OPERATION and MAINTENANCE MANUAL

MODEL 144-692

FOL-100 FIBER OPTIC LINK

Serial Number _____

February 3, 2000

Revision C

NOTICE ON SCHEMATICS

Please be advised that there may or may not be references in the text of this manual to schematic drawings. TrueTime's general policy is to not include schematics because they may contain proprietary information. If you require copies of any schematic, please contact:

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5. DETAILED DRAWINGS

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1. GENERAL INFORMATION

1.1. SCOPE OF MANUAL

This manual contains the information necessary to operate and maintain a TrueTime Model FOL-100 Fiber Optic Link.

1.2. PURPOSE OF EQUIPMENT

The Model FOL-100 provides a secure, low loss method of interconnecting a standard TrueTime Down Converter and a GPS clock equipped for use with a down converter. It can be employed wherever a security boundary must be entered, or when protection against lighting strikes is desired, or where the down converter must be located a long distance from the clock.

1.2.1. Physical Specifications

1.2.1.1. FOL UNITS

Form:	Two small enclosures, alodined and painted aluminum.
Dimensions:	4.28"w X 1.50"h X 2.13"d (each)
Weight:	Approximately 12 ounces (each)
Fiber Length:	1 to 2000 M (6560')
Coax Length:	122 M (400') Clock to FOL or FOL to D/C
Connector Type:	ST

1.2.1.2. Optional Power Supply

Form:	Plastic desktop enclosure.
Dimensions:	2.96"w X 5.83"l X 1.78"d
Weight:	Approximately 1.04 pounds.

1.2.1.3. Optional Outside Enclosure

Form:	Fiberglass enclosure, hermetically sealed.
Dimensions:	6.50"w X 8.00"h X 5.38"d
Weight:	Approximately 10 pounds
Standard:	NEMA 4X and many others.

1.2.2. Environmental Specifications

1.2.2.1. FOL UNITS

Operating Temp:	-40 to +80° C
Storage Temp:	-60 to +100° C
Humidity:	95% relative, non-condensing
Cooling Mode:	Convection
Special:	When installed in the Truetime specified Outside Enclosure, (NEMA 4X) and with TrueTime specified power, fiber, and coaxial cables, the antenna end may be safely installed in any natural or industrial environment.

1.2.2.2. Optional Power Supply

Operating Temp:	-0 to +40° C
Storage Temp:	-40 to +70° C
Humidity:	20-90% relative, non-condensing
Cooling Mode:	Convection

1.2.3. Power Requirements

1.2.3.1. Antenna End

Voltage:	12 VDC +30-10% (external source)
Optional Voltage:	39.5 to 60 VDC (external source)
Power:	5 Watts maximum

1.2.3.2. Clock End

Voltage:	12 VDC (supplied by clock)
Power:	3 Watts maximum

1.2.3.3. Optional Power Supply (for antenna end)

Input Voltage:	90-265 VAC
Output Voltage:	12 VDC
Power:	30 Watts maximum

1.2.4. Signal Specifications

1.2.4.1. Inputs (Clock End)

Type:	Coaxial (mixed with 4.092 MHz output, see below)
Amplitude:	100 mV minimum
Impedance:	50Ω
Frequency:	16.368 MHz
Type:	Optical Fiber, 62.5/125 μM, 850 nM carrier
Amplitude:	-16 dbm (typical)
Frequency:	4.092 (spread spectrum) MHz

1.2.4.2. Inputs (Antenna End)

Type:	Coaxial (mixed with 16.368 MHz output, see below)
Amplitude:	100 mV minimum
Impedance:	50Ω
Frequency:	4.092 (spread spectrum) MHz
Type:	Optical Fiber, 62.5/125 μM, 850 nM carrier
Amplitude:	-16 dbm (typical) - 3db/km fiber length
Frequency:	16.368 MHz

1.2.4.3. Outputs (Clock End)

Type:	Coaxial (mixed with 16.368 MHz input, see above)
Amplitude:	100 mV minimum
Impedance:	50Ω
Frequency:	4.092 (spread spectrum) MHz

