OFW-1217 Technical Description

INTRODUCTION:

The MPS-1217-D/IFL, henceforth referred to as the IFL, is an analog fiber optic modem designed to transport X-Band SATCOM uplink and downlink signals between an earth station facility and a remotely located antenna site. The IFL is derived from industry proven commercial-off-the-shelf (COTS) hardware.

PHYSICAL LAYOUT

The IFL consists of two identical rack mountable equipment chassis that serve as the interface units between the uplink and downlink segments of the X-Band SATCOM system. The two chassis are separately located with one at the earth station facility and the other at the remote antenna site. Each IFL unit can accept three separate uplink signals and three separate downlink signals, simultaneously. Figure (1) provides an IFL system block diagram.

The IFL equipment chassis are compatible with standard 19" racks. The overall dimensions of each chassis are 7.5"(h) x 19"(w) x 21"(d). The front panel of each chassis is populated with the following types of Plugin modules: a) X-Band Analog Optical Transmitter, Model 10550A, b) X-Band Analog Optical Receiver, Part # 10315A, c) Monitor and Control Microprocessor Module, Part # DM 1001A, d) Universal (125/220 V, 50-60 Hz) AC to DC Power Supply, Part # PM 1505. Figure (2) provides detailed views of the IFL front and rear panels and identifies the various Plugin modules with their associated electrical and optical interfaces.

UPLINK/DOWNLINK

The IFL is capable of simultaneously transporting X-Band SATCOM uplink and downlink signals between an earth station facility and its remote antenna site. The IFL, in its basic configuration, can support earth station to antenna site interconnection distances of up to 10 miles. That is, the antenna site can be remotely linked to the earth station using up to 10 miles of telecommunications grade singlemode (9/125 micron) fiber optic cable. The typical fiber optic cable attenuation (dB) per mile at the 1310nm and 1550nm wavelengths are 0.67 dB/ml and 0.34 dB/ml, respectively. The data indicates that the 1550nm-wavelength window is preferable to the 1310nm-wavelength window in IFL applications that require extremely long transmission distances.

The uplink and downlink segments of the IFL each contain three independent uplink channels and three independent downlink channels. The individual uplink and downlink channels each consist of a Primary Transmission Circuit and an Auxiliary Transmission Circuit. The Primary Transmission Circuits of each uplink and downlink are capable of transporting signals within the 7.9 to 8.4 GHz passband and the 7.25 to 7.75 GHz passband, respectively.

The Auxiliary Transmission Circuits of each uplink and downlink are capable of transporting the same respective passbands. The Auxiliary Transmission Circuits enable the IFL to provide 1:1 redundant optical transmission paths for both the uplink and downlink segments of the X-Band SATCOM system. In the event of a failure in the optical hardware of any one of the Primary Transmission Circuits the IFL automatically switches to the appropriate (redundant) Auxiliary Transmission Circuit.

The uplink and downlink channels formed by both the Primary and the Auxiliary Transmission Circuits consists of one (1) each Analog Optical Transmitter module and one (1) each Analog Optical Receiver module. The optical transmitter consists of a high power solid-state Distributed Feedback (DFB) laser diode, Mach-Zender electro-optical modulator, and thermal/bias-point stability controller. The optical receiver consists of a photodiode detector, variable optical attenuator, and a RF post amplifier.

The electrical and optical interface back panel of each IFL chassis provides the RF, optical, monitor, control, and DC power interconnections to the transmitter and receiver modules. The modules can be plugged in and out of their respective slots without the need to de-energize the IFL chassis‰ primary or auxiliary AC to DC power supplies.

Functionally, each IFL uplink channel accepts X-Band input signals (7.9 to 8.4 GHz), from the earth station facility equipment, through a Type-N (female) connector located on the back panel of the IFL unit. The input signals are then routed through a RF switching matrix to either the Primary Transmission Circuit or the Auxiliary Transmission Circuit. The RF switch matrix is monitored and controlled by a microprocessor located within the IFL unit. Once the Primary or Auxiliary transmission circuit is selected the input signals are routed to the appropriate optical transmitter module. The transmitter module uses a DFB laser diode to generate an optical carrier at a wavelength of 1550 nm.

Information transfer is accomplished by externally modulating the optical carrier with the uplink-input signals by applying them to the Mach-Zender electro-optical modulator to produce an amplitude modulated optical signal. The optical signal is then routed to the back panel of the IFL unit using a single-mode fiber optic pigtail terminated with a FC/APC connector.

The optical output signal from the IFL back panel can then be interconnected to the earth stations long haul fiber optic cable through an optical patch panel or through a direct connection. The optical output signal is then transported through the long haul fiber optic cable from the earth station facility to the remotely located antenna site. Once inside the antenna site, the optical signal can be routed through a patch panel or directly connected to the antenna site IFL unit.

The optical signal is routed through the FC/APC connector located on the back panel of the (antenna site) IFL. The optical signal is then fed to the optical receiver module were the photodiode detector converts it back to the original X-Band signals. The inline optical attenuator preceding the photodiode is used to adjust the received optical power to the desired level.

