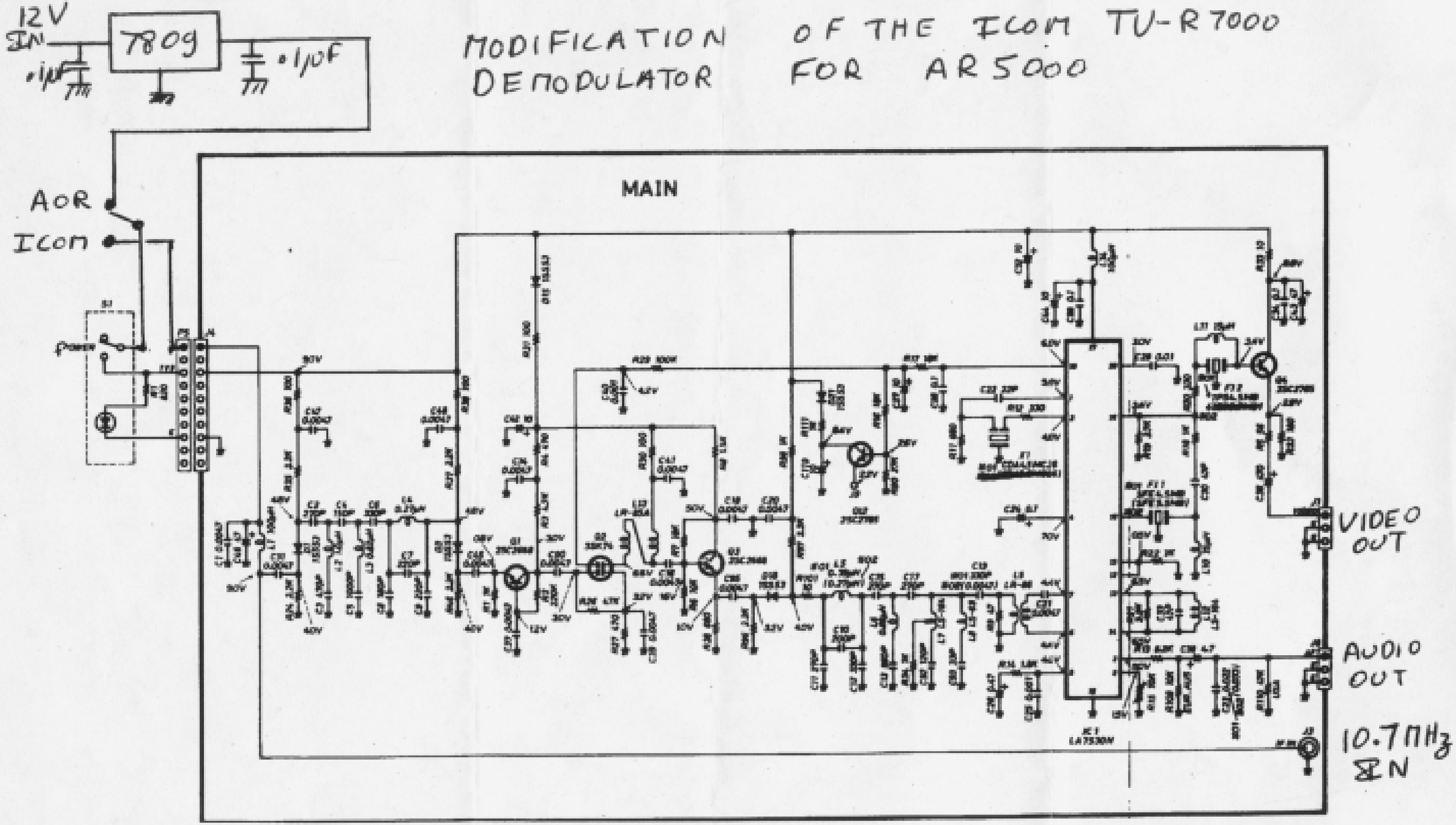
MODIFICATION OF THE ICOM TU-R7000 DEMODULATOR FOR AR5000



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Building a video converter

From Jason Reilly

This story begins six months ago when a work colleague asked me to help with a problem. Mobile phone coverage in his shopfront has suddenly gone from useable to useless, and my colleague offered the explanation of fitting security bars over the windows as a possible reason. I knew that this couldn't be the reason, and I was looking for other things to accuse. I noted that in his recent security upgrade, my work colleague had fitted a security camera. A *wireless* security camera. Ah ha! Problem found. This camera was transmitting a video carrier smack bang in the middle of the GSM mobile phone band. The offending device was duly removed and the 'problem' disappeared. I note that the latest version of these cameras transmit away from the GSM band, and so shouldn't cause this sort of problem.

