Written in 2005, this feature was due to appear in 'Television' magazine when that journal was suddenly closed down by its new owner. The first two parts of the feature subsequently appeared in 'Technology at Home', but before the last two sections could be published that magazine ceased publication as well!
Written at the original editor's request for readers who are small traders, the article is slanted a little bit towards the money-making aspect of TV system installation, and reading it now (2008) it seems to have a slightly cynical tone in places.
This article was written before the advent of Sky HD, BBC/ITV Freesat, or the devices that allow several Sky boxes to be controlled via the same return path.
Bill Wright 2008

Domestic RF distribution systems for television and radio, Part 2

Bill Wright

Mini-systems: a cheap and cheerful method
Some customers simply want to be able to watch satellite and change satellite channel from two or three bedrooms. Such modest requirements are usually well served by one of the small amplifiers that support the tvLINK system. Some of these are powered by the Sky receiver itself, so they can be installed where there is no mains supply. These amplifiers have a return path that carries the 7MHz signal from the tvLINK 'eyes' back to the Sky receiver. They also provide 9VDC at each output for the 'eyes'. If I had written this a year ago I would have warned you that a lot of the small amplifiers on the market attenuated the return signal so severely that operation of the tvLINK system was hit and miss at best. At the time this was a severe problem. Fortunately most or all of these early teething troubles seem to have been cured, and as far as I know from talking to other installers all the amplifiers currently available pass the 7MHz signal back to the Sky receiver more or less unscathed. I can personally vouch for the current Global, Antiference, and Labgear products in this respect.
Before I get to the serious large-scale systems I'll deal with these 'mini-systems', which are based on a simple multi-output amplifier. There's really nothing to these, and they are normally within the scope of any reasonable DIY man. However lots of people don't have the time or inclination for DIY, and you should find these jobs quite profitable, since they don't take much time. Sometimes the DIY installation hits the rocks, usually due to the troublesome nature of the aerial signals. The instructions packed with the amplifier tend to gloss over these drawbacks. This is where you can step in with your test gear and make a few quid.
Amplifiers with various numbers of outputs are available from Global, Antiference, Labgear, Triax, and Televés. Incidentally the word 'professional' in this context seems to mean 'having f type connectors rather than Bellings'.

Product code	F120	F140	F180	F280
Frequency range	47 to 860MHz			
Number of outputs	2	4	8	16
Gain when 12V psu used	7dB	7dB	8dB	8dB
Max output with 12V psu	25dBmV	24dBmV	25dBmV	25dBmV
Power	Digibox RF2 or 12V psu	Digibox RF2 or 12V psu	12V psu	12V psu

The Global range of tvLINK distribution amplifiers

Note that the gain to each output is quite modest. Since the Sky receiver's modulator output is about 11dBmV more gain would be undesirable. The designer has assumed (reasonably) that the aerial signals are at good strength. The maximum output capability is generous, which can be useful where cable runs are long. Other makes generally have similar specifications to these Global products.

The usual layout for a 'mini-system' is simplicity itself. The aerial loops through the Sky receiver. RF1 on the receiver feeds the TV set. RF2 feeds the amplifier, which can be behind the satellite receiver or in the loft. The amplifier feeds all the other TV sets in the house, and that's it.