The X-Band signals are then post-amplified and routed to the RF switching matrix. The RF switching matrix is configured such that either the Primary or the Auxiliary Transmission Circuit is selected. The output of the RF switching matrix is routed to the back panel of the IFL unit and fed to the appropriate antenna site uplink equipment, through a Type-N (female) connector.

Figure 3(a) provides a block diagram of an IFL uplink channel. It should be noted that the inline optical attenuator is typically adjusted to provide an overall link RF gain of 0 dB between the earth station equipment and the antenna site equipment.

Functionally, each IFL downlink channel accepts X-Band input signals (7.25 to 7.75 GHz), from the antenna site equipment, through a Type-N (female) connector located on the back panel of the IFL unit. After this point, the downlink signal flow from the antenna site IFL unit to the earth station IFL unit occurs in a completely analogous method as the uplink signal flow from the earth station IFL unit to the antenna site IFL unit. Again, the overall link RF gain is typically adjusted to 0 dB between the antenna site equipment and the earth station equipment. Figure 3(b) provides a block diagram of an IFL downlink channel.

OPTICAL PARAMETERS
Wavelength Range:... .... 860nm +/- 20nm
Fiber Type:.. 62.5 microns (multimode)
Return Loss:.. >22 dB
Insertion Loss:.. <1.5 dB/channel
MECHANICAL
Size:... 13” x 9.5” x 5/8"
Weight:.. 3 lbs.

The overall RF and optical performance specifications of the IFL optical transmitter and optical receiver modules are listed. The RF parameters are measured from the RF input of the optical transmitter to the RF output of the optical receiver. It should be noted, that although the transmitter and receiver module's RF parameters are specified across a frequency range of 7.0 to 9.0 GHz the actual frequency range of these modules extends from 0.1 to 18.0 GHz.

RF PARAMETERS

Frequency Range:	0.1 to 18.0 GHz
Amplitude Flatness:	+/- 1.0 dB (max.) @ 7.0 to 9.0 GHz
Input/Output Impedance:	50 ohms
Input/Output VSWR:	1.35:1 (max.) @ 7.0 to 9.0 GHz
Input 1 dB Comp.:	>+13.0 dBm @ 7.0 to 9.0 GHz
Max. RF Input Power:	>24.0 dBm @ 7.0 to 9.0 GHz
Input Third Order (IP3):	>+27.0 dBm @ 7.0 to 9.0 GHz, refer to Figure (4)
Eq. Input Noise (EIN):	<-126.0 dBm/Hz @ 7.0 to 9.0 GHz
Noise Figure (NF) (1):	<48.0 dB @ 7.0 to 9.0 GHz; refer to Figure (4)
Spur Free Dynamic Range:	>+102.0 dB-Hz(2/3) @ 7.0 to 9.0 GHz, refer to Figure (5)
SNR @ 1 dB Comp.	>+141.0 dB @ 7.0 to 9.0 GHz, 1Hz BW, refer to Figure (6)

MONITOR AND CONTROL

The IFL System shall posses the capability of being Monitored and Controlled by a 486-based computer, located at either the earth terminal station or the remote antenna site of the IFL System. The Monitor and Control System (MCS) to be utilized, is a commercial MS-DOS based RS-485, multi drop / multi node, data acquisition and control system. The MCS will allow an operator, located at the earth station terminal, to view the status of any monitored digital or analog signal, as well as the status and/or control of digital alarm/control outputs. The MCS will also perform manual or automatic control sequences, as well as, initiate various alarm functions such as lights, sirens, or even activation of pagers with alarm text, etc. The MCS's user-friendly software will be customized to suit specific user requirements as needed to perform the IFL System's Monitoring and Control functions.

The MCS software interface consists primarily of four main viewing screens. The first main viewing screen is referred to as the STATUS Screen. The STATUS Screen will be the primary viewing screen to be utilized by IFL System personnel. This screen will display the functional sub-component modules comprising the IFL System, depicted as a color graphic block diagram. Within each of the sub-component module graphic blocks, the modules operational STATUS, a DIRECTORY and CONTROL block will be displayed.

The sub-component module graphic STATUS block will display the operational status parameters of the respective sub-component graphic block module. For example, a power supplies' operational status would be displayed as either On-line, Off-line, or Failure, depicted in green, yellow and red respectively. In the event of an alarm condition, the Failure indicator will flash on and off and the host computer will sound an audible alarm until the operator acknowledges the alarm condition. Alarm conditions are acknowledged by selecting the ALARM file icon located inside the failing sub-components graphic block DIRECTORY.

The DIRECTORY identifies three files, ALARM, EVENT and MONITOR, where pertinent sub-component module information is kept relative to the context of the file. If any one of the file icons is selected, that screen is displayed to the operator for viewing.

The ALARM screen contains a time and date stamped chronological order of every situation, which had occurred for that specific module which had been previously defined in the SET-UP screen as an alarm condition. An example of some IFL System alarm conditions would be; Low Optical Power, Sub-component Module Failure, Power Supply Failure, etc. Additionally, each time the operator acknowledges an alarm condition by selecting the alarm file, the alarm file records the acknowledgment, also accompanied by a time and date stamp.

The EVENT screen contains a time and date stamped in chronological order of every situation which had occurred for that specific module which will include both alarm and non-alarm conditions.

