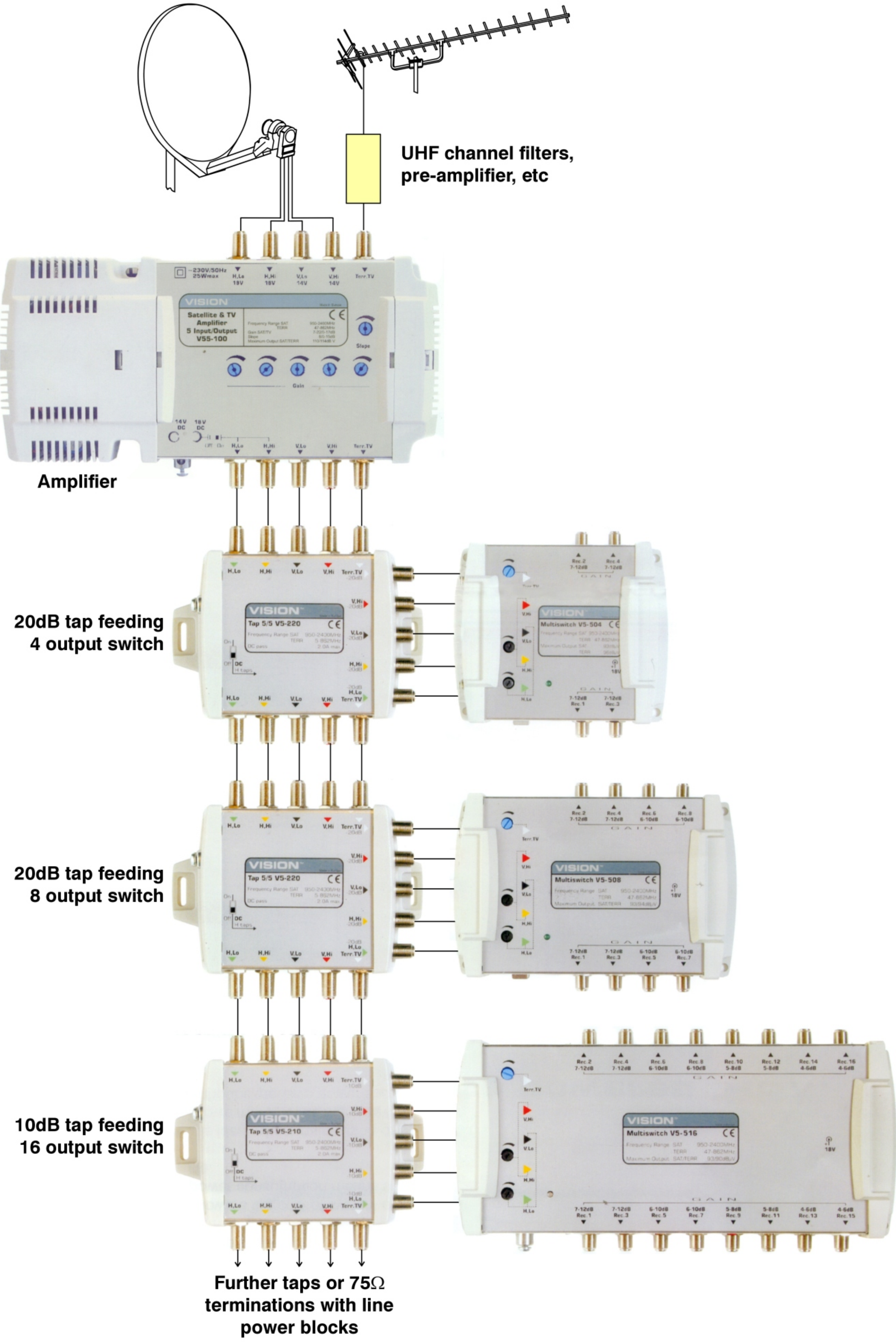


Fig 25. A tap-off line system using the Vision V5 range of amplifiers, tap-off units and multiswitches.

line power on long tap-off lines and trunk cables always made the system very susceptible to damage by electromagnetic pulse from nearby lightning strikes. I haven't yet heard of this happening to the Vision kit though. An advantage of the Vision V5 line-powering system is that the power can be injected at any point on the system, wherever a mains supply is available.
To avoid re-amplification problems the Vision range uses quite high tap-off values. This reduces through loss and minimises or eliminates the need for tap-off line amplification. This is simply a manifestation of a basic principle of RF distribution, which is to get the signal as far down the system as possible without amplifying it. To compensate for the tap loss each switch includes amplification. The switches have variable attenuators for terrestrial, high band and low band to allow accurate adjustment of signal levels. The ability to adjust terrestrial signal levels is particularly important because it is inevitable that UHF signal levels will not match satellite ones at each point on the system. The larger switches in the Vision range have the gain of each group of outputs varying in 2dB increments, to compensate for different downlead lengths. This is a good idea in principle, but it means that the electricians who first-fix the cables must label them accurately, and I'm afraid this often seems to be insurmountably difficult for them.
Fig 26 shows the schematic of part of a larger system that follows the same basic principles but uses discrete components. There is a head-end and a number of tap-off locations. Only part of the system is shown, but the rest is much the same. This is a system that we installed recently. The building design dictated the system layout to a large extent, and the only feasible place for the tap-off locations was in the risers. Although this meant that the downlead lengths varied considerably it made the numbers of flats connected to each tap-off location relatively high. Because the flats were quite large and the building isn't high rise the numbers ranged in fact from only six up to twenty, but a system to this design will often have forty downleads meeting at each riser. The more the merrier is the rule when considering ease of installation and maintenance. As you can see the schematic gives the addresses of the flats connected to each tap-off location, for the benefit of those who have to fault find in later years. For the same reason the downleads should be labelled at the tap-off locations, even if no allowance is to be made for different lengths.
Where the tap-off locations have mains powered amplification this layout more resembles a UHF system with a head-end feeding repeaters via trunk cables than it does a simple tap-off line.
There are of course five parallel trunk cables, four for satellite IF and one for terrestrial. The trunk cable should be CT167 or equivalent on a system of this size. The figures in red give the losses on each section of trunk.

