Domestic multi-channel TV distribution systems

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from *Television*, October and November 1995

TV distribution systems in private houses are becoming ever more elaborate, and trial-and-error installation methods are not adequate. Some of the techniques used in major commercial installations are now appropriate for the domestic environment. In this article Bill Wright considers the fundamental principles of system design and looks at the use of channel pass filters and other components.

Introduction

How to combine and distribute aerial signals, satellite receiver outputs, VCR outputs, and other sources so that they can be distributed to a number of locations.

1995 was a long time before the advent of digital television, and even analogue Channel 5 was a nightmare yet to come. The basic principles outlined in the article still apply though, and it still has relevance to the modern situation.

Incidentally, the article was written as Bill slowly recovered from a severe back injury. He remembers, 'I was immobile, in severe pain, and drugged up to the eyeballs. The keyboard was taped to a gantry above my chest, made from aerial masts. The painkillers caused memory loss, and when the article came out I had only a slight recollection of writing it.'

Many private houses, especially the larger and more affluent ones, often have a surprisingly large number of tv sets in use. As well as the obvious locations we now find sets in Dad's study or workshop (bolthole?), the gazebo, the granny flat, and even places where only a few years ago tv watching would be regarded as highly eccentric. Even some small properties, especially those where the owners are blessed with a host of adult children, their live-in-lovers and the fruit of the latters' loins, seem to have astonishingly large quantities of tv sets tucked into every possible nook and cranny. I have a customer whose originally tiny terraced house has been enlarged over the years in every possible direction in order to accommodate his ever-increasing extended family. At the last count the house contained nine tv sets and four VCRs.

Our customers range from the nouveau riche kid in his six bedroom, triple garage monument to bad taste, set in five acres with Olympic-size pool, to the hard-pressed grandfather of 45 who finds that his house seems to have turned into a multi-occupancy doss house and crèche. These people, and lots of others in between, have one problem in common that you can solve for them. How to get good reception, including satellite and VCR playback, on all their tellys.

It may be that you are initially asked to fit a simple aerial for the tv set in the bedroom of, say, child number three. This can be regarded as no more than evidence of the customer's lack of imagination. There is an obvious opening here for the sale of a distribution system. This is not unscrupulous salesmanship. These people have got about £3000 worth of consumer electronics, and none of it is working to anything like its full potential, just for the lack of a few hundred pounds worth of tv distribution system. These installations, carried out properly, generate a lot of customer satisfaction, and frequently lead to recommendations. The existing hotchpotch of aerials, cheapo amplifiers, splitters, and loose cables probably has considerable irritant value. It might not have occurred to the customer that the VCR and satellite outputs could be piped all round the house, or even that everyone could actually enjoy good terrestrial reception. Point out that a proper distribution system would mean an end to interminable ear-splitting Mtv in the living room, and to add extra psychological pressure make sure that the family teenagers are present during the discussion!

Another possibility is that the house has had some sort of cobbled-up distribution system installed, so the customer is aware of the concept and the possibilities, and would be very happy if the system could be made to work reasonably well. Very often the opportunity for a sale arises when such a customer moves house, and is determined to have the thing working properly at his new address. Where the new house is being built to the customer's specification the opportunity arises to install a really excellent system, with all cables hidden and ducting installed for future expansion. Get in at the planning stage: if possible use the site electricians to install the cables, following your plans, as part of their first fix.

