10MHz Distribution Systems

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Increasingly we need a 10MHz reference source in our shacks – a very good OXCO, a GPS controlled source etc – which is used to lock up our transverter LO's, our test equipment (counters, signal generators and spectrum analysers etc), and in some cases the main transceiver. The single or dual outputs from the 10MHz source will not serve all of those, so the answer is a distribution amplifier (DA) to give a larger number of outputs. See refs [1, 2 and 3] for examples of DA's. Typically, these will give either 4 or 6 outputs from your source, so that should be the answer to everything?

Sometimes it is, and you're lucky. But there are factors which may cause you further work –e.g. the output spectrum of the OCXO, whether your DA is analogue or 'digital', and the 'sensitivity' of your 10MHz inputs. Dealing with each of those issues in turn:

> **OCXO Output Spectrum** –the OCXO can be considered as essentially a good quality, low noise crystal oscillator, so it ought to be giving a good sine wave output, with minimal harmonics? Well maybe, but often there is considerable harmonic content, especially odd. Typical levels can be -20dBc at the 3rd harmonic, decreasing with frequency. This may not be a problem, depending on what you are driving with it.
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> **Analogue and 'Digital' DA's** – Some designs of DA, including those based on video techniques are analogue, and effectively run in Class A – being therefore relatively power hungry, but reproducing at the output what is presented at the input – harmonics and all, if there is no filtering in the DA. The other class of DA's (mostly home constructed) are based around digital buffers, such as the 74HC04, which is why I have referred to them as 'digital'. They will effectively switch at the lowest input frequency (10MHz), and provide a 10MHz square wave on each output – which, as we know contains the higher order odd harmonics too. So even if your input from your OCXO is clean, a digital DA will have a harmonic rich output.
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> **10MHz inputs** – neither of the two previous situations necessarily represent problems by themselves. The problem is usually created in the equipment that is being driven, but action at the earlier stages is required to solve it. Some test equipment especially is designed to operate from a clean 10MHz reference, and does not like to see significant levels of harmonics present. Thus the output of a digital DA will always give it a problem, and the output of an analogue DA may if the input source is not clean.

Getting it sorted

Fortunately, the answer to all of these issues can be found cheaply – old PC network cards! Now that most motherboards have LAN capabilities built in, it's common to find boxes of old PC cards underneath the stands of some surplus traders – a few moment digging can provide a set of useful components for a very small outlay – 50p or £1 is often all that is being asked for the cards, and the traders will also often be prepared to take offers if you feel that is excessive!

So what can you find?

They may be 10MHz only, or 10/100MHz, and may have a BNC connector and RJ45 ethernet (10MHz cards) or RJ45 only (10/100 cards). They may also have either ISA or PCI connectors for the motherboard. But what the 10MHz cards all have in common is very good packaged isolation transformers and low pass filters optimised for 10MHz, and a packaged DC-DC converter. Some examples of 10MHz cards are shown in Fig 1, below. The 10/100MHz cards (RJ45 only, no BNC connector) have the filter only, so are less useful. Removal from the board requires a bit of care and effort, but it's worth it since the initial outlay is very small, and the quality of the parts is very good. You can also salvage the insulated BNC connector too!

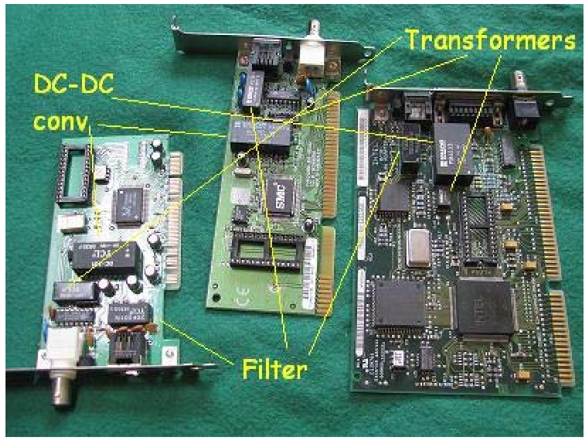

Fig 1 – Typical 10MHz Ethernet cards. At left is a PCI card, the other two are ISA connectors