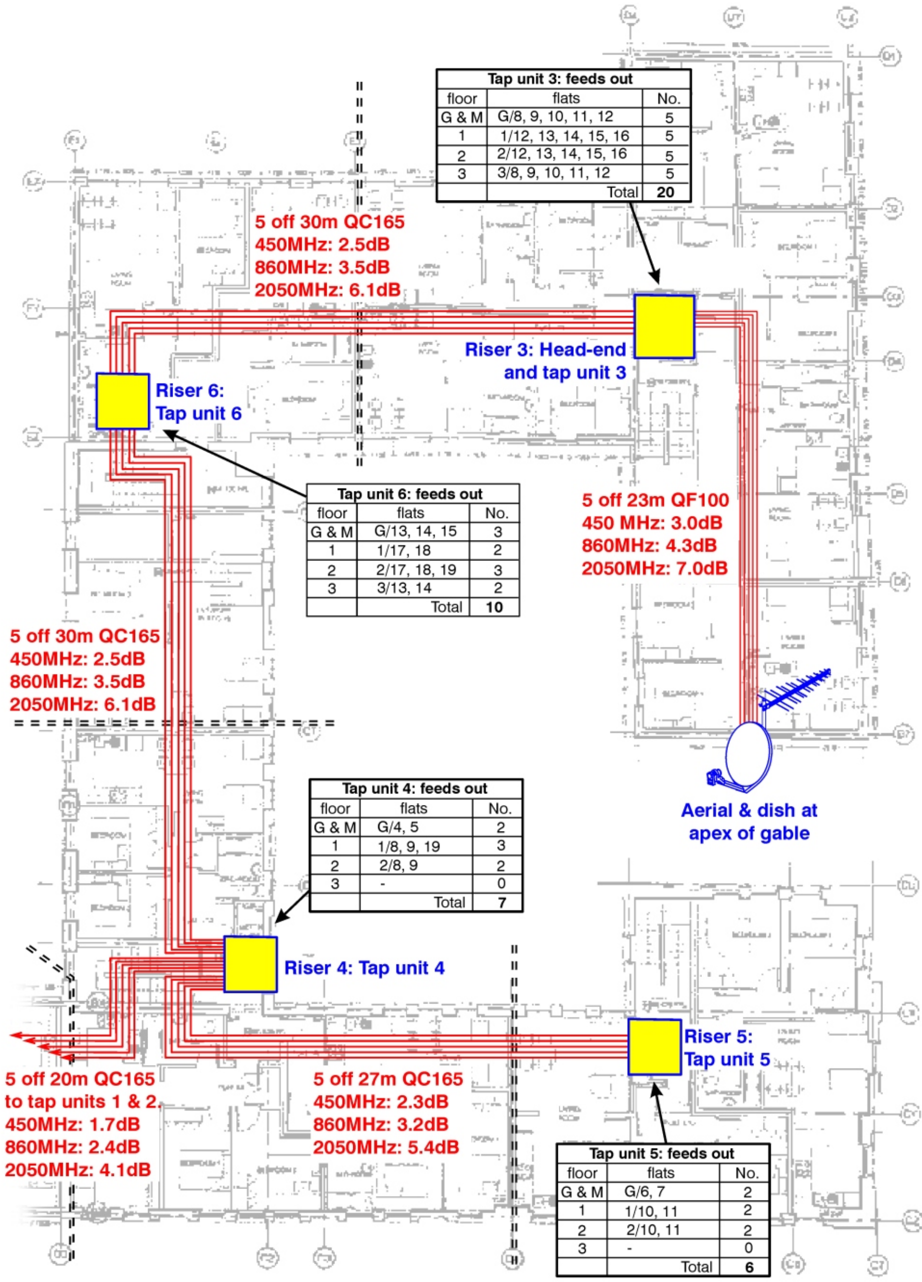


Fig 26. A schematic of part of a system based on tap-off lines.

The head-end

The head end for this system is shown in figs 27 (below) and 28 (overleaf). The photograph shows the satellite section of the head-end only, and was taken during installation. The numbers in red on the schematic give approximate signal levels in dBmV for the strongest multiplexes at the upper end of the band. The four satellite IF amplifiers are mounted on a common backplate with their power supply unit. For a closer view of an amplifier see fig 29 (overleaf).

