

OPERATION AND MAINTENANCE MANUAL

FOL-100 FIBER OPTIC LINK

150-704 / 150-705

Serial Number _____
January 28, 1999
Revision N/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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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 two pieces of equipment with a variety of time code and pulse train type signals. It can be employed wherever a security boundary must be entered, or when protection against lightning strikes is desired, or where the two pieces of equipment must be located a long distance apart.

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:	100 M (either end)

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

1.2.2. 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, either end may be safely installed in virtually 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. Transmitter End

Voltage: 12 VDC \pm 10% (external source)
Power: 3 Watts maximum

1.2.3.2. Receiver End

Voltage: 12 VDC (external source)
Power: 3 Watts maximum

1.2.3.3. Optional Power Supply (for either end)

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

1.2.4. Signal Specifications

1.2.4.1. Input (Transmitter End)

Type: Coaxial
Amplitude: 1-3 Vpp for AC signals, .5 -10 Vpk for digital signals
Impedance: $>10K\Omega$
Frequency: DC to 100m KHz

1.2.4.2. Output (Transmitter End)

Type: Optical Fiber, 62.5/125 μ M, 850 nM carrier
Amplitude: -16 dbm (typical)
Frequency: 10 MHz Frequency Modulated (DC to 100 KHz modulation)

1.2.4.3. Input (Receiver End)

Type: Optical Fiber, 62.5/125 μ M, 850 nM carrier
Amplitude: -16 dbm (typical) - 3db/km fiber length
Frequency: 10 MHz Frequency Modulated (DC to 100 KHz modulation)

1.2.4.4. Output (Receiver End)

Type: Coaxial
Amplitude: 1-3 Vpp (IRIG CODES), 5 Vpk (DC pulse trains)
Load Impedance: 50Ω
Frequency: DC to 100 KHz

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 equipment sites. Mounting the FOL units on a suitable surface, connecting the fibers and coax cables, and installing the power supply and hooking up its power cables is also required. **Note that the mounting holes in the mounting flange were designed to mate with any two vertical holes in a standard 19-inch 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 bad effect on system performance.

2.1.2. Method 1

The OPTIONAL power supply is a desktop unit that 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 either FOL.

2.1.3. Method 2

For other than standard conditions, the power supply needs to provide 12 VDC $\pm 10\%$ at the connector to the FOL. I^2R losses in the DC power cable must not reduce the voltage at the FOL below 10.8 VDC worst case. 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 feet. This must be doubled since the current goes both directions. If the FOL is 1000 feet away, the voltage loss is $.25 \times 20 = 4V$ in the power cable. Therefore, 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, 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. Alternatively, you can 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. In this case adjust the power supply voltage so that there is 12 VDC $\pm 10\%$ measured right at the power connector.

2.1.4. Finish

Install the associated equipment according to their manuals. Install the Transmitter End FOL near the source equipment and connect the FOL to the source equipment with the provided coax cable. Install the Receiver End FOL near the destination equipment and connect the FOL to the destination equipment with the provided coax cable. Secure the optical cable near the FOLs and attach it to the FOLs after any required fiber connections.

2.2. OPERATION

Other than insuring that power is applied to the FOLs, there are no other operating instructions. However, if the fiber is a long one, you will want to compensate the destination equipment for its length, using the standard cable length compensation function of the equipment. 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 source equipment and the transmit end FOL and the propagation delay of the FOL modules ($\cong 180$ ns). The exact delay through the modules is marked on the rear panel of the receiver end FOL.

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 source and destination equipment 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.

3.2. HARDWARE DESCRIPTION

The FOL-100 Assembly, which consists of two enclosures and a length of fiber optic cable is intended to be used in systems that need the advantages of fiber in transmitting various types of coded signals. The transmit end sends the signal to the receive end by frequency modulating a 10 MHz carrier which is then used to modulate a cw lightwave and launch it into a 62 micron glass optical fiber. The receiver takes the lightwave signal and converts it to an electrical copy which it detects and amplifies and buffers to compensate for fiber and conversion losses. The buffer is capable of driving a 50 Ω load. Refer to the schematic diagrams for the discussion below.

3.2.1. Transmitter

Refer to the 86-705 schematic for the following discussion. Power is brought onboard via P2 and is filtered by C5, L1, and C7. F1 is a Polyswitch fuse device which self-resets when the fault level current is removed. CR1 is an over-voltage and reverse voltage protection device that serves to limit input voltage to a safe level and polarity. U5 regulates the nominal input 12 VDC to 5 VDC. C9 serves to improve the transient response of the regulator. U6 is a voltage inverter used to generate -12 VDC from the 12 VDC input. L2 and C12 serve as a low pass filter designed to prevent the U6 switching noise from propagating into other circuits. Q1 serves as a protection device for U6 to prevent latch-up during turn on transient conditions.

CR2 is a stabilized 5 VDC reference diode which is powered via R9. The stable reference voltage is fed to two voltage dividers consisting of R1 and R7 for the DC mode of operation and R13 and R14 for the AM mode of operation. A voltage follower, U1:A buffers the voltage divider and drives a summing node consisting of R2, R3, and R5. The purpose of this signal is to set the operating point of the VCO to an appropriate level for the type of signal to be sent. The input signal comes aboard at P1 and drives two voltage dividers consisting of R16 and R20 for the AM mode and R15 and D1. D1 clips the signal to about 350 millivolts and allows for a very wide range of digital inputs to be accommodated. Buffer amp U1:B has its gain controlled by jumper JP3 which selects between R17 and R18 and which serves to normalize the frequency deviation generated by the VCO. Its output drives the summing node at R3. U7:A is a non-inverting summing amplifier whose gain is 2/3 as seen by U1:A or U1:B. Its output drives the VCO control pin which causes the VCO output to become frequency modulated around a center frequency of 10 MHz. This output drives a Power Amplifier (U3 which boosts the 10 MHz FM signal to a power level suitable for driving U4, which is an LED fiber optic transmitter. U7:B is unused but connected to prevent noise problems associated with open inputs.

3.2.1.1. Mode Setting (Transmitter End)

The transmitter has two modes of operation which differ mainly in the operating point of the VCO (U2). Functionally, the two modes are identical. The two modes are named after the main types of time code signal likely to be sent through the link, DC for DC level shift IRIG codes and AM for Amplitude Modulated sinusoidal IRIG codes. In fact, the DC mode will pass virtually any signal of a digital or DC nature up to 100 KPPS. 1 PPS would be a good example. The AM mode will pass virtually any bipolar sine, Square, triangle, or arbitrary waveshape whose frequency does not exceed 100 KHz. It could, in fact be used as a secure voice link if used in pairs. Changing from one mode to the other is accomplished by setting all three sets of jumpers to one position (DC) or the other (AM).

