

10G BROADBAND WIRELESS

Ogier Electronics

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1 INTRODUCTION

The Ogier 10G broadband wireless system has been designed to provide broadband services to residential and business users at the lowest possible cost.

The system uses the 10 GHz band and has been proven in service in a number of countries around the world under all weather conditions and terrains.

The most important feature of the system is its compatibility with DOCSIS the world standard for data transmission over cable, a system that is in use by tens of millions of subscribers. The wireless is transparent and behaves identically to cable.

Because of this, the system is supported by major manufacturers of broadband routers and cable modems. This gives operators the opportunity to select the correct mix of peripheral equipment without being tied to a single supplier. The level of standardisation is the target to which other wireless systems are trying to aspire.

2 FEATURES

2.1 Summary

- Licenced band for interference free operation
- Compatible with the DOCSIS open standard, with many millions of users worldwide
- Scalable to high capacity
- Low cost CPEs for residential and SMEs
- 3rd party DOCSIS Cable Modem Termination System (CMTS) suppliers (e.g. Arris, Cisco and Motorola among others) provide support for full Network Management, QoS, VPN and other services
- Simple and straightforward installation with no set up or adjustment
- Rugged, high-reliability RF design
- Low cost 3rd party DOCSIS Cable Modems

2.2 Licenced Band

The system operates in the 10.15 to 10.6 GHz licenced band. To optimise the use of the spectrum, it uses DOCSIS SC-64QAM modulation in the higher capacity downstream direction. In the UK or similar climactic conditions an operating range of 10 km range is available with this modulation using standard CPEs with integrated antennas. Ranges of up to 25 km at the full data rates are available for special cases using separate larger antennas.

The system typically uses QPSK or 16QAM in the upstream direction. The 10 and 25 km ranges are achieved with QPSK, but are reduced at higher level modulations.

2.3 World Standard

A key feature is that the system interfaces directly to open standard Cable network routers and modems that are in use in almost every country in the world. Many manufacturers can supply these elements, which means that all their developments are available to the benefit of the network. They include upgrades of the DOCSIS specifications, Video streaming and higher data rate operation.

The standards are supported by some of the most respected companies in broadband and data transmission. All their equipment are compatible with the wireless system. Major manufacturers including Cisco systems and Arris supply DOCSIS compatible Routers of various types and there are a number of other significant manufacturers.

We will be pleased to help advise on the most suitable products for any particular application, though generally it is best to approach the CMTS manufacturers directly.

2.4 Proven Turnkey Solution

The equipment has been designed to be simple and straightforward to install. It is generally the case that operators choose to undertake all the installation work themselves. Indeed in some cases, local electricians have installed Base Stations and subscribers have installed their own CPEs.

2.5 Capacity

Typically each Ogier Base Station equipment transmits a number (up to 4) of DOCSIS 6MHz SC-QAM Downstream channels. Each of these channels provides approximately 27Mbps over-the-air bit-rate. Allowing for overheads this equates to a nominal 24Mbps actual downstream throughput (note that actual throughput is dependant on a number of factors).

For the Upstream, assuming a 6.4MHz SC-QPSK channel then the over-the-air bit-rate is nominally 10Mbps, perhaps 8Mbps actual throughput.

Assuming a licence with 28 MHz bandwidth is available then a single 90 degree coverage Base Station will have a nominal capacity of 96 Mbps in the downstream direction and 32 Mbps in the upstream.

These capacities are conservative in that they assume the use of QPSK modulation in the upstream direction. If 16QAM is used, the capacity is effectively doubled in that direction.

The directivity of the CPE antennas is high. This, combined with extensive filtering allows a high degree of frequency re-use. The capability is enhanced even further by polarisation diversity in which different combinations of vertical and horizontal polarisation can be used at different Stations.

It is important to note that the performance and specifications quoted for the system essentially apply at all ranges in the downstream direction and at the full range if QPSK is used in the upstream, or at half the range if 16QAM is used. Note that different upstream channels on the same Base Station can be provisioned by the CMTS for different modulations allowing closer subscribers higher throughput while still covering the full range.

In contrast some radio systems are specified with a bewildering range of "adaptive" modulations, with and without lines of sight. In practice the maximum ranges only apply at low data rates with the higher data rates only applicable to higher modulations at 1/10th of the range. Because of this, a system with an apparent 30 km range is only able to provide the full data rate at 3 km or less.

