How to select a Multi-Band

Medium Frequency (MF) ~ Ultra High Frequency (UHF)

Transceiver (Transmitter – Receiver)

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Elecraft K-3 (MF ~ VHF Transceiver)

Kenwood TS-990S (MF ~ VHF Transceiver)

Before buying <u>your first</u> (or) buying <u>a new</u> Multi-Band, Medium Frequency (MF) ~ Ultra High Frequency (UHF) Transceiver, you must ask yourself the following questions:

1. **What are my Amateur Radio Communication Operating Goals [Normal Conversations (Ragchewing), DX Station Hunting or Contesting]?**
2. **What are my desired operating modes [CW (A1A), DSBFC (A3E) RTTY (F1B), SSBSC (J3E)]?**
3. **What bands do I want to operate on [MF (160 Meter), HF (80 ~ 10 Meters), VHF (6 ~ 1.25 Meters), UHF (.70 ~ .23 Meters)]?**
4. **What type of Amateur Radio Operator do I want to be [courteous or discourteous (called a LID)]?**
5. **What features and specifications of the Transceiver make the difference between a *<u>'Low-Range Model'</u>* (those under $1000), *<u>'Mid-Range Model'</u>* (those between a $1000 ~ $3000) and a *<u>'High-Range Model'</u>* (those above $3000)?**
6. **What Transceiver model price range can I afford?**
7. **Is the Transceiver model price a good indication of it's quality?**
8. **What are the models specifications for *<u>Sensitivity</u>, <u>Selectivity</u>, <u>B</u>locking <u>D</u>ynamic <u>R</u>ange (BDR) and <u>I</u>nter<u>M</u>odulation <u>D</u>istortion - <u>D</u>ynamic <u>R</u>ange (IMD-DR)?***
9. **Is Ceramic Filtering, Crystal Filtering or Mechanical Filtering better?**
10. **Is a <u>D</u>igital <u>S</u>ignal <u>P</u>rocessor (DSP) necessary?**
11. **Is a 'Roofing Filter' necessary?**

<u>Note:</u> In addition to the asking yourself the above questions, you need to do a thorough head-to-head 'Comparison' and 'Study' of all technical specifications of the different Transceiver models must be accomplished.

Now lets move on to the main subject of this lesson plan which is "How to select a Multi-Band Medium Frequency (MF) ~ Ultra High Frequency (UHF) Transceiver".

1. The **<u>'First and "Most" important point'</u> is to <u>'Optimize the Active Antenna System'.</u>** This must be done at any RF Communication Electronics Station, whether it is for portable, mobile or fixed station operations. A few microvolts of RF Electromagnetic (EM) energy, intercepted by the Active Antenna System, fed to the Receiver and displayed on the 'S'-Meter is not very strong.
2. The **<u>'Second important point'</u> is that <u>'The performance of a Transceiver depends first and foremost on the quality of its Receiver!'</u>** The Receiver is a very complex module, and a good performing Receiver is needed to detect weak RF EM signals.
3. The **<u>'Third important point'</u> is that <u>'A RF EM signal produced by the Transmitter module, requires fewer components and uses the same Intermediate Frequencies (IF) as the Receiver</u>.**

If your are not reading regularly published Amateur Radio Magazine reviews of the Transceiver Technical Specifications, or are not having discussions with other Amateur Radio Operators, you probably will have difficulty understanding the current technology used, and how it performs compared to 'Older' Transceiver Models, especially if you are interested in the new developments of both Hardware and Embedded Software.