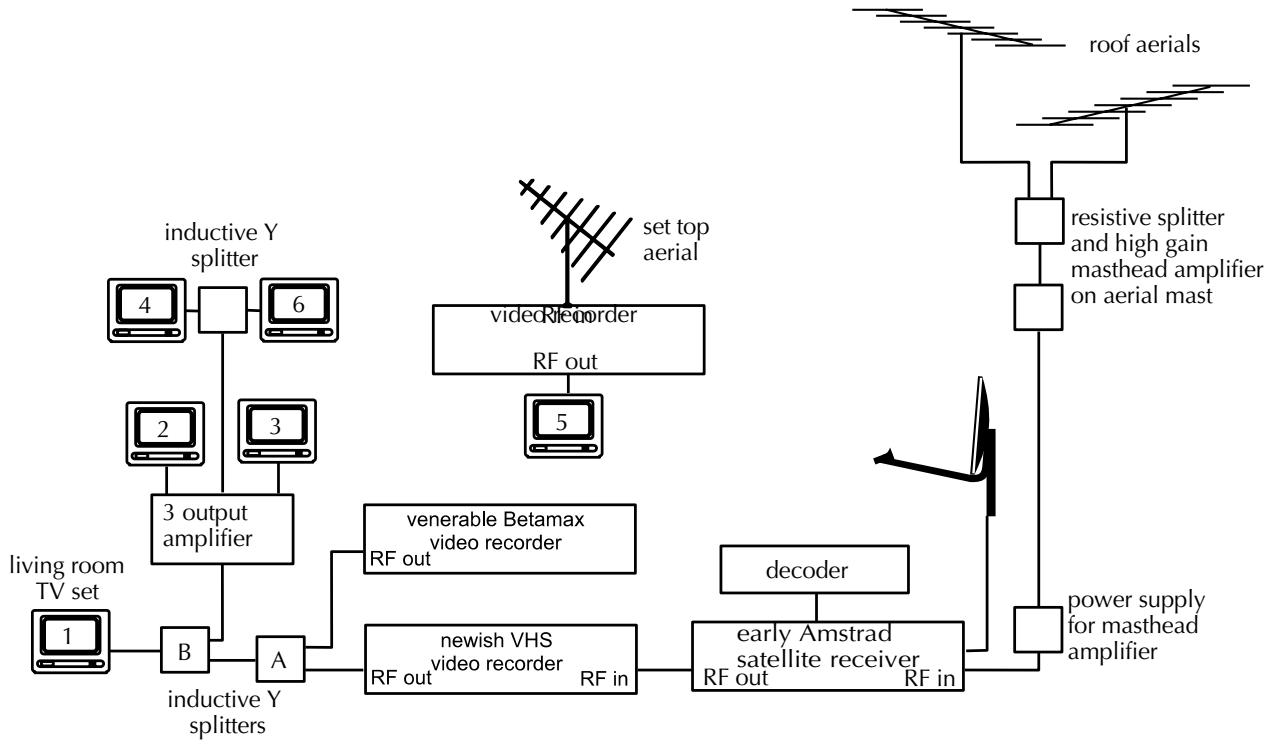
Before we discuss the design of good systems that obey all the rules of correct RF distribution practice, let's look at a representative example of a cheap and cheerful system. Later in the article, I'll describe how this system was redesigned. I'm not necessarily saying that these cheap and cheerful methods are wrong, by the way. I spent too many years of my life installing fixed-price aerials for national rental chains to take that highfalutin' attitude. Often the customer's price limit or scale of priorities precludes anything other than the most basic installation. After all, if the sole requirement is VCR reception on the monochrome portable in the kitchen so that Grandad's sudden craving for a bacon sandwich doesn't cause Grandma to miss the long-awaited exhumation of Mr Jordache from under the patio, then there's nothing wrong with a splitter in the back of the VCR, 5 metres of coax, a hole in the plasterboard wall with a screwdriver, and off to the next call sharpish. This article, however, is primarily concerned with the other end of the market: the man who wants it all, and wants it all to work well. This is the section of the market which is rapidly expanding downwards to take in the middle ground.

The system that had slowly evolved

Fig. 1 shows a system we found recently at the home of Mr and Mrs Clutter. Mr Clutter makes a very decent living as a 'general dealer', but his weakness is that he can't bear to part with certain items, so the house is, well, rather over-stocked. To make things worse, the Clutters are well-off technofreaks who acquire gadgets of all kinds, never quite master their use, and then leave them lying about gathering dust. Huge piles of all sorts of things stand on every horizontal surface. Mrs Clutter has long ago given up all pretence of domestic tidiness, and the general impression is that the only clear spaces are those just wide enough for a human body of Mr Clutter's generous proportions to make the journeys essential to reach the armchair, the fridge, and the lavatory. I was never able to work out quite who was who amongst the other inhabitants of the house, but there seemed to be plenty of them.

Initial impressions were that this was not a promising call. The feeling was strengthened

Fig.1. Mr Clutter's original distribution system



when I saw the densely-packed, dust-covered pile of assorted consumer electronics in the corner of the living room. A massive tv set, a prehistoric Amstrad satellite receiver with outboard decoder, two VCRs, assorted bits of hi-fi, and other apparently disused items, all gave the impression that making even the simplest connection at the rear would need help from Pickfords. A badly faded press cutting in a frame surmounted the heap. It showed a remarkably slim Mr Clutter in 1970s attire with a large silver cup and two prize greyhounds. Despite my initial impressions I began to warm to Mr Clutter when he interrupted my nervous preamble—'Your television system is a load of old rubbish and we'll have to start from scratch…' with an airy wave of his lager can, a scratch of his impressive abdomen, and words to the effect that he was more than ready to pay out some serious money to get the tv system sorted. He'd had bad service from the satellite installer, the local tv shop, and the local aerial rigger; the problems had been going on for years, and he was mighty fed up. I didn't know it at the time but I'd come highly recommended. Nor did I know that the local rigger's last visit had culminated in his being pursued from the premises by Mr Clutter's well-trained tyre-biting pit bull. I arranged to commence work on the following Thursday, by which time Mr Clutter would have 'sorted out the telly and that'—presumably with a JCB—and would even have moved enough stuff out of the loft so that I would be able to squeeze in there.

Mr Clutter's tv system was by no means a particularly hair-raising example; it was typical of a set-up that had not so much been installed as had evolved, over a period of about twenty years. As requirements had changed, little bits had been added piecemeal. There's some out-and-out botchery, certainly; but mainly the faults were just the result of ignorance of the basic principles of RF distribution. I'll list these basic principles, and then we'll look at how this system cheerfully disregards them. Then we'll look at the alterations which were made subsequently.

