Receiver front-end characteristics

By Harold Kinley, C.E.T.

The old slogan, "It's what's up front that counts," certainly holds true in the design of radio receivers. Under ideal conditions—low site noise, moderate-to-strong desired signal and no strong off-channel signals—almost any receiver will perform well. However, under less-than-ideal conditions, the design of the receiver front end becomes critically important. Design of the RF amplifier as well as front-end selectivity determines much of the operating capabilities of the receiver.

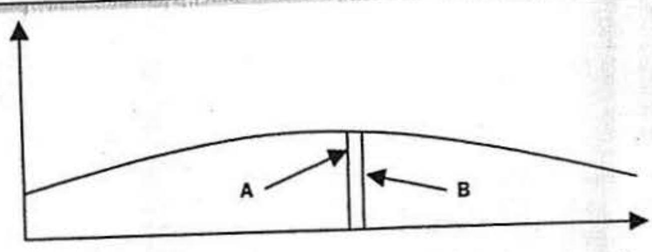

Figure 1. Relative frequency vs. amplitude response of wideband receiver front end.

Wideband receivers

Wideband receivers designed for mobile use can cause significant problems when used as a base station receiver. If you are forced to use a wideband receiver for a base station, be aware of the limitations and weaknesses of such an arrangement. Many wideband mobile receivers have "wide-open" front ends. That is, there is little selectivity up front. Some wideband receivers use electronically tuned resonant circuits that use a varactor diode tuned by a control voltage as the receiver operating frequency is changed. Other receivers might provide one of more front-end "windows" that are changed or shifted for certain frequency ranges.

Intermod rejection

If you are comparing the specifications of a receiver with a wide front end with those of a receiver with a narrow front end, you might be a little misled. The front-end selectivity is critical to good intermodulation performance. The more tuned stages ahead of the first active component (RF amplifier), the better the intermodulation rejection capability of the receiver will be, as long as the mixing signals fall out of the passband of the front end. If you look at just the receiver specifications, you might interpret that the intermodulation rejection figure of a specific wide front-end receiver is almost as good as another one with a relatively narrow front end. However, this doesn't tell the whole story. Suppose we are using a narrowband receiver and that the third-order intercept point for the RF amplifier is +10dBm. Further suppose that a signal at the first adjacent channel above the desired frequency is present at the amplifier input at a level of −20dBm. Let's call this signal *A*. (Refer to Figures 1–3.) Also present at the amplifier input is a signal (*B*) that is two channels up from the desired frequency at a level of −30dBm. Signals *A* and *B* will produce an intermod product (2*A* − *B*) at a level of −90dBm on the receiver frequency. When using the same signal inputs on a receiver with a wide front end, you might get similar results. However, a comparison of the receivers, using signal inputs far-removed from the center frequency, will show a significant difference in the results. Suppose for the narrow front-end receiver that the receiver is tuned to 152MHz and that signal *A* is 154MHz and signal *B* is 156MHz. Then the third-order intermod signal, 2*A* − *B*, is equal to the receiver's tuned frequency, 152MHz. The wide front-end receiver will stay essentially the same, using the same signal levels at the input to the RF amplifier that were used in the previous example. However, the narrow front-end receiver will attenuate these out-of-band signals. Let's assume that signal *A* is down by 10dB to a level of −30dBm at the RF amplifier input and that signal *B* is down by 15dB to a level of −45dBm at the input to the RF amplifier. The level of the intermod signal at the output of the RF amplifier is down to −125dBm in the narrow front-end receiver. This intermod signal would cause much less trouble than the intermod signal of -90dBm in the wide front-end receiver. The bottom line is that receivers with wide-open front ends allow more signals to reach the input to the RF amplifier at a higher level. This increases the odds of intermodulation interference occurring.

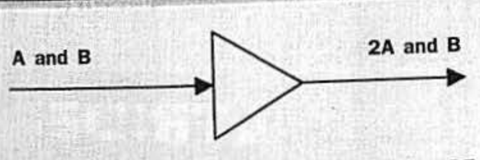

Figure 3. Signals *A* and *B* reach the input of the RF amplifier and produce the intermod signal 2A−B at the output.

Desensitization

Receiver desensitization occurs when a strong off-channel signal overloads a receiver front end and thus reduces the sensitivity to weaker on-channel signals. Receiver *desense* is usually measured by injecting an on-channel signal to produce 12dB SINAD at the receiver output. This is the *reference sensitivity*. Then the signal generator is increased by 3dB to produce a better-than 12dB SINAD at the receiver output. Then an off-channel (one of the adjacent channels) signal at a

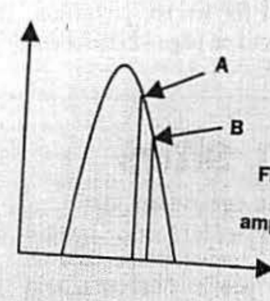

Figure 2. Relative frequency vs. amplitude response

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different modulating frequency is applied through a combining network to the receiver input. The off-channel signal is increased in amplitude until the SINAD meter again indicates 12dB SINAD. The difference in the level of this *undesired* signal and the *reference sensitivity* is the *desense figure* or *adjacent channel selectivity*. In one sense, this could also be called *dynamic range*, although this term is used to refer to a number of things regarding a receiver.

In a receiver with a wide front end, the undesired signal generator can be set several megahertz away from the on-channel (desired) signal generator and still cause desense. A practical example of this happened to one of the users of a repeater system. The repeater input was several megahertz down from the repeater output. While standing next to his mobile radio and using a walkie-talkie to "hit" the repeater, the user could not hear the repeater in the mobile radio until the walkie-talkie stopped transmitting. The walkie-talkie output was desensitizing the mobile receiver even though the receiver frequency was several megahertz away from the walkie-talkie output frequency.

Many times the phenomenon of receiver desense goes undetected. That is, the receiver never "hears" the desired signal and the operator might never be aware that there was a problem. In a mobile unit, the vehicle might have been near a powerful transmitter a few megahertz away from the receiver operating frequency, and the operator was never aware that desense was occurring in his receiver. When asked why he didn't respond to a call, he might answer that he didn't hear your call. This can create problems both from the personnel standpoint and technical standpoint. The technician is called to check his radio, and no problem is found. Is the receiver intermittent? Is the vehicle operator lying? Is the radio technician incompetent?

Parameters such as desense, intermodulation immunity and dynamic range all are interrelated. The design of the receiver front end has a great bearing on all of these parameters. In receivers with a wide front-end design, users must be careful to reduce the possibility of overload from strong, off-channel signals. Avoid using a receiver with a wide front end as a base station—especially at a site with many local transmitters. If you must do so, then use a couple of bandpass cavities ahead of the receiver. If you are operating single-frequency simplex, it can help the site noise problem if you run the transmitter through the cavities also.

Until next time—*stay tuned!* ■