V_{IH}$	2.0		$V_{DD}+0.3$	V	$4.75 \leq V_{DD} \leq 5.25$
$V_{IL}$	-0.3		0.8	V	$4.75 \leq V_{DD} \leq 5.25$
Input leakage current		50	120	$\mu A$	$V_{DD} = 5.25$
Input capacitance		5.5		pF	

Note: Input has a 100K (nominal) internal pull-up resistor.

**Output Parameters For TTL2mA**

Parameter	Min	Typ	Max	Unit	Test Conditions
$V_{OH}$	$V_{DD} - 0.5$			V	$V_{DD} = 4.75$ ; $I_{OH} = -1.0$ mA
$V_{OL}$			0.4	V	$V_{DD} = 4.75$ ; $I_{OL} = 2.0$ mA
$I_{OL}$			2.0	mA	
$I_{OH}$			-1.0	mA	



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Parameter	Min	Typ	Max	Unit	Test Conditions
$t_{RISE}$	5.5	12.5	18.2	ns	$C_{LOAD} = 15\text{pF}$
$t_{FALL}$	2.3	4.4	6.5	ns	$C_{LOAD} = 15\text{pF}$

## Output Parameters For TTL4mA

Parameter	Min	Typ	Max	Unit	Test Conditions
$V_{OH}$	$V_{DD} - 0.5$			V	$V_{DD} = 4.75; I_{OH} = -2.0\text{ mA}$
$V_{OL}$			0.4	V	$V_{DD} = 4.75; I_{OL} = 4.0\text{ mA}$
$I_{OL}$			4.0	mA	
$I_{OH}$			-2.0	mA	
$t_{RISE}$	2.8	6.5	9.2	ns	$C_{LOAD} = 15\text{ pF}$
$t_{FALL}$	1.3	2.3	3.4	ns	$C_{LOAD} = 15\text{ pF}$

## Output Parameters For TTL24mA

Parameter	Min	Typ	Max	Unit	Test Conditions
$V_{OH}$	$V_{DD} - 0.5$			V	$V_{DD} = 4.75; I_{OH} = -12.0\text{ mA}$
$V_{OL}$			0.4	V	$V_{DD} = 4.75; I_{OL} = 24.0\text{ mA}$
$I_{OL}$			24.0	mA	
$I_{OH}$			-12.0	mA	
$t_{RISE}$	0.8	1.4	1.8	ns	$C_{LOAD} = 25\text{ pF}$
$t_{FALL}$	0.5	0.8	1.0	ns	$C_{LOAD} = 25\text{ pF}$

## Output Parameters For CMOS8mA

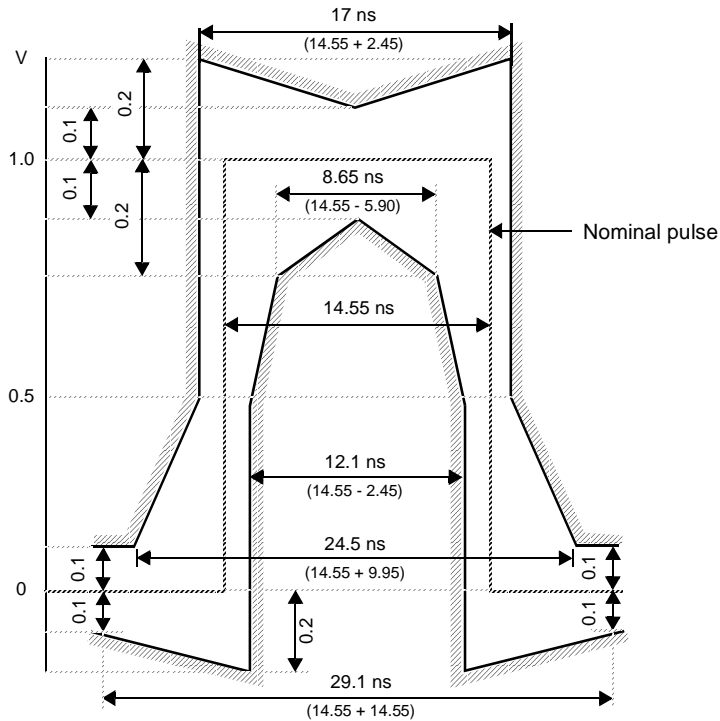
Parameter	Min	Typ	Max	Unit	Test Conditions
$V_{OH}$	$V_{DD} - 0.5$			V	$V_{DD} = 4.75; I_{OH} = -8.0\text{ mA}$
$V_{OL}$			0.4	V	$V_{DD} = 4.75; I_{OL} = 8.0\text{ mA}$
$I_{OL}$			8.0	mA	
$I_{OH}$			-8.0	mA	
$t_{RISE}$	1.3	2.4	3.8	ns	$C_{LOAD} = 25\text{ pF}$
$t_{FALL}$	1.1	1.8	2.5	ns	$C_{LOAD} = 25\text{ pF}$

**TIMING CHARACTERISTICS**

Detailed timing diagrams for the MRT are illustrated in Figures 3 through 9. All output times are measured with maximum load capacitance appropriate for the pin type. Timing parameters are measured at voltage levels of  $(V_{IH} + V_{IL})/2$  for input signals or  $(V_{OH} + V_{OL})/2$  for output signals.

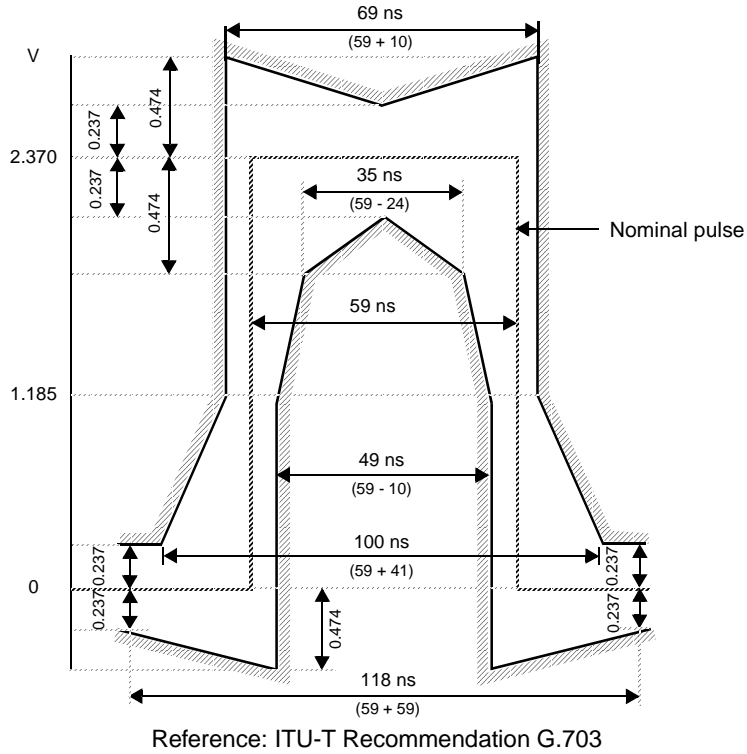
**Line Side Timing Characteristics**

The line side timing characteristics of the MRT are designed so that the line output at the transformer output meets the pulse shapes specified in ITU-T Rec. G.703 for 34 and 8 Mbit/s operation and the NTT Technical Reference for High-Speed Digital Leased Circuit Services for 6 Mbit/s operation. The pulse masks for each of the three modes of operation are shown in Figures 3, 4, and . Refer to the corresponding standard cited in each case for further details regarding the interface. The output circuits to be used are shown in Figures 12, 13 and 14.