First, though, I must say a word about test equipment. It is not possible to do this job professionally without the right gear. A really good signal strength meter is the minimum. A spectrum analyser is highly desirable. An analyser is not a luxury: it will pay for itself over and over again.

UHF tv distribution systems: the basic principles

The off-air signals, both satellite and terrestrial, should be as strong, clean, and consistent as possible.

Each signal source (tv channel) should, if necessary, pass though sufficient filters before it is combined with other signals, so that its accompanying noise cannot interfere with other signals.

Signals should pass through active devices at a level within the correct operating range of the device.

The signal levels of each channel should be equal, or sloped to allow for differential cable loss if appropriate.

Channel allocation must obey the following rules:
No two signals on the same channel (!)
No two signals on adjacent channels
No two signals 5 channels apart if possible
No two signals 9 channels apart if possible

If for some reason strong local tv broadcasts are not carried on the system, the relevant channels should not be used on the system.

Very strong unwanted signals such as local UHF police repeaters should be filtered out at all inputs.

If the system has to carry VHF-FM radio, the VHF aerial input should pass though a bandpass filter, and the filter output should be closely examined for high level (possibly intermittent) signals.

Off-air reception

At Mr Clutter's location reception of the nearby high-powered transmitter was badly affected by screening and ghosting, and the only way to get half-decent reception was to use a distant transmitter which gave rather weak signals, and Tyne Tees ITV instead of Yorkshire. Hence the two aerials, connected together with a splitter. Since the received channels were 23 to 33 and 41 to 51 respectively, a diplexer would have been far better than a splitter, since the aerial intended for reception of the distant transmitter was able to contribute a lot of ghosting to reception of the local transmissions. The amplifier following the splitter was having a hard time. Input levels from the distant

transmitter were about -14dB/mV on three of the four channels, which is a reasonable level to feed a two-stage masthead amplifier. Because of the cheap aerial used, channel 33 was at about –18dB/mV: badly designed aerials usually have very poor gain on the top few channels of the group. Also entering the amplifier, however, was the output from the other aerial. Because of the reception conditions from the local transmitter the signal levels on each channel varied widely and unpredictably. At times when any channel exceeded about +12dB/mV the cross-modulation from the masthead amp. was wondrous to behold, especially on the channels coming in at about -12dB/mV, which of course were the ones without the ghosting…

The masthead amplifier was one of the very cheap ones with no input filtering of any kind—all signals from long wave to cellphones cheerfully accepted. I didn't know it at the time but about 75m from the house was a police transmitter using the 450MHz band, which I later found was putting about 20dB/mV for a few seconds every so often into the unfortunate masthead amplifier. All this adds up to a really horrible RF mess. No distribution system can work from an aerial input like this.

The other off-air reception, of course, was from Astra via an Amstrad dish with the old bluecap LNB. I'm sure it's unnecessary for me to describe the resulting reception quality. The aerial was looped through the Amstrad satellite receiver. As is customary, the outboard decoder was adding slight patterning to the lower Group A channels. Mr Clutter also showed me his 'calmer-downer'. This turned out to be a 12dB attenuator which some previous expert had advised should be fitted at the input to the Amstrad 'when the weather was bad'. Following the Amstrad was a modern VCR. The output from this entered a Y splitter . The other leg of the splitter introduced the output of a Betamax VCR into the system. This machine had long ago lost the ability to record, and so thankfully had no aerial input.

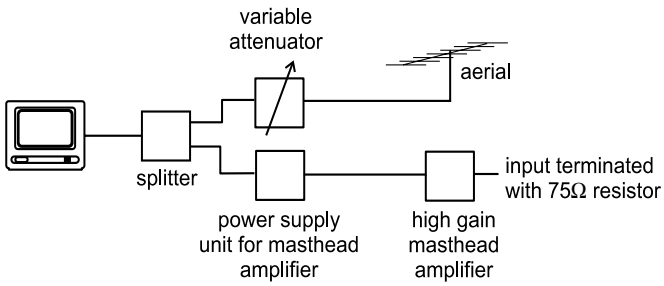


Fig. 2.Test set-up to show that lifting the noise floor has the same effect on the picture as reducing the signal level

At the output of that splitter, marked 'A' on fig 1, all the various signals are together on the same piece of coax for the first time. This is the RF spectrum which is fed into the amplifier, and which eventually finds its way to the tv sets. Let's look in some detail at the output of splitter 'A'.

Channel 'planning'

Firstly, the question of channel allocations. The RF output frequencies of the three appliances with modulators would have been tweaked in order to minimise mutual interference. 'Minimise' is the word: not 'eliminate'. The family knew, and accepted without question, that if the satellite was on there would be wavy lines on BBC2, and that if Mr Clutter felt the urge to relive the glory of his greyhound racing days his Betamax playback would snarl up both the satellite and the BBC1. These things had been accepted in the Clutter household like the rest of us accept supermarket queues and contraflow.