An example of some IFL System event conditions would be; Optical Transmitter #1 Failure, Optical Transmitter #1 Off-line, Optical Transmitter #2 On-line, Optical Receiver #1 Off-line, Optical Receiver #2 On-line, Power Supply #1 Failure, Power Supply #1 Off-line, Power Supply #2 On-line, etc.

The MONITOR screen provides the operator with a one-hour history of a sub-component module's monitored analog and digital data. For example, the MONITOR screen associated with the power supply module would display a one-hour log of the modules voltage and current values, as well as the digital control function utilized for ON-Line and OFF-Line transfer and ALARM control output. The MONITOR screen may be useful for viewing historical trends, which may lead to potential sub-component failure or degradation.

The CONTROL block contains a TRANSFER icon, which would be selected if the operator had the need to perform manual transfer of ON-Line status from the primary to the redundant back-up module. Additionally, this function would be selected to define auto redundancy switch over periods, which the MCS would utilize to exercise the IFLs redundant modules. Once the TRANSFER icon is selected, a pop-up sub screen will appear prompting the operator for transfer or parameter definition. The CONTROL block will also allow the operator to manually initiate an ALARM control output for each of its associated sub-component modules. Manual control of the ALARM output function may be utilized for testing of external alarm circuits, or simply as a user function for control of an external device co-located at either or both rack drawer sites.

Each of the IFL System sub-component modules will posses a Z180 microcontroller, which will monitor and control all of the necessary functions associated with its respective sub-component module. The Z180 microcontroller will be configured as an addressable node of a multi drop RS-485 network resident to each of the IFL rack mount units. Addressability of the sub-component modules will allow for individual access of their monitor and control functions by either the companion IFL rack unit or the MCS host.

The Z180 microcontroller will monitor the following functions of their respective sub-component modules:

Optical Transmitter Module:

Monitor:	Laser Bias Current, mA. (analog)
	Laser Optical Output Power, mW. (analog)
	Low Optical Power, Alarm (binary)
	Module Current Drain (analog)
Control:	Module Alarm Annunciator, Output (binary)
	RF Switch Control, Input (binary)
	Automatic Module Switch Over, Output (binary)
	Automatic Module Switch Over, Input (binary)
	Emergency Module Switch Over, Input (binary)

The IFL Systems sub-component modules located at both the earth station and remote antenna site, as well as the MCS host, when utilized. Upon receipt of the emergency broadcast message, the companion sub-component module, i.e. the mating receiver or transmitter module located at the opposite end of the transmission circuit, will interpret the message accordingly, and perform an automatic control sequence similar to that of the initiating sub-component module, thereby transferring the RF optical link from the primary to the auxiliary transmission circuit.

In the event that an emergency switch over is requested through the status and control I/O port, located on the rear of the rack panel, the optical receiver module associated with the respective channel which the emergency switch over is requested will initiate the switch over sequence as previously described under automatic sub-component module switch over.

Manual sub-component switch over will be initiated by the MCS under direct control of the IFL system operator. Upon an operator request for sub-component switch over (see the CONTROL function as part of the MSC software description.) the MCS will initiate the switch over sequence by transmitting a control message string through the MCS host port located on the rear panel of the IFL rack unit.

The MCS host port will route the message string through the RS-485 bus, thereby presenting it to every sub-component module in the IFL System. Upon receipt of the message by the appropriately addressed sub-component module, the module will initiate the switch over sequence as previously described under automatic sub-component module switch over.

The IFL System is also capable of exercising the rack unit sub-component modules periodically as defined by the operator in the MCS operating system. Exercising of the sub-component modules is useful for maintaining auxiliary sub-component module operational readiness by identifying faults in modules before they are requested as essential back-ups to a faulty primary module.

Optical Receiver Module:

Monitor:	Receiver Load Current, mA. (analog)
	Receiver Optical Input Power, mW. (analog)
	Receiver Low Optical Power, Alarm (binary)
	Module Current Drain (analog)
Control:	Module Alarm Annunciator, Output (binary)
	RF Switch Control, Output (binary)
	Automatic Module Switch Over, Output (binary)
	Automatic Module Switch Over, Input (binary)
	Emergency Module Switch Over, Input (binary)

Power Supply Module:

Monitor:	Supply Load Current, Amps (analog)
	Supply Load Voltage, Volts (analog)
Control:	Module Alarm Annunciator, Output (binary)
	Automatic Module Switch Over, Output (binary)
	Automatic Module Switch Over, Input (binary)
	Emergency Module Switch Over, Input (binary)

The RS-485 network will operate at a data rate speed of 38.4 Kbps through the IFL rack unit's back plane bus. The back plane bus will be common to all sub-component modules, the RS-485 data expansion port, the RS-232 diagnostic / monitoring port, the RS-232 MCS host interface port, as well as the optical interface for data communication with the companion IFL rack unit (see Figure (7) for an illustration of the IFL System Monitor and Control System Architecture).

The IFL rack unit provides an RS-485 data expansion port located on the back panel of the rack drawer. The expansion port will allow additional IFL rack units to be cascaded to the primary unit without degradation to any of the IFL System functions. The addition of an expansion IFL rack unit will not require any hardware or software modifications to the system except for a few setup parameter definitions in the MCS software SET-UP function.

