HIGHLAND TECHNOLOGY

MODEL T735

OPTICAL / ELECTRICAL CONVERTER

Technical Manual

July 3, 2023

650 Potrero Avenue San Francisco, CA 94110 www.highlandtechnology.com tel: 415 551-1700 fax: 415 551-5129

650 Potrero Avenue, San Francisco, CA 94110
Phone 415-551-1700 • Fax 415-551-5129
www.highlandtechnology.com

NOTICE

HIGHLAND TECHNOLOGY, INC. PROVIDES THIS PUBLICATION “AS IS” WITHOUT WARRANTY OF ANY KIND, EITHER EXPRESS OR IMPLIED, INCLUDING, BUT NOT LIMITED TO, THE IMPLIED WARRANTIES OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE.

(Disclaimer of expressed or implied warranties in certain transactions is not allowed in some states. Therefore, the above statement may not apply to you.)

This manual may contain technical inaccuracies and/or typographical errors. Changes are periodically made to this manual, which are incorporated in later editions. Highland Technology, Inc. may make changes and improvements to the product(s) and/or programs described in this publication at any time without notice.

These products have finite failure rates associated with their hardware, firmware, design, and documentation. Do not use these products in applications where a failure or defect in the instrument may result in injury, loss of life, or property damage.

IN NO EVENT WILL HIGHLAND TECHNOLOGY, INC. BE LIABLE FOR DAMAGES, INCLUDING LOST PROFITS, LOST SAVINGS OR OTHER INCIDENTAL OR CONSEQUENTIAL DAMAGES ARISING OUT OF THE USE OF OR INABILITY TO USE SUCH PRODUCT, EVEN IF HIGHLAND TECHNOLOGY, INC. OR AN APPROVED RESELLER HAS BEEN ADVISED OF THE POSSIBILITY OF SUCH DAMAGES, OR FOR ANY CLAIM BY ANY OTHER PARTY.

Table of Contents

1. Introduction

Figure 1 shows the external appearance of the T735 O/E Converter. The T735 converts a simplex optical signal to dual differential RS422/485 or LVDS, and TTL logic output levels.