Noise

Every active device adds thermal noise. Noise on a system is additive: the more sources of noise there are the higher is the noise floor. The higher the noise floor, the harder it is to achieve a signal-to-noise ratio which gives apparently noise free pictures. It doesn't need much noise to degrade a tv picture: thermal noise 30dB below signal has a visible effect. You can see this clearly on a spectrum analyser, or you can set up a little experiment which makes the point. Connect up the arrangement shown in fig 2. With the power to the masthead amp turned off, adjust the variable attenuator until the picture is just grain-free. Turning on the masthead amp will introduce noise: the effect is virtually indistinguishable from reducing the attenuator setting. The signal to noise ratio has been reduced by adding noise from the amplifier rather than by reducing the signal level. The result is the same. The designers of good quality masthead amplifiers strive to reduce the noise figures of their products: for a more dramatic demonstration precede the masthead amp with something noisy, such as a cheapo distribution amplifier. This is pure thermal noise with no modulation. It makes tv pictures look 'snowy' or 'grainy'.

Even more pernicious is noise in the sense of 'unwanted signals', such as co-channel interference or cross-modulation. Quite tiny

signals can have a disastrous effect. A co-channel tv signal at –46dB will produce noticeable patterning.

The point of all this is that the noise, both thermal and in the form of modulation, from two VCRs, a satellite receiver, and a masthead amplifier, were all present at splitter A. More noise would be added at the distribution amplifier. If all the signals were well above this rather elevated noise floor no great harm would be done. But because nothing had been done to set the signal levels the signal to noise ratio of each channel was a matter of chance. Of course, the practice of cascading, or 'daisy-chaining' a satellite receiver and a VCR is almost universal, and usually no harm is done. The problems start when more and more equipment is allowed to add noise, and where signal levels are incorrect.

The amplifier

Signal levels entering the distribution amplifier were very low. Splitter B was a Y splitter of the inductive type. Unlike the resistive version, it is necessary to differentiate between the input and the two output ports on these items. Very little signal passes from one output port to the other. Unfortunately, the fact that the output ports are female and the input port is male had led Mr Clutter to fit the input port directly into the aerial socket of the living room tv set. This severely attenuated the signal feed to the distribution amplifier. Since the amplifier had very high gain at each output, measured signal strength at each outlet was quite acceptable. Picture quality was very poor, however, due to the poor signal to noise ratio. Just because the meter reading is OK, don't assume that the picture will be noise-free! The best terrestrial reception in the house was on the tv set fed from a set-top aerial!

The design and installation of the new system

Obtaining good off-air signals

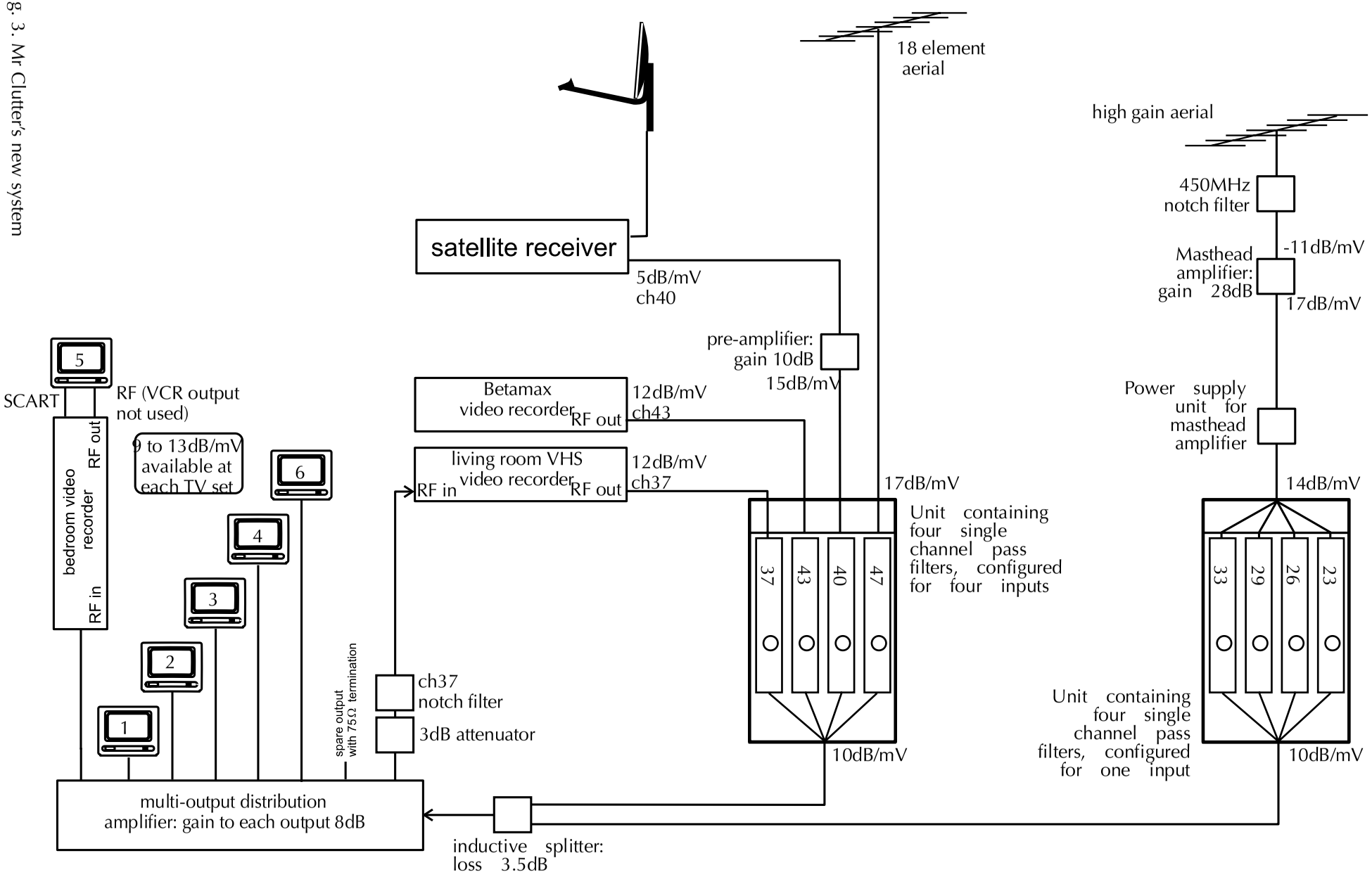
Not wanting to take anything for granted, the first job was to check that the local transmitter could not be made to yield good reception. Tests showed that this was in fact the case; a great pity because the use of strong local signals including the correct ITV region would have simplified matters greatly. The use of a third possible transmitter, Belmont, was considered, but was ruled out because field strengths were little better than Bilsdale, and Belmont reception is all too susceptible to co-channel interference from Europe in this area, since an aerial which is pointing at Belmont is also pointing at Holland and Belgium.

