HIGHLAND TECHNOLOGY

# Model T760

# Dual-Channel High Voltage Optical-Electrical Converter


## Technical Manual

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# Table of Contents

# 1 Introduction

This is the technical manual for the Highland Model T760 high voltage optical-to-electrical converter. The -1 version is the high-speed, 80 volt variant of the T760. The -2 version is slightly slower with 100 volt outputs.

Features of the T760 include:

- Two transformer-isolated digital pulse outputs
- Adjustable pulse amplitudes from 5 volts to 80 volts (-1 version) or 100 volts (-2 version) into 50 Ω
- Outputs clean, flat pulses with typical risetimes below 1 nanosecond (-1 version) or 2.5 nanoseconds (-2 version)
- Two 850 nanometer fiberoptic inputs with analog signal monitors and adjustable trigger thresholds
- External universal power supply or 12-volt DC power
- Compatible with Highland J720, J724, V720, and P730 optical pulse sources
- Ideal accessory for Highland's P400/P500 and T560/T660 digital delay/pulse generators, and the T34x family of embedded waveform generators

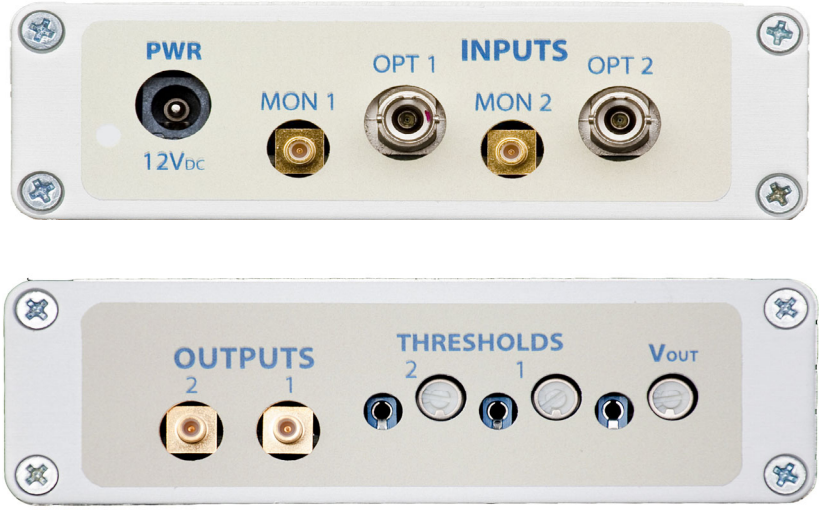



Figure 1: Model T760 O/E Converter, Front and Rear Panels

# 2 Specifications

| | |
|---|---|
| FUNCTION | Dual-channel compact high voltage optical-to-electrical converter |
| INPUTS | Two 850 nm fiberoptic ST inputs<br>1 mW nominal, single or multimode |
| OPTICAL THRESHOLD | Trimpot adjustable per channel, 250 µW to 1500 µW<br>Monitor outputs and trigger level test points provided |
| OUTPUTS | Two individually-isolated transformer-coupled square pulses with common amplitude adjustment<br>T760-1: 5 to 80 volts into an external 50 Ω load<br>T760-2: 5 to 100 volts into an external 50 Ω load<br>Tip jacks monitor logic threshold and output level<br>750 ns width, 6.5% duty cycle max at 5 volts<br>270 ns width, 0.5% duty cycle max at 80 volts<br>200 ns width, 0.2% duty cycle max at 100 volts |
| RISETIME | T760-1: less than 1 ns typ.<br>T760-2: less than 2.5 ns typ. |
| FALLTIME | See manual section 4.5 |
| JITTER | Less than 30 ps RMS |
| INSERTION DELAY | 8 ns typ. |
| OPERATING TEMPERATURE | 0 to 60 °C |
| CALIBRATION INTERVAL | One year |

| | |
|---|---|
| POWER | +12 volts, 0.8 amps max<br>Highland J12 wall-plug power supply is included |
| CONNECTORS | Fiber: ST<br>Signals: SMB<br>Power, 2.1 x 5.5 mm coaxial, center positive<br>Tip jacks monitor for high voltage output level<br>Tip jacks monitor trigger threshold level |
| INDICATORS | Green power on LED |
| PACKAGING | 4.75" (L) x 4.05" (W) x 1.25" (H) extruded aluminum enclosure |

# 3 Overview

The T760 converts two digital fiberoptic inputs into two high-voltage isolated electrical pulse outputs. Each optical input has an individual threshold trimpot, analog signal monitor, and threshold test point, allowing optimal settings of receiver thresholds.

Outputs are transformer isolated. A single trimpot, with test point, sets the output levels from 5 volts to 80 volts peak for the -1 version, to 100 volts for -2.

Electrical outputs directly follow optical inputs.

The T760 block diagram, depicting one channel, is presented in Figure 2. The T760 design and bandwidth are optimized for minimum jitter when driven by a Highland J720, J724, or compatible e/o converter.