Type:	Optical Fiber, 62.5/125 μM, 850 nM carrier
Amplitude:	-16 dbm (typical)
Frequency:	16.368 MHz

1.2.4.4. Outputs (Antenna End)

Type:	Coaxial (mixed with 4.092 MHz input, see above)
Amplitude:	100 mV minimum
Impedance:	50Ω
Frequency:	16.368 MHz

Type:	Optical Fiber, 62.5/125 μM, 850 nM carrier
Amplitude:	-16 dbm (typical)
Frequency:	4.092 (spread spectrum) MHz

2. INSTALLATION AND OPERATION

2.1. INSTALLATION

2.1.1. General

The TrueTime Model FOL-100 Fiber Optic Link requires consideration of certain parameters prior to installation. The simplest installation requires that a suitable length of Optical Fiber be installed between the clock site and the Antenna / Down Converter site. Mounting the FOL units on a suitable surface, and connecting the fibers and the coax cables is also required. In the case of the Antenna side, you must install the power supply and hook up its power cables. **Note that the mounting holes in the mounting flange were designed to mate with any two vertical holes in a standard 19" equipment rack or cabinet.** They may also be used to mount the modules to any flat surface. Be careful to allow enough room for the fibers to make any required bends in a gentle radius. Typically no bend radius should be less than 10X the cable outside diameter. The optical connectors are the "ST" style. See Appendix A for a list of recommended electrical and optical cables and suppliers. TrueTime may also have supplied cable or cable assemblies as part of the order. Be especially careful when handling the optical fibers to avoid the inclusion of dirt or any other contaminant in the optical fiber connectors since this will have a negative effect on system performance.

2.1.2. Method 1

The OPTIONAL power supply is a desktop unit which will accept all world wide power. It is not designed for extreme environmental conditions, and so must be located in a benign location. See Specifications. It comes with a 1M long cable with installed connector for direct connection to the Antenna End FOL.

2.1.3. Method 2

For other than standard conditions, the power supply needs to provide 12 VDC +30-10 % at the connector to the FOL. I^2R losses in the DC power cable as well as the coax cable between the FOL and the down converter must not reduce the voltage at the down converter below 8 VDC worst case. The recommended coax is Belden 8219 which has a center conductor DC resistance of 8.8Ω/1000' and a shield DC resistance of 4.1Ω/1000' for a total DC resistance of 12.9Ω/1000'. The Antenna / Down Converter draws about 200 mA of current. 4V drop allowed from the 12 VDC in @ 200 mA equals total DC resistance of 20Ω or 1,550' of Coax. Since the maximum run of coax is limited to 1000' for RF reasons, this is no problem. However, if you need to locate the power supply some distance away, you should consider the I^2R losses in the DC power cable. The maximum gauge wire that will fit in the power connector is 20 AWG. Typical 20 AWG wire has a dc resistance of about 10Ω per 1000'. This must be doubled since the current goes both directions. If the antenna/down converter is 1000' away, the I^2R loss is 12.9Ω X .2A or 2.58 V, leaving a maximum I^2R loss of 1.42V in the Power cable. Since the combined load of the antenna, down converter and fiber is about .4 A that leaves only 3.55 Ω or 177.5' of power cable. Furthermore, the input voltage at the FOL module should be maintained within +30-10 % of the nominal 12 VDC input for proper operation. If the Power supply must be located more than 50'

from the FOL module, it is recommended that a remote sensing supply be used with Kelvin sense leads on both the Plus and the Minus leads, and attached to the current carrying leads right at the FOL module. Please refer to the power supply operating instructions for hook-up information. Also found in the instructions are methods that may be required to frequency-compensate the supply and prevent oscillations that may occur in this mode of operation. Another option is to set the power supply voltage higher than nominal to compensate for the line losses. This works because the load is fairly constant and tight regulation is not required.