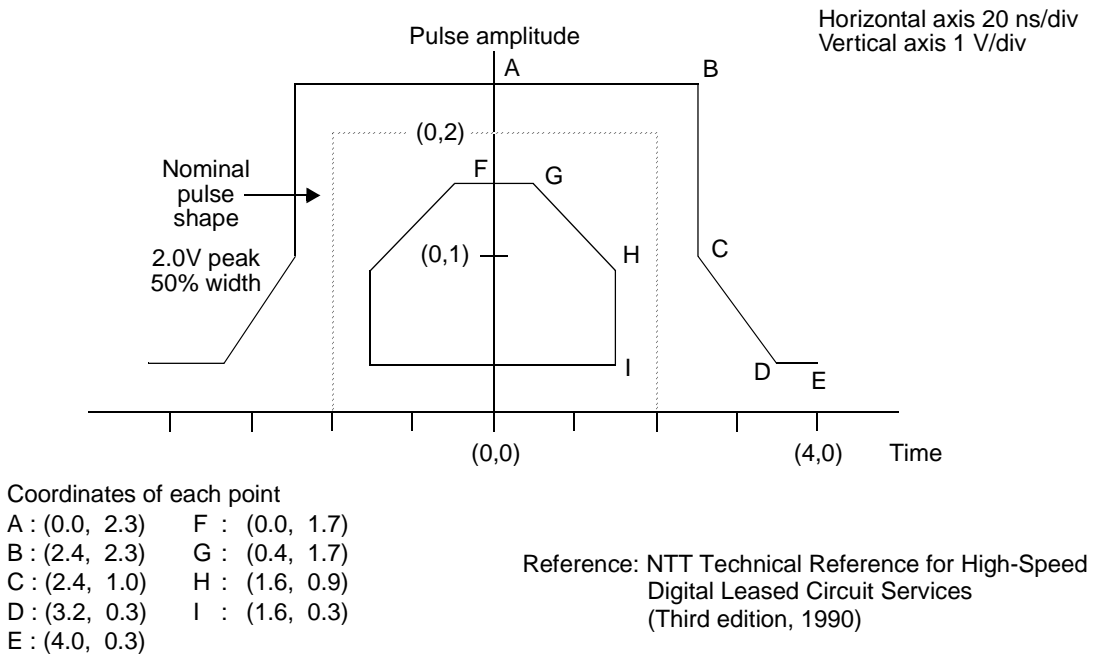


Reference: ITU-T Recommendation G.703

**Figure 3. Pulse Mask at the 34368 kbit/s Interface**



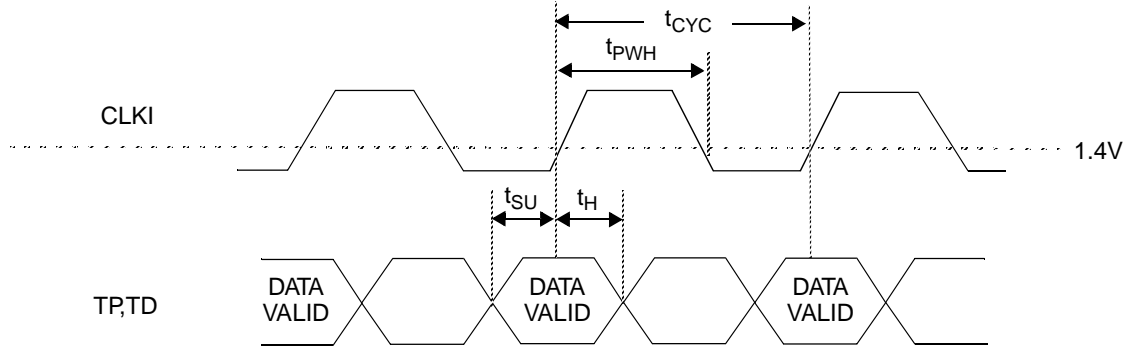
**Figure 4. Pulse Mask at the 8448 kbit/s Interface**



**Figure 5. Pulse Mask at the 6312 kbit/s Interface**

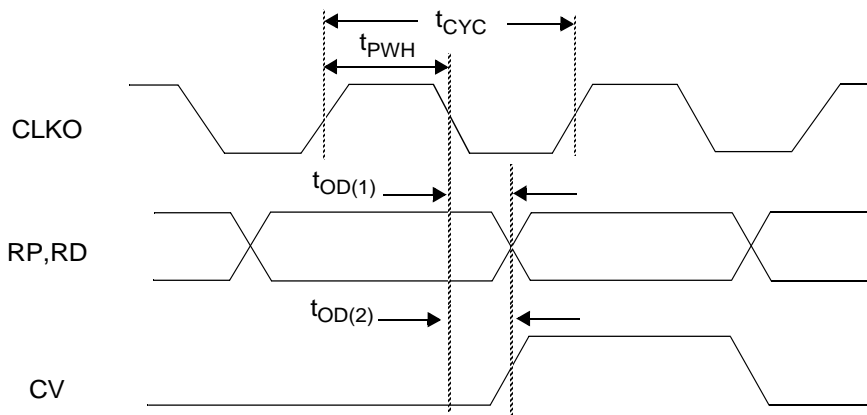
**Terminal Side Timing Characteristics**

**Figure 6. NRZ Transmit Input Timing**



Parameter	Symbol	Min	Typ	Max	Unit
CLKI clock period	$t_{CYC}$		(Note 2)		ns
CLKI duty cycle ( $t_{PWH}/t_{CYC}$ ) (Note 1)	--	45		55	%
TP,TD set-up time to CLKI↑	$t_{SU}$	3			ns
TP,TD hold time after CLKI↑	$t_H$	2			ns

**Figure 7. NRZ Receive Output Timing**



Parameter	Symbol	Min	Typ	Max	Unit
CLKO clock period	$t_{CYC}$		(Note 2)		ns
CLKO duty cycle ( $t_{PWH}/t_{CYC}$ ) (Note 1)	--	45		55	%
RP,RD output delay after CLKO↓	$t_{OD(1)}$	-5		5	ns
CV output delay after CLKO↓ (Note 3)	$t_{OD(2)}$	-5		5	ns

