"Dual Conversion Receivers Are Better Than Single Conversion Receivers" *… Fact or Fiction??*

Much has been written about the performance of "Dual Conversion Receivers" (DC Rx) versus that of "Single Conversion Receivers" (SC Rx).

In general, it is assumed that all DC Receivers are 'better' than all SC Receivers, an incorrect assumption, often based on experiences with low-cost park flyer receivers which are, in general, Single Conversion Receivers. Many people have had good experiences with these park flyer receivers; others have had bad experiences with them.

PARK FLYER RECEIVERS

These receivers were designed with four goals in mind: 'reasonable' range, small size, lightweight, and inexpensive to manufacture. It will be clear that, in order to achieve these goals, these receivers are designed with a minimum in components to get the job done. As such, they will function adequately when used for their intended purpose, i.e. to control a park flyer type model within relatively close proximity, on a quiet day—and then only when and if not too many other transmitters on other frequencies are around.

These small, inexpensive receivers have made a great contribution to the hobby in that their low cost and easy availability has brought an influx of new modelers into the hobby. However, when these newbies started flying in more congested areas or busier flying fields, they often began experiencing all kinds of glitching problems.

The reasons are one or more of the following:

ADJACENT CHANNEL INTERFERENCE

Say you are flying on channel 50 and someone turns on his transmitter on channel 51. The channel spacing in the USA is 20 KHz. Since nothing in this world is perfect, your channel 50 receiver will see a tiny bit of high frequency radio energy (RF) from the channel 51 transmitter that is radiating RF energy only 20 KHz away from your frequency. Therefore, if your receiver has sufficient RF filtering to reject this small amount of adjacent channel RF energy, you will not have a problem. Good filters are large and expensive. They are typically not used in Park flyer receivers. It gets even worse when your airplane is closer to the other guy's transmitter than to yours.

INTERFERENCE FROM PAGERS AND OTHER TRANSMITTERS

Some 25 years ago, when the FCC allocated the many frequencies we are now using, a channel spacing of 20 KHz was assigned. This required the manufacturers of R/C receivers to look for filters which had to provide sufficient neighboring channel suppression at 20 KHz. In the years since then, the FCC has allowed 'other' transmitters to operate in-between 'our' channels. Examples are railroad signaling and communication devices, and pager transmitters. The latter can be very strong because they have much higher output energy than our small R/C transmitters. So, instead of having to design receivers for a 20 KHz channel spacing, the engineers now all of a sudden had to design R/C receivers for a 10 KHz channel spacing, which required the development of even better IF filters! Again, these filters may not be found in Park flyer receivers.

SWAMPING

A weak front-end in the receiver can make it sensitive to swamping. "Swamping" is overload of the receiver front-end as a result of a strong interfering signal on 'any' frequency or channel, as might be encountered by flying the model close to someone else's transmitter or in an area which is close to pager or railroad transmitters. The result is that no signals from your transmitter get through to your model. Not good!

3IM (sometimes erroneously called 3OIM)

Third-order Intermodulation (3IM) products are caused by the mixing of two RF signals which are not on your frequency, to produce a signal which is on your frequency. This mixing typically happens in the front-end of the receiver and is caused by operating the front-end in a non-linear part of its range. In simple SC or DC receivers, there is no easy way to fix this; it costs parts, room and money to do so.

As an example, say you are flying on channel 50 so your carrier frequency is 72.790 MHz. Now, two more people arrive at the field and they have channels 51 and 52. With a reasonably good receiver, if either one of them turns on their transmitter, you will maintain control. However, when both of them turn their transmitters on, the following will happen. The RF energy radiated by the transmitters on channels 51 (72.810 MHz) and 52 (72.830 MHz) will create, when encountered by a 'cheapie' receiver's non-linear front-end, several undesired signals, with one of the worst ones being 2x [frequency of channel 51], e.g., the second harmonic, minus 1x [frequency of channel 52] which is (you guessed it!) exactly the frequency of channel 50, which is *your* channel! Now, only a 'good' receiver will suppress this interfering signal set. For this it needs: controlled, very linear operation of the front-end, and other suppression techniques (some of which are proprietary). All these efforts are, of course, not implemented in the simple receivers, because they require (a) additional components with their inherent additional size and weight, and (b) additional cost.

SENSITIVITY AND RANGE

Of course, a receiver has to have sufficient range to control the model as far away as the user can (or wants to) fly it. It is clear that a small park flyer or helicopter is kept a lot closer in than, e.g., a pattern or turbine-powered model or a large sailplane. Therefore, most park flyer receivers have a limited range, whereas the higher-end receivers have what is commonly termed "full range."

A definition of "full range" would be "as far as you can see your airplane," with sufficient margin that when things go wrong or are not as intended by the original equipment manufacturer (low battery, reduced-size antenna on transmitter and/or receiver), you still have full and reliable control.

It should be noted that nowhere in this definition is the term SC or DC receiver used since "full range" has nothing to do with the type of receiver but only with the reliable or usable sensitivity/range of the receiver.

REJECTION OF SIGNALS ON THE IMAGE FREQUENCY

This effect, also known as "Image Frequency Problem," has been the subject of many assumptions, misunderstandings and incorrect statements in recent conversations on some bulletin boards.

Both DC receivers and SC receivers utilize conversion techniques to arrive at a 455 KHz intermediate frequency (IF) for ease of amplification and demodulation. DC receivers do this in two steps (Dual Conversion) and SC receivers do this in one single step (Single Conversion). But in both types of receivers, final filtering and demodulation is performed in exactly the same way, i.e. at a 455 KHz IF.

