TME

Third Millennium Engineering

“Helping customers create and manufacture advanced technology products for our future”

ABBREVIATIONS

The following abbreviations are used throughout this catalog.

Abbreviation	Meaning	Abbreviation	Meaning
AGC	automatic gain control	mod.	modulation
APD	avalanche photodiode	nm	nanometer
BER	bit error rate or bit error ratio	NRZ	digital non-return to zero
BERT	bit error rate tester	OEO	optical to electrical to optical
CAD	computer aided design	OMA	optical modulation amplitude
CDR	clock-data recovery	OPM	optical power monitor
CR	clock recovery	ORX	optical receiver
CRZ	chirped return to zero	OTX	optical transmitter
CWDM	coarse WDM	OTR	optical transceiver
dB	decibel of power ratio	PIN	PIN photodiode
dBm	decibel of power relative to 1 milliwatt of power	RF	radio frequency
Diff.	differential electrical signal	RMS	root mean square
DPSK	differential phase shift keying	RX	receiver
DWDM	dense WDM	RZ	digital return to zero
EA	electro-absorptive (external modulator)	SBS	stimulated Brillouin scattering
EDFA	erbium doped fiber amplifier	SDH	synchronous digital hierarchy
ESD	electro-static discharge	SE	single ended electrical signal
FEC	forward error correction	SM	single mode fiber
Gb/s	giga bits per second (billion bits per second)	SOA	semiconductor optical amplifier
GHz	gigahertz (billion cycles per second)	SONET	synchronous optical network
IGA	insertable gain amplifier	TIA	trans-impedance amplifier
IL	insertion loss	TME	Third Millennium Engineering
ITU	International Telecommunication Union	TR	transceiver
KHz	kilohertz (thousand cycles per second)	TX	transmitter
$LiNbO_3$	lithium niobate (external modulator)	typ.	typical
max.	maximum	UI	unit interval (one bit period)
Mb/s	mega bits per second (million bits per second)	USD	United States dollars
MHz	megahertz (million cycles per second)	VOA	variable optical attenuator
min.	minimum	WDM	wavelength division multiplexing
MM-50	multi-mode 50 micron fiber	WWDM	wide WDM
MM-62	multi-mode 62.5 micron fiber	~	approximately

Third Millennium Engineering Catalog

Engineered Fiber Optic, RF/Microwave, and Electronic Communication Equipment, Products, and Services

Custom Functional Test Equipment

- **Fiber Optic Translators**
  Digital and/or analog transmitters, receivers, transceivers, regenerators, & wavelength converters. 850, 1310, and 1550 nm regions, single and multiple channels, up to ~43 Gb/s, many options.
- **Fiber Optic Spans**
  Programmable communication “superhighway in a box”, ~100 meters to ~10,000 km. For optical transmitter, receiver and amplifier dispersion, compensation, and regeneration tolerance measurements.
- **FEC Translators**
  Transmitters, receivers, and transceivers with forward error correction between SONET, SDH, 10GE, G.709, G.975, advanced FECs, and other data rates up to ~13 Gb/s, many options
- **Electronic Translators**
  Transmitters, receivers, and transceivers, single and multiple channels. For converting, distributing, and selecting single-ended and differential signals between analog, digital, and communication formats
- **Horizon Functional Test Fixture System**
  Flexible, economical, and re-configurable functional test fixture and test equipment interface system
- **Communication Switch Matrices**
  RF, microwave, and fiber optic switch matrices with multi-channel communication industry topology. For routing signals between test equipment and communication products.

Custom Products and Services

- **Fiber Optic Link Products**
  Transmitters, receivers, and transceivers from ~10 Mb/s to ~43 Gb/s. Single wavelength, WDM, CWDM, and DWDM in 850, 1310, and 1550 nm regions. Extended temperature, ruggedizing, and other options.
- **Custom Test and Process Equipment**
  Partial or complete performance test and specialized assembly systems for wafer, die, component, module, equipment, and system level products. Specialized fixtures, carriers, tooling, and other items.
- **Standard Product Engineering and Prototyping**
  Product definition, data sheets, engineering, prototyping, characterization, qualification, low volume production, and high volume production support services.
- **Technology Reports**
  Technical ideas or business ventures explored, defined, cost analyzed, and critiqued. Difficult technical topics, tradeoffs, and alternatives considered. Competitors, products, manufacturability, testability, expensive endeavors, and concepts assessed. New or used capital equipment, products, components, and materials located and evaluated. Test strategy, test methods, or assembly processes developed.

Why make it or do without when you can buy it?
Visit http://www.tmeplano.com for the latest catalog and other information

Third Millennium Engineering
Helping customers create and manufacture advanced technology products for our future

Box 867178, Plano, Texas 75086-7178 USA
Phone (972) 491-1132 Fax (214) 227-3155
sales@tmeplano.com www.tmeplano.com

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

INTRODUCTION

The communications industry has experienced remarkable growth and diversification over the last two decades by using fiber optic and related microwave and RF electronic technologies. A wide variety of fiber optic and high-speed electronic communication products are now routinely used for data and voice communications between billions of networked telephones and computers worldwide and in almost every industry.

COMMUNICATION PRODUCTS AND NETWORKS

Fiber optic and related microwave and RF components, equipment, and networks are used in many terrestrial, submarine, airborne, and free space transmission and cross-connect communication applications. Multiple channels, data rates, wavelengths, and protocols are often required, which involve SONET, SDH, DWDM, CWDM, WWDM, Ethernet, Fibre Channel, video, proprietary, and many other standards. Components include single and multiple lane fiber optic laser, receiver, transponder, driver, multiplexer, clock-data recovery, FEC, and other active and passive optical, opto-electrical, electro-optical, and electrical devices. Equipment includes computers and metropolitan and long haul fiber optic and high-speed electronic transmission and cross-connect line cards and card-cage products. Networks include communication equipment, trunk lines, and client lines found in telecom central offices and on business, academic, and military campuses.

Fiber optic, wireless, or wire-line communication products typically use a transmitter at one location to communicate through a transmission line to a receiver at another location. A wide variety of related switching, amplifying, filtering, error correcting, multiplexing, de-multiplexing, and other supporting devices are also involved. Many thousands of different fiber optic and high-speed electronic transmitter and receiver types are used in communication products involving many hundreds of companies. This variety originates from the many possible combinations of transmission line types (optical fiber, electrical cable, free space), data rates, distances, standards, nationalities, and other economics involved.

TESTING COMMUNICATION PRODUCTS AND NETWORKS

The communications industry uses a wide variety of standard and custom functional test equipment for analog and digital fiber optic, microwave, and RF performance tests of products and networks. Tests include optical and electrical bit error rate, transmitted and received power, receiver sensitivity and overload, eye pattern and extinction ratio, S-parameters, spectrum analysis, timing, and jitter. Such tests are typically performed when products are created, developed, and produced by manufacturers. They are also often performed during procurement, deployment, and maintenance of communication equipment and related networks. A wide variety of standard test equipment products are commercially available to perform these tests. However, certain kinds of essential functional test equipment are not available as standard products or very few models are offered. Without such equipment, communication companies must bypass important tests at the expensive risk of losing market share from poor test quality.

The small market for any particular model of such special functional test equipment makes it difficult for most test equipment suppliers to justify development engineering resource allocation. Without a procurement choice, communication companies are often faced with allocating precious company resources on engineering-intensive capital projects to create their own special test equipment. Creating test equipment is rarely a company's core competency and usually carries a high opportunity cost for their employees. Projects initially involve cost estimation for capital funding, which is based on the budgets, schedules, and expertise associated with the equipment design concepts originated by existing employees. Project execution faces the direct costs for manning and materials, which involve design, multiple CAD tools, component selection, small quantity procurement, inventory management, engineering documentation, assembly, and test. Projects also involve hidden costs for learning curve redesigns and ongoing support due to the technical and business risks involved.

FUNCTIONAL TEST EQUIPMENT AND PRODUCT SOLUTIONS FROM TME

Third Millennium Engineering (TME) engineers and manufactures custom fiber optic, microwave, RF, and other functional test equipment and short run products. TME offers six semi-custom product lines to supply customer-specific manual and automatic functional test equipment and products. The product lines are named Fiber Optic Translators, Fiber Optic Spans, FEC Translators, Electronic Translators, Horizon Functional Test Fixture System, and Communication Switch Matrices. All models are offered in computer controllable, worldwide AC line powered, ESD compliant, rack-mountable housings. Many models are also offered in various small housing sizes with manual control and display for laboratory bench top use or for short run products.

TME semi-custom functional test equipment and short run products are made to order with model specifications, price, delivery, and part number provided with a quote. Each TME model is a custom final assembly, but is constructed from TME standard designs using high quality standard and customer-specified components and sub-assemblies. Being semi-custom, customers can freely originate, specify, and procure TME equipment and options without incurring full engineering and tooling costs. Feasible, economical, and excellent test equipment and short run product solutions can be created that exactly meet customer needs by combining TME semi-custom products with standard equipment. TME products can often be modified or rebuilt at a later date if needed, as customer needs change. Powerful, compact, flexible, economical, multi-function, multi-channel, multi-rate, and multi-protocol fiber optic and RF/microwave functional test systems and products are possible with an excellent return on capital investment.

TME test equipment is used along with standard test equipment and test fixturing for performance testing of wafer, component, module, equipment, and system level products. TME products are typically used along with SONET/SDH analyzers, bit error rate testers, protocol analyzers, network analyzers, sampling and real-time oscilloscopes, network and spectrum analyzers, power and wavelength meters, timing and jitter analyzers, attenuators and switches, and other similar standard test equipment. Together they can performance test single and multiple lane fiber optic lasers, receivers, transponders, line cards, card-cage products, network equipment, and trunk lines.

TME short run products provide customers with a procurement choice for their specialized fiber optic and RF/microwave product needs, especially where low manufacturing volumes are involved. With low volumes and specialized needs, it is difficult for customers to find a supplier and avoid engineering-intensive in-house capital projects. Example short run products are inter-building and intra-vehicular fiber optic links. Such links may require non-standard or multiple data rates, non-standard equipment interface levels or connectors, wide temperature ranges, ruggedizing, radiation resistance, specialized packaging, etc.

FEATURES AND BENEFITS OF TME EQUIPMENT

- Procure the exact unique or specialized custom functional test equipment or short run product you need by outsourcing to TME
- Test advanced technology products and networks using an efficient mix of custom, semi-custom, and standard test equipment. Minimize total cost and effort for functional performance test of electronic, RF, microwave, and fiber optic components, sub-assemblies, modules, and networks in R&D, production, and field environments.
- Avoid or significantly reduce in-house expertise, manning, schedule, and cost risks for creating, developing, documenting, and supporting your own special custom functional test equipment or short run products. Get expert assistance defining, planning, and costing your test or product requirements.
- Many choices of channel count, wavelengths, data rates, bandwidths, sensitivities, configurations, topologies, options, packaging, etc. Choices continually added as components become available in the market.
- Compact, multi-functional, custom functional test equipment and short run products offered at semi-custom prices in single quantities
- Computer controlled models offered in tabletop or rack-mountable, ESD compliant, worldwide AC line powered housings with GPIB-IEEE488.2-HPIB, RS-232, 10/100Base-T Ethernet LAN, USB, or digital I/O interfaces (others on request)
- Manually controlled models offered in tabletop, ESD compliant housings with external regional power supply, basic controls and displays, and without a computer interface

FIBER OPTIC TRANSLATORS

Fiber Optic Translators are semi-custom fiber optic test instruments that provide customers with exactly the optical functions needed to performance test their fiber optic products and networks when combined with standard test equipment. Customers can choose from millions of possible made-to-order models due to the many functions, channel count, wavelengths, fiber types, speeds, options, and packaging choices offered. These same product line features and functions are also available to customers for short run products. Model numbers are assigned when a quote is originated.

MODEL VARIATIONS

The product line consists of single and multiple channel, rate, and wavelength analog and digital fiber optic transmitters (OTX), receivers (ORX), transceivers (OTR), and regenerators or wavelength converters (OEO) as indicated in Figure 1.

Basic single channel test systems using Fiber Optic Transceivers are shown in Figure 25 starting on page 47. Example OTX and ORX configurations are shown in Figure 26 and Figure 27 starting on page 49 for testing a 16-channel product. More specialized test systems using Fiber Optic Translators are shown for Parametric BERT test systems in starting on page 52 and a DWDM network test system on page 57. These figures represent only a few of the many equipment choices available.

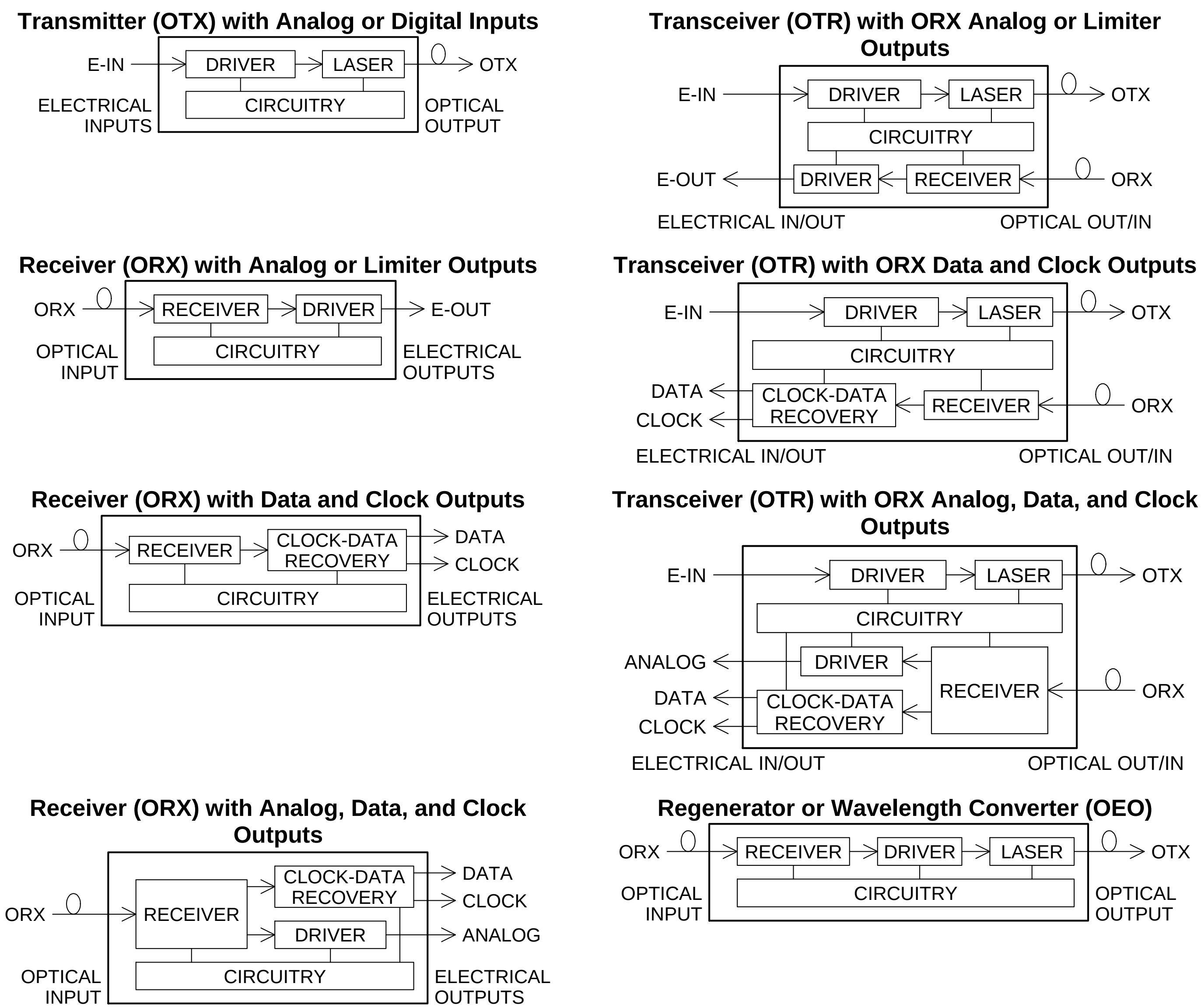


Figure 1. Basic Fiber Optic Translator Types

FUNCTIONS AND CHANNELS

- Fiber optic Transmitters (OTX), Receivers (ORX), Transceivers (OTR), Regenerators (OEO), and Wavelength Converters (OEO) are offered with analog and/or digital functions for single mode and 50 or 62.5 micron multi-mode fiber types
- Up to 32 channels of transmitter or receiver and up to 16 channels of transceiver, regenerator, or wavelength converter can be packaged into one chassis, depending on speed and options
- Regenerator (same wavelength on optical I/O) and wavelength converter models are offered in 1R (linear analog), 2R (limiting analog), and 3R (digital regeneration via clock-data recovery) configurations. These configurations functionally connect an analog or digital fiber optic receiver (ORX) to a fiber optic transmitter (OTX) at their electrical ports (OEO).
- Special analog transmitter and receiver models can be provided with receiver calibration data for use with electrical network analyzers. These models include microwave pass-thru relays, which results in a network analyzer with active and passive optical, opto-electrical, electro-optical, and electrical device test capabilities.
- Special digital fiber optic receiver models are offered that provide single or multi-rate clock-recovered electrical output signals. Receiver models with an optical tap coupler are used to trigger high-speed optical sampling oscilloscopes. Models with wider jitter transfer bandwidth and/or lower jitter generation are used to provide jitter test equipment with a clock signal from data-only sources. See “Clock Regenerators” on page 25 for more information.

TRANSMITTERS

- Fixed single mode wavelengths at popular 1310 nm, 1310 nm CWDM, 1550 nm, 1550 nm WWDM, and 1550 nm S-C-L band DWDM channels on 100, 50, or 25 GHz ITU grid spacing
- Wide range and narrow range tunable laser single mode wavelengths at 1550 nm C and L bands on 100, 50, or 25 GHz ITU grid spacing
- Fixed multi-mode wavelengths at popular 850 nm, 1310 nm, and 1310 nm CWDM with 50 or 62.5 micron fiber
- Optical output power from –15 dBm to +10 dBm depending on wavelength and speed
- Cooled fine wavelength control (DWDM) and un-cooled coarse wavelength models (CWDM, WWDM)
- Direct, electro-absorptive (EA), or lithium niobate ($LiNbO_3$) modulation
- Linear analog and digital NRZ, RZ, and CRZ wave shapes with programmable extinction, contrast ratio, and chirp control respectively
- Analog bandwidths from ~50 MHz to ~40 GHz, AC coupled (~50 KHz roll-off) or DC coupled
- Digital speeds from ~1 Mb/s to 3.3 Gb/s, 9.9 to 12.6 Gb/s, and 39 to 43 Gb/s, other rates upon request
- Data only or data and clock for digital electrical inputs
- Single-ended or differential, AC or DC coupled electrical inputs
- Non-inverting, inverting, or programmable E-to-O polarity control

TRANSMITTER OPTIONS

- Programmable Stimulated Brillouin Scattering (SBS) suppression – needed for testing long fiber optic spans with inline optical amplifiers
- Programmable channel identification tone generation – used for multi-channel and DWDM testing
- Controlled output levels using variable optical attenuator (VOA) and optical power monitor (OPM) – useful for product under test receiver sensitivity and overload tests or DWDM channel matching
- Multiple optical output configurations with several different transmitters driven by one electrical input, either one at a time (selector function) or at the same time (splitter or fan-out function)
- Special transmitter modulation methods, wave shapes (CRZ, solitons, etc.), speeds, and power levels
- Special wavelengths (such as 980 nm, Raman pump wavelengths, < 850 nm, >1625 nm)
- Special fiber types (such as polarized or plastic)

RECEIVERS

- Choice of high speed PIN or APD photodiode detectors using silicon, germanium, GaAs, and InGaAs materials
- Single mode wavelengths include 1310 nm range and 1550 nm range models
- Multimode wavelengths include 850 nm range and 1310 nm range using 50 or 62.5 micron fiber
- Analog outputs with fixed linear gain, single or multiple insertable linear gain, continuously variable gain, or non-linear limiter amplifier models - for optical input dynamic range control
- Analog bandwidths from ~50 MHz to ~40 GHz
- Digital data and clock outputs with single or multiple rate clock-data recovery (CDR) circuits
- Digital data rates from ~1 Mb/s to ~3.3 Gb/s or 9.9 Gb/s to 12.6 Gb/s, ~40 Gb/s as components become available in the market, other rates upon request
- Simultaneous analog output and per channel or selected channel digital data and clock output – for BER and for eye patterns with oscilloscope trigger
- Optical dynamic ranges are offered from –38 dBm to –7 dBm sensitivity and –7 dBm to +3 dBm overload power, depending on wavelength and speed limitations
- Single-ended or differential, AC or DC coupled electrical outputs
- Non-inverting, inverting, or programmable O-to-E polarity control

RECEIVER OPTIONS

- Fixed, tunable, or lock-on optical channel filters – 25 GHz, 50 GHz, 100 GHz, various nm wide ranges, and other filter bandwidths available
- Channel identification tone detection – useful for multi-channel and DWDM testing
- Input optical power monitor – also makes extinction ratio tests possible with parametric BER testers, such as the Agilent ParBERT™ or SytheSys Research BitAlyzers™
- Insertable single or multiple SONET, Fibre Channel, and other low pass filters on analog outputs - for eye pattern mask testing
- Multiple input configuration - one electrical output driven by one of several different receivers
- Special receiver CDR data rates and programmable CDR thresholds
- Special fiber types (such as polarized or plastic)

OTHER OPTIONS

- Optical I/O connector choices include FC (SPC, UPC, APC), SC, ST, LC, DIN 47256, others on request
- Electrical I/O connector choices include SMA, 3.5mm, K, 50 or 75 ohm BNC, D-Sub, others on request
- Various arrangements of optical amplifier (EDFA or SOA), fixed or variable attenuator, coupler, WDM splitter, WDM combiner, polarization scrambler, polarizer, power monitor, etc.
- Data and clock boost amplifiers, programmable data to clock phase shifter (for electrical SONET analyzers)
- Time or wave division multiplexer and/or demultiplexer, FEC translator encoding and decoding
- Optical and/or RF-microwave channel bypass, pass-thru, loop back, and/or selector switches
- Special optical or microwave connectors, front or rear panel mounted
- Customer specified architectures, components, circuit design usage, packaging, and other special optical and electrical options considered upon request

PACKAGING

All models are offered in 19 inch rack-mountable, ESD compliant, aluminum housings. They are worldwide AC line powered (90-265 VAC, 47-63 Hz) with computer control and monitoring implemented using a GPIB-IEEE488.2-HPIB, RS-232, 10/100Base-T Ethernet LAN, or USB interface (others on request). Manual control and display is minimized on most computer controlled models, but can be increased as an option. All internal subassemblies are modular, 2 screw mounted, and interconnected with pluggable cable assemblies. Models can contain any mix of module types and options. All optical and/or microwave I/O connectors are front panel mounted with rear panel mounting offered at no cost impact.

Some lower cost manually operated models are offered with limited features in various sized, ESD compliant, small aluminum housings intended for laboratory bench top use. They are AC line powered by a wall outlet or tabletop mounted regional AC-to-DC power supply. Manual control and display is provided with a computer interface provided as an option.

STANDARD DATA RATES FOR CLOCK AND CLOCK-DATA RECOVERY

Table 1. Standard Fixed Data Rates for Clock and Clock-Data Recovery Circuits

CDR Group	Standard Data Rates
A	44.736 Mb/s
A	51.840 Mb/s
A	139.264 Mb/s
A	155.52 Mb/s
A	166.63 Mb/s
A	622.08 Mb/s
A	666.51 Mb/s
A	1.0625 Gb/s
A	1.244 Gb/s
A	1.250 Gb/s
A	1.339 Gb/s
A	2.125 Gb/s
A	2.488 Gb/s
A	2.500 Gb/s
A	2.666 Gb/s

CDR Group	Standard Data Rates
B	9.953 Gb/s
B	10.312 Gb/s
B	10.512 Gb/s
B	10.664 Gb/s
B	10.709 Gb/s
B	11.095 Gb/s
B	12.249 Gb/s
B	12.4 Gb/s
B	12.5 Gb/s

Table 2. Standard Variable Data Rates for Clock and Clock-Data Recovery Circuits

CDR Group	Standard Data Rates
C	9.95 to 10.75 Gb/s
C	9.95 to 11.1 Gb/s
C	12 to 12.6 Gb/s
C	28 Mb/s to 2.7 Gb/s
C	1.0 to 1.5 Gb/s
C	1.5 to 2.5 Gb/s
C	2.5 to 4.0 Gb/s
C	3.0 to 5.0 Gb/s
C	4.0 to 6.0 Gb/s
C	5.0 to 8.0 Gb/s
C	8.0 to 12.0 Gb/s
C	9.0 to 14.0 Gb/s
C	8.0 to 16.0 Gb/s

Notes: Other variable data rate ranges, multiple ranges, and multiple loop bandwidths between 1 Mb/s and 16 Gb/s can be provided as a “special” upon request. Contact TME for details.

DESKTOP FIBER OPTIC TRANSLATORS WITH MANUAL CONTROL

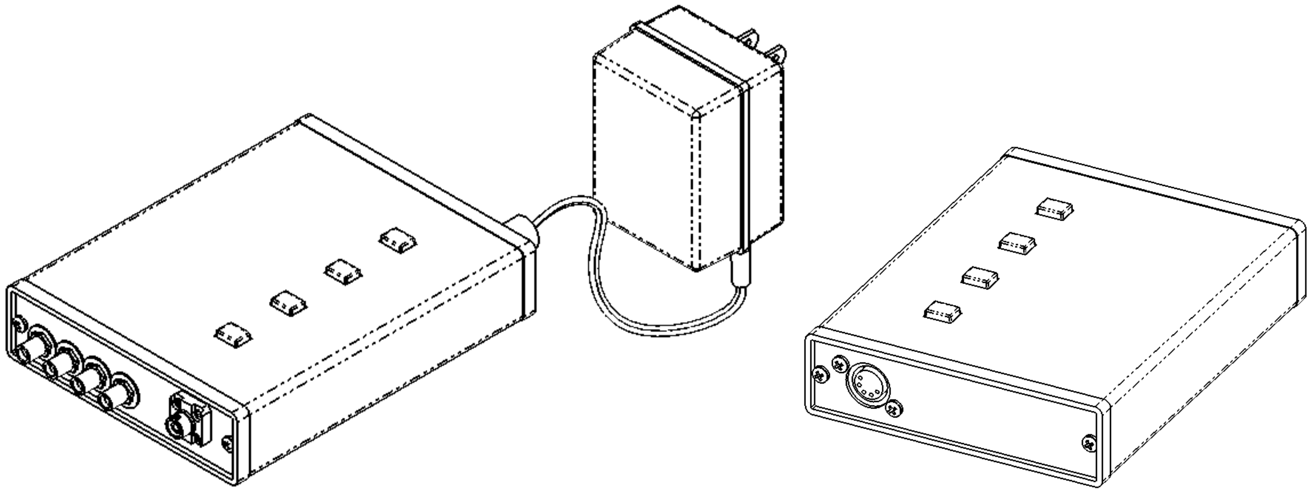


Figure 2. Typical ~2.5 Gb/s Fiber Optic Translator Desktop Model with Manual Control (Single Channel Transmitter with Differential Data and Clock Inputs shown)

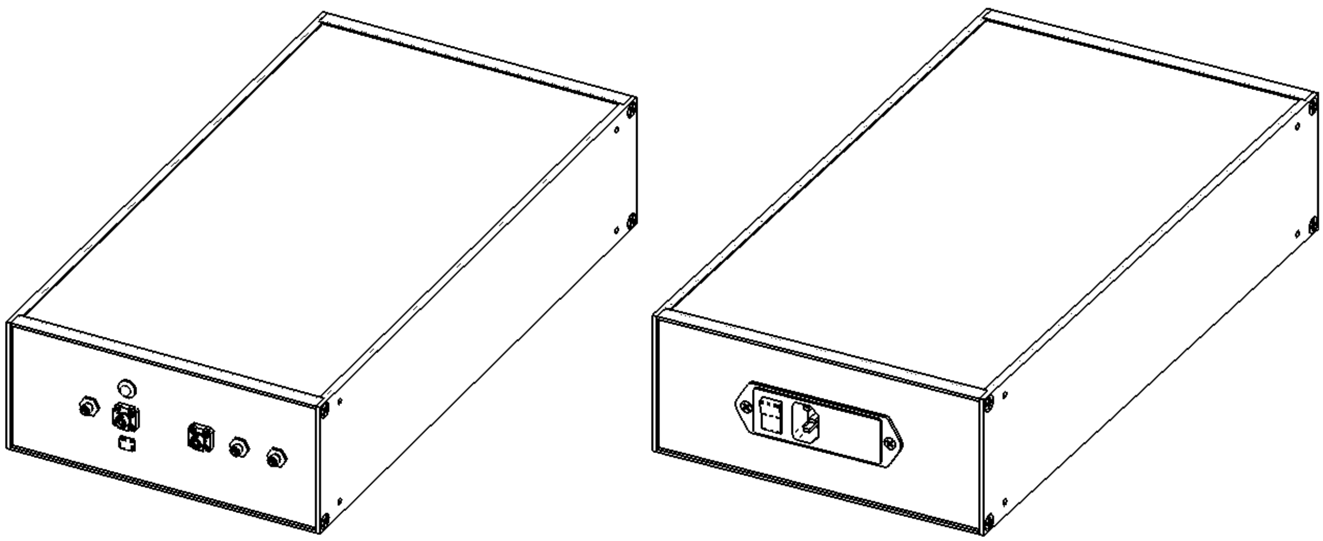


Figure 3. Typical ~10 Gb/s Fiber Optic Translator Desktop Model with Manual Control (Single Channel Transceiver with Single-Ended Data and Clock I/O shown)

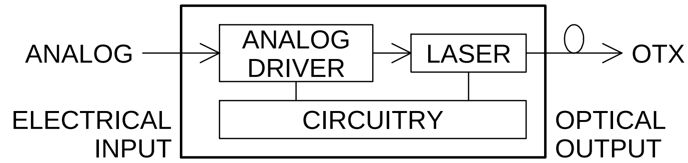
GENERAL CHARACTERISTICS FOR MANUALLY CONTROLLED MODELS

Unless otherwise specified, all manual models in this section have the following characteristics:

- All models are single channel with non-inverting polarity (for single-ended models), and use SMA electrical I/O connectors (K or 3.5mm for ~10 Gb/s models) and FC optical I/O connectors (others upon request)
- All digital models are for use with NRZ modulation to rated maximum data rate
- All electrical signal inputs and outputs are AC-coupled with ~50 KHz -3 dB roll-off frequency
- All transmitter and transceiver models have a single fixed wavelength. Models using 1550 nm lasers in ITU-100GHz C or L bands are available for any ITU grid frequency as given by the tables on page 68.
- All transmitter and transceiver models using 1550 nm lasers in ITU-100GHz C or L bands have cooled lasers providing ~±10 GHz wavelength tolerance. All others models have un-cooled lasers with ~±5% wavelength tolerance.
- All models using 1550 nm lasers have an inline optical isolator
- All transmitter and transceiver models have manual controls for TX enable and TX extinction ratio
- All analog receiver and transceiver models have manual controls for receiver gain and polarity
- 120VAC 60 Hz, with simple manual control and display

- Models with many other performances and options are available
- See Abbreviations on page 1 for terminology used
- All listed prices and specifications may change without notice, made firm upon quote. Prices in USD.