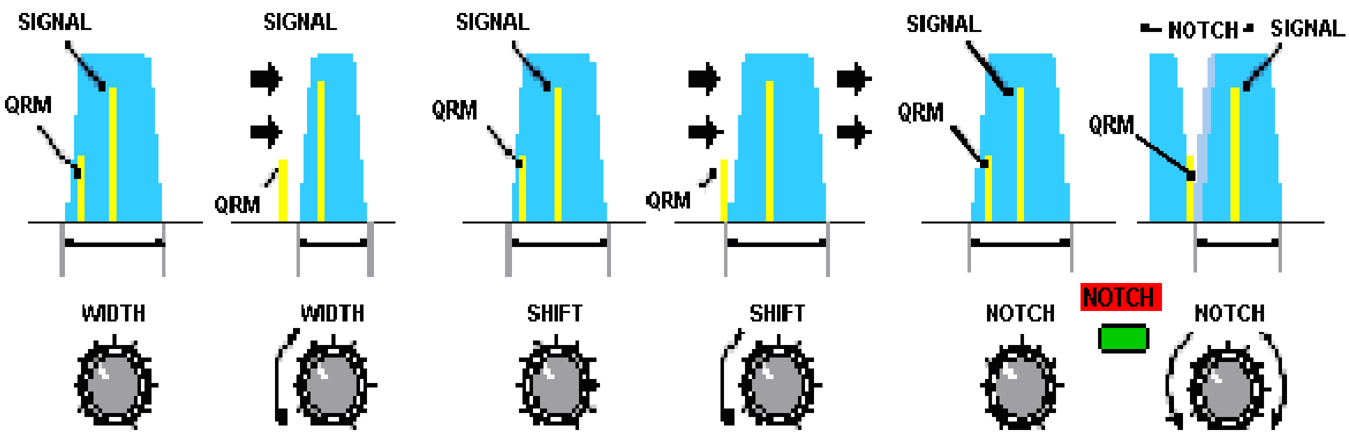
Receiver Sensitivity

The 'First Quality Factor' of a receiver concerns 'Sensitivity'. 'It is the measure of a receivers ability to detect very weak signals against normal background noise'. This is referred to as the receivers 'Noise Floor' or also called 'Minimum Discernible Signal'. It is the minimum input signal required to produce a specified output signal, under which threshold, you will only hear the electronic noise of components in the transceiver or, the atmospheric noise on the frequency but no readable signal.

Receiver Selectivity

The 'Second Quality Factor' of a receiver concerns the 'Selectivity'. It is the measure of a receivers ability to receive a desired signal and to reject any nearby undesired signals. This is probably the first feature where your receiver will show its performance. In a discussion on selectivity there has to be a distinction between modes of operation. The response curve of a filter is defined by its bandwidth at different characteristic attenuation levels (0, -6, -40, -60 dB). Such a curve usually does not display the theoretical model rectangular shape, but has a bell shape with wings which are more or less abrupt with skirts more or less short. Filters are inserted all through the receiving chain at each IF stage. Some of the best Mechanical filters ever made are the Collins, which are offered as an optional feature in the **Main Receiver 455 kHz 3rd IF** and in the **Sub Receiver 455 kHz 2nd IF** of the Yaesu FT-1000MP Mark-V and Yaesu FT-1000MP Mark-V Field Transceivers.

Look at a **Yaesu FT-1000MP Mark-V** and **Yaesu FT-1000MP Mark-V Field** in the **CW** mode, the standard narrowest filter bandpass has **250 Hz bandwidth at -6 dB and 700 Hz bandwidth at -60 dB**, which is all that is necessary to work weak signals in the CW mode submerged by interference. But in the **SSB** mode, the signal is much wider and the standard narrowest IF filter bandpass is **1.8 kHz bandwidth at -6 dB and 3.6 kHz bandwidth at -60 dB** which does not give similar results in the SSB mode as it does in the CW mode.



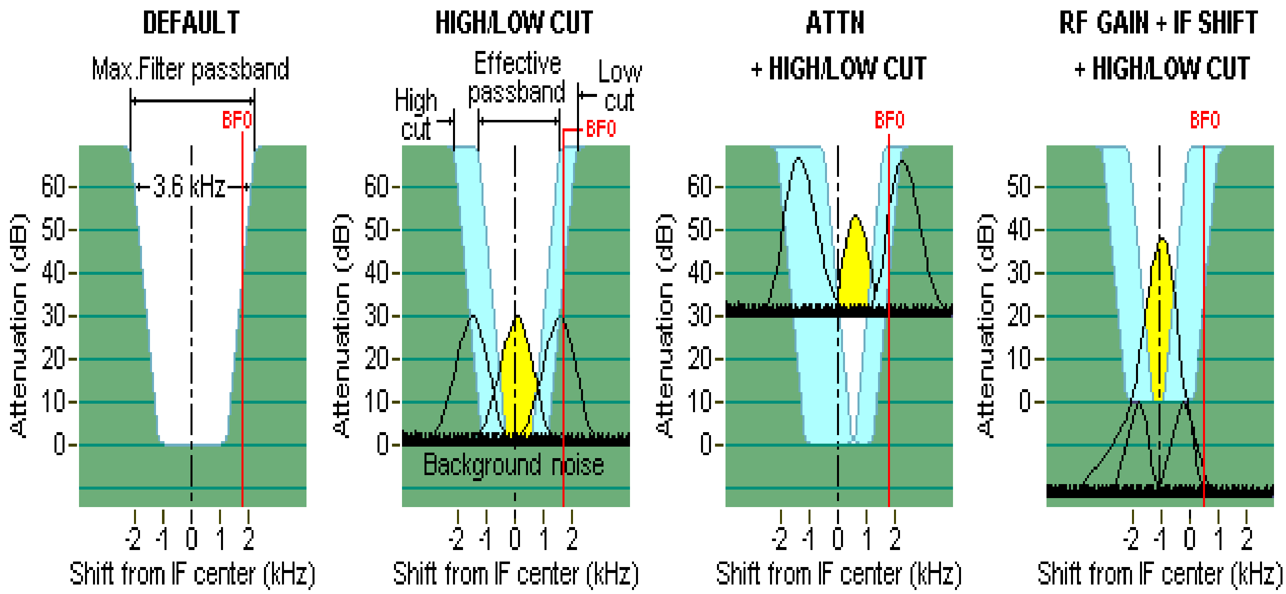
Three of the many ways to suppress interference using a Yaesu FT-1000MP Mark V and Mark V Field are the "IF WIDTH", "IF SHIFT" and "DSP NOTCH". These Yaesu filters are installed at the second IF at 8.215 MHz and at the third IF at 455 kHz. They can be combined in 'Cascade' to form the equivalent of one filter showing a variable bandwidth.

