



Control and monitoring of remotely mounted microwave systems

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Background

Increasingly, amateur microwave operators are moving over to remotely mounted microwave systems to take advantage of the lower feedline losses available when equipment is located close to the antenna feedpoint. This has become more practical with the relatively availability of solid state amplifiers with moderate output power and high gain, low noise preamplifiers. It is now possible to obtain 10 Watt output GaAs FET amplifier to cover 10368 to 10452MHz for under £400 and 10W output 5668 to 5760MHz amplifiers for under £150. There have also been a number of 50 Watt output 2320 to 2400MHz ex-PCS amplifiers available for less than £100.

Mounting these amplifiers at a remote antenna feedpoint is not without its problems, including power supply feedline voltage drop, cost and number of multi-strand cables, environmental housing and remote control and monitoring. This article proposes the adoption of an open standard for the remote control and monitoring of such equipment. Control and monitoring cables can be eliminated and the only cables required for each set of mast head equipment then becomes the connecting coaxial cable normally used for the intermediate frequency (IF) connection, perhaps together with a separate power supply cable. The idea may not be original, but the author knows of no other such current proposal. This is not a constructional project. I leave it to others to engineer a practical solution for the amateur microwave operator.

The proposal is based on the European Eutelsat open standard for switching satellite LNBS and more recently used to operate remote switches in Integrated Receiver Systems (IRS) for apartment and hotel blocks. The standard is known as DiSEqC™ and that stands for Digital Satellite Equipment Control. Although Eutelsat calls this an open standard, it is not known if they are amenable to amateurs using the standard in the proposed way. However, it is my understanding that this is just what an 'open' standard should allow!

Introduction

Early satellite TV systems used a simple Low Noise Block (LNB) with a single Dielectric Stabilised Oscillator (DRO) operating at 10GHz to mix the received satellite signals between 10.950 to 11.700GHz down to 950 to 1700MHz.

As satellite broadcasting has become more popular the satellite TV band has been expanded to cover from 10.7GHz to 12.75GHz. With a standard set top box it would



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therefore be necessary to tune the whole frequency range from 700 to 2750MHz if a single 10GHz DRO were still used in the LNB. This is a very large tuning range for a simple set top box receiver, but by allowing the set top box receiver to select either a 9.75 or 10.6GHz DRO local oscillator in the LNB, the satellite TV band can be tuned in two smaller bands each between 950 and 2050MHz. These so called universal LNBs use a 22kHz tone transmitted over the coaxial cable from the set top box to the LNB to select either of the two DROs. No tone selects the lower DRO frequency, whilst the presence of the tone selects the higher DRO. In this way no extra control wires are required between the set top box and the LNB other than the coaxial cable. Sky Digital set top boxes usually transmit the 22kHz tone continuously to select the higher satellite TV band used by the Astra satellites at 28.2 degrees east. Incidentally, polarisation is selected by the use of either +13 or +17 volts supply over the same cable. Truly, the coaxial cable is being used for many purposes.

What Eutelsat have done is to expand the use of the 22kHz tone to enable the set top box to control a much wider range of functions, such as the selection of an alternative LNB where the same dish and coaxial cable are used to receive a second satellite, or to command an actuator to move the dish to another selected spot in the sky. This is done by modulating the 22kHz tone by turning it on and off as a data carrier. The actual modulation is applied as pulse width keying of the 22kHz tone. The modulated tone is superimposed on the +13 or +17 volt LNB supply on the coaxial cable. This will be explained in more detail in the next section.

A further development of the DiSEqC™ protocol allows the set top box to interrogate the LNB or other head end device to ascertain its status e.g. the DRO frequency. This makes the protocol a very powerful two-way data link and a candidate for use in our amateur microwave (and VHF/UHF) satellite and terrestrial stations.

A full explanation of DiSEqC™ can be found on the Eutelsat web site at www.eutelsat.com

The DiSEqC™ protocol

A full description of DiSEqC™ can be found at the above web site. Here, I have attempted to give my own shortened explanation.

DiSEqC™ expands on the simple universal LNB switching systems that use a 22kHz tone to switch the LNB local oscillator between two frequencies. In the DiSEqC™ protocol the tone is pulse width modulated in such a way as to be able to transmit either a '1' or a '0' bit. This then forms the basis of a digital data system.

A digital '0' is transmitted as 1ms of 22kHz followed by 0.5ms of no tone. A '1' is transmitted as 0.5ms of 22kHz tone followed by 1ms of no tone. This is shown in figure 1 below. A '0' bit contains approximately 22 cycles of 22kHz, whilst the '1' bit



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contains approximately 11 cycles. The use of 1.5ms bit periods means the data rate is:

$$1000/1.5 = 666.667\text{bit/second}$$

This is fast enough for most data control and monitoring applications of this type. The end of the data message is signalled by at least 6ms of no tone.