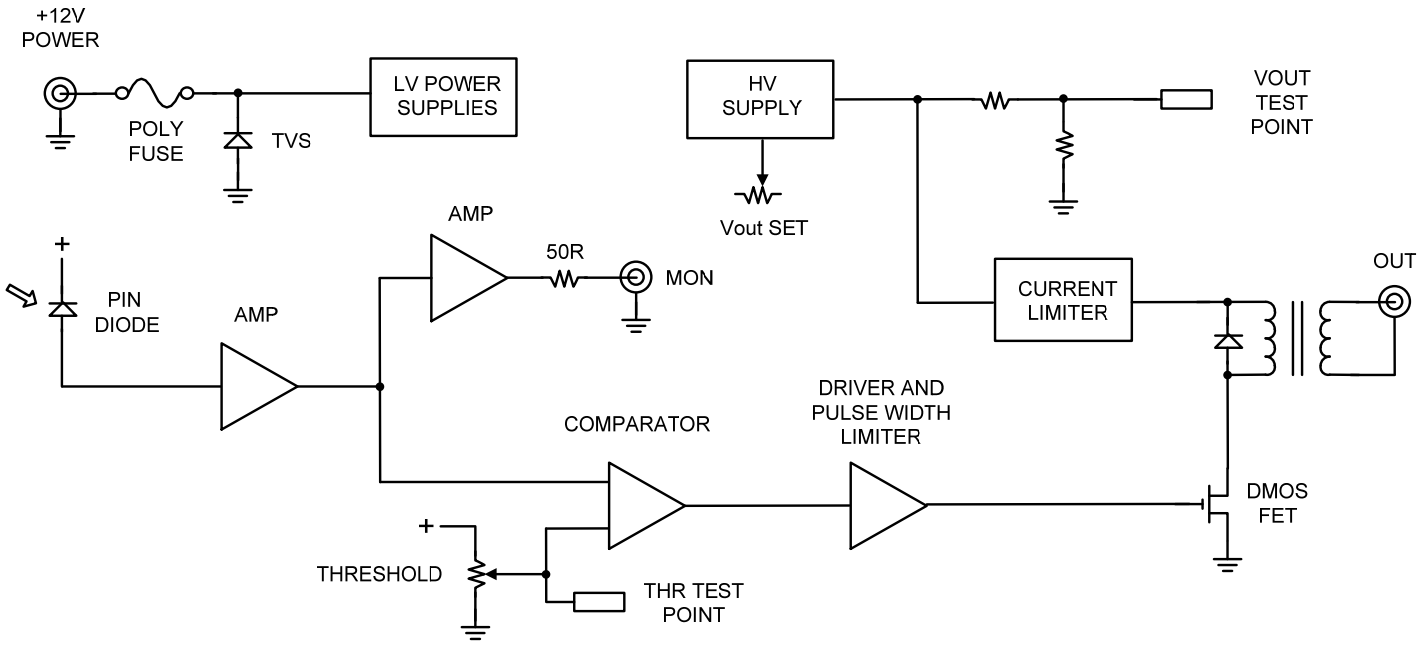



Figure 2: T760 Block Diagram

# 4 Setup and Operation

⚠ **CAUTION: The outputs must always be terminated into 50 Ohm loads. Operation without termination can damage the output circuitry.**

## 4.1 Power

The T760 requires an external source of +12V DC power. The power connector on the unit is a female coaxial-type 2.1 x 5.5 mm connector with positive center. The Highland Model J12 power supply is provided.

The T760 enclosure is ground and circuit common. The T760 is protected against polarity reversal and reasonable overloads.

## 4.2 Threshold Adjustments

The THRESHOLDS 1 and 2 trimpots set each channel's optical input comparator decision level. The T760 outputs go high when incoming optical power exceeds the thresholds setting. Threshold test points are provided, scaled +1 volt per milliwatt, and may be measured with a DVM using the cover screws or a MON connector shell as ground.

The MON 1 and 2 connectors are analog electrical outputs that allow the user to monitor the optical signal quality or quantify the fiber-coupled optical trigger power level. The signal level is scaled to +1 volt per millwatt into a 50-ohm load and +2 volts per milliwatt into a high-impedance load.

The optical thresholds are factory-set to 350 μW (350 mV measured at the test points) and are adjustable from below 250 μW to at least 1500 μW. A setting of 30 percent of expected optical pulse power is recommended. Setting the threshold too high or too low can result in excess jitter or unreliable operation. When the optical signal is monitored with a 50 ohm oscilloscope, the threshold voltage at the test point is scaled identically to the analog output voltage, allowing the threshold pot be set for an ideal 30 percent value of the peak observed analog pulse level. If a high-impedance scope is used, set the test point voltage to15 percent of the observed peak analog voltage level.

## *4.3 Optical Inputs*

The T760 electrical outputs directly follow the optical input signals; outputs go high when incoming optical power exceeds the threshold setting; see Section 4.2. The pulse width and duty cycle limitations of the output pulse should be considered when programming the input signal; see Section 4.6 for details about pulse width and duty cycle limitations.

Figure 3 shows an optical input pulse as observed at the analog MON connector, into a 50 ohm oscilloscope.