Also, the use of mixed modulations can effectively degrade the capacity of the network for all the other users, even those using higher modulations at short

ranges. A single BPSK user at a long range takes more time, which inevitably reduces the time available for all the other users.

2.6 Low Cost

The system is scalable and the infrastructure cost need only be committed when it is needed, which makes it ideally suited to meet the growing needs of a developing market. In particular a Master/Slave Hub configuration can be used in lower subscriber density areas to minimise costs (see later).

The growth in capacity, combined with the low cost of the customer premises equipment, a fraction of that of other proprietary systems operating in the licenced bands, means that the system is inexpensive and affordable to residential as well as business users.

Remote PHY solutions for the CMTS (whereby the RF functions of a fully integrated CMTS are separated and moved to the network edge) also reduce the cost of the network equipment required at each Base Station site while still providing full performance and functionality and improving reliability.

2.7 DOCSIS 3

The system has been tested successfully with DOCSIS 3 routers and modems. DOCSIS 3 allows for much higher peak data-rates by using channel-bonding protocols to combine downstream (or upstream) channels so they act as a single high-capacity pipe. Note though that in common with all radio systems, the maximum operating range of the equipment is reduced as more downstream channels are transmitted.

2.8 Simple Installation

The innovative design employed in the equipment results in a number of benefits for the operator which ease the installation tasks. A minimum of hardware is needed and no adjustment or set up is required to any of the wireless units, either at the Base Stations or at the subscribers. The only tasks involved in bringing new subscribers on-stream are those that have to be done for any internet subscriber on a cable network. This enables the complete Base Station to be installed and commissioned rapidly. It also allows CPEs to be installed and operational in hours. Subscribers can often install the CPEs themselves.

The system planning is straightforward. In many cases it is even simpler than that required for cable networks. The additive noise and mutual interference are not present, which means that the number of subscribers is not artificially limited in any way.

Software tools are available that model complex networks of Base Stations. The antenna, transmitter and receiver characteristics are modelled to predict the signal level at any subscriber in the coverage

area with any Base Station transmitting on any frequency and polarisation. This allows the C/I levels to be established over the full area and the optimum frequency plan to be determined for the complete network.

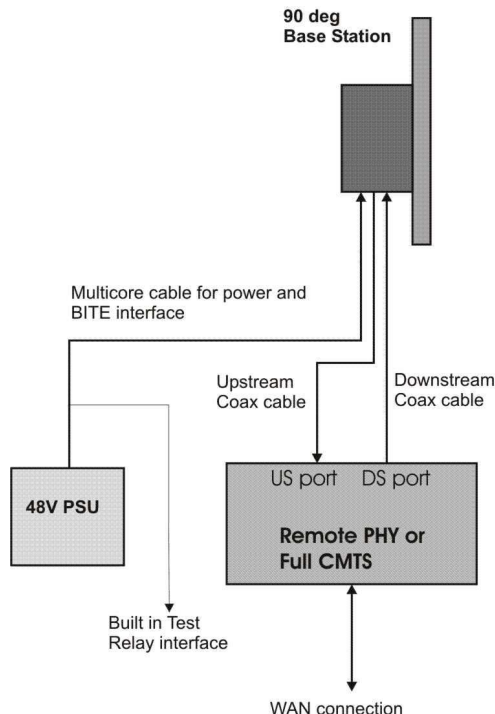
3 SYSTEM OVERVIEW

3.1 System Elements

There are essentially 2 system elements, the Base Station system comprising the 3rd party CMTS (or Remote PHY) and the Ogier Base Station Radio(s) and the Customer Premises equipment comprising the Ogier CPE Radio and the Cable Modem.

3.2 Base Station System

The Base Station provides the link from the CPEs to the outside world.



Single Base Station install Schematic Figure 3.1

A schematic of a typical Base Station System installation is shown in Figure 3.1. For simplicity only a single Base Station is shown. The equipment configuration in this arrangement comprises:

- The DOCSIS CMTS or Remote Phy Node (with US and DS channels as required).
- The Ogier Standard Base Station with 90deg sector antenna.
- The -48 Volt Power Supply.