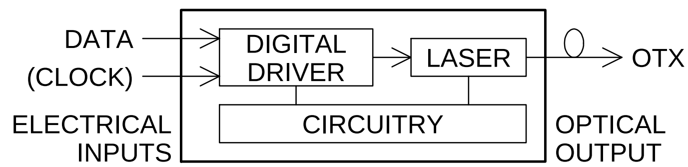
TRANSMITTERS: ANALOG



Description	Maximum Bandwidth	Maximum Optical Output	Price
850 nm, MM-50, direct mod.	1.7 GHz min.	-5 dBm min.	$14,875
850 nm, MM-50, direct mod.	1.0 GHz min.	0 dBm min.	$16,375
1310 nm, MM-50, direct mod.	1.7 GHz min.	-5 dBm min.	$14,875
1310 nm, SM, direct mod.	1.7 GHz min.	+5 dBm min.	$20,575
1550 nm (ITU-100C-L), SM, direct mod.	1.7 GHz min.	+5 dBm min.	$20,575
1550 nm (ITU-100C-L), SM, Amplifier-EA mod.	10 GHz min.	-4 dBm min.	$30,475
1550 nm (ITU-100C-L), SM, Amplifier-LiNbO3 mod.	10 GHz min.	+7 dBm min.	$36,800

TRANSMITTERS: DIGITAL NRZ

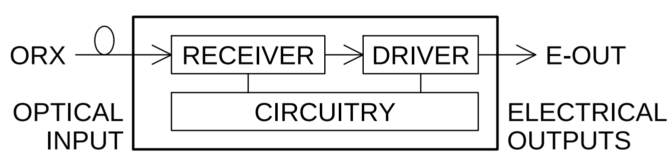
- Models with clock inputs have mode selector for data only or data and clock operation



Description	Electrical Inputs	Maximum Data Rate	Maximum Optical Output	Price
850 nm, MM-50, direct mod.	Diff. Data	2.5 Gb/s min.	-5 dBm min.	$14,875
850 nm, MM-50, direct mod.	Diff. Data, clock	2.5 Gb/s min.	-5 dBm min.	$15,875
850 nm, MM-50, direct mod.	Diff. Data	1.25 Gb/s min.	0 dBm min.	$16,275
850 nm, MM-50, direct mod.	Diff. Data, clock	1.25 Gb/s min.	0 dBm min.	$17,275
1310 nm, MM-50, direct mod.	Diff. Data	2.5 Gb/s min.	-5 dBm min.	$14,875
1310 nm, MM-50, direct mod.	Diff. Data, clock	2.5 Gb/s min.	-5 dBm min.	$15,875
1310 nm, SM, direct mod.	Diff. Data	2.5 Gb/s min.	+5 dBm min.	$20,575
1310 nm, SM, direct mod.	Diff. Data, clock	2.5 Gb/s min.	+5 dBm min.	$21,575
1550 nm, SM, direct mod.	Diff. Data	2.5 Gb/s min.	+5 dBm min.	$20,575
1550 nm, SM, direct mod.	Diff. Data, clock	2.5 Gb/s min.	+5 dBm min.	$21,575
1550 nm (ITU-100C-L), SM, direct mod.	Diff. Data	2.5 Gb/s min.	+5 dBm min.	$20,575
1550 nm (ITU-100C-L), SM, direct mod.	Diff. Data, clock	2.5 Gb/s min.	+5 dBm min.	$21,575
1550 nm (ITU-100C-L), SM, Limiter-EA mod.	SE Data	12 Gb/s min.	-4 dBm min.	$30,475
1550 nm (ITU-100C-L), SM, Limiter-LiNbO3 mod.	SE Data	12 Gb/s min.	+7 dBm min.	$36,800

RECEIVERS: ANALOG

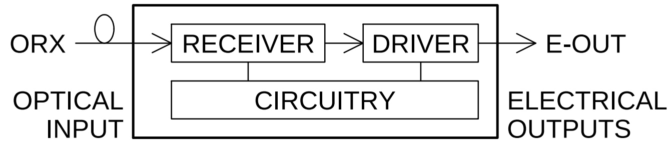
- All models have single-ended analog outputs
- Photodiode-TIA-AGC-IGA or photodiode-TIA-IGA structure



Description	Maximum Bandwidth	Optical Input Range (dBm)	Price
850 nm, MM-62, PIN, Linear with AGC and IGA	1.7 GHz min.	-18 to 0	$15,150
1310 nm, MM-62, PIN, Linear with AGC and IGA	1.7 GHz min.	-18 to 0	$15,150
1310/1550 nm, SM, PIN, Linear with AGC and IGA	1.7 GHz min.	-20 to 0	$20,850
850 nm, MM-62, PIN, Linear with IGA, no AGC	1.7 GHz min.	-18 to 0	$15,150

Description	Maximum Bandwidth	Optical Input Range (dBm)	Price
1310 nm, MM-62, PIN, Linear with IGA, no AGC	1.7 GHz min.	-18 to 0	$15,150
1310/1550 nm, SM, PIN, Linear with IGA, no AGC	2.7 GHz min.	-20 to 0	$20,850
1310/1550 nm, SM, PIN, Linear with IGA, no AGC	10 GHz min.	-15 to 0	$41,175
1310/1550 nm, SM, APD, Linear with IGA, no AGC	10 GHz min.	-22 to -6	$44,050

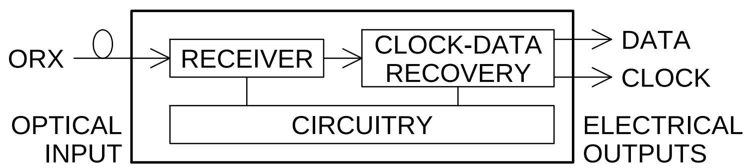
RECEIVERS: DIGITAL WITH LIMITER, NO CDR



- All models have differential data outputs
- Photodiode-TIA-AGC-Limiter structure

Description	Maximum Data Rate	Optical Input Range (dBm)	Price
850 nm, MM-62, Diff. data output, PIN	2.5 Gb/s min.	-18 to 0	$15,150
850 nm, MM-62, Diff. data output, PIN	3.2 Gb/s min.	-18 to 0	$16,650
1310 nm, MM-62, Diff. data output, PIN	2.5 Gb/s min.	-18 to 0	$15,150
1310 nm, MM-62, Diff. data output, PIN	3.2 Gb/s min.	-18 to 0	$16,650
1310/1550 nm, SM, Diff. data output, PIN	2.5 Gb/s min.	-20 to 0	$20,850
1310/1550 nm, SM, Diff. data output, PIN	3.2 Gb/s min.	-20 to 0	$22,350
1310/1550 nm, SM, SE data output, PIN	10 Gb/s min.	-15 to 0	$41,175
1310/1550 nm, SM, SE data output, APD	10 Gb/s min.	-22 to -6	$44,050

RECEIVERS: DIGITAL NRZ WITH CDR

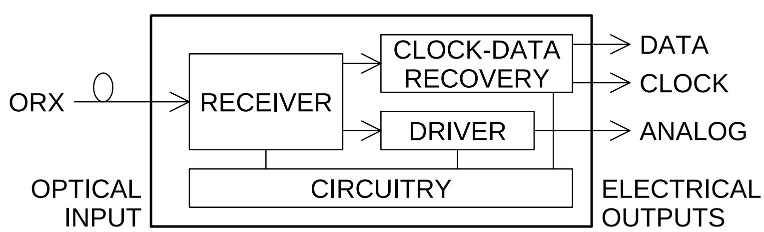


- Photodiode-TIA-AGC-Limiter-CDR structure

Description	Optical Input Range	CDR Group	Price
850 nm, MM-62, Diff. data and clock outputs, PIN	-18 to 0 dBm	A	$15,150
1310 nm, MM-62, Diff. data and clock outputs, PIN	-18 to 0 dBm	A	$15,150
1310/1550 nm, SM, Diff. data and clock outputs, PIN	-20 to 0 dBm	A	$20,850
1310/1550 nm, SM, SE data and clock outputs, PIN	-15 to 0 dBm	B C	$41,175 $48,150
1310/1550 nm, SM, SE data and clock outputs, APD	-22 to -6 dBm	B C	$44,050 $51,025

- Models are available according to the CDR Group for the desired CDR data rate given by Table 1 on page 13.

RECEIVERS: DIGITAL NRZ WITH CDR AND ANALOG



- Photodiode-TIA-AGC-IGA with Limiter-CDR structure

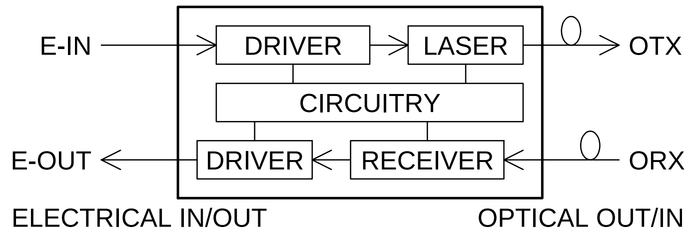
Description	Maximum Bandwidth	Optical Input Range	CDR Group	Price
850 nm, MM-62, PIN		-18 to 0 dBm	A	$17,125
1310 nm, MM-62, PIN		-18 to 0 dBm	A	$17,125
1310/1550 nm, SM, PIN		-20 to 0 dBm	A	$21,500
1310/1550 nm, SM, PIN		-15 to 0 dBm	B C	$42,625 $49,600

Description	Maximum Bandwidth	Optical Input Range	CDR Group	Price
1310/1550 nm, SM, APD		-22 to -6 dBm	B C	$46,025 $53,000

- Models are available according to the CDR Group for the desired CDR data rate given by Table 1 on page 13.
- Single-ended analog & differential data and clock outputs for CDR Group A.
- Single-ended analog, data, and clock outputs for CDR Group B.

TRANSCEIVERS: OTX=ANALOG, ORX=ANALOG

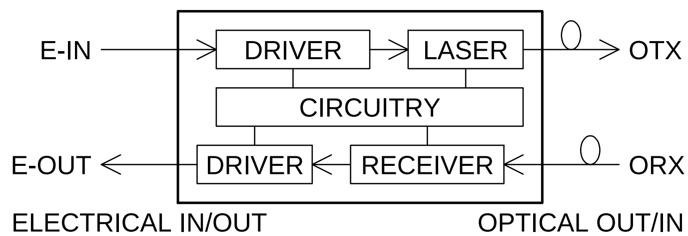
- Photodiode-TIA-AGC-IGA structure with single-ended analog outputs
- Transmitters use direct modulation and have single-ended analog inputs



Description	Maximum Bandwidth	Optical I/O	Price
OTX: 850 nm, MM-50 ORX: 850 nm, MM-62, PIN	1.7 GHz min.	Pout = -5 dBm max. Pin = -18 to 0 dBm	$20,850
OTX: 1310 nm, MM-50 ORX: 1310 nm, MM-62, PIN	1.7 GHz min.	Pout = -5 dBm max. Pin = -18 to 0 dBm	$20,850
OTX: 1310 nm, SM ORX: 1310/1550 nm, SM, PIN	1.7 GHz min.	Pout = +5 dBm max Pin = -20 to 0 dBm	$29,650
OTX: 1550 nm (ITU-100C-L), SM ORX: 1310/1550 nm, SM, PIN	1.7 GHz min.	Pout = +5 dBm max Pin = -20 to 0 dBm	$29,650

TRANSCEIVERS: OTX=DIGITAL, ORX=ANALOG

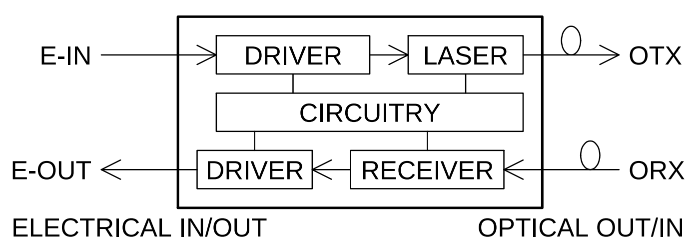
- Transmitters have single-ended data inputs
- Photodiode-TIA-IGA structure with single-ended analog outputs



Description	Maximum Speed	Optical I/O	Price
OTX: 1550 nm (ITU-100C-L), SM, EA mod. ORX: 1310/1550 nm, SM, PIN	10 Gb/s 10 GHz	Pout = -4 dBm max. Pin = -15 to 0 dBm	$41,300
OTX: 1550 nm (ITU-100C-L), SM, EA mod. ORX: 1310/1550 nm, SM, APD	10 Gb/s 10 GHz	Pout = -4 dBm max. Pin = -22 to -6 dBm	$44,200
OTX: 1550 nm (ITU-100C-L), SM, LiNbO3 mod. ORX: 1310/1550 nm, SM, PIN	10 Gb/s 10 GHz	Pout = +7 dBm max. Pin = -15 to 0 dBm	$47,625
OTX: 1550 nm (ITU-100C-L), SM, LiNbO3 mod. ORX: 1310/1550 nm, SM, APD	10 Gb/s 10 GHz	Pout = +7 dBm max. Pin = -22 to -6 dBm	$50,525

TRANSCEIVERS: OTX=DIGITAL, ORX=DIGITAL WITH LIMITER, NO CDR

- Transmitters use direct modulation and have differential data inputs
- Photodiode-TIA-AGC-Limiter structure with differential data outputs

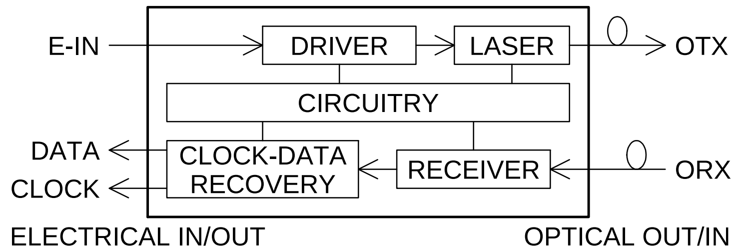


Description	Maximum Speed	Optical I/O	Price

Description	Maximum Speed	Optical I/O	Price
OTX: 850 nm, MM-50 ORX: 850 nm, MM-62, PIN	2.5 Gb/s min.	Pout = -5 dBm max. Pin = -18 to 0 dBm	$20,850
OTX: 1310 nm, MM-50 ORX: 1310 nm, MM-62, PIN	2.5 Gb/s min.	Pout = -5 dBm max. Pin = -18 to 0 dBm	$20,850
OTX: 1310 nm, SM ORX: 1310/1550 nm, SM, PIN	2.5 Gb/s min.	Pout = +5 dBm max Pin = -20 to 0 dBm	$29,650
OTX: 1550 nm (ITU-100C-L), SM ORX: 1310/1550 nm, SM, PIN	2.5 Gb/s min.	Pout = +5 dBm max Pin = -20 to 0 dBm	$29,650

TRANSCEIVERS: OTX=DIGITAL, ORX=DIGITAL NRZ WITH CDR

- Photodiode-TIA-AGC-Limiter-CDR structure

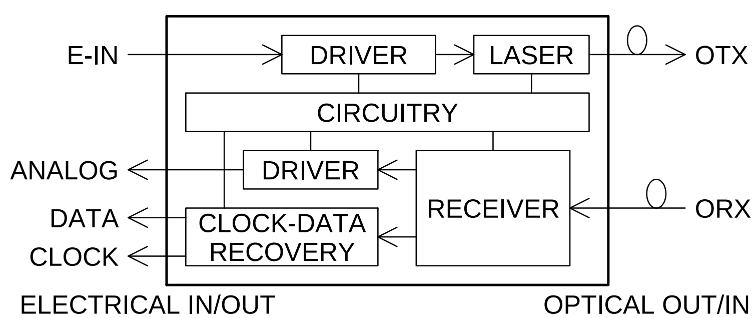


Description	Maximum Speed	Optical I/O	CDR Group	Price
OTX: 850 nm, MM-50, direct mod. ORX: 850 nm, MM-62, PIN	2.5 Gb/s min.	Pout = -5 dBm max. Pin = -18 to 0 dBm	A	$20,850
OTX: 1310 nm, MM-50, direct mod. ORX: 1310 nm, MM-62, PIN	2.5 Gb/s min.	Pout = -5 dBm max. Pin = -18 to 0 dBm	A	$20,850
OTX: 1310 nm, SM, direct mod. ORX: 1310/1550 nm, SM, PIN	2.5 Gb/s min.	Pout = +5 dBm max Pin = -20 to 0 dBm	A	$29,650
OTX: 1550 nm (ITU-100C-L), SM, direct mod. ORX: 1310/1550 nm, SM, PIN	2.5 Gb/s min.	Pout = +5 dBm max Pin = -20 to 0 dBm	A	$29,650
OTX: 1550 nm (ITU-100C-L), SM, EA mod. ORX: 1310/1550 nm, SM, PIN	10 Gb/s min.	Pout = -4 dBm max. Pin = -15 to 0 dBm	B	$57,925
OTX: 1550 nm (ITU-100C-L), SM, EA mod. ORX: 1310/1550 nm, SM, APD	10 Gb/s min.	Pout = -4 dBm max. Pin = -22 to -6 dBm	B	$60,825
OTX: 1550 nm (ITU-100C-L), SM, LiNbO3 mod. ORX: 1310/1550 nm, SM, PIN	10 Gb/s min.	Pout = +7 dBm max. Pin = -15 to 0 dBm	B	$64,275
OTX: 1550 nm (ITU-100C-L), SM, LiNbO3 mod. ORX: 1310/1550 nm, SM, APD	10 Gb/s min.	Pout = +7 dBm max. Pin = -22 to -6 dBm	B	$67,150

- Models are available according to the CDR Group for the desired CDR data rate given by Table 1 on page 13.
- Transmitters have differential data inputs for CDR Group A and single-ended data inputs for CDR Group B.
- Receivers have differential data and clock outputs for CDR Group A and single-ended data and clock outputs for CDR Group B.

TRANSCEIVERS: OTX=DIGITAL, ORX=DIGITAL NRZ WITH CDR AND ANALOG

- Photodiode-TIA-AGC-IGA with limiter-CDR structure



Description	Maximum Speed	Optical I/O	CDR Group	Price
OTX: 850 nm, MM-50, direct mod. ORX: 850 nm, MM-62, PIN, CDR	2.5 Gb/s min. 1.7 GHz min.	Pout = -5 dBm max. Pin = -18 to 0 dBm	A	$20,850

Description	Maximum Speed	Optical I/O	CDR Group	Price
OTX: 1310 nm, MM-50, direct mod. ORX: 1310 nm, MM-62, PIN, CDR	2.5 Gb/s min. 1.7 GHz min.	Pout = -5 dBm max. Pin = -18 to 0 dBm	A	$20,850
OTX: 1310 nm, SM, direct mod. ORX: 1310/1550 nm, SM, PIN, CDR	2.5 Gb/s min. 1.7 GHz min.	Pout = +5 dBm max Pin = -20 to 0 dBm	A	$29,650
OTX: 1550 nm (ITU-100C-L), SM, direct mod. ORX: 1310/1550 nm, SM, PIN, CDR	2.5 Gb/s min. 1.7 GHz min.	Pout = +5 dBm max Pin = -20 to 0 dBm	A	$29,650
OTX: 1550 nm (ITU-100C-L), SM, EA mod. ORX: 1310/1550 nm, SM, PIN, CDR	10 Gb/s min. 10 GHz min.	Pout = -4 dBm max. Pin = -15 to 0 dBm	B	$59,375
OTX: 1550 nm (ITU-100C-L), SM, EA mod. ORX: 1310/1550 nm, SM, APD, CDR	10 Gb/s min. 10 GHz min.	Pout = -4 dBm max. Pin = -22 to -6 dBm	B	$62,800
OTX: 1550 nm (ITU-100C-L), SM, LiNbO3 mod. ORX: 1310/1550 nm, SM, PIN, CDR	10 Gb/s min. 10 GHz min.	Pout = +7 dBm max. Pin = -15 to 0 dBm	B	$65,725
OTX: 1550 nm (ITU-100C-L), SM, LiNbO3 mod. ORX: 1310/1550 nm, SM, APD, CDR	10 Gb/s min. 10 GHz min.	Pout = +7 dBm max. Pin = -22 to -6 dBm	B	$69,125

- Models are available according to the CDR Group for the desired CDR data rate given by Table 1 on page 13.
- Transmitters have differential data inputs for CDR Group A and single-ended data inputs for CDR Group B.
- Receivers have single-ended analog and differential data and clock outputs for CDR Group A and single-ended analog, data, and clock outputs for CDR Group B.

RACK-MOUNTABLE FIBER OPTIC TRANSLATORS WITH COMPUTER CONTROL

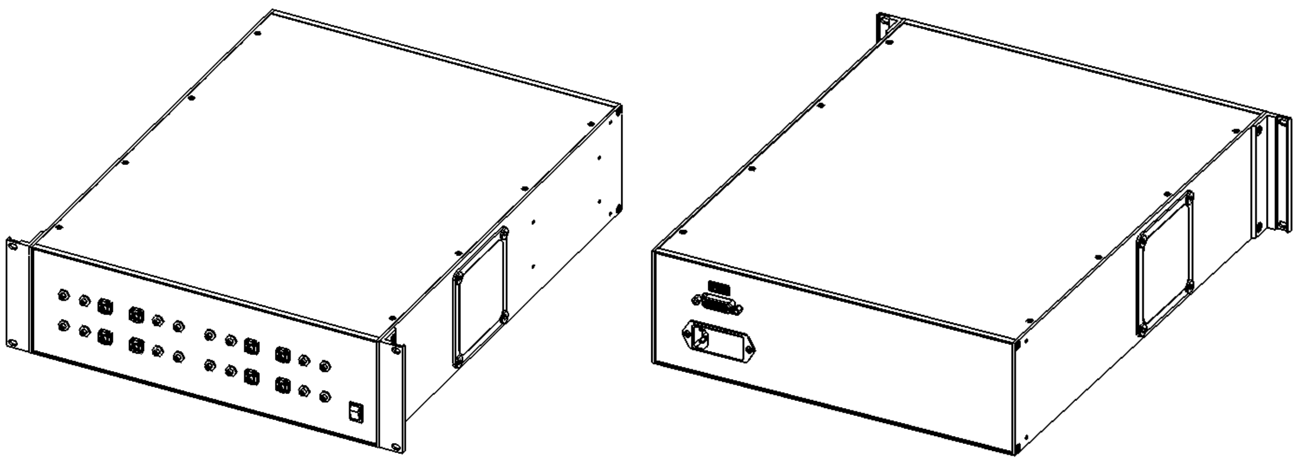


Figure 4. Typical Rack-Mountable Fiber Optic Translator with GPIB Control (4 Channel Transceiver with Differential I/O shown)

GENERAL CHARACTERISTICS FOR COMPUTER CONTROLLED MODELS

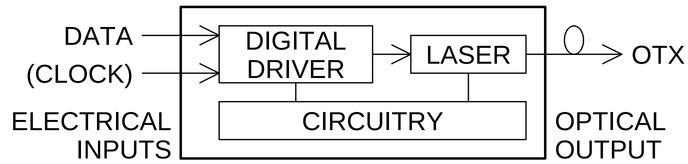
Unless otherwise specified, all automatic models in this section have the following characteristics:

- All models have non-inverting polarity (for single-ended models)
- All digital models are for use with NRZ modulation to rated maximum data rate.
- All models have FC optical connectors (others upon request)
- All models have SMA electrical connectors (K or 3.5mm for ~10 Gb/s models)
- Worldwide AC powered, with simple manual control and display
- GPIB-IEEE488.2-HPIB control and monitor (RS-232, USB, and 10/100Base-T LAN on request)
- All electrical signal inputs and outputs are AC-coupled with ~30 KHz -3 dB roll-off frequency
- All OTX and OTR models have a single fixed wavelength
- All OTX and OTR models using 1550 nm lasers in ITU-100GHz C or L bands have cooled lasers providing ~±10 GHz wavelength tolerance. All others models have un-cooled lasers with ~±5% wavelength tolerance.

- All OTX and OTR models using 1550 nm lasers have an inline optical isolator.
- All OTX and OTR models have manual controls for TX enable and TX extinction ratio
- All ORX and OTR models have manual controls for RX gain and RX analog polarity
- Models with many other performances and options are available
- All listed prices and specifications may change without notice, made firm upon quote. Prices in USD. Call TME for any prices on models showing $X until updated in next catalog edition (visit www.tmeplano.com for most current catalog edition).

DIGITAL TRANSMITTERS FOR ELECTRICAL BER TESTERS

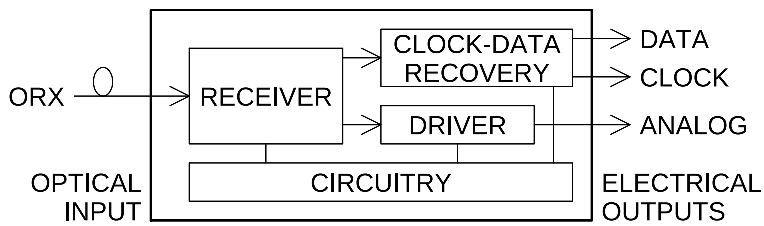
- NRZ or NRZ and RZ-Sine modulation



Description	Maximum Data Rate	Maximum Optical Output	Price
1550 nm (ITU-100C-L), SM, LiNbO3, selectable NRZ or RZ-sine modulation	10 Gb/s min.	+5 dBm min.	$86,000 (1 Ch.) $139,500 (2 Ch.)
1550 nm (ITU-100C-L), SM, LiNbO3, NRZ	10 Gb/s min.	+7 dBm min.	$46,800 (1 Ch.)

DIGITAL RECEIVERS FOR ELECTRICAL BER TESTERS

- Photodiode-TIA-AGC-IGA with Limiter-CDR structure

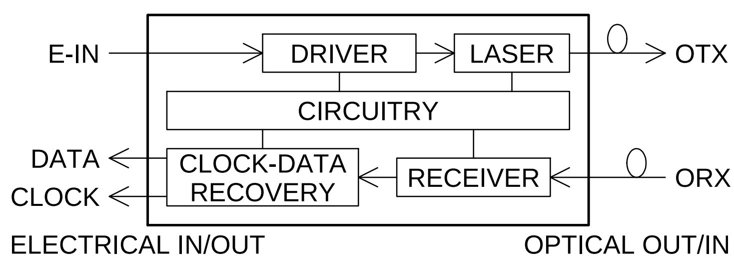


Description	Maximum Speed	Optical Input Range (dBm)	Price
1310/1550 nm, SM, PIN-TIA-Limiter-CDRx2, Dual Rate	Two rates from CDR Group B	-15 to 0	$87,250 (1 Ch.) $143,000 (2 Ch.)

- Models are available according to the CDR Group for the desired CDR data rate given by Table 1 on page 13.
- Single-ended analog & differential data and clock outputs for CDR Group A.
- Single-ended analog, data, and clock outputs for CDR Group B.

DIGITAL TRANSCEIVERS FOR ELECTRICAL BER TESTERS

- Photodiode-TIA-AGC-Limiter-CDR receiver structure
- All models are single-mode



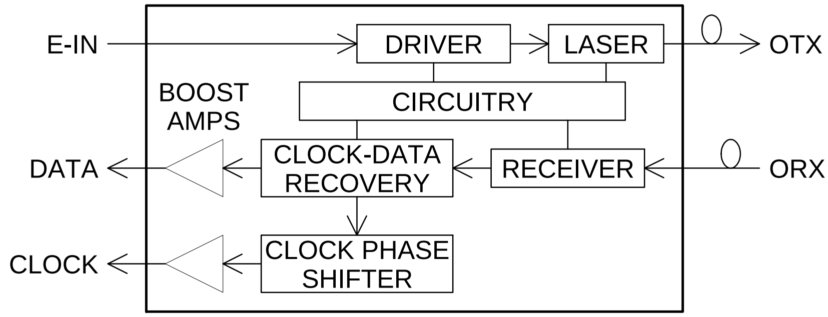
Description	Maximum Speed	Optical I/O	CDR Group	Price
OTX: 1550 nm (ITU-100C-L), direct mod ORX: 1310/1550 nm, PIN	~2.7 Gb/s min.	Pout = 0 to +3 dBm Pin = -22 to -2 dBm	A	$46,800 (1 Ch.) $60,550 (2 Ch.) $88,100 (4 Ch.)
OTX: 1550 nm (ITU-100C-L), LiNbO3 mod ORX: 1310/1550 nm, PIN	~11 Gb/s min.	Pout = +5 dBm min. Pin = -15 to 0 dBm	B	$93,800 (1 Ch.) $154,000 (2 Ch.) $274,500 (4 Ch.)

- Models are available according to the CDR Group for the desired CDR data rate given by Table 1 on page 13.
- Transmitters have differential data inputs for CDR Group A and single-ended data inputs for CDR Group B.

- Receivers have differential data and clock outputs for CDR Group A and single-ended data and clock outputs for CDR Group B.

DIGITAL TRANSCEIVERS FOR ELECTRICAL SONET TESTERS

- Photodiode-TIA-AGC-Limiter-CDR receiver structure followed by data to clock phase shifter and boost amplifiers



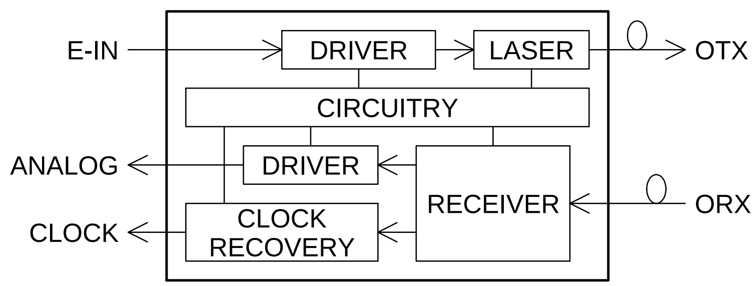
ELECTRICAL IN/OUT OPTICAL OUT/IN

Description	Maximum Speed	Optical I/O	CDR Group	Price
OTX: 1550 nm (ITU-100C-L), SM, Direct Mod ORX: 1310/1550 nm, PIN	~2.7 Gb/s min.	Pout = 0 to +3 dBm Pin = -22 to -2 dBm	A	$46,950 (1 Ch.) $60,850 (2 Ch.) $88,750 (4 Ch.)
OTX: 1550 nm (ITU-100C-L), SM, LiNbO3 ORX: 1310/1550 nm, PIN	~11 Gb/s min.	Pout = +5 dBm min. Pin=-15 to 0 dBm	B	$102,750 (1 Ch.) $172,000 (2 Ch.) $310,250 (4 Ch.)

- Models are available according to the CDR Group for the desired CDR data rate given by Table 1 on page 13.
- Transmitters have differential data inputs for CDR Group A and single-ended data inputs for CDR Group B.
- Receivers have differential data and clock outputs for CDR Group A and single-ended data and clock outputs for CDR Group B.

DIGITAL-ANALOG TRANSCEIVERS FOR AGILENT PARBERT TESTER

- Photodiode-TIA-AGC-Limiter-CDR receiver structure
- ParBERT capable of eye pattern, BER, and other tests



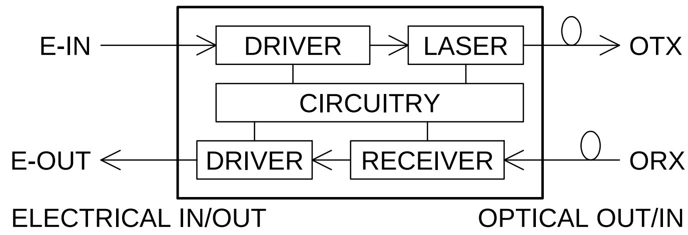
ELECTRICAL IN/OUT OPTICAL OUT/IN

Description	Maximum Speed	Optical I/O	CDR Group	Price
OTX: 850 nm, Direct Mod, NRZ, 30 dB VOA, Pout Monitor ORX: 850 nm, Analog/Digital, PIN-TIA-IGA w/CDR, SONET Filter, Pin Monitor	~622 Mb/s	Pout = -8 dBm Pin = -18 to 0 dBm	A	$92,325 (4 Ch.)

- Models are available according to the CDR Group for the desired CDR data rate given by Table 1 on page 13.
- Transmitters have differential data inputs for CDR Group A and single-ended data inputs for CDR Group B.
- Receivers have differential data and clock outputs for CDR Group A and single-ended data and clock outputs for CDR Group B.

DIGITAL-ANALOG TRANSCEIVERS FOR SYNTHESYS RESEARCH BITALYZER TESTERS

- Photodiode-TIA-AGC-Limiter-CDR receiver structure
- BitAlyzer capable of eye pattern, BER, and other tests



Description	Maximum Speed	Optical I/O	Price
OTX: 1310 nm, Direct Mod ORX: 1310 nm, PIN-TIA-IGA, Analog out	~155 Mb/s	Pout = -5 to 0 dBm Pin = -36 to –3 dBm	$45,950 (4 Ch.) $75,400 (8 Ch.) $134,300 (16 Ch.)
OTX: 1310 nm, Direct Mod ORX: 1310 nm, PIN-TIA-IGA, Analog out	~622 Mb/s	Pout = -3 to +2 dBm Pin = -30 to –7 dBm	$49,600 (4 Ch.) $82,700 (8 Ch.)
OTX: 1310 nm, Direct Mod ORX: 1310 nm, PIN-TIA-IGA, Analog out	~2.7 Gb/s max	Pout = 0 to +3 dBm Pin = -22 to –2 dBm	$33,550 (1 Ch.) $39,300 (2 Ch.) $62,100 (4 Ch.)
OTX: 1550 nm (ITU-100C-L), SM, LiNbO3, NRZ ORX: 1310/1550 nm, PIN-TIA-IGA, Analog out	~11 Gb/s max	Pout = +5 dBm min. Pin = -15 to 0 dBm	$68,000 (1 Ch.) $104,000 (2 Ch.) $176,000 (4 Ch.)

- Models are available according to the CDR Group for the desired CDR data rate given by Table 1 on page 13.
- Transmitters have differential data inputs for CDR Group A and single-ended data inputs for CDR Group B.
- Receivers have differential data and clock outputs for CDR Group A and single-ended data and clock outputs for CDR Group B.