1. ***In some literature it is written that a filter works better if signals applied to it are weak. This is not factual, because the response of a 'Ceramic Filter' or 'Crystal Filter' is very linear, and it responds exactly the same way to strong signals as it does to weak signals.***

2. *This means that whether the signal applied to the filter is within the filter's bandpass or not, the amount of signal appearing at the output of the filter is proportional to the amount of the input signal applied.*

3. ***Since a filters bandpass can not be changed, you need to apply one to three cascading methods to remove all interference and noise that prevents the reception of the desired signal.***

The method to suppress undesired noises (*atmospheric static noise or RFI*) consists of rejecting them outside the bandpass or, if they are on the same frequency, to attenuate them as much as possible before they reach the RF amplification stage.



The graphs above illustrate better than any amount of words, the effects filters have on the reduction of noise interference and other Interfering signals from the desired signal in the bandpass. The **'First Graph'** describes the default bandwidth of a SSB filter, **all controls are off**. Note that the **B**eat **F**requency **O**scillator (**BFO**) frequency (**red line**) is close to the filters center frequency (+1800 Hz). The **'Second Graph'** displays the effect of the **High and Low cut controls** on two tones interfering with a desired signal (**yellow**) in the center of the bandpass. In changing the High/Low cut, the effective bandpass becomes narrower, rejecting the interference. The **'Third Graph'** displays the effect of applying **Attenuation (30 dB) and High/Low cut** on two strong interfering signals adjacent to the desired signal. The **'Fourth Graph'** displays two interfering signals on the same frequency as the desired signal. This time the **IF shift control** was set to +500 Hz and the RIT was adjusted so that the BFO is properly positioned in the bandpass. In addition the **'RF Gain was reduced'**, and the **'Attenuation and High/Low cut controls were adjusted'** to isolate the desired signal. **Using all these controls can reject all residual atmospheric static noise and RFI. In "High-Range" Receivers these controls are completed with a Notch and DSP.**

High and Low cut settings

The **'First interference suppression method'** consists of shifting ***the bandpass of each filter***, up or down in frequency until the noise has disappeared. The signal is placed between the two filters, rejecting the interfering signals outside the bandpass. This technique does not modify the **B**eat **F**requency **O**scillator (**BFO**) tuned on the remote station frequency, so the signal sounds normal. You can also use the High and Low cut controls to remove undesired high and low pitch audio from the desired signal and thus reduce or remove interference as well.

Attenuation and RF gain

The **'Second interference suppression method'** is to remove interference without rejecting the signal, ***you need to apply attenuation***, displayed above in the center graph. Thanks to the RF **ATT**enuator (**ATT** control) adjusted to 20 or 40 dB for example depending on the strength of the noise, you can lower the intensity of all signals until the interference reaches the background noise hash. In these conditions you will reduce the generation of undesired products. If this is not enough, you can cascade it with low RF gain until the interfering signal is removed from the bandpass, offering you a chance to hear the desired signal without interference. If RFI is still heard adjust the High and Low cut controls to reduce the bandpass to less than 1.5 kHz, while keeping the BFO frequency close to the bandpass. However, adding more attenuation and reducing the RF Gain has one drawback. In many Receivers there is poor audio circuitry following the detection stage, which results in excessive noise (hiss) being added to the desired signals. The gain that you reduced on one side has to be made up for elsewhere. If the signals are not already above the AGC attack threshold for a same amount, a significant amount of audio gain must be applied to maintain the desired listening levels at the speaker output. Consequently, this audio gain will increase the amount of hiss present in most Receivers. This means that the operator has to manually adjust the AF or RF stage in order to maintain the desired signal levels under fading conditions.

