2m preamps under scrutiny

Putting in a preamp, though, always degrades the RF intermodulation performance, and so the design of the preamplifier has to be a compromise between an improved overall noise figure and an amount of gain which is not so high as to cause bad RFIM problems. This compromise between preamp noise figure and gain is quite difficult to make, and in any particular installation the first rule to observe when adding a preamp is to use the minimum amount of gain required for the preamp just to overcome the input noise of the main receiver.

There are, unfortunately, many rather deaf rigs around. These can usually be improved greatly as far as input sensitivity is concerned, by the addition of an RF preamplifier, either in the rig of external to it.

Intermodulation

Before looking more closely at the seven preamps reviewed in this article, let's have a look at all these compromises in great detail, and the different ways in which a preamp can be used. If you put the preamp inside the rig between the aerial changeover relay and the first RF stage, you will probably see a moderate improvement, but there are two snags to this. You will probably have a permanent grossly excessive gain and, therefore, strong signals on the band will start spreading more, and ruin your reception of weak signals. Remember that for every dB of additional gain before the front end, the intermod. product ratios will be degraded by at least 2dB. In some cases, if the RFIM performance of the receiver is poor because there are contributions from both the mixer and other stages you will find that above a certain quite moderate level, intermod. products may actually go up by 3 or more dB for every dB increase in the input RF level of the strong station.

Let's have an example of this by considering a rig that has two strong signals, each of 300μV. Let's say that the 3rd order product would be equivalent to a 0.1μV RF input level. If the disturbing signals were both raised by just over 10dB to 1mV, then the equivalent RF input level of the same IM product would be increased to at least 1.1μV (ie. +21dB), and perhaps to as high as 4μV (ie. +32dB). An RFIM product at 0.1μV is not too disturbing, although it might be a slight nuisance if you are trying to receive a very weak station, but a 4μV product is going to be near the S9 level which, frankly, will be extremely annoying, and yet the disturbing signals have only gone up by just over 10dB. Supposing you just have one SSB signal at 15kHz off channel which is developing slight spreading. The chap then throws in his linear, and the signal goes up by 10dB. His transmitted IM products shoot up if he is using a nasty linear, but whether his linear is good or bad, your receiver will be generating at least a 20dB inferior IM ratio. If you have a rig such as an *IC251E*, or *FT221*, and you have fitted a Mutek board in it, then your front end will be almost bomb proof, since the IM products even at highish levels are very low. But supposing your rig has a bad RFIM performance? When the other station puts in his clean linear and goes up 10dB, you'll go bananas, as you won't be able to hear that elusive HB9 any more! If you have provided the facility for bypassing your internal added preamp, you might be able to suffer the situation, for the intermod. products will drop by at least 20dB when you take out the preamp, whereas you might only lose 3dB, or so, of input sensitivity. There is another snag, though, in putting the preamp inside the rig. You are not overcoming the loss of the input SO239 socket, the input circuitry to the relay which may include lossy filters, the loss of the relay itself, followed by more loss in the circuit to the internal preamp. On a very good rig, such as one with a Mutek front end, the input

A pride of preamplifiers!

loss may be as low as 0.3dB or so, but I have measured some well known Japanese black boxes with over 4dB loss in the same route, which explains why the average noise figure of these black boxes is as bad as 7dB or so. So it is much better to put the preamp outside the rig, but this may involve marked losses in the two relays required to bypass the preamp on transmit, unless you use good quality ones. The main loss, of course, will be the relay on the aerial side of the preamp, so use the best one you can afford in this position. A good relay will only lose perhaps 0.05dB on 2m. If your rig has a large loss on the input circuit, and has the legendary 7dB noise figure, and the preamp/relay combination has a 1.2dB noise figure, then you will need around 16dB gain if you want to see almost all of the noise figure improvement given by the preamp. This will degrade your RFIM performance by a colossal 35dB or so on the average rig, which is dreadful. It is vital, therefore, to be able to switch your preamp in and out so that you can choose which is best in any circumstance. You may, of course, buy a preamp which has automatic RF sensing, in which case you will not need to incorporate wiring to the rig which changes the relays over, etc. But you may have a very long and lossy lead to your aerial. It is not unusual to have a loss of 3dB or so, in the coax lead, especially if you have rummaged around your junk boxes for various bits of coax, and have connected them up with umpteen SO239/PL259 back-to-backs to make the lead long enough. (I assisted one young amateur only last week who had done just this, and what was even worse, used plugs designed for CB use, which were very lossy on 145MHz!) The answer to this problem on receive is to put the preamp at the masthead. Now you've got an overall cable and receiver input loss of 10dB, ie. the cable loss plus the input noise figure. You'll need at least 18dB to overcome these losses almost completely.