A good quality high gain aerial was duly installed, pointing due north to Bilsdale, some 60 miles away. This yielded –9dB/mV to –11dB/mV, which made me happy. Because Bilsdale is north of here, we find that we can use it without fear of interference from Europe, even where the field strength is low, so –11dB/mV is OK. A standard Band IV notch filter was used to notch out the police transmissions, 450MHz being just within its tuning range. Because the police transmissions were of short duration and not very frequent it was not possible to tune the notch filter directly to the transmissions. Instead, a spectrum analyser was used to determine the exact frequency. The filter was then connected between a broadband noise source and the analyser and the filter tuned for a notch at the appropriate frequency. It was, of course, necessary to fit the filter in front of the masthead amplifier. Through loss on the notch filter was about 1dB on ch23.

Discussions with the Clutter clan revealed that they absolutely had to have Yorkshire TV, but they seemed oblivious to the regional differences on BBC1 and BBC2. I decided therefore to put Yorkshire ITV only on the system, removing the other three channels. This was done at the channel pass filter stage of the system—see later, and fig 3. There were a number of advantages. The fewer channels there are on a system the better, because the cross-modulation ceiling lifts 3dB every time the number of channels is halved. In this case, the Emley Moor signal levels varied widely, so reducing them to one channel greatly reduced the potential for intermittent cross-modulation. Furthermore, if I had left dodgy versions of BBC1, BBC2, and Channel 4 available, the Clutters would have undoubtedly tuned in to them and then moaned. As it was, I stressed that YTV should be regarded as a secondary service, only to be used when there was a different programme on Tyne-Tees.

Careful positioning of the Emley Moor aerial yielded 17db/mV on Ytv. This was about 12dB below the line-of-site figure. The aerial was aligned with reference to YTV reception only: there was noticeable ghosting on YTV, but two of the other channels were very poor and one was virtually unwatchable.

Fig. 3. Mr Clutter's new system



Channel pass filters

In the case of a 'difficult' system like Mr Clutter's, where the available off-air signals are not good and where a variety of modulator-derived signals are involved, each and every signal input must be filtered immediately before it is combined with the others. Since we are dealing with tv channels 8MHz wide, the basic filter used should handle one such channel, and should have bandwidth just sufficient to handle one channel without distorting the signal.

Channel pass filters are available from a number of manufacturers, but the types with which I am most familiar are imported by Taylor Bros of Oldham, and sold as the TCFL series. The filters come in units containing one, two, four, or six separate channel pass filters. Each channel passes through three tuned stages and a variable attenuator. Through loss is usually 2 or 3dB. A typical frequency response for a four channel unit is shown in fig 4. In all units the outputs of all channels are common; that is they all appear on the same socket; but any input configuration is possible. For instance, in the case of the four channel unit you can have four separate inputs, two inputs each of two channels, or one input of one channel and one input of three channels. This input configuration is specified when ordering, but it's easy enough to alter. Likewise the channels should be specified, but can be altered afterwards within a limit of about ±7 channels. Further retuning is possible, but through-losses may become excessive. It is impossible to stock every conceivable filter, so aertain amount of re-configuring and retuning is often necessary. Accurate retuning, however, is not possible without a spectrum analyser and a noise generator. Simply retuning for maximum output on a signal strength meter will give very poor results, as the tuned stages must be aligned for correct bandwidth.