Filters
The LPF packages contain two filters in a 16 pin DIP outline – one for Tx and one for Rx, associated with the RJ45 ethernet port. The Tx filter is a 7 pole device, and the Rx is 5 poles. Tx loss is approx 1.5dB, while Rx is about 1.3dB on the samples I measured. Attenuation on the odd harmonics is good, with 30MHz being around -30dBc, and increasing for higher orders. Filter sections can be cascaded for increased stop band attenuation, if you have sufficient signal available. The filters also include isolating transformers, with a specified 1500v breakdown. Each transformer is centre tapped on both primary and secondary for creating balanced paths if needed. Fig 2 shows a diagram of a typical filter package, with pin connections, taken from a datasheet, and Fig 3 shows the measured response of a transmit filter portion. See also [4]

Typically, the filter parts will most often have an F in the part number, some examples seen being 20F001N, 78Z1122B-15(this one breaks the 'F rule!), FBC16D001, FL1310, FC518LS, H16101DF – all identical in spec and pin-out.

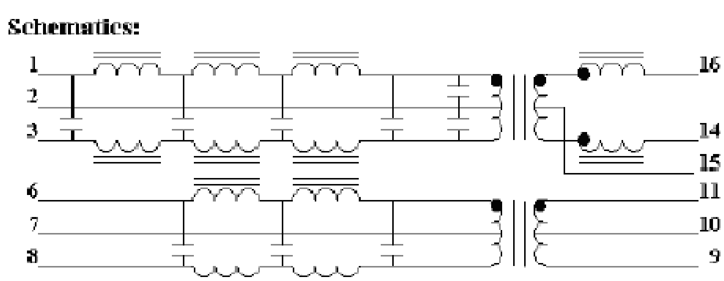

Fig 2 – 10MHz LPF Filter circuit (Tx top, Rx lower)

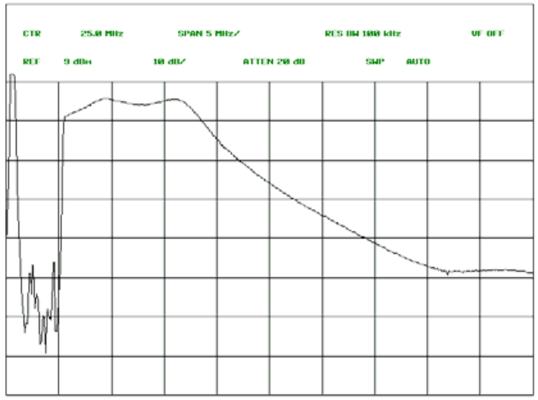

Fig 3 – Frequency response of the Tx filter over the range 5 to 50MHz

Removing the units from the card

Recovering parts in a usable state from commercially assembled PTH (plated through hole) boards is not easy. Of course we are most often concerned about repairing the board and wish to remove a faulty component – however, this time round it is the PCB which can be sacrificed. I find a vice and a hacksaw are the best weapons to start with – simply cut the PCB (unwanted components will yield easily to this combination) to release the component you want with a small piece of PCB attached.

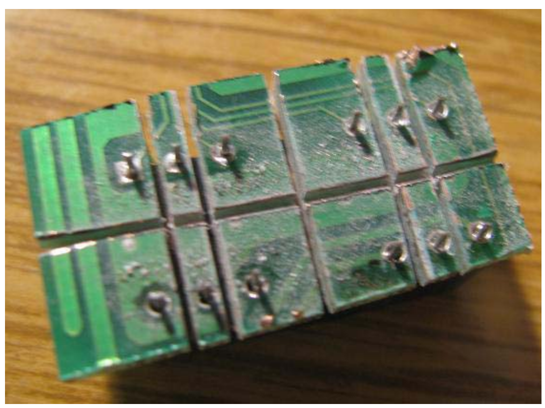

Fig 4 – Prepared PCB section, ready for filter removal

Next hold the component in the vice, PCB side up, and saw through the PCB between each set of adjacent pins, and one final cut along the centre of the module. Don't worry if you go slightly deeper, as the units are potted in epoxy. This should leave you with an independent land of PCB material attached to each pin, as shown in Fig 4, above, and you can remove these individually with a small bench vice, a hot iron and small pliers. The same approach can of course be used to recover any other through-hole mounted parts from commercial boards.

