RF Over Fibre

DrawCom represents Axell Wireless who are experienced in providing fibre optic fed coverage enhancement systems. Their wide experience in supplying cell enhancer equipments has been the basis of the systems solutions using fibre optics. Conventional cell enhancers are fed via an off-air antenna, or via coaxial cable, to repeat the wanted signals into an area without radio coverage. The use of fibre optics allows the off-air or BTS to be extended over great distances to remote locations.

Typically, cell enhancers are used locally at the area to be improved *e.g.* in-building, at the entrance of a tunnel or over a hill. The main limitation can be lack of sufficient isolation between the donor and in-fill antenna to prevent oscillation. Fibre fed systems separate the donor or master site from the in-fill site by the use of fibre optic cables, which provides higher isolation and allows the signals to be fed over greater distances without excessive cable attenuation.

The fibre optic systems are particularly suited to tunnel applications. Conventional daisy chained amplifiers fed via coax are limited by cable attenuation and amplifier intermodulation noise. Repeater reliability is a big issue also as failure of one amplifier can render the remainder of the cascaded chain useless. With fibre fed systems, each remote tunnel amplifier is fed radially with individual fibre cables from the master site. This provides a more robust solution against failure.

Fibre fed systems permit wide area low capacity coverage solutions at reduced costs. A base station may have a number of carriers and capacity to handle many calls. The use of multiple base stations, one for each location is expensive in terms of capital equipment and the ongoing line leasing costs for the control and modulation. With fibre fed systems a single BTS or off-air site is nominated as the master and each remote location is fed from that service. Hence BTS infrastructure costs are kept to a minimum, the use of off-air from existing coverage areas reduces the costs even further. Low capacity, low use users such as emergency services can benefit from the low cost implementation of coverage into tunnels.

System Design Issues:

There are a number of issues which need to be determined before designing a fibre fed system, including: frequency, power input/output, gain, number of sites *etc.* The wide band-width of the fibre optic equipment enables frequencies from 70 to 2500MHz to be sent via the fibre cable. The required frequencies are broken down into their specific operating bands and the frequencies from various services in the wide range can be coupled into the fibre by using cross band couplers.

The fibre optic transmitter is normally limited to a low level of composite power, thus any drive signals taken from a local BTS must be limited to prevent overload and intermodulation products being passed to the remote site. In the uplink direction, dynamic range and gain is important to prevent overload or near/far effect drop out when providing coverage to a number of subscribers in a cellular band, for example.

The propagation system will determine the amount of near/far effect dynamic range; leaky cable systems are more tolerant than antenna systems. The consistent coupling factor and low longitudinal attenuation give less than 40dB of level change.

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Fibre Optic Solutions

General overview of RF over Fibre

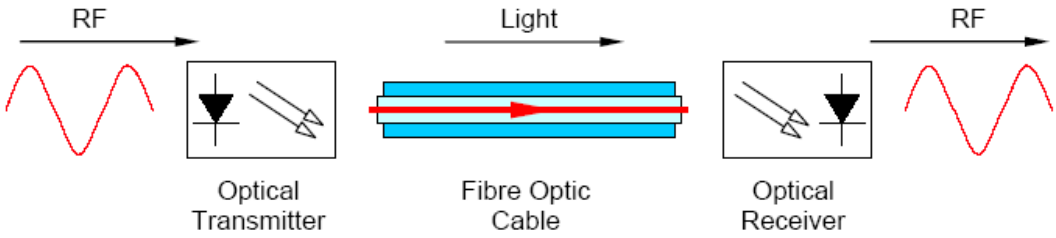
RF over Fibre techniques allow a large number of radio channels in different bands to be transported long distances over fibre optic cable with minimal degradation of the original RF signals. Multi-band combining techniques are applied prior to the RF / Fibre conversion and multi-band filtering and amplifier techniques are used to reconvert the optical signals to RF.

RF over Fibre is a solution particularly well adapted to the multi and mono band coverage requirements of metro railway systems and other indoor applications.

The key components of an RF over Fibre solution can be quantified as follows:

Monomode Fibre Optic Cable

The fibre has a very fine fibre inner core. The optical signal transmitted in the fibre is relatively unaffected by reflection and refraction, allowing the signal to travel long distances along the fibre without compromising the quality of the signal received at the far end.



It should be noted that the alternative fibre to Monomode, is Multimode fibre. This type of fibre is not particularly well adapted to RF applications over long distances as the optical signal passing through the fibre is subject to degradation from the refraction and reflections occurring within the fibre. The higher attenuation of the Multimode fibre means that Multimode fibre is used over relatively short distances.