Figure 1: Model T735 O/E Converter

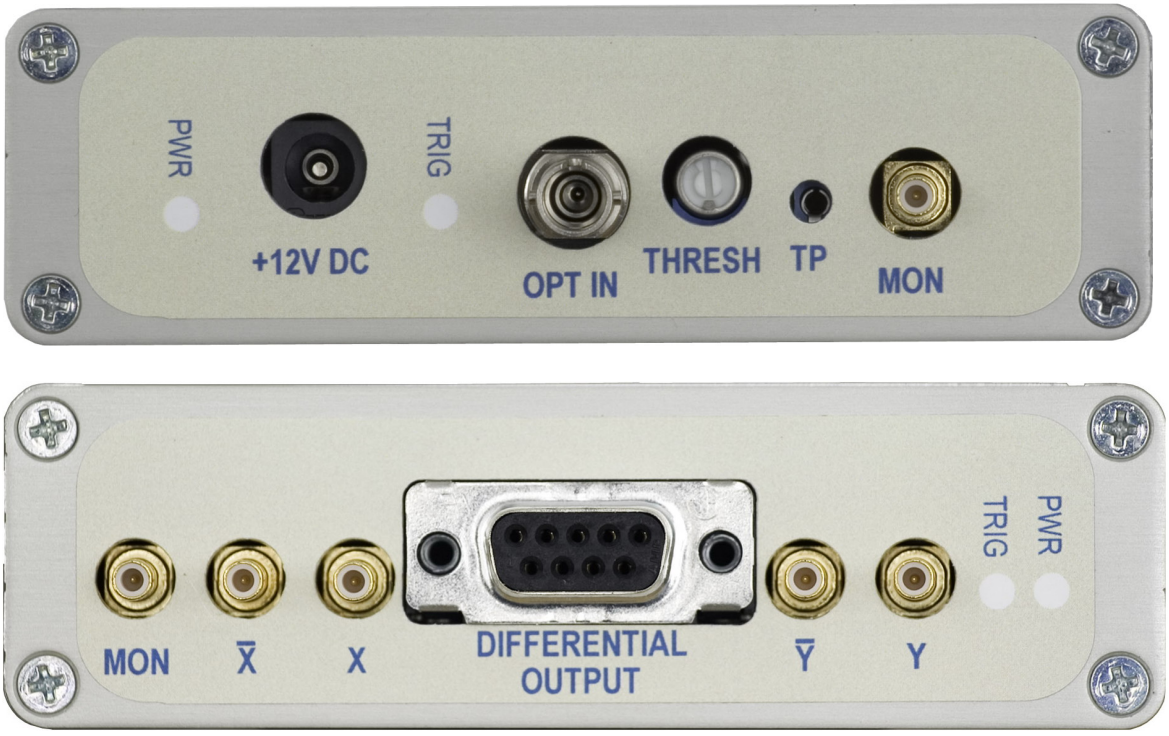

Figure 2: Model T735 O/E Converter (Front and Rear Panel)

Features of the T735 include:

- Converts fiberoptic input to electrical logic-level outputs
- T735-16 O/E incorporates a pulse-stretcher to translate 700ps FWHM optical pulses into 7ns, square pulses
- Dual differential RS422/485 or LVDS outputs on D9 female jack
- Dual complimentary TTL outputs on SMB jacks
- Logic and monitor paths are DC coupled
- Dash-23 version has DC coupled monitor paths and AC coupled Logic input paths
- Compact, rugged extruded package allows the O/E to be located wherever most convenient, including embedded applications
- Accepts optical inputs from Highland E/O converters or compatible sources
- The T735-3, T735-5, T735-13, T735-15, T735-16 and T735-23 versions are suited for use with singlemode or multimode fiber at 1310 nm and 1550 nm
- On-board analog O/E converter provides fast analog electrical output for monitoring fiberoptic link quality
- Compatible with Highland optical transmitter products:
    - J720 Electrical/Optical Converter
    - J724 Electrical/Optical Converter
    - V720 Electrical/Optical Converter VME Module
    - V880 System Timing Module

2. Specifications: T735 O/E Converter

FUNCTION	Logic-level DC coupled optical-electrical converter
INPUT	T735-3, T735-13, T735-23: ST connectorized, 1mW, 1310 nm nominal optical input T735-5, T735-15: ST connectorized, 1mW, 1550 nm nominal optical input T735-16: FC connectorized, 700ps FWHM, 1mW peak, 1550 nm nominal optical input
INPUT THRESHOLD	Optical: 100 µW to 800 µW (dash -3, -5, -13, -15) 100 µW to 2.5 mW (dash -23) 100 µW to 1.7 mW (dash -16) Factory threshold setting 300 µW (500 µW, nominal for dash -16)
PROPAGATION DELAY	25 ns, maximum
MONITOR OUTPUT	Optical monitor scaling: 1 V/mW into 50 Ω Monitor source impedance: 50 Ω
LOGIC OUTPUTS	T735-3, T735-5, T735-23: Dual RS422/485 differential and dual complementary TTL T735-13, T735-15, T735-16: Dual LVDS differential and dual complementary TTL Unloaded TTL output voltage: +5V TTL source impedance: 50 Ω Outputs are logic true when optical input receives light T735-16 stretches nominal 700ps FWHM input optical pulse to 7ns FWHM, nominal logic output pulse
BANDWIDTH	RS422/485 versions: DC to 10 MHz (0 to 20 Mb/s data rate) T735-23 (AC coupled): 4 kHz (kBaud) max LVDS versions: DC to 100 MHz (0 to 200 Mb/s data rate) T735-16 O/E impulse response: 7ns output pulse-width, nominal Pulse width adjustable over 2:1 range, typ.
RISETIME	RS422/485 versions: 10 ns, nominal (15 pF, 100 Ω load)