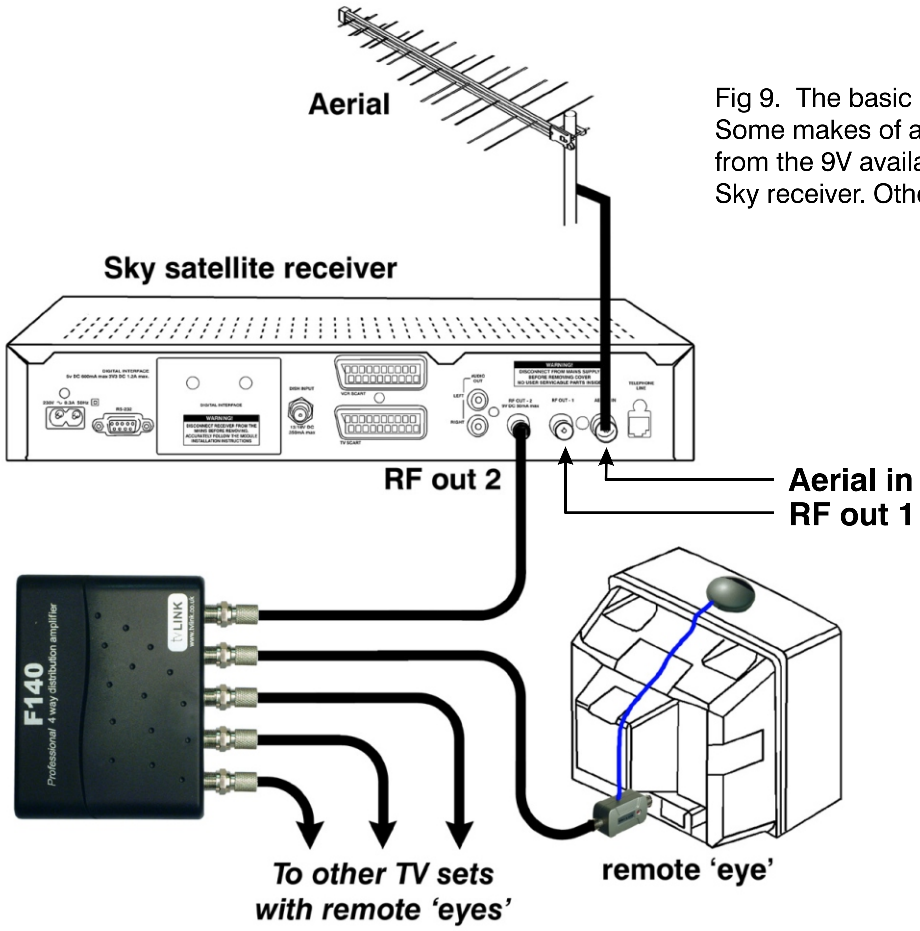

Fig 9. The basic 'mini-system' layout. Some makes of amplifier can be powered from the 9V available from RF 2 on the Sky receiver. Others are mains powered.

Once the connections have been made the Sky receiver needs adjusting so that it supplies 9VDC at RF2 to power the 'eyes'. The button pressing routine is as follows: Services, 4, 0-1-select, 4, set RF outlet power supply, save new settings. If the amplifier has its own power supply this is not necessary, because the receiver will accept commands via RF2 whether or not the 9V power is switched on. While you're in that menu page, set the RF output channel.
When installing a tvLINK system remember that the coax must provide a good DC path from the 'eye' to the Skybox. This means that safety isolating wall plates can't be used. This is all the more reason to earth the installation.

Mini-system problems and solutions
The use of these amplifiers is a lovely simple way to do the job, and for a small-scale domestic installation it usually works very well. Although it is normally possible to install a mini-system without snags, problems can be caused by the fundamental shortcomings of the arrangement, which is really just a 'daisy chain' of RF components. Any RF daisy chain assembled from items of consumer equipment is prone to problems of noise and mutual interference. If the daisy chain consists of nothing more than an aerial, a satellite receiver, and a small distribution amplifier then there's a good chance of success. But add a two-stage masthead amplifier and/or a VCR and there's likely to be trouble. Here's a list of daisy chain shortcomings:

- It might be difficult to find a clear channel for the satellite RF output.
- The relative levels of the aerial signals can't be adjusted.
- There are no input filters to protect the amplifier from strong in-band or out-of-band interference.

- If a masthead amplifier is used there is a daisy chain of three amplifiers (there's one in the Sky receiver of course) and this can cause unacceptable noise and intermodulation products. Impulse noise from vehicles can be a particular problem, badly affecting the satellite RF output channel.
- Out-of-channel noise from the satellite receiver's modulator will contribute to the general noise level.

Finding a clear channel

I'll look at the problem of finding a reliably clear channel for the satellite receiver RF output in some detail. It has relevance to the later section on large multichannel systems, even though such systems often have channelpass filters on the aerial input.