Noisy neighbours

Fortunately, or unfortunately, whichever way you look at it, the actual band noise on 2m is equivalent to a noise figure of at least 3dB, and sometimes a lot higher, particularly if you've got 10 neighbours, who all have thermostats on the go which are out of sync with one another. I reckon

Wood and Douglas PA4

that you won't gain much by improving your overall system noise figure to better than 2.5dB or so, unless you really are working in the middle of the night, and trying to receive a very weak station, with no other amateurs close to your frequency, with no local interference, and you are not pointing at the Crab nebula! Joking apart, you'll only need a significantly better noise figure for meteor scatter, moonbounce or satellite reception. I have a 1dB noise figure early SSB Products preamp at my masthead, and 1dB cable loss into a Microwave Modules 2m transverter which has a measured noise figure of 2.1dB, and I can notice only the minutest difference to the readability of the weakest signals when I switch on my masthead preamp. For this reason you will probably only need (in the example mentioned) 15dB gain. If your black box is a little better, and you are using UR67, or even better, H100 cable, then a 12sB gain might be sufficient, and even 10dB gain will give you a marked improvement. Don't forget that the lower the gain, the less will be the deterioration in overall RFIM performance.

Unfortunately, we've not yet finished with the discussion of problems encountered when adding preamps. Its bandwidth can be very important indeed in some locations, and out-of-band signals may be a dreadful nuisance if they are strong, since they may generate IM products within the 2m band. This is highly dependent on the performance of the main rig. If you live out in the country, and you do not have any police transmitters lurking around in the band 146MHz to 150MHz, nor any strong signals below 144MHz, then you won't have to worry. Living in Finchley, I am surrounded by police FM transmitters just above 2m, and a bad rig is soon shown up by intermod. products appearing on various FM channels. This can be most annoying, some rigs being virtually perfect, whilst others are diabolical. If the preamp has an overall flat bandwidth of tens of MHz around 2m, then you may be in a lot of trouble. One that starts falling in gain at the band edges fairly rapidly, but also preserves its noise figure reasonably across the 2m band is going to be a lot better. You will need to weigh up, therefore, the bandwidth, gain and noise figure, as well as the preamp's own IM performance, before you make your final choice. Most preamps are much better than the rigs which they feed, so the preamp RFIM performance is only going to be a fairly important factor if the main rig is bomb proof.

Transmitter power

Another important consideration is the relationship between overall receive performance, and the power used on transmit taken at masthead. Most stations run at least 10W PEP output, which will be, say, 5 to 8W at the aerial. If you are running a barefoot low power rig which is providing only a watt or two at the masthead, then you will not need a masthead preamp, unless you want to work other low power stations, or your rig is in desperate need of a deaf aid (you'd be surprised just how many rigs need this). If you are running anywhere from 50W to 400W at the masthead, then the likelihood is that you will be running more power than many other people, so you will need a good sensitive receiving system to pick them up if they are weak. Perhaps the chap the other end has a very deaf receiver, and if so, then you'll probably be all right! Sometimes a very good system sensitivity can be a boon, even if you have low power. Suppose you are beaming in West, and a juicy DX station is off the side of your beam, and is just audible within your preamp in, but not audible with it out. You can turn your beam onto him, and up he comes. When you have nailed him you will probably be able to take the preamp out. This facility can be very important in contest operating. If you are running 400W at the masthead, it becomes vital to use the best coax you can afford, not just to reduce the required output power of the linear, and thus reduce its intermod., but to decrease the loss between a masthead preamp and the receiver. This allows you to use a lower gain preamp. However, the loss of the coax will, of course, be cutting down the output level of a preamp, and thus reduce the system RFIM. There is just one final point which is worthwhile mentioning, this being the hold-on time of an RF sensed preamp, whether it is built into a linear, or on its own. You will go mad on SSB if it is clanking on and off between every word, and you will also be introducing annoying interruptions on transmit, with the beginnings of some words disappearing into thin air! On FM, though, a rapid return to receive is important, if you get just a very short, snappy comment from the other end. It is ideal, therefore, to have a system which is switchable between an almost instantaneous return for FM, and a hold-time of at least 1 second, and perhaps 2 seconds, for SSB. I do not know of any RF sensed pre-amp which has a remotely controllable sensing time, but there are linear amp/preamp combinations which can be switched to FM or SSB sensing, which is most useful.