3.2.2. Receiver

Refer to the 86-704 schematic for the following discussion. Power is brought onboard via P2 and is filtered by C21, L2, and C27. F1 is a Polyswitch fuse device which self-resets when the fault level current is removed. CR3 is an over-voltage and reverse voltage protection device that serves to limit input voltage to a safe level and polarity. U9 regulates the nominal input 12 VDC to 5 VDC. C22 serves to improve the transient response of the regulator. U10 is a voltage inverter used to generate -12 VDC from the 12 VDC input. L3 and C18 serves as low pass filter designed to prevent the U10 switching noise from propagating into other circuits. Q1 serves as protection device for U10 to prevent latch-up during turn on transient conditions. Unused gates in U1, 3, and 11 are grounded to prevent noise problems.

The signal comes on board via U4 which is a Fiber Optic Receiver. C5 AC couples and R7 terminates the output of the receiver. L1 and C6 are series resonant at 10 MHz and serves as a Bandpass filter. R3 biases the amplifier chain of U3:A, U3:B, and U3:C into its linear operating region so that they operate as cascaded RF amplifiers. Gain is sufficient to achieve limiting with a 2 KM long fiber. The output of the limiter is sent three places, a phase shift network (consisting of R6, C9, C7, R4, U3:E, and U3D), and inputs of two exclusive OR gates serving as phase detector. The phase shifted signal is applied to the other inputs of the exclusive OR gates, and at the nominal 10 MHz center frequency is 90 degrees out of phase with the other signal. Due to the action of the exclusive OR gates, a 50% duty cycle 20 MHz squarewave will be seen on their outputs. This signal is integrated over time by R2 and C3 with a long time constant and by R5 and C8 with a short time constant. With no modulation present, both signal will be equal and about midway between the rails. When modulation is present, a signal which follows the modulation will be superimposed on the steady state level of the short TC integrator, but will not be seen on the long TC integrator. This signal is used to re-establish a zero baseline for the output signal in following circuits. It also compensates for frequency drift and other time an temperature effects over a wide range. U2:A and U2:B are voltage followers which buffer the integrators to maximize their tracking ability. U5:B inverts the output of the long TC integrator and applies to a summing node at R8. R28 allows for minor offsets to be removed from the output signal when analog signals are being output and serves as a symmetry adjustment when digital squarewaves are being output. The short TC signal is fed to the other summing node at R9. U5:A is a non-inverting summing amplifier with a fixed gain of 11. It serves to combine the short TC signal with the inverted long TC signal to produce an AC signal centered around zero volts. Its output is fed to R26 which serves to adjust the output level of U6:B. This is a

gain stage with a fixed gain of 11. Its output is fed to U7 if JP1 is in position 1-2 and to the inverting input of comparator U8. If U7 is fed by U6:B then the output will be an analog signal closely replicating the analog signal at the transmitter. If JP1 is in position 2-3 then the output will be a digital replica of the input at the transmitter. It is re-generated by U8 from the analog signal from U6:B compared to a reference of 0 volts generated by U6:A. U6:A may also be configured for other reference voltages. CR1 and CR2 prevent saturation of the comparator and C100 was added to prevent input referred noise from causing hash at the zero transitions of the comparator. U11 was added to square up the edges from the comparator. Note again that in this mode of operation, R28 may be used to adjust the symmetry of a square wave. U7s' output is taken off-board by P1. Note that the output may be terminated with a 50 ohm load without loss in signal amplitude because U7 is easily able to drive plus and minus 300 milliamps.

3.2.2.1. Mode Setting (Receiver End)

The receiver is set up for AM or DC mode with a single jumper: JP1, which is set to position 1-2 for AM mode and to position 2-3 for DC mode.

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 preventative 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, also 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 warranty 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

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 hygroscopic 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.

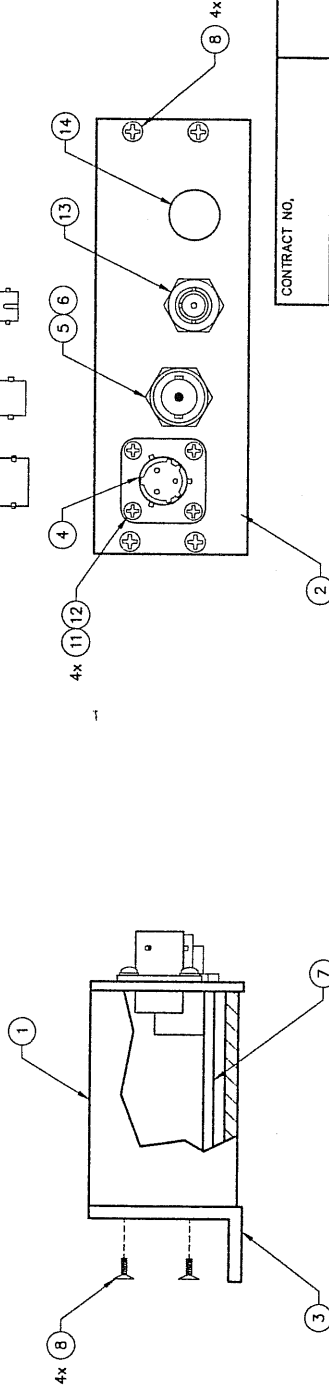
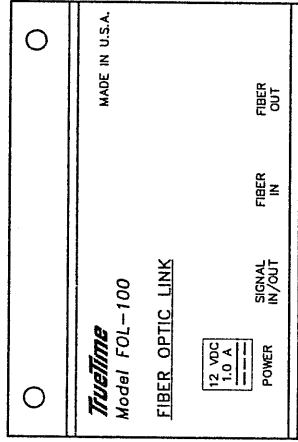
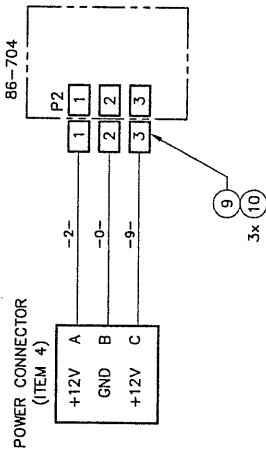
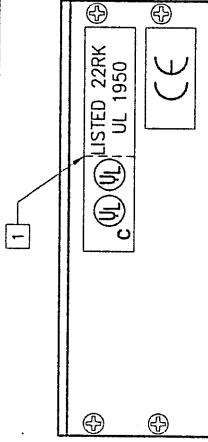
5. DETAILED DRAWINGS

- 5.1. 150-704 Top Assembly, Receive End, BOM
- 5.2. 86-704 PCB Top Assembly, Receive End, BOM
- 5.3. 150-705 Top Assembly, Transmit End, BOM
- 5.4. 86-705 PCB Top Assembly, Transmit End, BOM
- 5.5. 088-PSA122-1 Power Connector Installation

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 AND IT SHALL BE RETURNED UPON DEMAND.