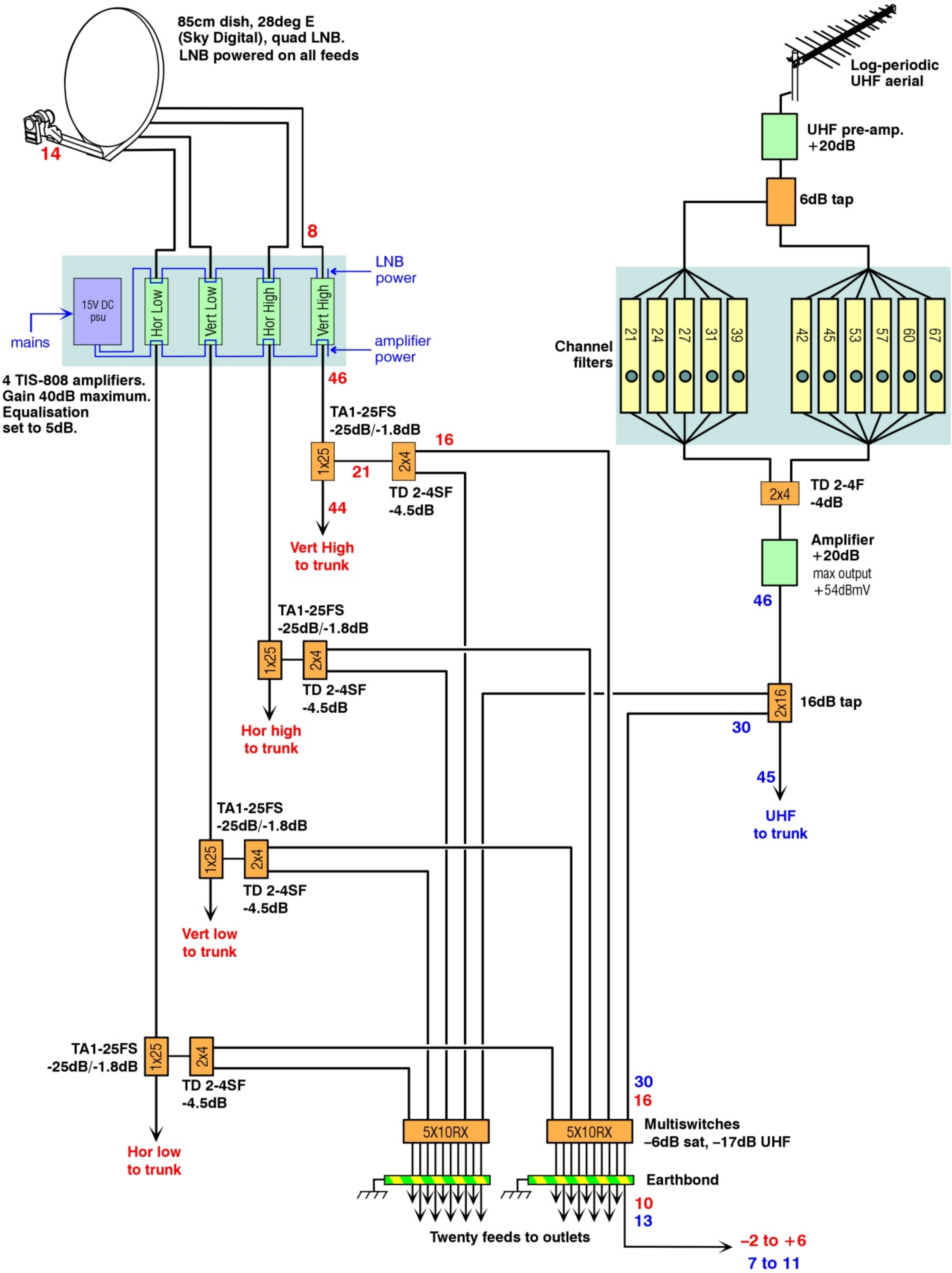


Fig 27. Schematic of a typical tap-off line system head-end. The numbers in red give approximate signal levels in dBmV for the strongest multiplexes at the upper end of the band. The blue numbers are approximate UHF analogue signal levels. High value taps feed the co-located multiswitches from the main tap-off line output.

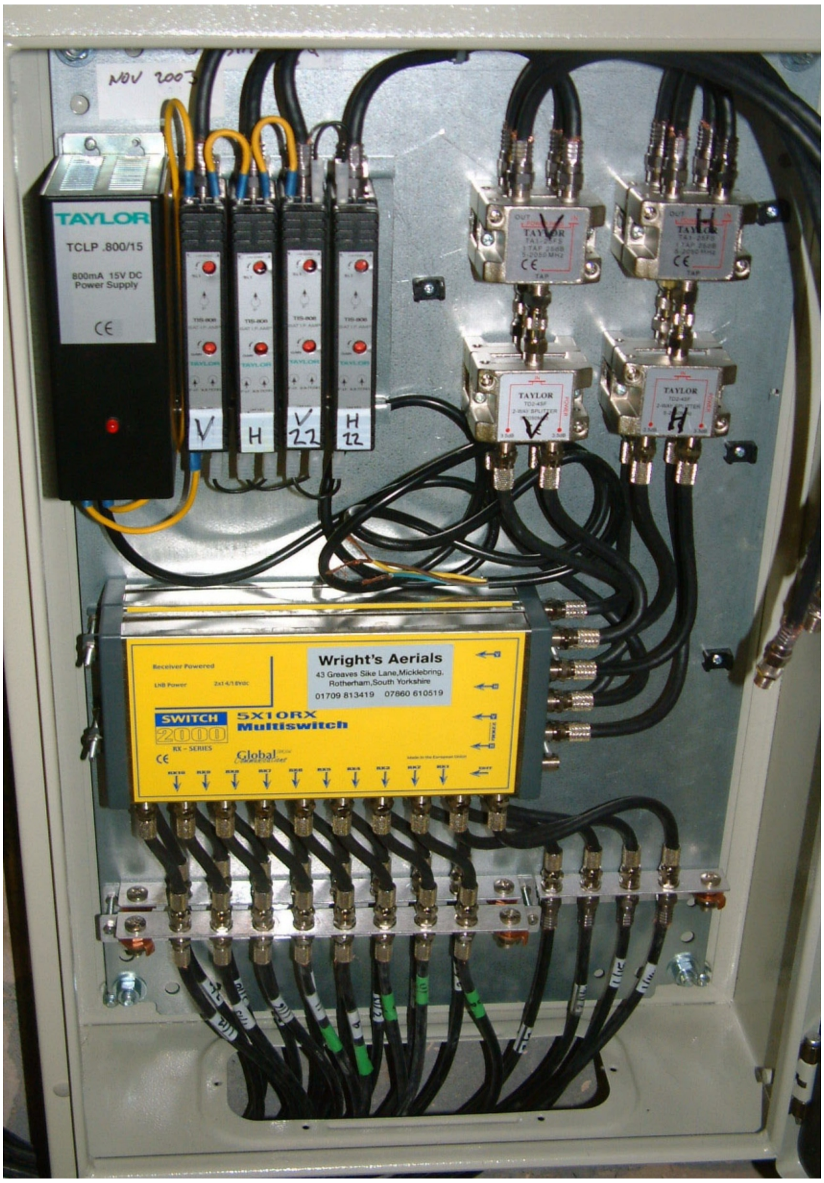


Fig 28. A typical tap-off line system head-end. The photograph was taken during installation, hence the unconnected outputs and lack of earth bonding. The multiswitches and tap-off units are stacked one above the other to save space. The UHF section is not shown in the photograph.This equipment is housed in a steel cabinet, but if the location is completely safe from tampering an open wooden backboard is quite acceptable.

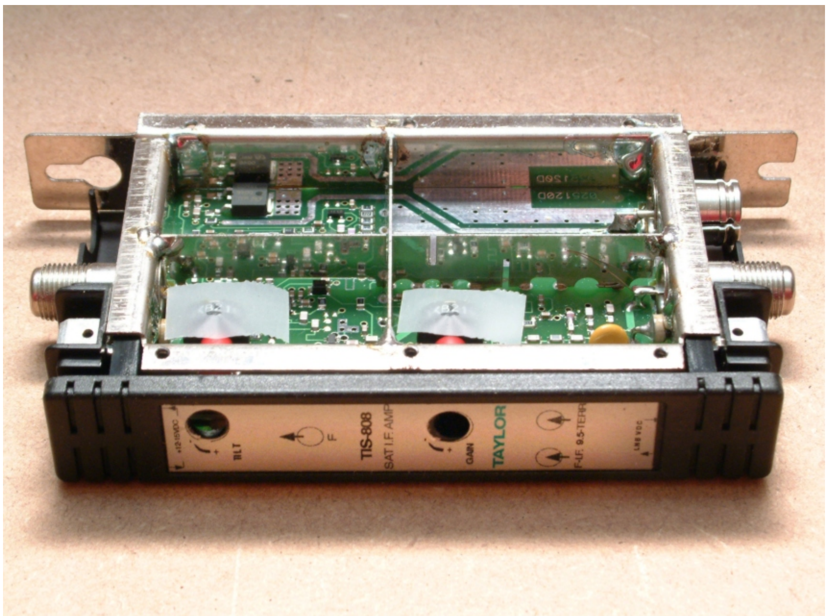


Fig 29. Taylor TIS 808 satellite IF head-end amplifier.