Preamp tuning

Most of the preamps were at least quite well aligned. The SEM *Sentinel,* however, was so badly aligned as to be almost ridiculous, and the Moulding was peaked above 146MHz. A few words about alignment might be useful here, since many users do tend to have a twiddle now and then. My first advice to you is never to attempt any alignment unless you have a very good reason to believe that the manufacturer has got it wrong, or that the shop who sold it to you, or the person you bought it from secondhand has 'been at it'. Alignment is, in fact, quite difficult, and is often wrong unless it is done with appropriate test equipment. To

SEM Sentinel Auto

do it in just a minute or two after the box has been opened is almost impossible, unless you have an immaculate noise source which chops on and off at least a few times every second. If you don't have such test equipment, and if you really must make adjustments, here are one or two suggestions. The ear is much more sensitive to minute changes in noise figure on FM than on CW or SSB. Furthermore, it is much easier to adjust the input circuits on an extremely weak signal. Since band noise is quite high, you should first put a high quality 20dB aerial attenuator in line as close to the preamp as possible. It is absolutely vital that this attenuator should be of the same rated impedance as that of your coax and aerial. This will reduce the band noise to well below any audibility, and also allow you to receive stations that are suitably weak. The reason why FM is to be preferred, is that on a very weak signal the rate of change of noise figure is perhaps 1/3 to 1/2 that of the apparent signal-to-noise ratio change. At around the 10dB SINAD ratio point you will get at least a 1dB improvement in ratio for every ½dB of noise figure improvement, provided you have effectively removed band noise. On the other hand, overall gain is better adjusted by using the 'S' meter on your rig when you have tuned to a signal which is about half scale. Many rigs have 'S' meters which vary rapidly in level with only small RF level changes on FM. If you look at the preamp circuit you will usually see trimmers on the input and output circuits. The output trimmer should normally be adjusted for maximum gain in the centre of the band, as a kick off. The input trimmer, however, will normally adjust for minimum noise figure at a position well away from the maximum gain point, and this is what is meant by 'noise matching' rather than 'gain optimising' an input. You may have to go backwards and forwards between input and output trimming, adjusting input for best signal-to-noise ratio, and output for best gain. Using this method, you should be able to get within half a dB or so of optimum performance, unless you have cloth ears! This method will only work properly, though, with the attenuator in the input circuit, for without it you will probably end up by adjusting for maximum gain, and you would also find the input trimmer to be much flatter in adjustment, as the null would be incredibly difficult to hear with all the band noise present. Matching the input for optimum gain normally results in the input impedance being lowered, and when this is near 50 ohms you should have the best power match. Best noise figure though, and thus best noise match, occurs when the input has a somewhat higher impedance, and at this point the internal noise has dropped more than the signal level has. The signal level has dropped at this point because of negative feedback which exists within any transistor. Neutralisation, incidentally, when added in a circuit, can bring optimum gain and noise match positions rather closer together, but correct neutralisation in a preamp is very difficult to achieve without appropriate test equipment. While writing this article, Myles Capstick, G4RCE, tried adjusting one or two of my preamps by ear, and then checked them on a Hewlett Packard noise figure and gain measurement system.

He almost always got to within 0.5dB, but we always managed to make a slight improvement with the HP system. Don't forget that you might not need all the gain that you can get, so you might make a useful improvement, if you can spare some gain, by loosening the output tuned circuit coupling, this also usefully increasing the Q of the output, which helps to keep out signals outside the band.

Noise figure and gain

We measured most of the preamps initially with a manual analogue system, including a Rohde and Schwarz *SKTU* noise figure source/meter, Andrew's *FSJ4* connecting cable, a 3dB pad, a very accurate 50 ohm screened input termination, with a Microwave Modules transverter down to an Icom *IC740* HF rig with the audio feeding a Bruel and Kjaer true RMS audio volt meter. The precise attenuation of the input lead, 3dB pad and adaptors was measured using a Marconi *2019* signal generator and a Racal RF power meter. We found that we got more accurate results by setting the noise-off level using the 50 ohm input termination, rather than turning the 'off' switch on the noise source, although there was only a minute difference. We increased the level of noise until the audio output noise power increased by 3dB within the pass band 300Hz to 3kHz. We restricted the pass band to avoid any possibility of interference being created from noise, etc., coming from the *IC740* outside this passband from circuits after the SSB filter.