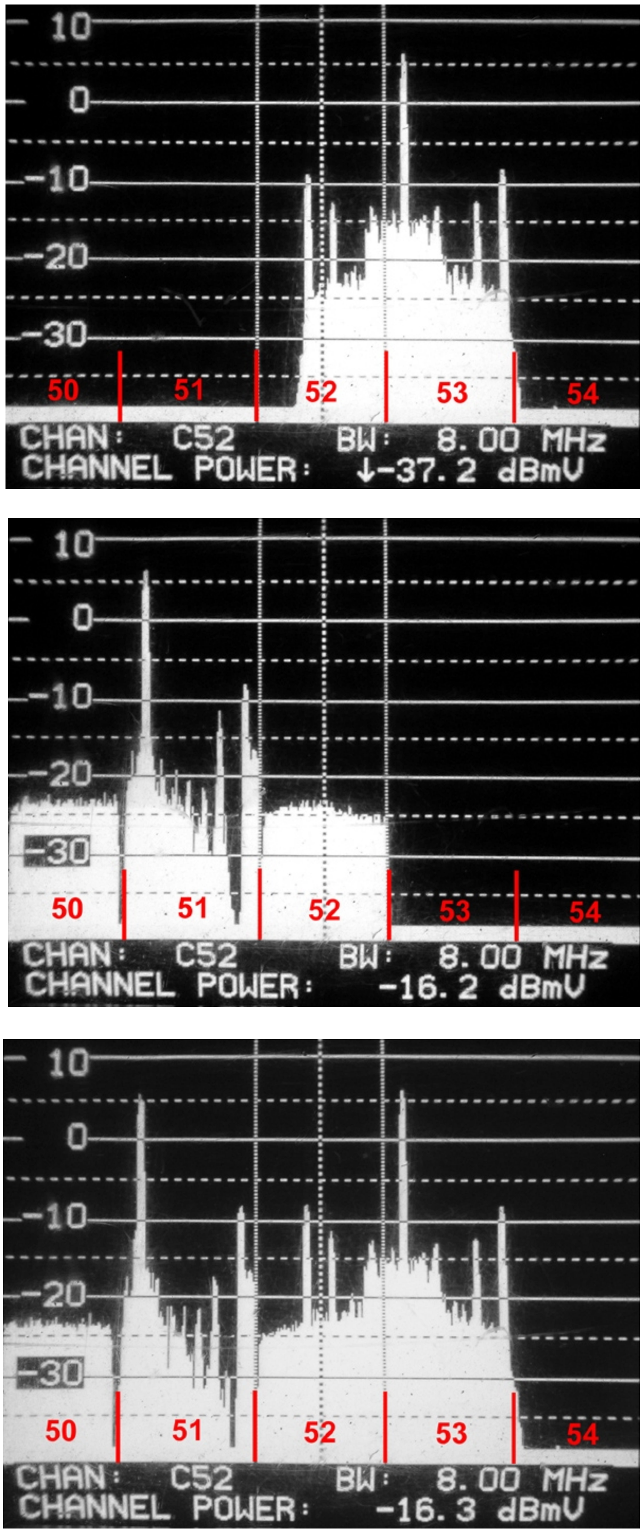

Fig 10. Spectrum analyser screenshots showing how the unsupressed lower sideband of a satellite receiver's RF output can disrupt reception of the lower adjacent channel. Channel numbers are in red and the left-hand scale is dB. The top image shows the RF modulator output from a Sky receiver set to channel 53. The modulators built into domestic equipment are DSB types, meaning that they do not suppress the lower sideband, so a lot of unnecessary and undesirable energy is deposited in the lower adjacent channel. The highest peak is the vision carrier, and the wanted and unwanted sidebands are centred on it.

The middle image shows unfiltered signals straight from the aerial. Channel 50 carries a DTT multiplex offset by 150kHz. Channel 51 carries an analogue signal. (Note that the lower sideband of a broadcast analogue signal extends only 1.5MHz below the centre frequency, unlike that from a DSB modulator.) Channel 52 has a mux offset by +150kHz.

The lower image shows what happens if a satellite receiver output is placed on a channel one above a multiplex. In this example the multiplex is at –16dBmV and the receiver output is at +6dBmV (vision carrier). These are realistic relative signal levels. It's obvious that the mux suffers greatly from the encroaching lower sideband of the modulator with some parts of it having a negative c/n ratio. The digital modulation system used in the UK is very good at dealing with such problems, but this amount of noise in the channel has to be detrimental. In this example the Bit Error Ratio worsened to the point where DTT pictures were constantly freezing.