Now, being a bit of an RF snoop, I just couldn't help but wonder if these wireless cameras could be received with the help of a scanning receiver. My own desktop scanner has a buffered 10.7 MHz IF output, which would be ideal for taking a modulated wideband video signal and feeding it to my humble television. While this is a good idea, not too many television receivers that I've seen will accept a 10.7 MHz input. What is needed is a device to convert the 10.7 MHz wideband IF output up to a standard TV RF channel. Thus begins my quest.

The internet is a wonderful source of information. I recall seeing on a web page a device that does exactly what I was looking for - upconverting 10.7 MHz to 70 MHz for a television or satellite receiver that has a 'looped through' 70 MHz IF. There was another circuit that I found that took the IF signal (up to 70 MHz) and directly converted it into a video signal, but this used an IC that is not available in Australia. Looking at several other ICs that are commonly used in VCRs to convert an IF signal to a baseband video signal, they are only designed for 'inverted' IF spectrums. I also recall that Icom produced a TV adaptor that worked on a similar idea for their IC-R 7000 and 7100 receivers. I ended up making my own upconverter, very similar to the one I originally found on the internet.

My aim was to have the IF output of the scanner upconverted to a TV channel, and to be simple and cheap to build. For less than $50 and half a day, I think that I have met my objectives.

The parts list:

1 x 78L05 voltage regulator	1 x small project or 'zippy' box
1 x 2uF tantalum capacitor	1 x DPDT, centre off switch
1 x 0.1 uF greencap	1 x BNC panel mount socket
1 x 8.2 pF disc ceramic	1 x 75 ohm panel mount TV socket
1 x 47 pF disc ceramic	short lengths of hookup wire
1 x 68 pF disc ceramic	short lengths of enamel coated copper wire or similar
1 x 100 pF disc ceramic	short lengths of shielded cable (audio cable is fine)
	veroboard 100mm x 100mm will be plenty

1 x 40 MHz universal output crystal oscillator module, Farnell part no 788-521
1 x 64 MHz universal output crystal oscillator module, Farnell part no 788-545
1 x SBL-1 double balanced diode mixer module, Stewart Electronics part no TC05

I began by taking the zippy box and measuring just how big a piece of veroboard I could fit inside, and cut the veroboard to the appropriate dimensions. The next stage was to place the items that form the voltage regulator onto the board. I left the 7805 regulator sitting proud of the board, so that the exposed leads would act as a heatsink - not that I'd be drawing anywhere near the full amount of current out of it, more for reliability reasons. Next comes the crystal oscillator. I mounted both the 64 and 40 MHz oscillators on board, and fed power to them through a centre off DPDT switch, with the centre pole connected to the output of the 5 V regulator. This selects which oscillator module receives power. The output of the oscillator modules are also switched using the other 'throw' of the DPDT switch. This is necessary to prevent any weird mixing products that may result from having the two outputs commoned together. The selected oscillator output is then fed through a simple low pass filter to reduce the harmonic content of the oscillator.

This filtered oscillator output is then applied to the 'local oscillator' input of the SBL-1 diode mixer. The 'RF in' port of this mixer is connected using shielded cable to a BNC panel mount connector. This is for connection to your receiver's 10.7 MHz IF output. The 'RF out' port of the diode mixer is then capacitively coupled to a TV type panel mount connector, which I mounted on the metal lid of the project box. The BNC connector for the IF input can be mounted on this, too, if you want, but I installed mine on the side.

I felt that the output to the TV didn't need a bandpass filter, but one could be installed if you find you have problems. My setup worked quite OK without it.

