SAT Fibre Optics

Satellite reception via fibre optic cable is on the rise

An attractive alternative to terrestrial television in the housing industry

Fibre optic cable has been used in satellite IF distribution technology to build fibre optic communal antenna systems for direct satellite reception since early 2010. Since then, and in collaboration with Triax, these products have undergone extensive further development.

Read on to find out how this development is facilitating new solutions in the housing industry for installing the infrastructure required to provide TV services.

Direct satellite reception provides a huge range of domestic and foreign TV channels at a practically unbeatable cost to the user; this is an important reason why the majority of residents who are non-native speakers in particular will install their own satellite dishes in front of their windows, despite this bringing them into conflict with housing authorities.

As a result, the issue of how to avoid accumulating a large number of dishes on building façades, whilst still providing residents with the necessary variety of channels at low running costs, has now grown into a major concern for the housing industry.

Until now, the high attenuation of the coaxial cable has limited extending SAT IF distribution at high frequencies, and satellite transmission requires an extremely high bandwidth due to its robust modulation method. This poses both bandwidth and cable length issues for conventional coaxial cables. In the new system, the satellite TV channels are supplied via larger communal antenna systems in a signal processing headend, from broadband DVB-S/S2 to the narrowband DVB-C cable TV format. Nevertheless, this is still a selection of programmes.

Fibre optic cable has a virtually negligible level of attenuation, provides high transmission bandwidths, saves space and is easy to install. Now, we will show solutions for installing very large direct satellite reception distribution systems at a relatively low cost based on new SAT Fibre Optic products.

Frequency stacking solves the bandwidth problem

As already outlined, high bandwidth is the main drawback of conventional SAT IF distribution via coaxial cable. The signal bandwidth of the entire range of programmes, which is sent via satellite, is much higher than one provided by a coaxial indoor drop cable.

As we know, this distributes the entire signal bandwidth of a satellite position via low noise block converter on four parallel SAT IF bands (950-2,150 MHz). Each of these bands is then transmitted over a separate coaxial cable. As a result, four coaxial transmission lines are required for each satellite position.

An additional coaxial cable is required to distribute terrestrial programmes. Transporting four satellite positions in addition to terrestrial programmes such as FM and DVB-T, for example, requires a cable bundle of at least 17mm x 7mm in diameter. Both the space and the large amount of installation work required, as well as cable attenuation, understandably mean that a coaxial satellite IF distribution system of this kind soon reaches its limits.
The trick made possible by fibre optic transmission:

SAT IF bands are no longer transmitted in parallel frequency positions, but stacked at a frequency multiplex between 950 and 5,450 MHz via a low noise block converter. These high frequencies are converted by the following optical laser transmitter into an intensity modulated light signal and are transferable via single-mode optical fibre. Therefore just one thin fibre-optic cable is enough for all four satellite bands at a satellite position. Transmission lengths of up to 10km are easy to implement without special measures.

The optical fibre of optical re-converters is completed on the user side. Here, the light-modulated signal is first converted back into an electrical HF signal, then the satellite IF band spectrum is converted into four individual, SAT receiver-compatible frequency positions (de-stacking).

Depending on the optical re-converter version, the bands will then be available separately, each at its own coaxial output (Quatro) or via an internal matrix switch (Quad). The Quatro type (see Glossary) is for connecting multiswitches in series and the Quad type for directly connecting terminals via SAT tuners.

Despite all the advantages of FO transmission, for the foreseeable future the satellite receiving system will remain – similar to the HFC (Hybrid Fibre-Coaxial) network in classic cable TV – a combination of FO and coaxial distribution; however, no terminals with an optical input are yet in sight.

But the trend for getting ever closer to the consumer with the optical fibre – known as “deep fibre” – is persisting. The structure of an optical satellite IF distribution system can be divided into three areas: (Figure 1):

- Optical headend with satellite parabolic reflector, optical LNB or IRS optical transmitter with terrestrial antennas
- PON consisting of the optical splitters and FO cabling
- Optical network terminations with the different types of optical re-converter, where the downstream coaxial distribution system is connected with the consumer sockets

We will now look at these three network segments in more detail.

A mix of copper and optical fibre

When building new residential areas, the recommendation is to install optical fibres in parallel with Cat 6 cables right into the home – which is already a legal requirement in France, for example. Once inside the home, we consider point-to-point coaxial and Cat 6 cabling from the home distribution board to the individual consumer sockets to be more than fit for the future.