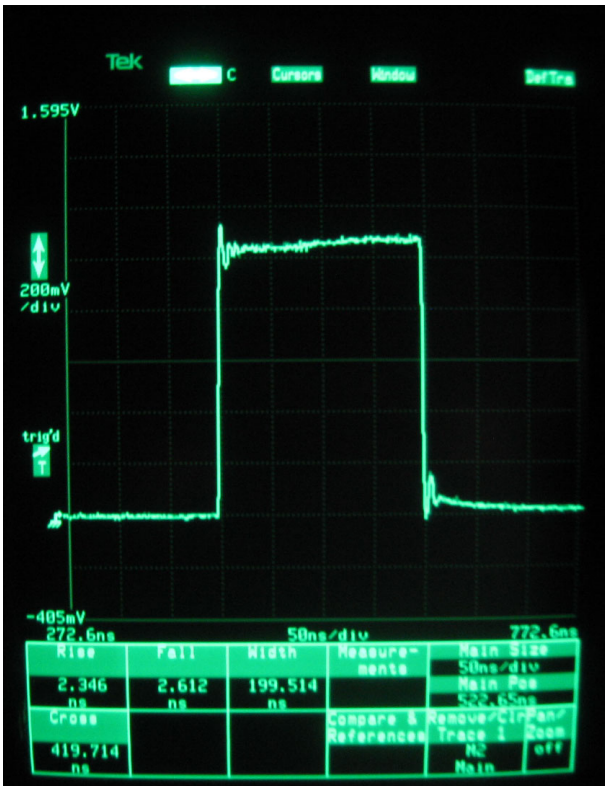



Figure 3: MON output into 50 ohms, 1 mW optical pulse, 200 mV/cm

## 4.4 Vout Adjustment

The VOUT trimpot allows the user to adjust the output pulse amplitude from +5V to +80V (to 100 volts for the -2 version) for both outputs simultaneously. The Vout test point may be measured with a high-impedance DVM using the test point as positive and cover screws or a MON connector shell as ground. The test point voltage is scaled to +1 volt per 10 volt output pulse amplitude.

Vout is factory-set to +2V at the test point, equivalent to +20V output pulse into a 50 ohm load.

The outputs are isolated positive pulses, so may be inverted by external wiring. Cleanest negative pulses can be obtained by adding a coaxial crossover (swapping inner and outer conductors) some distance from either the T760 or the load. If any ringing is observed, slipping a ferrite core or EMI suppressor over the cable near the crossover will usually improve pulse shapes.

## 4.5 T760-1 Outputs

Figure 4 shows a typical T760-1 80V, 200ns pulse into a 50 ohm load with the oscilloscope set to 50ns per division. Figure 5 shows the same pulse with the oscilloscope set to 1ns per division. Risetime is 925 ps.

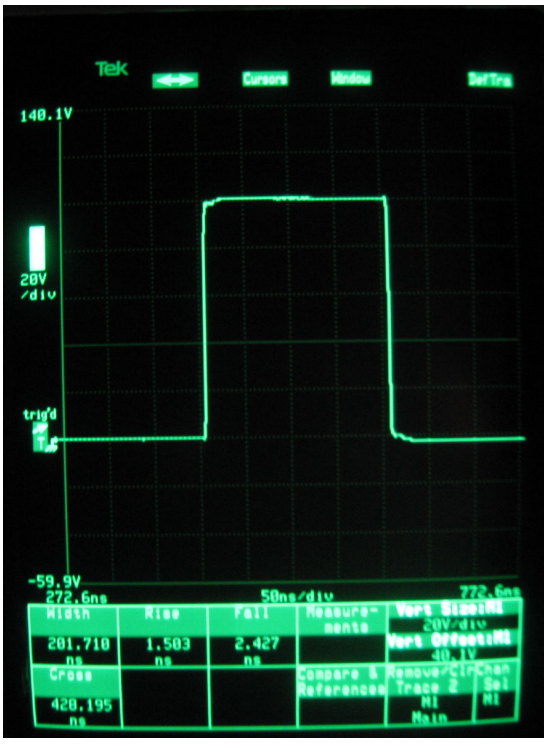



Figure 4

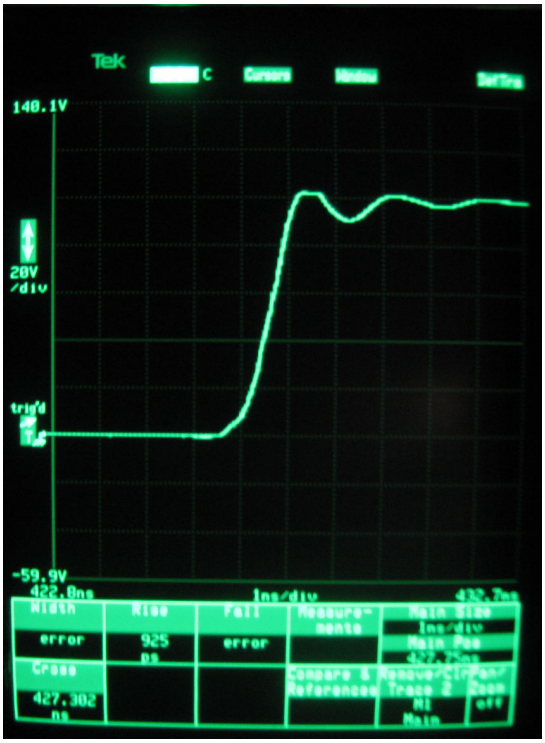



Figure 5

Figure 6 shows a typical T760-1 5V, 750 ns pulse into a 50 ohm load with the oscilloscope set to 200 ns per division. Figure 7 shows the same pulse with the oscilloscope set to 1 ns per division.  Risetime is 518 ps.