IF Shift

The **'Third interference suppression method'** is using IF shift displayed above in the third graph at right. Until now we haven't modified the BFO frequency that was fixed in relation to the filter center frequency. The BFO was set at about 1 kHz or a bit more up or down from the IF center frequency. In some conditions, you can hear both interference and noise on the frequency, as well as static noises. In the worst case all signals are on the same frequency. In most cases you will have to cascade all three methods, playing with them together to create a string of attenuation, a low RF gain, adjusting the High/Low cut, and at last setting the IF shift to some hundreds of Hz above the filter center frequency, and adjusting the RIT to properly position the BFO close to the bandpass. In most conditions, in using this approach you will get a reception free of noise and interference. **However, if a strong interfering signal gains access to the amplification stage located behind the last IF stage, you will hear it loud and clear in your headset. To remove it, modern Transceivers are equipped with a fourth IF stage, called the DSP. We will come back on this technology later when we will speak about the "High-Range" Transceivers.**

Blocking Dynamic Range (BDR) of some Transceivers (In dB at 5 kHz spacing)		
Transceiver	**Blocking**	**IMD**
Elecraft K2	126	88
Ten-Tec Omni 6+	119	86
WinRadio G303i	113	93
Yaesu FT-1000MP Mark V	106	78
Icom IC-756PRO	104	80
Icom IC-775DSP	104	77
Kenwood TS-2000	99	67
Icom IC-746	88	78
Kenwood TS-570D	87	72
Icom IC-706MKIIG	86	74
Yaesu FT-847	82	73
BDR is the signal level required to 'Block' or to reduce the sensitivity of a Receiver to weak signals. When this occurs the strongest signal from an adjacent frequency tends to "capture" the amplifier		

reducing the strength of the other signals. **IMD quantifies the InterModulation Distortion, non-linearities by a single number, the intercept point (IP2, IP3). This is a measurement of the mixing products produced when two strong signals are fed to the Receiver simultaneously**.

Competition between Transceivers

Now that the Transceiver is equipped with two or more IF stages, each of them taking advantage of the finest filters, let's examine what are some of the different features offered in some well-known Transceivers, and some of their respective performances in order to help understand the difficulty of selecting a Transceiver suited to your needs.

To clarify the problem, we will compare different Transceivers. On one side the 'Mid-Range' Kenwood TS-570D, famous for its performance and sold at an affordable price, and on the other side the 'High-Range' models like the Icom IC-7800, Ten-Tec ORION, Yaesu FTdx9000MP, and the older Icom IC-775DSP, Yaesu FT-1000MP Mark-V and Yaesu FT-1000MP Mark-V Field. The 'High-Range' models are approximatively three times more expensive than the 'Mid-Range' models. Are they worth their price and do they display all similar performances? **There is a tendency to believe that in the same category all Transceivers are on par with each other, even if their price fluctuates somewhat from one brand to another.** ***This is an opinion, and far from reality.***

'Mid-Range' versus 'High-Range' Transceivers

The Kenwood TS-570D is a fine Transceiver for casual conversational (ragchew) operations. It's DSP noise reduction is great, and with the optional 1.8 kHz SSB filter the selectivity is good. **But under heavy stress, trying to carve a place in a crowded band, to work a DX pile-up or work when the atmospheric static is strong, the TS-570D shows its limits due to it's limited number of filtering means.** Although it uses DSP technology, it is installed at the **A**udio **F**requency (**AF**) stage rather than at the **I**ntermediate **F**requency (**IF)** stage, which presents some drawbacks when it tries to remove interference or even a simple signal on a nearby frequency that successfully passes through the detection chain.

The Icom IC-775DSP, which is an older model HF Transceiver, available from time to time secondhand and the default settings in the IC-775DSP has two narrow filters at the IF-stages where the TS-570D only has one at the AF-stage. What is the result? The Twin Bandpass Tuning used in conjunction with the two 1.8 kHz filters of the IC-775DSP is far superior to the IF Shift method offered on the TS-570D. It also has a manual notch filter, which is another feature not available on the TS-570D. This is where the Icom excels, and still more when it is equipped with all optional filters.

Under strong signal reception the IC-775DSP receiver does not overload or desense like the TS-570D. The sensitivity is about the same, as you would expect because the TS-570D is really a great transceiver in its category, providing an excellent signal and a good reception in usual working conditions. **As explained previously, when the propagation is good and there is no atmospheric noise on the band, filtering is not necessary and both transceivers yield the same results.**

On the other hand, when involved in a contest against world class competitors, or trying to work a DX pileup, you need powerful tools to remove the interference and preferably a high gain antenna to pick up the weak signals. The system must be able to discriminate between incoming signals without being interfered with by nearby strong signals. **To reach these two objectives you need high sensitivity, excellent 3d-order IMD and the best selectivity possible.** With these objectives in mind, the TS-570D will leave you desiring better, contrary to the IC-775DSP, equipped with all optional filters in its two IF-stages which has unbelievable selectivity and audio. **However the IC-775DSP is not as**

selective as the Yaesu FT-1000MP Mark-V, or Yaesu FT-1000MP Mark-V Field which has more IF stages and more analog and digital filtering features to fight against interference.