Power for the project can be derived from any DC source between 6 and 28 volts. I scrounged a second hand plug pack, which delivered 10 volts unloaded for $5. Current draw is only about 60 mA, so you could even use a 9 volt battery, but this wouldn't last too long.

How it works:

The voltage regulator is a fairly standard configuration, providing a nice, smooth 5 volts to operate the crystal oscillator modules. Depending on where the DPDT switch is set, a 40 or a 64 MHz crystal oscillator is powered with the 5 volts, and also switches the powered oscillator modules output to a simple low-pass filter that reduces the harmonic content of the generated signal, which is just as well, there are heaps of harmonics! The output from the filter produces about +5 dBm, which is just the right level to inject as a 'local oscillator' to the SBL-1 double balanced diode mixer.

The SBL-1 mixer takes the local oscillator signal and mixes this with your receiver's 10.7 MHz IF signal, to produce 50.7 and 29.3 MHz if the 40 MHz oscillator is selected, or 74.7 and 53.3 MHz if the 64 MHz oscillator is selected. Being a passive device, there is some conversion loss (about 6 dB) when using a diode mixer module like this, but given a good IF input level (my AR 5000 produces -30 dBm for a weak signal at the IF), the output is still quite sufficient to produce a good output, remembering that even -40 dBm is quite a strong signal in RF terms. Notice that for two of the mixed outputs, one being the difference of 64 MHz and 10.7 MHz and the other being the sum of 40 MHz and 10.7 MHz, the result is around 50 MHz - which happens to correspond to Australian TV Ch 0.

All we need to do now is to pass the output of the SBL-1 mixer through a capacitor to block any DC from the TV input, and feed the converted IF signal to a TV or VCR tuner set to Ch 0. The result: using your scanner, you can tune into, and watch TV signals.

Now, while that last statement might not sound spectacular, and you might find yourself saying "so what? I can already watch TV without all of this", consider that you can now snoop on TV signals transmitted by those wireless security cameras that I mentioned first up, or tune in to amateur TV transmissions on 70cm or 23 cm that use a standard PAL TV format. It also means that you can use your more elaborate scanner/receiver antenna setup to home in on weak signals, or on signals that may not correspond to our own Australian band plan. That is the reason for this project.

At this stage of the game, you might ask 'why the two crystal oscillators?'. Good question. When your scanner receives a signal, it is downconverted (or mixed, if you like) to produce a certain IF or intermediate frequency, generally in the vicinity of 10.7 MHz. If you could look at the signal at this point, you may find that the IF spectrum is inverted or not, that is, high frequencies are transposed to the lower end of the IF or not transposed at all. If the IF spectrum is inverted, this will place the sound carrier and colour subcarrier *below* the vision carrier, which is opposite to the norm. If we were to view an inverted spectrum after upconverting to TV Ch 0 with our project described here, the result is a black and white picture only with no sound. Hence the addition of a 64 MHz mixing signal to invert the inverted IF spectrum, which causes the output to not be inverted. I know that last sentence is somewhat difficult to grasp, but it works. Of course, if you know that your scanner or receiver's IF spectrum is not inverted, you can get by, using just the 40 MHz oscillator. However, some scanners, particularly the wide coverage models will change their IF spectrum from inverted to not inverted as you change frequency bands. This requires the ability to choose the mixing signal, so that you can invert or not invert the output signal as you desire.

When connecting the TV to the output of the converter, ensure that the 0.01 uF capacitor is in place to prevent any DC from the TV or VCR from upsetting the mixer. Standard TV coax will be fine to connect the converter output to the TV or VCR.