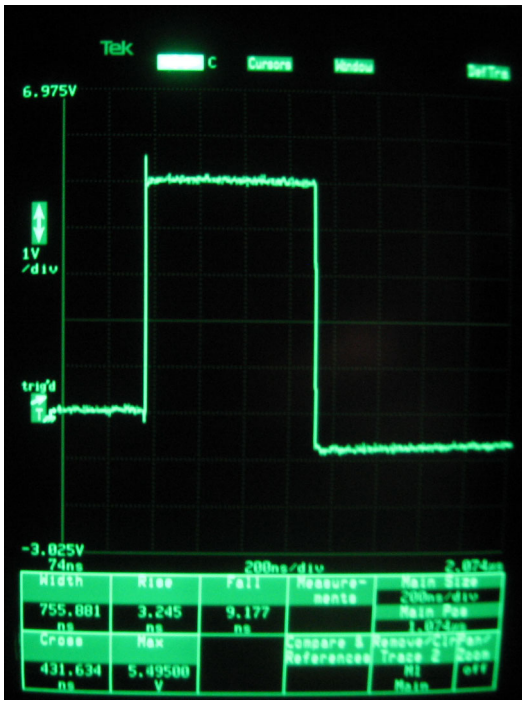



Figure 6

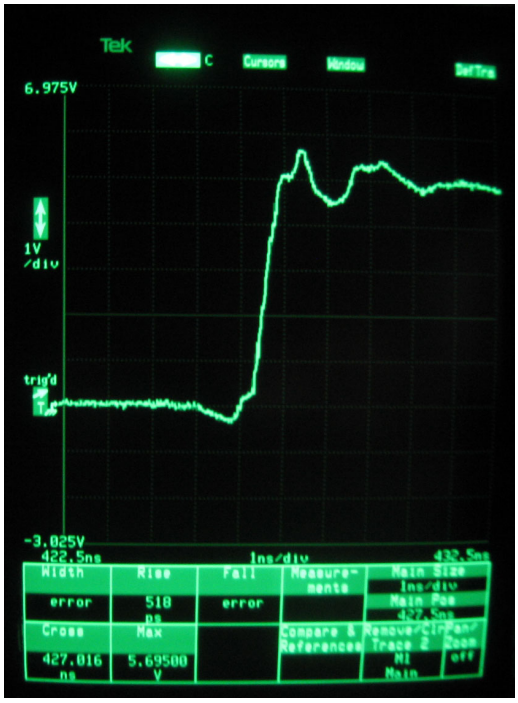



Figure 7

Figure 8 below shows typical T760-1 rise and fall times for various voltage outputs, into a 50 ohm load.

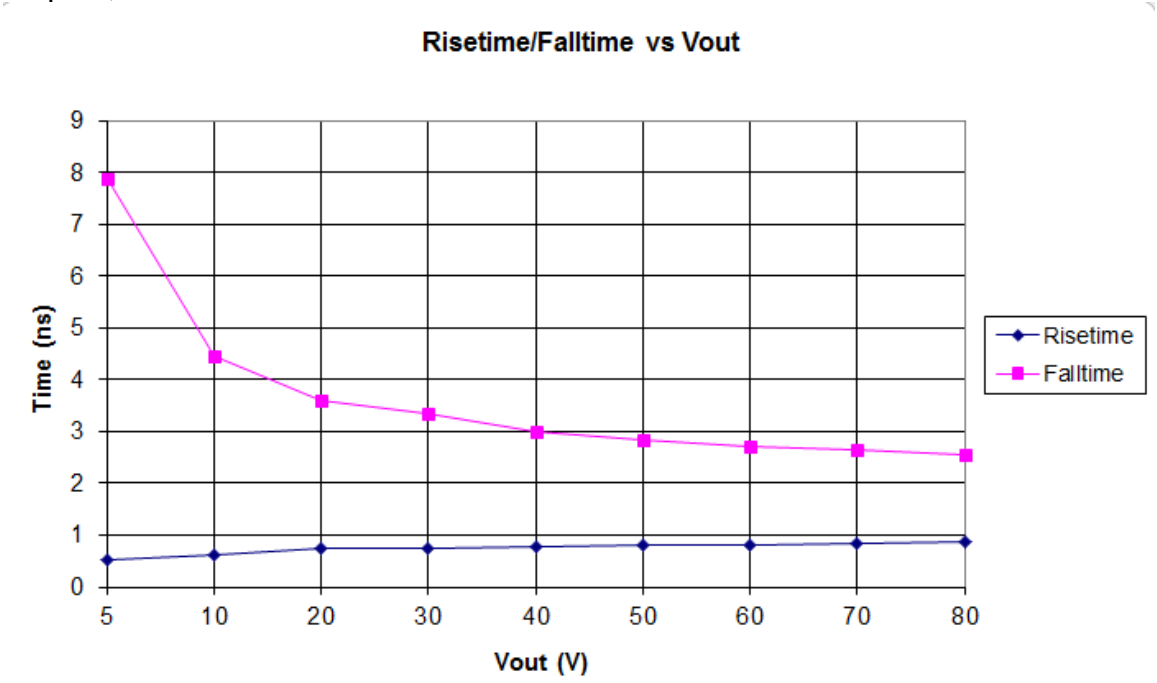



Figure 8

## *4.6 T760-2 Outputs*

Figure 9 shows a typical T760-2 100V, 50ns pulse into a 50 ohm load with the oscilloscope set to 10 ns per division. Figure 10 shows the same pulse with the oscilloscope set to 2 ns per division. Risetime is 1.9 ns.