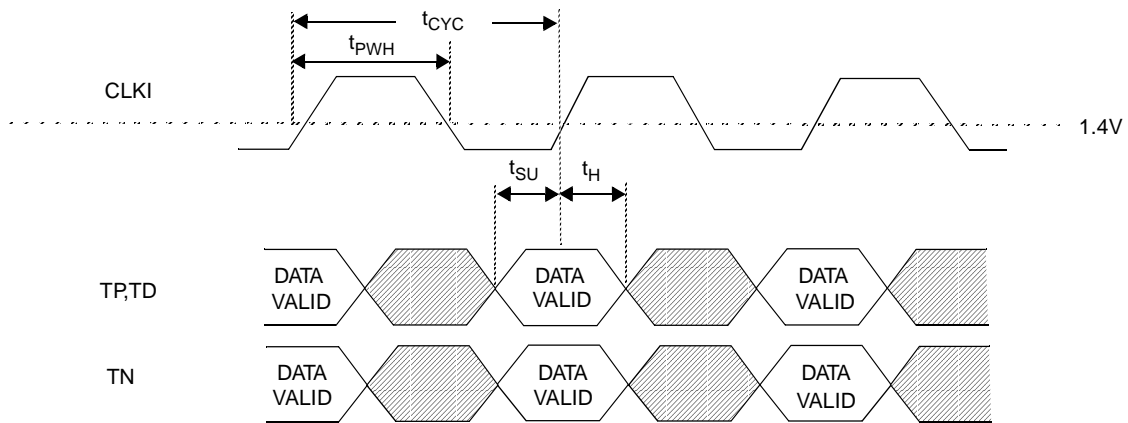
See Notes on next page.



Notes:

1. CLKO symmetry is measured about the 50% amplitude point.
2. 158.4 ns for 6312 kbit/s; 118.4 ns for 8448 kbit/s; 29.10 ns for 34368 kbit/s.
3. The CV pulse occurs at the same time as the errored bit is presented at the output.

**Figure 8. P and N Rail Transmit Input Timing**

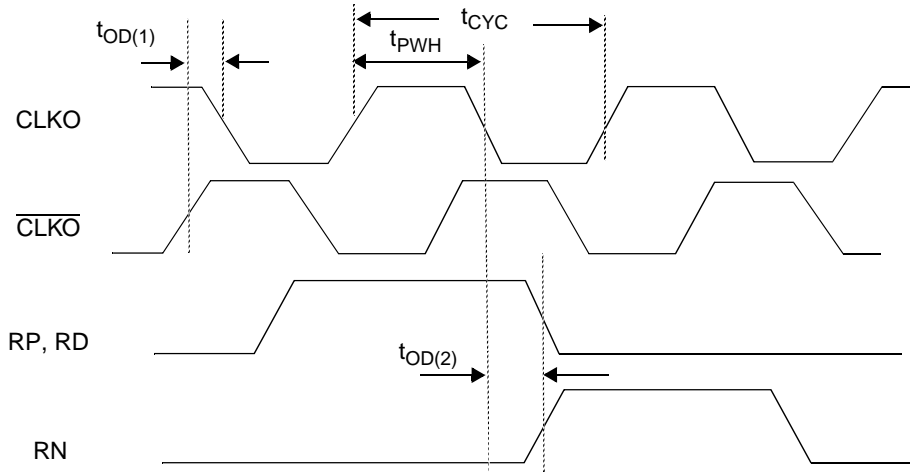


Parameter	Symbol	Min	Typ	Max	Unit
CLKI clock period	$t_{CYC}$		(Note 2)		ns
CLKI duty cycle ( $t_{PWH}/t_{CYC}$ ) (Note 1)	--	45		55	%
TP,TD & TN set-up time to CLKI $\uparrow$	$t_{SU}$	3			ns
TP,TD & TN hold time after CLKI $\uparrow$	$t_H$	2			ns

Notes:

1. CLKI symmetry is measured about the 1.4VDC threshold in order to assure symmetric output waveforms.
2. 158.4 ns for 6312 kbit/s; 118.4 ns for 8448 kbit/s; 29.10 ns for 34368 kbit/s.

**Figure 9. P and N Rail Receive Output Timing**



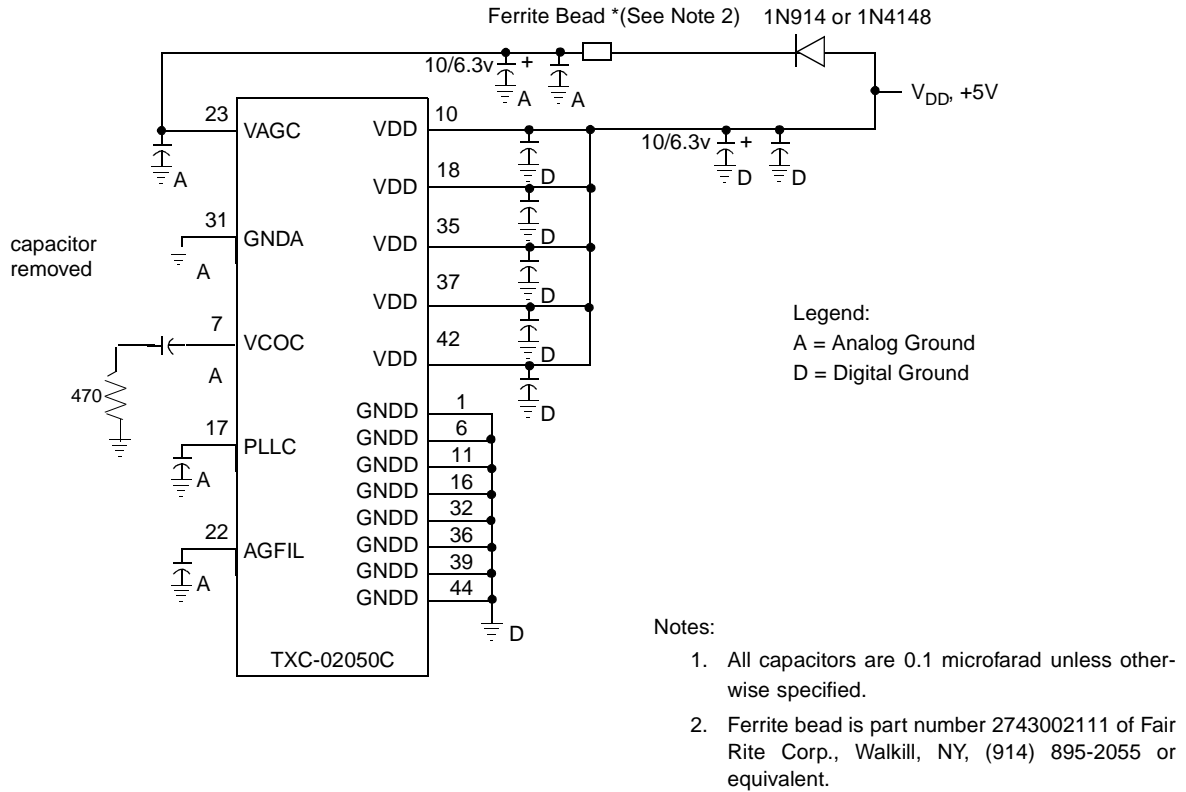
Parameter	Symbol	Min	Typ	Max	Unit
CLKO clock period	$t_{CYC}$		(Note 2)		ns
CLKO duty cycle ( $t_{PWH}/t_{CYC}$ ) (Note 1)	--	45		55	%
CLKO↓ output delay after $\overline{CLKO}\uparrow$	$t_{OD(1)}$			2	ns
RP, RD and RN output delay after CLKO↓	$t_{OD(2)}$	-5		6	ns

Notes:

1. CLKO symmetry is measured about the 50% amplitude point.
2. 158.4 ns for 6312 kbit/s; 118.4 ns for 8448 kbit/s; 29.10 ns for 34368 kbit/s.