Hewlett Packard very kindly loaned me, for a short period, their complete new noise figure measurement system, worth around £8,000! We found to our great pleasure that preamps measured on both the R and S and HP systems gave readings within 0.1dB of each other which surprised me considerably, although we did not attempt to measure the very best preamps with the R and S system. The HP system employs a noise source which includes a noise diode and source impedance extremely accurately matched to 50 ohms from quite low frequencies up to many GHz. The noise head is designed to give out a level of 15.2dB excess noise over that which would be generated from a resistive source of 50 ohms, taking into account the temperature, etc. Noise is generated immediately upon a 28V DC source being switched through to the noise head. The measurement system switches this 28V on and off many times a second. The meter looks at the on and off noise values of the head when it is directly connected to the measurement system's input socket, which again is very carefully controlled at 50 ohms. The internal microprocessors were previously calibrated to expect a certain value of on to off noise, the calibration procedure being simple for the operator, but extremely complex for the microprocessor! Not only is the input noise figure of the measurement system calculated on calibration, but the frequency band over which the measurement is to be made can be pre-set on the instrument, together with the lower and upper limits of frequency at which measurements are to be taken. When you are calibrating, you must include all the adaptors, or those with equivalent loss, that you are going to use in the measurement loop, so that you are measuring only the device under test, and not the additional attenuation of a heap of adaptors! On placing the device in the loop, you can then get an immediate readout of noise figure and gain around the frequency of measurement. There are three very serious snags, though, with using the HP gear, which absolutely must be taken into account: since the machine without ancillary mixers, etc. measures from 10-1,500MHz and with a bandwidth of around 4MHz, the internal local oscillator must be capable of avoiding image problems, and so the IF within the instrument is way above 1500MHz, and the yig oscillator is above this. These microwave oscillators are notoriously wibbly-wobbly, and the Hewlett Packard spec is fairly wide on the tuned-in input frequency, therefore. This in effect means that you must not accept the indicated tuned frequency as precise, especially at UHF, let alone microwave, unless you are measuring a wide bandwidth preamplifier. To get over this problem, you have to ascertain, by experimental means, the centre of the input passband of the measurement equipment. In fact, we never found the HP to be significantly out on VHF, although by 1296MHz it was quite a long way out. A more serious problem is that of the measurement bandwidth, for it measures the average noise fiture over a 4MHz bandwidth, as well as the total power gain over the same bandwidth. The only way of getting around this problem is to recalibrate with a much narrower filter immediately before the HP. For this, we used in many of our experiments, our Boonton tuneable preamplifier type *230A,* which has a 700kHz equivalent noise power bandwidth. I also had to use a 20dB attenuator immediately after it to get rid of some gain! By calibrating with

Wood and Douglas 144PA3 Miniature preamplier

this in circuit, the equipment completely excludes the contribution of noise from the Boonton, the attenuator, and the input stage of the HP. Only on one amplifier did it make a significant difference, one of my own having a very narrow bandwidth.

I measured around 30 pieces of equipment, and only on 3 or 4 did I notice a significant change in noise figure, the improvement being between 0.2 and 0.4dB. Gain, however, quite frequently showed up as being significantly lower than expected, and so I could not trust the measurement on equipment having 3dB points tighter than around 5MHz or so, and so we decided to make all gain measurements with another set-up. Although the HP accuracy is quoted by them as being within 0.1dB, with all other things right, I must emphasise most strongly that the HP figures should be regarded as having an accuracy of + or – at least 0.2dB, despite the fact that my colleagues and I were extremely careful. I must here acknowledge the help of Hewlett Packard, and many other friends professionally involved in noise figure measurement.

Gain

After many discussions with colleagues, we felt the best way to measure gain was to use a Marconi *2019* generator as a source, connected via screened attenuators and Andrew's coax to the input of the preamp, with an attenuator right at the preamp as well, followed by the output feeding through a Marconi UHF attenuator, feeding through an attenuator again into an HP *8558B* spectrum analyser. All these attenuators were used to preserve an accurate 50 ohms throughout the measurement system, and to reduce any mismatching resulting from transformer action of lengths of 50 ohm coax with preamp input and output impedances. The attenuator before the analyser is used to load the line more accurately, thus allowing the Marconi variable attenuator to be accurate. We measured gain at a reasonable level of just over 100μV into the preamplifier, having set the analyser on the 1dB per vertical division position. The through loss was measured by observing the level on the analyser, whereas gain was measured at various frequencies by inserting attenuation on the attenuator, to bring the level to the same point on the screen as it had been on calibration. We measured the frequencies at which gain dropped by 3, 10 and 20dB, and the gain at 144, 145 and 146MHz.

