What's Wrong with our Present Receivers?

Multiple Conversion, Filters and IF
DSP

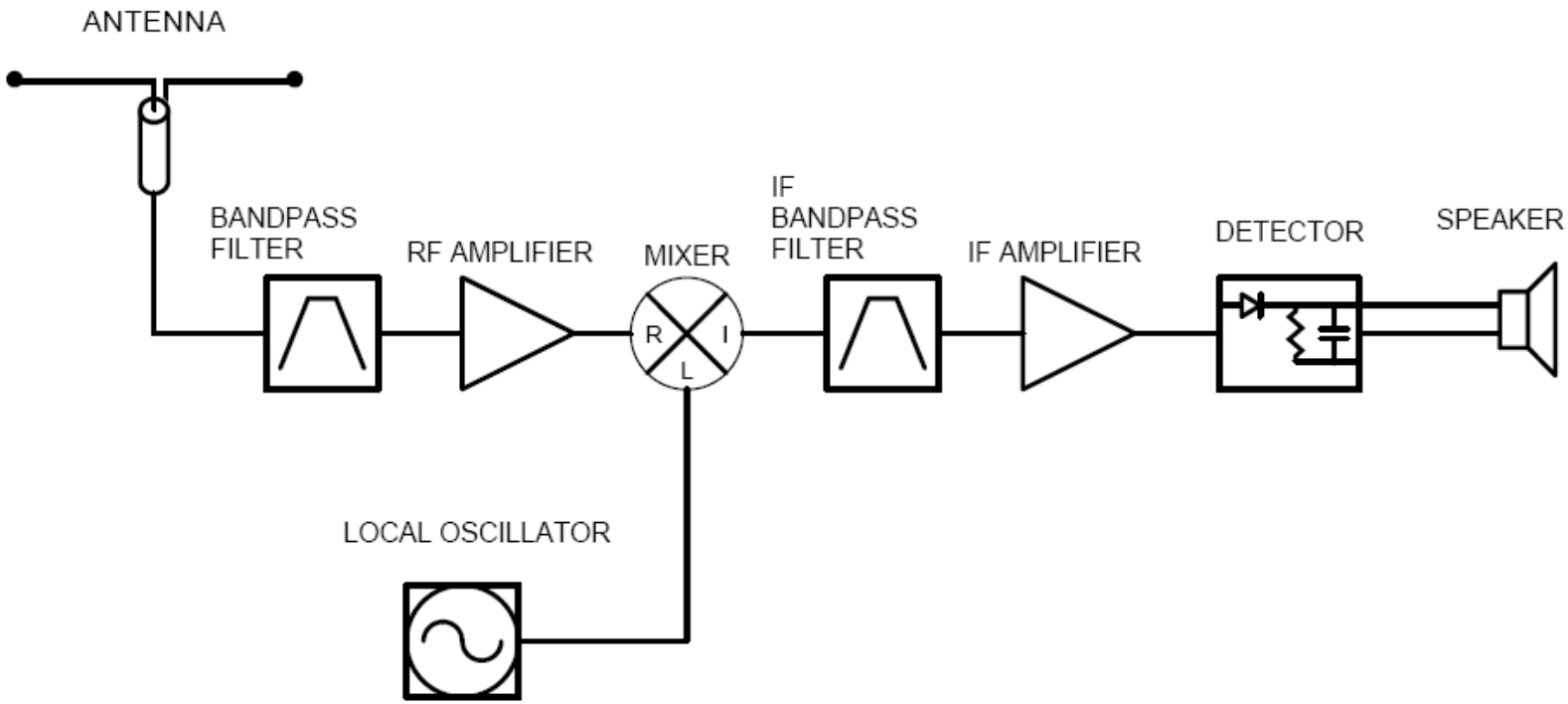
Topics:

- Single-Conversion and Multiple-Conversion
- Analog (Crystal) IF filters and DSP Filters
- IF DSP – How it works

QST, JANUARY, 1957
"What's Wrong with Our Present Receivers?" By Byron Goodman, W1DX

- "…no better attack on the cross-modulation problem was proposed than … putting the adjacent channel selectivity as close to the antenna as possible."
- "…the high-frequency band-pass crystal filter makes it possible to build a receiver that overcomes the ills thrust upon us by multiple conversion…"