The two IFL rack units will communicate with each other via. a redundant fiber optic pair dedicated to the monitor and control functions associated with each of the IFL sub-component modules, as well as the diagnostic , expansion , and MCS host control functions. The IFL data link will operate at a data rate of 38.4 Kbps over a primary and an auxiliary data channel consisting of a pair of single mode fiber optic cables terminated with FC/APC connectors.

Switching between the primary and auxiliary data channel will occur automatically as the IFL rack units detect a fault in the links ability to transfer the necessary data. Communications between the two IFL rack units will allow the IFL System to perform the automatic switching from the primary to the auxiliary transmission circuits for any of the three RF uplink or downlink channels, as well as provide monitor and control accessibility to the remote IFL rack unit, relative to the MCS location.

TECHNICAL ADVANTAGES

The MPS-1217-D/IFL, X-Band Fiber Optic Analog Modem, offers several key technical advantages to the designer and operator of commercial and military SATCOM systems. The technical advantages inherent with the MPS-1217-D/IFL are a direct result of the use of an externally modulated DFB laser transmitter operating at an optical wavelength of 1550nm.

The technical advantages of this design approach include:
The optical attenuation or loss through a fiber optic cable is a function of the wavelength of the propagating light. Single-mode fiber optic cable has two discrete wavelength windows used for the transmission of analog signals. The wavelength windows are 1310nm and 1550nm. Typical fiber optic cable attenuation (dB) per mile at the 1310nm and 1550nm wavelengths are 0.67 dB/ml and 0.34 dB/ml, respectively. The data indicates that the 1550nm-wavelength window is preferable to the 1310nm-wavelength window in IFL applications that require extremely long transmission distances

. Additionally, the lower cable losses afforded by the use of the 1550 nm window provides for an increased optical power margin for the IFL, when compared to an equivalent performing system operating at the 1310nm window.

Laser transmitters operating in the 1550nm-wavelength window offer a broad tuning range of wavelength. For this reason they are exclusively used in high-density wavelength division multiplexing (WDM) applications. The use of WDMs in the optical telecommunications industry is a cost-effective means of increasing the signal loading within preexisting optical cable networks. That is, the use of WDM technology enables the system designer to rapidly expand the signal carrying capacity of the optical network without having to install new fiber optic cables. The IFL optical transmitter and receiver plug-in modules are capable of supporting future applications of WDM technology, should increased signal capacity be required.

The commercial and military satellite communications industry is transitioning to next generation satellites that operated in the Ku-Band region of the RF spectrum. The uplink and downlink frequencies used by these systems are 17.3 to 17.8 GHz and 12.2 to 12.7 GHz, respectively. The use of Ku-Band satellites offers many operational advantages to the ground based and space based segments of these systems. The IFL optical transmitter plug-in modules, Model # 10550A, covers a frequency range that includes Ku-Band. The IFL system can be configured to support Ku-Band satellite operations by exchanging the X-Band optical receiver plug-in module, Model # 10350A, with the Ku-Band optical receiver plug-in module, Model # 10350B. The IFL can also support mixed mode satellite operations; that is, simultaneous X-Band and Ku-Band operations.

The technical advantages of an externally modulated 1550nm-wavelength based IFL system can provide significant cost benefit/cost reduction to the SATCOM community, when compared to a directly modulated 1310nm-wavelength based IFL with similar performance.

The IFL System will posses the capability of automatic, emergency, and manual switch over, as well as the ability to exercise all IFL System sub-component modules. Each of the IFL sub-component module's microcontroller will posses the ability to evaluate its modules operational parameters and determine its functional status as either functional or nonfunctional. In the event that the microcontroller determines that the module is nonfunctional i.e., a fault condition exists, it will initiate an automatic sub-component switch over sequence.

The initiating sub-component module will begin the automatic switch over sequence through the use of the backplane control lines by asserting an ON-Line control and transferring the RF input to the respective auxiliary module, initiating an ALARM closure output accessible through the status and control I/O port located on the rear of the rack panel, and initiating an emergency broadcast message through the RS-485 bus. The emergency broadcast message will consist of a transmitted serial data string identifying the source sub-component module and the fact that a fault condition was detected.

As a result of the RS-485 Ether net based architecture, the transmitted message will be received by all of