Modulator signals can however usually be placed on channels one below multiplexes with no problem, as long as the relative signal strengths are correct.

Channels that just can't be used
I'm sorry but this is where I have to state the bloomin' obvious: don't use channels that are in use by the local transmitter! I know it sounds silly, but if your customer is a Sky fanatic and there isn't a DTT receiver in the house it really is possible to forget that the DTT channels have to be avoided just as much as the analogue ones.

Adjacent channel use
Channels adjacent to the local analogue ones shouldn't be used for the satellite receiver's RF output, mainly because there might be a TV set somewhere in the house with poor adjacent channel rejection. Having said that, if there's no alternative it can be worth a try. Channels that are adjacent and above a broadcast channel can't be used for another reason, and this really does rule them out. The unsuppressed lower sideband from the satellite receiver's modulator will cause severe interference to the broadcast channel. This applies whether the broadcast channel is analogue or digital. If you ignore this rule on the grounds that the broadcast channel in question is digital and there isn't a DTT receiver in the house, then I can almost guarantee that the customer will acquire a DTT box within weeks. He will blame you for the dreaded 'stop-start' effect on some of his channels, and he will be justified in doing so.
As far as possible avoid five-channel or nine-channel spacing. There's more about this in our Aerial Topics Section. Some older and cheaper TV sets are susceptible to image interference and other spurious responses, and local oscillator interference can also be a problem, though this is less common. Many modern TV sets and recording devices are virtually immune to these problems, but some aren't, so avoid n±5 and n±9 channel spacing where possible. If it's unavoidable try five-channel spacing first since this is less risky than nine channel spacing.

Congestion on the UHF band
It can be hard to find a truly clear channel, because often there's no such thing! A good installer will look carefully through the UHF band until he finds a 'clear' channel. It can help to draw up a chart showing the occupancy of the UHF channels in the area. A blank chart can be found at *http://www.wrightsaerials.tv/reference/UHFTVChannelPlanner.htm.* If the link doesn't work look in the Reference Section: the chart's in there somewhere.
Now remember that we are dealing with analogue TV signals here. An interfering signal 46dB weaker than the RF output of the Sky receiver will cause visible patterning. In practical terms this means that a signal too weak to be visible as a TV picture can still cause problems, so the 'clear channel' might not be as clear as you think!
Whether or not this is a real problem or merely a hypothetical one depends largely on your location, and on the field strength of the TV signals that you want to receive via the aerial. There's a place near my home that has close wooded hills all around it except in one direction. In the clear direction Emley Moor transmitter is clearly visible, about ten miles away. You won't have a problem finding a clear channel in a place like this. The aerial output looks like a direct feed from Emley Moor! There's nothing between channels 21 and 68 that comes within 50dB of the Emley Moor analogue channels, and most channels have nothing within 70dB. There are two reasons for this. One, of course, is the near all-round screening. The other is the strength of the Emley Moors signals. If the required off-air signals are so strong that a 12dB attenuator is needed then all the others channels have their interference and noise reduced by 12dB as well. So the point is, always attenuate the off-air signals when you can. Don't carry them on the system at unnecessarily high levels. Every dB of attenuation on the aerial lead improves the signal/noise ratio of the satellite channel by the same amount. Analogue channels should enter the Sky receiver at no more than 12dBmV (72dBμV). Given reasonable cables losses this will have all the off-air analogue channels and the modulator output arriving at the amplifier at about 7dBmV (67dBμV). The amplifier outputs will therefore be at about 14dBmV (74dBμV) – a nice comfortable 10dB below the amplifier's maximum figure and still more than adequate even for long downleads. By the way, that's the last time I'm going to convert to dBμV for you! Those accustomed to that unit should add 60 to my dBmV figures – see the next page.
In the example I've just given there would be no problem at all in finding a clear channel, but

this is a very unusual situation. Apart from slightly odd locations like that one, the only places where lots of UHF channels will be more-or-less completely clear at all times are remote areas (especially to the north-west of the UK) and heavily screened rural valleys where reception is from a local relay.