**OPERATION**

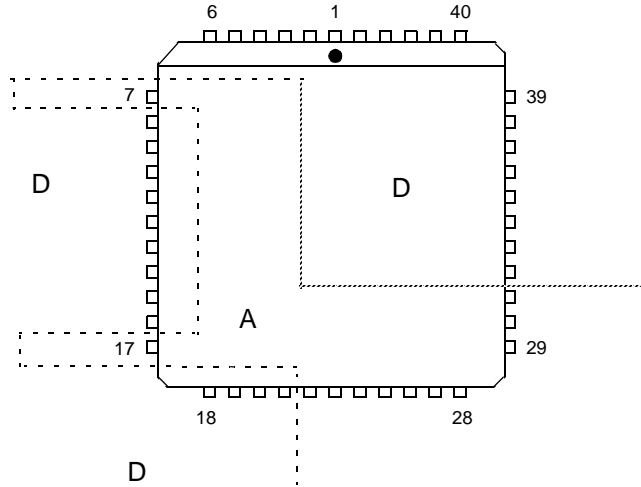
**POWER SUPPLY, GROUND AND PLL CONNECTIONS**



**Figure 10. MRT Power Supply, Ground and PLL Connections**

The MRT device has separate power supply pins labeled VDD and VAGC. The VAGC supply pin is connected to the internal AGC amplifier and is derived from the VDD supply as indicated in Figure 10. Separate bypass networks must be used for connecting the VDD and VAGC supply pins on the MRT to +5V. The bypass network on the VAGC pin consists of a 1N4148 or 1N914 diode, a ferrite bead and a 10 microfarad 6.3 volt (tantalum) capacitor connected to analog ground in parallel with a 0.1 microfarad capacitor, as shown in Figure 10. TranSwitch recommends that the 0.1 microfarad decoupling capacitors be of RF quality and that they be connected in close proximity to the device.

The recommended ground plane for the MRT device is a common ground plane for both analog and digital ground. The ground plane beneath and approximately 0.25" beyond the physical dimensions of the MRT needs to be separated into analog and digital grounds by notching approximately 25 mils of the copper ground plane, as shown in Figure 11. Additional MRT application design considerations are discussed in TranSwitch Application Note AN-517 "Design Considerations for use of the MRT device with the E2/E3F Device."



Legend: --- 25 mil notching of ground plane under device to separate analog (A) and digital (D) ground areas

**Figure 11. Ground Plane of Application Circuit Board**

**OVERVIEW**

**Line Side Input Impedance**

The input impedance of the MRT is a function of the state of the  $\overline{LOW}$  lead and the operating rate. The table below lists the input impedance of the MRT at the operating line rates (which are 1/2 the bit rates).

**MRT Input Impedance**

Condition	Minimum Input Impedance,   Z
$\overline{LOW} = 1$ , line rate = 17184 kHz (E3)	1260 ohms
$\overline{LOW} = 0$ , line rate = 4224 kHz (E2)	2390 ohms
$\overline{LOW} = 0$ , line rate = 3156 kHz (JT2)	3670 ohms

**Line Side Input Sensitivity**

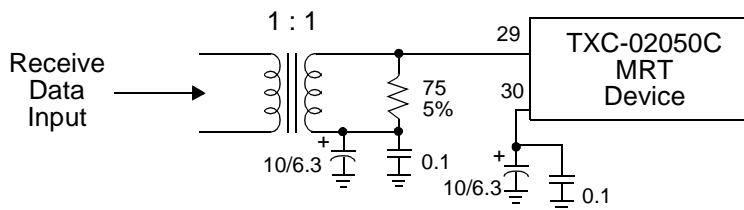
The input voltage sensitivity of the MRT depends on the state of the  $\overline{LOW}$  lead as shown in the table below.

**MRT Input Sensitivity**

$\overline{LOW}$ Lead	Rate, Mbit/s	Input Sensitivity (peak volts)	
		Min	Max
0	6/8 (JT2/E2)	0.5	2.7
1	34 (E3)	0.15	1.1

**Line Side Input Circuit**

The circuit shown in Figure 12 illustrates the components required for operating the MRT device at 34368, 8448 or 6312 kbit/s. The 1:1 transformer should have a frequency response of  $0.2 \text{ MHz} \leq f \leq 80 \text{ MHz}$  with an insertion loss of 1 dB, maximum (suitable devices include Coilcraft part no. WB-1010 and Pulse Engineering part no. PE-65966). This gives return loss and isolation voltage values that meet or exceed requirements.



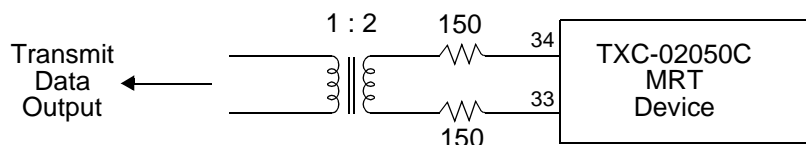
**Figure 12. Line Side Input Circuit**

**Line Side Output Characteristics**

The line side output of the MRT switches from “rail to rail” on both of its output leads, TPO and TNO. This provides the maximum voltage swing, and makes the output voltage depend on the +5 volt power supply input to the chip. The external circuit design must therefore be done with care in order to assure meeting the amplitude requirements.

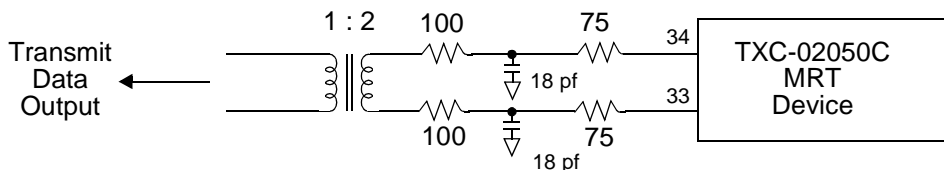
**Line Side Output Circuits**

Figure 13 illustrates the output circuit required for operating the MRT device in a 34368 kbit/s application without a socket. The transformer and resistors shown assure that the output waveform meets the ITU-T mask for 34368 kbit/s transmission and that the MRT device is operated within the current limits of the TTL24mA output parameters. The 1:2 transformer should have a frequency response of  $0.2 \text{ MHz} \leq f \leq 80 \text{ MHz}$  with an insertion loss of 1dB, maximum (suitable devices include Coilcraft part no. WB-1040 and Pulse Engineering part no. PE-65969).