These particular amplifiers (Taylor TIS 808) are capable of a maximum output level of 57dBmV, so there is no danger of cross modulation given the output levels needed here. However a practical test should always be done to find an amplifier's true maximum output (never mind what it says in the catalogue). With the amplifier connected to the actual set of signals to be carried, turn up the gain in small increments whilst observing the BER of one of the weakest multiplexes. To make sure that the measuring instrument isn't swamped fit a variable attenuator at the instrument's input and adjust it for the maximum BER reading at each amplifier gain setting. When an output level is reached where BER starts to deteriorate, you are about 6dB above the safe maximum level. It might be necessary to use a line amplifier as a pre-amp for this test, to lift input levels sufficiently to the point where BER starts to degrade.

In the example shown in figs 27 and 28 twenty dwellings are connected directly to the head-end, so it can be thought of as a combined head-end and tap-off location. As you can see, 25dB tap-off units are used to extract enough signal from the trunk to supply the local multiswitches. I've chosen here to use discrete taps for each trunk feed, but of course multiple units are available that handle all five feeds. Incidentally, the through loss of a single 25dB tap is less than that of a double 30dB tap, hence the splitters following the taps. It is important to minimise through loss at each tap-off location because, as I said before, we are trying to get the signal as far as possible along the trunks without further amplification. Amplification adds noise, and noise obviously lowers the c/n ratio and so reduces BER.

The blue numbers give the approximate levels of the analogue terrestrial TV signals at various points.

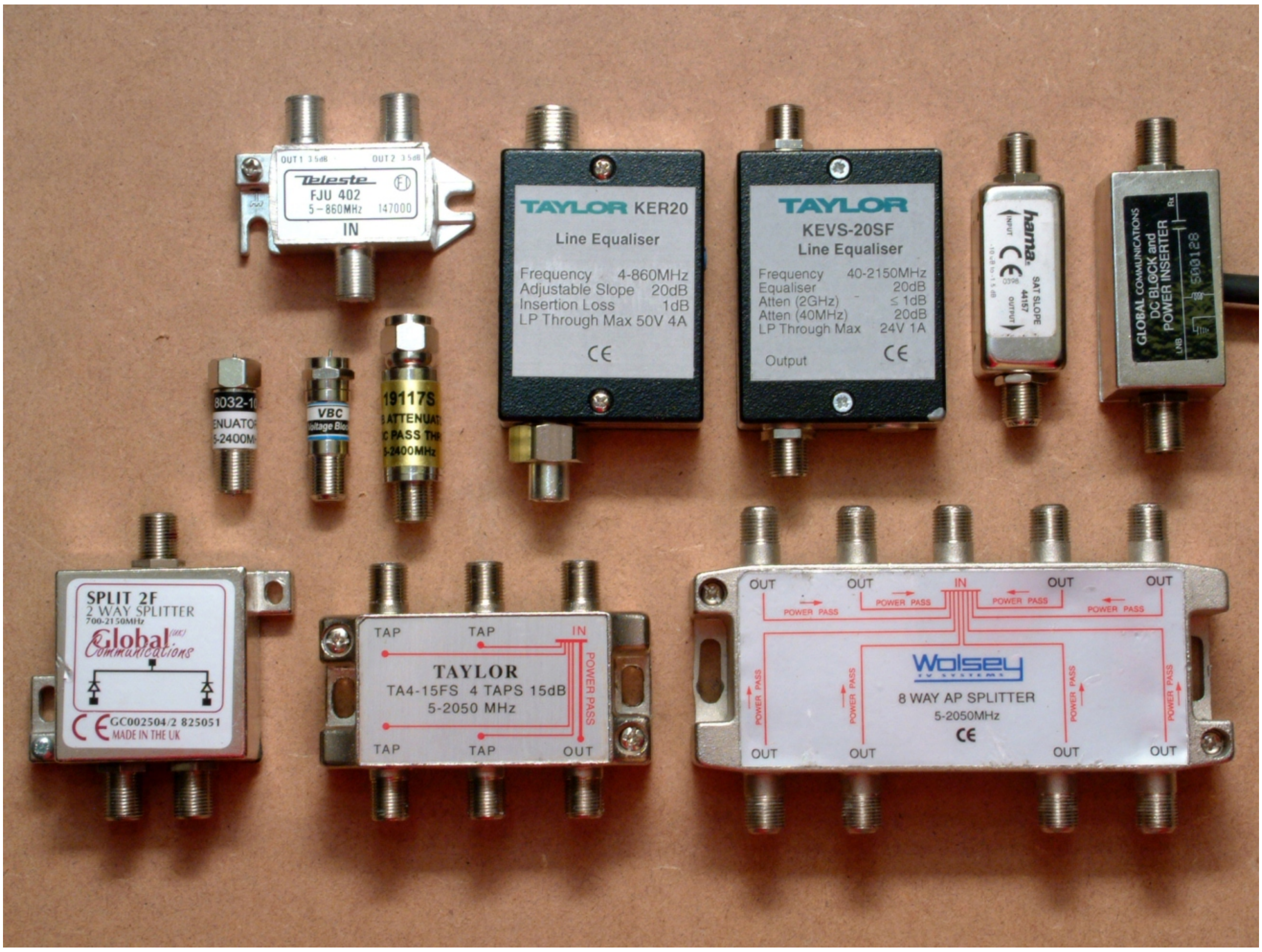


Fig 30. A few head-end components. Top row L-R: Teleste splitter, Taylor VHF/UHF 20dB variable equaliser, Taylor VHF/UHF/satellite IF 20dB equaliser, Hama satellite IF equaliser, Global line power injector and DC block. Middle row L-R: 'f' type attenuator, 'f' type DC block, 'f' type attenuator with DC pass. Lower row L-R: Global splitter with DC pass, Taylor satellite IF 4 way tap off unit, Wolsey 8 way VHF/UHF/satellite IF splitter with power pass to all outputs.