OPTIONS FOR RACK-MOUNTABLE FIBER OPTIC TRANSLATORS WITH COMPUTER CONTROL

Prices are per channel (many other options available, call TME)

Model Options	Price
OTX/ORX Channel ID, Programmable	$2,500
OTX SBS Suppression, Programmable	$1,250
OTX Optical Output Leveling – OC192	$7,000
OTX Alternate Coarse Wavelength – OC3, 1550 ±2% nm	$1,350
OTX Alternate Coarse Wavelength – OC12, 1550 ±2% nm	$150
OTX Alternate Coarse Wavelength – OC48, 1550 ±2% nm	$2,000
OTX/ORX Differential Electrical I/O – OC1 thru OC48	$450
OTX/ORX Differential Electrical I/O – OC192	$12,500
OTX Tunable Wavelength – OC192, whole C Band	$25,000
OTX Alternate ITU-50 Fixed Wavelength – C or L Band	$1,250
ORX Fixed Optical Channel Filter	$2,400
ORX Tunable Optical Channel Filter	$15,000
ORX Lock-On Optical Channel Filter	$22,500

MULTI-FUNCTIONAL FIBER OPTIC TRANSLATORS

1CF1 - NRZ to NRZ-RZ-CRZ Fiber Optic Translator

This fiber optic translator is a custom test instrument that performs wavelength and waveshape conversion. It operates in the C and L bands for data rates from 9.95 to 10.75 Gb/s or from 12.0 to 12.6 Gb/s. It has 19 operating modes that are either LAN controllable or manually controllable from front panel controls, status indicators, and graphic display. Four optical connectors and 5 microwave connectors are on the front panel and LAN and AC power inlet connectors are on the rear panel. It is packaged in a 1U high rack-mountable chassis with a universal AC power input and a LAN interface.

Operating modes include 6 optical to optical (O-O) modes, 1 optical to electrical (O-E) mode, 10 electrical to optical (E-O) modes, 1 electrical to electrical mode (E-E), and 1 optical out mode. An auxiliary clock/4 output is available and valid when the internal clock recovery circuits are used.

The O-O modes convert an optical NRZ input signal to NRZ, RZ, or CRZ optical output signals using either an internal fixed wavelength laser source with SBS control or an external fixed or tunable wavelength laser source. The O-E mode converts an optical NRZ input signal to an electrical NRZ output. Six E-O modes convert an electrical NRZ data input to NRZ, RZ, or CRZ optical output signals using either an internal fixed wavelength laser source with SBS control or an external fixed or tunable wavelength laser source. Four E-O modes convert electrical NRZ data and clock inputs to RZ or CRZ optical output signals using either an internal fixed wavelength laser source with SBS control or an external fixed or tunable wavelength laser source. The E-E mode converts an electrical NRZ data input to a recovered clock electrical output. The optical out mode produces +13 dBm laser output signal at a thermally controlled fixed wavelength in the C or L band. The laser has an SBS suppression circuit with amplitude and frequency control. The NRZ optical input has an optical power meter and crossover control.

Price is $176,000 each in order quantity of 1 unit.

Figure 5. Front View of 1CF1 - NRZ to NRZ-RZ-CRZ Fiber Optic Translator

1CF15 - 10 Gb/s Class Fiber Optic Translator with 2R OTX and 1R+3R ORX

- **2R Digital Fiber Optic Transmitter Section**
  - 2R NRZ lithium niobate modulator, up to 12.5 Gb/s operation, C+L band
  - Variable optical attenuator (VOA), C+L band, for optical output power level control
  - Optical power output port for output power level monitoring
  - Internal C-band CW laser for modulator utility light source
  - Direct modulator access for use with external C+L tunable laser sources
  - 0 to -25 dBm modulated output power range plus internal laser disable
- **1R Analog and 3R Digital Fiber Optic Receiver Section**
  - Fiber optic receiver, up to 9 GHz and 12.5 Gb/s, C+L band, -17 to +3 dBm input range
  - Input optical power level status monitor (LOS, Normal, Overload)
  - Optical power input port for input power level monitoring
  - Independent 1R analog output, 0.8 Vpp/mW typical conversion AC gain
  - Independent 3R CDR digital output, 9.95 to 10.8 Gb/s, with locked/unlocked indicator
  - Data and clock output source selector switch (CDR or external data and clock)
- **Operation**
  - Computer control via 10 Base-T LAN port and graphical user interface software
  - Manual control via front panel pushbuttons, status indicators, and graphic display
  - Control of transmitter extinction ratio, eye crossover point, optical output power level, and internal laser
  - Control of data and clock output from receiver CDR or external source
- **Package**
  - Six FC/SPC SM fiber optic connector ports, six SMA/3.5mm/K compatible microwave connector ports
  - Internal SM fiber optic “crash” cables on all fiber optic ports for low cost in-use protection
  - Black 19” rack mountable desktop chassis, 1U (1.72”) high x 22” deep
  - Weighs less than 15 pounds, internally modular construction for maintenance ease
  - 0°C to +50°C continuous operation, auto-ranging 120 or 240 VAC power input
  - Accessory package included
- **Pricing**
  - Price is $171,375 each in order quantity of 1 unit
- **Applications**
  - Used with a BERT, SONET, FEC, or other protocol tester to manually or automatically performance test fiber optic transmission components and equipment
  - Test terrestrial, submarine, and airborne communication product performance in the lab, factory, or field during creation, development, production, procurement, deployment, and maintenance
  - Useful for testing single and multiple lane fiber optic lasers, receivers, transponders, line cards, card-cage products, network equipment, dispersion compensators, etc.

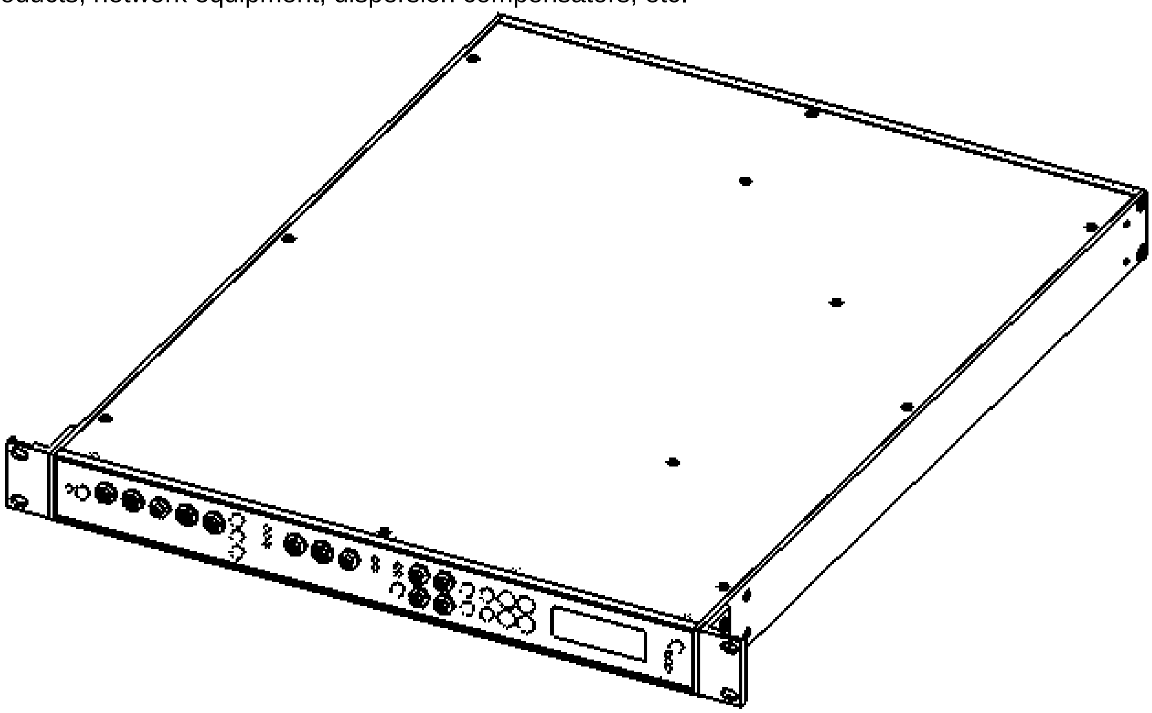


Figure 6. Front View of 1CF15 - 10 Gb/s Class Fiber Optic Translator with 2R OTX and 1R+3R ORX

1CF33 (TK0611ES1A) – 9.9-12.5 Gb/s NRZ/RZ/CRZ/CS/DPSK Fiber Optic Translator

This fiber optic translator is a custom test instrument that performs wavelength and multiple kinds of waveshape conversion. It operates in the C and L bands for any data rate from < 9.9 to > 12.5 Gb/s. It has multiple operating modes that are either LAN controllable or manually controllable from front panel controls, status indicators, and graphic display. Four optical connectors and 5 microwave connectors are on the front panel and LAN and AC power inlet connectors are on the rear panel. It is packaged in a 1U high rack-mountable chassis with a universal AC power input and a LAN interface. Price is $221,175 each in order quantity of 2 units.

Brief Features:
1. Produces fiber optic output modulated signal within C+L bands from an NRZ optical or electrical input
2. Modulation user selectable as NRZ, RZ, CRZ, NRZ-DPSK, RZ-DPSK, CRZ-DPSK, CS-RZ, CS-CRZ, CS-RZ-DPSK, or CS-CRZ-DPSK. Note that NRZ = non-return to zero, RZ = return to zero, CRZ = chirped RZ, DPSK = differential phase shift keying.
3. Full control over bias, gain, and timing for three cascaded lithium niobate modulators. Data modulator can be driven by external NRZ input, CDR retimed NRZ data, or DPSK data. RZ and CRZ modulators can be driven independently or in cascade by full or half rate recovered sine wave clocks.
4. DPSK switchable between whether logic 1 or logic 0 causes differential phase transitions
5. Optical output, non-polarized, 12.5 dB loss max. between CW optical input and optical output
6. Data rates from 9.9 to 12.5 Gb/s, continuous range, two CDR loop bandwidths selectable (normal, slow)
7. NRZ receiver optical input from –15 dBm to 0 dBm, 1250-1610 nm, non-polarized. Input optical power meter and coarse optical power indicators provided. Adjustment provided for received input crossover point.
8. Polarized CW optical input to modulator string, +20 dBm max., 1528-1610 nm (C+L band)
9. Internal temperature controlled fixed wavelength (1554.94 nm default or customer chosen) CW laser with SBS suppressor, adjustable output power to 15 mW (+11.7 dBm), tunable +/- two 100GHz channels minimum
10. Transfer switch provides electrical access to NRZ receiver output and CDR input
11. Recovered digital clock, re-timed digital data, and programmable (2, 4-9) divided digital clock trigger outputs
12. FC/SPC single-mode optical input and output connectors with internal “crash” cables. CW optical input requires polarized fiber with slow axis aligned with connector key.
13. Electronic phase shifters provided to adjust clock to data relationship and chirping function
14. Aluminum enclosure, 19” rack mountable, nominal 1.75” high (1U) by 16.75” wide (less rack-mount ears) by 22” deep, detachable rack mount ears, removable top cover (screws), black aluminum color with white durable graphics on front and rear panels, internal convection and conduction cooling to case (no fans)
15. 120/240 VAC (85-260 VAC), auto-ranging, 47-63 Hz, single phase, universal power supply, 75 watts maximum, rear panel power switch and inlet. For stationary office, lab, or factory environments, not for outdoor use, 25°C ± 20°C minimum operating temperature range.
16. Manually controllable or computer controllable via 10/100Base-T Ethernet LAN port, LAN GUI provided
17. Store and recall of 10 instrument states. Status indicators for “power” and clock-data recovery “locked/unlocked” state. Lighted graphic pushbutton switches for gain, offset, and timing adjustments for each modulation mode (on-switch graphic display labeling) and access to and navigation of VFD menus.

Figure 7. Front View of 1CF33 (TK0611ES1A) – 9.9-12.5 Gb/s NRZ/RZ/CRZ/CS/DPSK Fiber Optic Translator

1CF38A – Tunable C-band Fiber Optic Transmitter

1CF39A – Tunable C-band Fiber Optic Receiver

This fiber optic transmitter and receiver pair are custom fiber optic test instruments that are entirely controlled by an external FPGA or other 3.3V logic method (no manual controls). They operate in the C band for any data rate from < 100 Mb/s to > 12.5 Gb/s. Each instrument is packaged in a 1U high rack-mountable chassis with a universal AC power input and a 20-pin ribbon connector interface. Price is $69,200 each for the 1CF38A in order quantity of 1 unit. Price is $69,350 each for the 1CF39A in order quantity of 1 unit.

Brief Features for 1CF38A Transmitter (see Figure 8):

1. Produces NRZ fiber optic output modulated signal from an NRZ electrical input.
2. Internal CW laser - temperature controlled, tunable wavelength over C-band (1528-1563 nm), 50 or 100 GHz channel spacing, 5 MHz line width, SBS dither capability, electronic shutter, RS-232 protocol controlled.
3. Full control (via serial DACs) over bias, modulation gain, and eye pattern crossover control (30% to 70%) using a 10 Gb/s class lithium niobate (LN) modulator and modulator driver. Operational with data rates < 100 Mb/s to > 12.5 Gb/s, protocol-agnostic.
4. Internal MEMS-type variable optical attenuator (VOA) with 20 dB range, >10^7 operational lifetime, serial operation.
5. Optical power output minimum range is +7 dBm to -12 dBm.
6. Electrical data input is 50 ohm single-ended and internally AC coupled. Electrical input range is 250 mVpp to 1000 mVpp with a 1500 mVpp absolute maximum input (damage threshold).
7. Low speed (1 Kb/s) FSK envelope modulation input provided, where logic 0 is 25 KHz and logic 1 is 50 KHz, adjustable output level from 0 to 100% modulation depth.
8. Optical output power monitor provided via a 5% tap coupler, PIN photodiode, TIA, and serial output A to D converter.
9. Computer controllable via digital I/O interface, all lines using LVTTL/LVCMOS 3.3 volt logic. Serial control (data, clock, enable) of DACs, ADC, and VOA. RS-232 control of tunable laser.
10. Power-up default state is laser off with all DACs in an indeterminate state. User control at digital I/O port required to turn laser on, set a wavelength, and to set DACs at desired state. See common features for a TME “manual” tester option.

Brief Features for 1CF39A Receiver (see Figure 9):

1. Accepts an NRZ modulated fiber optic input signal and produces NRZ differential electrical output signals for recovered clock and re-timed data.
2. Internal tunable filter – athermal design (< ±1 pm/°C), tunable wavelength over C-band (1528-1562 nm), 50 or 100 GHz channel spacing, 10 pm resolution, flat topped pass band, 25 GHz BW @ 3 dB points, < 4 dB IL, RS-232 controlled.
3. 12.5 Gb/s linear PIN-TIA fiber optic receiver with 30 KHz to 10 GHz bandwidth. Operational with data rates < 100 Mb/s to > 12.5 Gb/s, protocol-agnostic. Optical input power minimum range is -18 dBm to +3 dBm typical with a +9 dBm absolute maximum input (damage threshold). Direct input/output access provided.
4. Electrical data and clock outputs are complementary 50 ohm single-ended and internally AC coupled. Each clock or data output signal level (true or complement) is 400 mVpp typical (CML logic), which is 800 mVpp when complementary outputs are used differentially. (Note: PECL 600/1200 mVpp logic levels available on request at no charge).
5. Synthesizer based Clock-Data Recovery circuit (CDR) used to produce recovered clock and re-timed data from the received data. Adjustable via serial control from ~100 Mb/s to ~2.7 Gb/s.
6. Received power monitor provided via serial A to D converter output.
7. Low speed (1 Kb/s) FSK de-modulation output provided, where logic 0 is 25 KHz and logic 1 is 50 KHz.
8. Computer controllable via digital I/O interface, all lines using LVTTL/LVCMOS 3.3 volt logic. Serial control (data, clock, enable) of ADC and CDR. RS-232 control of tunable filter.
9. Power-up default state is tunable filter reset, receiver active, and CDR in an indeterminate state. User control at digital I/O port required to turn tune filter to desired wavelength and to set CDR for desired data rate. See common features for a TME “manual” tester option.

Common features for both models:

1. Fiber optic I/O connectors are FC/UPC (flat tip) with metal ferrules, intended for use with single mode optical fiber. Connectors have internal “crash cable” for low cost damage protection.
2. RF/Microwave I/O connectors are SMA female with an internal “crash cable” for low cost damage protection.
3. Serial control (3.3V LVTTL/LVCMOS levels) provided via rear panel “Digital I/O Port” connector. Mating cable (36”) with pigtail end included with equipment.
4. Aluminum enclosure, 19” rack mountable, nominal 1.75” high (1U) by 16.75” wide (less rack-mount ears) by 22” deep, detachable rack mount ears, removable top cover (screws), black aluminum color with white durable graphics on front and rear panels, internal convection and conduction cooling to case (no fans).

5. 120/240 VAC (85-260 VAC), auto-ranging, 47-63 Hz, single phase, universal power supply, 25 watts maximum, rear panel AC power switch and AC inlet, dual fused, front panel power status indicator.
6. For stationary office, lab, or factory environments, not for outdoor use, 25°C ± 20°C minimum operating temperature range.
7. Not safety agency approved (UL, CSA, etc.), but is designed, marked, and constructed to meet safety agency requirements (safety agency approval quoted upon request, unit would pass as-is). For industrial use only, user accepts liability for use.
8. A simple TME “manual” tester (Visual Basic program, controller, interface, and cables) is available for optional purchase. Controller operates DACs, ADCs, and CDR. PC serial port used for RS-232.

Figure 8. Front View of 1CF38A – Tunable C-Band Fiber Optic Transmitter

Figure 9. Front View of 1CF39A – Tunable C-Band Fiber Optic Receiver

CLOCK REGENERATORS

Clock Regenerators are semi-custom test instruments containing specialized fiber optic or microwave digital receivers. These receivers use resonator or phase-locked loop clock recovery technology to extract an electrical clock signal from an optical or electrical data-only stream produced by a product or network under test. The extracted clock signal is typically used to trigger a sampling oscilloscope for eye pattern, OMA, and extinction ratio measurements or to make jitter measurements. Such measurements are made on single and multiple lane fiber optic lasers, drivers, modulators, transponders, line cards, card-cage products, network equipment, and trunk lines.

TME offers two kinds of clock regenerators called “Sampling Oscilloscope Triggers” and “Data-only Jitter Adapters”. Customers can choose from many kinds of made-to-order models due to the functions, wavelength ranges, fiber types, sensitivities, clock recovery rates, jitter bandwidths, number of channels, options, and packaging choices offered. Model numbers are assigned when a quote is originated.

SAMPLING OSCILLOSCOPE TRIGGERS

A “Sampling Oscilloscope Trigger” is a Clock Regenerator designed to provide the external trigger signal required for a sampling oscilloscope from an input signal. In coupler models, the data-only stream from a product or network under test passes through the Trigger and is delivered to the oscilloscope as the input signal. A small portion of the pass-through signal is tapped off and used to extract a clock signal that is supplied to the oscilloscope for the external trigger input signal. The oscilloscope uses the input signal and the trigger signal to create a display or “eye” pattern on its screen.

Sampling Oscilloscope Triggers are used with standard commercially available optical or electrical sampling oscilloscopes, such as those made by Agilent, Tektronix, and others. They are usually needed for data rates above ~1 Gb/s where real time self-triggering oscilloscopes are not readily available. Standard sampling oscilloscope triggers are commercially available for some popular single data rates, wavelengths, and fiber types. TME models are used for less popular data rates, wavelengths, and fiber types or for improved sensitivity or when multiple data rates are needed in one unit.

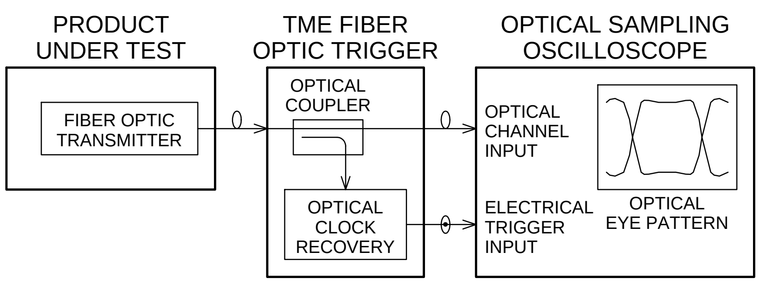


Figure 10. Fiber Optic Sampling Oscilloscope Trigger Application using Optical Coupler

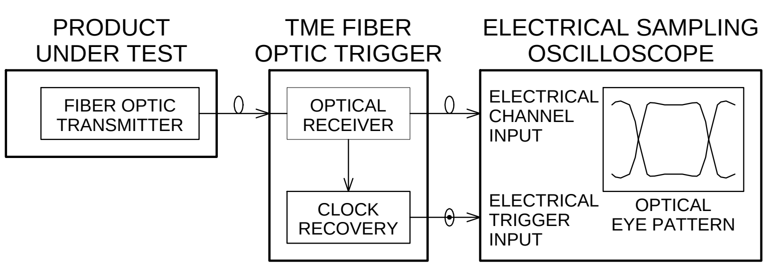


Figure 11. Fiber Optic Sampling Oscilloscope Trigger Application using Optical Receiver

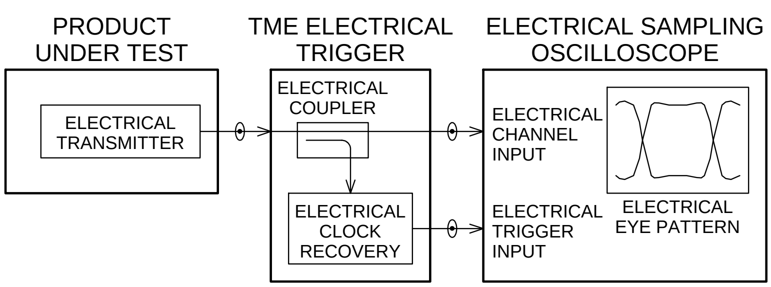


Figure 12. Electrical Sampling Oscilloscope Trigger Application using Electrical Coupler

TME offers various Sampling Oscilloscope Trigger types and models for both fiber optic and electrical data-only signal stream applications. Two fiber optic types are offered that differ in the kind of sampling oscilloscope needed (optical or electrical input signal) and optical sensitivity attained. The fiber optic Trigger type shown in Figure 10 is for use with a sampling oscilloscope having a fiber optic input channel. This Trigger type uses an optical coupler to tap off a portion of the optical data stream to produce a recovered clock trigger signal. The fiber optic Trigger shown in Figure 11 is for use with a sampling oscilloscope having an electrical input channel. This Trigger type uses an analog optical receiver to convert the optical data stream into an electrical data stream. The electrical data stream is delivered to the oscilloscope as the input signal and a small portion is tapped off to produce a recovered clock trigger signal. The electrical Trigger shown in Figure 12 is for use with a sampling oscilloscope having an electrical input channel. This Trigger type uses an electrical coupler to tap off a portion of the electrical data stream to produce a recovered clock trigger signal.

DATA-ONLY JITTER ADAPTERS

A "Data-only Jitter Adapter" is a Clock Regenerator where the extracted clock signal and a reference clock drive the two clock inputs of a jitter analyzer. The reference clock also drives the product or network under test. TME offers two kinds of Jitter Adapters as shown in Figure 13 and Figure 14 applications.

These Clock Regenerator instruments can be built with wider jitter bandwidths than normal and lower jitter generation than normal, both difficult requirements. Applications are shown in Figure 13 and Figure 14.

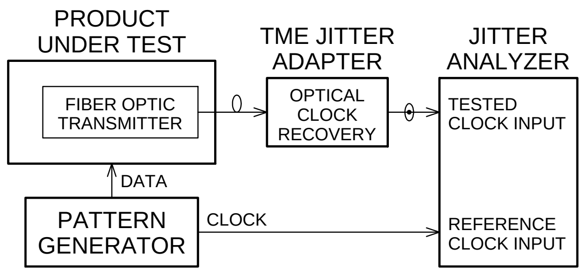


Figure 13. Fiber Optic Jitter Adapter Application

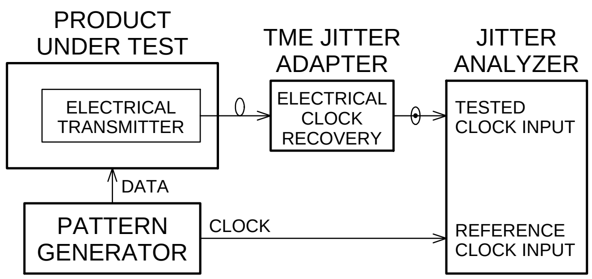


Figure 14. Microwave Jitter Adapter Application

MODEL VARIATIONS

TME offers customers a wide variety of possible model choices to exactly meet their needs. Other rates and performance options are offered upon request or as components become available in the market. Special models using all-optical clock recovery can be provided upon request for trigger rates between 39 Gb/s and 65 Gb/s.

- Wavelength and fiber type choices include 850 nm and 1310 nm in MM-50 or MM-62, 1310/1550 nm SM using non-polarized or polarized fiber, special wavelengths on request
- Optical coupler type choices include 1%, 2%, 5%, 10%, 20%, 30%, 40%, 50% taps for tap couplers, multi-port tap couplers
- Optical receiver type choices include PIN or APD photodiode and TIA, with or without AGC, with or without limiter amplifier, and with or without an output limited SOA
- NRZ data rates from 1 Mb/s to 3.3 Gb/s and from 9.9 Gb/s and 12.6 Gb/s, analog bandwidths from ~50 MHz to ~40 GHz
- Electrical coupler type choices include 3 dB, 10 dB, 14 dB, 20 dB tap couplers, multiple output couplers

- Clock regenerator choices include one or more fixed or variable data rates, clock only or both clock and data outputs, divided clock outputs, analog outputs, differential or single-ended outputs, standard, narrow, or wide jitter bandwidths
- Optical I/O connector choices include FC (SPC, UPC, APC), SC, ST, LC, DIN 47256, others on request
- Electrical I/O connector choices include SMA, 3.5mm, K, others on request
- Packaging choices include desktop housing with manual control and display and regional power supply or 19 inch rack-mountable chassis with manual and/or computer control and display and worldwide power supply
- Other optical options include switches, fixed or tunable channel filters, booster amplifiers, power monitors
- Other electrical options include analog, data, or clock splitters or switches, clock phase shifters (timing skew adjustment), programmable clock recovery thresholds, analog low pass filters, and booster amplifiers
- Other general options include special packaging and special or customer specified connectors, components or circuit design

STANDARD DATA RATES AND JITTER BANDWIDTHS

Table 3. Standard Data Rates and Jitter Performance for Clock Regenerators

CR Group	Rate Type	Standard Data Rates	Technology	Standard Jitter Bandwidth	Max. Jitter Generation	Other Jitter Bandwidths
A	Fixed	44.736 Mb/s	PLL	45 KHz typ.	13 mUI RMS	
A	Fixed	51.840 Mb/s	PLL	52 KHz typ.	13 mUI RMS	
A	Fixed	139.264 Mb/s	PLL	E4 standard	E4 standard	
A	Fixed	155.52 Mb/s	PLL	130 KHz max.	10 mUI RMS	60 KHz max. 10 KHz max.
A	Fixed	166.63 Mb/s	PLL	250 KHz max.	10 mUI RMS	
A	Fixed	622.08 Mb/s	PLL	500 KHz max.	10 mUI RMS	350 KHz to 3.5 MHz
A	Fixed	666.51 Mb/s	PLL	1 MHz max.	10 mUI RMS	
A	Fixed	1.0625 Gb/s	PLL	FC standard	FC standard	
A	Fixed	1.244 Gb/s	PLL	SONET standard	SONET standard	
A	Fixed	1.250 Gb/s	PLL	1 MHz max.	10 mUI RMS	
A	Fixed	1.339 Gb/s	PLL	GbE+FEC std.	10 mUI RMS	
A	Fixed	2.488 Gb/s	PLL	2 MHz max.	10 mUI RMS	
A	Fixed	2.500 Gb/s	PLL	2FC standard	2FC standard	
A	Fixed	2.666 Gb/s	PLL	2 MHz max.	10 mUI RMS	
B	Fixed	9.953 Gb/s	PLL	5 MHz	7 mUI RMS	20 or 80 MHz
B	Fixed	9.953 Gb/s	Resonator	3 MHz	13 mUI RMS	20 or 80 MHz
B	Fixed	10.312 Gb/s	PLL	5 MHz	7 mUI RMS	20 or 80 MHz
B	Fixed	10.312 Gb/s	Resonator	3 MHz	13 mUI RMS	20 or 80 MHz
B	Fixed	10.512 Gb/s	PLL	5 MHz	7 mUI RMS	20 or 80 MHz
B	Fixed	10.512 Gb/s	Resonator	3 MHz	13 mUI RMS	20 or 80 MHz
B	Fixed	10.664 Gb/s	PLL	5 MHz	7 mUI RMS	20 or 80 MHz
B	Fixed	10.664 Gb/s	Resonator	3 MHz	13 mUI RMS	20 or 80 MHz
B	Fixed	10.709 Gb/s	PLL	5 MHz	7 mUI RMS	20 or 80 MHz
B	Fixed	10.709 Gb/s	Resonator	3 MHz	13 mUI RMS	20 or 80 MHz
B	Fixed	11.095 Gb/s	PLL	5 MHz	7 mUI RMS	20 or 80 MHz
B	Fixed	11.095 Gb/s	Resonator	3 MHz	13 mUI RMS	20 or 80 MHz
B	Fixed	12.249 Gb/s	PLL	5 MHz	7 mUI RMS	20 or 80 MHz
B	Fixed	12.249 Gb/s	Resonator	3 MHz	13 mUI RMS	20 or 80 MHz
B	Fixed	12.4 Gb/s	PLL	5 MHz	7 mUI RMS	20 or 80 MHz
B	Fixed	12.4 Gb/s	Resonator	3 MHz	13 mUI RMS	20 or 80 MHz
B	Fixed	12.5 Gb/s	PLL	5 MHz	7 mUI RMS	20 or 80 MHz
B	Fixed	12.5 Gb/s	Resonator	3 MHz	13 mUI RMS	20 or 80 MHz
C	Continuous	9.95 to 10.75 Gb/s	PLL	5 MHz	7 mUI RMS	20 or 80 MHz
C	Continuous	9.95 to 11.1 Gb/s	PLL	Selectable	10 mUI RMS	-
C	Continuous	12 to 12.6 Gb/s	PLL	5 MHz	7 mUI RMS	20 or 80 MHz
C	Continuous	1.0 to 1.5 Gb/s	PLL	Selectable	10 mUI RMS	-

CR Group	Rate Type	Standard Data Rates	Technology	Standard Jitter Bandwidth	Max. Jitter Generation	Other Jitter Bandwidths
C	Continuous	1.5 to 2.5 Gb/s	PLL	Selectable	10 mUI RMS	-
C	Continuous	2.5 to 4.0 Gb/s	PLL	Selectable	10 mUI RMS	-
C	Continuous	3.0 to 5.0 Gb/s	PLL	Selectable	10 mUI RMS	-
C	Continuous	4.0 to 6.0 Gb/s	PLL	Selectable	10 mUI RMS	-
C	Continuous	5.0 to 8.0 Gb/s	PLL	Selectable	10 mUI RMS	-
C	Continuous	8.0 to 12.0 Gb/s	PLL	Selectable	10 mUI RMS	-
C	Continuous	9.0 to 14.0 Gb/s	PLL	Selectable	10 mUI RMS	-
C	Continuous	8.0 to 16.0 Gb/s	PLL	Selectable	10 mUI RMS	-

Notes:

- Any fixed data rate between 1 Mb/s and 3.3 Gb/s with jitter bandwidths between 1 KHz and 8 MHz or between 9.9 Gb/s and 12.6 Gb/s with jitter bandwidths between 50 KHz and 80 MHz can be provided as a “special” upon request.
- Lower jitter generation (1/2 to 1/3) is available at many data rates. Contact TME for details.
- Multiple fixed data rates, data rate ranges, or jitter bandwidths (2, 3, 4, up to ~10) are available in one unit for many data rates. Contact TME for details.