A shorter data bit period would allow the data rate to be increased to, perhaps, 9.6kbit/s but the system would then become more critical due to the shorter period of time available to detect the presence or not of the 22kHz tone.

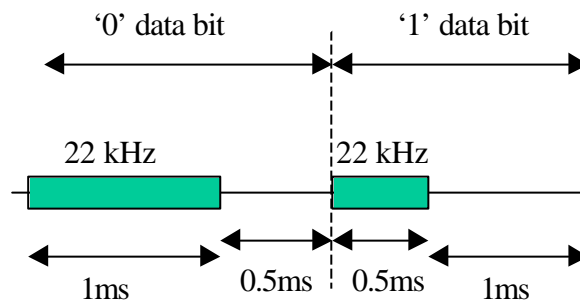


Fig 1 the DiSEqC™ modulation

DiSEqC™ messages are made up of one or more bytes of data formed from 8 bits as described above, with each byte followed by an odd parity bit. The most significant bit is always transmitted first. A basic control (command) message is made up of 3 (or more) bytes. The first is the framing byte, consisting of high level controls, a slave address byte and the command byte. Additional data can be carried in one or more subsequent data bytes.



Fig 2 the basic messages format consisting of 3 bytes plus an additional data byte with a single odd parity bit between each byte.

A simple system is made up of a control or command unit (usually the set top box in the original proposal) and one or more slaves (usually the LNB or switches).

In a simple system the command unit will send command messages as in figure 2 and not expect any return acknowledgement from the slave units. This is covered by the DiSEqC™ level 1 protocols. DiSEqC™ level 2 describes a more sophisticated version where the slave units can signal back to the command unit a range of information such as local oscillator frequency, actuator position or even analogue values such as signal strength.



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When a command unit wants to signal a control operation to a slave unit it will transmit a message as above. The framing byte consists of two nibbles of 4 bits each. The first is always HEX 'E' followed by HEX 0 to 7 depending on the function. Eight functions have so far been identified and published by Eutelsat. The first group of 4 is used with level 1 protocols only. The second group of four are the slave replies as specified in the level 2 protocol.

The address byte is divided into two nibbles of four bits to define a family and a sub-type. Although many of these have already been defined, a large block are reserved for OEM (Other Equipment Manufacturers) and it is possible the RSGB (or maybe Amsat?) could reserve one or more of these for future amateur radio use (well, it's a thought!).

The Command byte defines what the slaves should do. Many of the defined functions have no logical use in amateur radio, but a few do and these are ones of interest (together with some new ones I'm sure we could add). The 'set switch' positions selecting 'oscillator high' or 'low' and 'polarisation' seem to be the most useful of those defined. These would be used to select, for example, the position of a common 6 way relay as described in the section on practical uses.

In the level 2 protocol there are some useful bytes used to read analogue values back from actuators as well as polarisation skew. These could usefully be used to read temperature, supply voltage, relative output power or current drain in an amateur remote equipment system. It is also possible to write BCD strings to define frequencies in a synthesised local oscillator scheme. Although not a common requirement today, future microwave operators may regard this as quite useful.

This final section on DiSEqC™ describes the electrical interface conditions. Since it is a single wire bus it needs to be terminated at the 22kHz frequency. The recommendation is that the load capacitance is no more than 250nF, and preferably no more than 100nF. Where level 2 protocol is used the command unit should present a terminal source impedance of 15 Ohm to the cable (at 22kHz) for the return direction.

The amplitude of the DiSEqC™ signal should be 650mV +/-250mV riding on a nominal +12V supply. The supply voltage can be as high as +17V to allow for voltage switched polarisation in early universal LNBS. It is recommended that the 22kHz detector work down to 300mV +/-100mV.

Implementation of DiSEqC™

DiSEqC™ is a good deal more complicated than a simple multi-strand wire control cable and although it can be implemented using discrete logic blocks in CMOS or similar, a better way is to use a microcontroller. Not only can this be used as a state machine but, if it is dedicated to the purpose, it can also perform the tone generation, detection and decode, all in software. Recognising this, Eutelsat have arranged with Philips Semiconductors for a low cost mask programmed microcontroller to be made



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available. Controllers also appear to be available as part of larger satellite TV integrated circuits, where their function is combined with other essential decoding functions. The Mitel VP310 appears to be one such device. Other manufacturers such as the German company Hirschmann GmbH use an ASIC in their range of professional TV distribution equipment.