REVISIONS

REV	DESCRIPTION	DATE	APPROVED
A	CAR 491 ADD LABELS	03-16-98	
B	CHANGE POWER CONNECTION LABELS	05-21-98	<i>Agg</i>



TOP ASSEMBLY FOL RX, FM	
CONTRACT NO.	DATE
APPROVALS	4/96
DRAWN BY SEIFERT	CHECKED BY
APPROVED BY <i>Agg</i>	5-21-98
NEXT ASSY	
REV	CODE IDENT NO. DRAWING NO.
B	150-704
SCALE	NONE
SHEET 1 OF 1	

FILENAME: \100\50-704
 DATE: 05-21-98

[1] TO FIT "UL" LABEL CUT WHERE INDICATED BY DASHED LINE.
 NOTES: UNLESS OTHERWISE SPECIFIED

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

PART IDENTIFIER	DESCRIPTION 1	DESCRIPTION 2	EFF DATE	ECN #	QTY/ASSY	UOM LVL	REV REFERENCE DESCRIPTION
150-704	FNL ASSY FIBER OPTIC LINK RX FM					EA	
0000-APPROVAL	PARTS LIST APPROVAL		0000		1.0000	EA	<i>G2 / 02 5/98</i>
0000-PL	PARTS LIST REV LEVEL		0000		1.0000	EA	REV B (05-21-98)
0000-PRINT	REFERENCE PRINT		0000		1.0000	EA	150-704 REV B
048-4411	FIBER OPT NUT	HP HFBR-4411	0000		1.0000	EA	13
093-692-1	CASE FIBER OPTIC LINK	FAB/PAINT/SCREEN	0000		1.0000	EA	01
206-692	PNL,FRT FOL ANTENNA	FAB/PAINT	0000		1.0000	EA	02
216-692	PNL,REAR FIBER OPTIC LINK	FAB/PAINT	0000		1.0000	EA	03
240-004-002	SCREW PH PN SS 4-40X1/4	SCREW PAN	0000		4.0000	EA	12
249-003	SCREW PH FH SS 4-40 X 3/8	100 DEG BLK	0000		8.0000	EA	08
254-.312	WSHR SPLIT #4 SS	STAINLESS	0000		4.0000	EA	11
274-005	PLUG HOLE NYL 3/8 DIA	HH SMITH 3091/HEYCO 2617	0000		1.0000	EA	14
315-022-002	WIRE 22AWG PVC INS RED	UL1429-22-7/30	0000		0.5000	FT	4 IN. SEE WIRING
315-022-009	WIRE 22AWG PVC INS WHITE	UL1429-22-7/30	0000		0.5000	FT	4 IN. SEE WIRING
315-022-010	WIRE 22AWG PVC INS BLACK	UL1429-22-7/30	0000		0.5000	FT	4 IN. SEE WIRING
372-03R	CONN,3-P RECEPTACLE	CANNON KPT02F8-3S	0000		1.0000	EA	04
375-022	LOCKWASHER,BNC PC MT	AMP 1-329632-2	0000		1.0000	EA	05
375-023	NUT BNC PC MT	AMP 1-329631-2	0000		1.0000	EA	06
400-043	LABEL,F/O V/A DC	MADE FROM 400-031	0000		1.0000	EA	SEE DRAWING
400-051	LABEL,CE SYMBOL	MADE FROM 400-031	0000		1.0000	EA	SEE DRAWING
400-056	LABEL,UL/CUL LISTED	MADE FROM 400-030	0000		1.0000	EA	SEE DRAWING
402-001	PIN 22-30 AWG MINI-KK	MOLEX 08-65-0805	0000		3.0000	EA	10
403-003L	CONN 3-P CBL MT LCK .100	MOLEX 22-01-3037	0000		1.0000	EA	09
86-704	ASSY FOL RX FM	MADE FROM 085-704	0000		1.0000	EA	07
LA	LABOR ASSEMBLY COST HRS		0000		0	EA	
LT	LABOR TEST COST HOURS		0000		0	EA	

A B C D

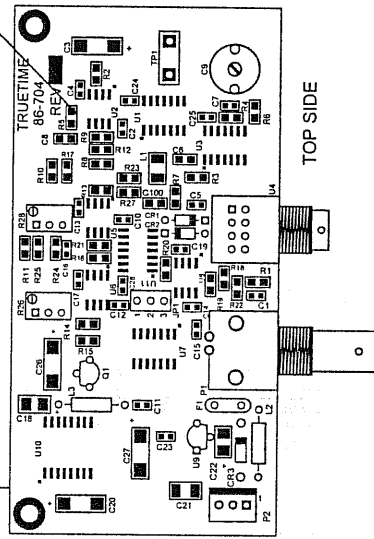
NOTES: UNLESS OTHERWISE SPECIFIED

1. ASSEMBLE PER ASSEMBLY REQUIREMENTS DOCUMENT 421-11.
2. RESISTOR VALUES IN OHMS, CAPACITORS IN MICRO FARADS.

REVISIONS

LTR	DESCRIPTION	DATE	APPROVED
A	ECO 1027	7-15-97	<i>DRW</i>

① — STAMP REVISION LEVEL HERE.