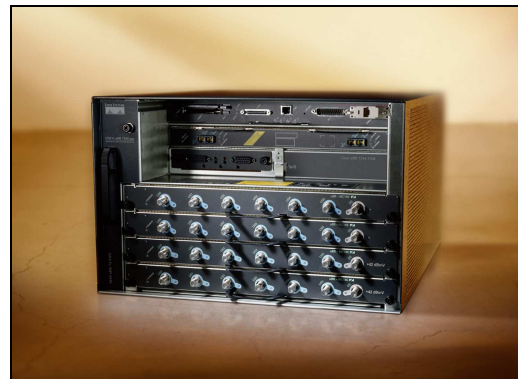
Coaxial cables connect each Base Station to the IF ports of the CMTS/Remote Phy. Downstream frequencies are around 480MHz, while Upstream channels are in the range 12 to 42MHz. Up to 50 metre runs are possible using standard low cost cables.

Each Base Station is powered by a 48V PSU and the same multicore cable used for power also carries a two-wire relay based Built in Test interface that indicates the operational status of the Base Station (Downstream AGC state, internal Oscillator phase locked state, internal PSU status).

Multiple Base Stations can be connected to the same CMTS or Remote Phy node if the CMTS/Remote Phy has sufficient Downstream and Upstream ports. In this way 360deg coverage can be achieved with four standard Base Stations from a single CMTS or Remote Phy.

3.3 CMTS/Remote Phy

A fully integrated router (Cisco uBR7246VXR) is shown in Figure 3.2. It includes the Cable Management and Termination System and the Dynamic Host Control Protocol Server, which provides the over-air conditioning of the subscriber's equipment, including the IP addresses and the channel allocations.



Cisco Systems uBR7246VXR Figure 3.2

Typically each downstream channel uses a 6 MHz band with 64QAM modulation. All the channels are modulated onto I.F carriers in the 400 to 500 MHz band (as configured on the CMTS/Remote Phy) and fed through coaxial cables to the Base Stations for transmission in the 10 GHz band.

Optionally a Remote Phy (see Figure 3.3) rather than a full CMTS will be located at the Base Station site, with the core CMTS located elsewhere on the providers network. The Remote Phy will then provide the upstream and downstream channel interfaces to the Base Stations.



Arris E6000n Remote Phy Figure 3.3

In the upstream direction, the Base Station output is fed directly to the CMTS/Remote Phy. Upstream channel bandwidths can be set to between 0.8 to 6.4 MHz. With QPSK modulation the total data rate is 5 Mbps per 3.2 MHz channel. With 16QAM it is 10 Mbps.

3.4 Base Station configurations

The Base Station provides the two way communication to the subscribers. A Standard unit comprises a transmitter and receiver with their antennas in a single integrated assembly shown in Figure 3.4. Each Standard Hub covers a 90deg sector.

A cost-effective alternative to the Standard Hub is the Master/Slave Hub configuration, this is intended for low-density installations. Here a single downstream channel is transmitted over two opposing 90deg sectors (one from the Master and one from the Slave). The Slave has no Downstream circuitry of its own (making it a lower cost assembly). Instead it is cabled to the Master and uses its Downstream RF signal. Both Master and Slave incorporate their own Upstream circuits.

In addition to the data, the Transceiver/Hub also transmits a beacon signal, which provides a precise frequency reference used by the CPE's. This technique allows transmission at 10GHz without imparting frequency errors that could otherwise impact on the DOCSIS channel performance.

The transmit power levels are sufficiently low to avoid any radiation hazards. The antennas employ innovative beam shaping to minimise the variation in signal power at all offset angles and ranges.



Transceiver covers a 90 degree sector Figure 3.4

If greater capacity is required, additional Base Stations can be installed in each sector, though these require different operating frequencies.

3.5 CPEs

The standard MK2 CPE unit is shown in Figure 3.6 with its standard bracketry. It has a compact antenna assembly integrated with the wireless circuits and provides a typical all weather range of 10 km.

The CPE has a single F-type connector that connects via a coaxial cable to a bias injector which is fed with 12V DC from a plug-top adaptor. The bias injector is also cabled to the Cable Modem which is installed indoors.



Customer Premises Equipment Figure 3.5

Note that in special cases long range versions of the CPE have been supplied that use a separate 60 cm antenna to increase the operating range to 25 km.

The CPE must have line of sight to the Base Station and is typically installed on the roof or wall of a building.

3.6 Cable Modem

DOCSIS standard Cable Modems can be used without adjustment. Different subscribers within the system share both the up and the downstream channels to the Base Station in the FDM/TDM arrangement specified by the DOCSIS protocol.

There are various suppliers of Cable Modems including Arris, Netgear, D-link, Cisco and Linksys.