In the conversion process, the incoming signal on, say, channel 50 (72.790 MHz or 72,790 KHz) is converted to a lower frequency by means of a mixing process. Inputs to this mixer are the transmitter frequency (72,790 KHz) and the crystal frequency (xtal freq). Outputs from the mixer are the sum and the difference of these two frequencies, plus a whole bunch of undesired mixing products such as harmonics of transmitter frequency plus-and-minus harmonics of crystal frequency.

The crystal frequency on channel 50 in an SC receiver is 73,245 KHz, so the difference in frequencies is 455 KHz. The SC receiver filters this out, amplifies it and does some other neat tricks to the signal, demodulates the original transmitter signal and preps it for the decoder, which unravels these data so that it can feed each individual servo. Neat and simple. But…the receiver is (almost) as sensitive to a signal with a frequency that is two times your 455KHz IF (910 KHz) plus your transmitter frequency.

As an example, channel 50 is 72.790 MHz; add 910 KHz, and the image frequency is 73.700 MHz. Your receiver will see a signal on that frequency just like your channel 50 frequency. This is a law of physics, unavoidable, and we engineers had better design for it. And we have. We also have a name for it: Image Frequency (IF).

With a DC receiver, things are exactly the same, except that the DC receiver utilizes two mixing processes: the first one typically resulting in an IF of 10.7 MHz, the second one resulting in the (same as for the SC receiver) 455 KHz IF.

The (first) mixer has outputs of [transmitter frequency] minus [crystal frequency] and also has an image on the other side, the image frequency. But the image frequency is farther removed from the desired frequency; and, therefore, signals on the image frequency can be filtered out better (to some extent). But…this mixer also produces a whole bunch of undesired mixing products of harmonics of the transmitter frequency plus-and-minus harmonics of the oscillator frequency. Some of these are filtered out in the 10.7 MHz first IF filter, but this filter is MUCH too wide to filter out all undesired signals.

This 10.7 MHz filter in a quality DC receiver is a simple two-pole crystal filter with a typical bandwidth of—depending on type—anywhere from 80 KHz to 500 KHz (4~25 channels) at the 35 to 40 dB point. For neighboring channel suppression, a minimum of 60~70 dB is required; thus, this filter does not hack it. Therefore, the DC receiver employs a second mixer, using yet another crystal, to arrive at the same 455 KHz frequency where the SC receiver already was after its first conversion. In this second mixing process, the DC receiver produces additional spurious mixing products (harmonics of input signal mixed with harmonics of the crystal frequency), so there are even more undesired frequencies to which a DC receiver may react.

This does not make a DC receiver bad (or good). Nor does it make an SC receiver bad (or good).

Let's tackle the solutions to the above conditions.

ADJACENT CHANNEL INTERFERENCE

This requires the use of a very high quality filter in the 455 KHz IF in both SC and DC receivers. Most simple, inexpensive receivers do not have enough room (or money invested) for a really good filter so don't use it. Note that there is a difference between "good enough most of the time" and "highest quality."

INTERFERENCE FROM PAGERS AND OTHER TRANSMITTERS

Again, this requires the use of a high-quality filter in the 455 KHz IF in both SC and DC receivers. It is ignored in most simple, inexpensive receivers.

SWAMPING

This happens (almost) entirely in the front-end of the receiver. Some receivers can have circuits saturated (swamped) in other parts as well. It requires very careful design. The requirement is the same for SC and DC receivers and is mostly ignored in park flyer receivers.

3IM

This requires very careful design. It can be achieved with equal quality in SC and DC receivers. Some manufacturers of DC receivers (FMA) and of SC receivers (JR, Berg, Schulze, Multiplex) use exotic techniques to achieve good 3IM performance. Typically ignored in park flyer receivers.

SENSITIVITY AND RANGE

Sensitivity and range are directly related to each other. More sensitivity = more range. However, range should be expressed as "usable range"; i.e., distance you can fly without interference. In some receivers, range is reduced to also reduce the sensitivity to interference from undesired signal sources (other transmitters, spark interference, etc.). With careful design and the investment in best quality parts, both SC and DC receivers can be made sensitive enough to qualify for full range without experiencing interference (glitches).

IMAGE FREQUENCY SUPPRESSION

Image frequency suppression is easier in general with a DC receiver than with a SC receiver. This is the only advantage of DC receivers.

Design guidelines which favored DC receivers were based almost 25 years ago on then-current technology. Modern integrated circuits and design techniques, better packaging with surface mount technology, and now the use of microcomputers in the decoder, have increased the receiver's ability to separate the good from the bad by carefully weighing and measuring each and every change in the signal it receives from your transmitter and eliminating the signals it receives from any other signal source. The difference in performance between well-designed DC receivers and well-designed SC receivers has all but evaporated.

SINGLE CONVERSION VS. DUAL CONVERSION RECEIVERS (one more time)

There is a place for every kind of receiver. Park flyer receivers belong in park flyers. Do not put them in a large sailplane which you will 'speck out' against a nice blue sky. Do not fly them on congested fields or in domes with conductive (reflecting) trusses.

There are some very good single-conversion receivers on the market today. There are also some darned poor examples.

There are some very good dual-conversion receivers on the market today. There are also some darned poor examples.

In general: Listen to what other people's experiences are, and go with a brand that others have had good experiences with. Otherwise, you are a test pilot. Is your model worth it?

OK, and now one-on-one:

ADVANTAGES OF A DC RECEIVER

Higher suppression of the image frequency—was useful 25 years ago but today, with much improved 455 KHz filters and microprocessor decoding techniques, not a big issue anymore.

ADVANTAGES OF AN SC RECEIVER

Only one conversion step—results in about half the spurious frequency responses.

Fewer parts—can be built smaller and lighter with lower cost.

Only one crystal to break. DC receivers have three crystals.

Take your pick.

Peter Berg