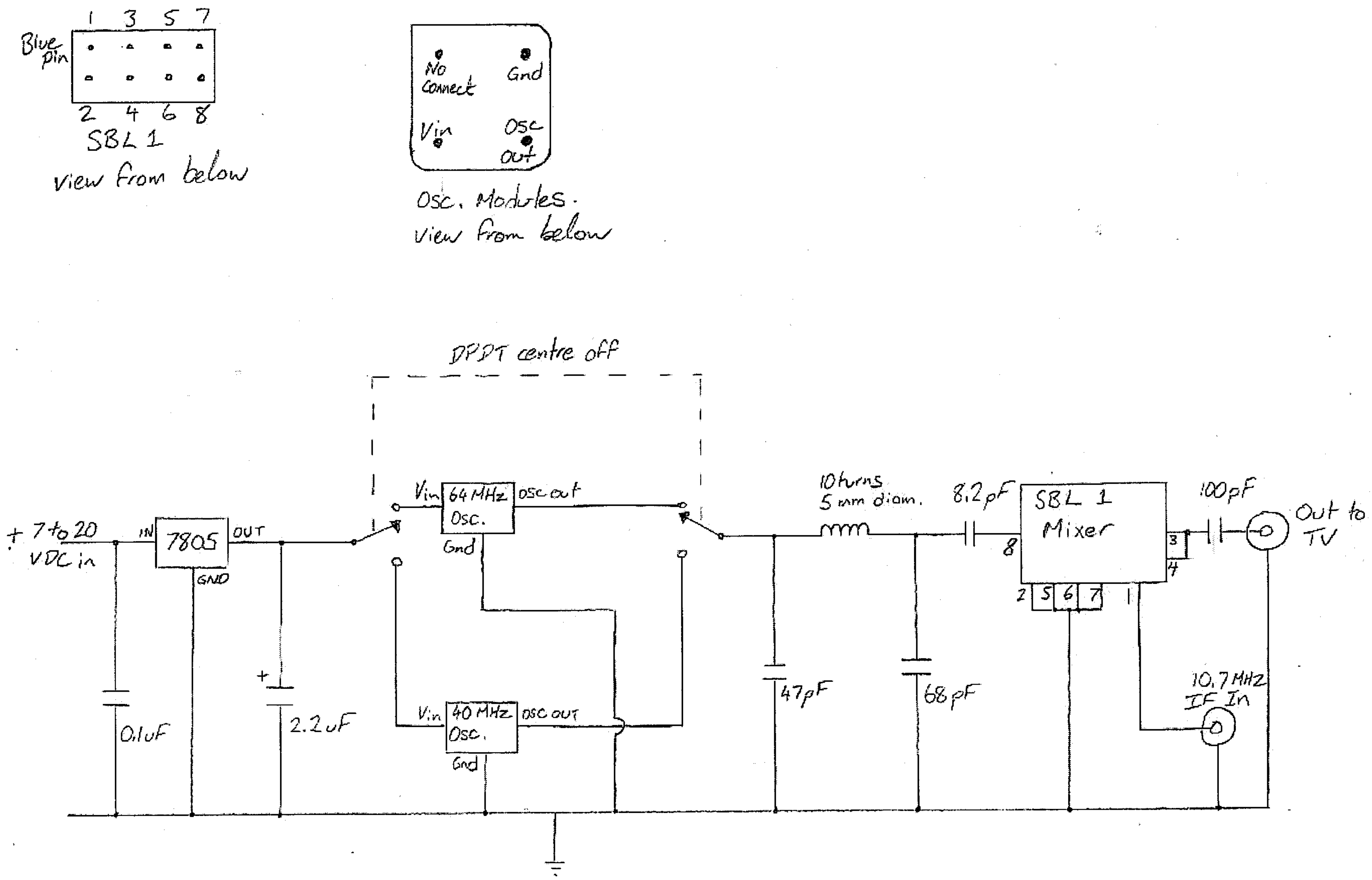
Using the converter

Testing the converter should be pretty easy. Find a strong TV signal that your receiver can tune. A TV broadcast is ideal, since it provides a nice strong and readily available test signal. Tune your receiver to about halfway between the vision carrier (will be heard as a buzzing noise, especially in the WFM mode) and the sound carrier. Next, set your converter to 64 MHz and then tune the TV in to see if it picks up the picture. As you tune the TV, you should see the picture appear, possibly in black and white only. You can confirm that this is the converted signal by switching the power off, and seeing the picture disappear. If the picture is in black and white only, try switching to the 40 MHz local oscillator, and retune the TV. Once you have a picture, you can experiment to get the best picture quality by re-tuning the scanner up and down a few megahertz, 50 KHz at a time and retuning the TV to suit. You will soon find the optimum combination. I find that the best setting is when the scanner is tuned right in the centre of the TV channel (ie for TV Ch 9, which extends from 195 to 202 MHz, tune to 198.5 MHz). An undesired mixing product, especially when using the 40 MHz oscillator, can occur with nearby FM broadcast stations mixing with the local oscillator, causing the vision and/or the audio to be disturbed. If you have this problem, which will manifest itself as 'waves' on the picture or the sound from the FM station wiping out the sound associated with the picture, you can try readjusting your scanner and TV tuning to minimise the effect, and installing the converter in a shielded aluminium project box. Remember that if you change bands, from say 430 MHz to 1290 MHz, you may have to change the oscillator frequency using the switch to keep the picture in colour and with sound, and this depends on your receiver. When using the TV or VCR to tune into the converted output, there are a few tricks to remember. If your TV or VCR is 'analog' tuned, you should have little trouble finding the output signal. The newer TVs and VCRs have the Australian TV channels pre-programmed into them, and only allows a small range of fine tuning. My VCR is a pretty new one, with the channel presets as described, however I found that it had enough 'fine tune' range to cope with the slightly off-centre output of the converter. Another trick to keep an eye out for is that some TVs and VCRs, again the newer variety, use Ch 0 programmed in as a preset to designate that preset as a 'pass' channel. In my case, I had to tune my VCR to Ch 20 into the channel preset. Apparently Ch 20 was TV RF Ch 0 in disguise. Yet another problem is that if the converted signal is distorted or inverted as discussed before, some TVs of VCRs may 'mute' the picture altogether.