Two-tone IM tests

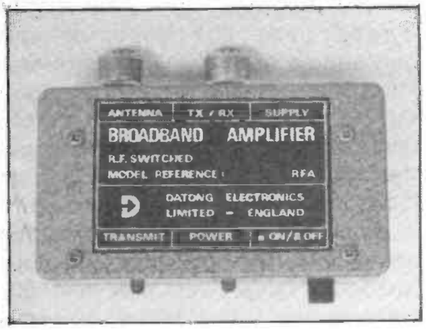
We used two Marconi *2019* signal generators with frequencies 200kHz apart in the middle of the band for this test, with both generators operating at the same output level feeding a high quality hybrid transformer. The output port of this was connected to the input of each preamplifier. The output fed straight into the HP spectrum analyser, allowing us to read off the IM products from the screen. We determined the input level of the tones required to give both 60dB and 30dB 3rd order products, the ratio being the IM product level to the level of either of the two tones. An intercept point was derived from these two measurements. Sometimes the ratios were not quite linear and this is due to either distortion being slightly too high at lower levels, or IM increasing very rapidly as a clipping point was reached. We show in the charts both input and output approximate intercept points, bearing in mind the measured gain.

Laboratory test results

I thought it would be helpful to discuss how each product fared, one parameter at a time, and then in the conclusions section make some recommendations for various situations. I must admit that having done all these tests I feel that I have learned quite a lot about preamps!

Let's have a look first at noise figure, perhaps the parameter which will be of most interest, although oddly enough, one of the least important, within reason, if you have the preamp at the masthead. By far the worst in the survey, and the worst that I have ever measured on 2m, even including the once ubiquitous 6CW4 Nuvistor of about 20 years vintage, was the SEM *Sentinel.* A 5dB noise figure, with such a low gain is, frankly, a fat lot of use. We decided to attempt to improve the alignment, and noted a ferrite cored inductance, which when tweaked greatly affected gain. We tried removing it completely, and in passing, for a few seconds, noted a moderately respectable noise figure before the contraption went into oscillation. After this attempt at alignment, we put it back again, and after much tweaking improved the noise figure to 2.1dB, and the gain shot up to around 19dB. However, in this condition the preamp tended to be unstable if we even looked at it, let alone change the input load slightly. It was virtually impossible to achieve a stable, respectable performance

Dressler VV200 GaAs



Datong RFA

across the entire band. Please note that the specification, as published in current advertisements, has been a claim of 1dB noise figure and 20dB gain. We are surprised that SEM claim such a gain from a BF981, let alone a noise figure of 1dB from their circuit.

The Chris Moulding preamp gave a useful noise figure, but was so asymmetrical in gain performance that I must infer that it had been poorly aligned.

The Datong *RFA* is an absolutely fascinating product, as it employs the proved negative feedback technique also used by Packer Communications and Mutek. The original principle was written up in VHF Communications. Packer, I believe, was the first to make available a commercial product. In this design the output is, in fact, placed in series effectively with the input source, by using a minute transformer with several windings on it. Datong uses a single transistor, and with 50 ohm output loading achieves a useful noise figure over an extremely broad range of frequencies. The review sample was RF sensed with a small bypass relay, which switched over with an input from a transceiver of only 15mW, but the hold-on time was too short. The two Wood and Douglas preamps were better for noise figure, and the Microwave Modules better still. This preamp was also RF sensed, but most surprisingly required 2.5W to pull it to the straight-through mode. In my opinion, therefore, it is only suitable for FM installations with a minimum power of 3W or so reaching it, or in SSB installations where at least 25W peaks pass through. The hold-time from transmit is very short, which would be annoying. By far the best noise figure was measured on the Dressler VV200 GaAs, at 1dB. This preamp is certainly excellent for almost all applications, as far as the noise figure is concerned, but see comments later on RFIM. We have, incidentally, recently measured an SSB Products model (GaAsFET) at an amazing 0.5dB!