This infrastructure offers the ideal conditions for providing broadcasting services using satellite FTTH technology and provides an independent structure for integration into different communication networks for high-speed Internet.

As far as the housing industry and installation companies are concerned, the issue of expanding or even converting over to satellite community reception is much more crucial for existing housing stock than for new builds. Here we come across a huge variety of different cabling configurations and it is up to planners to weigh up which of the basic solutions outlined below will give the best cost-benefit ratio in each case.

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Figure 1: Structure of a satellite IF distribution system with FO. Left: SAT parabolic reflector with stacking LNB and optical transmitter; centre: PON, right: re-conversion into an electrical signal.
Satellite-fibre headend
The satellite-fibre headend is determined by the number of satellites to be received and whether or not any terrestrial channels such as FM, DAB and DVB-T/T2 are required in addition.

There are three possibilities here:

a) Optical LNB (TOL, see Glossary), which includes a stacking LNB and a laser transmitter in a single unit (Figure 2). This enables a satellite position to be received with four bands and an optical split into max. 32 or 64 optical network terminations.

b) IRS (Integrated Receiving System) for satellite and terrestrial, which includes stacking LNB TWL 1 and external laser transmitter TOU 232 SA (Figure 3). A satellite position with four bands can be received, plus there is the option for feeding in terrestrial channels in FM, DAB and DVB-T/T2. The IRS transmitter TOU 232 SA has two optical outputs and enables a split into max. 2 x 32 optical network terminations.

c) Integrated Receiving System for satellite and terrestrial with optical LNB and optical repeater (see Glossary for an explanation of terms). The optical repeater consists of two components: an optical-electrical converter and an optical transmitter, which converts electrical signals back into optical ones (Figure 4). Benefit: The satellite parabolic reflector with optical LNB can be operated far away from the optical repeater. Here too, all four bands are received and there are also options for feeding in terrestrial channels in FM, DAB and DVB-T/T2. As in b), this is followed by a split into max. 2 x 32 optical network terminations. An optical transmitter with a fixed wavelength of 1,310nm is currently used for the optical distribution of the stacking signal of a satellite position. A laser transmitter of this kind therefore always feeds a separate optical fibre or PON. If another satellite is to be received too, then a second optical transmitter with stacking LNB or optical LNB will be needed, which will feed another optical fibre with dedicated optical distribution.

Alternatively, transmitting multiple satellites via different optical wavelengths on just one optical fibre is possible. However, due to the current technological level of laser transmitters, Triax recommends these wavelength multiplex techniques only in very specific applications, which this article will not cover further.
PON – the Passive Optical Network

The signals are actually distributed over the PON (Passive Optical Network), which in essence consists of the fibre-optic cables and the optical couplers and splitters.

The PON transmits the optical signals either into the building (FTTB) or a section of it, or into the home (FTTH) via optical fibre. An optical budget of around 19 dB is available for the insertion loss of the PON. For the most part, this is needed to compensate distribution attenuation at the splitter outputs: 0.3 dB per km of optical fibre and approximately 0.5 dB for each optical plug-in connection are added to this figure. Under these conditions, a passive split in the PON into up to 32 or 64 optical network terminations can be achieved with cable lengths of up to a few kilometres. There are basically two types of optical coupler:

a) Symmetrical couplers (splitters); these are very easy to plan and more future-proof, since they are designed as a star network.

b) Asymmetrical couplers (tappers); these can save on costs, as less fibre optic cable is required for feed-through. Nevertheless, the feed-through cable structure can be a hurdle for possible future network upgrades.

This is why Triax strongly recommends building star networks. Of course, the two approaches can be used in combination too. Generally speaking, single-mode fibre is exclusively suited to transmitting TV signals. TFC single-mode fibre optic cable has additional steel reinforcement with a PVC casing and is pre-assembled to be compatible with distribution components with FC and PC connectors. These robust, pre-assembled FO cables also enable beginners to fibre optic installation to easily build a PON. The connectors are electrically isolated from the cable’s steel casing, which prevents error loops in the network due to potential differences - a further considerable benefit of fibre optic technology.

Optical network termination and consumer end connections

The final section of a satellite IF system network poses the greatest challenges for installation specialists, especially where upgrading existing coaxial house distribution systems is concerned. However, installation specialists mostly deal with occupied developments, which cannot easily be provided with new cable channels.