Using the filters and transformers

The recovered packages can be mounted on small pieces of board with short coax leads attached to connectors mounted on the screening box. If these are made up as individual units (a filter or a transformer) they can be used where needed in the system, with the other items in the package ignored (or left for later use in case of failures).

Fig 5 – A recovered filter assembled in a small tin-plate enclosure, with insulated output connector

Fig 5 shows a very simple implementation of an isolating filter, using the Tx portion of a package. The 55 x 20 x 20mm enclosure is one of O Schubert's range, and is available pre-punched for BNC connectors at each end – ideal for making up RF attenuators, filters and bias tees. The frequency response shown in Fig 3 is the measured response of this filter. The isolating BNC connector used is not one recovered from a card, since these will not fit into the small enclosure.

Ground Loops

An additional problem, not mentioned above, can be caused by ground loops. Using isolating transformers alone can solve this, although of course you must ensure that there is no other ground path that compromises the measures you are taking. Here the isolated BNC connector found on the old network card can be useful, since it can be mounted in a screened box without automatically grounding the output connection on one side – it remains fully floating.

Transformers

In the transformer package there are three 1:1 transformers, again in a 16 pin DIP outline. There are also some versions around which use a 16 pin small outline (SO) package, but pin detail is the same for both. Where just isolation is needed these are excellent – 2 packages will provide all the isolation needed for every output port of a 4 or 6 way distribution amplifier for your 10MHz station source. Typical loss through each transformer at 10MHz is around 0.1dB.

Typical part numbers seen are 16PT-005B, ST7033 (SO16), PLC-1000, PT4235 – pin-out connections for all types (DIP and SO) are shown in Fig 6, below.

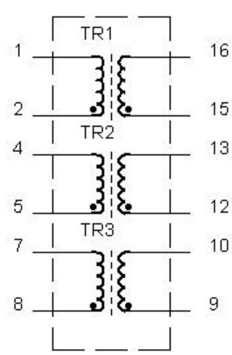

Fig 6 – Pin-out of the transformer package

DC-DC Converters

Although not of interest in the 10MHz application, small packaged DC-DC converters can be very useful for odd jobs around the work bench – and they're there for free if you've salvaged the other bits off the card! These are usually in a 24 pin 'wide' DIP package – ie 0.6" spacing between the rows of pins. They often only have a small number of pins installed, although I have seen the odd one which has most pins present – only 8 pins are actually used for connections. Most converters are 5V to 9V, with a 200mA capability on the output side, which is fully floating – so the output can be 'stacked' on the input, allowing around 14v to be generated. I have also seen some older converters that are 12v in and 9v out, which would allow up to approx 21v in stacked mode – this may be sufficient to operate some of the small 28v SMA relays that are around, directly off your 12v line. Handy when portable, or even for masthead mounted systems.

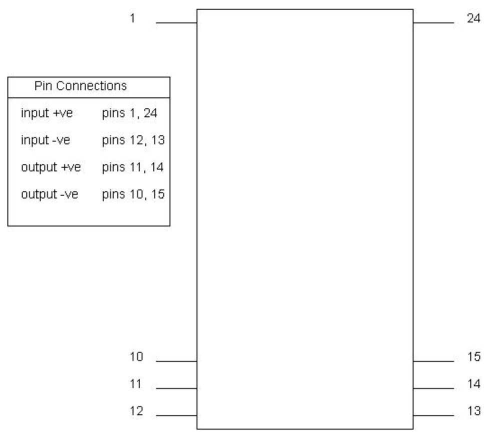

Fig 7 – DC-DC converter pin-outs

Typical part numbers are PM6133, DC-109 (both 12v to 9v), KUS-05090, PM6174 (both 5v to 9v) – connections are given in Fig 7, above.

Conclusions

If you're considering installing (or have already done so) a 10MHz reference source system in your shack, you can find useful parts that can be recovered from old PC network cards at very little cost. Once you begin to use a locked system you'll be surprised at the number of things you start to lock to it – that's when you get into the DA's, filters and isolators!

References

[1] http://g4hup.com/DA/DA1_4.htm

[2] http://www.tapr.org/kits_tadd-1.html

[3] http://www.thinksrs.com/products/FS710.htm

[4] http://www.uhf-satcom.com/misc/10MHz_dist/