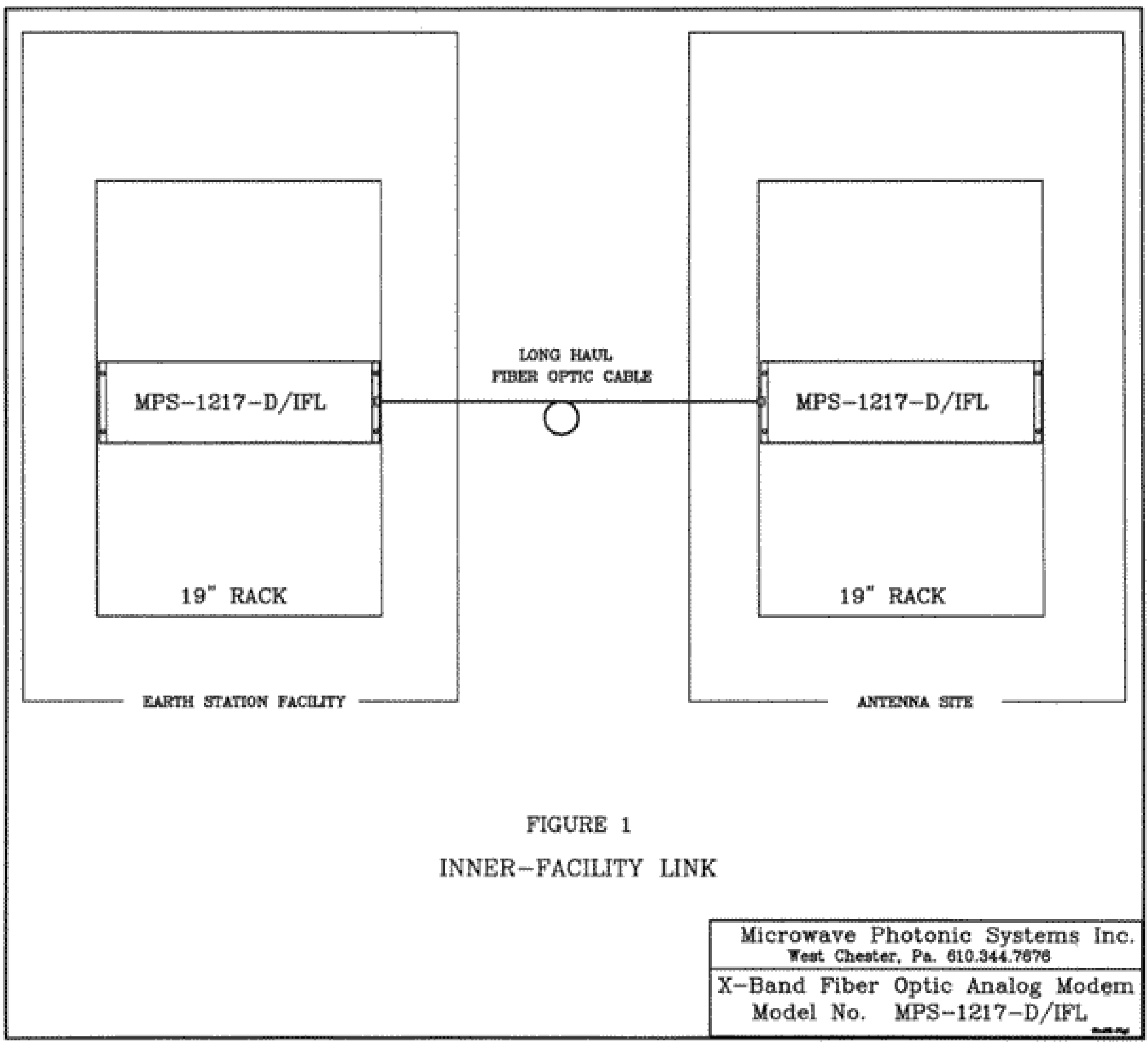


FIGURE 1

INNER-FACILITY LINK

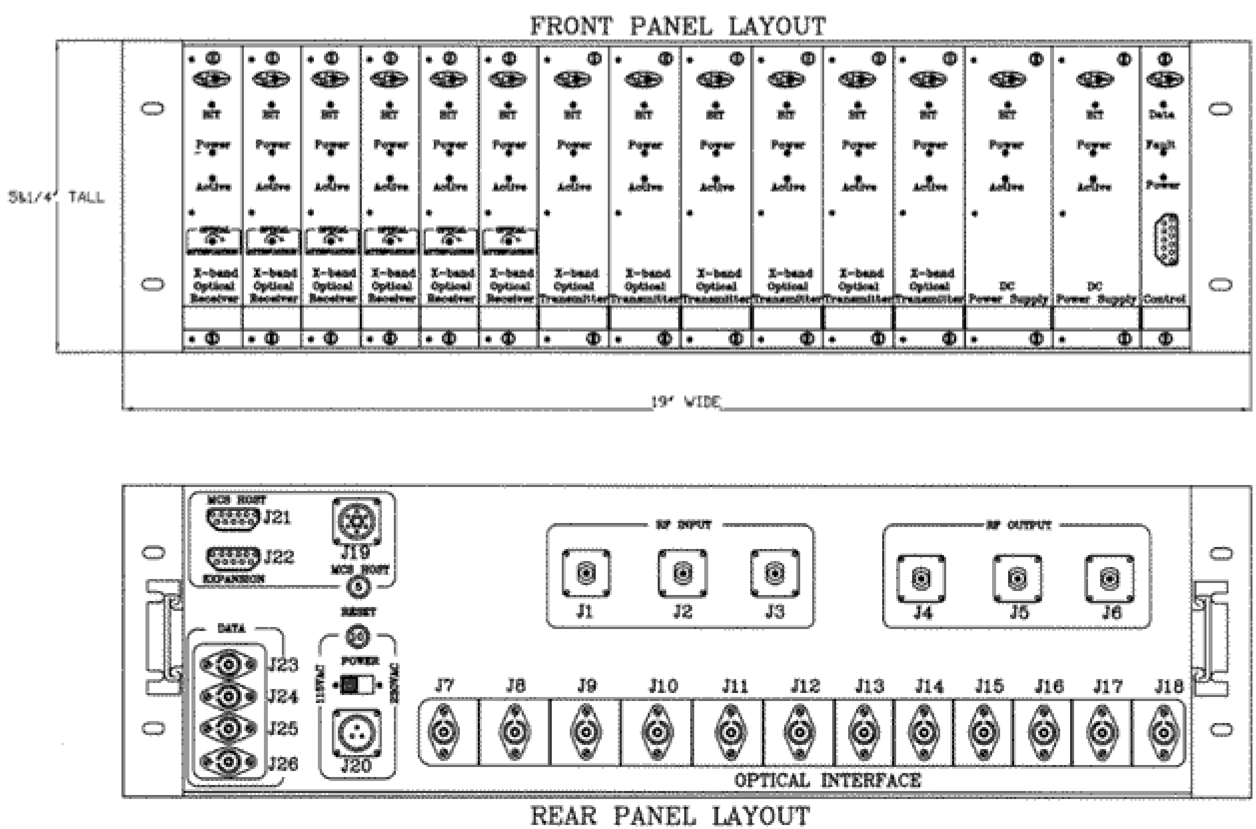


FIGURE 2

Microwave Photonic Systems Inc.
West Chester, Pa. 610.344.7676

X-Band Fiber Optic Analog Modem