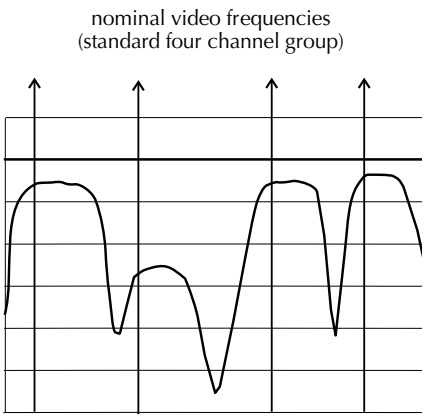


Fig. 4. Frequency response of a four channel pass filter. One channel has been set at -10dB

Planning signal levels

It is important that signals pass through an amplifier or other active device at a level which is within the device's correct operating range. A domestic system will inevitably use a single broadband amplifier to bring the signals up to the correct level for distribution. If levels are too low, excessive noise will be introduced; if they are too high cross-modulation and other undesirable effects will appear. As a rule of thumb, run the amplifier at a maximum of about 10dB below the level where cross-modulation is visible.

Usually the amplifier will be the multi-output type, where separate cables are taken back to the amplifier from each outlet socket. I am in the habit of planning my signal levels backwards: that is I start at the outlets and calculate back towards the signal sources. This makes sense, sort of, because if there's any signal shortfall the compensating amplifier should be in front of the channel pass filter, not after it. At no point should the level drop below about +3dB/mV, or noise will be introduced. To allow levels to get really low somewhere along the system and then to increase them by additional amplification is no good at all. In order to calculate the input signal required for the amplifier take into account the loss on the longest downlead and the amplifier gain to each output. Although it is supposed to be acceptable to provide a tv set with 0dB/mV, I always plan for no less than 8dB/mV at each outlet. The required amplifier input plus the filtering and combining losses gives the signal level required from each signal source. In the case of Mr Clutter's system the Amstrad satellite receiver produced only 5dB/mV, which was not sufficient. A little set-back 'booster' amplifier was used to correct this. It is most important that any such amplification is fitted before the channel pass filters. In cases where several inputs to one filter unit are low it is very tempting to fit one amplifier after the filter unit rather than several before it, but this negates the whole point of using filters, which is to keep each channel clean and uncontaminated by noise and interference from other sources.

The variable attenuators in the filter blocks are used for final adjustment of signal levels. Normally all channels will be set level, but if cable runs are long and channels at both ends of the band are used, a little bit of slope might be applied; say 4dB across the whole band. In the case of Mr Clutter's system, I was concerned that the ch47 Emley Moor signal might rise

sufficiently to affect reception of other channels. Careful alignment of the aerial had produced a signal 12dB below the line-of-sight figure, so I was confident that in practice the level was unlikely to rise more than about 6dB. Accordingly I set the ch47 level at –4dB relative to the other channels. What if the off-air level drops dramatically? Well, the Clutters don't get to watch YTV, unless they want to pay me to move the aerial to suit the changed reception conditions. When the incoming signal is unreliable, make the customer understand that you cannot guarantee reception.

If your signal level planning is about right it is likely that you will drop each channel about 4dB at the variable attenuator. If you have to leave any channel full up you have obviously pushed your luck. If you have to drop any previously amplified channel much more than about 10dB then you are using unnecessary amplification, which adds noise, gives the potential for instability, and is a waste of money. Always use just enough amplification. For instance, do not use a two stage masthead amplifier only to discover that a 12dB attenuator is needed at the distribution amplifier input: plan your signal levels and fit a single stage masthead amplifier.

Combining signals

Because each channel strip within a block of channel pass filters consists of a series of tuned filters, it is possible for the outputs to be simply connected together inside the unit without impedance mismatch. In this way up to six channels can be combined with virtually no loss. Compare this with the alternative of combining using a six way inductive splitter, with losses of about 10dB.

In many cases all channels can be passed through one block of filters, so the filter block output can go straight into the amplifier. In the case of Mr Clutter's system two filter blocks were used, and so the outputs were combined with an inductive splitter. This splitter should be a top quality item in a metal case. The ones that use 'f' sockets are ideal. There is no point in using a diplexer, even where this is possible. Three, four, six, or eight-way splitters can be used where necessary, but the lowest signal losses will be achieved by using the smallest possible number of channel pass units, each carrying the maximum number of channels.