CLOCK REGENERATORS WITH MANUAL CONTROL

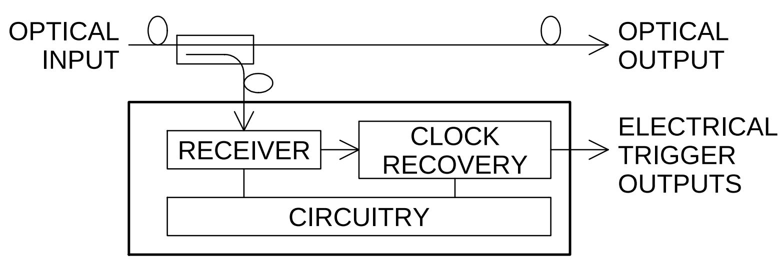
GENERAL CHARACTERISTICS FOR MANUALLY CONTROLLED MODELS

Unless otherwise specified, all manual models in this section have the following characteristics:

- All models are single channel and for use with NRZ modulation
- Models are available according to the CR Group for the desired data rate given by Table 3 on page 30.
- All models have SMA electrical connectors (K or 3.5mm for ~10 Gb/s models) and FC optical connectors (others upon request)
- All electrical outputs are AC-coupled with ~50 KHz -3 dB roll-off frequency
- See Figure 2 and Figure 3 on page 14 for example desktop packaging styles
- 19” rack-mountable styles packaged in 1U full-width or 2U half-width x 16” deep (see Figure 15 on page 34)
- 120VAC 60 Hz, with simple manual control and display
- All listed prices and specifications may change without notice, made firm upon quote. Prices in USD.
- See Abbreviations on page 1 for terminology used

FIBER OPTIC SAMPLING OSCILLOSCOPE TRIGGER WITH OPTICAL COUPLER

- For use with a sampling oscilloscope having an optical input channel and an electrical trigger input
- Photodiode-TIA-AGC-Limiter-CR receiver structure



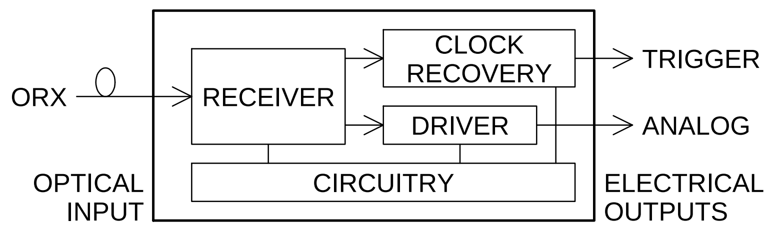
Description	Tap Ratio	Optical IL (dB)	Optical Input Range (dBm)	CR Group	Price
850 nm, MM-50 or MM-62 PIN photodiode, Diff. clock output	10% 20% 30% 40% 50%	1.2 1.7 2.4 3.2 4.1	-5.5 to +10 typ. -9.5 to +6 typ. -11.5 to +4.5 typ. -12.5 to +3 typ. -14 to +2 typ.	A	$17,650

Description	Tap Ratio	Optical IL (dB)	Optical Input Range (dBm)	CR Group	Price
1310/1550 nm SM, MM-50, or MM-62 PIN photodiode, Diff. clock output	10% 20% 30% 40% 50%	1.2 1.7 2.4 3.2 4.1	-9.5 to +10 typ. -13.5 to +6 typ. -15.5 to +4.5 typ. -16.5 to +3 typ. -18 to +2 typ.	A	$23,350
1310/1550 nm, SM PIN photodiode, SE clock output Clock/4, Clock/8 or Clock/16 outputs available on PLL styles	10% 20% 30% 40% 50%	1.2 1.7 2.4 3.2 4.1	-3.5 to +12 typ. -7.5 to +8 typ. -9.5 to +6.5 typ. -10.5 to +5 typ. -12 to +4 typ.	B C	$40,900 $47,875
1310/1550 nm, SM APD photodiode, SE clock output Clock/4, Clock/8 or Clock/16 outputs available on PLL styles	10% 20% 30% 40% 50%	1.2 1.7 2.4 3.2 4.1	-7.5 to +7 typ. -11.5 to +1 typ. -13.5 to -0.5 typ. -14.5 to -2 typ. -16 to -3 typ.	B C	$43,800 $50,775

- Optical input range is for proper operation of the trigger. Customer responsible for determining feasible test system optical budget by considering available source optical power and sampling oscilloscope channel sensitivity when selecting thru path optical insertion loss (IL) from available tap ratios.

ELECTRICAL SAMPLING OSCILLOSCOPE TRIGGER WITH OPTICAL RECEIVER

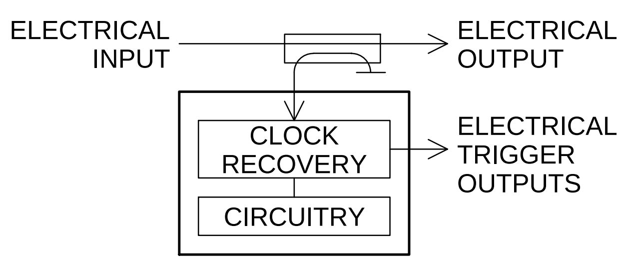
- For use with a sampling oscilloscope having an electrical input channel and electrical trigger input
- Photodiode-TIA-AGC-Limiter-CR receiver structure



Description	Optical Input Range (dBm)	CDR Group	Price
850 nm, MM-50 or MM-62 PIN photodiode, Diff. clock and SE analog outputs	-18 to 0 or better	A	$17,125
1310/1550 nm, SM, MM-50, or MM-62 PIN photodiode, Diff. clock and SE analog outputs	-22 to 0 or better	A	$21,500
1310/1550 nm, SM PIN photodiode, SE clock and analog outputs	-14 to 0 or better	B C	$41,050 $48,025
1310/1550 nm, SM APD photodiode, SE clock and analog outputs	-20 to –7 or better	B C	$44,450 $51,425

MICROWAVE SAMPLING OSCILLOSCOPE TRIGGER WITH ELECTRICAL COUPLER

- For use with a sampling oscilloscope having an electrical input channel and electrical trigger input
- CR or Limiter-CR receiver structure

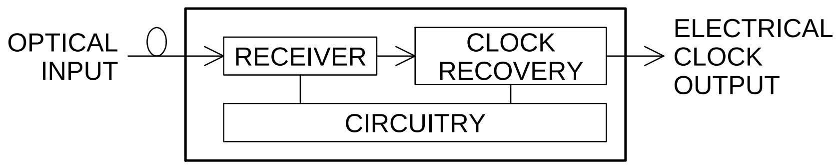


Description	Tap Ratio	IL (dB)	Electrical Input Range (dBm)	CR Group	Price
CR-normal SE clock output Clock/4, Clock/8 or Clock/16 outputs available on PLL styles	3 dB 6 dB 10 dB 14 dB 20 dB	6.9 2.4 1.4 0.8 0.7	0 to +10.4 +0.5 to +10.9 +4.5 to +14.9 +8.5 to +18.9 +14.5 to +24.9	B C	$35,400 $42,375

Description	Tap Ratio	IL (dB)	Electrical Input Range (dBm)	CR Group	Price
CR-sensitive SE clock output Clock/4, Clock/8 or Clock/16 outputs available on PLL styles	3 dB 6 dB 10 dB 14 dB 20 dB	6.9 2.4 1.4 0.8 0.7	-9.5 to +10.4 -9.0 to +10.9 -5.0 to +14.9 -1.0 to +18.9 +5.0 to +24.9	B C	$36,900 $43,875
CR-Limiter SE clock output Clock/4, Clock/8 or Clock/16 outputs available on PLL styles	3 dB 6 dB 10 dB 14 dB 20 dB	6.9 2.4 1.4 0.8 0.7	-26 to +14 -25.5 to +14.5 -21.5 to +18.5 -17.5 to +22.5 -11.5 to +28.5	B C	$40,900 $47,875

- Electrical input range is for proper operation of the trigger. Customer responsible for determining feasible test system electrical budget by considering available source electrical power and sampling oscilloscope channel sensitivity when selecting thru path electrical insertion loss (IL) from available tap ratios.

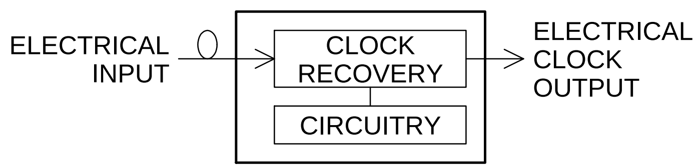
FIBER OPTIC JITTER ADAPTER



- Photodiode-TIA-AGC-Limiter-CR structure
- 1310/1550 nm, SM
- SE clock output

Description	Optical Input Range	CR Group	Price
PIN photodiode	-14 to 0 dBm or better	B C	$41,050 $48,025
APD photodiode	-22 to -6 dBm or better	B C	$44,450 $51,425

MICROWAVE JITTER ADAPTER



- CR or Limiter-CR structure
- SE clock output

Description	Electrical Input Range (dBm)	CR Group	Price
CR-normal	-6 to +3.5	B C	$34,400 $41,375
CR-sensitive	-15.5 to +3.5	B C	$35,900 $42,875
CR-Limiter	-32 to +7	B C	$39,900 $46,875

Example Variable Rate Fiber Optic Trigger

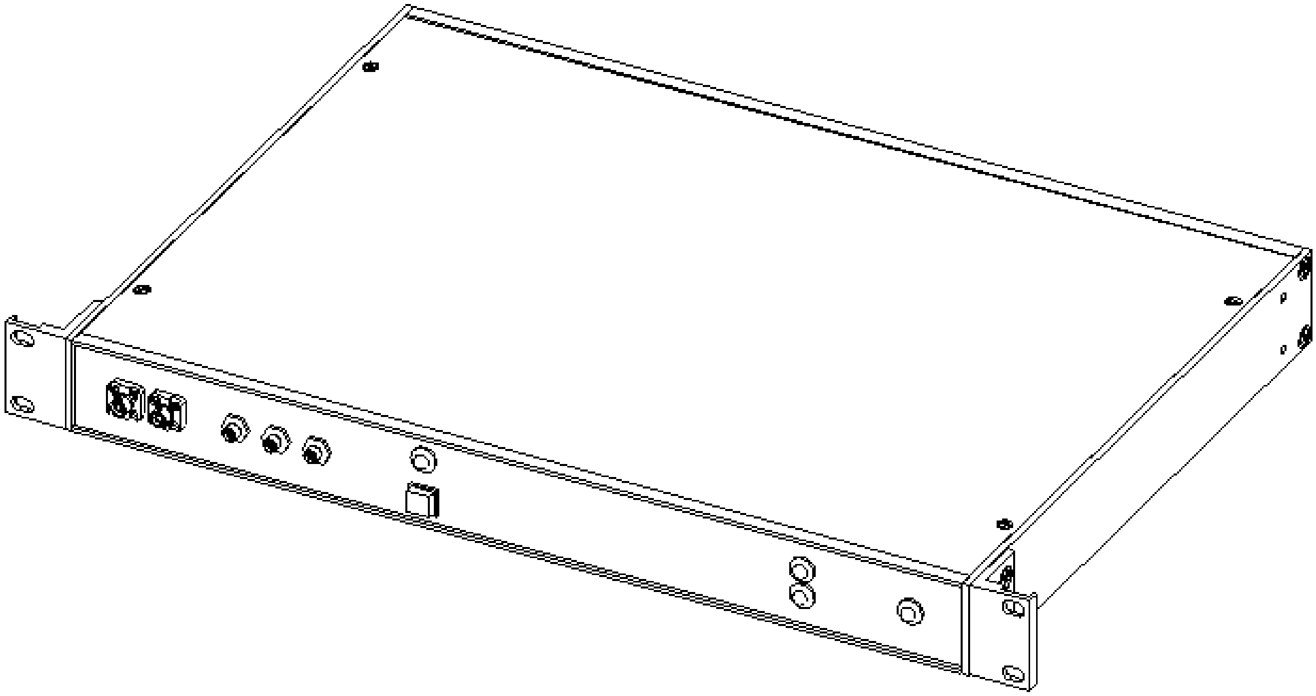


Figure 15. Example Variable Rate Fiber Optic Trigger

- For use with optical input sampling oscilloscope (Agilent 86100, etc.)
- Choice of 9.95 to 10.75 Gb/s or 12.0 to 12.6 Gb/s continuously variable auto-locking PLL clock recovery
- 1310/1550 nm receiver, single mode un-polarized fiber (SMF-28), 35 dB min. optical return loss, FC/SPC connectors, for NRZ signals
- Choice of optical coupler tap ratios
    - 10% coupler: thru-path IL = 1.2 dB, optical input range = -3.5 to +12 (PIN), -7.5 to +5 (APD) dBm
    - 20% coupler: thru-path IL = 1.7 dB, optical input range = -7.5 to +8 (PIN), -11.5 to +1 (APD) dBm
    - 30% coupler: thru-path IL = 2.4 dB, optical input range = -9.5 to +6.5 (PIN) or -13.5 to –0.5 (APD) dBm
    - 40% coupler: thru-path IL = 3.2 dB, optical input range = -10.5 to +5 (PIN) or -14.5 to -2 (APD) dBm
    - 50% coupler: thru-path IL = 4.1 dB, optical input range = -12 to +4 (PIN) or -16 to -3 (APD) dBm
- SE Clock and Clock/4 output (clock/8 or clock/16 available at no extra cost), K-female connectors, 1 Vpp typ. output, AC-coupled (~50 KHz roll-off), 30 ps typ. transition times
- 5 MHz typ. jitter transfer bandwidth (1-80 MHz optional at additional cost), 10 mUI RMS max. jitter generation
- 19 inch rack-mountable aluminum case, 1U (1.75”) x 16”deep, universal AC power supply (auto-ranging 90-264 VAC, 47-63 Hz, 50 W max.)
- $67,250 for PIN receiver version, $70,800 for APD version
- Data output option and dual range option (internally switched between both clock recovery ranges) at additional cost (model shown above)

Example Switched Fixed Rate Fiber Optic Trigger

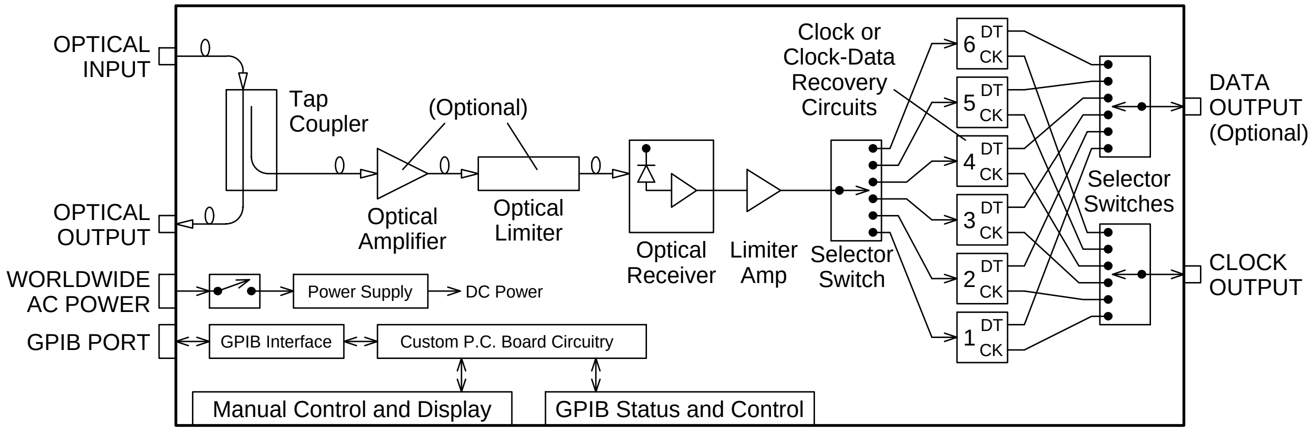


Figure 16. Block Diagram for 6 Channel, Switched Fixed Rate, Fiber Optic Trigger

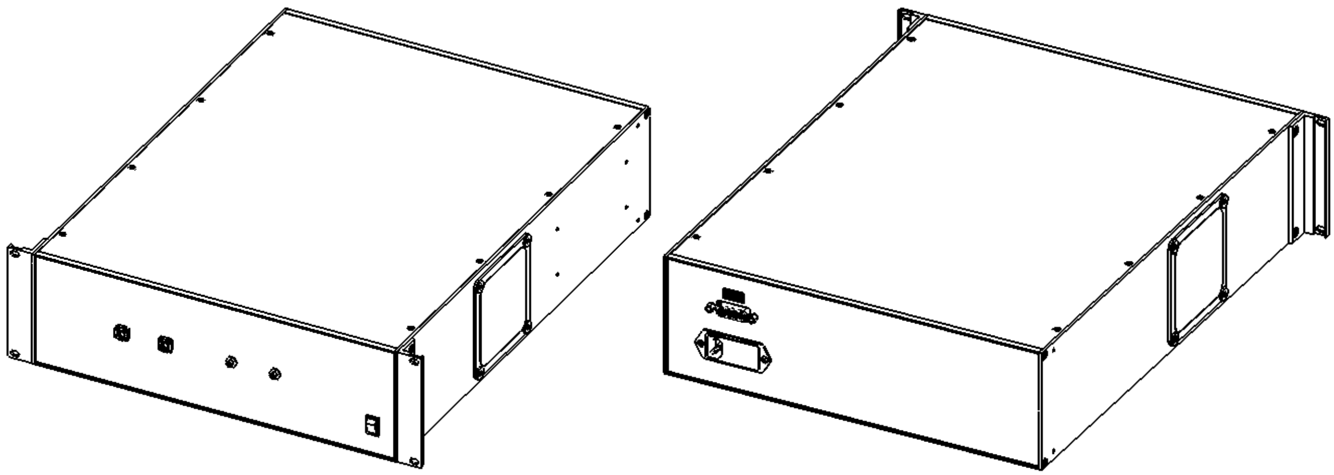


Figure 17. 6 Channel, Switched Fixed Rate, Fiber Optic Trigger with GPIB control

- For use with optical input sampling oscilloscope (Agilent 86100, etc.)
- Choice of 1 to 6 fixed clock recovery data rates between 9.95 and 12.6 Gb/s
- 1310/1550 nm receiver, single mode un-polarized fiber (SMF-28), 35 dB min. optical return loss, FC/SPC connectors, for NRZ signals
- Choice of optical coupler tap ratios
  - 10% coupler: thru-path IL = 1.2 dB, optical input range = -3.5 to +12 (PIN), -7.5 to +5 (APD) dBm
  - 20% coupler: thru-path IL = 1.7 dB, optical input range = -7.5 to +8 (PIN), -11.5 to +1 (APD) dBm
  - 30% coupler: thru-path IL = 2.4 dB, optical input range = -9.5 to +6.5 (PIN) or -13.5 to –0.5 (APD) dBm
  - 40% coupler: thru-path IL = 3.2 dB, optical input range = -10.5 to +5 (PIN) or -14.5 to -2 (APD) dBm
  - 50% coupler: thru-path IL = 4.1 dB, optical input range = -12 to +4 (PIN) or -16 to -3 (APD) dBm
- SE Clock and Clock/4 output (clock/8 or clock/16 available at no extra cost), K-female connectors, 1 Vpp typ. output, AC-coupled (~50 KHz roll-off), 30 ps typ. transition times
- 5 MHz typ. jitter transfer bandwidth (1-80 MHz optional at additional cost), 10 mUI RMS max. jitter generation
- 19 inch rack-mountable aluminum case, 1U (1.75”) x 16”deep, universal AC power supply (auto-ranging 90-264 VAC, 47-63 Hz, 50 W max.)
- Data output option and dual range option (internally switched between both clock recovery ranges) at additional cost

PIN Receiver Fiber Optic Trigger Models with GPIB – Clock output only

Item	Maximum Expansion	Price 1 Ch.	Price 2 Ch.	Price 3 Ch.	Price 4 Ch.	Price 5 Ch.	Price 6 Ch.
1	6 trigger channels	$62,675	$72,550	$82,425	$92,300	$102,175	$112,050
3	2 trigger channels	$53,425	$63,300				

5	1 trigger channel	$48,425					

PIN Receiver Fiber Optic Trigger Models with GPIB – Clock and Data outputs

Item	Maximum Expansion	Price 1 Ch.	Price 2 Ch.	Price 3 Ch.	Price 4 Ch.	Price 5 Ch.	Price 6 Ch.
2	6 trigger channels	$71,450	$83,325	$95,200	$107,075	$118,950	$130,825
4	2 trigger channels	$57,950	$69,825				
6	1 trigger channel	$50,650					

Options (others available)

Model Options	Added Price
Optical amplifier (SOA) and optical limiter added to any model, extends optical power range to –20 dBm minimum	$13,950
Change PIN Receiver to APD Receiver	$6,975
Retrofit 1 additional Clock only trigger channel up to maximum expansion, at TME factory, shipping not included	$10,875
Retrofit 1 additional Clock and Data trigger channel up to maximum expansion, at TME factory, shipping not included	$12,875

Note: All listed prices and specifications may change without notice and are made firm with a quote. Prices are in USD.

FEC TRANSLATORS

This is a product line of electronic transmitter, receiver, and transceiver functional test instruments that perform Forward Error Correction (FEC) on 2.5 or 10 Gb/s communication signals. Models with 1 to 4 channels for ~10 Gb/s communication signals are offered for SONET/SDH (9.953 Gb/s) or 10G Ethernet (10.312 Gb/s) data rates to G.975 (10.664 Gb/s), G.709 (10.709 Gb/s), or Super-FEC (~12.4 Gb/s) data rates with several options. Models for ~2.5 Gb/s signals are available on request and models for ~40 Gb/s signals will be offered as components become available. Model numbers are assigned when a quote is originated.

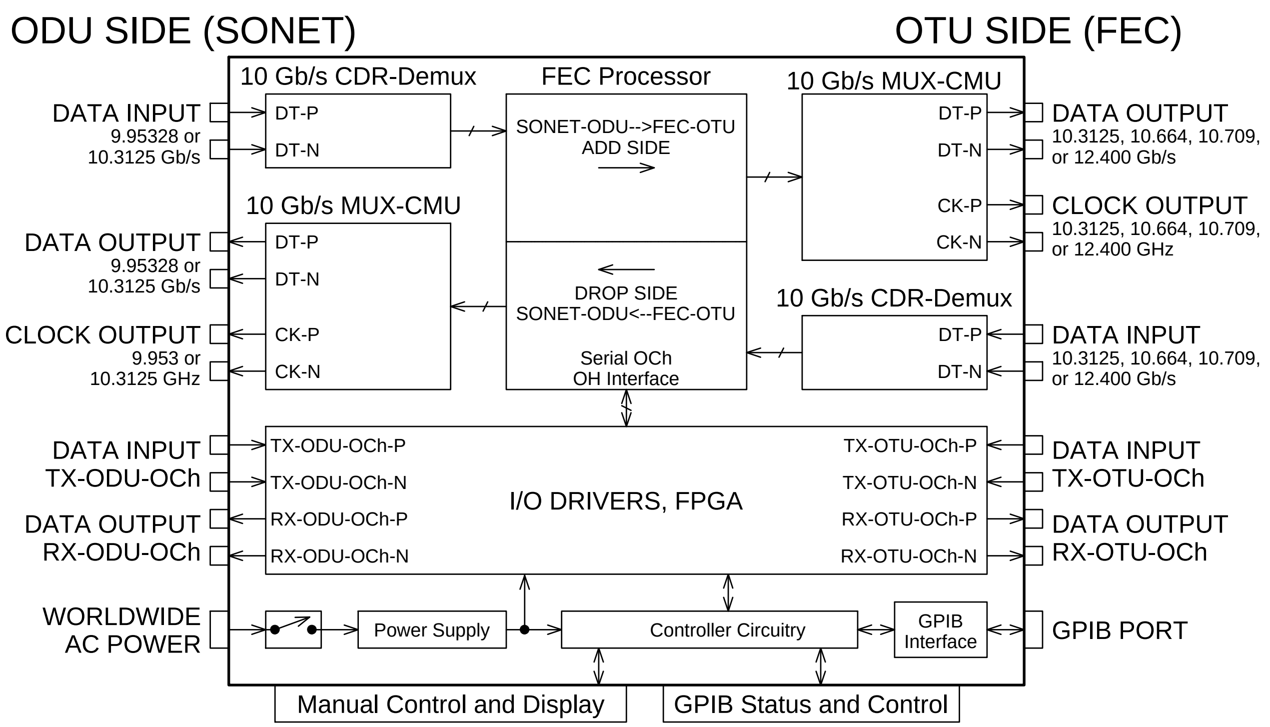


Figure 18. Block Diagram for Example ~10 Gb/s FEC Transceiver

FEC Translators are semi-custom test instruments that encode or decode electronic data streams using forward error correction conversion standards. The product line currently consists of multi-channel digital electronic transmitters, receivers, and transceivers that translate between ~10 Gb/s SONET, SDH, or 10GE data formats and G.709, G.975, or Super-FEC data formats. Fiber optic transmitters and receivers can be added as an option (see Fiber Optic Translators). Customers can choose from many kinds of made-to-order models due to channel count, options, and packaging choices offered.

FEC Translators are used with TME Fiber Optic Translators and BERT, BitAlyzer, SONET and protocol testers, attenuators, switches, and other similar equipment. Together they can performance test fiber optic and high-speed electronic products and networks employing forward error correction. Examples include FEC encoders, decoders, transmitters, receivers, transponders, line cards, card-cage products, network equipment, and trunk lines.

- Electronic transmitters, receivers, and transceivers offered with up to 8 transmitter, 8 receiver, or 4 transceiver channels per chassis
- FEC conversions from SONET or SDH (9.953 Gb/s) or 10G Ethernet (10.312 Gb/s) data rates to G.975 (10.664 Gb/s), G.709 (10.709 Gb/s), Super-FEC (>12 Gb/s), and other data rates
- Other FEC conversions and data rates (~2.5 Gb/s, ~40 Gb/s, etc.) offered upon request or as components become available
- Electronic choices include single-ended or differential I/O, pass-thru relays, polarity control, data and clock boost amplifiers, and clock phase shifters
- Options include optical I/O using TME Fiber Optic Translator functions, electronic power monitors, splitter or selector configurations, special connectors and packaging, customer specified components or circuit design
- Automatic models offered in tabletop or rack-mountable, ESD compliant, worldwide AC line powered housings with GPIB-IEEE488.2-HPIB, RS-232, 10/100Base-T Ethernet LAN, or USB interface (others on request)
- Manual models offered in tabletop, ESD compliant housings with external regional power supply, basic controls and displays, and without a computer interface

MULTI-FUNCTIONAL FEC TRANSLATORS

1CF17 – 4 Channel, SONET to G.709 or G.975, Fiber Optic FEC Translator

FEATURES

- Converts between fiber optic SONET formats and fiber optic G.709 or G.975 (selectable) forward error correction (FEC) formats
- Includes four FEC transceiver channels total
  - Two high speed channels (1 and 2) operating at ~10 Gb/s
  - Two low speed channels (3 and 4) operating at ~2.5 Gb/s
  - Implemented with Intel IXF300xx FEC devices, others on request
- Includes eight field pluggable fiber optic transceivers total on rear panel
  - Four XFP transceivers for ~10 Gb/s operation
  - Four SFP transceivers for ~2.5 Gb/s operation
  - Supplied with 1310 nm short reach transceivers with LC duplex connectors (alternates available)
  - Fiber optic receiver loss of signal (LOS) and transmitter fault (TXF) status monitoring on all channels
- Software supports basic FEC translator operation on all four channels, user access to all FEC control and monitor memory registers for more advanced uses
- Computer operation provided via 10 Base-T LAN and manual operation provided via front panel 2 line VFD display, pushbuttons, and LED indicators
- Packaged in a black anodized aluminum 19” rack mountable desktop chassis, 1U (1.72”) high x 22” deep, weighs less than 15 pounds, 0°C to +50°C continuous operation, internally modular construction, 120 or 240 VAC power input
- Price is $278,000 each in order quantity of 2 units

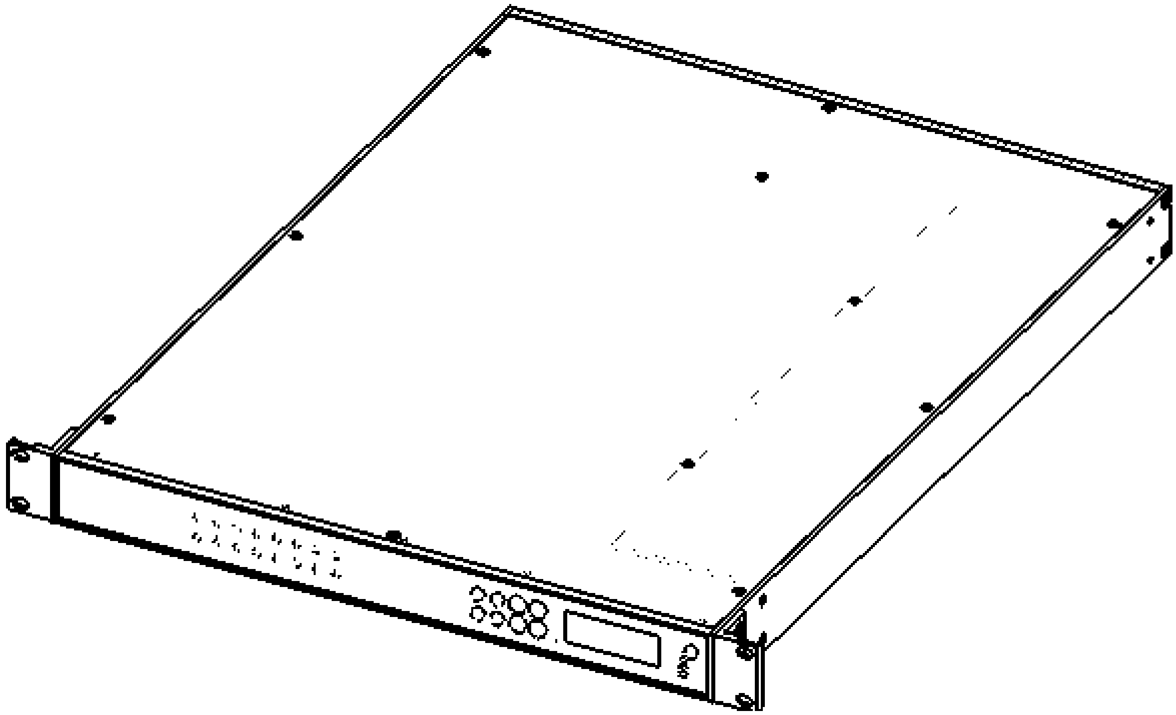


Figure 19. Front View of 1CF17 - 4 Channel, SONET to G.709 or G.975, Fiber Optic FEC Translator

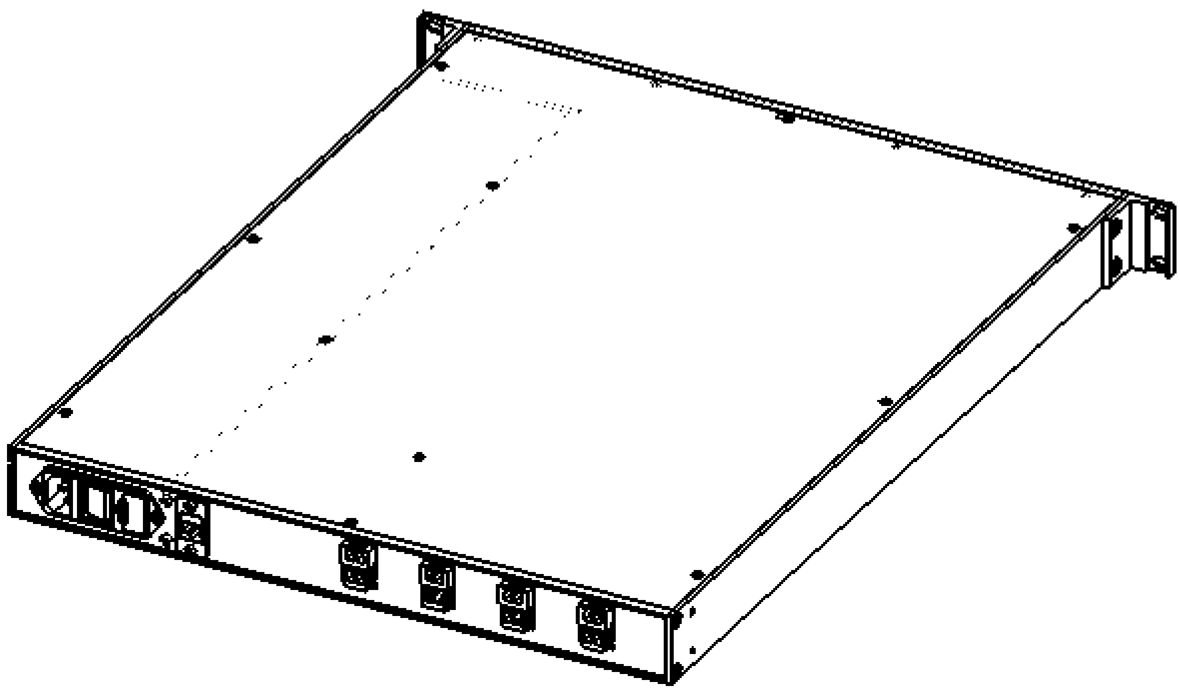


Figure 20. Rear View of 1CF17 - 4 Channel, SONET to G.709 or G.975, Fiber Optic FEC Translator

ELECTRONIC TRANSLATORS

Electronic Translators are semi-custom transmitter, receiver, and transceiver functional test instruments that perform various specialized electronic signal-conditioning functions. They typically distribute, select, modify, or convert between one or more analog, digital logic, and communication signal levels or formats. Analog signals include single-ended and differential 50, 75, and 100 ohm signals from DC to ~50 GHz. Digital logic signals include CMOS, BiCMOS, TTL, ECL, PECL, LVPECL, LVDS, and other logic types and levels. Communication signals include DS1, DS3, STS-1, STS-3, STS-12, and other formats. Input and output signals are usually delivered with coax, twisted pair, or other transmission line types.