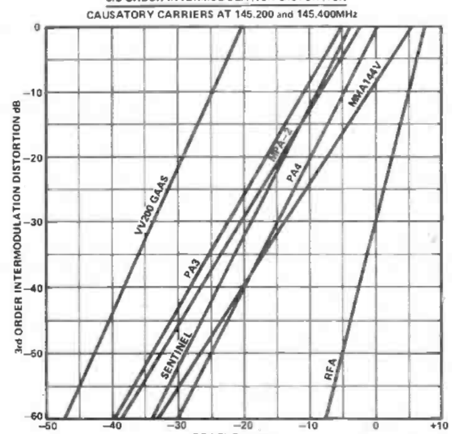
The Wood and Douglas *PA3* had the highest gain, which, however, I feel is excessive, unless you have an incredibly long, lossy aerial cable. The Wood and Douglas *PA4* also had a very high gain, but an internal attenuator of three resistors is provided for in the circuit, and you can change the values to fit your requirement. The Dressler had around 18dB gain and considering it is designed to go at masthead on an installation that would probably be a fairly good one, I feel the gain to be rather excessive. The Microwave Modules *MMA144V* had just about the right sort of gain for a medium quality system, having a few dB cable loss interconnected with an average noisy black box, taking everything into consideration. The Chris Moulding's gain was incredibly assymmetric across the band, having an extremely low gain at the bottom end, and nearly 2½ times the gain at the top end. The Datong, on 2m, had a very low gain of 9dB, but this is very useful, as any more gain would cause problems to broadband receivers, for which it was particularly designed. It will almost certainly hot up a *Bearcat,* without excessively degrading the already poor RFIM. This little unit is so adaptable, and I prefer to regard its RF sensing as a protection device in case you inadvertantly stuff RF through it! The SEM *Sentinel* gain was originally just under 4dB more than its noise figure, when measured at band centre. I suppose it could make a marginal improvement to some deaf black boxes, especially the *Liner 2.*

Bandwidth

The narrowest bandwidth of any of the preamps was in the Dressler. Note the response shown in the table. It will reduce, but by no means eliminate, interference from police transmitters HF of the band, and it could significantly improve the rejection of some annoying strong interference from various strange transmissions below 142MHz. The bandwidth of the Moulding preamp is very sharp indeed, peak gain on the review sample being set at just over 146MHz. If the equipment were properly aligned it would obviously have a very sharp bandwidth indeed which could actually be useful. We did not attempt re-alignment, since the box was sealed. The manufacturer will obviously have to take more care in alignment, for the review sample had a response which was ridiculous. The Wood and Douglas preamps had a reasonably controlled bandwidth of around 6MHz for 3dB points, the response falling reasonably outside this. The Microwave Modules is much wider than I like to see, the 3dB bandwidth covering 25MHz. The 20dB bandwidth is very wide indeed at 83MHz, although the PMR band around 165MHz is quite usefully attenuated. The SEM *Sentinel* had a 3dB bandwidth of 43MHz which is absurdly wide in the context of being claimed as a 2m band preamplifier. The Datong is a very special case, as it is marketed as a very broadband amplifier, having useful gain down to 1MHz. Depending on how you look at this, the LF response is either grossly too extended, or useful. My opinion is that a very steep cut should be built in below 20MHz or so, allowing it to be used for frequencies above this, but keeping out all the very strong lower frequency shortwave signals, and more importantly, medium wave. If you are using an ATU, then this will help a lot, but be careful about attempting to hot up a cheap receiver over most of its coverage, for you may have trouble. You will probably be all right using it on most VHF systems with aerials such as multi element log beams of discones as these reject lower frequencies anyway. Note that the gain is most useful up to well above the specified 200MHz.

It is in the performance field of radio frequency intermodulation that we saw the biggest differences in the preamps, which we found one of the biggest led downs. The Dressler would give a IμV product from two 21mV ones on the band, and so matters could be very serious if there

3rd ORDER INTERMODULATION DISTORTION
CAUSATORY CARRIERS AT 145.200 and 145.400MHz



are any very high power stations around. Someone running 400W PEP into a high gain antenna pointing across you from several miles away could cause you serious aggro if the Dressler was switched on, even if you had a bomb proof receiving system following it. The calculated intercept point at -22dBm (22mV PD on 50ohms) is easily the worst in the survey, and Dressler will have to improve on it. We should look at both the input levels required for -60dB 3rd order products, and the calculated intercept point which we derived from at least two levels. Looking at all these measurements, the Wood and Douglas *PA3*, and the Moulding were not particularly good either, although appreciably better than the Dressler. Of the remainder, the SEM *Sentinel*, the Microwave Modules and the Wood and Douglas *PA4* were good, with the Datong outstanding. The fascinating point about the Datong is that its onset of IM is remarkably sudden, IPs at lower levels being almost immeasurable, which is absolutely fascinating, and due to the negative feedback circuit employed. Incidentally, the intercept point will apparently be different depending upon how you estimate it, and there is a great danger in getting the wrong apparent point with only one reading. We drew graphs from two or more points to see a reasonable point, but of course this is always an imaginary one, as you cannot actually get a real 0dB figure.