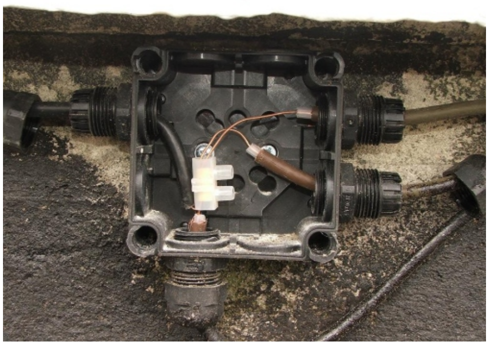
A little light relief!

Look now at the efforts of some of your brothers in the trade! All of these pictures show work done by 'professional' installers!

'Distribution system'

'Trunk splitter'

Words fail me . . .



'Tap-off unit'

Repeaters

Fig 31 shows Repeater 4 from fig 26. This is a tap-off, multiswitch and repeater amplifier installation, but for simplicity I'll call it a repeater. Because the system feeds two wings of the building from there on, this installation has splitters on all five feeds. Note that satellite IF splitters lose 4.5dB, about 1dB more than VHF/UHF ones. The signal levels needed on the two wings are slightly different, so the taps that feed R4's multiswitch are on one splitter output rather than being connected directly to the incoming feeds. This gives the necessary signal level differential between the two outgoing feeds of each polarity/band. The tap value for VHF/UHF is different to that for satellite IF, and the use of discrete components give complete flexibility in this respect. This repeater has amplification on the UHF line but not on the satellite IF lines. Again, building the repeater from discrete components allows flexibility of design. This is the only repeater on the system that needs a mains supply. Since a 'landlord's supply' was available nearby it was thought better to take advantage of it than use line power.

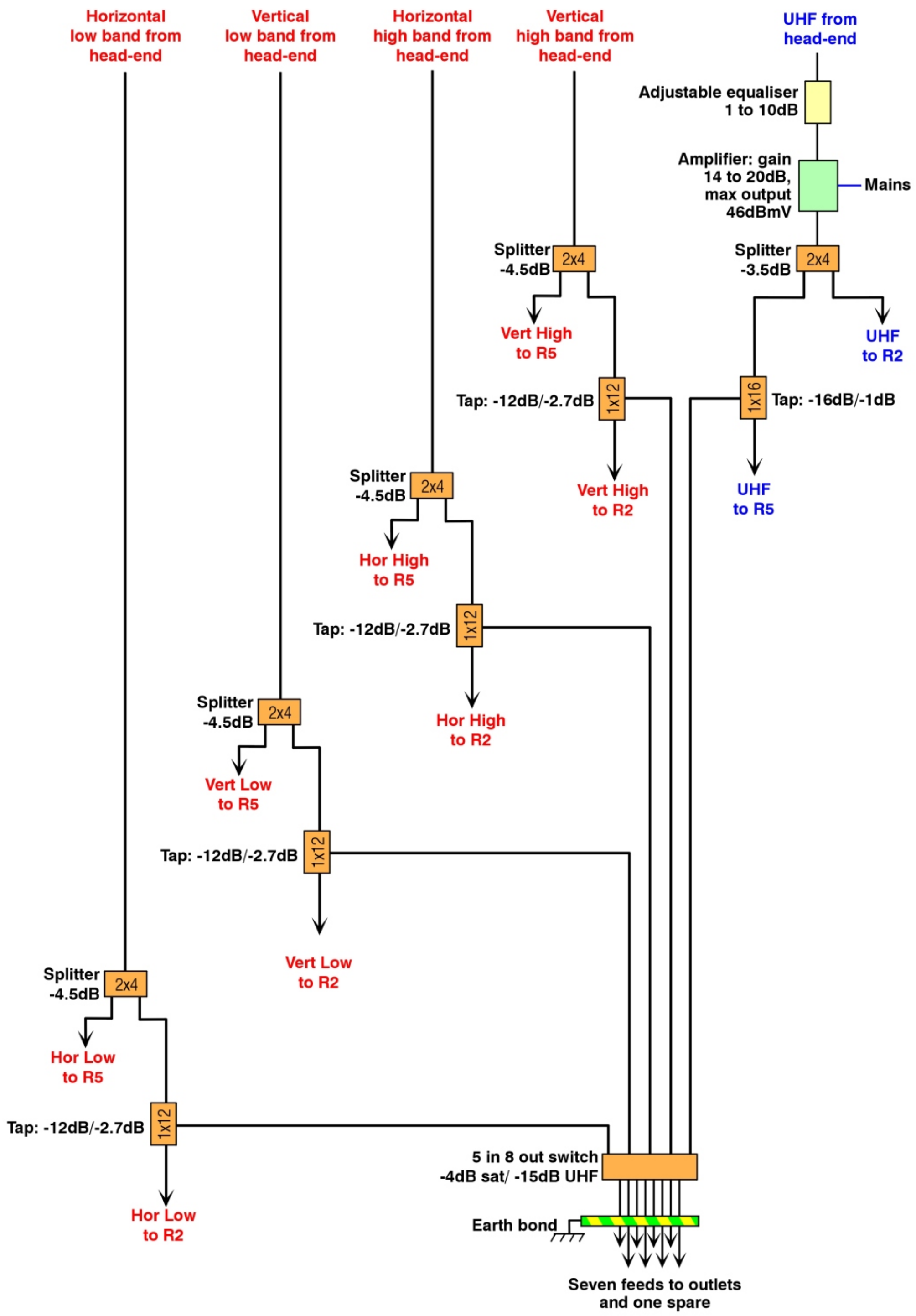


Fig 31. A tap-off, multiswitch and amplifier ensemble. This is tap unit 4 on fig 26.

Equalisation

As far as possible all the multiplexes should arrive at each receiver at more or less the same level. Unfortunately coax cable attenuates the higher frequencies more than the lower ones, so as the cable run gets longer there is more and more inequality between the top and bottom multiplexes. I've tried to show this in fig 32. If the analyser is connected to any of the outlets the response should be reasonably flat, as shown in fig 33.