The frequencies used by IF stages in many "High-Range" Transceivers, and even the TS-570D, are outside amateur bands (around 73 MHz, 8.8 MHz and 455 kHz) and do not have 'image' frequencies that disturb your receiver. ***Avoid any transceiver that has an IF frequency within the amateur bands, which will cause 'images' (birdies) in the bands.***

When looking at ergonomics and function access, the TS-570D only has software menu driven functions, without many direct controls, which slows down operation. The Icom IC-7800, Kenwood TS-990S, Yaesu FTdx9000MP, Yaesu FT-1000MP Mark-V and Yaesu FT-1000MP Mark-V Field have front panel controls for all the common functions. Many features of the Kenwood TS-2000 are also accessible from the front panel, but to enable them, it requires pushing two keys (FUNC key + specific key). In operating a contest or a DX pile-up with nearby interfering signals, the design of the Kenwood TS-2000 is much less practical than a radio offering direct access keys and lights that provide a visual indication of when some features are enabled.

Which DSP Filtering is better, Intermediate Frequency (IF) or Audio Frequency (AF)?

If you are only interested in CW, a crystal filter placed on the audio frequency stage is sufficient enough to get good results in most traffic conditions. DSP doesn't work the same way, and in SSB for example it is able to automatically remove carriers that fall in the current bandpass, and this without using a notch circuit and is a great improvement.

Block diagram of the **Interlocked Digital Bandwidth Alignment Technique (IDBT),** one of the best interference-fighting systems developed by Yaesu to get the sharpest signal at reception. An analog IF includes both IF WIDTH and IF SHIFT controls in conjunction with cascaded filters to modify the IF bandpass width and center frequency. Thanks to this technique, the DSP filter is automatically re-programmed to match the custom bandwidth you set to extract the weak signals from QRM.

The Bandpass of IF DSP is programmable to get abrupt wings contrary to an AF DSP audio filter that usually displays a bell shape. The first is thus "better", in theory. At last, the elimination of noise is ruled by signal processing protocols, whereas an audio filter depends on its bandwidth, which affects the audio and therefore, it is not always suited to the mode used.

In selecting a filter, keep in mind these reference parameters when comparing performances of filters. **Remember also that not all mechanical filters display the short skirts of the Collins and many are not worth their price.**

Generally speaking it can be said that an IF DSP is more versatile as it can be used with more modes of traffic than mechanical filters. Let's see how DSP performs when it is used in "High-Range" Transceiver.

The competition between "High-Range" Transceivers

Due to its plethora of analog and digital filters of all kinds, the Icom IC-7800, Kenwood TS-990S and the Yaesu FT-dx5000MP are three "High-Range" Transceivers that push the sensitivity as well as the selectivity and high-order IMD a bit farther than other Transceivers. Their performances are considered among the best to date.

The excessively high price for the Yaesu FTdx5000MP ($5500) limits its sales to some contest teams and fortunate Amateurs, but at 23% of this price the yaesu FT-2000D ($2500) is much more accessible.

In the Yaesu FT-1000MP Mark-V and FT-1000MP Mark-V Field for example, the shape of the optional Collins Mechanical Filter bandpass is very effective at removing noises in the Single Sideband (SSB) mode, without impacting the desired signal. **The profile of these Collins filters is similar to a square wave, showing very short skirts, which allow this system to eliminate a interfering signal located a fraction of hertz near your frequency.** Better, thanks to its DSP functions (Enhanced DSP like IDBT and contour and several others) the FT-1000MP Mark-V and FT-1000MP Mark-V Field are able to extract the weakest signals from the background hash where most of its competitors fail. Very few other models can perform as well, not even the Kenwood TS-2000 or the Icom IC-756PROII Transceivers. Only the Kenwood TS-990S is on par with the Yaesu FT-1000MP Mark-V and FT-1000MP Mark-V Field if not in all aspects.

On the other side, using integrated circuits, if the digital filters envelope is poorly programmed it can sometimes look more like a gaussian curve than a square wave, with such specifications, if the weak signals are not completely filtered at both extremes of the filter bandpass, they will capture the AGC and will still be heard. **In these conditions you can never reach the performance of a Collins mechanical filter. For decades Collins filters, internal or external, have proven their quality.** The DSP noise reduction filters, which are found in most transceivers, are a powerful feature that no Amateur can bypass.

In usual conditions the adjustable Noise Blanker (NB) of the Kenwood TS-990S or the ones on the FT-1000MP Mark-V, FT-1000MP Mark-V Field and FTdx5000MP are some of the best that you could hear. **The greatest NB is perfect for all but very noisy conditions. Applying maximum noise blanking helps to eliminate even the most stubborn pulse noise, like power lines or engine noises that other NBs (like the TS-570) can't touch, without compromising audio quality.** SSB audio is very customizable for either fidelity, or cutting through a pile up using compression. On the other side the NB offered on the Icom IC-775DSP cannot reach the performances offered by the optional Collins Mechanical Filters installed in the FT-1000MP Mark-V and FT-1000MP Mark-V Field.