	LVDS versions: 1 ns, nominal (10 pF, 100 Ω load) TTL outputs: 600 ps, nominal (50 Ω load)
FALLTIME	RS422/485 versions: 10 ns, nominal (15 pF, 100 Ω load) LVDS versions: 1 ns, nominal (10 pF, 100 Ω load) TTL outputs: 700 ps, nominal (50 Ω load)
JITTER	Optical input to RS422/485 versions: ≤ 50 ps RMS Optical input to LVDS versions: ≤ 20 ps RMS Optical input to LVDS (T735-16): ≤ 75 ps RMS
OPERATING TEMPERATURE	0 to 60ºC
CALIBRATION INTERVAL	One year
POWER	+12 V at 500 mA max 2.1 mm x 5.5 mm connector J12 Universal Wall-Plug Adapter furnished
CONNECTORS	FC or ST input receptacle (depending on version) Gold plated SMB TTL and optical monitor outputs D9 female, RS422/485 or LVDS differential signal output 2.1 mm x 5.5 mm barrel power connector
INDICATORS	LEDS: Front and rear panel green Power and blue Trigger Trigger LED intensity indicates trigger status: Dim for optical input above DC threshold, Bright for optical trigger edge transitions above threshold
PACKAGING	4.75” (L) x 4.00” (W) x 1.25” (H), extruded anodized aluminum Optional removable mounting flange
CONFORMANCE	OEM product has no UL/FCC/CE compliance requirements Designed to meet UL/FCC/CE requirements Power adapter when furnished is UL/CE certified

3. Theory of Operation

The T735 block diagram is presented in Figure 3. It incorporates a InGaAs detector, a fast analog amplifier, an analog output driver, an adjustable comparator, and output drivers. An edge-triggered one-shot drives the trigger monitor LEDs.

A calibrated analog monitor output is available at the front and rear panels for electrically monitoring optical signals. Power and Trigger status LEDs are located at front and rear panels for optimum visibility.

The T735-16 adds a pulse stretcher at the O/E input amplifier, permitting response to 1550nm pulses as narrow as 700 ps, FWHM.