Example Cable Modem Figure 3.6

Depending on the model these can incorporate features such as DOCSIS 3 operation and built-in Wi-Fi. Due to the worldwide use of DOCSIS equipment they are sold in very large quantities bringing an economy of scale to unit pricing.

Ogier can help with selection of a suitable modem but system operators invariably approach manufacturers directly for their advice and for sales.

3.7 Frequency Plan Principles

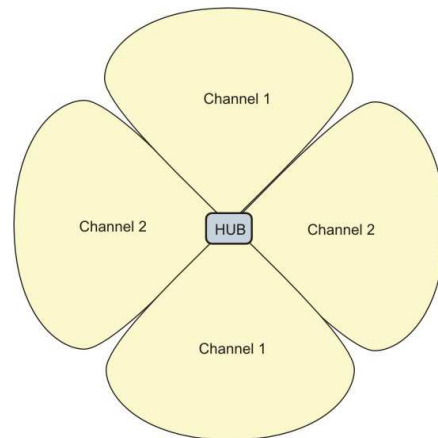
The object of frequency planning is to ensure that subscribers receive downstream data from the Base Station without being affected by another Station operating on the same channel. The same is true in the upstream direction.

As licence fees for spectrum are not insignificant, the objective of avoiding interference must be matched by making as efficient use of the spectrum as possible.

Frequency is re-used in opposite quadrants of the Base Station. Half the channels are used in the sectors facing North and South and the other half in the sectors facing East and West. This arrangement,

illustrated in Figure 3.7, avoids interference at the cross-over between the antennas.

The front to back ratio of the subscriber antennas – see the polar diagrams in Section 4 - is such that CPEs can receive data in the forward direction from a Base Station whilst simultaneously being illuminated from behind by another Station only 5 kilometres away. This means that the frequencies can be re-used at different sites, providing their separation is at least 10 km.



Frequency re-use Figure 3.7

4 SPECIFICATIONS

4.1 General

RF Band

Downstream Frequencies:
Any 28MHz Band from 10.15 to 10.3GHz

Upstream frequencies:
Any 28MHz band from 10.5 to 10.65GHz

Instantaneous Bandwidth

28 MHz

Sectorization

A "Standard" BS covers a 90 degree sector
A "Master/Slave" BS covers two opposing 90deg sectors but the sectors use a common Downstream channel and share the data capacity

Transmission Channels

Downstream Up to 4 x 6 MHz channels per BS
Upstream Upstream channels can be 0.8, 1.6, 3.2 or 6.4MHz wide. Note that a BS can receive multiple Upstreams but each CPE can only transmit one.

Data Capacity per Channel (nominal)

Downstream 27 Mbps total - 24 Mbps usable per 6MHz SC-QAM channel
Upstream 10 Mbps total - 8 Mbps usable per 6.4MHz QPSK channel

Max Capacity per 90 deg Base Station (28 MHz)

Direction	Total	Usable (nom.)
Downstream	108 Mbps	96 Mbps
Upstream (QPSK)	40 Mbps	32 Mbps
Upstream (16QAM)	80 Mbps	64 Mbps

Range

QPSK Upstream:
Standard CPE 10 km from Base Station
Long Range 25 km from Base Station
16QAM Upstream:
Standard CPE 5 km from Base Station
Long Range 10 km from Base Station

Modulation

Downstream Typically 64QAM
Upstream QPSK, 8QAM or 16QAM

Access Method DOCSIS 1.0, 1.1, 2.0, 3.0

PHY

Downstream TDM (DOCSIS)
Upstream FDMA/TDMA (DOCSIS)

MAC Protocol MAC protocol is DOCSIS

QoS

The network management system allocates different Quality of Service levels, data rates and bandwidths to different types of user

4.2 Wireless Specifications

EMC and radio Compliance EN 301 489-1, EN 301 489-4 & EN 301 021

Antenna compliance

Base Station Hub
(see polar diagrams) EN 302 085 CS Class 1
Standard CPE EN 302 085 TS4 Range 3

4.3 CPE Wireless Unit

General

O/P frequency to modem 469 to 497MHz
I/P frequency from modem 14.5 to 42.5 MHz
Frequency error <20 kHz
Phase noise <-77 dBc/Hz at 10 kHz
Out of Band Spurious <-40 dBm on RF ports

Receiver

Noise Figure <4 dB (3.0 dB typical)
Gain 28 dB nominal +/-6 dB
Gain flatness <4dB total, <2 dB / 6MHz
In band spurious Below noise in 100 kHz
1 dB compression -20 dBm at output