The comprehensive range of optical network terminations available in the meantime, also known as optical re-converters, provides a number of planning approaches in order to find an optimal solution for every resident’s request that complies with structural requirements.

In the first step, the planner has to check the extent to which existing coaxial cabling in the building or home can or should still be used. On this basis, the PON structure can be determined and the most suitable optical network termination selected. The following basic solutions are options:

a) FTTB, if the building has an existing point-to-point coaxial distribution system.

b) FTTH, if the building does not have point-to-point coaxial cabling.

c) Additional integration of the BC (Broadband Cable) network is desired for high-speed Internet access via cable.

We will now look at these options and their most suited network terminations in more detail:

a) FTTB with optical network termination in the central distributor

This consists of a modern, point-to-point coaxial distribution system in each home, with a choice of the following three optical network terminations:

1) Optical re-converter Quatro (TVQ) plus coax multiswitch

2) Optical re-converter Quatro (TVQ) plus Unicable multiswitch

3) Optical multiswitch TOM

So let’s now look at the various FTTB solutions in more detail.

a1) Optical re-converter Quatro (TVQ) plus coax multiswitch

The first and up to now most commonly used option comprises an optical network termination with re-converter Quatro (TVQ) and an additional external multiswitch (Figure 5).
Benefit:
This variant is suitable for either one or several satellite positions. Transponders are selected using the classic DiSEqC control, with the selection procedure not putting any special demands on terminals such as satellite receivers or TV sets.

Drawback:
This technology requires a great deal of cabling space in the distribution cabinet. Furthermore, each additional socket in the home needs a separate coaxial cable from the central multiswitch in the building distribution board (coaxial star wiring in the home distributor).

a2) Optical re-converter Quatro (TVQ) in combination with a Unicable switch
This system consists of an optical re-converter Quatro (TVQ) plus a Unicable multiswitch from the TMU family (Figure 6).

Benefit:
The second variant saves on the laborious star-type cabling for several sockets within the home. A maximum of three satellite receivers connected to antenna socket with loop-through cabling can be operated in each home. This system can also be extended to cover up to four satellite positions.

Drawback:
In order to operate several satellite terminals on one cable, these terminals must be capable of running Unicable. This single-cable control has become standard, receiving increasing support from the terminals industry and should now encounter all but a few genuine obstacles.

a3) Optical re-converter and multiswitch in one
The third solution is based on using the new optical multiswitch TOM, which was first introduced at the ANGA COM 2015 trade fair. This network termination combines optical re-conversion and a multiswitch function (DiSEqC) in one compact device.

Benefit:
The optical multiswitch can be extended to receive up to four satellite positions plus terrestrial channels (Figure 7). Installation is easy, since there is no need for any laborious cabling between the optical re-converter and the multiswitch. The TOM uses the DiSEqC control in all satellite tuners for band selection.

Drawback:
In contrast to the Unicable multiswitch in solution a2), each additional socket in the home needs a separate coaxial cable to the TOM multiswitch.
a) **FTTH with optical network termination in the home**

Now let’s turn to the variants available if there is no point-to-point and low-loss coaxial cabling to homes but there is a need for several sockets in a residence. In most cases, FO cabling will save more space and be easier to install FO building cabling than the alternative option of retrofitting point-to-point coaxial cabling, especially the aim is receive signals from a number of satellites. The cable ducts and empty conduits are often completely unable to accommodate the larger number of coaxial cables required, which are also thicker than fibre-optic cables.

We can also consider different optical network terminations here:

b1) **Optical re-converter Quatro with simple Unicable multiswitch in the home**

This FTTH solution (Figure 8) is an ideal candidate if several sockets can only be connected inside the home using the coaxial loop-through technique.

b2) **Optical re-converter Quad in the home**

The new mini optical re-converter TVC 6 Quad offers another, extremely elegant FTTH solution (Figure 9). Here optical re-conversion is rolled into one with a multiswitch function, giving a practical solution for providing TV services to a home with up to four sockets connected to the home distribution board via star-type cabling. This is a particularly recommended option for new developments and refurbishment if receiving one satellite position and possibly terrestrial is sufficient.

b3) **Optical multiswitch TOM in the home**

Finally, for those who insist on having all the latest mod cons, there is the previously mentioned optical multiswitch TOM for FTTB (Figure 10), which can be used as an FTTH network termination. After all, to supply four satellite dual sockets for terminals with twin tuners, eight optical multiswitch outputs are required – of interest and increasingly in demand for large, high-quality apartments or detached homes. The optical multiswitch TOM can be extended to receive up to four satellites, is easy to install and does not take up much space – although as an optical network termination for one home, it is an investment in the future.
c) Additional integration of the BC (Broadband Cable) network for high-speed Internet

Now let us explain the opportunity to integrate high-speed Internet from the BC network. Often there will be existing access agreements and contracts for the Internet with local network operators, which should continue to be used. It is not possible to transmit the BC signal over the satellite FO network via QAM modulation using the extremely cost-effective laser technology illustrated here. As already stated in the optical headend section, transmission of the robust DVB-T/T2 via the PON remains reserved.