Electronic Translators are used between a product under test and various kinds of standard test equipment, depending on the application. Standard equipment includes BERT, SONET and other protocol testers, sampling and real-time oscilloscopes, network and jitter analyzers, power meters, and other similar equipment. Customers can choose from many kinds of made-to-order models by selecting a function from the example model list below and choosing channel count, connector types, packaging, and other variations. Customers can also request new functions be added to the product line. Model numbers are assigned when a quote is originated.

EXAMPLE ELECTRONIC TRANSLATORS

- Analog Linear Converter with differential 100 ohm to single ended 50 ohm I/O, 4 channels, DC-1 GHz unity gain amplifiers, and RJ45-8 (4 twisted pair) to 4 SMA I/O connectors - used between 4-lane differential 250 Mb/s source and oscilloscope for eye patterns (see Figure 21)
- Analog Limiting Converter with differential 100 ohm to single ended 50 ohm I/O, 1 channel, 100 KHz-10 GHz unity gain amplifier, and 3.5mm I/O connectors - used between back-plane with high speed differential signals and BERT or jitter analyzer
- Generic Signal Converters with choice of converter type (any analog, digital logic, or communication receiver and driver combination), conversion technology, speed, I/O impedance, single-ended or differential I/O, AC or DC coupled I/O, and I/O connectors
- DS1 Distributor and Selector (Splitter-Scanner) with 100 ohm differential I/O, 28 channels, DC-100 MHz, and shift-by-one-bit circuitry - used between one channel DS1 BERT and 28 channel transceiver communication product
- DS3 or STS-1 Distributor and Selector (Splitter-Scanner) with 75 ohm single-ended I/O, 32 channels, DC-1 GHz, and shift-by-one-bit circuitry - used between one channel DS3 or STS-1 BERT and 32 channel transceiver communication product
- Digital Boost Amplifiers with choice of data, clock, or data and clock function and ~2.5 Gb/s, ~10 Gb/s, or ~40 Gb/s speed – used between BERT or SONET analyzer and communication product
- Digital Clock Phase Shifter with choice of ~2.5 GHz, ~10 GHz, or ~40 GHz speed – used between BERT or SONET analyzer and communication product
- Digital Modulator Driver with choice of ~2.5 Gb/s, ~10 Gb/s, ~40 Gb/s speed, lithium niobate or electro-absorptive drive, and NRZ or RZ drive circuits – used between BERT or SONET analyzer and communication product
- Digital EE-Trimpot Controller with byte parallel to bit serial control and 16 channels - used between a computer digital I/O card or GPIB interface and product with EE-Trimpots
- Automatic models offered in tabletop or rack-mountable, ESD compliant, worldwide AC line powered housings with GPIB-IEEE488.2-HPIB, RS-232, 10/100Base-T Ethernet LAN, or USB interface (others on request)
- Manual models offered in tabletop, ESD compliant housings with external regional power supply, basic controls and displays, and without a computer interface

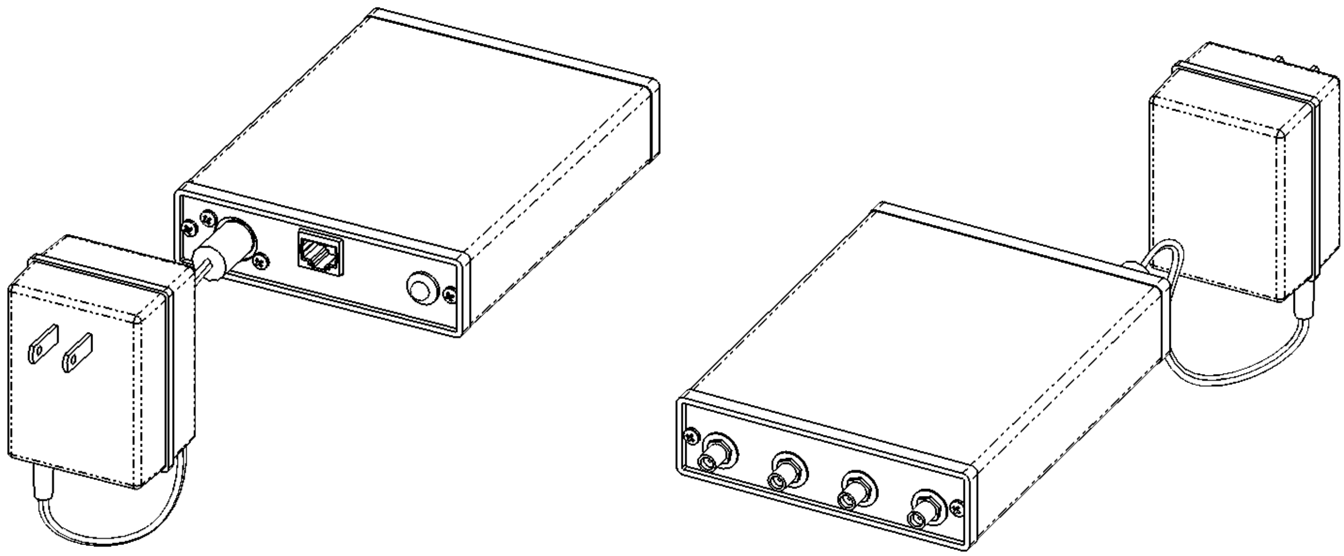


Figure 21. Desktop Differential to Single Ended Converter

4 Channel, DC-1 GHz, RJ45-8 input, 4 SMA-F outputs, $8,875 each

FIBER OPTIC SPANS

Fiber Optic Spans are semi-custom test instruments that provide programmable optical dispersion using optical fiber. They function as “programmable telecom superhighway in a box” by providing a compact, programmable, optical transmission line medium between a fiber optic transmitter and receiver. Customers can choose from hundreds of possible short reach, metropolitan, and long-haul made-to-order models due to the many functions, fiber lengths, fiber types, dispersion compensation, amplification, options, and packaging choices offered. Model numbers are assigned when a quote is originated.

With TME Fiber Optic Spans, customers can easily “Road Test” optical transmission components and equipment for dispersion, compensation, and regeneration performance and limitations. TME Spans are useful for testing terrestrial, submarine, and airborne communication products during their creation, development, production, procurement, deployment, and maintenance. Such products include single and multiple lane fiber optic lasers, receivers, transponders, line cards, card-cage products, network equipment, and Raman amplifiers. Fiber Optic Spans are typically used with a Fiber Optic Translator, and a BERT, SONET, FEC, or other protocol testers. Other useful equipment includes sampling oscilloscopes, network analyzers, jitter analyzers, power meters, attenuators, switches, and other similar equipment.

TME can supply a variety of Fiber Optic Span arrangements ranging from single-mode, long haul, “superhighways” between kilometers and mega-meters in length to multi-mode, short haul, “streets” between meters and kilometers in length. Each Fiber Optic Span is configured with one or more spools of optical fiber of various types and lengths in various arrangements with optical switches, optical amplifiers, optical filters, dispersion compensating fiber, and dispersion compensators with many related options. TME can also provide popular Optical Circulating Loops for simulation of very long fiber optic spans (~10,000 km) with a fraction of the overall system hardware (fiber, amplifiers, filters, etc.).

An example single mode C-band model is shown in Figure 22 and Figure 23. It provides –660 ps/nm to +1900 ps/nm (118 km) in 100 ps/nm (6.25 km) steps at 1550 nm using standard single-mode fiber, dispersion compensating fiber, optical switches, and a C-band DWDM optical amplifier.

MODEL VARIATIONS

- Single-mode, long haul, fiber optic span arrangements from kilometers to mega-meters long using Corning (SMF-28™, SMF-28e™, LEAF®, MetroCor™), Alcatel (Teralight™, 6900, 6901, 6912), Furukawa-Lucent (TrueWave® RS, SRS, XL, AllWave™), or other products
- Multi-mode, short haul, fiber optic span arrangements from meters to kilometers long using Corning (InfiniCor™ series), Alcatel (Glight™ 6930, 6931, 6932, 6933), Furukawa-Lucent (LaserWave™ 150, 300, GigaGuide™ 50, 50XL, 62.5, 62.5XL), Boston (Optimega™, Optigiga™), or other products

- Dispersion compensating fiber modules include Corning, Furukawa-Lucent, Sumitomo, or other products
- Multi-mode plastic: Boston Optimega™, Optigiga™, other manufacturer's products on request
- Other fiber types, compensators, amplifiers, and related elements offered as components become available in the market or upon request
- Optical I/O connector choices include FC (SPC, UPC, APC), SC, ST, LC, DIN 47256, others on request
- Options offered include optical I/O selector switches, optical power monitors, optical noise injection, PMD compensation, special connectors and packaging, customer specified components or circuit design
- Automatic models offered in tabletop or rack-mountable, ESD compliant, worldwide AC line powered housings with GPIB-IEEE488.2-HPIB, RS-232, 10/100Base-T Ethernet LAN, or USB interface (others on request)
- Manual models offered in tabletop, ESD compliant housings with external regional power supply, basic controls and displays, and without a computer interface

RACK-MOUNTABLE FIBER OPTIC SPANS WITH COMPUTER CONTROL

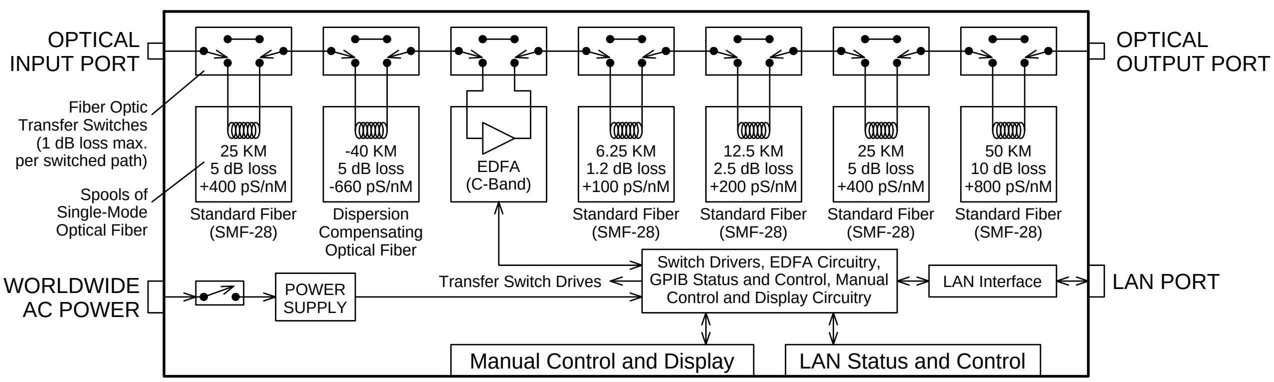


Figure 22. Block Diagram for Example Fiber Optic Span (1CF16A-1B1)
Standard Fiber (SMF-28) and 40 km Dispersion Compensating Fiber with C-band Optical Amplifier
0 to 118.75 km in 19 programmable steps of 6.25 km (-660 to +1900 ps/nm in 100 ps/nm steps @ 1550 nm)

Figure 23. Example Fiber Optic Span Test Instrument, Model 1CF16A-1B1
LAN Programmable, 7 Spool, EDFA Instrument shown, 7U height

Fiber Optic Span Models

Item	Description	Price Each

Item	Description	Price Each
1	**Model 1CF16A-1A1** Programmable Single Mode Fiber Optic Span C-band, 118.75 km span in 19 steps of 6.25 km with one insertable DWDM EDFA optical amplifier	$120,000
1	**Model 1CF16A-1B1** Programmable Single Mode Fiber Optic Span C-band, 118.75 km span in 19 steps of 6.25 km with insertable 40 km DCF in 1 step of 40 km with one insertable DWDM EDFA optical amplifier	$145,500
2	**Model 1CF16A-1C1** Programmable Single Mode Fiber Optic Span C-band, 118.75 km span in 19 steps of 6.25 km with insertable 80 km DCF in 2 steps of 40 km with two insertable DWDM EDFA optical amplifiers	$178,125
3	**Model 1CF16A-1D1** Programmable Single Mode Fiber Optic Span C-band, 118.75 km span in 19 steps of 6.25 km with insertable 120 km DCF in 3 steps of 40 km with two insertable DWDM EDFA optical amplifiers	$188,750
4	**Model 1CF16A-1F1** Programmable Single Mode Fiber Optic Span C-band, 218.75 km span in 35 steps of 6.25 km with insertable 40 km DCF in 1 step of 40 km with two insertable DWDM EDFA optical amplifier	$179,500
5	**Model 1CF16A-1G1** Programmable Single Mode Fiber Optic Span C-band, 218.75 km span in 35 steps of 6.25 km with insertable 80 km DCF in 2 steps of 40 km with three insertable DWDM EDFA optical amplifiers	$224,750
6	**Model 1CF16A-1H1** Programmable Single Mode Fiber Optic Span C-band, 218.75 km span in 35 steps of 6.25 km with insertable 120 km DCF in 3 steps of 40 km with three insertable DWDM EDFA optical amplifiers	$235,375

Options

Item	Model Add-On Options	Price Adder
1	1X2 optical input selector switch and 1x3 optical output distributor switch	$8,750
2	Programmable signal to noise ratio via optical amplifier noise injection, optical attenuators, optical coupler	$36,000

Note: All listed prices and specifications may change without notice and are made firm with a quote. Prices are in USD.

HORIZON TEST FIXTURE SYSTEM

The Horizon Functional Test Fixture System is a semi-custom system for constructing functional test fixtures and connecting them to a wide variety of standard test equipment. The ESD compliant system consists of a stationary mainframe that is mated to one or more removable functional test fixtures using a modular quick-connector. This flexible, economic, and re-configurable system can standardize over 75% of test fixture internal contents in an enterprise. Fixtures can be rapidly originated, modified, and recycled and are usable in both manual product development and automatic manufacturing environments. Both convective (forced air) and conductive (heat pump) temperature test options are offered.

This system can be used to functionally test electronic, RF, microwave, or fiber optic components, sub-assemblies, or modules in R&D or production environments including temperature tests. A wide choice of standardized power and signal functions, options, and packaging are offered. Customers can significantly reduce the recurring costs and time for creating, developing, documenting, and supporting functional test fixtures.

GENERAL DESCRIPTION

The system consists of a Stationary Mainframe that can be quickly connected to one or more removable functional Test Fixtures. The mainframe is a user-configured chassis containing modular electronic utility modules, half of the quick-connector, and standardized cabling. It is packaged for rack-mount or tabletop use, worldwide AC line or DC powered, computer programmable, ESD compliant, and uses compressed air for boost cooling when needed. Quick-connect feed-thru blocks provide access for external power, electrical, RF-microwave, fiber optic, and other test equipment.

Each test fixture is configured for one or more specific products or “unit under test” (UUT) and accesses mainframe resources through the Quick-Connect. Each fixture contains a custom UUT Contactor and UUT Adapter p.c. board assembly (separate or combined), half of the quick-connect (equipped as needed), standardized cabling, and optional items such as microwave or optical switches, temperature sensors, and pneumatic probes and actuators. The UUT Contactor makes mechanical, electrical, optical, and/or thermal (forced air or heat pump) connections to the UUT and may include a “connector saver”. The UUT Adapter converts the UUT pin-out and any optional fixture item wiring to the quick-connect pin-out and may include relays and other electronic circuitry. Various standard p.c. board adapters are offered to quickly implement hardwired fixture changes or to originate a prototype UUT Adapter.

- Basic system is a stationary mainframe containing modular electronic utility modules mated to one or more removable functional test fixtures via a modular quick-connector
- Modular quick-connector passes power, compressed air, electronic signals (analog, digital, RF, microwave), and fiber optic signals (non-contact single mode and multimode) between mainframe and test fixtures
- Utility module functions include fixed and programmable power supplies, D-to-A converters, digital voltmeter with relay MUX decoder, digital I/O, latching and non-latching relay drivers, serial EEPOT/EEPROM controller, thermo-electric heat pump controller, temperature sensor circuitry, and pneumatic solenoid valves
- Convective and conductive temperature test capabilities via forced air or heat pump options
- Automatic mainframe models offered in tabletop or rack-mountable, ESD compliant, worldwide AC line powered housings with GPIB-IEEE488.2-HPIB, RS-232, 10/100Base-T Ethernet LAN, or USB interface (others on request)
- Manual mainframe models offered in tabletop, ESD compliant housings with external regional power supply, basic controls and displays, and without a computer interface

STATIONARY MAINFRAME

The Stationary Mainframe is an ESD compliant aluminum chassis containing AC power, computer, and compressed air interfaces along with electronic utility modules and half of the modular Quick-Connect. Standard cable assemblies are used to interconnect the interfaces, modules, and quick-connect. Various mainframe models can be rack-mounted or used on a table top with front or top mounted Quick-Connect. Mainframes can be configured with Quick-Connect feed-thru blocks for access to external power, electrical, RF-microwave, and optical test equipment. Computer interfaces choices include GPIB-IEEE488.2-HPIB, RS-232, 10/100Base-T Ethernet LAN, or USB (others on request).

Utility modules are chassis mounted, open-frame, shielded, p.c. board assemblies. Functions include fixed and programmable power supplies, D-to-A converters, digital voltmeter with relay MUX decoder, digital I/O, latching and non-latching relay drivers, serial EEPOT/EEPROM controller, thermo-electric heat pump controller, temperature sensors, and pneumatic solenoid valves. Heat dissipating modules are thermally connected to the mainframe chassis. Compressed air is used to increase module cooling under high dissipation conditions.

QUICK-CONNECT

The Quick-Connect is used to pass power, signals, and compressed air between the stationary mainframe and removable test fixtures. Half of the Quick-Connect is mounted in the mainframe making all of the mainframe resources available, including external test equipment. The other half is mounted in each test fixture, configured to access only the mainframe resources needed for a UUT. Each Quick-Connect half consists of one or more modular Quick-Connect blocks mounted in a Quick-Connect frame. Quick-Connect blocks for power and low frequency signals use spring probe technology and have connectors to mate with standard cable assemblies. Special connectors are used for RF, microwave, fiber optic, and pneumatic Quick-Connect blocks.

REMOVABLE TEST FIXTURE

The test fixture is an aluminum chassis containing half of a modular Quick-Connect, a UUT-Adapter, and a UUT-Contactor. The fixture also contains optional UUT resources as needed, such as microwave relays, optical switches, temperature sensors, and robotic probes and actuators. In some cases, two or more UUTs can be tested with one fixture.

The Quick-Connect is configured to access the mainframe resources needed for a UUT. Standard cable assemblies connect the Quick-Connect to the UUT-Adapter. The UUT-Adapter is a custom p.c. board assembly that connects to the UUT-Contactor and any optional UUT resources in the fixture. The UUT-Adapter adapts pin-outs between the UUT and the Quick-Connect and usually contains relays and electronic circuitry. The UUT-Contactor is a custom assembly that makes mechanical, electrical, and optional conductive thermal contact to the UUT. The UUT-Contactor may include a “connector saver” to reduce maintenance from connector wear-out. In some test fixtures, the UUT-Adapter and UUT-Contactor are combined into one p.c. board assembly.

UUT TEMPERATURE TESTING

Temperature testing can be accomplished with convective or conductive temperature control, depending on the UUT. Convective control is suitable for most p.c. board UUTs, but can require considerable test time to arrive at a temperature. A commercial forced air temperature system can be used with a thermally insulating shroud for convective UUT temperature control.

Conductive control is suitable for some unpackaged, hybrid, or sub-assembly UUTs where there is a solid material thermal contact with temperature sensitive components. Horizon thermo-electric heat pumps are available for inclusion in UUT-Contactors for conductive UUT temperature control. These heat pumps have built-in temperature sensors and are cooled by compressed air. The Heat Pump controller module in the mainframe is used to control the heat pump temperature. When the UUT is held in close thermal contact with the Horizon heat pump within the UUT contactor, the UUT can be driven hot or cold in a short time.

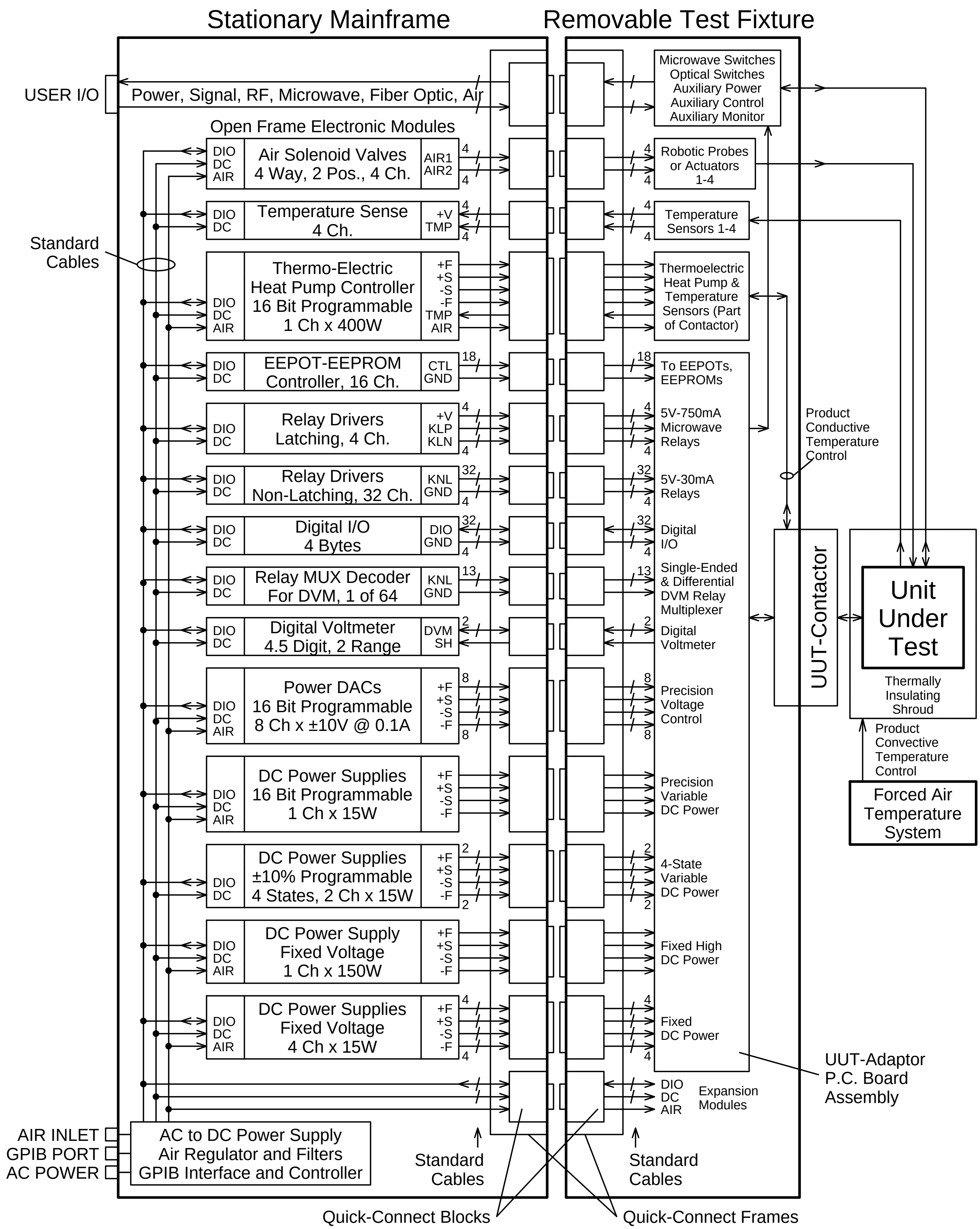


Figure 24. Example Horizon Test Fixture Configuration

COMMUNICATION SWITCH MATRICES

Communication Switch Matrices are semi-custom test instruments that have a multi-channel RF, microwave, or fiber optic switching topology peculiar to the communication industry. They are used to route analog and digital signals between standard high-speed electronic or fiber optic functional test equipment and communication products or networks. Customers can choose from many kinds of made-to-order models by specifying topology type, I/O impedance or wavelength range and fiber type, bandwidths, channel count, I/O connector types, options, packaging, and other variations. Model numbers are assigned when a quote is originated.

MODEL VARIATIONS

Path Director modules implement switch topologies having loop-back, daisy chain, daisy bypass, open, terminate, short, and test access features. Test access ports are routed through a selector switch module to a Measurement Processor module, which implements all stressor and measurement switching needed for performance tests. Tests include bit error rate, jitter and wander, interfering tone, receiver sensitivity and overload, transmission line length insertion, line rate, power level, eye pattern, spectrum, and S-parameters. Conventional cross-connect, transfer, and selector switch matrix topologies are also offered. Customers can choose from a variety of matrix sizes, topology features, bandwidths, options, and packaging to procure the exact RF, microwave, or fiber optic switch topology needed to connect a product to standard test equipment.

EXAMPLE SWITCH MATRICES

- RF Path Director, single-ended 75 ohm, 32 channels, DC-1 GHz bandwidth, BNC or SMB I/O connectors
- RF Path Director, differential 100 ohm, 28 channels, DC-100 MHz bandwidth, ribbon I/O connectors
- Microwave Path Director, single-ended 50 ohm, 8 channels, DC-26 GHz bandwidth, SMA or 3.5mm I/O connectors
- Fiber optic Path Director, single mode, 1200-1600 nm, 16 channels, FC I/O connectors
- Fiber optic Path Director, multi-mode, 850 nm, 32 channels, LC or SC I/O connectors
- Fiber optic cross-connect switch, single mode, 8x8 or 16x16 MEMS switch fabric, FC or MTP I/O connectors
- Automatic models offered in tabletop or rack-mountable, ESD compliant, worldwide AC line powered housings with GPIB-IEEE488.2-HPIB, RS-232, 10/100Base-T Ethernet LAN, or USB interface (others on request)
- Manual models offered in tabletop, ESD compliant housings with external regional power supply, basic controls and displays, and without a computer interface

FIBER OPTIC TRANSCEIVER TEST SYSTEM APPLICATIONS

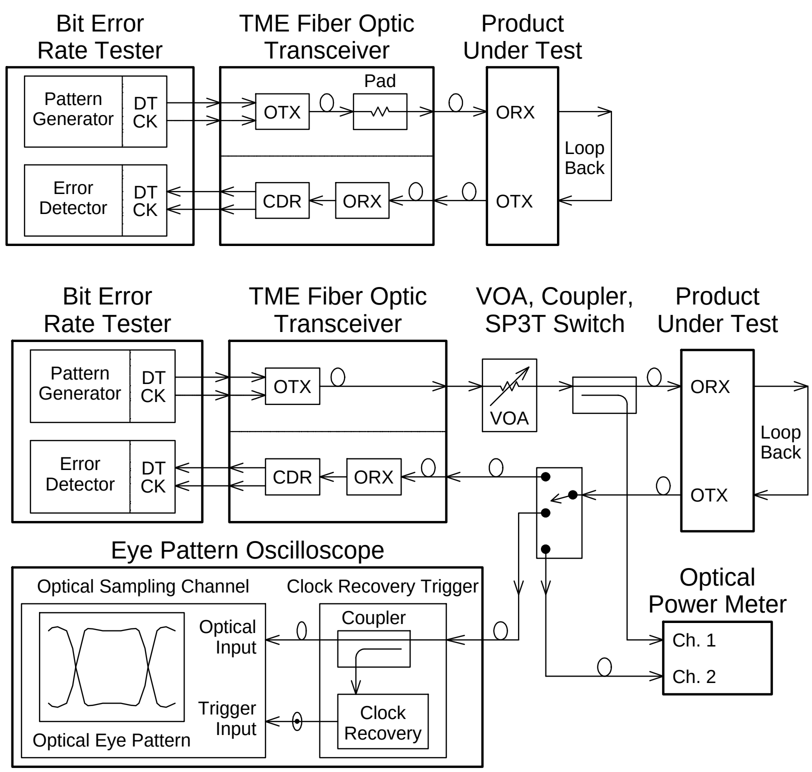
Several basic and advanced test systems are shown using TME Fiber Optic Transceivers along with BERT and parametric BER testers, such as the Agilent ParBERT™ 81250 or SytheSys Research BitAlyzers™. These test systems are capable of bit error rate (BER) tests and various parametric tests, such as eye pattern and extinction ratio. Many other configurations are possible due to the variety of standard test equipment available. In particular, the flexibility and expandability of the ParBERT™ and the wide variety Fiber Optic Transceivers and features offered makes powerful, compact, flexible, multi-channel, multi-rate, multi-protocol test systems possible.

Test systems with both electrical microwave and fiber optic inputs and outputs provide considerable test setup flexibility. Performance tests can include optical and electrical bit error rate, transmitted and received power, receiver sensitivity, fast eye opening mask tests, extinction ratio, output timing measurements, and jitter generation, transfer, and accommodation. TME Fiber Optic Transceivers with conventional BER and related equipment or parametric BER test equipment can provide an excellent return on capital investment, especially for manufacturing operations. Testing of multiple sub-assemblies in parallel makes it possible to save considerable test time and significantly improve test system throughput.

BASIC TEST SYSTEMS USING FIBER OPTIC TRANSCEIVERS

Various basic test system examples using fiber optic transceivers are shown in Figure 25 and Figure 26. These test systems are equipped for single channel, single wavelength, and single data rate operation. They differ in test comprehensiveness, flexibility, and cost.

Figure 25. Basic Test Systems using Single Channel-Wavelength-Data Rate Fiber Optic Transceiver



TME Transceiver

- Digital OTX and Digital ORX
- Internal OTX Fixed Pad

Test System UUT Test Capabilities

- Optical BER

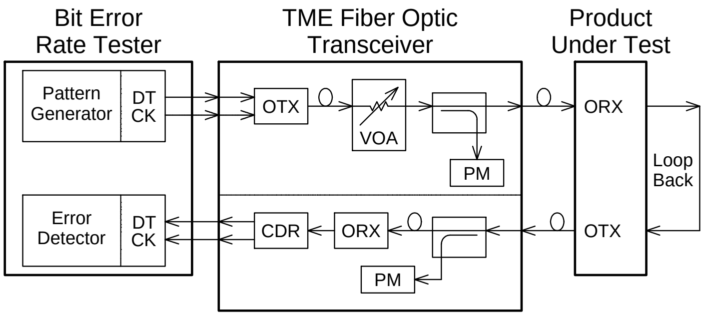
TME Transceiver

- Digital OTX and Digital ORX

Test System UUT Test Capabilities

- Optical BER
- OTX power
- OTX eye pattern
- OTX extinction ratio
- OTX jitter generation
- ORX sensitivity and overload

Figure 25. Basic Test Systems using Single Channel-Wavelength-Data Rate Fiber Optic Transceiver

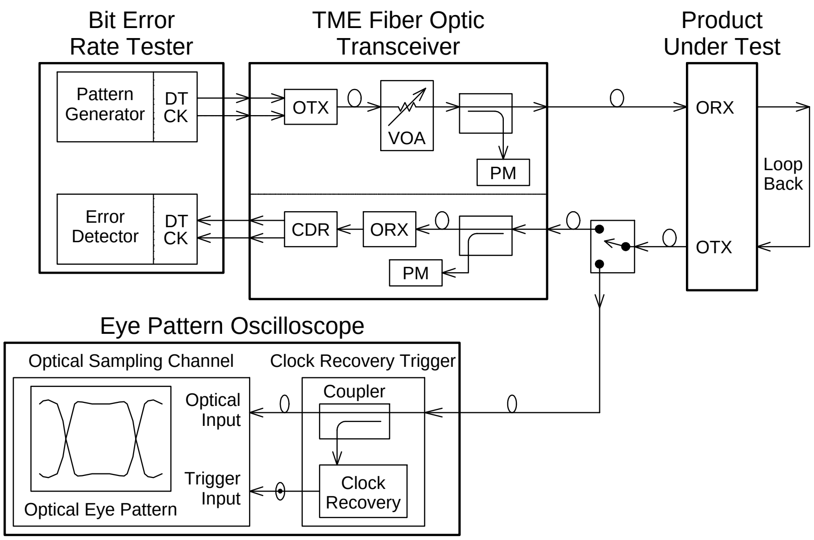


TME Transceiver

- Digital OTX and Digital ORX
- Internal OTX VOA
- Internal OTX Power Monitor
- Internal ORX Power Monitor

Test System UUT Test Capabilities

- Optical BER
- OTX power
- ORX sensitivity and overload

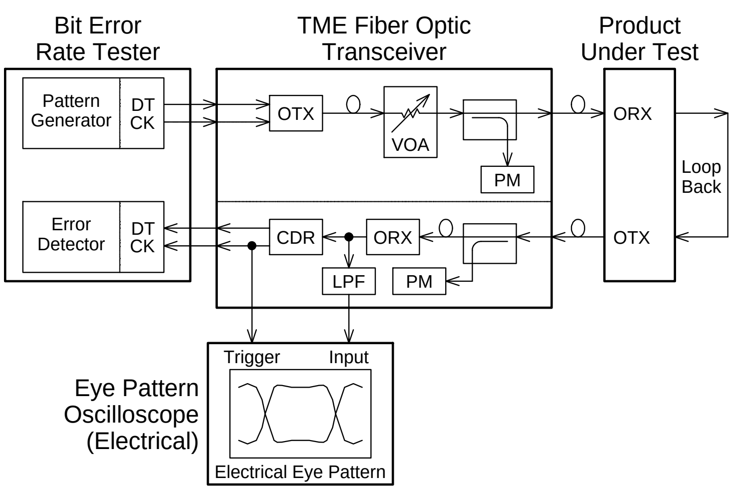


TME Transceiver

- Digital OTX and Digital ORX
- Internal OTX VOA
- Internal OTX Power Monitor
- Internal ORX Power Monitor

Test System UUT Test Capabilities

- Optical BER
- OTX power
- OTX eye pattern
- OTX extinction ratio
- OTX jitter generation
- ORX sensitivity and overload



Digital-Analog Transceiver configured for

- Digital OTX and Digital-Analog ORX
- Internal OTX VOA
- Internal OTX Power Monitor
- Internal ORX Power Monitor

Test System UUT Test Capabilities

- Optical BER
- OTX power
- OTX eye pattern
- OTX extinction ratio
- OTX jitter generation
- ORX sensitivity and overload

16 CHANNEL TEST SYSTEMS USING FIBER OPTIC TRANSCEIVERS

Example OTX and ORX configurations are shown in Figure 26 (OTX) and Figure 27 (ORX) for testing a 16-channel product.