2.1.4. Method 3

In this method you order the optional input voltage option which adds a 5W DC to DC converter module to the FOL module. This module accepts a wide range of input voltages (39.5-60VDC) and converts it to 12VDC with about 80% efficiency. This results in an input current of only 0.156A at 40V or 0.104A at 60V. The 4X reduction in current allows cable lengths to be at least 4X longer, and an un-regulated supply may be used. Further, the larger input voltage compliance (20V Vs 4V) allows potentially even longer lengths of wire to be used. Lastly, this input range was chosen to allow use in Telecom sites running on 48VDC (nom.) battery systems.

2.1.5. Outside Installations

When installing the Antenna End FOL outside or in an unprotected location, use TrueTime specified components such as the optional Outside Enclosure (or a TrueTime approved substitute) to obtain reliable long term operation. The methods outlined above are essentially the same, but extra steps, such as mounting the enclosure and installing connectors are required. We have made certain recommendations based on a survey of what is available in the market, but other products may work as well. Since TrueTime has no control over the installation process, the customer's installer assumes all responsibility for any deviations from recommended products or practices. This may be required by such material conditions as having to use an existing fiber optic cable. Since there are so many possibilities, only the "standard" installation will be described.

Install the Outside Enclosure in the most favorable location. Consider such factors as service access (especially in inclement weather) power availability, and vandalism. Route the coax cable from the Down Converter into the box through the middle packing gland. Allow enough cable for a generous service loop and cut off any excess. Route the recommended power cable into the box through the left hand packing gland. Route the recommended optical cable into the box through the right hand packing gland. Allow enough cable for a generous service loop and cut off any excess. In the case of the optical cable allow enough cable for 2 full loops of the minimum bend radius. Tighten the packing gland collars so that they will prevent the cable from being withdrawn from the box with a minimum of a 20 pound pull. Using cable ties, tie back the cables to avoid hazards to personnel. The recommended optical fiber and power cable can both be used outdoors in aerial or direct burial applications without any additional protection from the elements. Aerial installations should use a suitable messenger wire to support them. Take wind and ice loading into account when sizing the messenger. The recommended optical fiber is a tightly coupled product which can be installed with regular wire - pulling techniques in long vertical runs without

problem. It is UL listed and Riser rated so that it does not require a splice box or vault when coming inside a building. Terminate the power, coax, and fiber connectors per standard practice and connect them to the FOL module inside the box. It doesn't matter which fiber is which, if the clock doesn't acquire satellites in a normal amount of time, simply reverse the fibers at the clock end. Install the fibers with a very generous loop so that they are not bent too tightly. A loop as big as the inside dimensions of the box will do. Tuck all loops neatly inside the box and close and secure it with the screws provided. Be careful not to kink either the fibers or the coax cables. Where lightning is a problem, use a properly installed coaxial lightning arrester outside of the box to extend the life of this product. In an extensive antenna farm the use of lightning dispersing systems may be economically advisable.

2.1.6. Finish

Install the Clock and Down converter according to their manuals. Install the Clock End FOL near the Clock and connect it to the antenna input of the clock with the provided coax cable. The Clock End FOL is powered by the clock. Secure the optical cable near the FOL and attach it to the FOL after any required connections.

2.2. OPERATION

Other than insuring that power is applied to the FOL, there are no other operating instructions. However, if the fiber is a long one, you will want to compensate the clock for its length by using the standard cable length compensation function (51) of the clock. The propagation delay of the fiber is roughly the same as the coax that would normally be installed. It is more precisely equal to the speed of light (2.998×10^8) divided by the group refractive index of the fiber. For the fiber we recommend the group refractive index is 1.496 at 850 nM and 1.491 at 1300 nM. Thus, at 850 nM, the correction factor for the recommended optical cable is 1.52 ns per foot. Don't forget to add in any coax between the down converter and the propagation delay of the FOL modules which is $\cong$180 ns. The exact delay through the modules is marked on the rear panel of the clock end FOL. Also, do not forget that the position the clock reports is the position of the antenna, not the clock, since they may now be physically quite a distance apart.