However, the BC signal can be fed in at the coaxial end of the optical network termination. The passive terrestrial path of the multiswitch (Figure 5) or of the Unicable multiswitch (Figure 6) is used for this purpose. As a result, all consumers are provided not only with satellite reception but also with BC services. If optical multiswitches are used, the BC signal is fed in via its own BC satellite diplexer at the multiswitch output. This requires some space in distribution board, but is an acceptable solution for feed-in to individual sockets.

Due to the frequently higher insertion loss of the passive BC path in the multiswitch, the BC building distribution amplifier must be re-calibrated according to the BC network operator’s specifications or, if applicable, replaced by a more powerful type. Special four-hole satellite multimedia sockets are available, which provide not only satellite, TV and radio ports, but also an additional F socket for a cable modem.

Now we will look at extension options and the innovations currently being introduced by Triax to the specialist installation trade.

Intelligent optical network terminations

Mini Optical Re-Converter Quad

Based on a chip family redeveloped for satellite applications, the mini optical re-converter TVC 6 provides a considerably smaller optical network termination with an integrated multiswitch (Figure 11), available immediately. Its compact dimensions mean this device is destined for use as an intelligent home distribution board for four satellite sockets (see also Figure 9). The mini re-converter Quad TVC 6 is therefore suitable, as an FTTH network termination, for systems that distribute the signal of a satellite position with all four bands.

Figure 11: Mini optical re-converter TVC 6 Quad
Optical multiswitch TOM

In the shape of the Triax optical multiswitch TOM (Figure 12), a completely new generation of optical network terminations for fibre-optic satellite IF systems is available as of now. These too are based on the new chip family mentioned above and extend the principle of the optical mini re-converter Quad (TVC 6) to appliances with eight or 16 coaxial outputs.

The TOM base unit “SwitchMaster” has three main functions: optical receiver, SAT IF de-stacker and multiswitch integrated in one single device (Figure 13). The benefits of this over the classic solution of an optical re-converter Quatro and a downstream external multiswitch are considerable savings in terms of space and considerably simpler installation — all the coaxial patch cables between conventional optical re-converters and the multiswitch have been done away with, for a start.

The standalone SwitchMaster TOM 16M/08M base unit enables 16 or eight single antenna sockets, or eight or four dual satellite sockets to be supplied via their coaxial F outputs (see also Figures 7 and 10). All four bands of a satellite position can be accessed via each output, using 13/18 V and 0/22 kHz control of the satellite terminal (DiSEqC).

The optical network termination can be extended really easily so additional satellites can be received by plugging in “SwitchSlave” units TOM 16S/08S (Figure 14). The satellite is selected via the SwitchMaster in the DiSEqC protocol, controlled by the satellite receiver. This, of course, requires feeding the signal of every satellite position via its own separate optical fibre from the relevant PON.

If more than 16 consumer connections are required in a building, an optical splitter is inserted into the incoming fibre-optic cable and this splits the optical signal across several optical multiswitches. This is a very easy way to modify the number of consumer connections by eight or 16, as the case may be.

All in all, the optical multiswitch drastically simplifies the process of installing FTTB and FTTH systems for several satellites, with the slightly higher price of the device being justified by the savings made in terms of installation costs in most cases.
Increasing the number of optical connections
Extended fibre-optic distribution systems require sufficiently high optical distribution factors (split) and the ability to position these splitters locally at the desired points in the network.

As has already been mentioned, in its standard configuration the satellite-fibre optic system facilitates a passive split in the PON into max. 32 FO network terminations at one laser transmitter output. For example, if there is an optical multiswitch TOM 16M as a network termination at every fibre-optic cable, up to 16 x 32 = 512 coaxial satellite terminal connections will be available, fed by an optical LNB TOL 32. If fed by an IRS optical transmitter TOU 232, the network can directly operate 16 x (2 x 32) = 1024 satellite receivers on one satellite reflector.