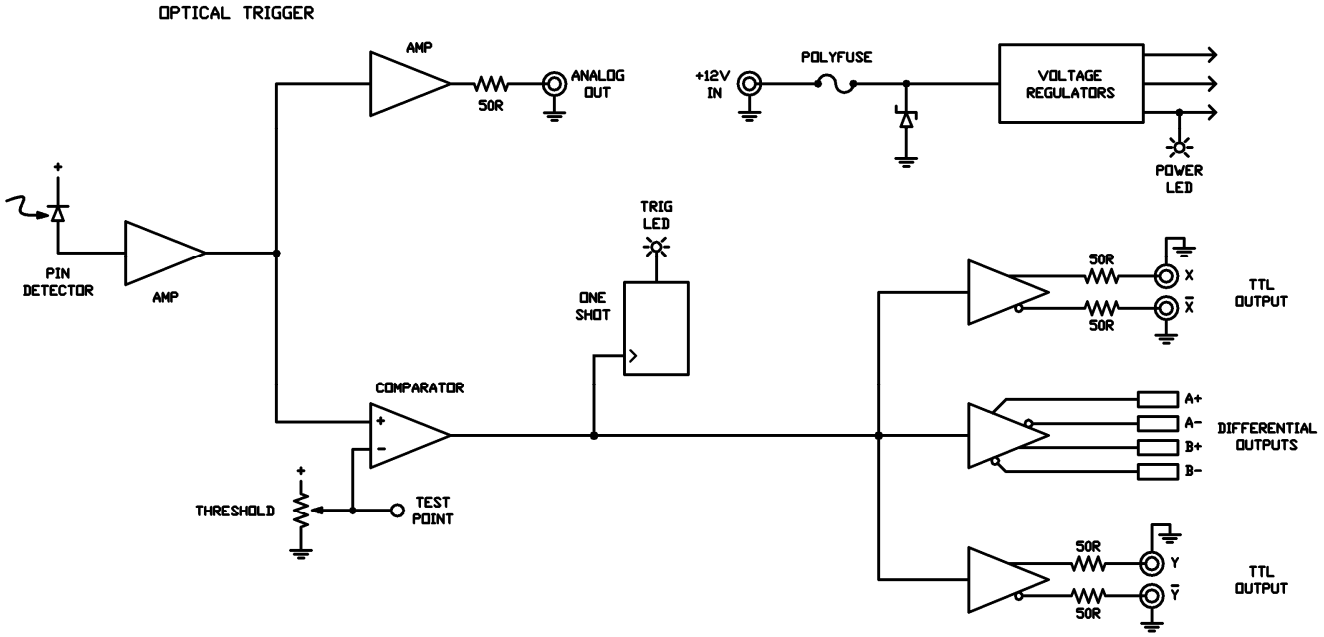

Figure 3: T735 Block Diagram

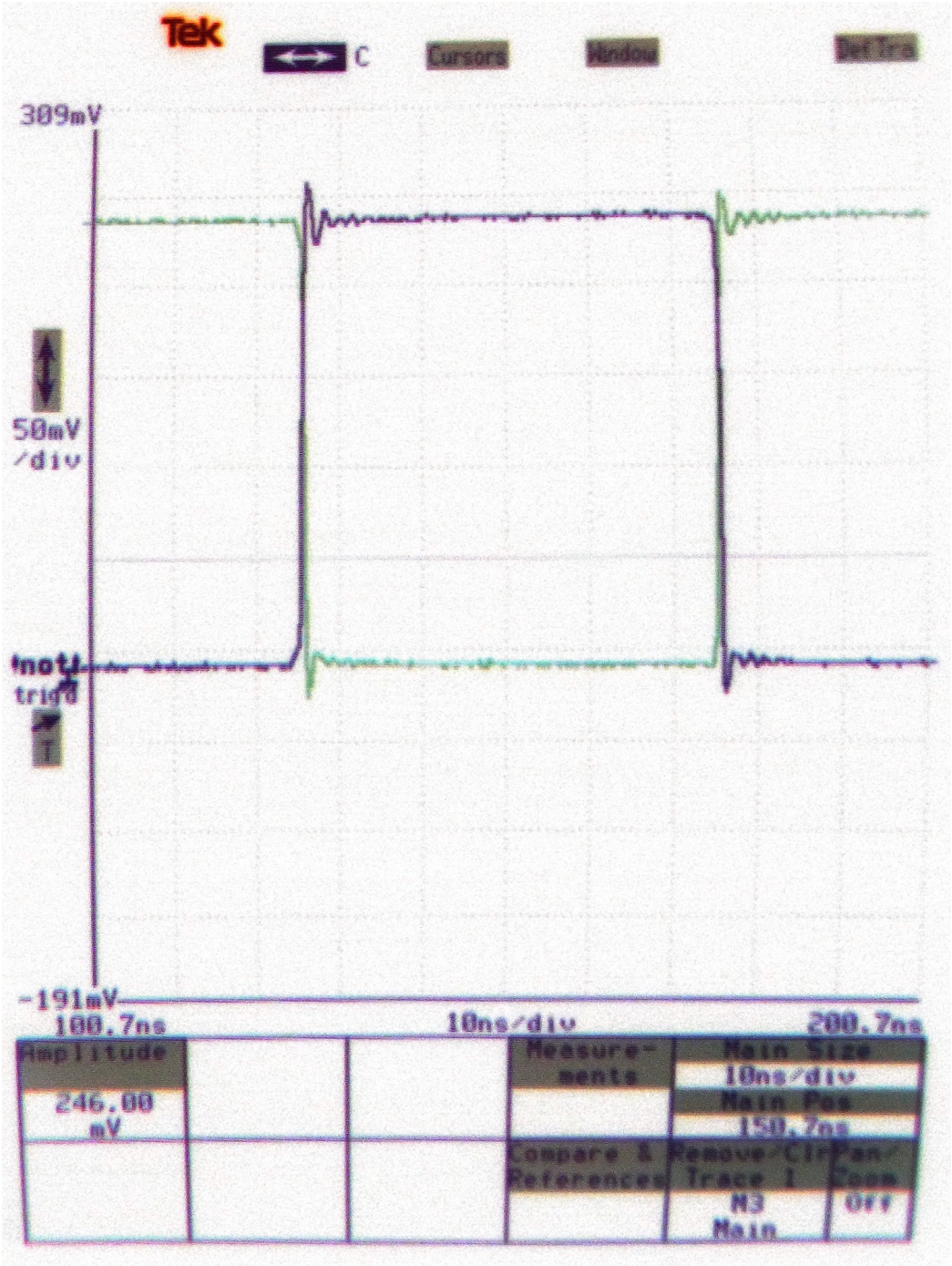

Figure 4: Typical complimentary TTL output waveform driving 50 Ω load. Vertical scale is 500 mV/cm.

4. Setup and Application

Power

The T735 requires an external source of +12 V DC power. The power connector on the unit is a female coaxial-type 2.1 mm x 5.5 mm connector with positive center. The model J12 power supply is recommended. Power may also be applied to pin 7 of the D9 connector.

The T735 enclosure is ground and circuit common. The T735 is protected against polarity reversal and reasonable overloads.