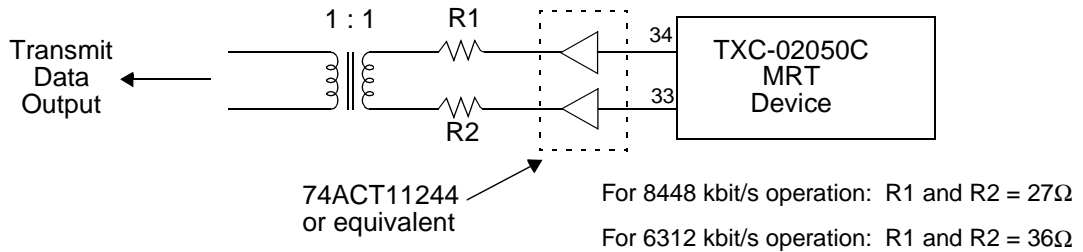
**Figure 13. Line Side Output Circuit Outline - No Socket (34368 kbit/s)**

Figure 14 shows a variation of the circuit in Figure 13. This circuit improves performance in applications when a plastic device is mounted in a socket. The additional low-pass filter compensates for possible overshoot caused by inductance created by the device/socket interface. The 1:2 transformer should have a frequency response of  $0.2 \text{ MHz} \leq f \leq 80 \text{ MHz}$  with an insertion loss of 1dB, maximum (suitable devices include Coilcraft part no. WB-1040 and Pulse Engineering part no. PE-65969).



**Figure 14. Line Side Output Circuit Outline - Socket (34368 kbit/s)**

The peak voltage and current output requirements for 6312 and 8448 kbit/s operation are different from those for 34368 kbit/s operation. Figure 15 illustrates the output circuit required for 6312 kbit/s and 8448 kbit/s operation. The 1:1 transformer should have a frequency response of  $0.2 \text{ MHz} \leq f \leq 80 \text{ MHz}$  with an insertion loss of 1dB, maximum (suitable devices include Coilcraft part no. WB-1010 and Pulse Engineering part no. PE-65966). The transformer, drivers and resistors assure that the output waveform meets the pulse mask requirements for these rates and that the MRT device is operated within the current limits of the TTL24mA output parameters.



**Figure 15. Line Side Output Circuit Outline (8448 and 6312 kbit/s)**

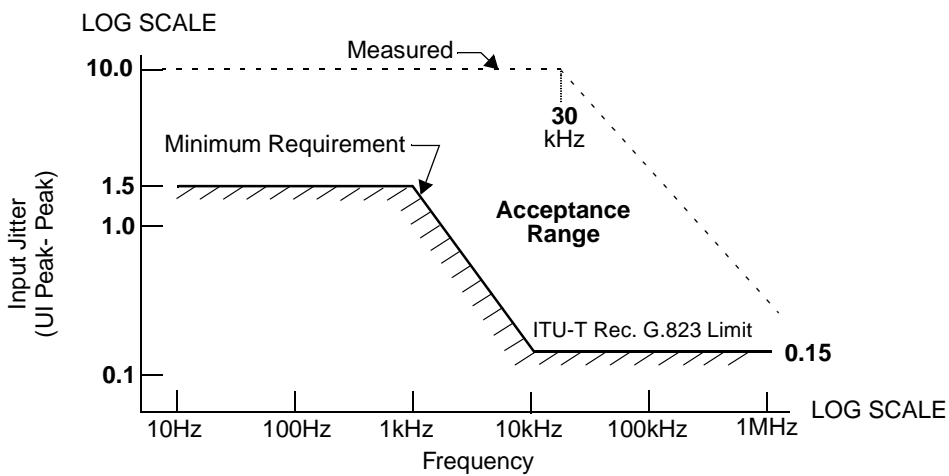
**JITTER AND INTERFERING TONE TOLERANCES**

The jitter measurements described in this subsection are performed using an ANRITSU model ME502B Digital Transmission Analyzer, or equivalent.

**Jitter Tolerance**

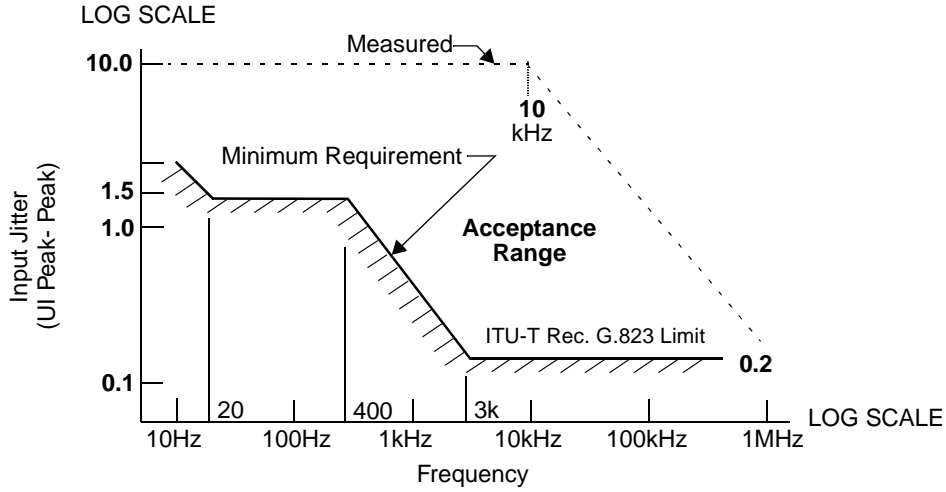
ITU-T Recommendations G.823 and JT-G703 specify that network equipment must be able to accommodate and tolerate levels of jitter up to certain specified limits. The MRT accommodates and tolerates more input jitter than the level of input jitter specified by these Recommendations.

With input jitter applied to the MRT line side receive input DI1 (pin 29), the MRT properly recovers clock, decodes the signal, and outputs error-free NRZ data over (and beyond) the ITU-T ranges specified for jitter input and frequency. Performance characteristics are shown below in Figure 16 (34368 kbit/s operation), Figure 17 (8448 kbit/s operation) and Figure 18 (6312 kbit/s operation).



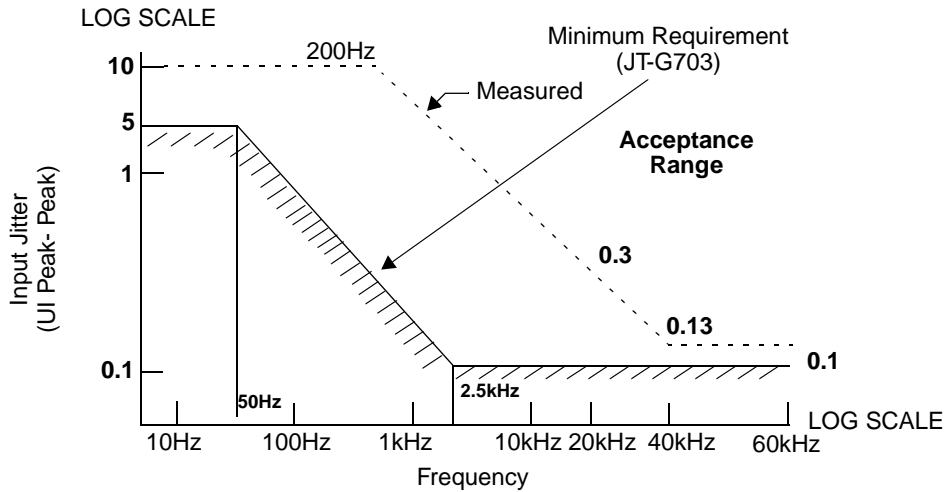
Notes: Unit Interval (UI) = 1/(System Clock Frequency) = 29.10 ns  
 Test conditions: V<sub>DD</sub>=5V, T<sub>A</sub>=25°C, HDB3 coding, 2<sup>23</sup>-1 data pattern