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CONTRACT NO.	APPROVALS	DATE
	<i>DRW</i>	3-27-95
DRAWN BY	CHECKED	APPROVED
NEXT ASSY		

TrueTime, Inc. Santa Rosa, California	
Title	FIBER OPTIC LINK, RX FM ASSEMBLY DRAWING
Size	B
Number	86-704
Rev	A
Date	7-15-97
Filename	85-705A.PCB
Sheet	1 of 2

1 2 3 4

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

PART IDENTIFIER	DESCRIPTION 1	DESCRIPTION 2	EFF DATE	ECN #	QTY/ASSY	REV UOM LVL	REFERENCE DESCRIPTION
86-704	ASSY FOL RX FM	MADE FROM 085-704				EA	
0000-APPROVAL	PARTS LIST APPROVAL				1.0000	EA	<i>8/97</i>
0000-PL	PARTS LIST REV LEVEL				1.0000	EA	REV A (08-20-97)
0000-PRINT	REFERENCE PRINT				1.0000	EA	85-704 REV A
0000-REV	PCB REV LEVEL HERE >>>>				1.0000	EA	085-704 REV A
002S-000	RES 0 OHM 0805	NIC NRC10Z0TR			1.0000	EA	R21
003S-100	RES 10 OHM 5% 0805	NIC NRC12R100TR			1.0000	EA	R1
008S-102	RES 1K OHM 1/8W 1% 0805	NIC NRC12R102FTR			1.0000	EA	R20
008S-103	RES 10K OHM 1/8W 0805 5%	NIC NRC12R103TR			4.0000	EA	R10,11,14,17
008S-104	RES 100K OHM 1/8W 1% 0805	NIC NRC12R104FTR			9.0000	EA	R3,4,8,9,12,13,15,18,19
008S-202	RES 2K OHM 1/8W 0805	NIC NRC12R202TR			2.0000	EA	R5,6
008S-472	RES 4.7K OHM 1/8W 0805 5%	NIC NRC12R472TR			1.0000	EA	R22
008S-473	RES 47K OHM 1/8W 0805	NIC NRC12R473TR			1.0000	EA	R2
008S-5110	RES 510 OHM 1/8W 0805	NIC NRC12R5110TR			1.0000	EA	R7
019-011	POT 2K 20 TURN T ADJ	BECKMAN 63WR2K			1.0000	EA	R28
019-017	POT 10K 20 TURN T ADJ	BECKMAN #68WR10K			1.0000	EA	R26
033-060	CAP CER TRIM 10-30PF	MURATA DV11PS50Q			1.0000	EA	C9
036S-104	CAP,CHIP .1UF 25V (0603)	ROHM MCH132F104ZK			17.0000	EA	C1,2,4,5,7,10-15,17,19,23-25,28
036S-NP0103	CAP .01UF NPO 50V 1210	NIC NMC1210NP0103J50TR			1.0000	EA	C21
036S-NP0220	CAP 22PF NPO 100V 0805	NIC NMC0805NP0220J100TR			1.0000	EA	C100
036S-NP0271	CAP 270PF NPO 100V 0805	NIC NMC0805NP0271J100TR			1.0000	EA	C8
036S-NP0330	CAP 33PF NPO 100V 0805	NIC NMC0805NP0330J100TR			1.0000	EA	C6
037S-106	CAP 10UF 25V 7343	NIC NTC-T106K25TRD			2.0000	EA	C3,27
037S-107	CAP TANT 100UF 16V 7343	AVX TPSE107K016R0125			2.0000	EA	C20,26
037S-225	CAP 2.2UF 16V 3528	NIC NTC-T225K16TRB			2.0000	EA	C18,22
045-73F270	INDUCTOR 27UH AXIAL	JW MILLER 78F270J			2.0000	EA	L2,3
045S-8.2UH	INDUCTOR 8.2UH 1210	NIC N1H-FA8R2KTR			1.0000	EA	L1
048-2416TC	FIBER OPT RCVR, ST STYLE	HP HF3R-2416TC			1.0000	EA	U4
055-SA15	TRANSIENT VOLT SUPP 15V	GEN'L INSTRUMENTS SA15CA			1.0000	EA	CR3
085-704	PCB FOL RX	FAB			1.0000	EA	O1
175-BS170	XSISTOR TMO5 N-CHNL	MOTOROLA #BS170			1.0000	EA	Q1
178-78L05	LM78L05ACP +5V REGULATOR	LM78L05ACP			1.0000	EA	U9
178S-LM311M	VOLTAGE COMPARATOR	NATL LM311M (8SOIC)			1.0000	EA	U6
178S-LM6321M	HIGH SPEED BUFFER	NATL LM6321M (SOIC)			1.0000	EA	U7
178S-LT1054	LT1054 (16SOL)	LINEAR TECH LT1054CS			1.0000	EA	U10
178S-TL082	J-FET INPUT OP AMP (8SO)	TI TL082BCD			3.0000	EA	U2,5,6
178S-74AC14	74AC14 (14SO)	RCA CD74AC14M			1.0000	EA	U11
178S-74AC36	74AC36 (14SO)	RCA CD74AC36M			1.0000	EA	U1
178S-74HCU04	74HCU04 (14SO)	RCA CD74HCU04M			1.0000	EA	U3
273-009	TERMINAL TEST POINT	COMP CORP PJ-201-25			1.0000	EA	TP1
363-.50LV	POLYSWITCH .50 LOW VOLT	RAYCHEM RXE050			1.0000	EA	F1
375-227677-1	CONN BNC PC MT	AMP 227677-1			1.0000	EA	P1
401-01-01-03L	CONN 3-P PC MT STR LOCKG	MOLEX 22-23-2031			1.0000	EA	P2
401-01-01-34	CONN 34-P HDR SNGL RW W/W	3M #929834-01-36			1.0000	EA	JP1

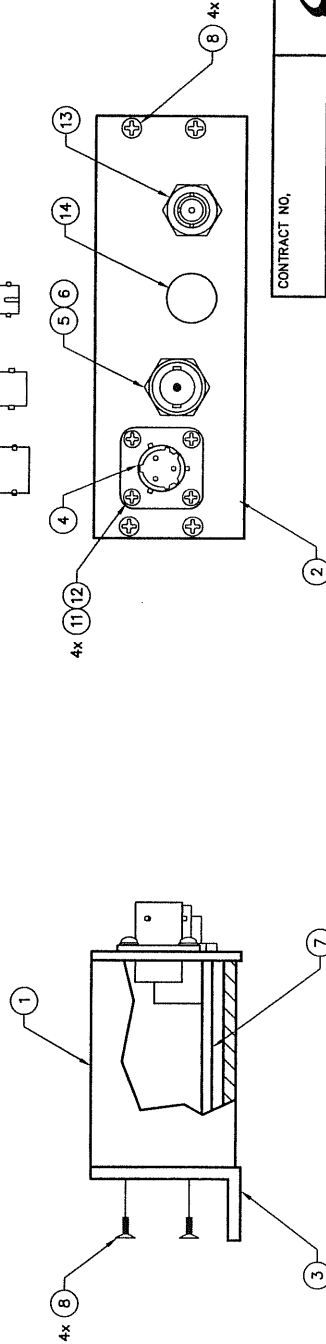
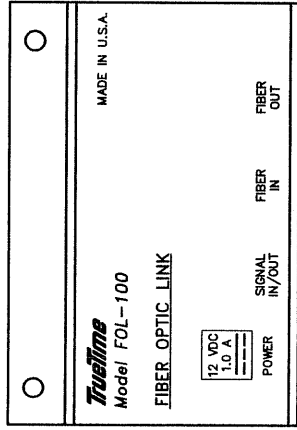
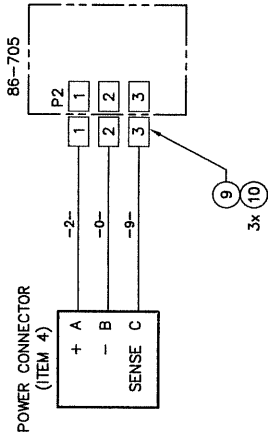
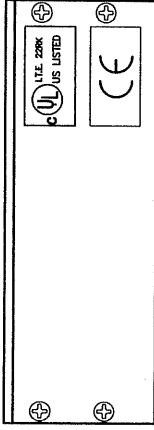
MAX * BILL OF MATERIALS * SINGLE-LEVEL EXPLOSION BY PART IDENTIFIER W/REFERENCE