On the transmit side the RF power of the Icom IC-775DSP, Kenwood TS-990S, FT-1000MP Mark V, FT-1000MP Mark-V Field and FTdx5000MP Transmitters develop 200 W PEP and do not even get warm during long conversations on SSB or at 100 W using PSK31. This supplemental power adds 3 dB to the TX signal, improving a CW signal lost in interference.

Many digital "High-Range" rigs like the Icom IC-775DSP have a sub Receiver, although not as flexible as the Kenwood TS-990S, Yaesu FT-1000MP Mark-V, FT-1000MP FT-1000MP Mark-V Field and FTdx5000MP that allow you to listen to '2' frequencies at the same time. Why use a double VFO? Imagine that there are two pile-ups working on the 20 Meter band. If the first station is hard to work you can switch to second one and try to work the second DX, while listening to the other station waiting for a lull in the traffic. A double VFO is also very appreciated in CW (or even SSB) when working DX whose QSX frequency shifts regularly off a few kHz. So such a feature is great for spots and split operations. The TS-570D also has A/B VFO push-button that can be very useful in split operations when the operator uses a fixed QSX (e.g. " up 5 "), but it makes DX spotting moving in frequency (e.g. « 5 to 10 up ») or working in CW difficult.

Roofing Filters

Following the antenna connection, of a **Transceiver** (**Trans**mitter / Re**ceiver**), there is an ***Inductive – Capacitive (LC) Band Pass Filter (BPF)*** in the Receiver section, which is usually as wide as the entire band or even wider.

The first mixer stage has a large quantity of signals at its input while trying to separate out one signal for reception.

1. **The function of the design of the first mixer circuit gives it the ability to handle signals without excessive InterModulation Distortion (IMD).**

2. **The first mixer circuit does have a limit though, above which there is an IMD level, which becomes stronger than the *Noise Floor* (NF).**

3. **The difference between the IMD and NF levels is known as the Dynamic Range (DR).**

4. **The DR characteristic is generally measured with just two signals of the same strength and some particular frequency spacing. For two signals within the operating band, this is called the 3rd Order IMD-DR.**

5. **When signal spacing is much greater than the BPF bandwidth, the first mixer and any other early stages determine the dynamic range of the receiver.**

Most high-end Transceivers today have a dynamic range in the area of '95 - 105 dB' for a signal spacing of '20 kHz' or more. **As the signal spacing decreases, at some point they will fall into the bandpass of the filter and they will then infringe on the following second mixer and IF stages, which will create IMD at much lower levels. Thus for closely spaced signals the receiver dynamic range drops dramatically to maybe '60 dB' or '70 dB'. The transition width from the first mixer dynamic range limit to the second mixer limit is determined by the bandwidth of the filter.**

Let's assume we have a Transceiver with '100 dB' of Dynamic Range (DR) and a NF of '–135 dBm' for signals spaced '20 kHz' apart. This means there are two signals, one off tune by '20 kHz' and the second one off tune by '40 kHz' and they create a false response on the tuned frequency when their level is '–35 dBm' or '100 dB' above the noise floor. How strong is that? Well, an 'S9' meter reading in a typical Transceiver is '–73 dBm' (50.1 uV), so these signals are '38 dB' above 'S9'. Any signals weaker then that will cause no problem for these or wider signal spacing.

There are two basic designs for modern Transceivers.

1. The first design is those Transceivers with only the MF & HF Amateur Radio Bands that use a first IF, typically between ‘4 MHz’ and ‘10 MHz’.

    a. These filters are easy to make and have been available for many years.

2. The second design are those Transceivers which also include one or more of the VHF Amateur Radio Band(s), well above ‘30 MHz’. Which are usually called “Up Conversion” Transceivers.

    a. In the up conversion Transceivers the first IF is at VHF, somewhere in the ‘40 MHz a ‘to ‘75 MHz’ region.

    b. Narrow bandwidth VHF filters have not been available until recently, so the Transceivers with VHF IFs typically use ‘10 kHz’ to ‘20 kHz” wide filters.

The ability of a Transceiver to ignore strong signals near the tuned frequency is greatly enhanced by a “**Roofing filter**”. A roofing filter is the **current buzzword** in high-end Transceivers. Just what does it mean? ***Basically, a Roofing Filter is simply the “First Intermediate Frequency (IF) BPF” in a Transceiver.*** **All of which are “Crystal Filters”, either discrete or monolithic types**. **It is usually placed as close to the first mixer as possible in order to be effective**. ***The term “roofing” stems from the fact that it protects the rest of the Transceivers receiver section following it from signals out of the bandpass***. **Ideally, the final desired selectivity should be in the first IF to protect the following high gain stages from strong out of band signals**. At the lower IF’s it is possible to use filters as narrow as ‘250 Hz’. At VHF it is not yet possible to make practical filters that narrow. ‘3 kHz’ or ‘4 kHz’ is about as narrow as they go in the VHF region.