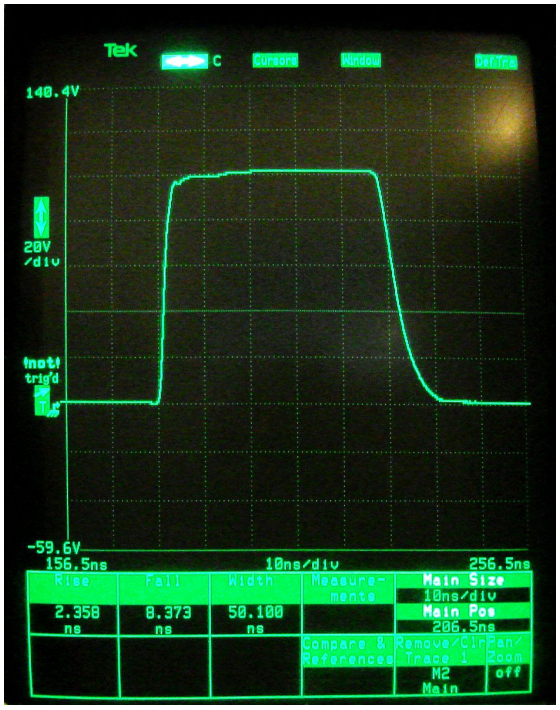



Figure 9


Figure 10

Figure 11 below shows T760-2 rise and fall times at various output voltages.