Model No. MPS-1217-D/IFL

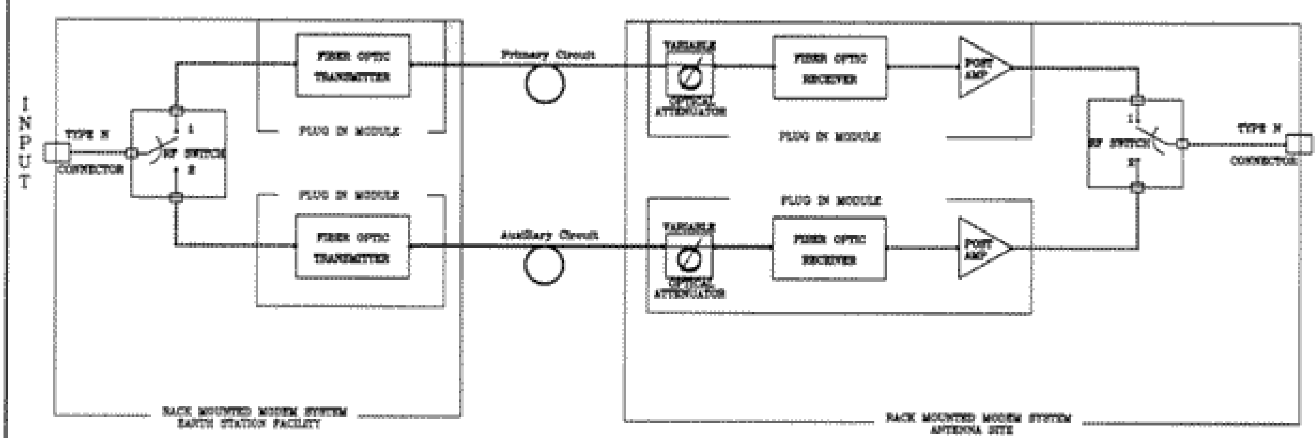


FIGURE (3a)
IFL UPLINK CHANNEL

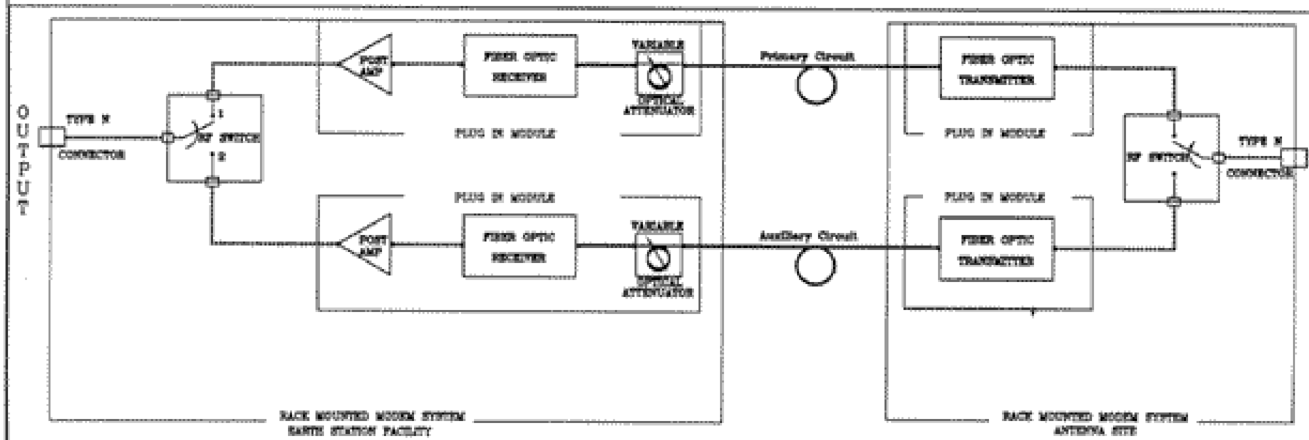


FIGURE (3b)
IFL DOWNLINK CHANNEL

RF PATH
OPTICAL PATH

Microwave Photonic Systems Inc.