**Figure 16. MRT Jitter Tolerance at 34368 kbit/s**



Notes: Unit Interval (UI) = 1/(System Clock Frequency) = 118.4 ns  
 Test conditions:  $V_{DD}=5V$ ,  $T_A=25^\circ C$ , HDB3 coding,  $2^{15}-1$  data pattern

**Figure 17. MRT Jitter Tolerance at 8448 kbit/s**



Notes: Unit Interval (UI) = 1/(System Clock Frequency) = 158.4 ns  
 Test conditions:  $V_{DD}=5V$ ,  $T_A=25^\circ C$ , B8ZS coding,  $2^{15}-1$  data pattern

**Figure 18. MRT Jitter Tolerance at 6312 kbit/s**



### Maximum Output Jitter In Absence of Input Jitter

ITU-T Recommendation G.823 specifies that it is necessary to restrict the amount of jitter generated by individual equipment at an output port. The amount of jitter allowed is dependent on the application in which the equipment is used. For example, in a repeater application the recovered clock will be used for the transmit clock. The recovered clock will have jitter due to the sending transmitter and to clock recovery of distorted data. The jitter will be additive through each repeater. Therefore, it would be necessary to add a dejitter buffer (a PLL with a very low bandwidth, usually using a VCXO) to reduce the jitter in the recovered clock before using it as a transmit clock.

For the MRT in non-repeater applications, the maximum output jitter measurement is made on the transmit path. The recovered clock output jitter is unimportant as long as proper clocking of following devices is possible (with the exception of the above-mentioned repeater applications). The transmit clock in these cases is coming from a device such as a framer whose clock is derived from the local oscillator on the board. To make this measurement, apply a signal with known jitter characteristics to the transmitter inputs and measure the jitter at the transmitter outputs.

In the absence of applied jitter, the transmit path of the MRT introduces a maximum 0.05 Unit Intervals (UIs) peak-to-peak jitter over the following frequency ranges:

At 6.312 Mbit/s: 10 Hz to 160 kHz

At 8448 kbit/s: 20 Hz to 400 kHz

At 34368 kbit/s: 100 Hz to 800 kHz

This operation is with the MRT terminated by the external components (and component values) specified in the Pin Description Table for pin 7 (VCOC), pin 17 (PLL), and pin 22 (AGFIL).

### Jitter Transfer

Transfer of jitter through individual equipment is characterized by the relationship between the applied input jitter and the resulting output jitter as a function of frequency. ITU-T Recommendation G.823 specifies that it is important to restrict jitter gain. Figure 4 of G.823 shows a typical jitter transfer characteristic. Note that a small jitter gain is allowed. British Standard 6328: Section 8.1, 1990 gives the allowable gain as 0.5 dB.

With applied input jitter at the MRT receive input terminals, the maximum MRT receive output jitter is not greater than the level of input jitter plus a maximum of 0.05 UI peak-to-peak jitter in the range of 10 Hz to 160 kHz for 6 Mbit/s, 20 Hz to 400 kHz for 8 Mbit/s, and 100 Hz to 800 kHz for 34 Mbit/s. These values are measured by applying a controlled, sinusoidal jitter signal to pins DI1 and DI2, then measuring the jitter at the receiver output (i.e., CLKO).

This operation is with the same MRT external terminations as described in the Maximum Output Jitter section above.

### Interfering Tone Tolerance

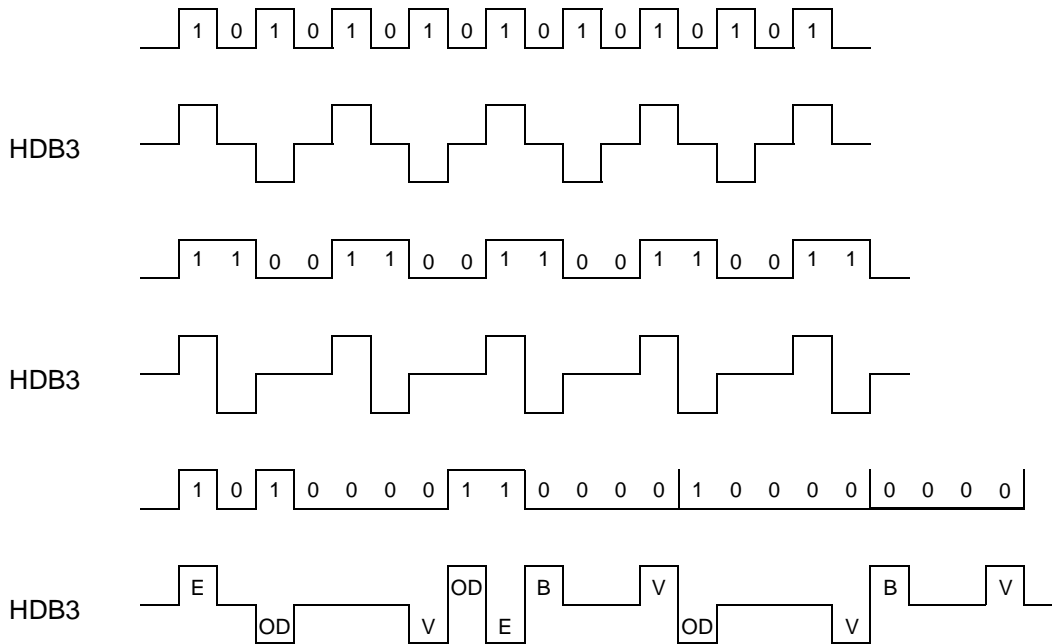
The MRT will properly recover clock and present error-free output to the receive terminal side interface in the presence of a PRBS interfering tone with the same data sequence as the data input while operating at 6, 8 or 34 Mbit/s, as specified in the following table:

**PRBS\* Interfering Tone Tolerance**

Data Rate (kbit/s)	Tone Rate (kbit/s)	Maximum Tone Level	Data Sequence	Requirement
34368	34368 ± 100ppm	-11.5 dB	2 <sup>23</sup> - 1	- 20
8448	8448 ± 100ppm	-14.5 dB	2 <sup>15</sup> - 1	- 18.5