FO Transmitters

The Fibre Optic transmitters and receivers must operate on a common optical wavelength. Presently, 2 wavelengths are adapted to Monomode applications, 1310 nm and 1550 nm. In general, the transmitter RF input port can only accept a maximum peak envelope power (PEP) of 0 dBm. Therefore, for multi channel or multi band applications it is necessary to verify the PEP of the RF input to the FO transmitter. An alarm circuit monitors the bias current of the laser and indicates an alarm if too much or too little current is being drawn.

FO Receivers

The optical receiver feeds a low noise amplifier . The intermodulation performance of this amplifier determines the output signal level per carrier. An alarm facility is available to indicate low optical input. For general applications, the RF carrier levels will typically be in the range -20 to -10dBm.

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Fibre Optic Solutions *(cont.)*

Fibre Optic Connectors

Particular care has to be taken when handling FO connectors. Unnecessary handling of the connectors is best avoided as dust on the fibre or a poor mating connection can severely attenuate the optical signal. At each installation, verify the connector type prior to connection. The external housing of certain connectors is identical to that of our preferred connector, the FC/APC, which means that this type of connector can be joined to another type, resulting in high attenuation of the optical signal. The FC/APC offers a large surface area of contact between both fibres.

Optical Couplers and Splitters

As with RF applications, the optical signal can be split equally into several different fibres or the signal can be coupled off a fibre with a fixed level of coupling loss. Care should be taken in selecting the coupler or splitter to be used as they are wavelength dependent, and therefore need to be compatible with the RF/Fibre converters. For either solution, it is recommended that the overall link budget should not exceed 9 dBoptic (or 18 dBRF). It should be noted that 1dB optic = 2 dBRF.

System Solutions

As detailed previously, optical signals can be split into several outputs or coupled from the fibre to the receiver. These solutions apply principally to the DL component of the system. For the UL signals, it is recommended that each UL path contains no optical combining. Each UL optical transmitter should have a corresponding UL optical receiver. The combining of several UL signals can only normally be undertaken after the Fibre/RF conversion..) If UL combining is unavoidable (normally due to the lack of available fibre), it is necessary to convert Fibre/RF before mixing the different RF signals prior to a second RF/Fibre conversion. (Normally due to the lack of available fibre), it is necessary to convert Fibre/RF before mixing the different RF signals prior to a second RF/Fibre conversion.

WDM -Wave Division Multiplexing

WDM allows two optical signals to use the same Monomode fibre. This technique is generally used to allow the UL and DL signals to pass over the same fibre link. Each optical signal has a different wavelength, e.g. the DL signal could have a λoptic of 1310 nm and the UL a λoptic of 1550nm. As previously mentioned, care should be taken in the selection of the component parts to take into account the different optical wavelengths.

Base Station or Off Air Interface

The signals to be transported by the fibre need to be filtered, and in most cases attenuated before the conversion RF/Light. If the base station is available locally, the DL signals can be coupled off the antenna port and fed to the optical transmitter. If the base station is not available locally, a cell enhancer or repeater needs to be installed to capture the external signals prior to the RF/Light conversion. Similar techniques are applied for the UL signals. The RF signals from the fibre are either coupled into the antenna port of the base station or amplified by the repeater towards the external base station. Both the local base station interface and repeater can be supplied by DrawCom.