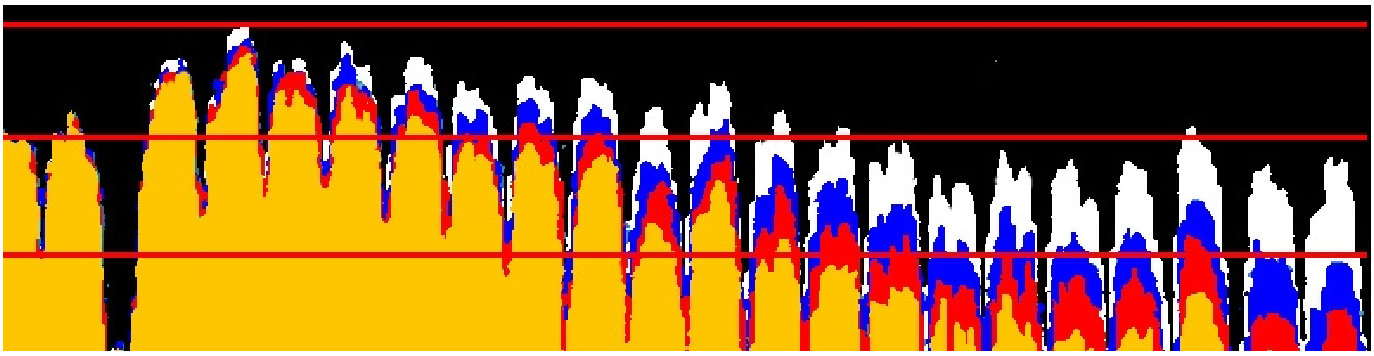


Fig 32. An analyser display of one of the high band polarities. The whole satellite IF band is shown, with the low frequencies to the left. The horizontal red lines are 5dB divisions. The white, blue, red and yellow areas represent the response after 20, 40, 60, and 80 metres of CT100 cable respectively. The blue, red, and yellow areas have been moved upwards so that the response of the lowest multiplex is equalised. This highlights the extra signal loss at higher frequencies.

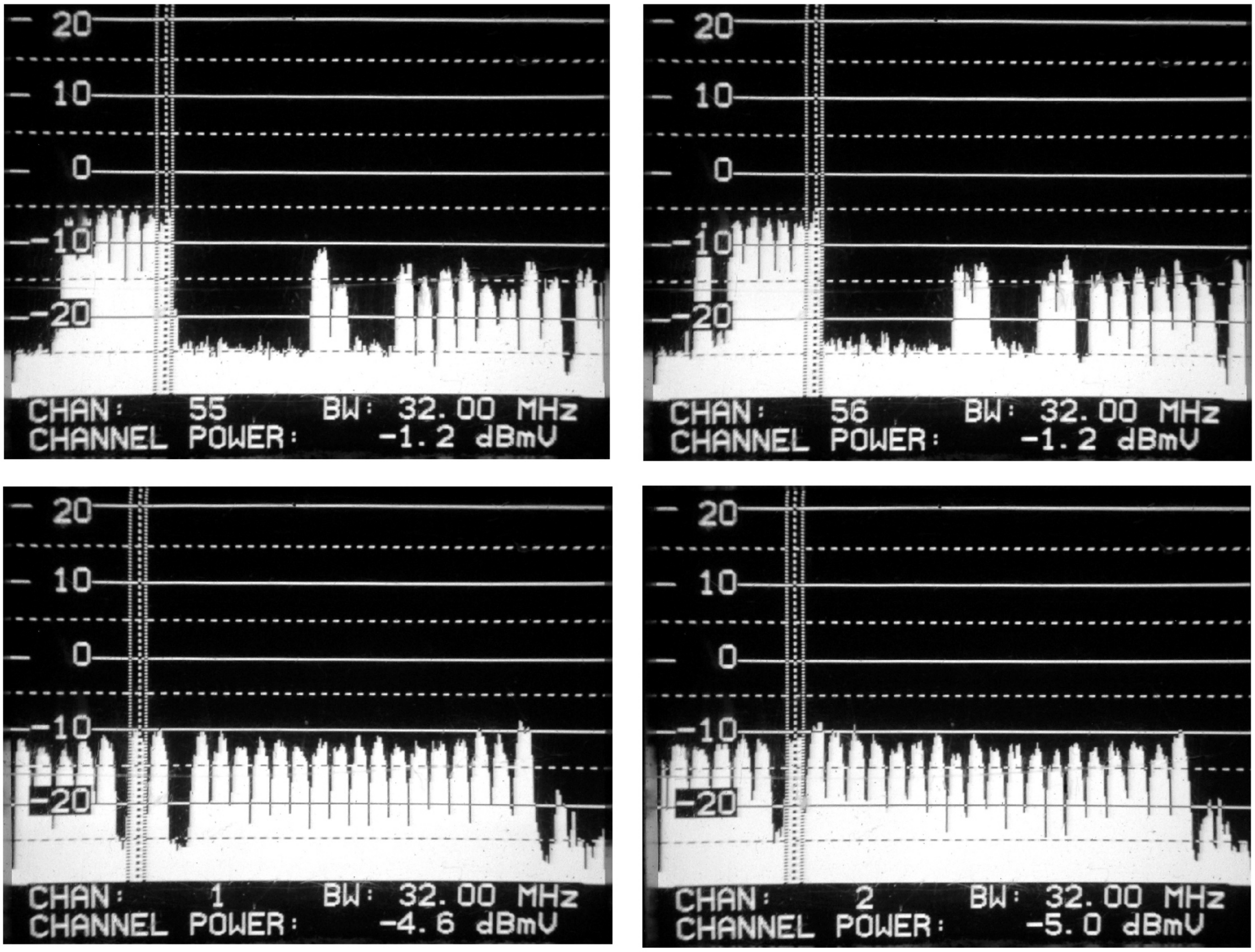


Fig 33. Typical analyser displays of the four groups of signals as measured at the outlets. If the signal levels decrease significantly from left to right equalisation is needed.

Equalisers are available to compensate for the extra losses in cable at higher frequencies. They are also known as slope filters. Some have a fixed slope of 3, 6, or 9dB, and some are adjustable. Equalisers with the range 40 to 2050MHz are suitable for satellite IF use, but if the maximum equalisation figure quoted

is, say, 20dB, only about 9dB of that will be across the satellite IF band. Some cheap equalisers intended for the domestic market have a non-linear response, attenuating the middle of the band hardly at all. Of course these are no use. Equalisers fitted between the LNB and the main amplifier need DC pass.
As I mentioned in the section on small systems some pre-amplifiers have equalisation built in. There isn't any point in buying ones without really, because whenever you use a line amplifier you will pretty well always find a bit of equalisation useful.
Passive equalisers reduce the strength of the low frequency signals so that they match the higher frequency ones. When calculating the signal levels for the whole system it is best to work out the high frequency levels first, using this to decide on amplifier gain, tap values, etc, then decide how much equalisation is needed and where to put it. Once the signal levels for the high frequencies have been calculated, working through the system again but with the loss figures for the low frequencies should produce the equalisation figures. Allow 1dB through loss at the higher frequencies for each equaliser. Table 5 gives the losses in 100 metres of each of several types of cable, at various frequencies.