Signal input for the VCR

If a VCR is feeding into a distribution system, a difficulty arises if it uses a system output for its aerial input, as would normally be the case. A signal loop will exist, and if the overall gain of the loop is unity or more, the system will oscillate. For this reason a notch filter, tuned to the VCR output channel, should be fitted on the amplifier output which feeds the VCR. The unsuppressed lower sideband of the VCR modulator output needs to be notched out, even though it will have been somewhat attenuated by the channel pass filter. For this reason a double notch is best, with the tuning slightly staggered, as shown in fig 5. As an additional precaution ensure that signal levels at the VCR

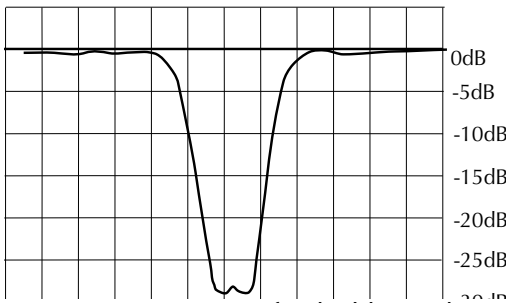


Fig. 5. Frequency response of a double notch filter, with the tuning staggered slightly. A deeper and narrower notch is obtained if the two stages are tuned to precisely the same frequency.

input are not unnecessarily high. Care must be taken to ensure that the notch filter does not affect the VCR's reception of the channels just above and below the VCR output channel. This is easy with a spectrum analyser; not so easy without. If channel space allows it is helpful to have two unused channels on each side of the VCR output rather than one. This makes the adjustment of the notch filter less critical. The RF output of the VCR also includes all other channels on the system, but these are removed by the channel-pass filter, which is of course tuned to the VCR output channel.

If a system is carrying nothing but off-air terrestrial channels all derived from one aerial, there is no need for the VCR to be fed from the amplifier output. It can be fed direct from the aerial, via a splitter. This avoids all the complications described above.

Channel planning

There are 47 channels in the UHF tv band. It sounds a lot, if your system only needs six or eight active channels. So what's the problem? Well, there are constraints which must be considered if various forms of interference are to be avoided. It is surprisingly easy to 'run out of channels', in fact.

It may seem that I am stating the obvious, but no two signals should occupy the same channel. Yes, I have seen it done, and more than once. Actually, I feel a funny story coming on, but I'll restrain myself.

Adjacent channels should not be used. It is possible to get the impression that you can get away with adjacent channel working, but in this domestic context don't do it.

As far as possible avoid five channel or nine channel spacing. Some tv sets are very susceptible to image interference and other spurious responses, and local oscillator interference can also be a problem, though this is less common. In practice it is not necessary to consider the finer technical details. Simply avoid n±5 and n±9 channel spacing and you will keep out of trouble for 99% of the time. If there is a real shortage of channels, risk five channel spacing. It is less likely to cause problems than nine channel spacing.

All signals should be exactly on the nominated channel. When setting the output frequency of the modulator in a VCR or whatever it is necessary to tune it to a known reference frequency. This usually means using the frequency synthesised tuner in a spectrum analyser.

The frequencies we can't normally alter are the terrestrial broadcasts, and these form the fixed points of the eventual channel plan. In an extreme case it might be necessary to translate a channel using a 'channel changer'. This is common practice on commercial systems but is best avoided in the domestic environment, if only on grounds of cost.

It is my practice when planning a system to draw up a chart of the UHF band (see fig 6). The first things to mark up are the terrestrial channels to be carried, with all their n±5 and n±9 relations. Any strong local signals which are not to be carried should be marked, together with any other channels where there is an obvious possibility of interference. A scan with the spectrum analyser will ofteneveal these. The channels derived from modulators can then be slotted in, making sure that all the rules are obeyed. VCRs and satellite receivers at subscriber outlets should be connected to the tv set using a SCART lead if at all possible, and the RF output tuned to somewhere where it will do no harm. In the case of Mr Clutter's system the chart showed that theoretically there was no channel available for the bedroom VCR, although if it had not been possible to SCART it into the tv set I would have used ch 31 or ch 35, checking for n±5 or 9 problems on channels 26 and 40 on the associated tv set.

It is unfortunate that the modulators in most VCRs and satellite receivers will only tune a limited range of channels in the middle of the band—roughly from ch30 to ch40. The result of this is that it is often difficult to find suitable channels in the middle of the band, while vast tracts of unused space lie at the top or bottom ends. Mr C.'s system is a good example of this, with nothing above channel 47, but with a problem finding a spot for the second VCR within the tuning range of its modulator. The channel chart showed up this problem immediately. I envisaged having to put the Betamax output on ch31, which would consitute an n±5 clash with BBC2 Bilsdale and an n±9 clash with the satellite output on ch40. I found, to my surprise and delight, that the Betamax would tune up to ch43—just. If that had not been the case I would have had a problem.