PART IDENTIFIER	DESCRIPTION 1	DESCRIPTION 2	EFF DATE	ECN #	QTY/ASSY	UCM	REV LVL	REFERENCE DESCRIPTION
403-000LP	JUMPER FEMALE LOW PROFILE	SAMTEC SNT-100-BK-T			1.0000	EA		FOR JP1
57-5082-2835	DIODE, SCHOTTKY LOW VOLT	HP 5082-2835			2.0000	EA		CR1,2
LA	LABOR ASSEMBLY COST	HRS			0	EA		
LT	LABOR TEST COST	HOURS			0	EA		
OSV86-704	OUTSIDE LABOR 86-704	ASSY FOL RX FM			1.0000	EA		

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REVISIONS

REV	DESCRIPTION	DATE	APPROVED
A	CAR 1406	03-24-99	DAA
B	ECO 1696	02-26-02	<i>[Signature]</i>



TRUETIME		CONTRACT NO.	APPROVALS	DATE
TOP ASSEMBLY FOL RX, FM		DRAWN BY SEIFERT	CHECKED BY	4/96
SIZE CODE IDENT NO. DRAWING NO.		APPROVED BY DTM	APPROVED BY	4/22/96
REV B		NEXT ASSY		REV B
SCALE NONE		150-705		SHEET 1 OF 1

FILENAME: 150-705
 DATE: 02-26-02

ORIGINAL

Parent Item	Component Item	Parent Description	Component Description	Batch Quantity		UM	Bubble	Seq No	Remarks	Level		T	Effective			
				Quantity	Per					Draw	Ty		Seq	From	Thru	
150-705	0000-PL	FINAL ASSY FIBER OPT	PARTS LIST REV LEVEL	1.00	EA	EA	M		REV B (03-05-02)	150-705	1	S	2.0	M	1/1/2000	12/31/2010
0000-PRINT		REFERENCE PRINT		1.00	EA	EA	M		150-705 REV B		1	S	3.0	M	1/1/2000	12/31/2010
048-4411		FIBER OPT NUT W/WASHER		1.00	EA	EA	13				1	S	4.0	P	1/1/2000	12/31/2010
093-692-1		CASE FIBER OPTIC LINK		1.00	EA	EA	1				1	S	5.0	M	1/1/2000	12/31/2010
206-692		PNL,FRT FOL ANTENNA		1.00	EA	EA	2				1	S	6.0	P	1/1/2000	12/31/2010
216-692		PNL,REAR FIBER OPTIC LINK		1.00	EA	EA	3				1	S	7.0	P	1/1/2000	12/31/2010
240-004-002		SCREW PH PN SS 4-40X1/4		4.00	EA	EA	12				1	S	8.0	P	1/1/2000	12/31/2010
249-003		BLK PH FH SS 4-40 X 3/8		8.00	EA	EA	8				1	S	9.0	P	1/1/2000	12/31/2010
254-.312		WSHR SPLIT #4 SS		4.00	EA	EA	11				1	S	10.0	P	1/1/2000	12/31/2010
274-005		PLUG HOLE NYL 3/8 DIA		1.00	EA	EA	14				1	S	11.0	P	1/1/2000	12/31/2010
315-022-002		WIRE 22AWG PVC INS RED		.50	FT	FT			4 IN. SEE WIRING		1	S	12.0	P	1/1/2000	12/31/2010
315-022-009		WIRE 22AWG PVC INS WHITE		.50	FT	FT			4 IN. SEE WIRING		1	S	13.0	P	1/1/2000	12/31/2010
315-022-010		WIRE 22AWG PVC INS BLACK		.50	FT	FT			4 IN. SEE WIRING		1	S	14.0	P	1/1/2000	12/31/2010
372-03R		CONN,3-P RECEPTACLE		1.00	EA	EA	4				1	S	15.0	P	1/1/2000	12/31/2010
375-022		LOCKWASHER,BNC PC MT		1.00	EA	EA	5				1	S	16.0	P	1/1/2000	12/31/2010
375-023		NUT BNC PC MT		1.00	EA	EA	6				1	S	17.0	P	1/1/2000	12/31/2010
400-043		LABEL,F/O VIA DC		1.00	EA	EA			SEE DRAWING		1	S	18.0	M	1/1/2000	12/31/2010
400-051		LABEL,CE SYMBOL		1.00	EA	EA			SEE DRAWING		1	S	19.0	M	1/1/2000	12/31/2010
400-056		LABEL,U/L/CUL LISTED		1.00	EA	EA			SEE DRAWING		1	S	20.0	M	1/1/2000	12/31/2010

TrueTime, Inc.
Single Level Bill of Material Report

Parent Item	Parent Description	Batch Quantity	UM	Bubble	Level	Ty	Seq	T	From	Thru
Component Item	Component Description	Quantity Per		Seq No						
402-001	PIN 22-30 AWG MINI-KK	3.00	EA	10	1	S	21.0	P	1/1/2000	12/31/2010
403-003L	CONN 3-P CBL MT LCK .100	1.00	EA	9	1	S	22.0	P	1/1/2000	12/31/2010
86-705	ASSY FOL TX FM	1.00	EA	7	1	S	23.0	M	1/1/2000	12/31/2010