All the preamps in combination with a rig having a bad RFIM performance will not contribute a marked degradation in RFIM, other than that given by the gain of a preamp, but the better your rig is, or the higher the loss between the preamp and the rig, the more important becomes the performance of the preamp.

Overall conclusions

As a double check on the effect of noise figure and gain we interposed each preamp in turn between a Marconi *2019* signal source, delivering 1kHz modulation at 4kHz deviation with attenuators on the output, and the *IC251E* with Mutek front end, as reviewed in the last issue. Give or take a small fraction of a dB, the noted improvement (or degradation) was as expected, with the exception that the Datong gave a significant lack of degradation which required much investigation, for we expected around 0.75dB degradation. Please note that the *251E* front end is already extremely good, and all the preamps would probably make at least a marginal improvement to the average black box with its usual 6 or 7dB noise figure. Returning to the Datong, as the input impedance follows in the same direction as that of the load on the output, and the Icom rig has a very high input impedance, the Datong preamp input would be at a significantly higher impedance, than with the output loaded with 50 ohms. It seems clear that the Datong noise matches slightly better with a 75 ohm, (or higher) output load. What is more important is that the Datong performance may vary considerably depending on the length of line between its output and the effective input of the preamp circuit of the main rig. Making the line longer or shorter might make a dramatic difference to the Datong's input impedance, and so it's worth trying a few different coax leads of different lengths. If you are using the Datong over a wide frequency range, you may find the performance to be better in some frequency bands than others, for the same reason. A half-wavelength at a particular frequency, or a multiple, will reflect the same impedance both ends, whereas a ¼-wave will give the maximum effective transformation ratio.

Taking all measurements into

Table 1: Lab tests & data

1. Gain

Preamp	Gain at 144 MHz (dB)	Gain at 145 MHz (dB)	Gain at 146 MHz (dB)
Dressler *VV200* GaAs	17.5	18.0	17.0
Chris Moulding *MPA-2*	6.5	12.5	16.5
Mic. Modules *MMA144V*	15.0	15.0	15.0
Wood & Douglas *PA3*	22.0	23.5	25.0
Wood & Douglas *PA4*	18.5	19.0	19.0
SEM *Sentinel Auto*	8.2	8.9	9.2

2. Noise figure

	Noise figure at 144 MHz (dB)	Noise figure at 145 MHz (dB)	Noise figure at 146 MHz (dB)
Dressler *VV200* GaAs	1.1	1.0	0.8
Chris Moulding *MPA-2*	2.5	2.4	2.3
Mic. Modules *MMA144V*	1.4	1.4	1.4
Wood & Douglas *PA3*	1.8	1.8	1.9
Wood & Douglas *PA4*	1.9	1.9	2.0
SEM *Sentinel Auto*	5.4	5.0	5.3

3: Datong *RFA* measurements

Frequency (MHz)	Gain (dB)	Noise figure (dB)
10	8.8	5.0
20	8.7	4.2
30	8.7	1.8
40	8.7	1.8
50	8.7	1.9
60	8.7	1.9
70	8.7	2.1
80	8.8	2.2
90	8.9	2.3
100	8.9	2.2
110	9.0	2.2
120	9.1	2.2
130	9.2	2.2
145	9.1	2.6
160	9.1	2.5
170	8.9	2.6
180	8.7	2.7
190	8.8	3.0
200	8.5	3.0

consideration, the Dressler can only be recommended quite strongly if you have no high power stations within quite a large radius, although in a tropo opening you could have trouble. The *Sentinel* was such a poor performer, judging by the review sample, that I would not consider it. I contacted Mr Crapper of SEM but unfortunately it took nearly a week to receive a phone call as he had been unavailable. He kindly supplied a second sample received just after this article had been submitted to the Editor, we could only briefly test the second sample which gave a gain of 18dB +/− 0.5dB across the band, and judging by FM and SSB SINAD tests into the *IC 251E*/Mutek the noise figure at mid band was around 2dB, degrading to 3dB at band edges. Quite clearly it had been far better set up, and the reader will have to draw his own conclusions in the circumstances. The Chris Moulding preamp had such a poor response characteristic, that there might be a chance that another one which you might buy could be equally off tune. The Datong preamp, whilst being extremely good as a wide band model, is for specialist applications, and it should certainly hot up a general coverage receiver, and may also be worthwhile on 2m if you have already chosen it for its amazing merits. The Wood and Douglas *PA3* has in my opinion a rather excessive gain which could degrade the system IM performance too much, so two preamps come out the leaders in overall performance, the Wood and Douglas *PA4*, and the Microwave Modules RF sensed model.