Figure 26. Example OTX Configurations for testing a 16 Channel Product

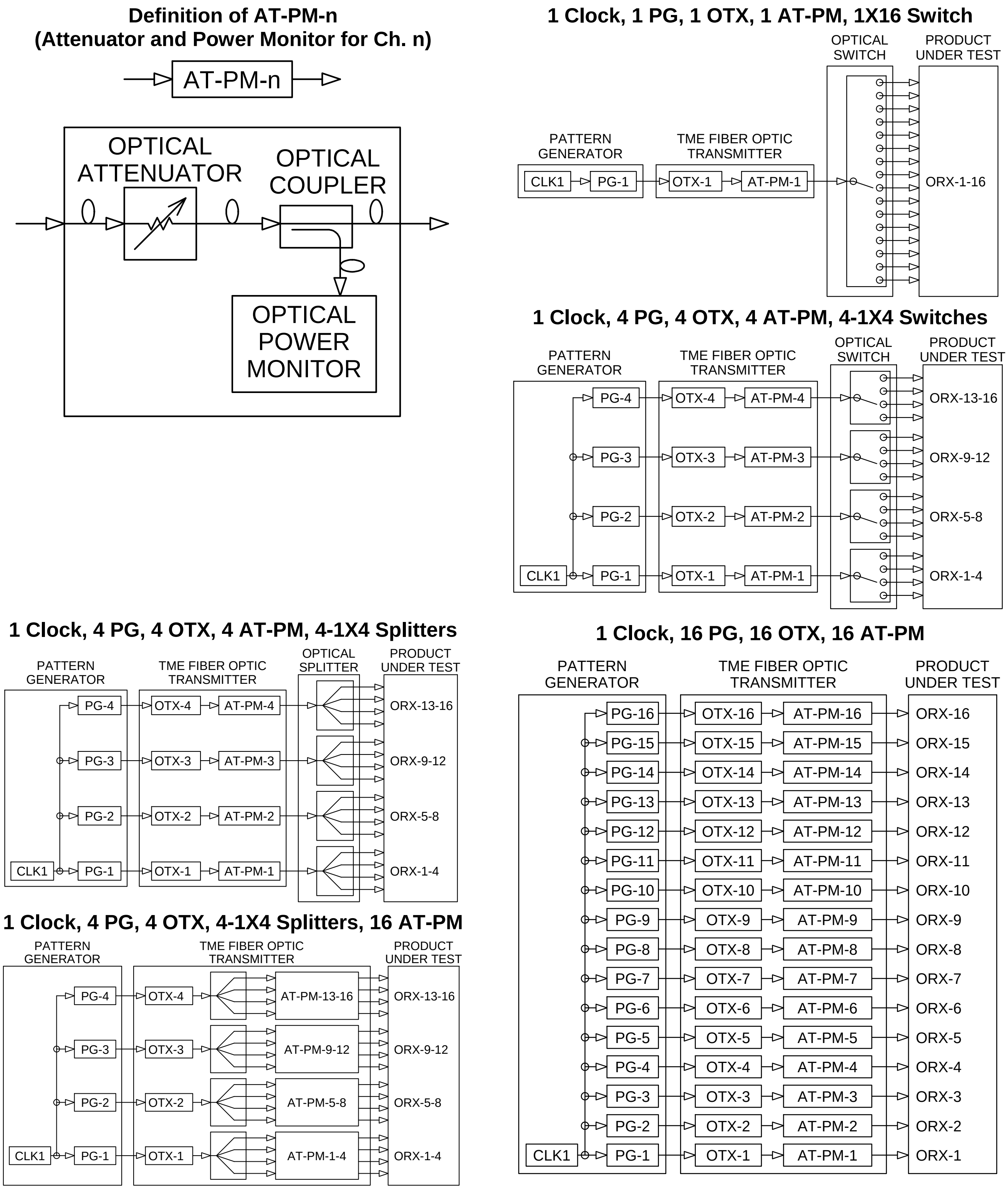
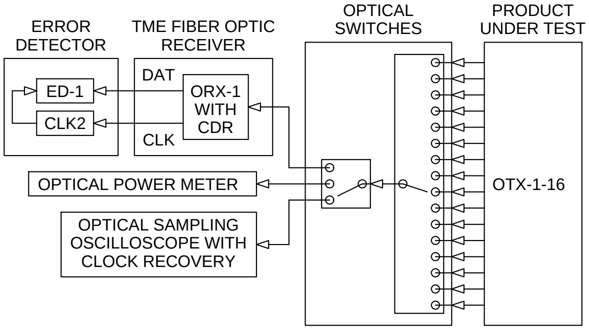
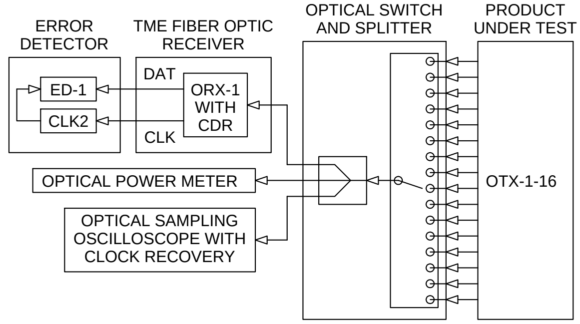


Figure 27. Example ORX Configurations for testing a 16 Channel Product

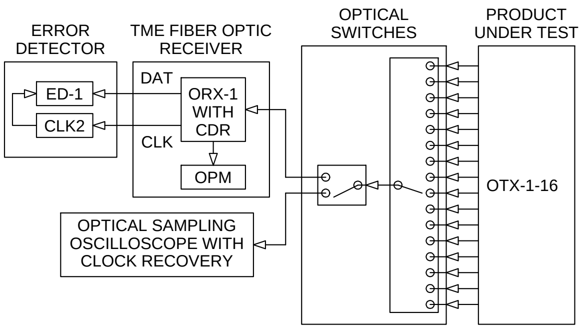
1X16 Switch, 1X3 Switch, 1 ORXDC, 1 ED, 1 OPM, 1 Scope-CR



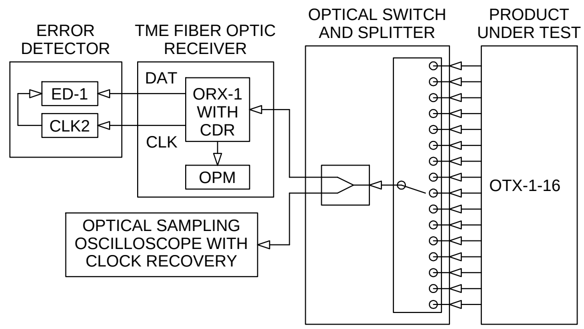
1X16 Switch, 1X3 Splitter, 1 ORXDC, 1 ED, 1 OPM, 1 Scope-CR



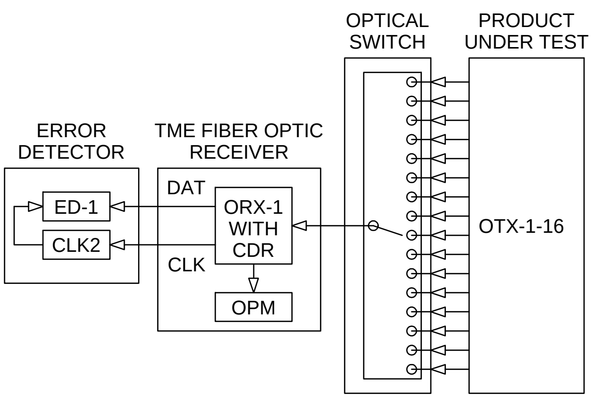
1X16 Switch, 1X2 Switch, 1 ORXDC-OPM, 1 ED, 1 Scope-CR



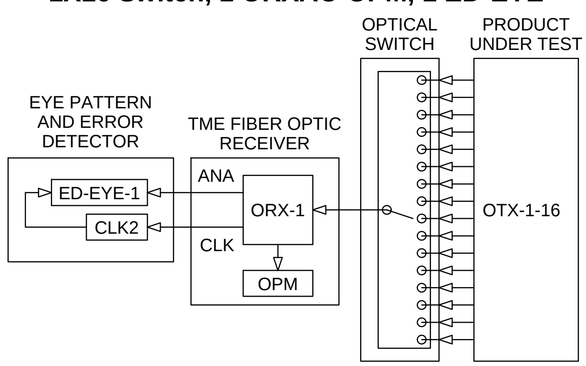
1X16 Switch, 1X2 Splitter, 1 ORXDC-OPM, 1 ED, 1 Scope-CR



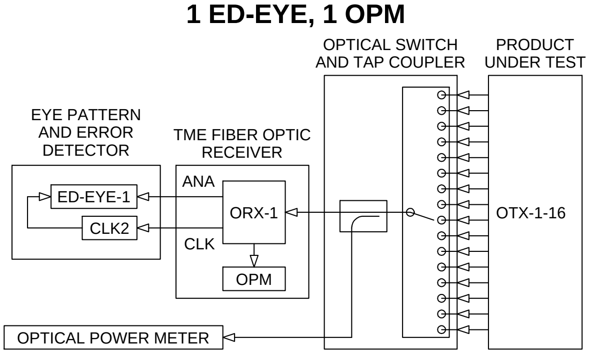
1X16 Switch, 1 ORXDC-OPM, 1 ED



1X16 Switch, 1 ORXAC-OPM, 1 ED-EYE



1X16 Switch, 1 Coupler, 1 ORXAC, 1 ED-EYE, 1 OPM



1X16 Switch, 1 ORXADC-OPM, 1 ED, 1 Scope-CR

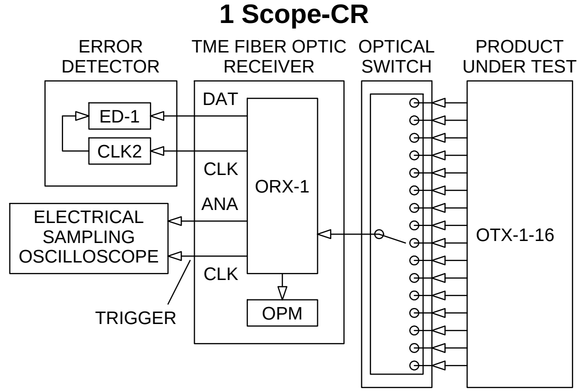
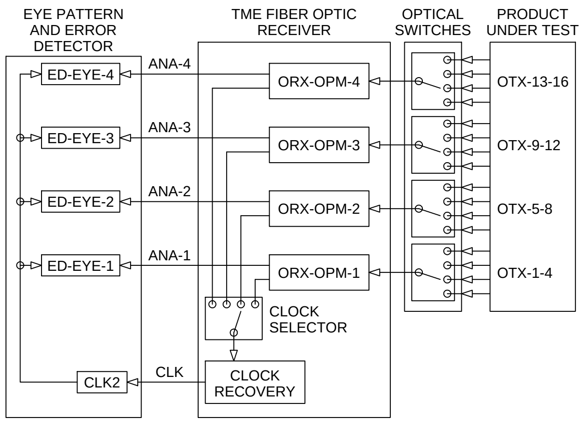
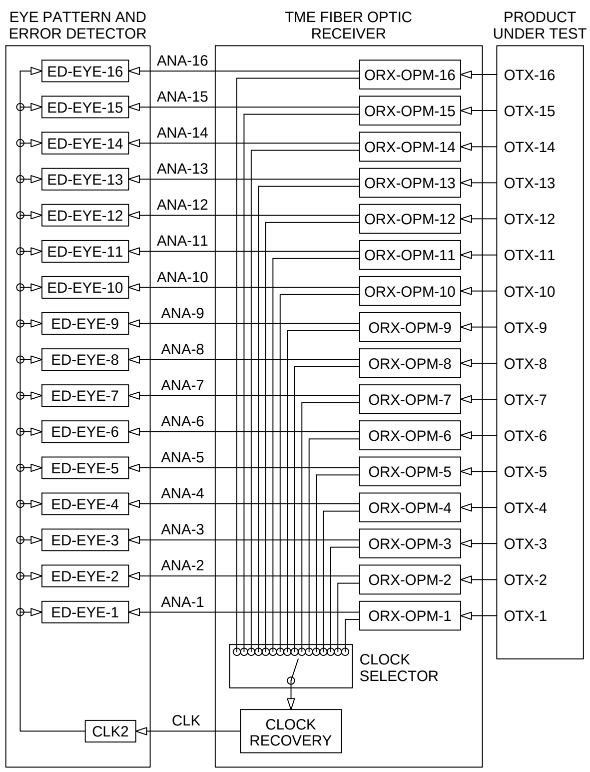


Figure 27. Example ORX Configurations for testing a 16 Channel Product

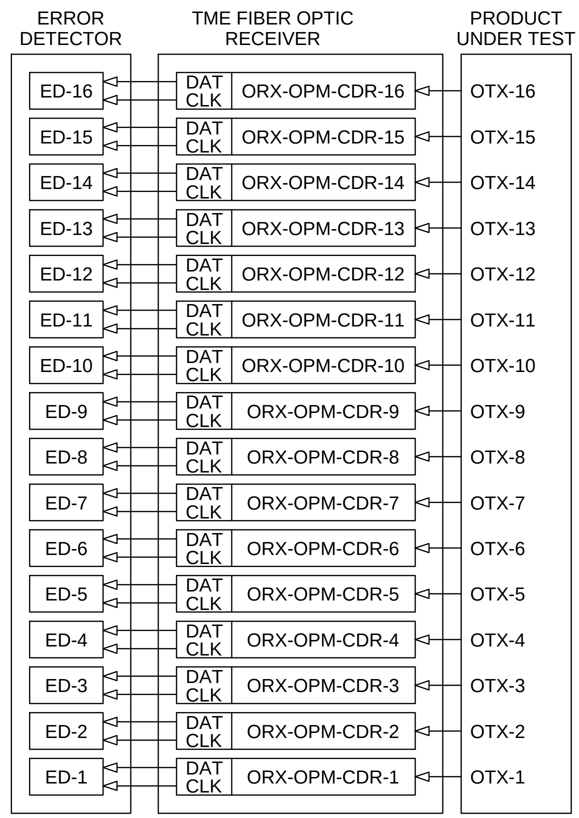
4-1X4 Switch, 4 ORXAC-OPM, 4 ED-EYE, 1 Clock



16 ORXAC-OPM, 16 ED-EYE, 1 Clock



16 ORXDC-OPM, 16 ED, 16 Clock



PARAMETRIC BERT SYSTEMS

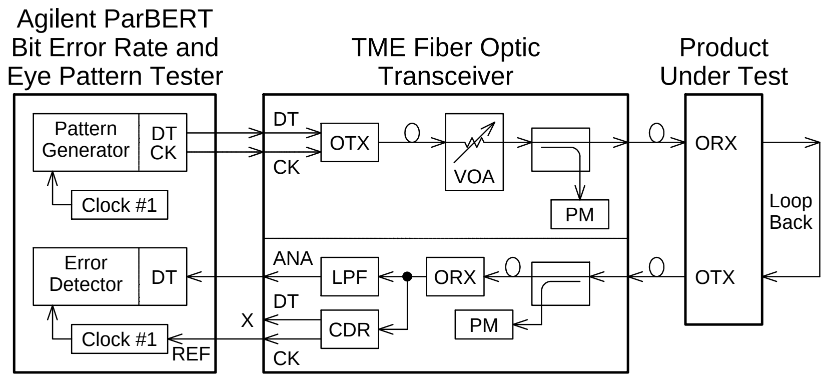


Figure 28. Single Channel Parametric BER Test System with Digital-Analog Transceiver Configured for Single Wavelength and Data Rate, Internal VOA and Power Monitors Tests optical BER, TX and RX power, RX sensitivity, eye pattern, extinction ratio, jitter generation

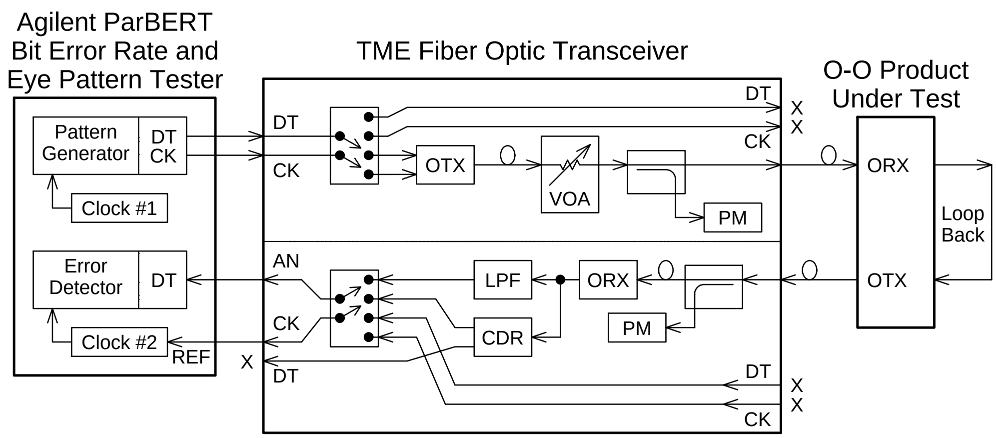


Figure 29. Single Channel Parametric BER Test System with Digital-Analog Transceiver Configured for Single Wavelengths and Data Rate, Internal VOA and Power Monitors, Pass-thru Tests O-O BER, TX and RX power, RX sensitivity, eye pattern, extinction ratio, jitter generation

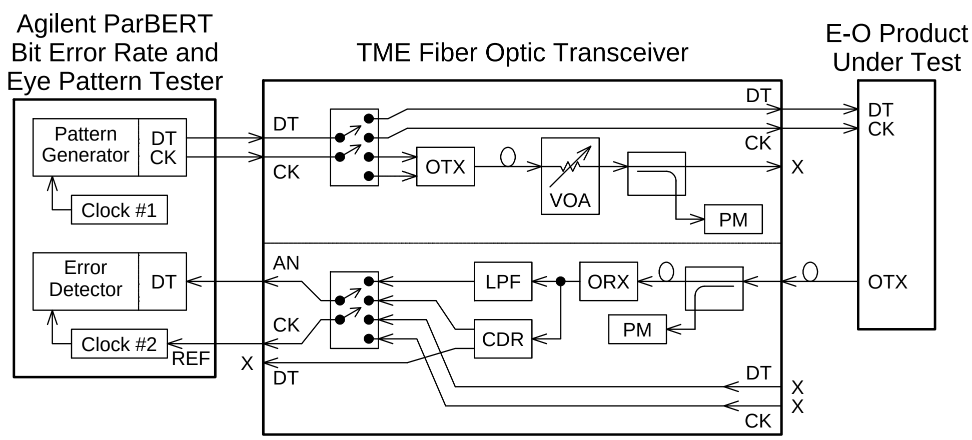


Figure 30. Single Channel Parametric BER Test System with Digital-Analog Transceiver Configured for Single Wavelengths and Data Rate, Internal VOA and Power Monitors, Pass-thru Tests E-O BER, TX power, eye pattern, extinction ratio, jitter generation

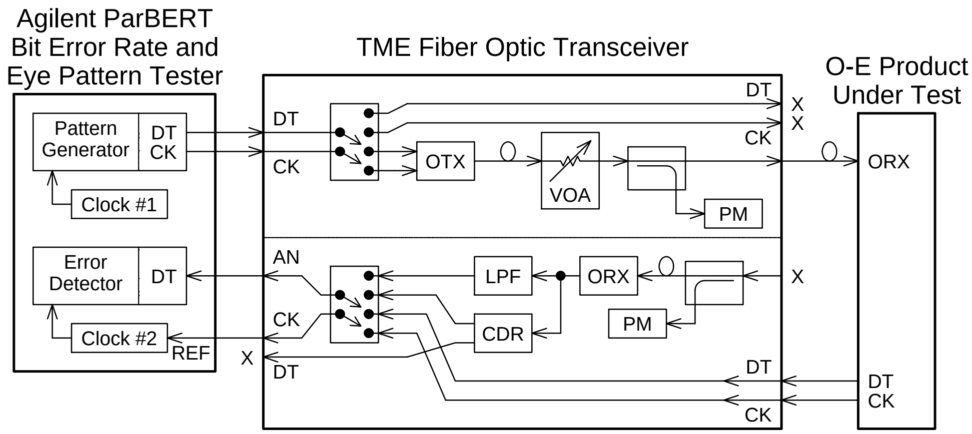


Figure 31. Single Channel Parametric BER Test System with Digital-Analog Transceiver Configured for Single Wavelengths and Data Rate, Internal VOA and Power Monitors, Pass-thru Tests O-E BER, RX power, RX sensitivity, eye pattern, extinction ratio, jitter generation

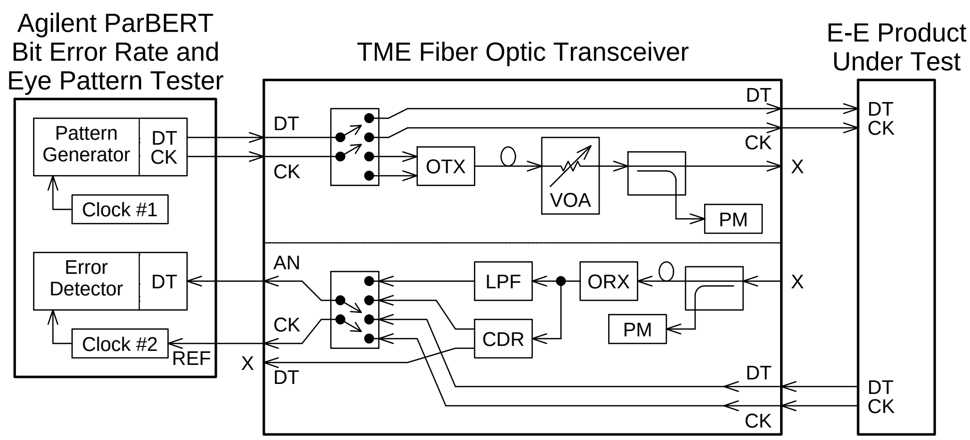


Figure 32. Single Channel Parametric BER Test System with Digital-Analog Transceiver Configured for Single Wavelengths and Data Rate, Internal VOA and Power Monitors, Pass-thru Tests E-E BER, eye pattern, extinction ratio, jitter generation

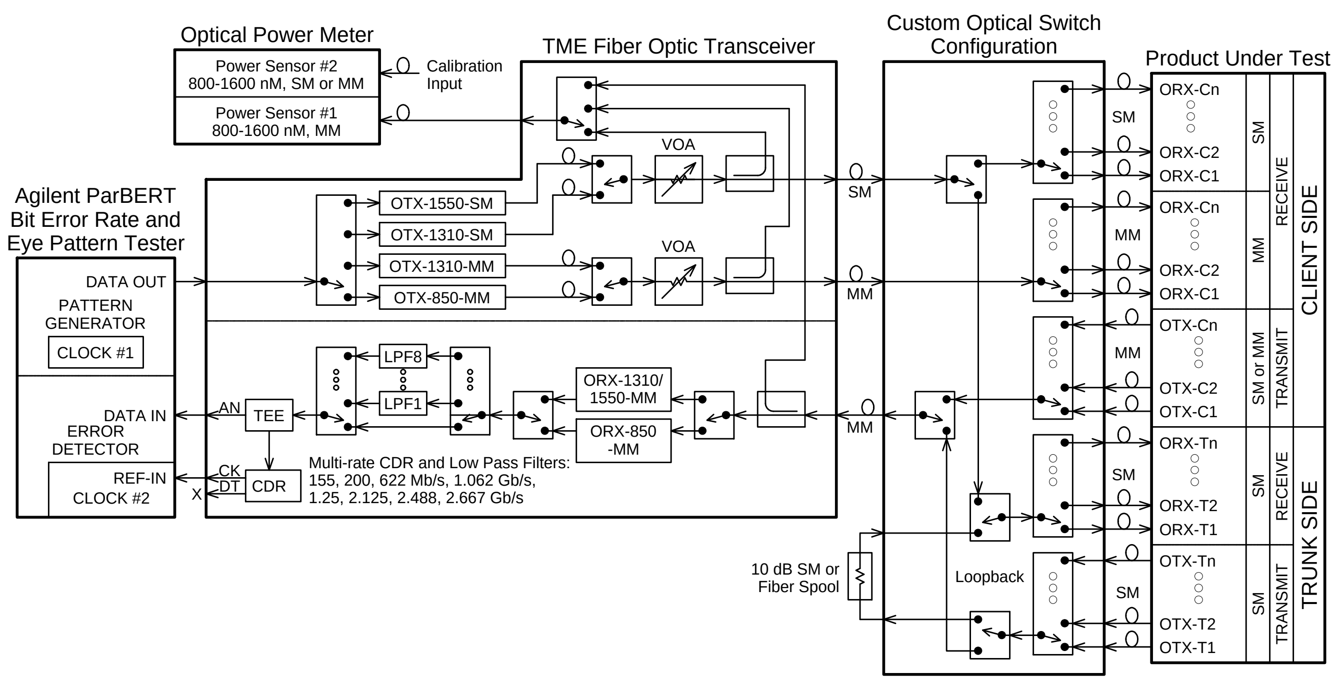


Figure 33. Single Channel Parametric BER Test System with Digital-Analog Transceiver & Selector Configured for 4 Wavelengths, 2 modes, and 8 Data Rates, Internal VOA and Power Taps Tests optical BER, TX and RX power, RX sensitivity, eye pattern, extinction ratio, jitter generation

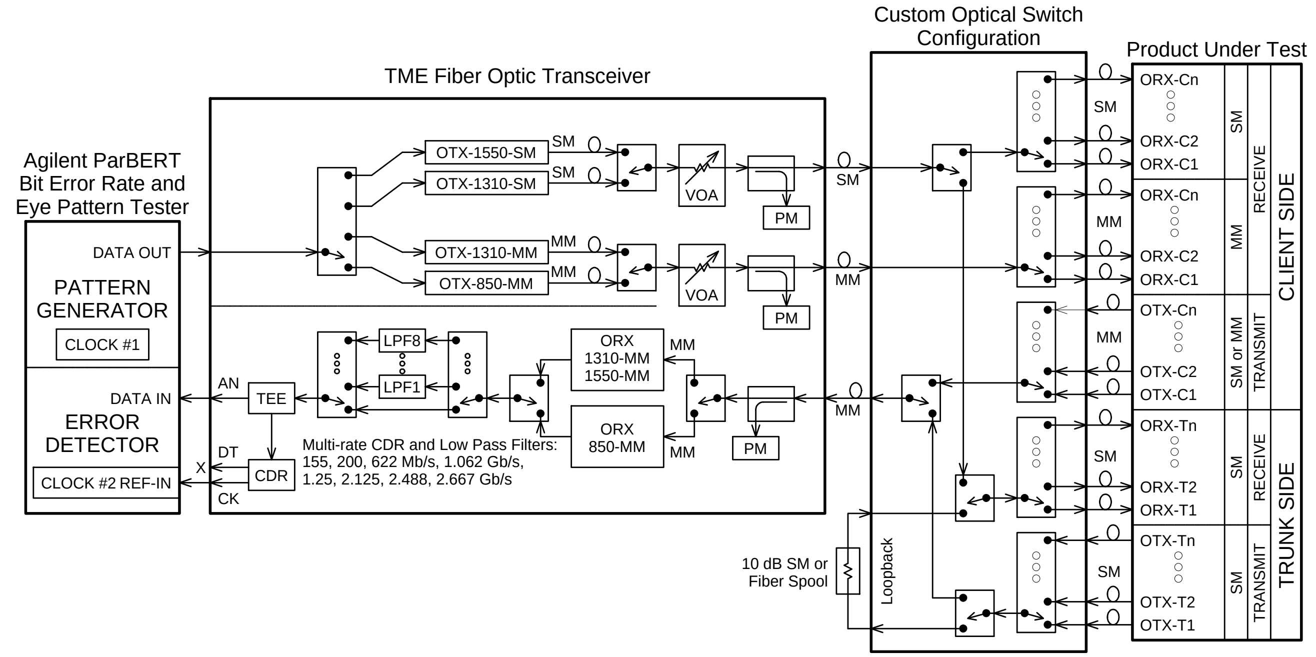


Figure 34. Single Channel Parametric BER Test System with Digital-Analog Transceiver & Selector Configured for 4 Wavelengths, 2 modes, and 8 Data Rates, Internal VOA and Power Monitors Tests optical BER, TX and RX power, RX sensitivity, eye pattern, extinction ratio, jitter generation

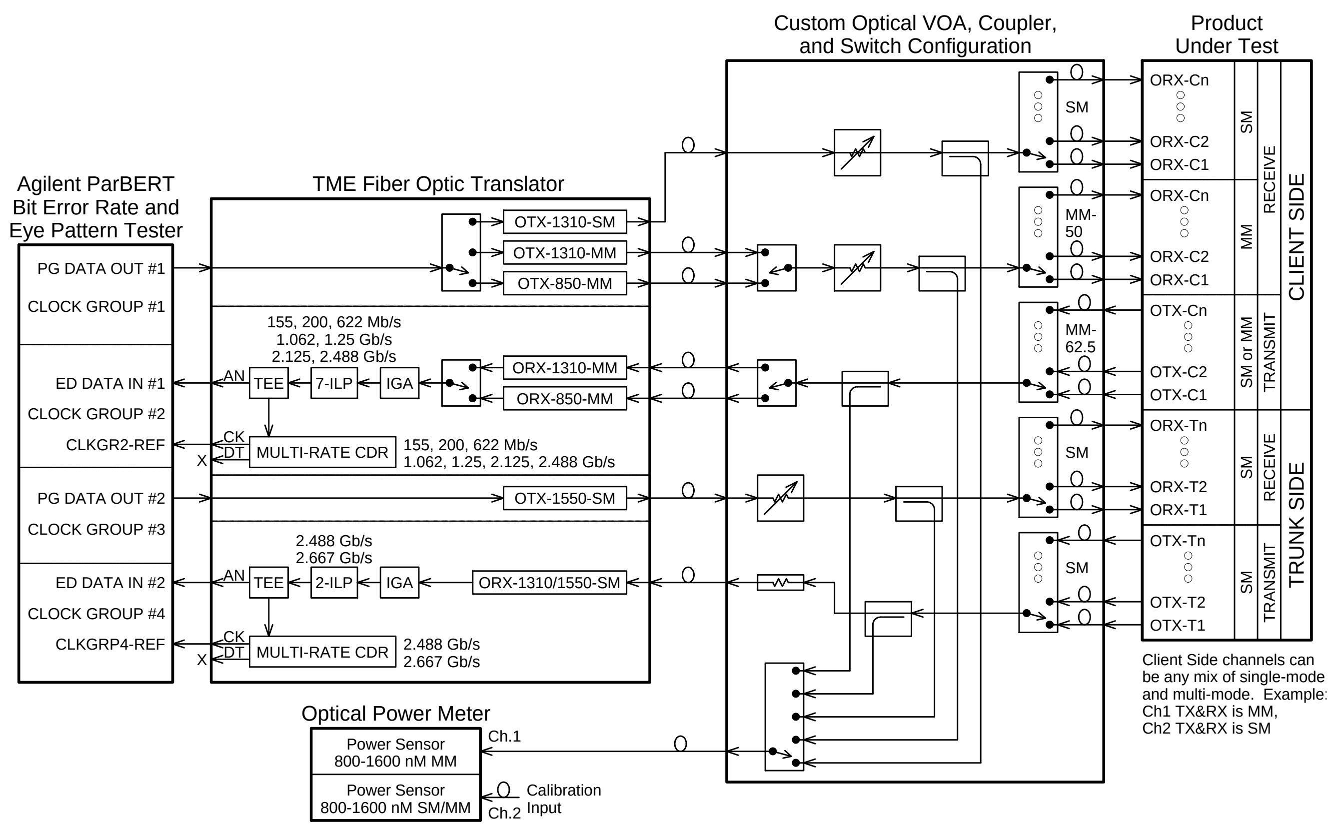


Figure 35. 2-Channel Parametric BER Asynchronous Test System with Digital-Analog Transceiver Configured for 3 Wavelengths, 2 modes, Multiple Data Rates, and Multiple Low Pass Filters Tests optical BER, TX and RX power, RX sensitivity, eye pattern, extinction ratio, jitter generation