3. THEORY OF OPERATION

3.1. GENERAL INFORMATION

This section contains the theory of operation of the FOL-100 Fiber Optic Link. The link is used to provide a secure connection between clock and down converter for Tempest or other secure facilities. It is also used to provide an extra long link, up to 2 KM, or to provide an EMI immune link in a noisy environment. The FOL can be used to provide a lightning-proof link where lightning is a problem. In this respect the Antenna End FOL is considered expendable since there is not much that would save it from a direct stroke. However, the clock end of things would be safe.

3.2. HARDWARE DESCRIPTION

The FOL-100 Assembly, which consists of two enclosures and a length of dual fiber optic cable is intended to be used in systems that are equipped to use the TrueTime down converter. The clock end serves to separate the 16.368 MHz signal going to the down converter from the 4.092 MHz coming from the down converter. It also uses the DC component of the mixed signal provided by the clock to power itself. It is equipped with a fiber receiver and a fiber transmitter. The transmitter sends the 16.368 MHz to the down converter by amplitude modulating a cw lightwave and launching it into a 62 micron glass optical fiber. The receiver gets a similar signal at about 1/4 the frequency which it buffers and then adds to the 16.368 MHz signal coming from the clock. At the Antenna end of the link, the FOL receives the 16.368Mhz signal from the clock end, buffers it and adds it to the 4.092 MHz signal coming from the down converter. It takes the 4.092 MHz signal and sends it down to the clock by amplitude-modulating a cw lightwave and launching it into a 62 micron glass optical fiber.

The two signals are separated in the fibers, but combined in the coax cables.

4. MAINTENANCE AND TROUBLESHOOTING

4.1. INTRODUCTION

Effective maintenance and troubleshooting of this equipment requires a thorough understanding of equipment characteristics, operating procedures, theory of operation and knowledge of both linear and logic circuit elements. The equipment characteristics, operating procedures, and the theory of operation for the system processor (if one exists) are provided in SECTION ONE through SECTION THREE of this manual. A working knowledge of Fiber Optics theory and connection methods is also required.

4.2. PREVENTIVE MAINTENANCE

A systematic preventive maintenance routine can reduce the possibility of a malfunction. This routine should include inspection, qualification and cleaning of the instrument.

4.2.1. Inspection

Exercise care when handling this equipment. It contains sensitive parts that can be damaged by improper handling. Do not touch connector pin surfaces because of the danger of static discharge. Deposits on contact surfaces can cause corrosion, resulting in equipment damage or failure. Inspect the unit for damaged components, loose or frayed connections and corrosion on metal surfaces. If damage is found, correct it immediately. Be careful not to get any foreign material into fiber optic connections as it will degrade or destroy the connection. Keep in mind that the active signal path in the fiber is only 62.5 microns in diameter, which is thinner than a human hair, and so requires only a trace quantity of material to disrupt it.

4.2.2. Cleaning

Accumulations of dust and dirt can impair cooling and cause performance degradation. The equipment may be cleaned by the use of a vacuum cleaner or compressed air, and if the problem is bad enough with a cloth dampened with clean water and a mild detergent. Thoroughly rinse cloth with clean water after washing, and wipe off washed areas to remove any residue. Be careful not to get water into switches or pots or ***Fiber Optic connectors***. Thoroughly dry the equipment with compressed air, and/or time permitting, by air drying. Circuit cards may be cleaned using the procedure in their manuals. If you suspect that a fiber connector has been fouled, it may be cleaned with ***clean*** isopropyl alcohol in spray form, followed by a jet of ***clean, dry*** air. Do not use any form of cloth or tissue to attempt cleaning as this may only aggravate the problem.

4.2.3. Qualification

Verify that the unit meets all of the applicable specifications listed in Section One. Failure to meet a specification is an indication of malfunction and should be corrected immediately.