> 'dBμV' means 'decibels referred to 1μV'. 1μV is one millionth of a volt. 'dBmV' means 'decibels referred to 1mV'. 1mV is one thousandth of a volt. The dB scale as used here is logarithmic with 60 representing a ratio of 1,000 to 1. So those accustomed to the 'dBμV' unit should add 60 to my dBmV figures. Incidentally 'dBμV' is pronounced 'dB microvolt'and 'dBmV' is pronounced dB millivolt'. The advantage of using dBmV is that the sort of signal levels encountered in a distribution system are, with that unit, represented by small negative and positive numbers, making it very easy to tot up the losses and gains along a long signal path. For instance, amplifier output 48, less tap-off losses of 1, 1, 1, 1.5, 1.5, 2.0, 2.0, 2.0, 2.5 and 2.5dB and tap-off cable losses totalling 15, followed by a line amp with gain of 30dB, followed by another identical tap-off line, would mean that the repeater input would be 16, its output would be 46, and the input to the last tap on the system would be 14 – which isn't enough, so a re-think would be necessary.

Interference from DTT
A scan through the band using an analogue TV set might find channels that appear to be completely empty, the screen showing pure noise with not the faintest trace of a picture. But when the channel is used for distribution the results are terrible. The picture is very snowy. A DTT transmission appears to an analogue receiver to be pure noise, and will even mask other analogue signals on that channel. If you put your satellite receiver's output on a channel with even a very weak DTT signal in occupation the analogue picture will be snowy. If in doubt, unplug the aerial input at the Sky receiver and see if the picture clears up.

No clear channels
Here's an example of the sort of location where it can be difficult if not impossible to find a clear channel.
I have a customer who lives near the Crosspool transmitter, above Sheffield city centre. Alas he is screened from Crosspool by a large building, making reception impossible due to reflections from the big buildings down in the city. The only possible transmitters for good reception are Waltham and Belmont, but signals are also present from Emley Moor, Bilsdale, Crosspool (of course), and four local relays. When you remember that each main transmitter occupies eleven channels (five analogue and six digital) you start to realise why there aren't many clear channels!
The aerial is aligned on Belmont transmitter, which means that it is also pointing towards northern Holland and Germany. Even the slightest 'lift' brings in all sorts of continental RF rubbish, right across the band.
Because the Belmont signals are rather weak, the aerial has a single stage masthead amplifier. The gain is 12dB, so all other things being equal any signal received by the aerial on the channel used to distribute the satellite RF has a 12dB 'advantage' over the modulator's output. Incidentally, if a two-stage masthead amplifier is used because field strength is very low the likelihood of co-channel interference on the satellite RF channel is even greater, and there might also be impulse interference from passing vehicles. The masthead amplifier's own thermal noise will also certainly degrade the satellite picture.
The Sheffield customer rung to say that he'd had Sky fitted but reception was very variable in the bedroom. The installer apparently hadn't made any attempt to find a clear channel, but when I called I couldn't find one either! To my surprise both channels 36 and 38 had faint analogue signals, probably from illegal video senders. Channels 36 and 38 are not used for broadcast in

the UK and are often clear, although unfortunately in many areas they are adjacent to 'five' transmissions on channel 37 and therefore can't usually be used. Signals from abroad can also appear on these channels. The TV set wouldn't operate on channel 69, so the number of available clear channels was zero! I had to 'make' a clear channel.

Make a clear channel

If at all possible attenuate the aerial signals, but don't reduce the weakest analogue signal below 6dBmV or the weakest DTT mux below –14dBmV.

A notch filter, or 'channel blocker', can be inserted in-line with the aerial feeder. It will attenuate a specific channel by up to 30dB but leave the others more or less unscathed. The filter should be fitted in front of the satellite receiver. It should be tuned to the channel to be used for the receiver's RF output, so that it attenuates everything on and near that frequency. There's more about notch filters later.

Notch filters should not be plugged directly into the satellite receiver (or anything else). The tuning and notch depth can be affected, and in any case they are too heavy to hang from a coaxial socket. Instead make up a short flylead using CT100 or equivalent coax.

Don't imagine that a notch filter will allow you to use any old channel in the UHF band. Don't use a channel close to a wanted broadcast channel or reception of the latter might be affected. Use a channel that is as clear as possible, because the notch attenuation isn't infinite, and signal can find its way into amplifiers, flyleads, and outlets without coming in via the aerial feed.