Let's consider the merits of the final two alternatives. Both Wood and Douglas preamps are available in kit form, or as completed circuit boards, at an extremely reasonable price. You'll have to at least make up your own box for them, and the *PA4* receives a very strong recommendation for its outstanding performance, particularly at the price. There is an RF sensed version of the *PA4* which you may need. The *PA4* was within its specification on all points, and will obviously do quite a lot for an average rig.

If you want a complete, ready to go, preamp with RF sensing, then I very strongly recommend the Microwave Modules, which has the second best noise figure, a good but not excessive gain, very good RFIM performance, but a little too wide a bandwidth. It is expensive, though, but good products supplied ready to go, cost more of course, and so I recommend it strongly for normal uses, but it has got too much gain for use in esoteric installations with a low loss cable, and a rig with a reasonable front end noise figure.

The Microwave Modules pre-amp would be suitable for special use in excellent systems if you put a pad of three resistors in the output circuit before the relay of, say, 3 or 4 dB, which will improve the system RFIM performance by around 7dB, which could be useful. Just before going to press, and after discussing all our measurements with Microwave Modules, we received a letter from them informing us that by the time this is in print, the *MMA 144V* will have a switchable RF VOX hold time from 0 for FM to 1 second for SSB, the later being variable with a preset pot. I welcome this greatly and it will make their preamp an even better buy. I would like to thank all the manufacturers/dealers who have loaned the equipment for review, and the many who have been most helpful on the telephone.

I would also like to thank Wood & Douglas for generously donating their review samples to RAIBC.

4. Bandwidth

	-3dB bandwidth (MHz)	-10dB bandwidth (MHz)	-20dB bandwidth (MHz)
Dressler *VV200* GaAs	5.5	13.0	28.8
Chris Moulding *MPA-2*	7.1	13.9	21.4
Mic. Modules *MMA144V*	24.7	38.7	82.9
Datong *RFA*	232	360	574
SEM *Sentinel Auto*	42.9	57.8	111.6
Wood & Douglas *PA3*	5.6	15.2	28.9
Wood & Douglas *PA4*	6.4	16.4	36.6

5. Third order intercept

	RF level at input for: -30dB 3rd order intermod. (dBm)	RF level at input for: -60dB 3rd order intermod. (dBm)	Input/output for 0db 3rd order intercept (dBm)
Dressler *VV200* GaAs	−33.7	−47.2	−20.0/ −2.0
Chris Moulding *MPA-2*	−20.2	−38.7	−1.8/ +10.7
Mic. Modules *MMA144V*	−13.7	−33.2	+5.8/ +20.8
Datong *RFA*	−0.2	−7.7	+7.0/ +16.1
SEM *Sentinel Auto*	−18.7	−34.2	−3.5/ +5.4
Wood & Douglas *PA3*	−22.2	−39.7	−4.5/ +19.0
Wood & Douglas *PA4*	−14.7	−30.2	+0.5/ +19.0

6. Sensitivity

	Sensitivity of Icom *IC251/E*/Mutek front end when used with preamp (RF level in dBm for 12dB SINAD on FM)
Dressler *VV200* GaAs	−128.5
Chris Moulding *MPA-2*	−126.4
Mic. Modules *MMA144V*	−128.0
Datong *RFA*	−127.1
Wood & Douglas *PA3*	−127.5
Wood & Douglas *PA4*	−127.6
SEM *Sentinel Auto*	−126.2

7. Price

	Price (£ including VAT)
Dressler *VV200* GaAs	75.00
Chris Moulding *MPA-2*	33.50
Mic. Modules *MMA144V*	34.90
Datong *RFA*	33.92
SEM *Sentinel Auto*	28.00
Wood & Douglas *PA3*	6.95 (kit) 8.10 (board)
Wood & Douglas *PA4*	7.95 (kit) 10.95 (board)