The goal of the 1st IF (roofing) filter is to reduce the bandpass to about ‘6 kHz - 20 kHz’, so that overloading and distortion in the following amplifier stages and mixers stages are reduced. **The receiver's bandwidth is not determined by the 1st IF (roofing) filter but by a following crystal, mechanical or DSP filter. These allow a much better filtering curve than a roofing filter, which often uses a high 1st IF of higher than ‘40 MHz’. It should be noted that while a ‘6 kHz - 20 kHz’ roofing filter is acceptable for general purpose MF / HF radio reception, demanding uses like listening to weak CW or SSB signals require the use of 1st IF (roofing) filter that has a much smaller bandwidth appropriate to the reception mode in use. A ‘250 Hz’, ‘500 Hz’, or ‘1.8 kHz’ would be acceptable values. These also require that the receiver uses a low first IF perhaps ‘9 MHz’ or ‘11 MHz’.**

Suppose the dynamic range within the roofing filter bandwidth is only ‘70 dB’ and the filter is ‘12 kHz’ wide, two signals spaced at ‘3 kHz’ or less will fall inside this filter, and if they are ‘70 – 135 = -65 dBm’ or stronger, they will cause IMD signals in the bandpass. This is only ‘S9 +8 dB’ per signal. In a Transceiver used in a contest it is possible to have several signals in the ‘+ / - 6 kHz’ range around your tuned frequency which are stronger than ‘S9 +8 dB’, and this is why we hear false signals under those conditions.

Narrowing the roofing filter has no effect on widely spaced signals, as the IMD is earlier in the signal chain of the receiver. **However, it can improve the receiver performance for close-in signals. In the above example, if we reduce the roofing filter bandwidth to ‘4 kHz’, the widest separation, which will cause a problem, becomes ‘1 kHz’ instead of ‘3 kHz’. This can reduce the**

interference substantially in crowded band conditions. ***So it's apparent that signals spaced at the roofing filter bandwidth divided by '4' is the minimum spacing at which the dynamic range of the Transceiver will be improved.*** Shall we go as narrow as possible? Suppose we use a '250 Hz' roofing filter, signal spacing down to '62.5 Hz' will be improved. Doesn't this seem a bit close to operate next to your neighbor in a contest? I think the DX station would have some difficulty trying to copy one of you and not the other. What is reasonable? Maybe something which starts attenuating at signal spacings of '100 Hz' makes sense. This is a roofing filter with '400 Hz' bandwidth. The other advantage of making the filter a bit wider is that the insertion loss is not as great. Insertion loss can reduce the sensitivity of the Transceiver.

Is an '8-pole' filter necessary? How does a '4-pole' filter compare? One difference between the two filters is insertion loss. For a '500 Hz' filter this difference can be a difference of about '5 dB' for a '9 MHz' filter. **The receiver overall gain should be kept fairly constant as filter bandwidths change to preserve the Automatic Gain Control (AGC) characteristics and to keep the "S" meter reading constant.** Also, the receiver NF can suffer if there is a gain reduction close to the front end. We need to insert an amplifier or otherwise change the gain to make up for the extra filter loss when a narrow '8-pole' filter is selected. This can reduce the dynamic range of the Transceiver. So '4 pole' filters have an advantage, particularly for narrow bandwidths, even though the selectivity is not as good for signals falling down the skirts. There is less advantage in going to a wider filter such as a '2400 Hz' bandwidth. For example, a '10 pole', '2400 Hz' filter has an insertion loss of about '2.2 dB', while the '4-pole' filter with the same bandwidth has a loss of '1 dB'. The difference of '1.2 dB' is small enough that it could be ignored and the '10-pole' filter would provide better off-channel rejection. **Thus for the SSB bandwidths a good '8' or '10 pole' filter will outperform a '4 pole' filter, but for the narrow bandwidths the simpler filter is best.**

Kenwood TS-570D

Kenwood TS-2000S

Icom IC-755DSP

Icom IC-756PROII

Icom IC-756PROIII

Icom IC-7800

Ten-Tec ORION

Ten-Tec ORION II

Yaesu FT-1000MP Mark-V Field

Yaesu FT-2000

Yaesu FT-DX9000 Contest

Yaesu FTdx9000D & FTdx9000MP

Your antenna system

[**‘The best Transceiver is useless without a Good Antenna System’.**]

There is an antenna physics law called ***‘Reciprocity’*** which means ***’The more efficient your antenna is made for transmitting, the more efficient it will be for receiving or in other words it will reciprocate’.*** Using a quarter wave ‘Marconi’ vertical or a half wave ‘Hertz’ horizontal antenna, makes it very hard to operate against competitors equipped with High Power RF Power Amplifiers and High Gain Yagi-Uda or Quad beams.