It is a great advantage of Pace satellite receivers that the modulator output can be set to any channel in the range 21 to 68. About a month after Mr Clutter's system had been installed he rung up to say that the satellite reception was very poor. During the whole installation period I had deliberately avoided discussion of the merits or otherwise of the aged Amstrad satellite set-up. Mr Clutter seemed genuine enough, but I felt that I would like to be paid for the distribution system before embarking on anything else. I was fairly sure that a satellite sale would materialise eventually, but I preferred that it should be 'phase 2'; not an addition to 'phase 1'. I duly called round to 'have a look'. Reception on the terrestrial channels was extremely satisfactory, and this meant that the Clutters now knew for the first time what good reception looked like. This was the main reason for the dissatisfaction with the satellite reception, together with a week of very rainy weather. Mr Clutter had been told by the original installers that satellite reception would always be poor compared to ordinary tv because the satellite was millions of miles away, whereas ordinary tv only came from about ten miles away, and he had accepted this argument

completely because of its obvious logic and common sense. Mr Clutter was not short of money, and he liked his telly. Selling him a new satellite installation was just a case of convincing him that satellite reception could be as good as terrestrial. This proved to be an almost insurmountable intellectual hurdle, but we got there in the end. The possibility thus arose of installing a Pace with its RF output on a channel at the top end of the band, but in the event I kept to channel 40. This had been entirely satisfactory, and I didn't feel like fitting a new channel pass filter. Had a Pace receiver been installed at the start, however, I would certainly have put it up on channel 58 or thereabouts.

Another cause of channel congestion is the broadcasters' use of the standard four-channel groupings n, n+3, n+6, n+10, and n, n+3, n+7, n+10. This came about because it was felt at the time that 'adjacent plus one' channel spacing would cause problems. The next option was n, n+3, n+6, n+9, but this was rejected because of the n+9 clash. The groupings now in use take up ten channels. If 'adjacent plus one' spacing had been used the four transmissions could have been accomodated within a bandwidth of six channels. This would have greatly simplified the channel planning of multi-channel distribution systems using fully-tunable modulators because, in cases where only one grouping of the four terrestrial channels was to be carried, the 'adjacent plus one' sequence could be extended across the full band. With the standard groupings now in use a sequence of 'adjacent plus one' channels can be added, but channels have to be missed out because of n±5 or 9 clashes with the transmitted channels. Another advantage of 'adjacent plus one' spacing would have been the fact that the standard channel groups could have been much narrower, with a consequent improvement in aerial performance.

The standard groupings allow the insertion of one channel within the group: for instance in the grouping 21, 24, 27, 31 channel 29 can be added, and in the grouping 23, 26, 30, 33 channel 28 can be added. This will, however, always result in an n±5 clash.

In conclusion

The complexity and cost of domestic distribution systems varies enormously. At one end of thescale is the simple multi-outlet amplifier in the loft supplying terrestrial signals to three or four tv sets. At the other end are systems carrying the outputs from perhaps three VCRs, three satellite receivers, and a couple of surveillance cameras (via modulators), as well as a variety of terrestrial channels, to a large number of outlets. Most jobs fall somewhere in between these extremes. The first part of the installation process is to find out just what the customer needs and requires; to make him aware of the possibilities, if necessary; and to find out how much he is prepared to spend. Because of the many permutations which are possible, it's a good idea to have a separate rough price in mind for each part of an installation. This way you can build up a total price quite easily: simply add together the cost of the aerial, the basic distribution amplifier, the additional cost of adding each VCR or satellite output, the cost of each outlet and feeder cable, and so on. There's a good profit to be made from domestic tv distribution. A decent job can be worth as much as ten or more simple aerial rigging jobs. In these days, when the heyday of aerial rigging is long gone, and everyone in the domestic field is—let's be honest—a bit short of work most of the time, domestic system installation is a valuable source of extra income. If you go about the job methodically, plan in advance exactly what you're going to do, and use good test equipment, each job can be trouble-free and profitable. And I know of no other aspect of our trade that leads so readily to recommendations and further work.

Fig. 6. Channel planning on Mr Clutter's system

⊗ indicates n±5 or n±9 clash

channel	status
21	⊗
22	Adjacent channel
23	Channel 4 Bilsdale
24	⊗ Adjacent channel
25	Adjacent channel
26	BBC-2 Bilsdale
27	Adjacent channel
28	⊗ Adjacent channel
29	ITV Bilsdale
30	Adjacent channel
31	⊗
32	⊗ Adjacent channel
33	BBC-1 Bilsdale
34	⊗ Adjacent channel
35	⊗
36	Adjacent channel

channel	status
37	VHS VCR
38	⊗ Adjacent channel
39	Adjacent channel
40	satellite
41	Adjacent channel/ Emley Moor (not carried)
42	⊗
43	Betamax VCR
44	Emley Moor (not carried)
45	⊗
46	⊗ Adjacent channel
47	ITV Emley Moor
48	Adjacent channel
49	⊗
50	
51	Emley Moor (not carried)
52	⊗

channel	status
53	
54	
55	
56	⊗
57	
58	
59	
60	
61	
62	
63	
64	
65	
66	
67	
68	