Transmitter

Gain 20 dB nominal +/-6 dB
Gain flatness <4dB total, <2 dB / 6 MHz
1 dB compression >17dBm

Standard Integral CPE Antenna

Beamwidth <20deg
Nominal Gain 20 dBi
Polarisation Vertical upstream & Horizontal downstream (or vice versa)

Power

Voltage 12V+/-5%
Current drain < 520 mA

Physical

Operating Temp -20 to +55 degree C
Water and dust IP65 (without drain hole)
Connector Single 75 ohm F-type Female
Mass approx 1.6 kg
Dimensions 180 x 170 x 35 mm not including optional sunshield

4.4 Base Station Transceiver

General

O/P frequency to Router 14.5 to 42.5 MHz
Input freq from Router 465.5 to 493.5 MHz
Frequency error <2 kHz
Phase noise <-80 dBc/Hz at 10 kHz

Receiver

Noise Figure <4.0 dB
Gain 40 dB nominal +/-3 dB
Gain flatness <4 dB total, <3 dB over 6 MHz
In band spurious Below noise in 100 kHz band
1 dB compression -5 dBm at output

Transmitter

Input power range	23 to 38 dBmV AGC range
Output 1 dB comp	>35dBm
Transmit power	26 dBm nominal (single channel)
Power variation	<1.5 dB over temperature

Antenna

Beamwidth	Azimuth	90 degrees
	Elevation	cosecant ²
Nominal Gain		19 dBi
Polarisation	Vertical upstream & Horizontal downstream (or vice versa)	

Power (per downstream channel)

Voltage	-48 V +/-5%
Current drain	< 1.35A (-48V) after 5 minutes

Physical

Operating Temp	-20 to +55 degree C
Water and dust	IP66
Connectors	2 x 75 Ohm N Type Female 1 Multipole for power and BIT Built in Test Single Contact closure pair for oscillators & output powers
Mass	20 kg approx
Dimensions	approx 600 x 320 x 300 mm

4.5.2 Upstream

Polarisation	Vertical
Availability	99.99%
Rainfall rate	30 mm/hour
Modulation	QPSK
Bandwidth	3.2 MHz

Tx 1 dB Compression	17.0	dBm
Back-off	3.0	dB
Transmitter Output Power	14.0	dBm
Transmitter Antenna Gain	20.0	dBi
Cable Losses	0.0	dB
Transmitter Carrier ERP	34.0	dBm
Path Length	10.0	km
Theoretical Path Loss	132.9	dB
Rain Fade and Gas Loss	5.5	dB
Alignment Loss	1.0	dB
Total Loss	139.4	dB
Power at Receive Antenna	-105.4	dBm
Receiver Antenna Gain	17.0	dBi
Received Carrier Power	-88.4	dBm
KTb	-108.8	dBm
Receiver Noise Figure	4.0	dB
Receiver Noise Power	-104.8	dBm
Received Carrier/Noise	16.4	dB

4.6 Antenna Patterns

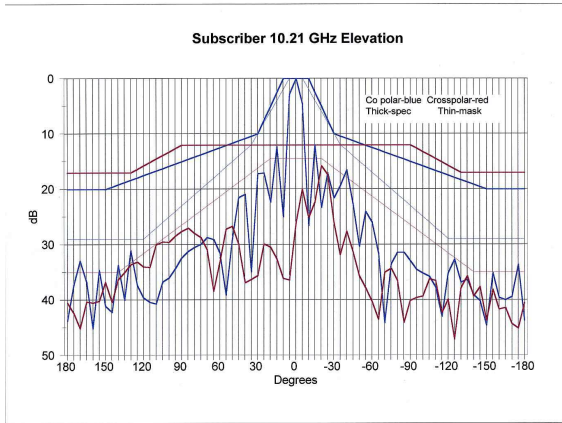
See overleaf

4.5 Link Budgets

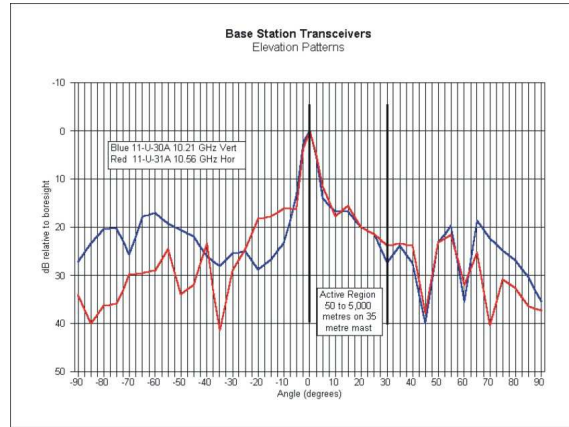
The ITU-R P.530-10, ITU-R P.837-3 and ITU-R P.838-1 recommendations have been used to establish the rain fade for 99.99% availability (in UK or similar climatic conditions) for a Standard Hub.