Adjustments

The “THRESH” trimpot pot sets the O/E input comparator decision level, with a test point provided to assist in accurately setting the level. The T735 outputs go true when incoming optical power exceeds the threshold setting. The threshold is adjustable using the trimpot located adjacent to the fiber input connector. The nearby test point voltage may be measured with a DVM to facilitate setting the threshold; it is scaled 1 volt per milliwatt; measure this voltage against any of the cover securing screws or the ST connector shell, all of which are grounded and circuit common.

The “MON” connector is an analog electrical output which reflects optical power input, scaled to +1V / mW into 50 Ω, and may be used to monitor optical signal quality or quantify the fiber-coupled optical trigger power level. Signal level will be 2 volts per milliwatt when connected to a high-impedance load.

The optical comparator threshold is factory-set to 300 μW (500 μW for the T735-16), and is adjustable from below 100 μW to at least 800 μW (1.7 mW max for the T735-16, 2.5 mW max for the T735-23). The optical comparator threshold conversion constant is 1mV / mW. Thus, a 300 μW comparator threshold setting would be measured as 300 mV at the threshold test point. A setting of about 30 percent of expected optical pulse power is recommended. Too high or two low a setting can result in excess jitter or unreliable operation. If the analog output is monitored with a 50 Ω oscilloscope, the threshold voltage at the test point is scaled identically to the analog output voltage, so the threshold pot might be set so the test point voltage is 30 percent of the peak observed analog pulse level. If a high-impedance scope is used to check the analog output, set the test point voltage to about 15 percent of the observed peak analog voltage level. The T735-16 nominal 7ns output pulse width can be adjusted over a range of at least 2:1 by varying the threshold setting.

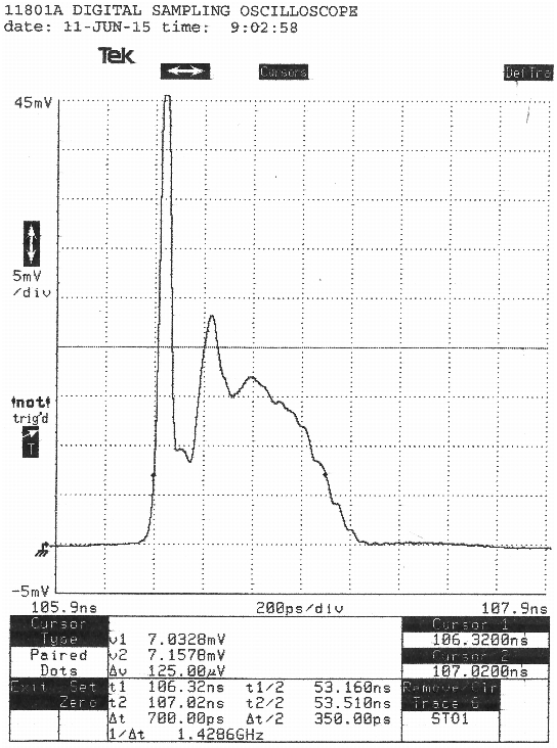

Figure 5: 700ps, 1550nm optical input to T735-16 (1mW, 15mV/mW)