Whilst it may be possible to purchase the Philips microcontroller in low volumes for amateur use, a better route may be for some enterprising amateur to develop a new microcontroller and PCB for use by amateur radio operators.

It is envisaged that surplus controllers, switches, LNBS etc., using DiSEqC™, will gradually become available in the next year or two, and because Eutelsat carefully control the open standard (sic), a large number of options will then be open to us to use in our stations.

Applications

Satellites like P3D will have increasing amounts of microwave band equipment on board. This means more amateur microwave ground stations. To minimise cable losses and achieve acceptable performance amateur satellite ground stations will tend to use transverters connected to indoor (shack) transceivers using coaxial cable that only has to carry relatively low frequency IF signals. However, if you have several bands remotely mounted, then the number of coaxial cables required, together with the number of control cables can be rather daunting, not to mention heavy and expensive. Using DiSEqC™ and a multi-pole relay much of this copper can be eliminated. Figure 3 shows how this could be implemented as a means of reducing the number of receive feeders required, together with control cables.

The use of the level 2 protocol would enable full monitoring of the conditions at the masthead equipment, such as relative power output, relay switching state confirmed etc.

One thing I have not mentioned is transmit / receive switching. I don't believe this should be implemented using DiSEqC™ as it might prove too slow when other functions also have to be signalled. I would prefer to use DC switching over the transmit feeder, such as would be available from a transceiver such as the FT290 or IC202, or from a modified transceiver of the TS711/IC275/FT847/FT736 variety. NOT RF switching! An adaptor, that would increase the usual +13V supply, used on receive to +17V on transmit is quite straightforward and could easily become the accepted TX/RX switching standard for amateur radio poletop systems, whilst also having the advantage of increased transmitter voltage at masthead to overcome increased volts drop to the current thirsty solid state amplifiers now appearing., e.g. Mikom at 10GHz.



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Conclusion

It cannot be stressed enough, the success of DiSEqC™ in the amateur market will require that simple, low cost, kits or ready built equipment must be available, that can be successfully used in place of that multi-strand cable. I can't pretend that, given the choice, most amateurs will not opt to use the simpler multi-strand cable approach. However, the growing complexity of our stations, the move to mounting equipment nearer to the antenna, and the need to have more information about how that equipment is performing, will gradually force us to look at techniques like DiSEqC™.

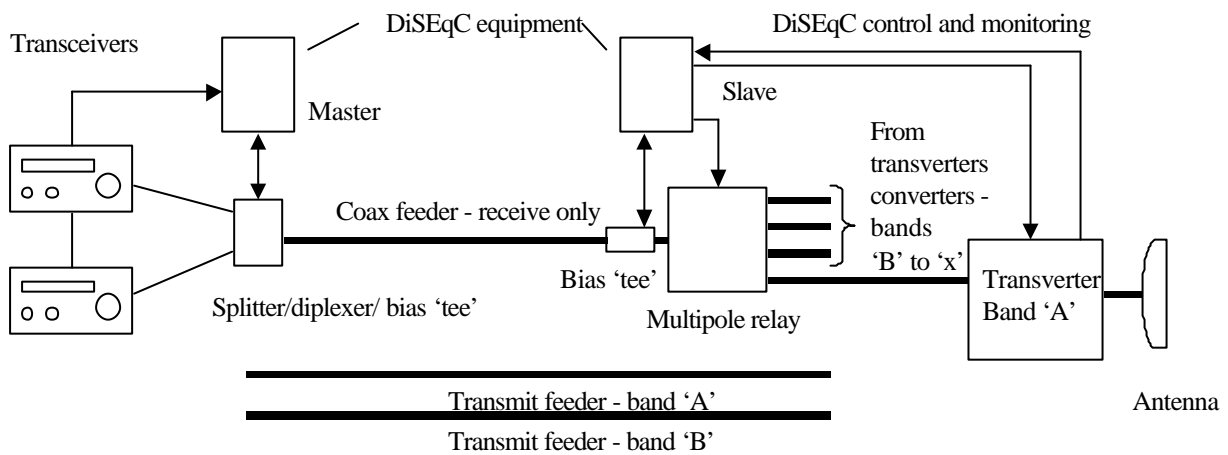


Fig 3 The use of DiSEqC™ to control a multi-pole relay that eliminates the use of separate receive feeders from the remote transverters. Separate transmit feeders are shown, but could also be eliminated in a similar way. It would be desirable to use separate power supply cables if high power amplifiers are to be mounted at masthead, to ease problems of power supply switching and incompatible supply voltage requirements.