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

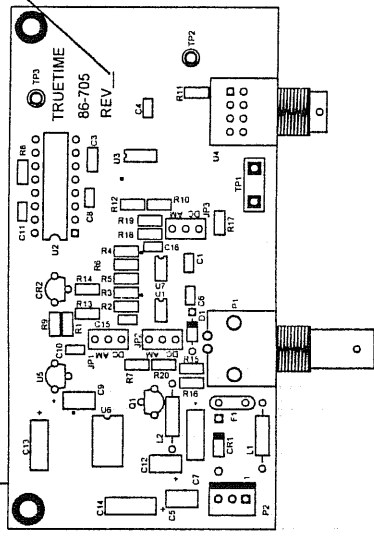
PART IDENTIFIER	DESCRIPTION 1	DESCRIPTION 2	EFF DATE	ECN #	QTY/ASSY	REV UOM LVL	REFERENCE DESCRIPTION
150-705-1	FNL ASSY FIBER OPTIC LINK TX FM					EA	
0000-APPROVAL	PARTS LIST APPROVAL				1.0000	EA	<i>DAVE 12.30.96</i>
0000-PL	PARTS LIST REV LEVEL				1.0000	EA	REV N/C (12-30-96)
0000-PRINT	REFERENCE PRINT				1.0000	EA	SEE 150-705
048-4411	FIBER OPT NUT	HP HFBR-4411			1.0000	EA	13
093-692-1	CASE FIBER OPTIC LINK	SCREEN MOD			1.0000	EA	01
206-692	PNL,FRT FOL ANTENNA	FAB/PAINT			1.0000	EA	02
216-692	PNL,REAR FIBER OPTIC LINK	FAB/PAINT			1.0000	EA	03
240-004-002	SCREW PH PN SS 4-40X1/4	SCREW PAN			4.0000	EA	12
249-003	SCREW PH FH 4-40 X 3/8	100 DEG BLK			8.0000	EA	08
254-.312	WSHR SPLIT #4 SS	STAINLESS			4.0000	EA	11
274-005	PLUG HOLE NYL 3/8 DIA	HH SMITH 3091/HEYCO 2617			1.0000	EA	14
315-022-002	WIRE 22AWG PVC INS RED	UL1429-22-7/30			0.5000	FT	4 IN. SEE WIRING
315-022-009	WIRE 22AWG PVC INS WHITE	UL1429-22-7/30			0.5000	FT	4 IN. SEE WIRING
315-022-010	WIRE 22AWG PVC INS BLACK	UL1429-22-7/30			0.5000	FT	4 IN. SEE WIRING
372-03R	CONN,3-P RECEPTACLE	CANNON KPT02F8-3S			1.0000	EA	04
375-022	LOCKWASHER,BNC PC MT	AMP 1-329632-2			1.0000	EA	05
375-023	NUT BNC PC MT	AMP 1-329631-2			1.0000	EA	06
402-001	PIN 22-30 AWG MINI-KK	MOLEX 08-65-0805			3.0000	EA	10
403-003L	CONN 3-P CBL MT LCK .100	MOLEX 22-01-3037			1.0000	EA	09
86-705-1	ASSY FOL TX FM	MADE FROM 085-705			1.0000	EA	07
LA	LABOR ASSEMBLY COST HRS				0	EA	
LT	LABOR TEST COST HOURS				0	EA	

NOTES: UNLESS OTHERWISE SPECIFIED

1. ASSEMBLE PER ASSEMBLY REQUIREMENTS DOCUMENT 421-11.
2. RESISTOR VALUES IN OHMS, CAPACITORS IN MICRO FARADS.

1

STAMP REVISION LEVEL HERE.



REVISIONS

DESCRIPTION	DATE	APPROVED
LTR		

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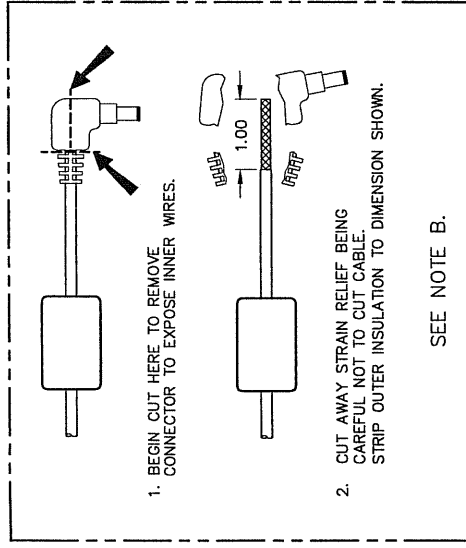
CONTRACT NO.	APPROVALS	DATE
	R.E.C.	3.14.96
DRAWN BY	CHECKED	APPROVED
	DATE	DATE
		5.7.96
NEXT ASSY		

TrueTime, Inc. Santa Rosa, California	
Title	FIBER OPTIC LINK FM ASSEMBLY DRAWING
Size	B
Number	86-705
Rev	N/C
Date	5-14-96
Filename	85-705.PCB
Sheet	1 of 2