West Chester, Pa 610.344.7676

X–Band Fiber Optic Analog Modem
Model No. MPS–12–17–D/IFL

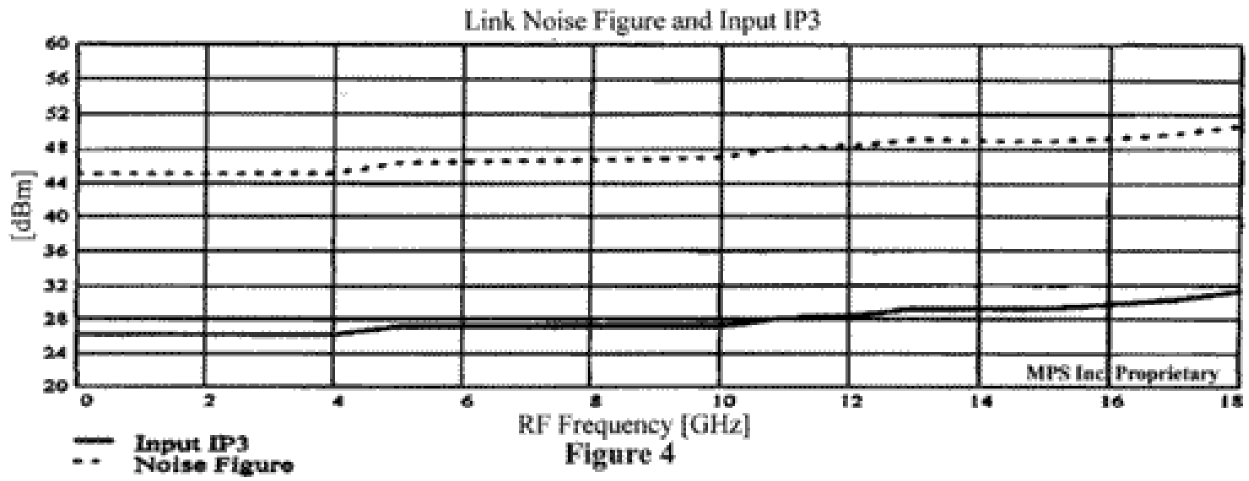


Figure 4

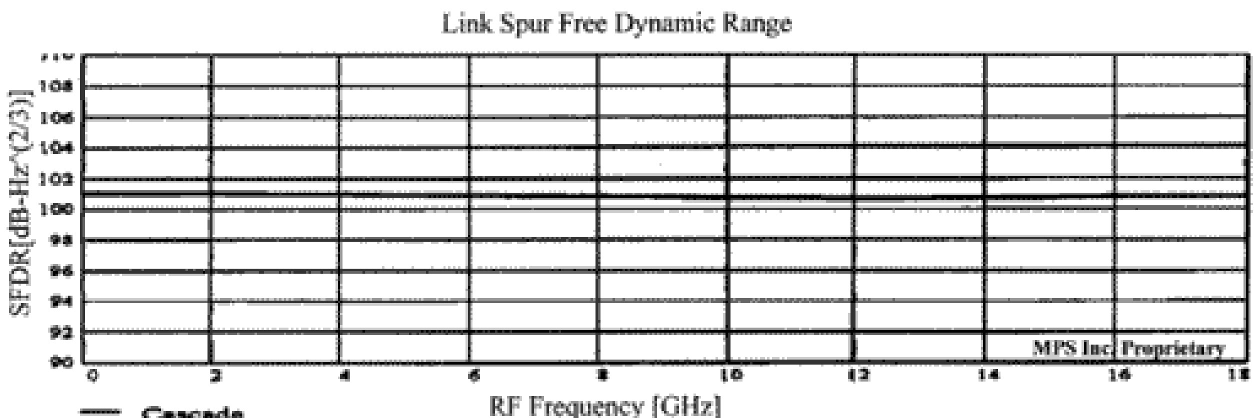


Figure 5

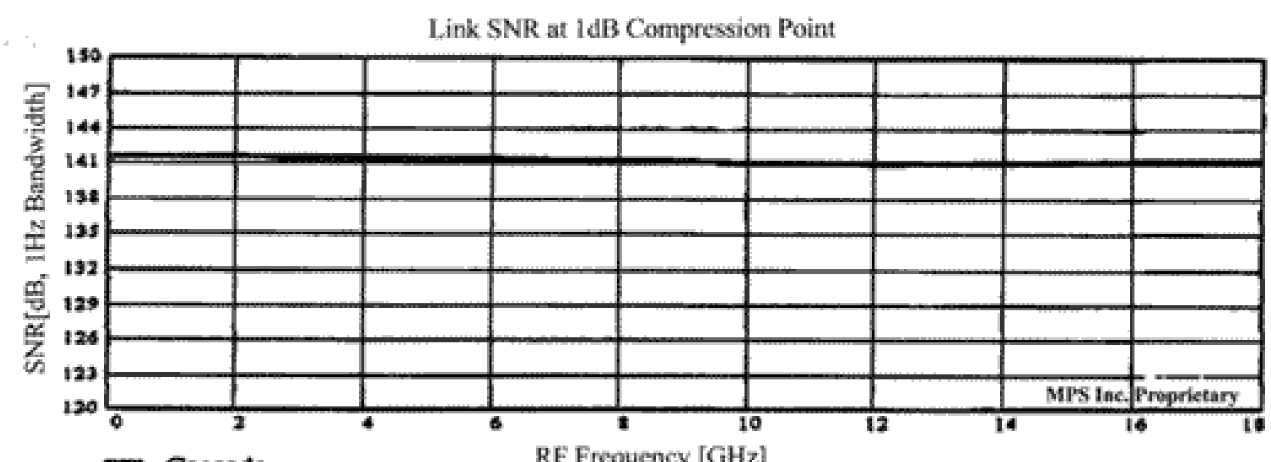