Scanners that support IF outputs:
Not every scanner has a built-in buffered IF output connector on them. The AOR AR5000, Icom R7000, R7100 and R9000 have these outputs already wired, and the AOR AR3000 series can have this output installed fairly easily as a do-it-yourself modification. Other scanners could also feasibly be modified to have this output, but to describe how to do this for each and every scanner is way beyond the scope of this article. Stated simply, you need to have a high input impedance buffer amplifier, capable of low noise, wideband flat gain amplification of up to 100 MHz, tapping off some of the 10.7 MHz IF signal before it reaches any bandpass shaping filters or IF crystal or ceramic filters. A circuit diagram of your particular receiver would be essential to find this point. Scanners that have 10.7 MHz IF stages as either the 1st IF or 2nd IF are very common, however it would be best to apply this to a wide coverage scanner, since they would be able to tune into more of the frequencies that these 'hidden' video signals lurk on. Scanners that make use of a 21.4 MHz IF can also make limited use of a modified version of this circuit, since 40 MHz mixed with 21.4 MHz produces a sum of 61.4 MHz - which is part of TV Ch 1. This would only allow the viewing of a non-inverted IF spectrum, since the inverted selection of 64 MHz mixed with 21.4 gives 42.6 MHz, which is most likely too low for a TV to tune into.
Other possibilities exist with scanners that have a 45 MHz or even 600 MHz IF stage, taking an amplified, buffered sample of the IF and directly tuning it with your TV. However, this too looses the flexibility offered by being able to select and 'inverted' IF signal or not.

Where to find the parts:
Just about all the standard 'discrete' components can be found at your local electronics shop, be it Dick Smith, Tandy, Altronics etc etc. The crystal oscillator modules can be ordered from Farnell Electronics on 02 9645 8888 for around seven dollars each plus postage, and the SBL-1 diode mixer module can be ordered from Stewart Electronics at a cost of just under twenty dollars posted anywhere in Australia. They can be contacted on 03 9543 3733. Your local electronics supplier may be able to order these items for you.

For minimal outlay, you can use your receiver or scanner to tune into amateur TV or wireless security cameras, with excellent quality. You can even receive stereo on the 'normal' TV broadcasts, if your TV or VCR supports this. Look up your local amateur TV net, and see what interesting 'alternate' programming they offer to the standard broadcast TV programmes. Who knows? It may open the door for a whole new aspect of the hobby for you: ATV.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