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

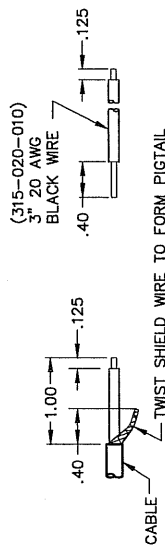
PART IDENTIFIER	DESCRIPTION 1	DESCRIPTION 2	EFF DATE	ECN #	QTY/ASSY	REV UOM LVL	REFERENCE DESCRIPTION
86-705	ASSY FOL TX FM	MADE FROM 085-705				EA	
0000-APPROVAL	PARTS LIST APPROVAL				1.0000	EA	<i>DATE 5-17-96</i>
0000-PL	PARTS LIST REV LEVEL				1.0000	EA	REV N/C (05-17-96)
0000-PRINT	REFERENCE PRINT				1.0000	EA	86-705 REV N/C
0000-REV	PCB REV LEVEL HERE >>>>				1.0000	EA	085-705 REV N/C
0085-1002	RES 10K OHM 1/8W 1% 0805	NIC NRC12R1002FTR			3.0000	EA	R15,16,19
0085-101	RES 100 OHM 1/8W 0805	NIC NRC12R102TR			1.0000	EA	R11
0085-102	RES 1K OHM 1/8W 1% 0805	NIC NRC12R102FTR			1.0000	EA	R18
0085-104	RES 100K OHM 1/8W 1% 0805	NIC NRC12R104FTR			5.0000	EA	R2-6
0085-1211	RES 1.21K 1/8W 1% 0805	NIC NRC12R1211FTR			1.0000	EA	R13
0085-202	RES 2K OHM 1/8W 0805	NIC NRC12R202TR			1.0000	EA	R9
0085-2261	RES 2.26K 1/8W 1% 0805	NIC NRC12R2261FTR			2.0000	EA	R7,14
0085-2671	RES 2.67K 1/8W 1% 0805	NIC NRC12R2671FTR			1.0000	EA	R8
0085-2741	RES 2.74K 1/8W 1% 0805	NIC NRC12R2741FTR			1.0000	EA	R1
0085-3741	RES 3.74K 1/8W 1% 0805	NIC NRC12R3741FTR			1.0000	EA	R20
0085-4022	RES 40.2K 1/8W 1% 0805	NIC NRC12R4022FTR			1.0000	EA	R17
0085-472	RES 4.7K OHM 1/8W 0805	NIC NRC12R472TR			2.0000	EA	R10,12
0365-104	CAP,CHIP .1UF 25V (0603)	ROHM MCH102F104ZK			8.0000	EA	C1,4,6,8,10,11,15,16
0365-NP0103	CAP .01UF NPO 50V 1210	NIC NMC1210NP0103J50TR			1.0000	EA	C5
0365-NP0271	CAP 270PF NPO 100V 0805	NIC NMC0805NP0271J100TR			1.0000	EA	C3
0375-106	CAP 10UF 25V 7343	NIC NTC-T106K25TRD			1.0000	EA	C7
0375-107	CAP TANT 100UF 16V 7343	AVX TPSE107K016R0125			2.0000	EA	C13,14
0375-225	CAP 2.2UF 16V 3528	NIC NTC-T225K16TRB			2.0000	EA	C9,12
045-78F270	INDUCTOR 27UH AXIAL	JW MILLER 78F270J			2.0000	EA	L1,2
048-1414T	FIBER OPT XMTR ST STYLE	HP HFBR-1414T			1.0000	EA	U4
055-336	DIODE LM336-5.0 + 5V REF	LM336Z-5.0			1.0000	EA	CR2
055-5A15	TRANSIENT VOLT SUPP 15V	GEN'L INSTRUMENTS SA15			1.0000	EA	CR1
085-705	PCB FOL TX FM	FAB			1.0000	EA	01
175-BS170	XSISTOR TMS N-CHNL	MOTOROLA #BS170			1.0000	EA	Q1
176-78L05	LM78L05ACP +5V REGULATOR	LM78L05ACP			1.0000	EA	U5
1765-LM6321M	HIGH SPEED BUFFER	NATL LM6321M (SOIC)			1.0000	EA	U3
1765-LT1054	LT1054 (16SOL)	LINEAR TECH LT1054CS			1.0000	EA	U6
1765-TL082	J-FET INPUT OP AMP (BSO)	TI TL082BCD			2.0000	EA	U1,7
178-74HC4046	MC74HC4046 PLL	NATIONAL ONLY 74HC4046			1.0000	EA	U2
273-009	TERMINAL TEST POINT	METHODE CD1283-103-205			1.0000	EA	TP1
273-015	TERM TEST POINT (WHITE)	COMP. CORR TP-104-01-09			2.0000	EA	TP2,3
363-.50LV	POLYSWITCH .50 LOW VOLT	RAYCHEM RYE050			1.0000	EA	F1
375-227677-1	CONN BNC PC MT	AMP 227677-1			1.0000	EA	F1
401-01-01-03L	CONN 3-P PC MT STR LOCKE	MOLEX 22-23-2031			1.0000	EA	P2
401-01-01-34	CONN 34-P HDR SNGL RW W/W	AP PROD #929834-01-36			1.0000	EA	JP1,2,3
403-000LP	JUMPER FEMALE LOW PROFILE	SAMTET SNT-100-BK-T			3.0000	EA	FOR JP1,2,3
57-5082-2835	DIODE, SCHOTTKY LOW VOLT	SCHOTTKY 5082-2835			1.0000	EA	D1
LA	LABOR ASSEMBLY COST HRS				0	EA	
LT	LABOR TEST COST HOURS				0	EA	

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1. BEGIN CUT HERE TO REMOVE CONNECTOR TO EXPOSE INNER WIRES.
2. CUT AWAY STRAIN RELIEF BEING CAREFUL NOT TO CUT CABLE. STRIP OUTER INSULATION TO DIMENSION SHOWN.

SEE NOTE B.

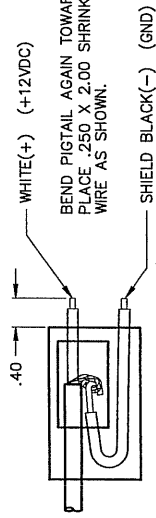


STRIP AND TIN WIRES AND PIGTAIL TO DIMENSIONS SHOWN.

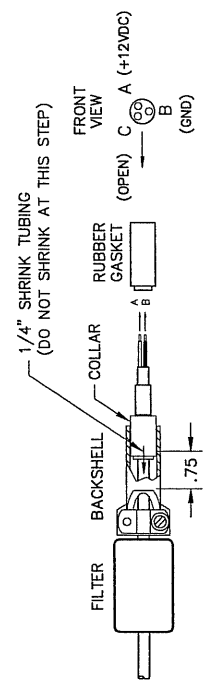
FORM HOOKS, LATCH TOGETHER, SOLDER AND CLEAN THE SHIELD, PIGTAIL AND .40 END OF BLACK WIRE (315-020-010, 3*) AS SHOWN.



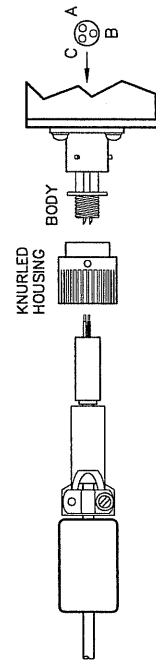
BEND BLACK PIGTAIL BACK ALONG CABLE AND PLACE .187 X 1.00 SHRINK TUBING OVER JOINT AS SHOWN.



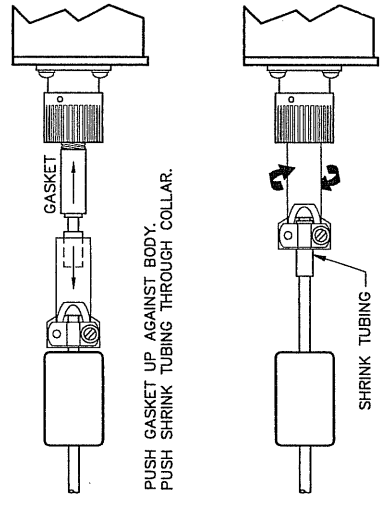
3. CABLE AND PIGTAIL TERMINATION.