Single Conversion



WHEN LO=RF+IF
RF IMAGE=LO+IF

Single Conversion Example

RF=14 MHz

IF=455 kHz

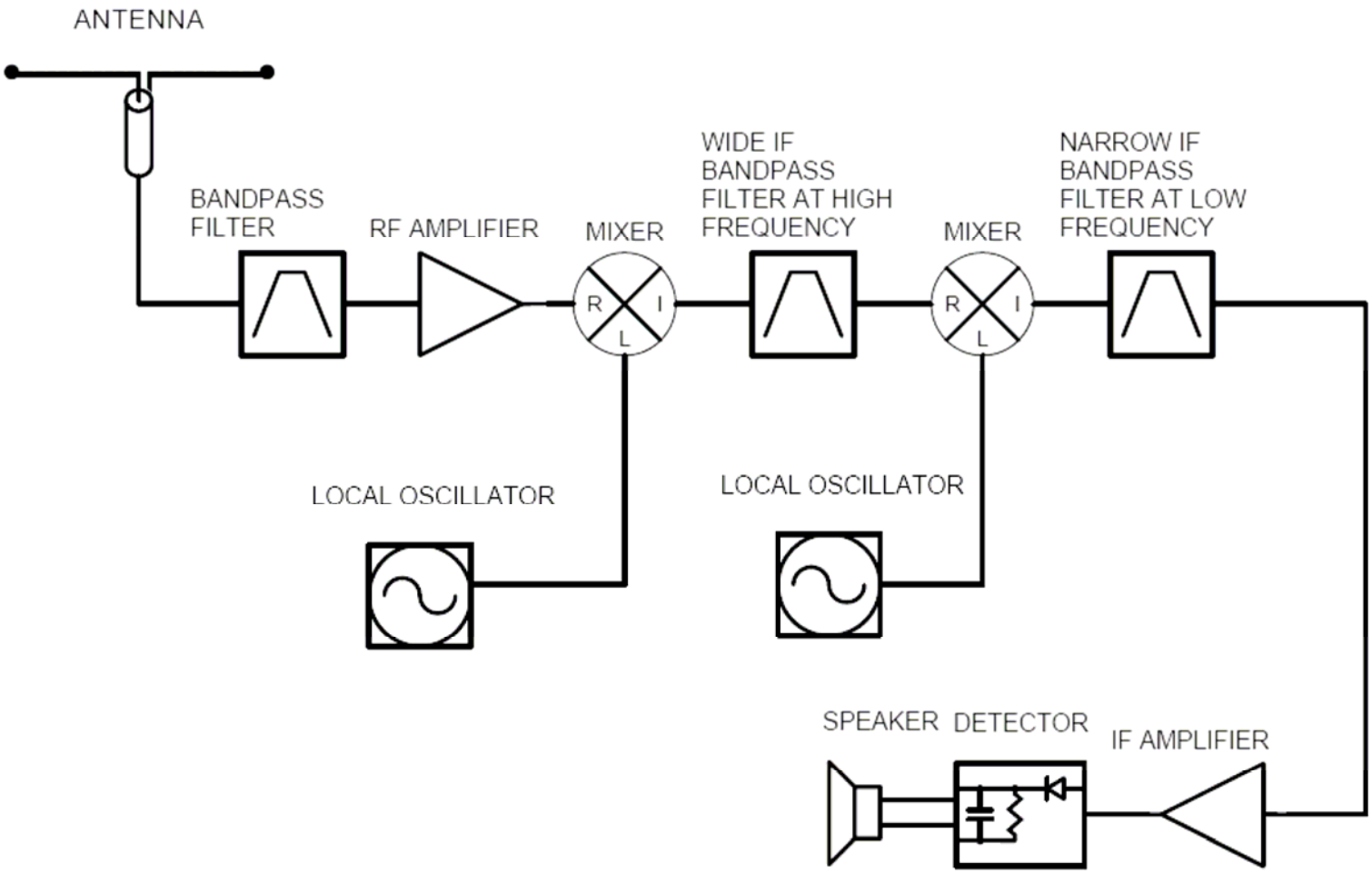
LO=14.455 MHz

Image Frequency is 14.455 + .455 = 14.910 MHz

The image is 910 kHz away from the desired signal.

This is too close for rejection by the RF band-pass filter.

Dual Conversion



Dual Conversion Example

RF=14 MHz

First IF=3.5 MHz

Second IF = 455 kHz

First LO=17.5 MHz

Image Frequency is 17.5 + 3.5 = 21 MHz

The image is 7 MHz away from the desired signal. It is much more easily rejected by the RF band-pass filter. The second IF image is at 3.955+0.455=4.410 MHz. This image is also easily rejected by the RF band-pass filter.