The following suggestions are general in nature. When followed, they will minimize equipment down time. Use these suggestions in conjunction with the drawings in Section Five and the circuit descriptions in Section Three to diagnose equipment malfunctions.

4.2.4. General Troubleshooting Procedures

Since an apparent problem may actually be the result of operator error, misunderstanding or misuse, the technician will need a thorough understanding of the normal operation. Refer to SECTION TWO for a description of normal operation. Thoroughly evaluate the procedures used by the operator when the malfunction occurred.

4.2.5. Power Circuits

Verify that the power supply is as specified. Verify that the primary power fuse has not blown and that primary power is present. Check external loads where applicable. In dual supply systems, verify that both are functional.

4.2.6. Locating Drawings

Reduced drawings of all mechanical assemblies and schematics are located in SECTION FIVE of this manual. The index contains a list of the drawings and circuit card manuals included in this manual.

4.2.7. Locating Circuits

SECTION THREE provides a written description of this equipment. Use this information in conjunction with the schematics while troubleshooting.

4.3. CORRECTIVE MAINTENANCE

4.3.1. Replacing Components

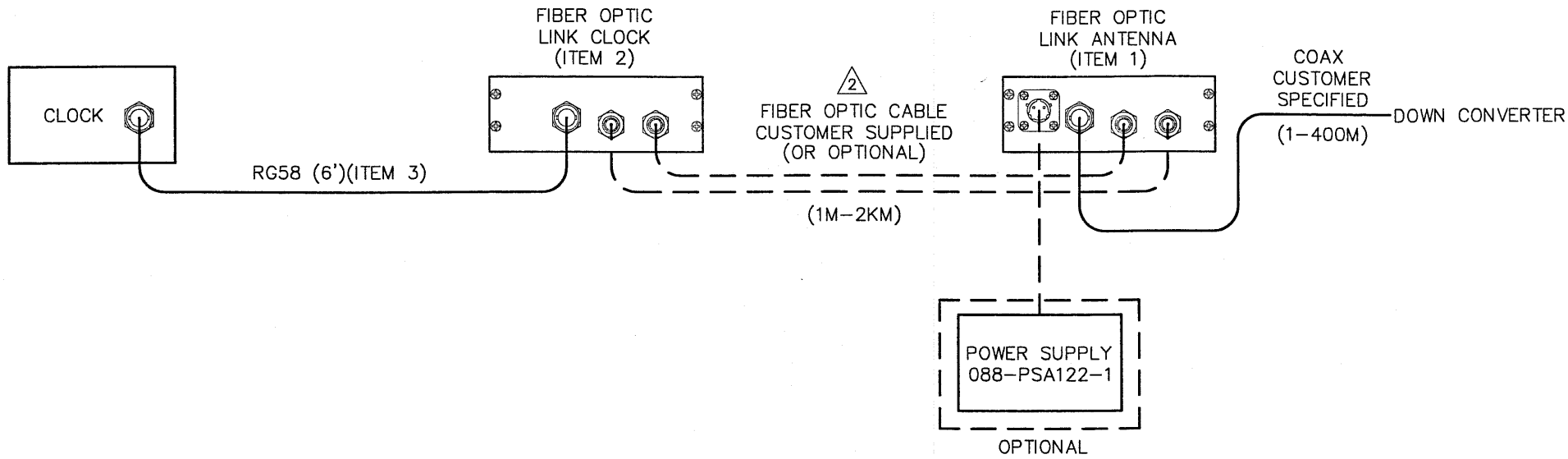
It is imperative that the ICs are replaced with exactly the same type of component. Do not guess in this area. Use the parts lists to find the exact IC part number. Use only a vacuum powered solder extractor to desolder parts. Many boards have ground and power planes which make it virtually impossible to desolder the power and ground pins of a part using solder wick or the spring or rubber bulb powered solder suckers without damaging the PCB. Using any but the recommended method will void any warrantee on the card. If in doubt, return

the card to the factory for repair or replacement. Be sure not to bend the IC legs under when replacing them.