4. TEMPORARILY INSTALL BACKSHELL UP AGAINST FILTER. SLIDE COLLAR INSIDE BACKSHELL. INSTALL WHITE (+) WIRE INTO HOLE "A" OF GASKET. INSTALL BLACK (-) WIRE INTO HOLE "B" OF GASKET.



5. INSERT BODY INTO KNURLED HOUSING BEFORE SOLDERING WIRES. SOLDER WHITE WIRE INTO SOLDER CLIP "A". SOLDER BLACK WIRE INTO SOLDER CLIP "B". MATING CONNECTOR SHOULD BE USED TO HOLD BODY DURING SOLDERING.
 NOTE THAT SOME MANUFACTURERS COMBINE THE HOUSING AND BODY INTO ONE MOULDED UNIT- NOT SEPARATED AS SHOWN.



6. PUSH GASKET UP AGAINST BODY. PUSH SHRINK TUBING THROUGH COLLAR.
7. SLIDE BACKSHELL FORWARD AND SCREW INTO BODY USING MATING CONNECTOR AS A WRENCH TO HOLD BODY TO TIGHTEN BACKSHELL SECURELY. PUSH SHRINK TUBING AGAINST RUBBER GASKET. SHRINK HEAT SHRINK TUBING. TIGHTEN CABLE CLAMP SCREWS.

- B. STEPS 1 AND 2 ARE NOT REQUIRED IF CUSTOMER PROVIDES THEIR OWN POWER SUPPLY.
- A. DIMENSIONS ARE IN INCHES.

NOTES: UNLESS OTHERWISE SPECIFIED.

REVISIONS

REV	DESCRIPTION	DATE	APPROVED
A	ADDED SHRINK TUBING	1/3/97	
B	CAR453	10/27/97	
C	ADD PWR CORD TO BOM	5/12/98	
D	ADD PIN OUT LABELING	5/21/98	
E	CAR 897	6/22/98	DR
F	CAR 1352	1/11/99	BVH/DR
G	PR 3859	06/02/00	

10000 Old Highway
 2855 DUNE CT. SOUTH REEF, SC 29547

POWER CONNECTOR INSTALLATION INSTRUCTIONS

CONTRACT NO.	DATE	APPROVALS	DATE
	10/95		10/95
	8/98	DRAWN BY SEIFERT	8/98
	8/98	CHECKED BY XL TEAM	8/98
		APPROVED BY DR	8/98
NEXT ASSY			

UNLESS OTHERWISE SPECIFIED
 DIMENSIONS ARE IN INCHES
 TOLERANCES ARE:
 DECIMALS ±.005
 FRACTIONS ±.005
 ANGLES ±.2°
 ALL THREADS TO BE CLASS 2 PER ANSI Y14-6
 MACH COR-005 TO .015 OR CHAM
 SH MAT-DEBURR & BREAK EDGES .015 MAX R
 DIM. AND TOL. APPLY FIN. TREAT.
 MATERIAL

FILENAME: \100\PSAPWR
 DATE: 06-02-00

SIZE CODE IDENT NO. DRAWING NO.
 B 088-PSA122-1

SCALE NONE SHEET 1 OF 1

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

PART IDENTIFIER	DESCRIPTION 1	DESCRIPTION 2	EFF DATE	ECN #	QTY/ASSY	UOM	REV LVL	REFERENCE DESCRIPTION
088-PSA122-1	PWR SUPPLY 12V 30W REG	088-PSA122 MODIFIED					EA	
0000-APPROVAL	PARTS LIST APPROVAL		000000		1.0000		EA	<u>DAK 6-8-00</u>
0000-PL	PARTS LIST REV LEVEL		000000		1.0000		EA	REV G (06-06-00)
0000-PRINT	REFERENCE PRINT		000000		1.0000		EA	088-PSA122-1 REV G
088-PSA122	PWR SUPPLY 12V 30W REG	PHIHONG PSA-30U-120(P)	000000		1.0000		EA	
315-020-010	WIRE 20AWG PVC INS BLACK	UL1429	000000		0.2500	FT		SEE DRAWING
326-002	SHRINK TUBING CLR 3/16 IN	MOUSER 5174-13163(4FT PC)	000000		0.2000	FT		SEE DRAWING
326-008	SHRINK TUBING CLR 1/4 IN.	MOUSER 5174-1143 (4FT PC)	000000		0.2500	FT		SEE DRAWING
332-002	CORD POWER	BELDEN 17250	000000		1.0000	EA		SHIPPING KIT
372-03P	CONN, 3-P PLUG (CABLE)	CANNON KPT06F8-3P	000000		1.0000	EA		
LA	LABOR ASSEMBLY COST HRS		000000		0	EA		
LT	LABOR TEST COST HOURS		000000		0	EA		

6. APPENDIX A

6.1. RECOMMENDED FIBER OPTIC CABLE

The fiber optic cable recommended for most indoor/outdoor installations is: **BX002-070D-W3SB/1TC/900-R**

MANUFACTURER IS **OPTICAL CABLE CORPORATION**

This is a riser rated indoor/outdoor tightly buffered breakout cable which is very easy to install compared with any other options. Due to the fact that it is a riser rated cable, it does not require any special handling to run it inside from outside. It is rated for direct burial and aerial installations (with the addition of a suitable messenger). It is also available in an armored version should protection from vermin be required. Where existing fiber cable is used it must be 62.5/125 micron fiber. The FOL uses 850 nM wavelength optical devices and has a 10DB power budget. All fiber links used must have $\leq 10\text{db}$ loss @ 850 nM.

6.2. RECOMMENDED POWER CABLE

For use with the optional Outside Enclosure the following cable is recommended: **ALPHA 35152 or 35154**

MANUFACTURER IS **ALPHA WIRE CORPORATION**

This is a double shielded 2 or 4 conductor cable suitable for use in direct burial or aerial installations (with the addition of a suitable messenger). It is also available in an armored version should protection from vermin be required. The 2 conductor style is for installations where the remote sense concept is not employed, and the 4 conductor cable provides two Kelvin sense leads where it is employed. Both cables fit the standard packing gland provided with the Outside Enclosure.

6.3. RECOMMENDED COAX CABLE

TrueTime normally supplies and recommends: **Belden 8219**

MANUFACTURER IS **BELDEN ELECTRONIC WIRE AND CABLE**

6.4. RECOMMENDED OPTICAL CONNECTORS

TrueTime normally supplies and recommends: **Amp 504034-1**

MANUFACTURER IS **AMP INCORPORATED**

This is a crimp style connector that requires no epoxy or other difficult or tedious assembly.