4.5.1 Downstream

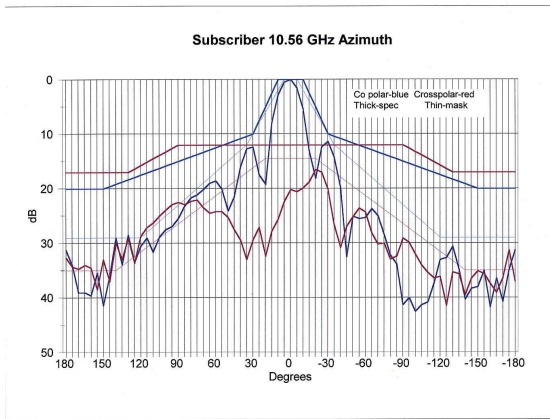
Frequency	10.2 GHz	
Polarisation	Horizontal	
Availability	99.99%	
Rainfall rate	30 mm/hour	
Modulation	64QAM	
Bandwidth	6.0 MHz	
Tx 1 dB Compression	35.0	dBm
Back-off	9.0	dB
Transmitter Output Power	26.0	dBm
Transmitter Antenna Gain	17.0	dBi
Transmitter Carrier ERP	45.0	dBm
Path Length	10.0	km
Theoretical Path Loss	132.6	dB
Rain Fade and Gas Loss	6.4	dB
Alignment Loss	1.0	dB
Total Loss	140.0	dB
Power at Receive Antenna	-95.0	dBm
Receiver Antenna Gain	20.0	dBi
Cable Losses	0.0	dB
Received Carrier Power	-75.0	dBm
KTB	-106.1	dBm
Receiver Noise Figure	3.5	dB
Receiver Noise Power	-102.6	dBm
Received Carrier/Noise	25.6	dB



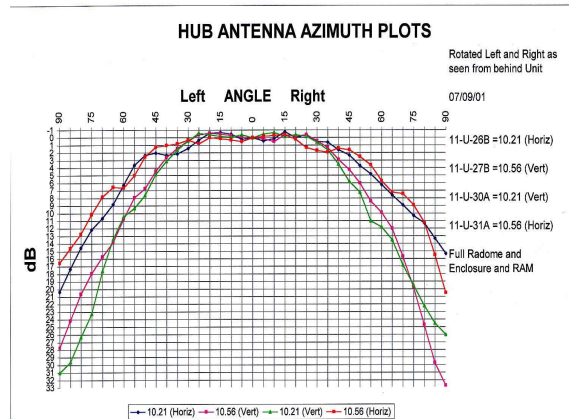
CPE Elevation Pattern Figure 4.1



Base Station, Hub Elevation Patterns Figure 4.3



CPE Azimuth Pattern Figure 4.2



Base Station, Hub Azimuth Patterns Figure 4.4

5 OGIER BACKGROUND



16 video channels over 60 km Figure 5.1

As well as broadband, we are in the forefront of many other innovative radio and microwave transmission technologies. They include multichannel systems capable of transmitting large numbers of high quality videos in complex microwave CCTV networks. Both analogue and digital non line of sight solutions are produced. The digital equipment uses technology compliant with the international DVB-T broadcast standard.

We also produce frequency and space diversity systems to transmit data and pictures to and from moving trains (such as shown below for the Hong Kong MTRC and also for London Underground) as well as low cost millimetre wave technology.



Track to Train transmission for MTRC Figure 5.2

Ogier are also introducing new, innovative and low-cost Surveillance Radars such as the Scan-360 shown below.



Scan-360 Surveillance Radar Figure 5.3

This 24GHz Radar provides 360deg coverage every second. If the Radar identifies a target within the area covered it immediately alerts the operator and slews a connected camera to the target bearing for image recording and further action.

For further information please visit:
<http://www.ogierelectronics.com/>

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