4.3.2. Soldering Components under

When replacing soldered components, use a low wattage 700°F iron and be careful not to overheat the etch or use excessive pressure. Remember that heat and pressure is all that it takes to lift the etch and possibly even the plated through-hole of the connection. Use solder with a water soluble flux core such as Kester QQS-571 and clean the soldered joints carefully with water. Do not allow water to penetrate the pots or switches. Thoroughly dry the PCB after cleaning using compressed air, a low temperature (100°F) oven or just plain sunlight. The flux is hydroscopic and must be removed to avoid corrosion of the PCB traces. Rosin core solders are not recommended because of the hazards posed by the required cleaning solvents.

REVISIONS			
REV	DESCRIPTION	DATE	APPROVED
A	ADD NOTE 2 AND CABLE LENGTH	10-25-95	
B	CHANGED DWG No. FROM 142-692 TO 144-692	3-7-96	



2 1 METER LONG DUAL TEST FIBER 048-001 IS SUPPLIED WITH EACH LINK FOR TESTING.

1. ASSEMBLY VIEW SHOWN FOR REFERENCE; ITEMS ARE NOT ASSEMBLED AT FACTORY.

NOTES: UNLESS OTHERWISE SPECIFIED.

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES ARE: FRACTIONS ± DECIMALS .XX=±.01 .XXX=±.005 ANGLES ±2° ALL THREADS TO BE CLASS 2 PER ANSI Y14-6 MACH COR-.005 TO .015R OR CHAM SH MATL-DEBURR & BREAK EDGES .015 MAX R DIM. AND TOL. APPLY FIN. TREAT. MATERIAL FINISH FILENAME: \100\44-692 DATE: 3-7-96	CONTRACT NO, APPROVALS / DATE DRAWN BY SEIFERT 10/95 CHECKED BY APPROVED BY 3-7-96 NEXT ASSY	TrueTime 2835 DUKE CT. SANTA ROSA CA 95407 FIBER OPTIC OPTION SIZE B · CODE IDENT NO. · DRAWING NO. 144-692 · REV B SCALE NONE · SHEET 1 OF 1

MAX 1 BILL OF MATERIALS 1 SINGLE-LEVEL EXPLOSION BY PART IDENTIFIER W/REFERENCE

PART IDENTIFIER	DESCRIPTION 1	DESCRIPTION 2	EFF DATE	ECN #	QTY/ASSY	UOM	REV LVL	REFERENCE DESCRIPTION
144-692	FIBER OPTIC OPTION					EA		
0000-APPROVAL	PARTS LIST APPROVAL				1.0000	EA		DMS 3-7-96
0000-PL	PARTS LIST REV LEVEL				1.0000	EA		REV B (02-26-96)
0000-PRINT	REFERENCE PRINT				1.0000	EA		144-692 REV B
048-001	FIBER OPTIC 1M TEST CORD	FIBER INST D2-55-M-1-FIS			1.0000	EA		CUSTOMER TEST CABLE
150-692	FNL ASSY FIBER OPTIC LINK	ANTENNA (UPPER)			1.0000	EA		01
150-693	FNL ASSY FIBER OPTIC LINK	CLOCK (LOWER)			1.0000	EA		02
338-006-0	COAX CA BNC-BNC 6 FT.	RG58			1.0000	EA		03
372-03P	CONN,3-P PLUG (CABLE)	CANNON KPT06F8-3P			1.0000	EA		SHIPPING KIT (P/S MATE)
LA	LABOR ASSEMBLY COST HRS				0	EA		
LT	LABOR TEST COST HOURS				0	EA		
NOTE 1					1.0000	EA		

THE FIBER OPTIC CABLE IS CUSTOMER SUPPLIED UNLESS SPEC'D (OPTIONAL) ON THE SALES ORDER.
THE POWER SUPPLY IS OPTIONAL (SALES ORDER ITEM).
THE ANTENNA COAX IS CUSTOMER SPECIFIED (SALES ORDER ITEM).