The following options can increase the number of optical cables (splits) still further:

a) Active RF distribution to several IRS optical transmitters
The satellite IF signal (950-5,450 MHz) converted by the stacking LNB TWL 1 is distributed to max. four IRS optical transmitters TOU 232 via the active HF splitter TAS 4 (Figure 15).

The optical headend can then be extended from two optical outputs to a maximum of eight optical outputs, facilitating an optical split of max. 8 x 32 = 256. If every optical cable is terminated with an optical multiswitch TOM 16M, up to 16 x 256 = 4,096 satellite terminal connections will be available.

b) Active optical distribution with optical repeater
At any local point in the fibre-optic distribution network, the optical signal can be converted back into electrical HF signals by the converter TOE 2 (Figure 16), which is now new to the range, so that another IRS optical transmitter TOU 232 SA can be activated (Figure 17). TOE 2 and TOU 232 SA form an “optical repeater” and enable an incoming fibre-optic cable to be split again across up to 2 x 32 optical connections. The passive split at an optical transmitter upstream of the repeater should not be greater than 16.

Another particular advantage of this option is that the repeater can be installed a long distance away from the optical headend, so it can supply remote buildings or sub-networks with an extensive sub-distribution board. The repeater solution permits a maximum of 2 x 16 x (2 x 32) = 2,048 optical connections to be realised – with a TOM 16M at each optical consumer cable that equates to 16 x 2,048 = 32,768 coaxial satellite and terrestrial terminal connections.

In principle, the two options described above can be combined, meaning up to 4 x 2,048 = 8,192 optical connections are possible in theory. If each has a downstream TOM 16M, this equates to 16 x 8,192 = 131,072 receiver connections for satellite and terrestrial reception at a satellite dish and a terrestrial antenna system – orders of magnitude which were previously unimaginable for satellite IF distribution systems and which, admittedly, are of virtually no practical relevance. However, they do allow satellite distribution systems based on fibre optics to be adapted to on-site structural conditions really flexibly.
Conclusion
We expect that the new "optical multiswitch" and "mini optical re-converter" optical network terminations will give satellite IF distribution technology a real shot in the arm, as will the ability to multiply the optical split using repeaters. There are virtually no limitations in terms of system size and consumer numbers. In fact, this is only one of the advantages when building larger satellite distribution systems. A further notable aspect is that satellite optical headend technology is very cost effective and low-maintenance. It should therefore always be taken into consideration whether building smaller individual networks with their own optical headends could avoid the need to lay costly underground cables.

Satellite optical systems are also really easy to plan, whilst the costs of materials and installation are at a comparably favourable level. Another enduring advantage of a satellite direct distribution system is in its transparent transmission of broadcast signals; the system is future-proof in terms of all currently detectable broadcast signal formats such as satellite SD, HD and 4K, FM, DAB, DVB-T and DVB-T2 in MPEG4 and HEVC. If there are subsequent signal conversions and transponder changeovers on the cards, no modifications whatsoever will need to be made to the distribution system or the headend.

As such, direct satellite reception now represents a very cost-effective alternative for the housing industry even in large building complexes – all thanks to fibre-optic technology. And in any case, satellite reception is already extremely attractive to residents: a fact that is coming increasingly to the fore and being taken into account when re-drafting licensing agreements for supplying TV services in residential buildings.

GLOSSARY
CATV Community Antenna Television
DAB Digital Audio Broadcasting
DiSEqC Digital Satellite Equipment Control
DVB-T/T2 Digital Video Broadcasting Terrestrial
FM Frequency Modulation
FTTB Fibre to the Building
FTTH Fibre to the Home
IRS Integrated Receiving System for SAT and terrestrial
LNB Low Noise Block Converter
FO Fibre Optics
PON Passive Optical Network
SAT Satellite
SAT IF Satellite Intermediate Frequency after conversion to LNB T
Triax Manufacturer
TMS Multiswitch
TMU Unicable multiswitch
TOE Optical-electrical converter/repeater
TOL Optical LNB, stacking LNB with optical transmitter
TOM Optical multiswitch
TOS Optical splitter
TOU IRS optical transmitter with separate HF inputs for stacking SAT IF signal and terrestrial (outdoor unit)
TVC Optical re-converter Quad (Virtual Converter)
TVQ Optical re-converter Quatro (Virtual Converter)

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