\*PRBS = Pseudo-Random Binary Sequence

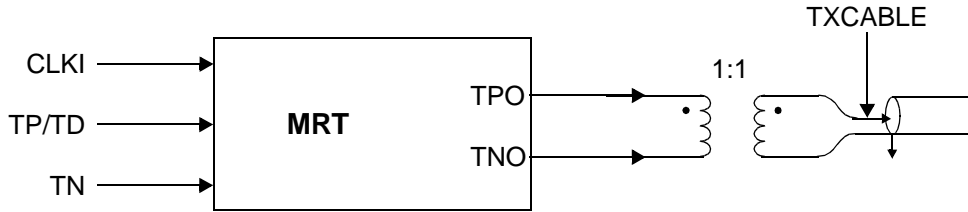
**HDB3 PATTERNS**



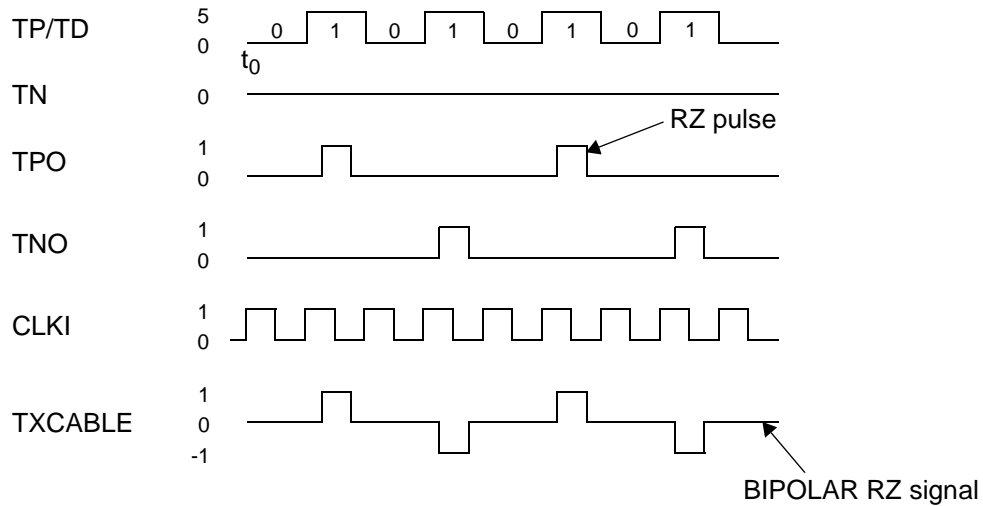
- E = indicates even number of pulses since last violation (V)
- OD = indicates odd number of pulses since last violation (V)
- V = intentional violation of alternating plus and minus pulses used for 1's
- B = pulse that follows the normal alternating Bipolar coding scheme
- four zeros are replaced with B00V or 000V; the substitution choice is made so that the number of pulses between violations (V's) is odd; note that sequential violations are of opposite polarity so the net charge on the transmission medium is zero.

**Figure 19. Examples of HDB3 Coding**

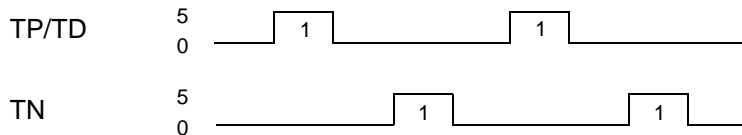
**EXAMPLES OF TRANSMIT INPUT AND OUTPUT DATA (34368 KBIT/S OPERATION)**



Unencoded NRZ Data (0 1 0 1 0 .....)



Encoded NRZ P & N Data (0 1 0 1 0 ....)

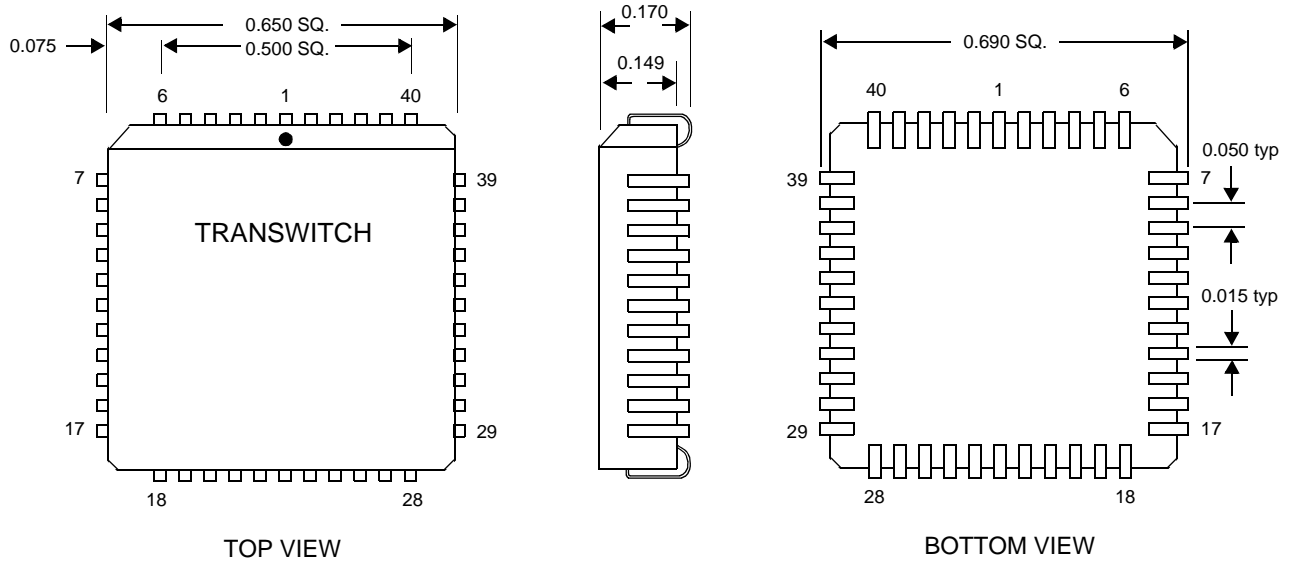


TPO, TNO, CLKI and TXCABLE are the same as in the unencoded NRZ case.

**Figure 20. Examples of Transmit Input and Output Data (34368 kbit/s operation)**

**PACKAGING**

The MRT device is packaged in a 44-pin plastic leaded chip carrier suitable for socket or surface mounting, as illustrated in Figure 21. All dimensions shown are in inches and are nominal unless otherwise noted.



**Figure 21. MRT TXC-02050C 44-Pin Plastic Lead Chip Carrier**

## ORDERING INFORMATION

Part Number: TXC-02050CIPL 44-pin Plastic Leaded Chip Carrier

## RELATED PRODUCTS

TXC-03701 E2/E3F Framer VLSI device. The E2/E3 Framer directly interfaces with the MRT and provides multi-mode framing for ITU-T Rec. G.751/G.753 (34368 kbit/s) or ITU-T Rec. G.742/G.745 (8448 kbit/s) signals.

TXC-03702 JT2F Framer VLSI device. The JT2F Framer directly interfaces with the MRT and provides framing for ITU-T Rec. G.704 (6312 kbit/s) signals.

TXC-06125 XBERT VLSI device (Bit Error Rate Generator / Receiver). Programmable multi-rate test pattern generator and receiver in a single chip with bit-serial, nibble-parallel or byte-parallel interface capability.

TXC-21055 MRT Evaluation Board. A complete ready-to-use single board that demonstrates the functions and features of the MRT line interface VLSI device.