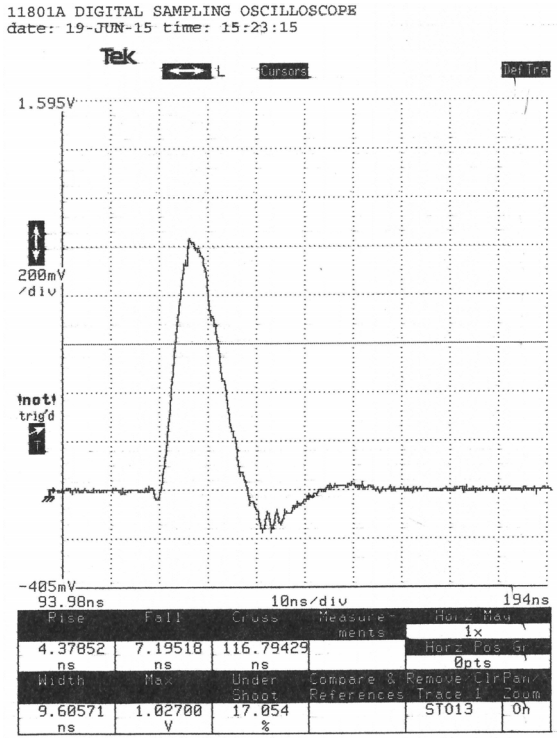

Figure 6: T735-16 analog MON out impulse response

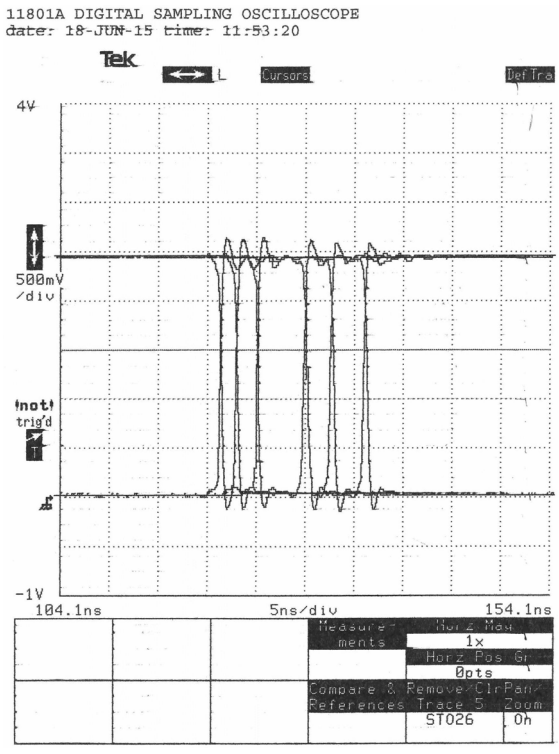

Figure 7: T735-16 TTL out, 5 – 15ns PW vs. Thresh adjust position

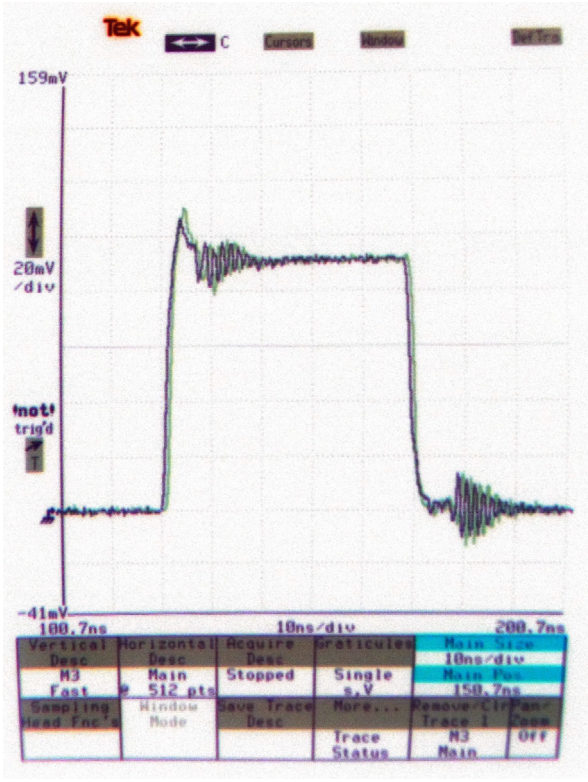

Figure 8: Internal O/E analog outputs into 50 Ω, 1mW optical pulse, 200mV/cm

5. Differential Signaling Notes

RS422/485

The RS422/485 standard is based on transmitting complimentary signals along two separate wires. Typically these wires are a 100-Ohm twisted-pair to minimize EMI interference. RS422/485 receivers change logic state when they detect a difference signal ≥ 200mV across their input pins. The T735-3 and T735-5 generate a difference signal of approximately 4.5 volts into 50 Ω, providing up to 26 dB of signal headroom in a lossy / noisy transmission system. Differential signaling subtracts out common-mode noise signals that may be present on the transmission line, contributing significantly to signal integrity in electrically noisy environments. Maximum data rates are dependent on transmission line length and loading. Typical data rates for the T735-3 and T735-5 are 5 Mb/s at 12 m and 100 kb/s at 1200 m. Up to ten receivers may be connected to a single T735 driver. The decision whether or not to terminate a data line may be based on the length of the line and the maximum signal data rate on the line. A general rule of thumb is to place a termination resistor (120 Ω for 100 Ω twisted-pair) across the receiver's input terminals if the data line's propagation delay is more than the time between successive data bits (bit width). If multiple receivers are driven at high data rates on long transmission lines, capacitive termination may be necessary to minimize power loading on the transmitter.