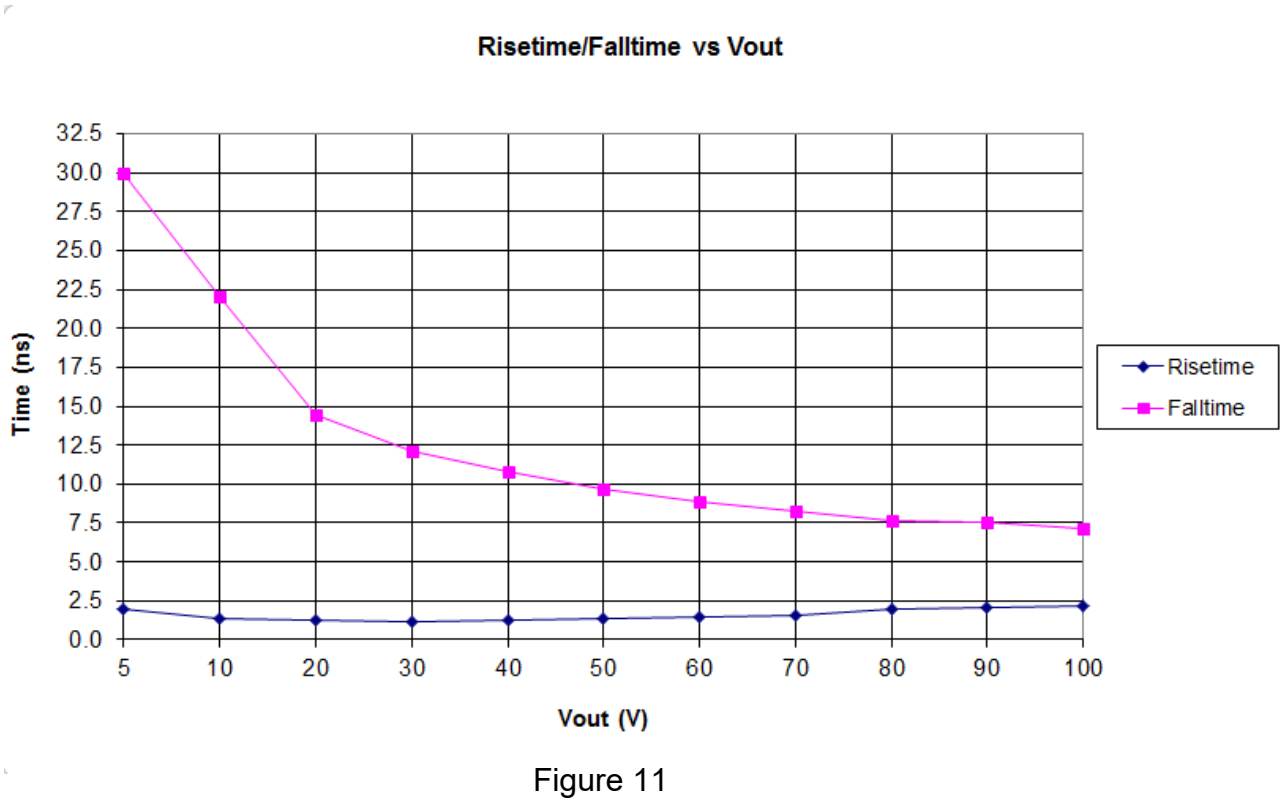


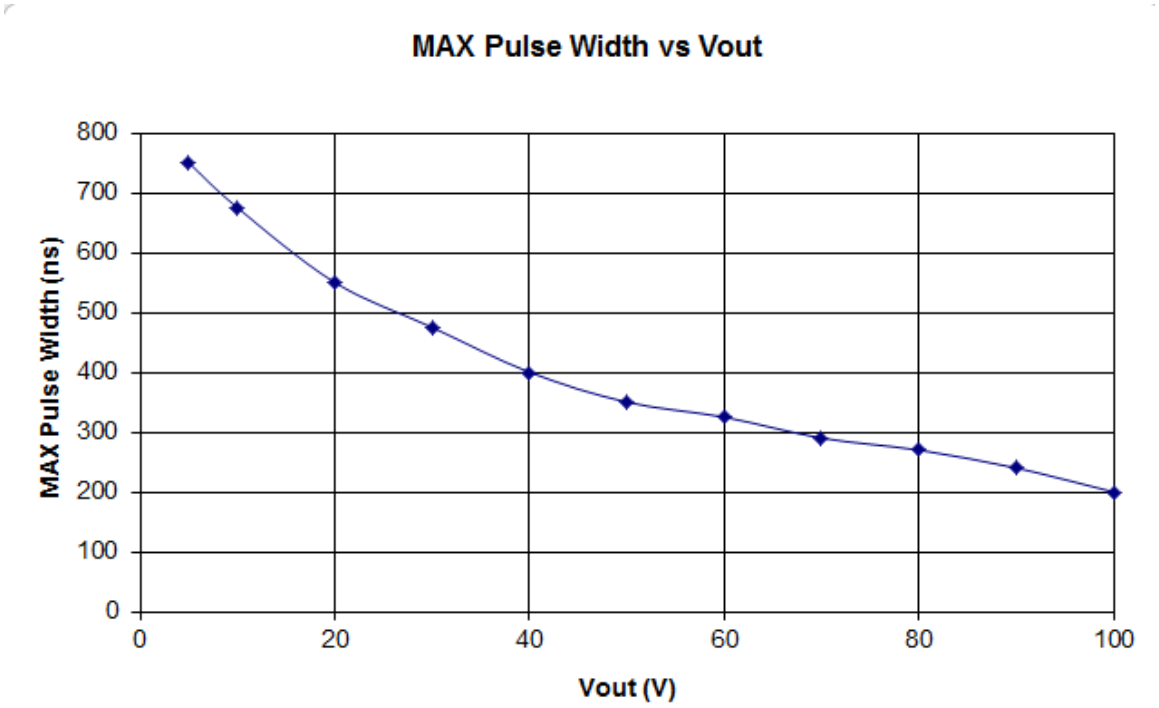

Figure 11

## *4.7 Pulse Width and Duty Cycle Limitations*

Each T760 channel includes a pulse-width limiter which truncates pulses if the output transformers are driven near saturation. Users may apply wide input pulses and allow the T760 to limit output pulse width.

To deliver output pulses which accurately track inputs, it is recommended to not exceed the following pulse widths for a given pulse amplitude:

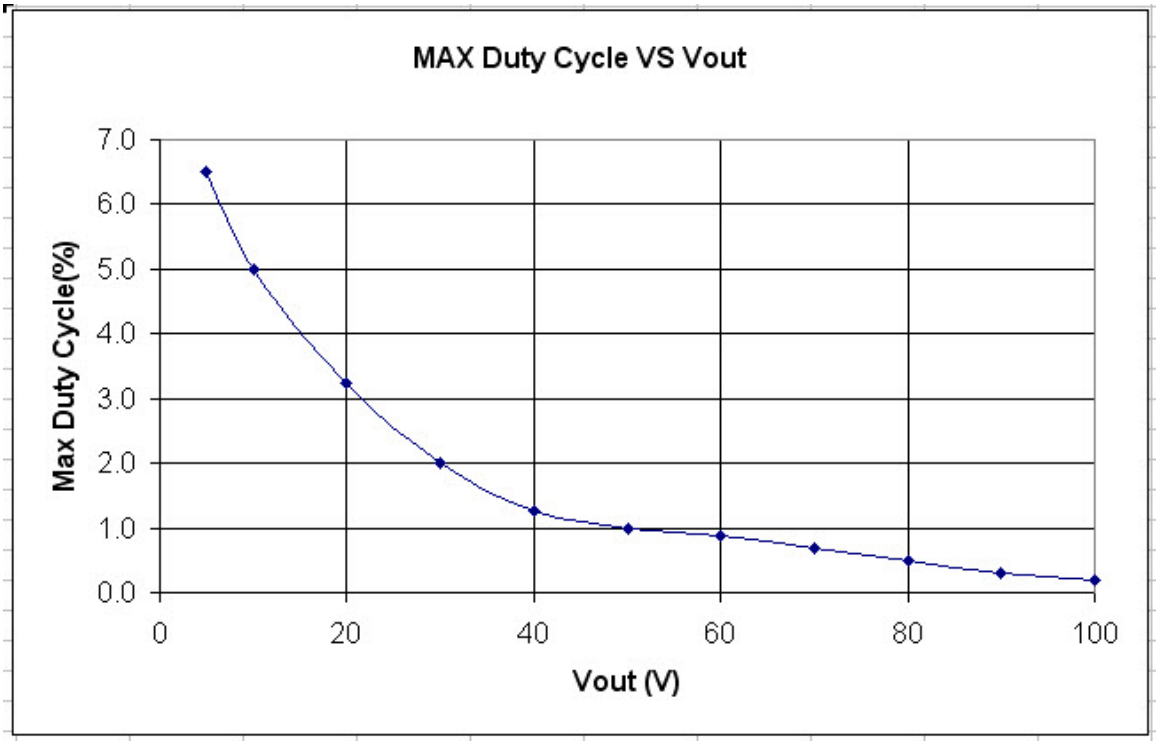
| Output Pulse Amplitude Volts | Maximum Pulse Width ns |
|---|---|
| 100 | 200 |
| 90 | 245 |
| 80 | 270 |
| 70 | 290 |
| 60 | 325 |
| 50 | 350 |
| 40 | 400 |
| 30 | 475 |
| 20 | 550 |
| 10 | 675 |
| 5 | 750 |