Having fitted either an attenuator or a notch filter at the satellite receiver input, common sense will tell you what the acid test is. Unplug the aerial from the satellite receiver and look closely at the satellite picture. If it improves, you've failed!

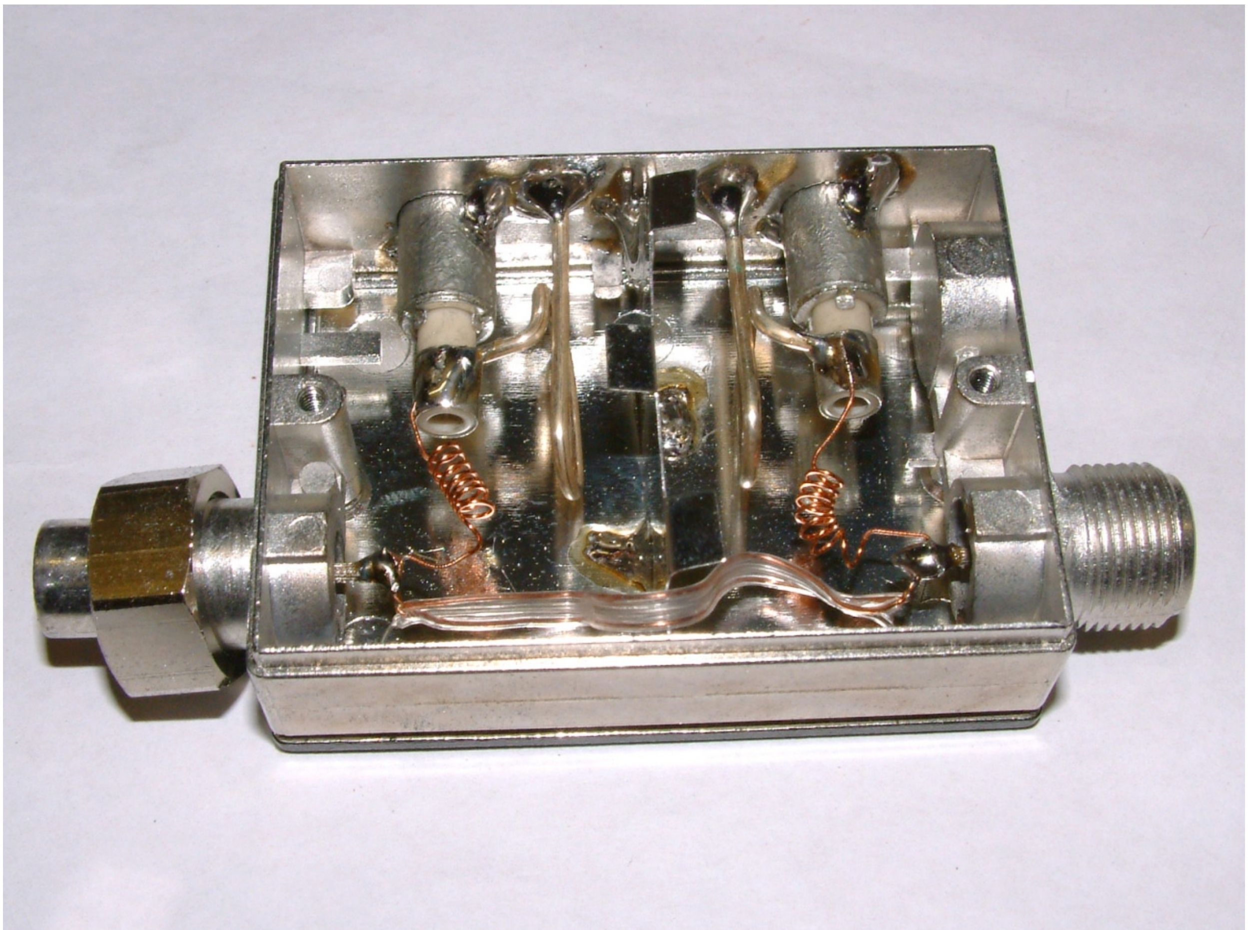

Fig 11. A Taylor TBBF4 double notch filter with the side cover removed.