LVDS

The LVDS standard is similar to RS422/485 in that it is based on transmitting complimentary signals along a twisted pair, but differs in signal levels and speed. LVDS may operate at significantly faster signal speeds, requiring that the output voltage swing level be reduced from 5 V (typical with RS422/485) to 250 mV for minimized EMI generation and power dissipation. LVDS typically operates at a common-mode voltage of +1.2 volts above ground. As with RS422/485, the maximum data rates of LVDS are dependent on transmission line length and loading. Typical maximum data rates for the T735-13 and T735-15 are 50 Mb/s at up to 10 m. The LVDS receiver is usually placed at the end of the transmission line with a termination resistor (120 Ω for 100 Ω twisted-pair) across the receiver's input terminals to minimize signal reflections.

D9 Female Pinout

Pin 1: Data A+	Pin 6: Ground
Pin 2: Data A-	Pin 7: Alternative +12V power in
Pin 3: Ground	Pin 8: Ground
Pin 4: Data B+	Pin 9: Ground
Pin 5: Data B-	

6. Fiber Notes

T735-3, T735-5, T735-13, T735-15 and T735-23 versions should be used with standard 62/125 µm ST connectorized graded-index multimode or 9/125 µm singlemode glass fiber cables.

The T735-16 utilizes FC connectors for improved retention, and should be used with standard 9/125 µm singlemode glass fiber cable.

Fiber connectors should be kept clean and covered with protective caps when not in use, and should be cleaned with an approved fiber wipe before each use. Dust and other contaminants may not only result in immediate coupling problems, but may lodge within the laser/detector housings and produce long-term degradation. This is especially critical with the relatively small aperture, singlemode fiber.

Do not bend the fibers to a radius below 1".

Multimode fiber propagation delay is typically about 0.66 C, or about 5 nanoseconds/meter, 1.5 nanoseconds per foot. Prop delay varies with temperature and is roughly +15 PPM per degree C but may vary considerably depending on the fiber and jacketing.

Communications-grade multimode fiber will have losses in the vicinity of 3 dB/km at 850 nm. Singlemode fiber losses are less, about 0.5 dB/km at 1310 nm and 0.25 dB/km at 1550 nm. A connector pair may add 1 dB loss. The T735 receive threshold can be reduced to accommodate fiber loss or splitters, at the cost of additional jitter; A receive threshold of perhaps 300 µW will generally result in good system performance when the T735 receives inputs in the 800 to 1000 µW range.

Dispersion results in a degradation of optical pulse risetime with distance; expect risetime loss of up to several nanoseconds per kilometer for graded-index multimode fiber.

The following reference discusses fiber losses and dispersion:

http://www.corning.com/docs/opticalfiber/wp4119_10-01.pdf

7. Outline and Mounting

Figure 9 shows the T735 outline and mounting dimensions.

An optional T566 mounting flange is available for surface mounting.

It is recommended that the T735 be securely bolted to a grounded metal surface.

The T735 may be bolted directly to a mounting surface with four 4-40 machine screws from below. If access to the rear of the mounting surface is inconvenient, the T735 flange may be bolted to the T735, and the flange mounted from above.

CAUTION: mounting screws must not penetrate more than 0.125 inches into the T735 enclosure.