The T760 is also equipped with current limiters which will prevent damage to the output FETs caused by excessive pulse amplitudes and duty cycles.

In order to assure that the output amplitude will not be limited, do not exceed the following duty cycles for a given pulse amplitude:

| Output Pulse Amplitude Volts | Maximum Duty Cycle Per Cent |
|---|---|
| 100 | 0.2 |
| 90 | 0.3 |
| 80 | 0.5 |
| 70 | 0.7 |
| 60 | 0.9 |
| 50 | 1.0 |
| 40 | 1.3 |
| 30 | 2.0 |
| 20 | 3.3 |
| 10 | 5.0 |
| 5 | 6.5 |



# 5 Fiber Notes

The T760 uses a GaAs PIN diode detector in an ST-connector housing. It should be used with standard 62/125 μm ST-connectorized, graded-index, multimode, glass-fiber cables. It is calibrated using multimode fiber but also works well with singlemode inputs.

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.

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

Multimode fiber propagation delay is typically about 0.66 C, or about 5 nanoseconds/meter (1.5 ns per foot). Propagation 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. A connector pair may add 1 dB loss. The receiver threshold can be reduced to accommodate fiber loss or splitters, at the cost of additional jitter. A receiver threshold of around 350 μW will generally result in good system performance when the T760 receives inputs in the 800-1000 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.

Singlemode fiber will typically have losses and dispersion that are a small fraction of those of multimode fiber.

# 6 Dimensions and Mounting

The dimensions of the T760 are shown in Figure 12 below.

The T760 may be mounted with four 4-40 machine screws from below. .

If access to the bottom of the mounting surface is inconvenient, an optional T565 flange is available allowing access to mounting screws from above; see Figure 13.