Freq (MHz)	CT100	CT125	CT167
5	1.3	1.1	0.8
50	4.3	3.4	2.6
100	6.1	4.9	3.7
200	8.6	7.1	5.4
450	13.2	11.0	8.6
600	15.4	12.7	9.9
860	18.7	15.5	12.0
1000	20.0	16.8	13.3
1200	22.0	18.5	14.8
1500	24.7	20.8	16.9
1750	26.9	22.6	18.6
2050	29.4	24.9	20.4
3000	36.2	31.0	25.8

Table 5. Signal loss per 100 metres of cable.

Here's a slightly different way of calculating equalisation. The only difference is that the sums are done before the necessary amplification is taken into account. Take the 1000MHz and the 2050MHz figures as the bottom and top of the satellite IF band and you can easily work out the difference for each of your cable runs. Total the equalisation needed for the whole tap-off line, from end to end. Add something for the dish feeds and the downleads, and bear in mind that splitters and taps usually lose a bit more signal at high frequencies than at low ones (despite published figures I always allow 0.5dB for this). The download figure has to be a rough average. This whole assessment, or educated guess, gives the total amount of equalisation needed. Actually, it gives the total amount needed for the outlet farthest away from the head end. The figure will be less for closer outlets, so a compromise is needed. Suppose the gross figure is 6dB. As a rule of thumb apply 4dB of equalisation. If the gross figure is 10dB or more the equalisation should be applied in two stages, at the head end and half way down the trunks.
The head-end shown in figs 27 and 28 uses separate amplifiers for each of the four sets of satellite IF signals, and these amplifiers have adjustable gain and equalisation. If you use amplifiers without built-in equalisation it might be necessary to fit passive equalisers at the amplifier inputs.

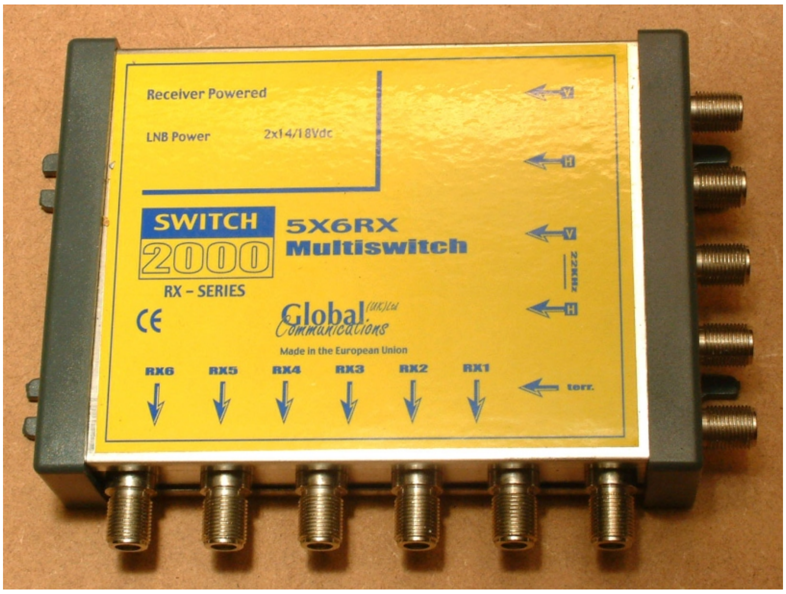


Fig 34. Global 5X6RX passive multiswitch.

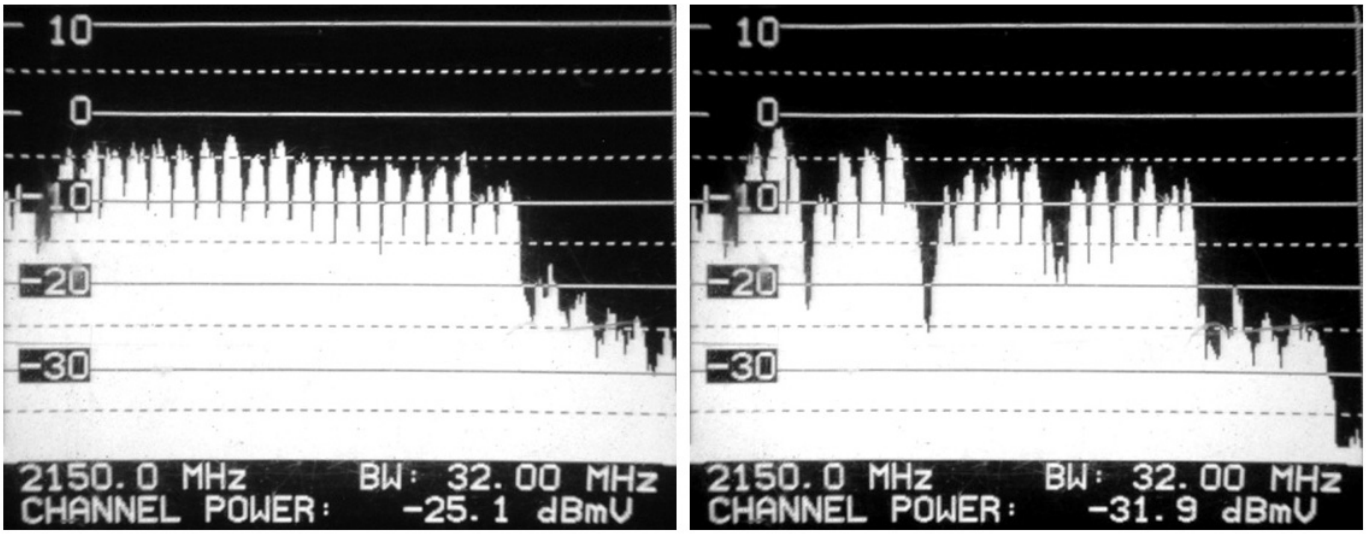
Receiver powered multiswitches
The multiswitch described in the sections about small systems is not ideal for use on a larger system where high-powered UHF/VHF amplifiers are used. There is no need for the added complexity of UHF/VHF amplification within the multiswitch. It is better to simply take the through loss of a passive switch into account at the planning stage and provide appropriate signal levels. These passive switches (fig 34) are sometimes called 'receiver powered switches ' because the polarity and band switching is powered by the receiver line power. They do not need a mains supply, and this can be a great advantage, saving £100 per tap-off location in some cases. Line powering via