**STANDARDS DOCUMENTATION SOURCES**

Telecommunication technical standards and reference documentation may be obtained from the following organizations:

**ANSI (U.S.A.):**

**American National Standards Institute**  
25 West 43<sup>rd</sup> Street  
New York, New York 10036

Tel: (212) 642-4900  
Fax: (212) 398-0023  
Web: [www.ansi.org](http://www.ansi.org)

**The ATM Forum (U.S.A., Europe, Asia):**

404 Balboa Street  
San Francisco, CA 94118

Tel: (415) 561-6275  
Fax: (415) 561-6120  
Web: [www.atmforum.com](http://www.atmforum.com)

**ATM Forum Europe Office**

Kingsland House - 5<sup>th</sup> Floor  
361-373 City Road  
London EC1 1PQ, England

Tel: 20 7837 7882  
Fax: 20 7417 7500

**ATM Forum Asia-Pacific Office**

Hamamatsucho Suzuki Building 3F  
1-2-11, Hamamatsucho, Minato-ku  
Tokyo 105-0013, Japan

Tel: 3 3438 3694  
Fax: 3 3438 3698

**Bellcore** (See Telcordia)

**CCITT** (See ITU-T)

**EIA (U.S.A.):**

**Electronic Industries Association  
Global Engineering Documents**  
15 Inverness Way East  
Englewood, CO 80112

Tel: (800) 854-7179 (within U.S.A.)  
Tel: (303) 397-7956 (outside U.S.A.)  
Fax: (303) 397-2740  
Web: [www.global.ihs.com](http://www.global.ihs.com)

**ETSI (Europe):**

**European Telecommunications  
Standards Institute**  
650 route des Lucioles  
06921 Sophia-Antipolis Cedex, France

Tel: 4 92 94 42 00  
Fax: 4 93 65 47 16  
Web: [www.etsi.org](http://www.etsi.org)

**GO-MVIP (U.S.A.):**

**The Global Organization for Multi-Vendor  
Integration Protocol (GO-MVIP)**

*3220 N Street NW, Suite 360  
Washington, DC 20007*

Tel: (800) 669-6857 (within U.S.A.)  
Tel: (903) 769-3717 (outside U.S.A.)  
Fax: (903) 769-3818  
Web: [www.mvip.org](http://www.mvip.org)

**ITU-T (International):**

**Publication Services of International  
Telecommunication Union  
Telecommunication Standardization Sector**

*Place des Nations, CH 1211  
Geneve 20, Switzerland*

Tel: 22 730 5852  
Fax: 22 730 5853  
Web: [www.itu.int](http://www.itu.int)

**MIL-STD (U.S.A.):**

**DODSSP Standardization Documents  
Ordering Desk**

*Building 4 / Section D  
700 Robbins Avenue  
Philadelphia, PA 19111-5094*

Tel: (215) 697-2179  
Fax: (215) 697-1462  
Web: [www.dodssp.daps.mil](http://www.dodssp.daps.mil)

**PCI SIG (U.S.A.):**

**PCI Special Interest Group**

*5440 SW Westgate Dr., #217  
Portland, OR 97221*

Tel: (800) 433-5177 (within U.S.A.)  
Tel: (503) 291-2569 (outside U.S.A.)  
Fax: (503) 297-1090  
Web: [www.pcisig.com](http://www.pcisig.com)

**Telcordia (U.S.A.):**

**Telcordia Technologies, Inc.  
Attention - Customer Service**

*8 Corporate Place Rm 3A184  
Piscataway, NJ 08854-4157*

Tel: (800) 521-2673 (within U.S.A.)  
Tel: (732) 699-2000 (outside U.S.A.)  
Fax: (732) 336-2559  
Web: [www.telcordia.com](http://www.telcordia.com)

**TTC (Japan):**

**TTC Standard Publishing Group of the  
Telecommunication Technology Committee**

*Hamamatsu-cho Suzuki Building  
1-2-11, Hamamatsu-cho, Minato-ku  
Tokyo 105-0013, Japan*

Tel: 3 3432 1551  
Fax: 3 3432 1553  
Web: [www.ttc.or.jp](http://www.ttc.or.jp)

**LIST OF DATA SHEET CHANGES**

This change list identifies those areas within the updated MRT Data Sheet that have technical differences relative to the superseded MRT Data Sheet:

Updated MRT "C" Data Sheet: Edition 1, May 2002

Superseded MRT Data Sheet: Edition 3, April 1994

The page numbers indicated below of the updated data sheet include changes relative to the superseded data sheet.

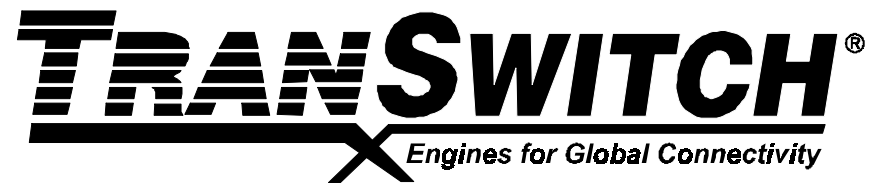
<b><u>Page Number of Updated Data Sheet</u></b>	<b><u>Summary of the Change</u></b>
All	Changed edition number and date.
All	Changed GND to GNDD.
1	Made changes to items 3, 5, 6, 7 and 10 of the Feature list.
1	Added items 9, 11 and 12 to the Feature list.
1	Modified the first paragraph of Description section. Changed Patent information.
2	Added Table of Contents and List of Figures.
3	Modified Figure 1 and added product number to the figure title.
4	Made changes to Block Diagram Description section.
5	Added product number to the Figure title 2.
6	Made changes to Name/Function column for VDD, GNDD, VAGC, GNDA, TNO and TPO.
6	Added a Note below the table to explain Type column heading for 'Line Side I/O' section.
6-7	Made changes to Type and Name/Function columns for RN, RP/RD, $\overline{\text{CLKO}}$ and CLKO.
7-10	Made changes to Name/Function column for CLKI, $\overline{\text{TXLOC}}$ , LQLTY, $\overline{\text{RXLOS}}$ , DCK, $\overline{\text{LOW}}$ , EQB1, EQB0, VCOC and AGFIL.
10	Made changes to I/O/P column for VCOC, PLLC, AGFIL and added Note below the table.
11	Added Test Conditions column to the second table. Made changes to $V_{\text{AGC}}$ row of the last table. Changed Test Condition for $I_{\text{AGC}}$ and changed Max for $P_{\text{AGC}}$ to the last table. Changed in first table Max. Operating Junction Temperature. Added a note below the table.





<u>Page Number of Updated Data Sheet</u>	<u>Summary of the Change</u>
12	Added Max for $V_{IH}$ and Min for $V_{IL}$ of the first three tables.
14-18	Made changes to Timing Characteristics section.
19-24	Made changes to Operation section. Removed capacitor from pin 31 and Note 3 from Figure 10. Updated Jitter requirements in Figure 18.
28	Made minor changes to Packaging section.
29	Added item 3 to the Related Products section.
30-31	Updated the Standards Documentation Sources section.
32-33	Updated List of Data Sheet Changes.
35	Added Documentation Update Registration Form.

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