A conversation is a two-way contact, which requires that the other station be able to hear you and you to hear them. Among the Kilowatt and Kilowatt plus RF stations, your barefoot 100 or 200-Watt Transmitter does not stand a chance of working that DX station in a pile-up! Like some of you, more than once you may have tried contacting a DX station that you heard very well, but they never responded to your call. At other times the DX station changed frequency before you had time to work them. You could probably work those DX stations if you were available all day long, but like most of us, you have work or other obligations and appreciate staying in touch with the family, friends, being outside and preserving your health by sleeping at night. With this criteria in mind, take into account the reason for not being able to work most DX can simply be a matter of propagation, less than an optimum Antenna or too low a RF power output to reach the station. **Therefore, before buying a RF Power Amplifier, improve the Antenna System you have or upgrade to a directive Antenna such as a Yagi-Uda, Quad or Log Periodic beam.** It should be directional with a substantial amount of gain. In addition your Transceiver must be properly coupled to the feed line and the feed line correctly coupled to the antenna.

When using a Yagi-Uda, Quad or Log Periodic beam you will quickly discover that you have less use for a High Power External Inline RF Power Amplifier because the interference of nearby stations have been reduced 20 dB or more in all directions excepting in a narrow beamwidth in the direction of the station you desire to contact. You will be able to work DX stations with 100 or 200 Watt even during a minimum sun spot solar cycle or when the atmospheric propagation conditions are poor. In fact using a High Gain Antenna (5 dB or better, with a F/B ratio gain over 20 dB) and working with a “High-Range” Transceiver having DSP Filtering, is very exciting and you won’t waste your time in calling the DX station in vain. Of course such equipment has a price and not everybody can invest a “fortune” in his or her installation. **This is a question to debate between you and your conscience.**

The Transceiver purchase & operating manual

Whether you like to have local conversations (ragchew), work DX stations or participate in Contests, you will recognize that depending on your chosen activities, the two main categories of Transceivers, the “Mid-Range” and “High-Range”, are an expensive piece of hardware with prices ranging usually between $2000 - $12000 or more and often a durable investment, of at least 20 years. You must select it with care so that you do not regret your purchase later. To prevent any mistakes, you have no other choice than to test it at a friends station or ask to rent a model from your dealer to test it in your station. The latter recommendation is however more difficult to meet because there a very few dealers who will rent Transceivers or antennas knowing that most users abuse this opportunity to use them in contests with the additional risk of not being able to sell the product once used or damaged. If you can’t get a Transceiver for rent or can’t visit a close friend using the antenna type or transceiver you are thinking of buying, try to read as many published technical reviews as you can and form your own opinion.

Lastly, if you really need the best Transceiver, equipped with the finest filtering and noise reduction, direct access keys and ergonomic menu, do not listen to the person who just bought a new rig. First they lack the practical experience and cannot not yet fairly compare the performance of the new Transceiver with their previous one. Check the QSL cards you have received from DX-peditions or Contest teams to know what equipment they used. Like you they have looked for not only an excellent Transmitter and Antennas, but also the best Receiver in terms of performance and overall ergonomics.

Making the right choice

Buy a “High-Range” Transceiver model if you want to hunt & chase DX, operate in Contests and during heavy noise and atmospheric interference conditions, in addition to conversational talking (ragchewing). Are the ‘High-Range’ Transceivers models worth their price? Well it depends, with the ‘High Range’ models being as much as three times more expensive as the ‘Mid-Range’ models. If you can find a older used Transceiver whose PA stage has not been damaged because of High SWR or a lightning strike, buy it. Consider purchasing the Icom IC-756PROII, Kenwood TS-850S, TS-950SD, Kenwood TS-950SDX, Ten-Tec ORION, Yaesu FT-1000MP Mark-V or Yaesu FT-1000MP Mark-V Field. The Kenwood TS-850S still uses analog devices – it was designed in the late ‘80s – but its performances exceed most of recent models, and these radios clearly trade off size for usability. If you are searching for the best, the Transceiver models described in this document are among the finest MF – UHF Transceivers models ever made! But a ‘High-Range’ Transceiver model is a very expensive Transceiver and probably not the best choice to make.

Buy a "Mid-Range" Transceiver model if you already have a good location and a quality antenna system and only participate in local conversations (ragchewing) and operate during very

low noise and atmospheric interference conditions. A ‘Mid-Range’ Transceiver model, with all options included, can be a great performer, rather than buying a ‘High-Range’ Transceiver model, and it will allow you to buy a lot of Antenna or a RF Power amplifier.