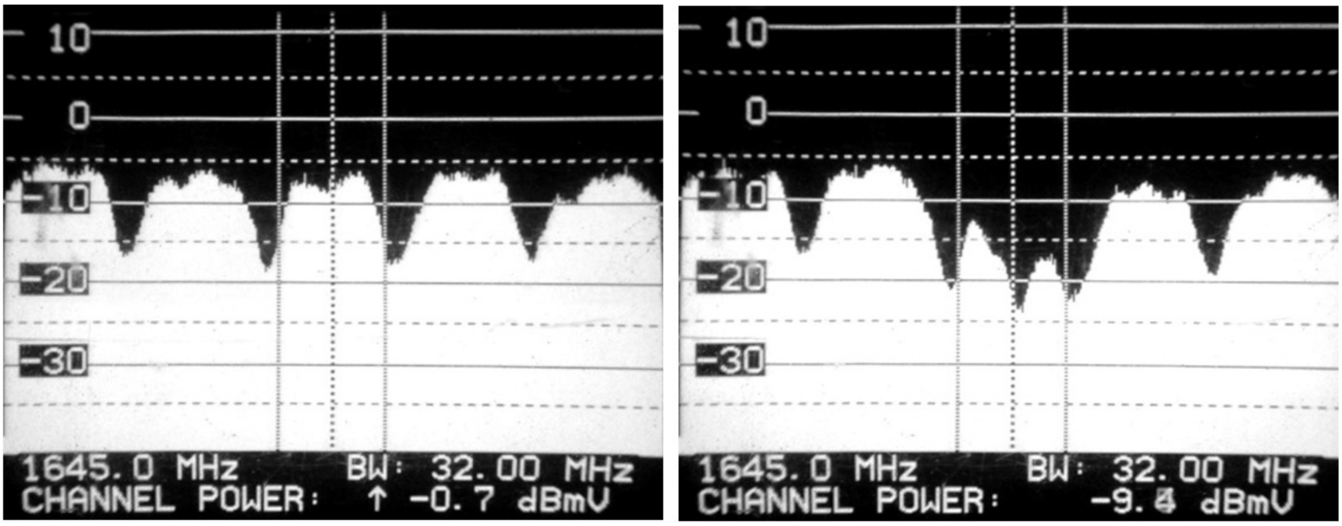
the trunk cables is a complication you can do without on a large system.
Passive switches are sometimes used as 'stand alone switches' where there are no terrestrial signals involved. To make this possible the receiver line power is passed through the switch to the four IF inputs, to power the LNB. Don't use this configuration for a Sky system because the current drawn by a quattro LNB can cause problems for Sky receivers. If you use these switches as part of a larger system check that the splitters or taps feeding them have a DC open circuit on the output ports to protect the receivers. Alternatively fit line power blockers at the switch inputs

.

Line terminations

As I near the termination of this article I must mention line termination. Not for the sake of making a pretty poor joke but because it really is important that every coaxial line ends with an impedance-matched load. Otherwise signal will reflect back from the end of the line, to cause all sorts of trouble. Specifically, a pattern of standing waves will be set up on the line. This means that at the points on the line where the reflection is 180˚ out of phase with the main signal there will be a null (figs 35 and 36). Near the end of the line the null can be deep enough to prevent reception of the affected satellite multiplexes. Further back from the end of the line analogue reception can suffer from close-spaced ghosting and degraded teletext. It's really easy to avoid this problem. Pretty well everything uses 'f' connectors these days, so screw an 'f' line terminator onto anything that doesn't have anything else screwed onto it. This includes unused





Figs 35 and 36. These four analyser screenshots show the effects of an unterminated tap-off line. The analyser was connected to an outlet fed from a multiswitch that was in turn fed from the penultimate tap-off unit on the line. The final tap-off unit was not very far away (so reflected signals suffered little cable attenuation) and had no line terminator fitted, hence the complaints of unreliable reception on just a few satellite channels.. Fig 35 (the upper pair of shots) shows on the left the full satellite IF band after a terminator had been fitted. The right-hand shot shows the response notches caused by the unterminated line. Ignore the channel power readings on these shots: the cursor had been moved out of band. Fig 36 (the lower pair of shots) is a 'close up' of one of the affected multiplexes, with the termination fitted on the left shot and missing on the right shot. The channel power reading gives the average attenuation caused by the unterminated line, but the distinct notch across the multiplex will degrade BER more than the average channel power would suggest.

multiswitch outputs, unused tap-off outputs, and of course the trunk-out from the last tap-off unit on the line. The terminators contain a 75Ω resistor that matches the cable impedance and efficiently soaks up any energy on the cable. They cost about 18p so if you use 200 before one prevents a call-back it will have been well worth your while. If the cable carries line power use a line power blocker before the terminator.

Concluding sermon

And that mention of call-backs brings me neatly to my conclusion. Never mind about call-backs, we are here to do an excellent job even beyond the point where the customer or resident has any direct realisation of the good things we've done. Isn't that what being a professional is all about? Mounting my soapbox I have to say that the standards of the RF system installation trade are often abysmally low. That's a strong claim, but I spend a lot of time looking at truly horrible installations and I can tell you with great regret that it is justified. If you need proof look at the Rogues' Gallery on http://www.wrightsaerials.tv .The attempts of the CAI (the Confederation of Aerial Industries) to improve matters are hampered by low membership and the consequent difficulty of imposing standards across the trade. Until membership of a recognised trade body with efficient policing of standards becomes effectively compulsory for the installers of medium and large systems there seems to be little hope that installation quality will improve. In the meantime the market is a jungle, with builders and management agencies crossing their fingers and sticking a pin in the Yellow Pages. You and I can't do much about this sad state of affairs, but at least we can make sure that our own work is up to scratch. To be cynical, when standards are generally low it's only necessary to do a reasonable job to be outstanding, and once you have a reputation for doing a really good job the world will beat a path to your door. The installation of TV and radio distribution systems is a growth industry at the moment, thanks to the buoyancy of the housing market and the change-over to digital television. There's a lot of money to be made, and repeat business is the key to success. If you're interested, buy some good test gear, learn all you can about the job (including learning from your mistakes), and with a bit of luck you'll prosper.

Bill Wright
May 2004