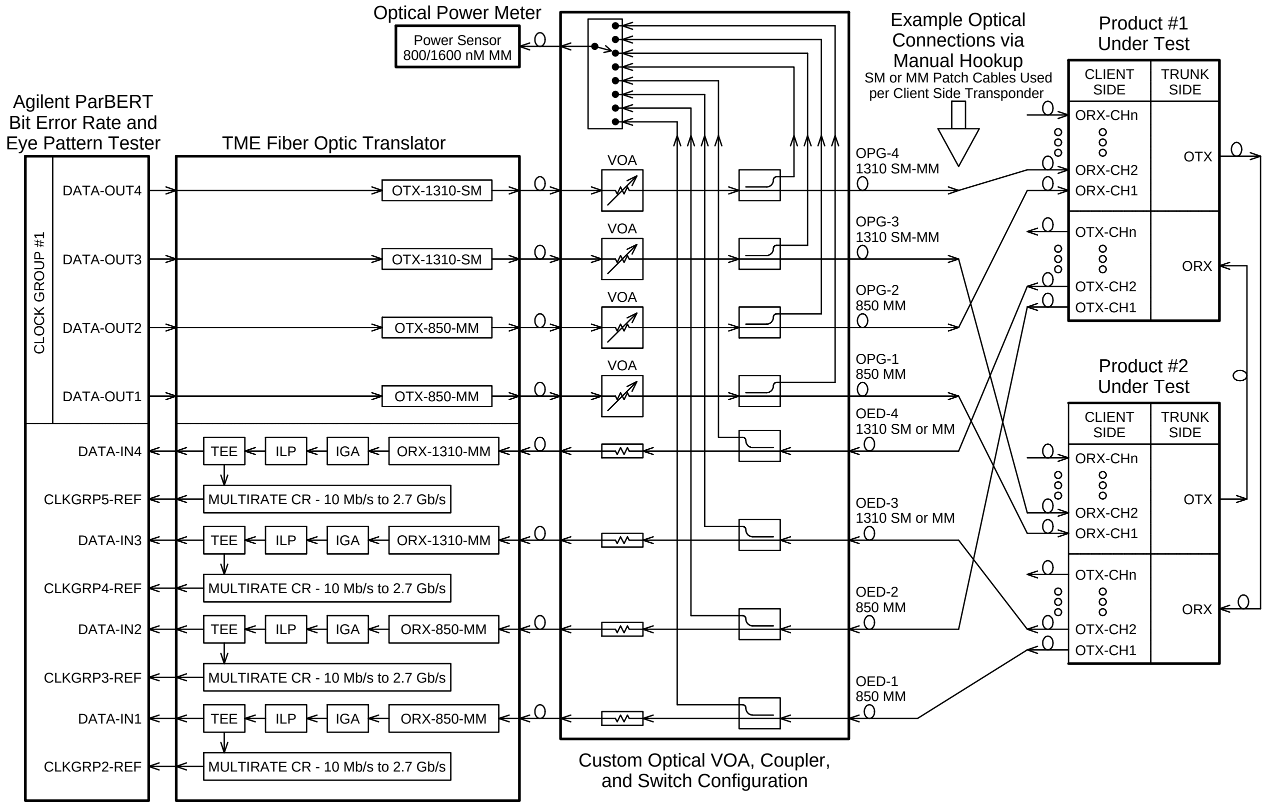


Figure 36. 4-Channel Parametric BER Asynchronous Test System with Digital-Analog Transceiver Configured for 2 Wavelengths, 2 modes, Multiple Data Rates, and Multiple Low Pass Filters Tests optical BER, TX and RX power, RX sensitivity, eye pattern, extinction ratio, jitter generation

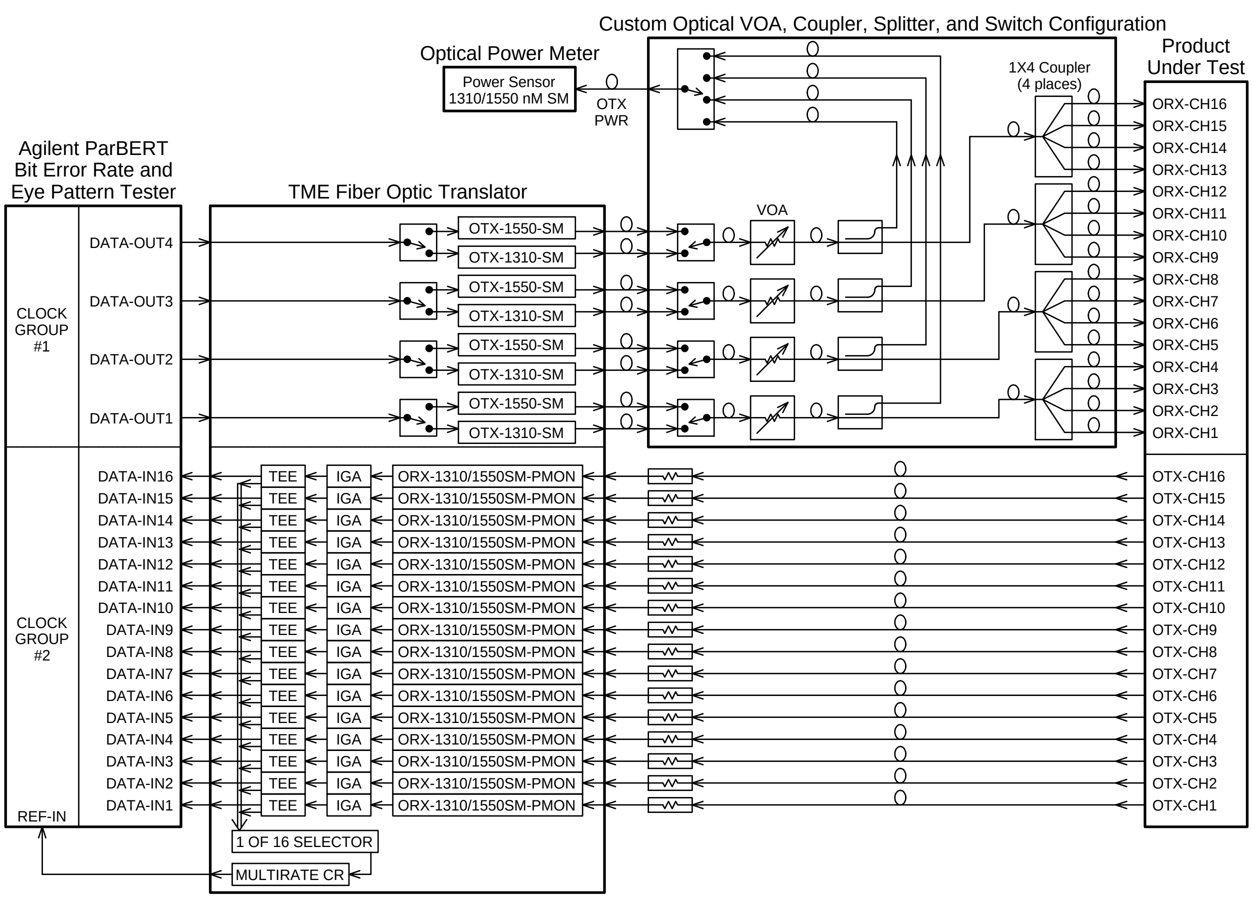


Figure 37. 4/16-Channel Parametric BER Synchronous Test System with Digital-Analog Transceiver Configured for 2 Wavelengths, 1 mode, Multiple Data Rates, and Multiple Low Pass Filters Tests optical BER, TX and RX power, RX sensitivity, eye pattern, extinction ratio, jitter generation

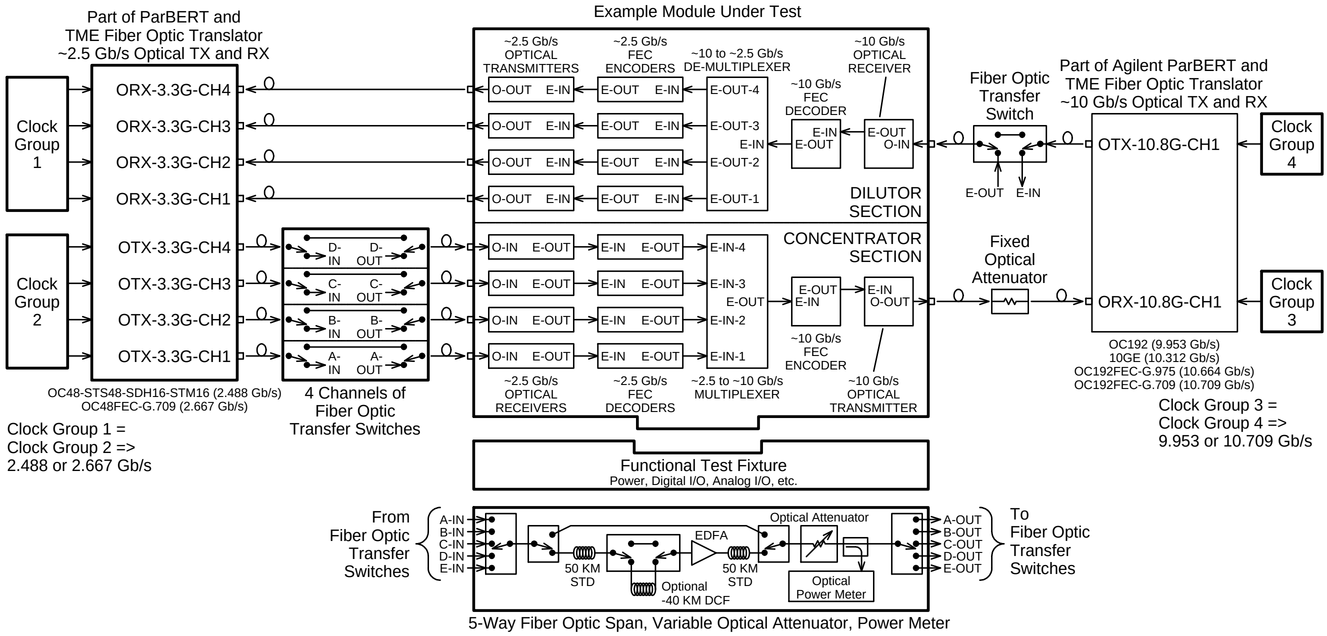


Figure 38. Test Setup for Example Module UUT, 4 Channel OC-48-FEC to OC-192-FEC Transceiver

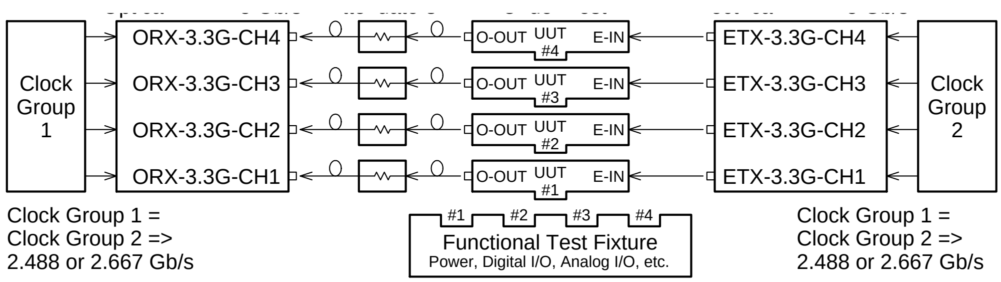


Figure 39. Test Setup for Example Sub-Assembly UUT, 1 to 4 ~2.5 Gb/s Optical Transmitters

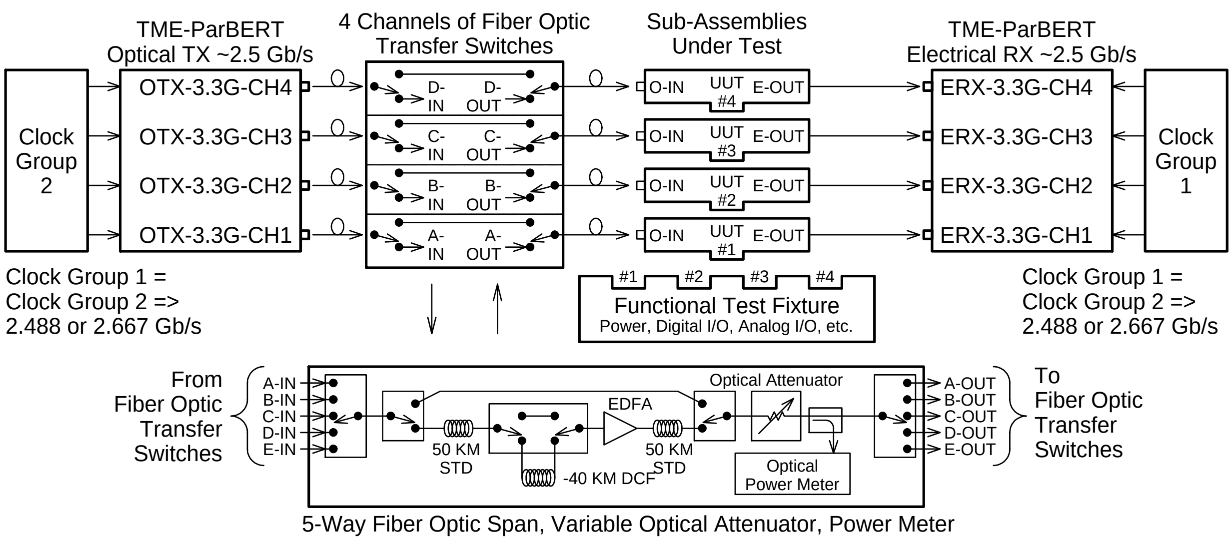


Figure 40. Test Setup for Example Sub-Assembly UUT, 1 to 4 ~2.5 Gb/s Optical Receivers

NETWORK TEST SYSTEM WITH FIBER OPTIC TRANSCEIVER

An example 40 wavelength ~10 Gb/s DWDM network communication test system is shown in Figure 41. It consists of optical couplers, a TME fiber optic transceiver, SONET or G.709 test equipment, and a controller. This system is designed to automatically test network quality of service (QOS) for each of the 40 wavelengths one wavelength at a time. It can test trunk lines paths between central offices or test paths through the central office equipment. In duplex mode, pattern generation and error detection is done at the same central office using loop-back at a remote central office. In simplex mode, pattern generation is at one central office and error detection is at a remote central office. Tests include bit error rate, transmitted optical power, received optical power, optical sensitivity, optical eye pattern, and extinction ratio for each wavelength.

The test system accesses central office trunk lines using low loss, 4-port, optical tap couplers. The tapped trunk lines are routed to a TME transceiver, which is equipped for ~10 Gb/s, 1550 nm C-band, 100 GHz spaced, NRZ operation. Optical switches select the proper trunk lines and optical amplifiers boost the low tapped optical power levels. The fiber optic transmitter is a tunable laser with variable optical attenuator, optical power monitor, and SBS suppression. The fiber optic receiver has a tunable filter with optical power monitor, a clock-data recovery circuit, and an analog output with eye pattern filter. The transceiver is connected to SONET or G.709 bit error rate tester (BERT) and an eye pattern oscilloscope. A computer with a test program controls the TME transceiver and BERT. It also issues traffic routing commands to the central office equipment to enable testing of one wavelength at a time.

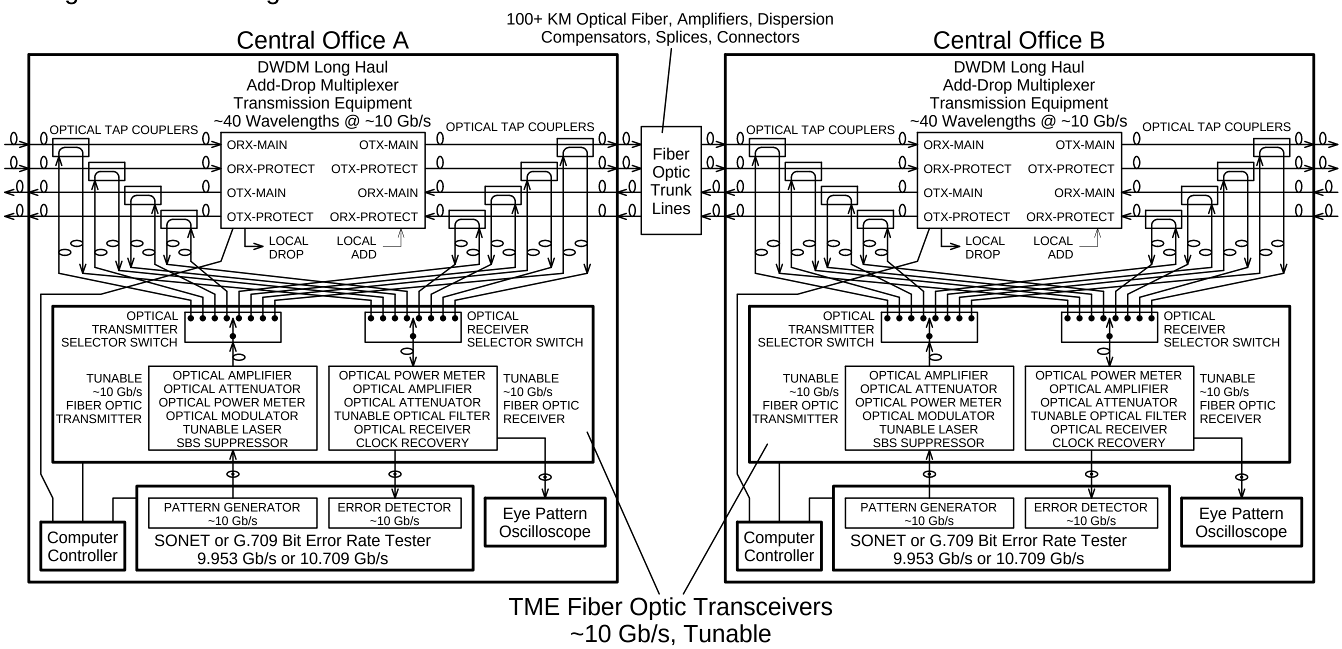


Figure 41. Network Test System with TME Fiber Optic Transceiver

CUSTOM PRODUCTS AND SERVICES

TME offers custom products and services to help customers create and manufacture advanced technology products. Custom test equipment can be supplied for products packaged as wafers, bare and packaged die, pre-lid and post-lid hermetic and non-hermetic hybrids, sub-assemblies, modules, and systems. Simple, complex, manual, or automatic custom functional test equipment can be supplied that complements standard products. TME can also supply precision single head, multi-head, and multi-technology test fixtures, test console-fixture interfaces, electronic and optical cabling, special calibration standards, and accessories. Customers can obtain the unique or specialized functional test equipment and systems they need when standard or TME semi-custom test equipment is not available.

Technical and business consulting services are offered to help customers with test system definition, alternatives, evaluations, critique, strategy and plans, project planning, equipment identification, and project costing. Multidisciplinary test engineering services are offered for specialized test system design, documentation, construction, integration, and contract administration of custom functional test equipment and systems. Product engineering services are also offered to assist in product design, manufacturability, testability, reliability, quality, cost reduction, failure analysis, or prototyping issues.

All TME products and services are based upon multidisciplinary engineering expertise with advanced and conventional technologies, components, materials, and processes. Electronic expertise includes signal, power, analog, interface, digital, RF, microwave, and transmission line engineering from DC to 110 GHz. Optical expertise includes single mode and multi-mode fiber optic and free space optical engineering from 800 nm to 1650 nm and to 43 Gb/s. Mechanical expertise includes micro to macro advanced technical packaging and mechanical, thermal, pneumatic, and acoustic engineering. Physical design expertise includes hermetic and non-hermetic thin and thick film hybrids, multi-chip and chip-on-board modules, surface mount and thru-hole p.c. board and flex assembly engineering. Other expertise includes sensors, actuators, magnetics, shielding, EMI/RFI, and regulatory agency engineering.

TME short run products provide customers with a procurement choice for their specialized fiber optic and RF/microwave product needs, especially where low manufacturing volumes are involved. With low volumes and specialized needs, it is difficult for customers to find a supplier and avoid engineering-intensive in-house capital projects. Example short run products are inter-building and intra-vehicular fiber optic links. Such links may require non-standard or multiple data rates, non-standard equipment interface levels or connectors, wide temperature ranges, ruggedizing, radiation resistance, specialized packaging, etc.

FIBER OPTIC LINKS

TME can design and short run manufacture Fiber Optic Translators with similar features and functions to the related test equipment described starting on page 10. Such products include single and multiple channel fiber optic digital and analog transmitters, receivers, and transceivers operating from ~10 Mb/s to ~43 Gb/s. Single wavelength, WDM, CWDM, and DWDM models can be supplied in the 850, 1310, and 1550 nm regions. Extended temperature, ruggedizing, and other options are available.

Example Transceivers

Description	Order Qty	Price Each
Single Channel Transceiver	1	$32,900
• 0 dBm Transmit power, -22 dBm Receive sensitivity	2	17,475
• 1310 nm, 1.1 Gb/s maximum data rate	3	12,325
• DIN 47256 optical I/O, for multimode 62.5 micron fiber	4	9,775
• D-Sub electrical I/O, 9 pin female, un-sealed	5	8,225
• AC coupled differential electrical I/O, ECL levels	10	5,075
• 2.6”x4.6”x1.2” gray aluminum case, gasket lid, 10 oz.	20	3,525
• -40°C to +75°C operating temperature (case)	50	2,550
• For military use in strong EMI/RFI and salt spray environment	100	2,100
Dual Channel Transceiver (fully redundant)	1	$34,150
• 0 dBm Transmit power, -22 dBm Receive sensitivity	2	18,725
• 1310 nm, 1.1 Gb/s maximum data rate	3	13,575
• DIN 47256 optical I/O, for multimode 62.5 micron fiber	4	11,025
• D-Sub electrical I/O, 9 pin female, un-sealed	5	9,275
• AC coupled differential electrical I/O, ECL levels	10	6,225

Description	Order Qty	Price Each
• 3.6”x4.6”x2.2” gray aluminum case, gasket lid, 16 oz.	20	4,625
• -40°C to +75°C operating temperature (case)	50	3,425
• For military use in strong EMI/RFI and salt spray environment	100	3,125

Example 3 Channel ECL Receiver

Description	Order Qty	Price Each
3 Channel Fiber Optic Receiver	1	$13,575
• 155.52 Mb/s data rate (STM-1 or OC-3)	2	11,200
• -20 dBm sensitivity and -3 dBm overload @ 10E-12 BER, minimum	3	10,075
(-30 dBm sensitivity on request)	4	9,400
• 1310/1550 nm (1250-1600 nm) optical input	5	8,950
• FC optical input connectors, single mode or multimode		
• 50 ohm BNC electrical output connectors		
• All connectors rear panel mounted		
• Differential data and clock electrical outputs, ECL levels, AC coupled (50 KHz roll-off)		
• 19 inch rack-mountable aluminum case, 1U (1.75”) x 12”deep, black (or natural aluminum) color with white (or black) silk-screened text on front and rear panels		
• Worldwide auto-ranging AC power supply (120/240 VAC, 50/60 Hz, 50 W max.)		
• 0°C to +50°C operating temperature, unattended operation (no controls included)		
• Operating manual		

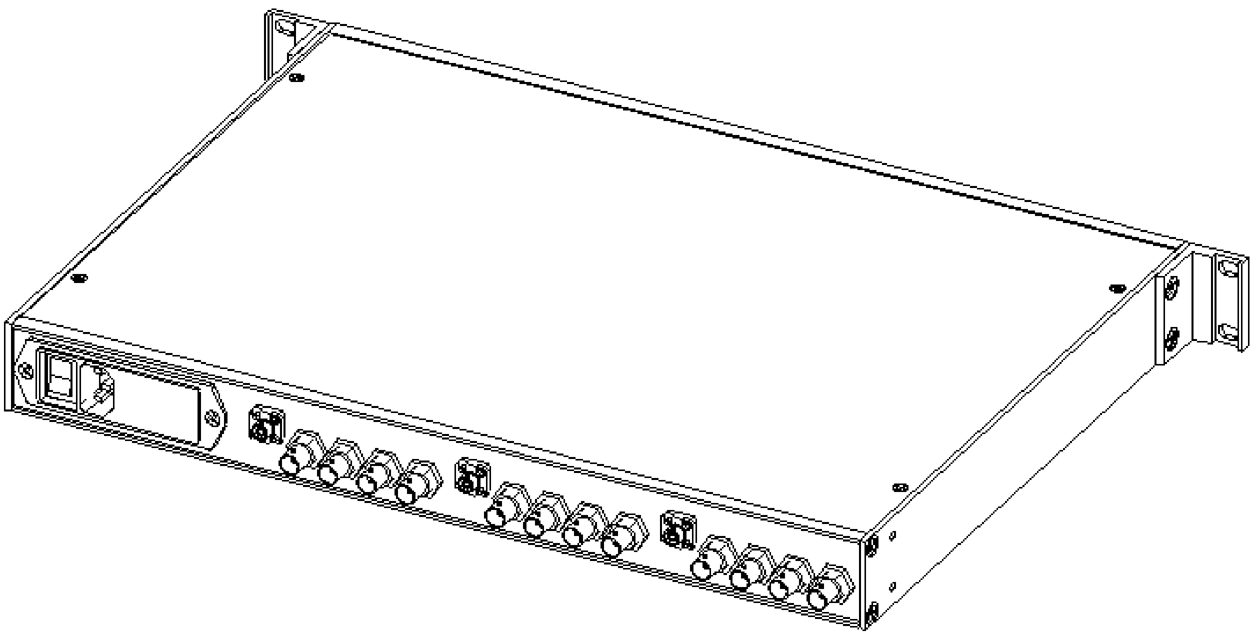


Figure 42. Rear CAD View of 3 Channel Fiber Optic Receiver

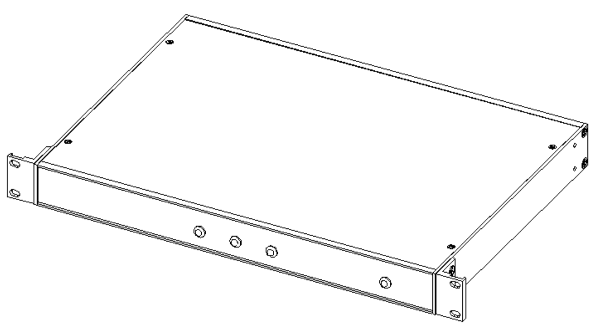


Figure 43. Front CAD View of 3 Channel Fiber Optic Receiver (4 LED indicators)

Example ECL Transceiver

Description	Order Qty	Price Each
Single Channel Transceiver (OTX and ORX) • 0 dBm min. optical transmitter power • -22 dBm min. optical receiver sensitivity, 0 dBm min. overload • 1310 nm ±10%, for single mode fiber up to 50 km or more • 600 Mb/s minimum optics bandwidth • Four clock-data recovery PLL circuits on receiver path • 25 Mb/s, 50 Mb/s, 75 Mb/s, and 150 Mb/s data rates • Data rate automatically selected • FC/SPC optical I/O connections • 50 ohm BNC-F electrical I/O • AC coupled differential electrical data and clock I/O, ECL levels • 3.5"Hx16"D natural aluminum 19" rack-mount enclosure • +0°C to +50°C operating temperature (case) • 120 VAC ±10%, 47-63 Hz, conduction cooled • Rear panel connectors, front panel power and data rate indicators	1 2 3 4 5 6 7 8 9 10	\$55,425 32,725 25,000 21,225 18,975 17,575 16,425 15,600 14,950 14,425

1CF2 SERIES - RUGGEDIZED FIBER OPTIC TRANSCEIVER

Description and Applications

The 1CF2 is a compact, ruggedized, laser class 1, fiber optic transceiver product series for Fibre Channel, Gigabit Ethernet, and other protocol applications up to 1.25 Gb/s. Models have differential electrical interfaces and are offered with single mode or multimode fiber optic interfaces for 1310 or 1550 nm operation.

- Land, air, or water vehicle communications
- Inter-facility communications
- Fibre Channel, Gigabit Ethernet, and other protocols

Figure 44. Front View of Ruggedized Fiber Optic Receiver, 1CF2

Features

- Flight qualified by a prime defense contractor
- Un-cooled 1310 or 1550 nm FP Laser with driver, 0 dBm output and ER = 10 typical
- Amplified PIN receiver with AGC and limiter, -3 dBm to -20 dBm range typical
- Ruggedized panel mount package, 2.75"H x 5.50"W x 3.65"L case
- Package sealed from dirt, salt water, EMI, and RFI, withstands vehicular shock and vibration, 22 ounces
- Rugged 38999 size 11 connectors with female electrical contacts and ball lenses
- -40°C to +71°C continuous operation
- 25 KHz to 1.25 Gb/s operation, protocol agnostic, non-inverting polarity
- Differential 150 ohm input, 200-2400 mVpp range, ESD protected
- Complementary single-ended 75 ohm outputs, 600-1200 mVpp, ESD protected

- 2 conductor single mode or multimode (50 or 62.5 uM) Tyco Expanded Beam™ optical input/output, usable with Expanded Beam™ fiber mating cable
- 4 conductor high-speed electrical differential input/output, mates to Gore 4-wire FC cable
- +5V ±10% @ 175 mA typical DC power, ESD and polarity reversal protected
- RS-485 laser enable input with open/short failsafe, ESD protected
- RS-485 transmitter fault and receiver loss of signal alarm outputs, ESD protected
- Many options and accessories available

Pricing

Price is $12,335 each in order quantity of 5 to 25 units

1CF53A – ECL TO FIBER OPTIC TRANSMITTER
1CF54A – FIBER OPTIC TO ECL RECEIVER

Description

The 1CF53A and 1CF54A form a simplex (one way) fiber optic data link operating from <10 Mb/s to > 1 Gb/s using a 1550 nm CWDM DFB laser. The 1CF53A is an ECL to Fiber Optic Transmitter (OTX) and the 1CF54A is a Fiber Optic to ECL Receiver (ORX). Their intended application is to send 100 Mb/s ECL level electrical signals from one location to another location over a long distance via a single mode optical fiber. Figure 45 shows an example simple inter-building link application.