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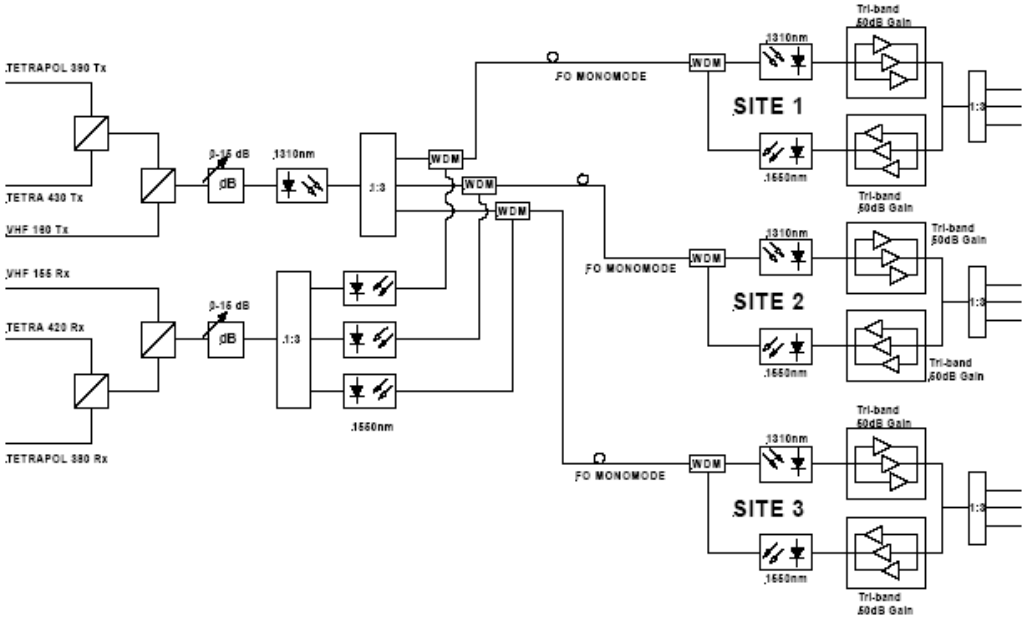
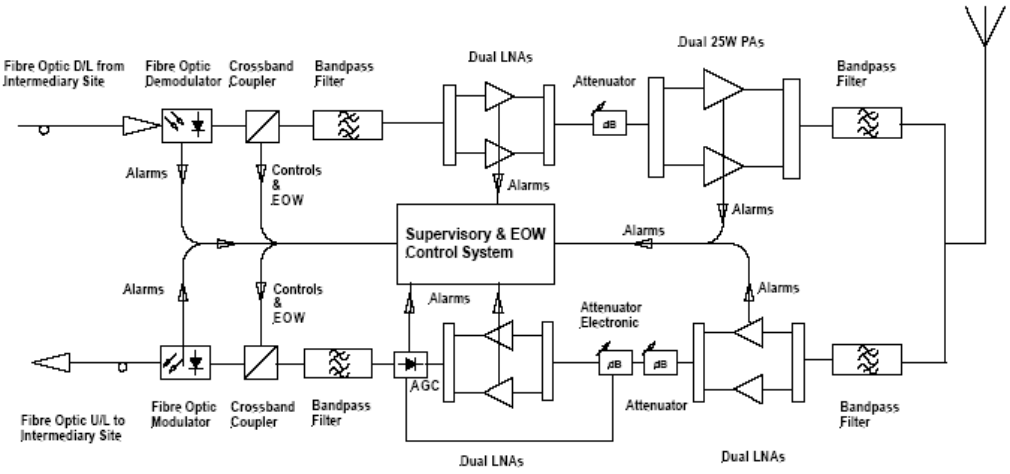
RF Bandpass Filtering and Repeater Solutions

DrawCom can supply a number of broadband Fibre Optic solutions using bandpass and crossband filtering techniques which allows each band or channel to be individually amplified, thus maximising the output levels and the intermodulation characteristics. The AFL range of highly linear Class A amplifiers add the gain necessary to achieve the required power output levels. After amplification, each band can be combined to provide one or several output ports for the cable or antenna infrastructure. The AFL range of multi band channelised or band selective solutions use highly linear Class A PAs with OIP3s of +40 to +60 dBm.



System Solution WDM : 1 Master & 3 Slaves



FO Out Station Solution: UHF

Fibre Optic Solution *(cont.)*

Typical RF Specifications	
RF Frequency Band	100 – 1000 MHz (Other bands available)
Maximum Input Power	0 dBm (PEP)
In Band Ripple	±1.5 dB
Typical Noise Factor	45 dB
Rx Gain	-20 to 0 dB
Rx Gain over the Band	±1.5 dB
OIP3 of Rx Output Amplifier	+ 26 dBm
Impedance	50 Ω
VSWR	Better than 1,5 : 1
Connectors	N or SMA

Typical Optical Specifications	
Optical Wavelength	1310 or 1550 nm
Maximum Optical Power Output Tx	3 dBm optic
Maximum Optical Power Input Rx	1 dBm optic
Link Budget	9 dB optic (18 dB RF)
Optical Return Loss	60 dB
Rx Gain	-20 to 0 dB
Connectors	FC / APC

Typical Fibre Optic Cable Specifications	
Fibre Type	Monomode
Attenuation / km	0.4 dB optic
Optical Connector Loss / mated pair	0.5 dB optic
Maximum Link Length	20 km

Options		
WDM	Both λ on the same Fibre (1310 & 1550nm)	
Main & Standby	Transmitters & Receivers	
Alarms	Tx Alarm –	Laser Power O/P
		Laser Temperature
	Rx Alarm –	Low Received Signal I/P
Supervision	Supervision of the Fibre & Associated Systems with Local & Remote Access	
Engineer's Order Wire	Facilitates the Link Commissioning	
PSUs	Several Integrated or External Solutions	

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