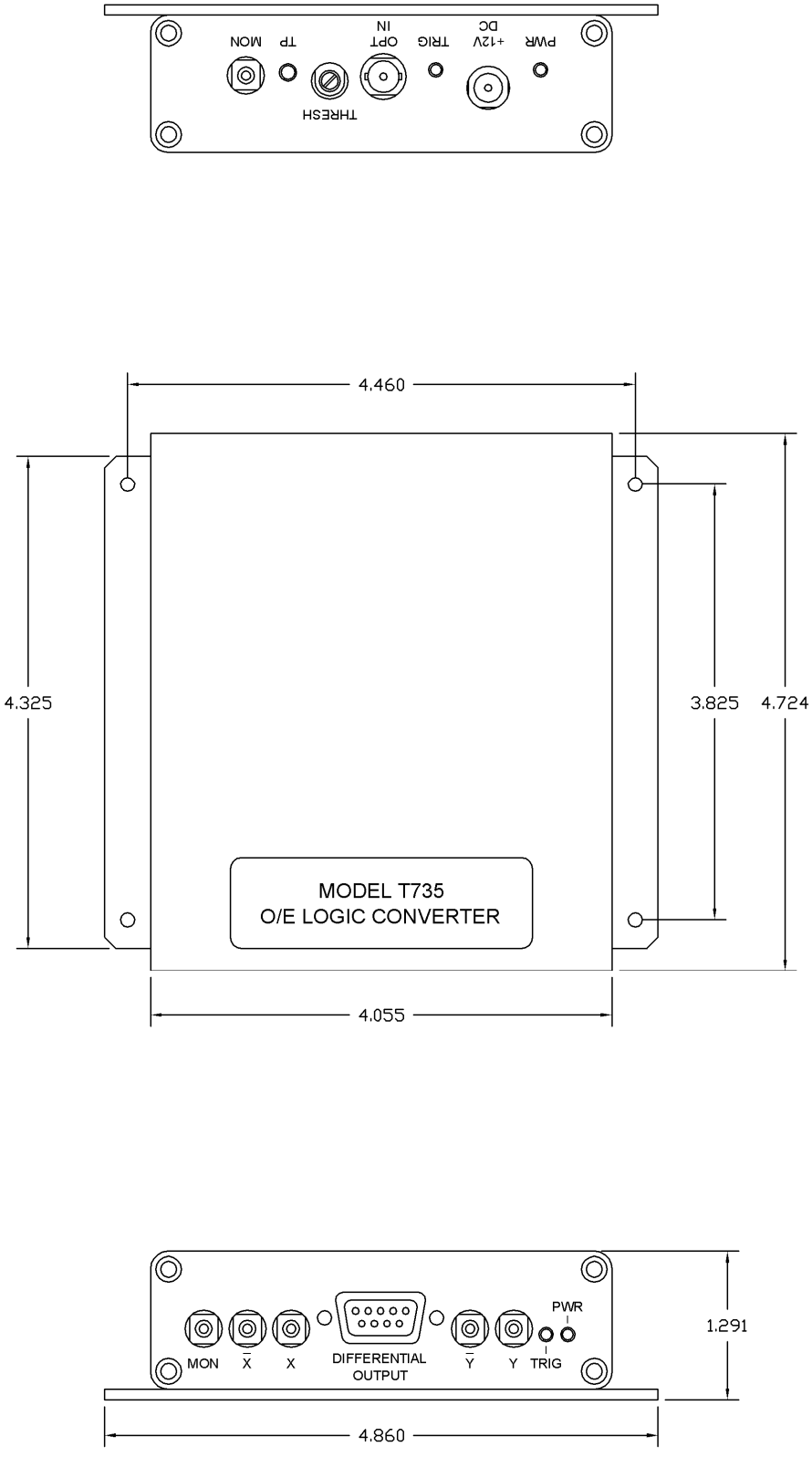

Figure 9: T735 Outline and Mounting Dimensions

8. Versions

Standard versions of the T735 include:

T735-3	1310 nm optical input with dual RS422/485 and complimentary TTL outputs
T735-5	1550 nm optical input with dual RS422/485 and complimentary TTL outputs
T735-13	1310 nm optical input with dual LVDS and complimentary TTL outputs
T735-15	1550 nm optical input with dual LVDS and complimentary TTL outputs
T735-16	1550 nm optical input with pulse stretcher, dual LVDS, and complimentary TTL outputs
T735-23	1310 nm optical input with expanded optical threshold range, and input AC-Coupling for the dual RS422/485, and complimentary TTL outputs

9. Customization

Consult factory for information about additional custom versions

10. Hardware Revision History

Revision B	Mar 2011 Functionally equivalent to Revision A Reduced switching power supply noise Improved voltage regulator cooling Increase D-sub connector to panel clearance
Revision A	Jan 2008 Initial PCB release

11. Accessories

J12-1	12 volt power supply (1 furnished with purchase)
J41-1	3' SMB to SMB cable
J41-2	6" SMB to SMB cable
J42-1	3' SMB to SMA cable
J53-1	3' SMB to BNC cable
J53-2	6" SMB to BNC cable
T566-1	mounting flange