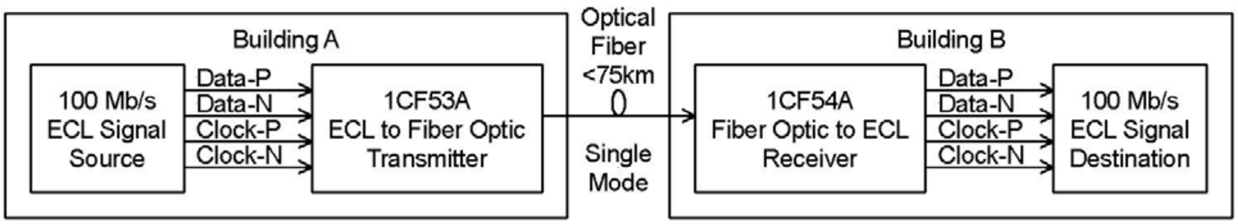


Figure 45. Basic ECL fiber link system, 100 Mb/s application

Figure 46. 1CF53A, ECL to Fiber Optic Transmitter, front and rear views

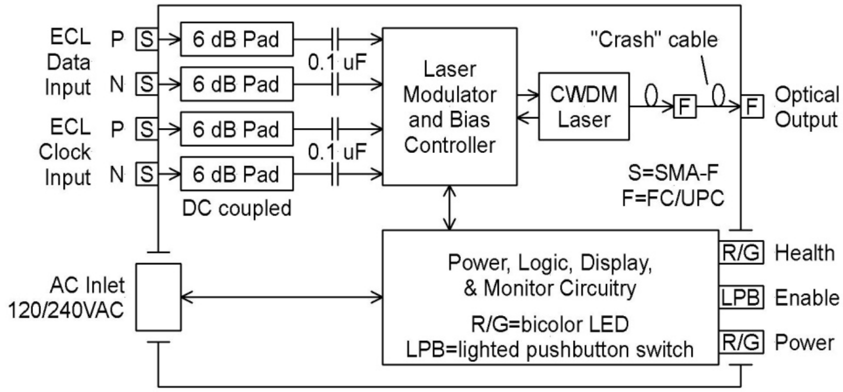


Figure 47. 1CF53A OTX, simplified block diagram

Figure 48. 1CF54A, Fiber Optic to ECL Receiver, front and rear views

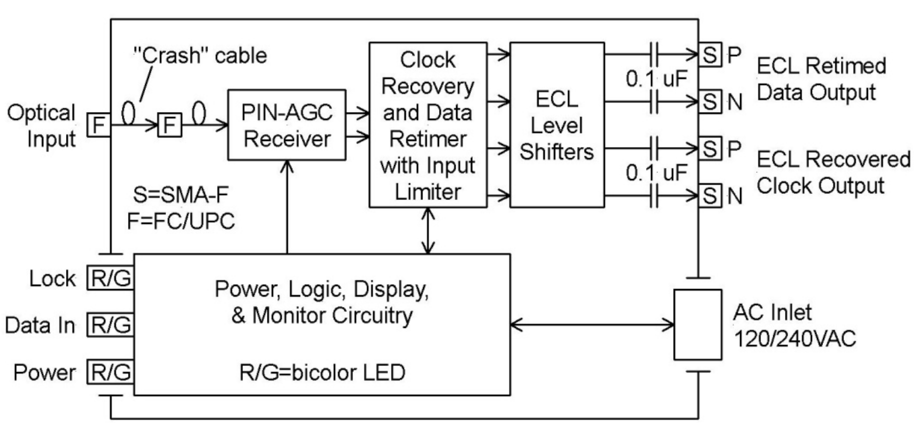


Figure 49. 1CF54A ORX, simplified block diagram

Features

- Transmitter: un-cooled CWDM 1310 or 1550 nm DFB Laser with driver, 0 dBm output
- Receiver: amplified PIN receiver with AGC, -3 to -20 dBm sensitivity, clock-data recovery, <10 ms lock time
- SMA female data and clock I/O connectors, differential, 50 ohms each connector, ECL levels, AC coupled
- FC/UPC single mode fiber optic connectors
- <10 Mb/s to > 1 Gb/s operation, protocol agnostic
- Rear panel connecttions
- Rack mount packages, 1.75”H x 19”W x 12”L, 120/240 VAC power
- Options and accessories available

Pricing

Price is $13,225 each (1CF53A) and $13,150 each (1CF54A) in order quantity of 1 unit

1CF41A – FOUR CHANNEL FIBER OPTIC DOPPLER VELOCIMETER

Description

The 1CF41A is a four channel fiber optic Doppler velocimeter. It is used with an external C-band laser, an external high speed oscilloscope, and up to four fiber optic probes to measure the velocity of reflecting metal surfaces from 5 to 3000 meters/second.

Brief Features

1. Accepts a fiber optic input signal from a CW coherent laser (0 to 2 watts max.) and produces four high speed electrical output signals derived from four fiber optic probes using interferometry.
2. Item contains one 1x4 splitter, four 3-port circulators, four manually adjusted (front panel screws) variable optical attenuators (VOA), a 4-channel fiber optic power meter, four high speed (~10 GHz BW) fiber optic receivers, four digital panel meters, fiber optic cabling and spooling, fiber optic connections, electrical cabling, power supplies, and I/O connectors for fiber optics, RF, and power.
3. Fiber optic input from laser is single mode C-band (~1528 nm to ~1565 nm) via an FC/APC connector (angled tip) with ceramic ferrule. Maximum optical input is 2 watts CW (connector cleaning very important)
4. Fiber optic I/O ports to fiber optic probes uses FC/APC connectors with ceramic ferrules.
5. All 5 fiber optic ports have internal FC/APC to FC/APC fiber optic “crash cables” that are user replaceable (open top cover). Crash cables avoid damage to expensive component connectors so that damage is done to the much lower cost crash cable connector instead. Damage typically originates by dirt from poor cleaning or breakage of FC/APC ceramic ferrule.
6. An extra set of 5 FC/APC fiber optic ports (laser and 4 probes) are provided on the rear panel so user can change from front panel to rear panel access. Connections made to front panel, unless otherwise requested.
7. Electrical RF signal output ports uses SMA female connectors and are DC coupled to the fiber optic receivers.
8. Four BNC female connectors are provided on rear panel to readout optical input power to the four receivers. Sensitivity is 1 mV per dBm (0 dBm = 0 volts, -20 dBm = -20 mV, etc.).
9. Four digital voltmeters (DVM) provided on front panel to readout optical input power to the four receivers. DVM read outs are in dBm units. DVM’s have 3.5 digits and are an LED type with green display color. Red, Blue, or Yellow LED DVM colors or an LCD type of DVM are available on request at no charge.
10. Aluminum enclosure, 19” rack mountable, nominal 1.75” high (1U) by 16.75” wide (less rack-mount ears) by 22” deep, detachable rack mount ears, removable top cover (screws), black aluminum color with white silk-screened graphics on front and rear panels, internal convection and conduction cooling to case (no fans). Natural aluminum chassis with black graphics on request at no price change. Durable laser engraved white graphics (black chassis only) at extra charge of $500 per unit.
11. 120/240 VAC (85-264 VAC), 47-440 Hz, single phase, 25 watts maximum (12 W typical), rear panel AC power switch and AC inlet, dual fused, detachable power cord, bi-color front panel LED power status indicators (green = normal, blinking yellow = DC power > 10% over or under range).
12. For stationary office, lab, factory, or moderate outdoors environments, not for exposed outdoor use, 25°C ± 20°C operating temperature range minimum. Unit fairly rugged, but is not ruggedized. Includes basic operating manual.
13. All optical I/O connectors are FC/APC (angled tip). Connections to an external laser having an FC/APC laser output connector must be made using an FC/APC to FC/APC adapter cable. The four fiber optic probes must have FC/APC connectors (angled tip). Damage will result if an FC/UPC connector (flat tip) is mated to an FC/APC connector (angled tip), which is not covered under warranty.
14. Because FC/APC connectors are used, all panel mounted fiber optic connectors use ceramic ferrules. Ceramic ferrules can break if mating is not carefully done and such ferrule breakage can easily damage both mating surfaces of fiber optic connections, which is not covered under warranty.

Pricing

1CF41A price is $96,025 each. 1K1A four probe kit (5 M long) price is $550 per kit.

Figure 50. Fiber Optic Doppler Velocimeter, 1CF41A, front and rear views

FUNCTIONAL TEST SYSTEMS AND PROCESS EQUIPMENT

Functional test systems typically have a high engineering content and still require mostly custom and typically expensive capital equipment unique to the product. This is especially true for specialized functional test systems and process equipment at the hybrid, sub-assembly and module levels. TME can provide technical and business consulting with planning and costing, multidisciplinary engineering and design, construction, and integration of specialized custom functional test and process equipment and systems needed in product research, development, and manufacturing.

Such equipment can be designed for products packaged as semiconductor or optical wafers, bare and packaged die, pre-lid and post-lid hermetic and non-hermetic hybrids, sub-assemblies, modules, and systems. Test equipment includes simple or complex, manual or automatic, functional test equipment including consoles, single or multi-head precision and/or multi-technology fixtures, custom test equipment, commodity test equipment selection, console-fixture interfaces, electrical and optical cabling, calibration standards, and accessories. Process equipment includes TME or customer defined assembly equipment, specialized precision fixtures, carriers, tooling, alignment equipment, and other items.

Partial or complete solutions can be created per customer needs, including evaluating, selecting, procuring, integrating, and documenting custom equipment with commodity equipment. Custom software can be provided upon request (Visual Basic or LabVIEW preferred) through a network of TME sub-contractors. TME can also create specialized high technology manual and automated process equipment upon request.

- Create custom capital equipment needed to test and assemble advanced technology products during research, development, and manufacturing
- Define, plan, engineer, design, manufacture, deploy, and support full-custom and semi-custom functional test and process equipment for product development and in-house or contract manufacturing operations
- Integrate TME custom equipment with new, used, or existing commodity equipment (commercial standard products) to form complete and engineered test and process systems
- Provide customers with “buy alternative” outsourcing that can also simplify needed equipment
    - Get exactly what is needed instead of using poor or expensive commercial equipment choices
    - Reduce both direct and hidden manning, time, costs, and risks with “make alternatives”
    - Avoid defining, documenting, making, revising, and supporting “home-made” equipment
- Supply manual or automated test and process consoles, fixtures, interfaces, cabling, custom equipment, etc.
- Supply fiber optic, microwave, electronic, and FEC transmitters, receivers, transceivers, sampling oscilloscope triggers, programmable fiber optic spans, switch matrices, converters, test fixtures, interfaces, etc.

TECHNOLOGY REPORTS

TME can compose an engineering technology report to help you make an informed decision. An engineering report can help you explore an idea or business venture, buy new or used capital equipment, consider a difficult technical topic and tradeoffs, or assess an expensive endeavor. An engineering technology report can help you reduce or avoid risks of failure, unexpected costs, and unconsidered alternatives. Contact TME today to discuss your needs and receive a free quote.

- Commercialize science, ideas, and prototypes into viable products at the material, component, module, equipment, or system level
- Provide or assist with advanced technology product and project definition, planning, cost analysis, performance tradeoffs, facilities, safety agencies, FCC, interoperability, offshore manufacturing, etc.
- Provide product engineering analysis for manufacturability, testability, robustness, reliability, and quality
- Help get your existing product working in production and to market on time with failure analysis, cost reduction, and design revision
- Provide second opinions, 'devil's advocacy', alternative exploration, and independent critique on product designs, proposals, capital procurement, and business decisions

FORWARD ERROR CORRECTION TECHNOLOGY REPORT

A technical report is available titled “Forward Error Correction Technology in Fiber Optic Communication Systems”. The report was originally written by Dr. Steve Morra in mid-2003 and was updated in mid-2005 to include adaptive optical and electrical equalization. The report is 228 pages long and includes 17 sections, 2 appendices, 155 figures, and 19 tables. The price is $15,000 for two paper copies, a CD copy with reference documents, and a site license to copy.

This technical report describes Forward Error Correction (FEC) technology as it is used in fiber optic communication systems, especially DWDM systems operating in the 10 to 13 Gb/s data rate range. It also describes adaptive electrical and optical equalization technologies. The report contains a great deal of technical content, which provides an excellent business and technical value to anyone involved with or considering these very complex topics.

The 17 sections of this report include: (1) Summary, (2) List of Figures, (3) List of Tables, (4) Introduction, (5) Fiber Optic Communication Systems, (6) Error Detection and Correction Codes, (7) Forward Error Correction and Digital Wrappers, (8) Digital Wrapper and FEC Transceiver Devices, (9) MUX and DEMUX Devices for Digital Wrapper and FEC Device Support, (10) Digital Wrapper and FEC IP Cores, (11) FEC Telecom Equipment Suppliers for ~2.5, ~10, and ~40 Gb/s Data Rates, (12) Testing 10 to 13 Gb/s Fiber Optic FEC Communication Systems, (13) Survey of Available 10-13 Gb/s FEC Test Equipment, (14) Conclusions, (15) References, (16) List of Abbreviations, and (17) Glossary. The two appendices are (A) FEC Update from Mid-2003 to Mid-2005 and (B) Optical Fiber, Dispersion, and Compensation.

First, a general overview of fiber optic communication systems is provided with discussion on the many kinds of fiber optic links, their optical power budgets, transmission impairments, and how FEC is involved. Various error detection and correction codes are then discussed, including some history, coding theory, block and convolutional codes, Reed-Solomon codes, turbo codes, and other codes.

Then, forward error correction and digital wrapper technologies are discussed in more depth, including a review of the ITU-T G.975 and G.709 Recommendations. Various commercial and developmental FEC approaches are discussed, including In-Band FEC, weak and strong FECs, SuperFEC™, advanced and enhanced FECs, and variable strength FEC. FEC related coding gain, bandwidth, modulation spectra, fiber optic link capacity, and other factors are examined for their advantages and disadvantages. A survey and comparison is then made for 22 available Digital wrapper and FEC transceiver (codec) devices and 11 FEC IP cores for ~2.5, ~10, and ~40 Gb/s data rates. 56 companion MUX and DEMUX circuits are also surveyed.

A discussion on testing FEC devices and test setups is used to extract the kinds of unique test equipment requirements needed for testing FEC products at the system level. A survey of available FEC test equipment is then made for eye pattern, bit error rate, jitter, optical transmitters, and optical receivers. Finally, references are provided for further FEC research.

Appendix A provides an 2005 update to the above descriptions. Appendix B discusses types of optical fiber and their non-linearities, which give rise to various kinds of signal dispersion. Then dispersion compensation is discussed, including passive and adaptive electrical and optical dispersion technologies and devices.

CONSULTING AND ENGINEERING SERVICES

TME can provide technical and business consulting, multidisciplinary design engineering, and prototypes of advanced technology hybrids, sub-assemblies, modules, equipment, and systems.

Consulting and engineering services can be provided using mature and advanced electronic, fiber optic, and packaging technologies. TME has expertise in areas that include electrical, electronic, RF, microwave, fiber optic, transmission lines, analog, digital, interface, power, sensors, actuators, thermal, EMI/RFI, pneumatic, acoustic, magnetic, shielding, mechanical design, micro to macro and advanced packaging, hermetic and non-hermetic thin and thick film hybrids and MCM-COBs, SMT and thru-hole p.c. board and flex assemblies, and other technologies.

Consulting services can assist customers with advanced technology product commercialization, conceptualization, alternatives, manufacturability, testability, definition, planning, cost analysis, performance tradeoffs, product and equipment evaluation, critique, engineering infrastructure (CAD tools, library parts, documentation, part numbering, etc.), etc.

Engineering services can assist customers with materials, components, mechanical, electrical, electronic, fiber optic, optical, system, thermal, EMI/RFI, packaging, safety, cost reduction, failure analysis, prototyping, test or process system design, CAD, etc. Designs are composed with solid modeling, drafting, schematic capture, circuit layout, publishing, and other CAD software tools. TME maintains extensive CAD and product data libraries and supplier relationships to perform the many engineering tasks needed concerning materials, components, and equipment.

- Commercialize science, ideas, and prototypes into viable products, whether a material, component, module, equipment, or system
- Provide or assist with advanced technology product and project definition, planning, cost analysis, performance tradeoffs, facilities, safety agencies, FCC, interoperability, offshore manufacturing, etc.
- Provide product engineering analysis for manufacturability, testability, robustness, reliability, or quality
- Help get your existing product working in production, profitable, and to market on time with failure analysis, cost reduction, and design revision
- Provide second opinions, 'devil's advocacy', alternative exploration, independent critique, and failure analysis on product designs, proposals, capital procurement, and business decisions
- Engineer or co-engineer your product and develop the capital equipment needed to manufacture your product
  - OEM components, hybrids, sub-assemblies, modules, equipment, systems
  - Consumer, commercial, industrial, medical, military product engineering
  - Planning, engineering, design, and construction of related test and process equipment
- Work with a wide variety of advanced and conventional technologies, materials, components, equipment, and people
  - Electronic and electrical engineering from DC to 110 GHz, signal or power, analog to digital
  - Single mode and multimode fiber optic engineering from 800 nm to 1650 nm
  - Material, component, process, and equipment engineering, selection, and evaluation
  - Electronic and photonic packaging, micro-to-macro sizes, hermetic or non-hermetic seals
  - Mechanical, thermal, EMI, pneumatic, etc. designs for manufacturability and testability
- Partially or fully engineer and low volume manufacture prototypes of your production product design
- Get prototype products to early adopters while production products are developed for the bulk of the market
- Use CAD-office-video tools for 3D solid modeling, schematic capture, p.c. board layout, documentation, costing, and other tasks

REFERENCE DATA

STANDARD FIBER OPTIC FREQUENCIES AND WAVELENGTHS

Table 4. Standard ITU Frequencies and Wavelengths for 100 GHz Grid C and L Bands

Frequency in THz	Wavelength in nm	Frequency in THz	Wavelength in nm	Frequency in THz	Wavelength in nm	Frequency in THz	Wavelength in nm
196.1	1528.77	193.6	1548.51	191.1	1568.77	188.6	1589.57
196.0	1529.55	193.5	1549.32	191.0	1569.59	188.5	1590.41
195.9	1530.33	193.4	1550.12	190.9	1570.42	188.4	1591.26
195.8	1531.12	193.3	1550.92	190.8	1571.24	188.3	1592.10
195.7	1531.90	193.2	1551.72	190.7	1572.06	188.2	1592.95
195.6	1532.68	193.1	1552.52	190.6	1572.89	188.1	1593.79
195.5	1533.47	193.0	1553.33	190.5	1573.71	188.0	1594.64
195.4	1534.25	192.9	1554.13	190.4	1574.54	187.9	1595.49
195.3	1535.04	192.8	1554.94	190.3	1575.37	187.8	1596.34
195.2	1535.82	192.7	1555.75	190.2	1576.20	187.7	1597.19
195.1	1536.61	192.6	1556.55	190.1	1577.03	187.6	1598.04
195.0	1537.40	192.5	1557.36	190.0	1577.86	187.5	1598.89
194.9	1538.19	192.4	1558.17	189.9	1578.69	187.4	1599.75
194.8	1538.98	192.3	1558.98	189.8	1579.52	187.3	1600.60
194.7	1539.77	192.2	1559.79	189.7	1580.35	187.2	1601.46
194.6	1540.56	192.1	1560.61	189.6	1581.18	187.1	1602.31
194.5	1541.35	192.0	1561.42	189.5	1582.02	187.0	1603.17
194.4	1542.14	191.9	1562.23	189.4	1582.85	186.9	1604.03
194.3	1542.94	191.8	1563.05	189.3	1583.69	186.8	1604.88
194.2	1543.73	191.7	1563.86	189.2	1584.53	186.7	1605.74
194.1	1544.53	191.6	1564.68	189.1	1585.36	186.6	1606.60
194.0	1545.32	191.5	1565.50	189.0	1586.20	186.5	1607.47
193.9	1546.12	191.4	1566.31	188.9	1587.04	186.4	1608.33
193.8	1546.92	191.3	1567.13	188.8	1587.88	186.3	1609.19
193.7	1547.72	191.2	1567.95	188.7	1588.73	186.2	1610.06

Table 5. Standard ITU Frequencies and Wavelengths for 50 GHz Grid C and L Bands

Frequency in THz	Wavelength in nm	Frequency in THz	Wavelength in nm	Frequency in THz	Wavelength in nm	Frequency in THz	Wavelength in nm
196.10	1528.77	193.60	1548.51	191.10	1568.77	188.60	1589.57
196.05	1529.16	193.55	1548.91	191.05	1569.18	188.55	1589.99
196.00	1529.55	193.50	1549.32	191.00	1569.59	188.50	1590.41
195.95	1529.94	193.45	1549.72	190.95	1570.01	188.45	1590.83
195.90	1530.33	193.40	1550.12	190.90	1570.42	188.40	1591.26
195.85	1530.72	193.35	1550.52	190.85	1570.83	188.35	1591.68
195.80	1531.12	193.30	1550.92	190.80	1571.24	188.30	1592.10
195.75	1531.51	193.25	1551.32	190.75	1571.65	188.25	1592.52
195.70	1531.90	193.20	1551.72	190.70	1572.06	188.20	1592.95
195.65	1532.29	193.15	1552.12	190.65	1572.48	188.15	1593.37
195.60	1532.68	193.10	1552.52	190.60	1572.89	188.10	1593.79
195.55	1533.07	193.05	1552.93	190.55	1573.30	188.05	1594.22
195.50	1533.47	193.00	1553.33	190.50	1573.71	188.00	1594.64
195.45	1533.86	192.95	1553.73	190.45	1574.13	187.95	1595.06
195.40	1534.25	192.90	1554.13	190.40	1574.54	187.90	1595.49
195.35	1534.64	192.85	1554.54	190.35	1574.95	187.85	1595.91

Frequency in THz	Wavelength in nm	Frequency in THz	Wavelength in nm	Frequency in THz	Wavelength in nm	Frequency in THz	Wavelength in nm
195.30	1535.04	192.80	1554.94	190.30	1575.37	187.80	1596.34
195.25	1535.43	192.75	1555.34	190.25	1575.78	187.75	1596.76
195.20	1535.82	192.70	1555.75	190.20	1576.20	187.70	1597.19
195.15	1536.22	192.65	1556.15	190.15	1576.61	187.65	1597.62
195.10	1536.61	192.60	1556.55	190.10	1577.03	187.60	1598.04
195.05	1537.00	192.55	1556.96	190.05	1577.44	187.55	1598.47
195.00	1537.40	192.50	1557.36	190.00	1577.86	187.50	1598.89
194.95	1537.79	192.45	1557.77	189.95	1578.27	187.45	1599.32
194.90	1538.19	192.40	1558.17	189.90	1578.69	187.40	1599.75
194.85	1538.58	192.35	1558.58	189.85	1579.10	187.35	1600.17
194.80	1538.98	192.30	1558.98	189.80	1579.52	187.30	1600.60
194.75	1539.37	192.25	1559.39	189.75	1579.93	187.25	1601.03
194.70	1539.77	192.20	1559.79	189.70	1580.35	187.20	1601.46
194.65	1540.16	192.15	1560.20	189.65	1580.77	187.15	1601.88
194.60	1540.56	192.10	1560.61	189.60	1581.18	187.10	1602.31
194.55	1540.95	192.05	1561.01	189.55	1581.60	187.05	1602.74
194.50	1541.35	192.00	1561.42	189.50	1582.02	187.00	1603.17
194.45	1541.75	191.95	1561.83	189.45	1582.44	186.95	1603.60
194.40	1542.14	191.90	1562.23	189.40	1582.85	186.90	1604.03
194.35	1542.54	191.85	1562.64	189.35	1583.27	186.85	1604.46
194.30	1542.94	191.80	1563.05	189.30	1583.69	186.80	1604.88
194.25	1543.33	191.75	1563.45	189.25	1584.11	186.75	1605.31
194.20	1543.73	191.70	1563.86	189.20	1584.53	186.70	1605.74
194.15	1544.13	191.65	1564.27	189.15	1584.95	186.65	1606.17
194.10	1544.53	191.60	1564.68	189.10	1585.36	186.60	1606.60
194.05	1544.92	191.55	1565.09	189.05	1585.78	186.55	1607.04
194.00	1545.32	191.50	1565.50	189.00	1586.20	186.50	1607.47
193.95	1545.72	191.45	1565.90	188.95	1586.62	186.45	1607.90
193.90	1546.12	191.40	1566.31	188.90	1587.04	186.40	1608.33
193.85	1546.52	191.35	1566.72	188.85	1587.46	186.35	1608.76
193.80	1546.92	191.30	1567.13	188.80	1587.88	186.30	1609.19
193.75	1547.32	191.25	1567.54	188.75	1588.30	186.25	1609.62
193.70	1547.72	191.20	1567.95	188.70	1588.73	186.20	1610.06
193.65	1548.11	191.15	1568.36	188.65	1589.15		

VARIOUS COMMUNICATION FORMATS AND DATA RATES

Table 6. Raw Data Rates and Communication Protocols

Data Rate in Mb/s	Data Format	Data Rate in Gb/s	Data Format
1.544	DS1, T1, J1	560.160	DS4C, T4C
2.048	E1	565.148	E5
3.152	DS1C, T1C, J1C	622.080	OC12, STS12
6.312	DS2, T2, J2	622.08	SDH4, STM4
8.448	E2	644.5	10GE / 16
10	10BaseT Ethernet	666.51	OC192FEC-G.975 / 16
32.064	J3	669.31	OC192FEC-G.709 / 16
34.368	E3	765.56	OC192FEC-Enhanced / 16
44.736	DS3, T3	781.25	OC192SuperFEC / 16
51.840	OC1, STS1	800	Fibre Channel
89.472	DS3C, T3C	822.528	DS4X, T4X
97.728	J4	933.12	OC18, STS18

Data Rate in Mb/s	Data Format
100	100BaseT Ethernet (Fast Ethernet, FE)
100	FDDI
100	P1394 (FireWire)
124.416	DVD
125	FDDI
132.8	Fibre Channel
134.208	DS3X, T3X
139.264	E4
140	DS4C
143	DTV
143.18	SMPTE 259M Level “A” (NTSC)
150	DS4C
155.52	OC3, STS3
155.52	SDH1, STM1
166.63	OC3FEC-G.975
177	SMPTE 259M Level “B” (PAL, 4 fsc)
200	ESCON
200	P1394 (FireWire)
265.6	Fibre Channel
270	DTV, HDTV
270	SMPTE 259M Level “C”, 4:2:2
270	CCIR656
270	ITU-R601
274.176	DS4, T4
278.528	CMI (Coded Mark Inversion of E4)
311.04	CMI (Coded Mark Inversion of OC-3)
360	SMPTE 259M Level “D”, 4:2:2 (HDTV)
400	P1394 (FireWire)
400.352	J5
411.264	DS4E, T4E
450	DTV
466.56	OC9, STS9
466.56	SDH3, STM3
531.3	Fibre Channel
540	Fibre Channel

Data Rate in Gb/s	Data Format
933.12	SDH6, STM6
1000	1000BaseT Ethernet
1.062	FC, Fibre Channel (100 Mb/s)
1.120	DS5, T5
1.130	DSC4
1.244	OC24, STS24
1.244	SDH8, STM8
1.250	1GE, Gigabit Ethernet (1000 Mb/s)
1.339	GbE + FEC
1.400	DS5X, T5X
1.440	EU95 (HDTV)
1.485	SMPTE 292M (HDTV)
1.680	DS5E, T5E
1.866	OC36, STS36
1.866	SDH12, STM12
2.125	2FC, 2xFibre Channel (200 Mb/s)
2.488	OC48, STS48
2.488	SDH16, STM16
2.500	2GbE
2.667	OC48FEC-G.709
3.125	XAUI-PMD (for 10GE)
4.250	4FC, 4xFibre Channel (400 Mb/s)
9.953	OC192
10.3125	10GE
10.625	10GFC, Fibre Channel FC-10
10.664	OC192FEC-G.975
10.709	OC192FEC-G.709
12.249	OC192FEC-Enhanced
12.276	?
12.400	?
12.500	OC192SuperFEC
12.750	10GFC, Fibre Channel FC-12
39.813	OC768, STM256, OTN OTU-3
42.836	OC768FEC-G.709

UNITS CONVERSIONS

Table 7. dBm to Power and Voltage Conversion (50 ohm system)

dBm	Power in milliwatts	Volts pk-pk	Volts peak	Volts RMS
+30	1000	19.997	9.998	7.071
+27	501.2	14.157	7.078	5.006
+25	316.2	11.245	5.623	3.976
+23	199.5	8.932	4.466	3.159
+20	100.0	6.324	3.162	2.236
+17	50.12	4.477	2.238	1.583
+15	31.62	3.556	1.778	1.257
+13	19.95	2.825	1.412	0.999
+10	10.00	2.000	1.000	0.707
+9	7.943	1.783	0.891	0.630
+8	6.310	1.589	0.794	0.562
+7	5.012	1.416	0.708	0.501
+6	3.981	1.262	0.631	0.446

dBm	Power in microwatts	Millivolts pk-pk	Millivolts peak	Millivolts RMS
0	1000	0.632	0.316	0.224
-1	794.3	563.6	281.8	199.3
-2	631.0	502.3	251.2	177.6
-3	501.2	447.7	223.8	158.3
-4	398.1	399.1	199.5	141.1
-5	316.2	355.6	177.8	125.7
-6	251.2	317.0	158.5	112.1
-7	199.5	282.5	141.2	99.88
-8	158.5	251.8	125.9	89.02
-9	125.9	224.4	112.2	79.34
-10	100.0	200.0	100.0	70.71
-13	50.12	141.6	70.80	50.06
-15	31.62	112.5	56.23	39.76

dBm	Power in milliwatts	Volts pk-pk	Volts peak	Volts RMS
+5	3.162	1.125	0.562	0.398
+4	2.512	1.002	0.501	0.354
+3	1.995	0.893	0.447	0.316
+2	1.585	0.796	0.398	0.282
+1	1.259	0.710	0.355	0.251
0	1.000	0.632	0.316	0.224

dBm	Power in microwatts	Millivolts pk-pk	Millivolts peak	Millivolts RMS
-17	19.95	89.34	44.67	31.59
-20	10.00	63.25	31.62	22.36
-23	5.012	44.77	22.39	15.83
-25	3.162	35.57	17.78	12.57
-27	1.995	28.25	14.13	9.988
-30	1.000	20.00	10.00	7.071

THIRD MILLENNIUM ENGINEERING

Third Millennium Engineering (TME) can supply the custom test or process equipment needed to produce your product, help your company create products, and make and test product prototypes. TME can also design and short run manufacture fiber optic and RF-microwave products and provide technical reports on complex topics. TME works with a wide variety of advanced and conventional electronic, microwave, photonic, micro to macro packaging, and other technologies as well as a variety of materials, components, equipment, processes, and people. TME can reduce the direct and hidden manning, time, costs, risks, documentation, and support for originating special capital equipment and products, improve your product quality and profitability, reduce product time to market, or help solve your most difficult engineering problems.

PROFILE AND MISSION

Third Millennium Engineering (TME) is a Texas licensed engineering company located in Plano, Texas USA. Our mission is "to help customers create and manufacture advanced technology products for our future". TME is owned and operated by Dr. Steve Morra, a Doctor of Engineering and a Texas Professional Engineer. TME is registered with the Federal Central Contractor (CCR), Dunn & Bradstreet, and SBA Pro-NET programs and is an Agilent Channel Partner. We have been in business since 1996, previously as Microsystem Design Services since 1984.

TME is a multi-disciplinary consulting, engineering, and low volume manufacturing company that can help you realize your technical ideas. We define, create, manufacture, and support custom engineered equipment, products, and reports involving fiber optic, microwave, electronic, packaging, and many other technologies. For over two decades, we have served customers in Communication, Semiconductor, Transportation, Sensors, Biotechnology, Energy, Aerospace, Military, and Test Equipment industries. You can buy exactly what you need with as little as verbal specifications from an email or phone call. Contact TME today to discuss your needs and receive a free quote.

For more details, please visit the TME web site at http://www.tmeplano.com. Dr. Morra can be reached by email at steve@tmeplano.com or by telephone at 972-491-1132.

PRICING, DELIVERY, AND BUSINESS TERMS

Due to their custom nature, custom products shown in this catalog are usually not stocked nor can they be re-stocked from an order cancellation. Therefore, a 75% minimum cancellation fee is required due to the custom nature. Depending on the model and options, delivery is typically 8 to 12 weeks ARO as a minimum without expediting (usually set by material procurement lead-times). Any listed prices and specifications in this catalog may change without notice and are made firm upon quote. Any prices are given in USA dollars.

See http://www.tmeplano.com/termsofsale-customitems.htm for TME “Terms and Conditions of Sale for Custom Equipment and Products”. See http://www.tmeplano.com/support.htm for warranty, repair, and support options. See http://www.tmeplano.com/termsofsale-engineering.htm for TME “Terms and Conditions of Sale for Consulting and Engineering Services”.

Contracted Projects and Retainers

TME will contract with a prospective customer for an outsourced engineering project or a consulting or engineering retainer. Example projects are engineered custom equipment, custom products, standard products, and technology reports. The process begins by discussing customer needs sufficiently so that TME can generate a free written quote. TME will negotiate, modify, and re-issue the quote until it is satisfactory to both parties. A typical quote names the parties involved, technically names and describes the project in high level terms, and states price and delivery. It also states any particular business terms and references general business terms for custom equipment and products or consulting and engineering services as applicable. A quote considers consulting and engineering efforts, project risks, travel, and other costs. Materials, labor, overhead, tooling, assembly, test, yield, rework, warranty, insured shipping, and other costs are considered for custom equipment, custom products, or standard product prototypes.

The quote becomes a contract when TME receives a purchase order and returns an order acknowledgement to the customer. At that time, TME will begin work and procurement on the project or begin retained work. The contract can be re-negotiated to some extent during the course of the project to accommodate significant changes in the project scope, requirements, or responsibilities. However, some kinds of project changes can be accommodated without contract re-negotiation by using TME engineering and consulting services. Call TME to discuss your custom project needs and receive a free quote.

Engineering and Consulting Services

TME engineering and consulting services can be useful in early stages of a project. Examples are for business and technical planning, project definition, idea generation, or other tasks with difficult-to-determine durations or scopes. They can also be used to accommodate minor changes in a contracted project and to perform material, component, or equipment searches where engineering or consulting judgment is important. These services are provided on a per diem plus expenses basis. Visit http://www.tmeplano.com/company.htm for more details.

NOTES