**CAUTION: Mounting screws must not penetrate more than 0.160 inches (4 mm) into the T760 enclosure.**

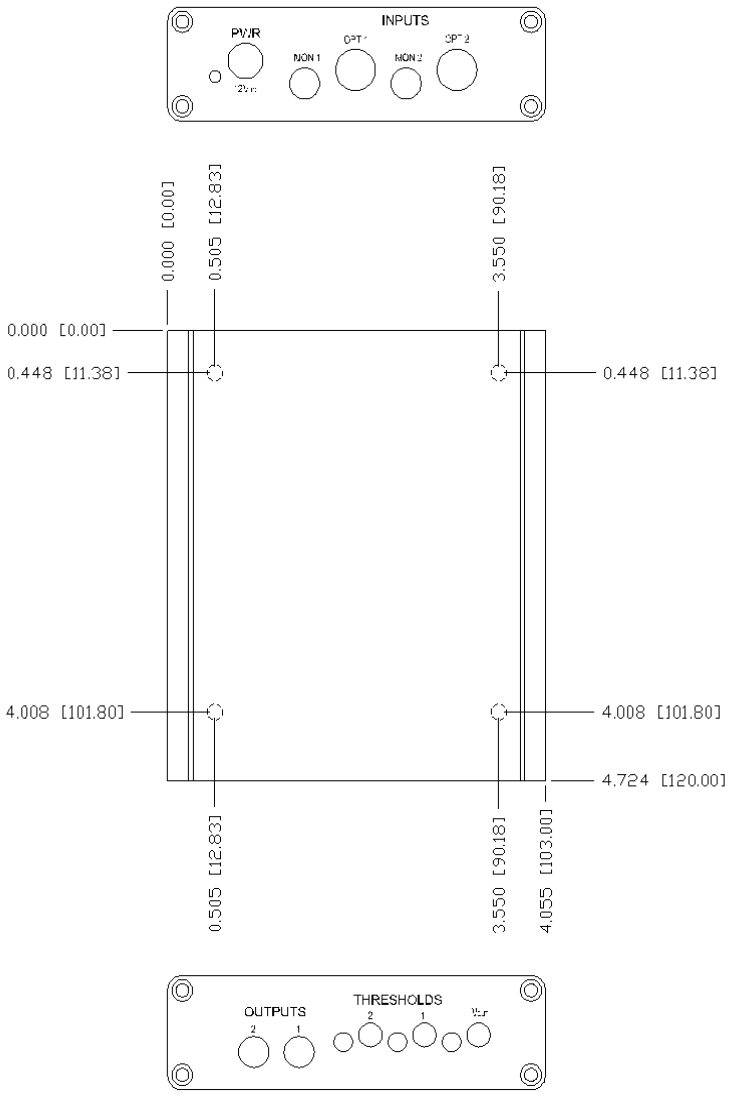



Figure 12 Dimensions

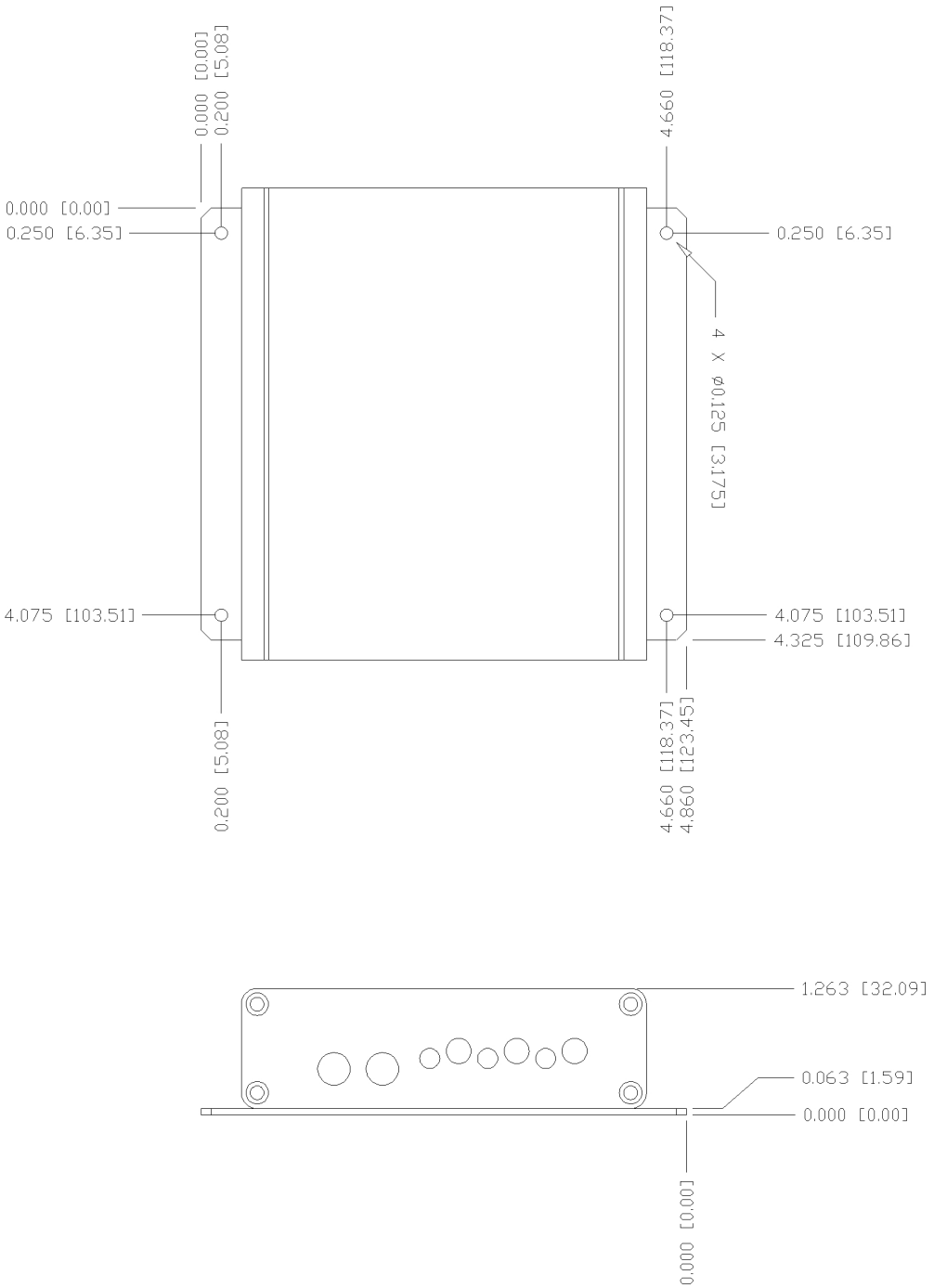



Figure 13 Optional Flange Mounting Dimensions

# 7 Versions

T760-1: 850 nm dual-channel compact 80V optical-to-electrical converter with ST/SMB connectors

T760-2: 850 nm dual-channel compact 100V optical-to-electrical converter with ST/SMB connectors

# 8 Customization

Consult factory for information about custom versions.

# 9 Hardware Revision History

| | |
|---|---|
| Revision D | Aug 2012<br>Introduced -2 version |
| Revision C | Jan 2011 |
| Revision B | Sep 2010 |
| Revision A | Dec 2009 |

# 10 Accessories

J12-1: 12 volt power supply (furnished with purchase)

J50-1: 50 ohm SMB terminator

J53-1: 3' SMB to BNC cable

J53-2: 6" SMB to BNC cable

J59-1: 3' ST to ST fiberoptic cable (multi mode simplex)

J60-1: 3' FC to FC fiberoptic cable (single mode simplex)

J61-1: 3' ST to ST fiberoptic cable (single mode simplex)

P10-1: 19" rack mount shelf (four t-boxes per rack)

T566-1: mounting flange