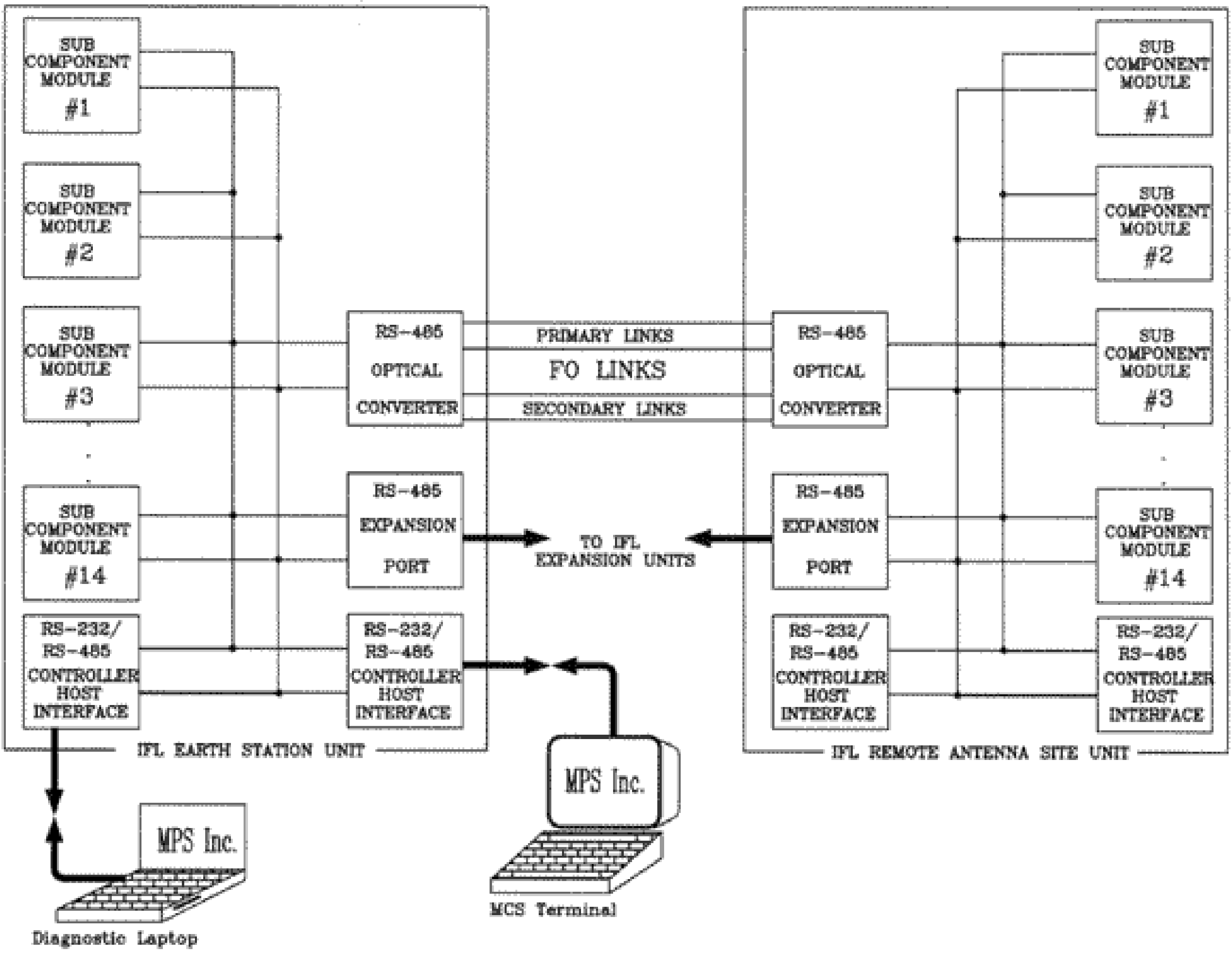


Figure 6



IFL SYSTEM MONITOR & CONTROL SYSTEM ARCHITECTURE

FIGURE 7

Microwave Photonic Systems Inc.
West Chester, Pa 610.344.7676

X-Band Fiber Optic Analog Modem
Model No. MPS-1217-D/IFL