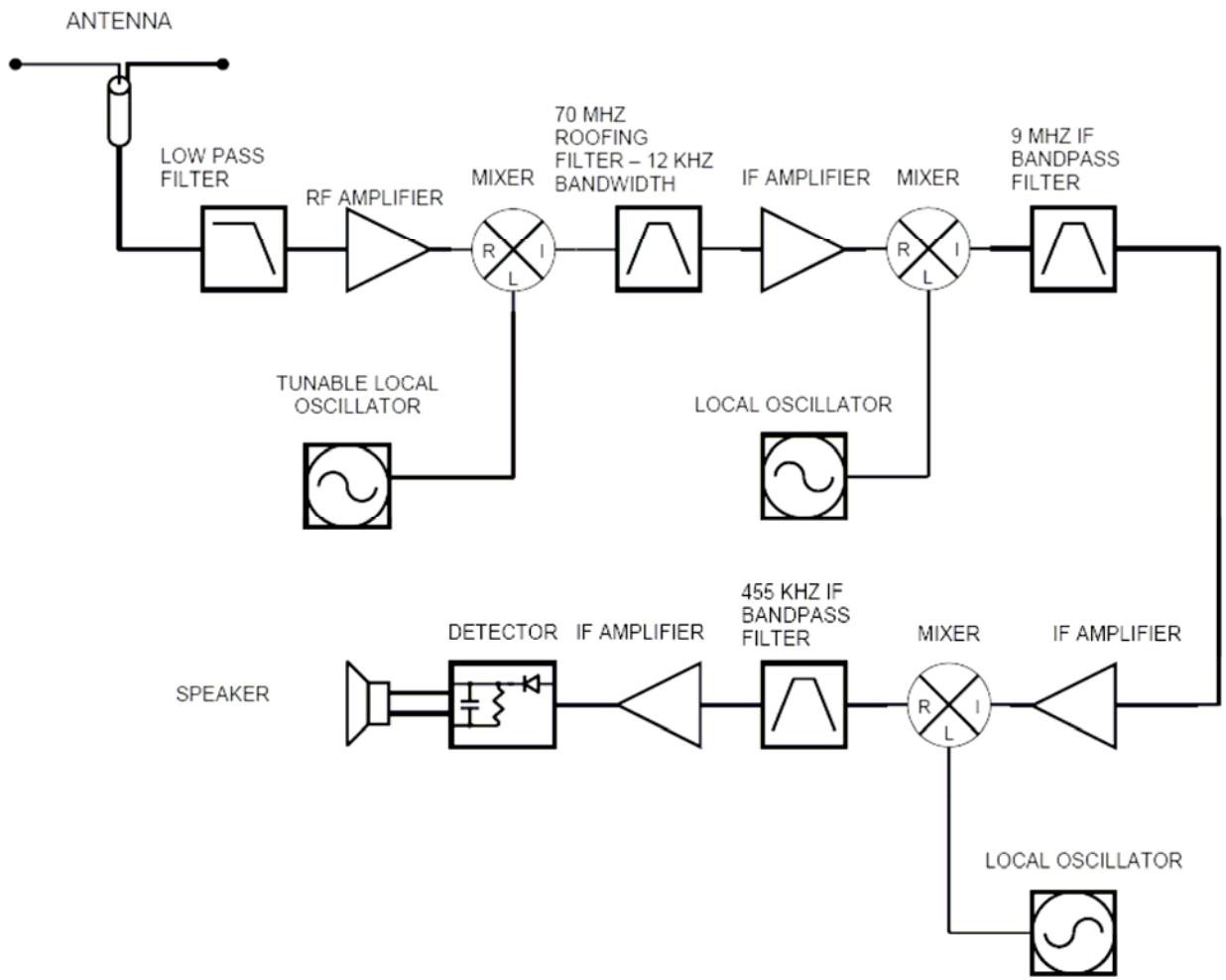
Multiple Conversion

- Allows narrow selectivity and good image rejection.
- Is subject to spurious responses – the more conversions, the more birdies.
- Is highly vulnerable to IMD problems.
- Is a good solution in a world with only LC IF band-pass filters.

Single Conversion Design

- Is a loser if we only have LC IF band-pass filters
- Is a clear winner if we have narrow crystal filters at high IF frequencies, e.g. 9 MHz.
- Allows high gain stages to be placed after the filter, reducing IMD.
- Only one mixer and LO, fewer birdies.
- Can have good image rejection with a high IF.

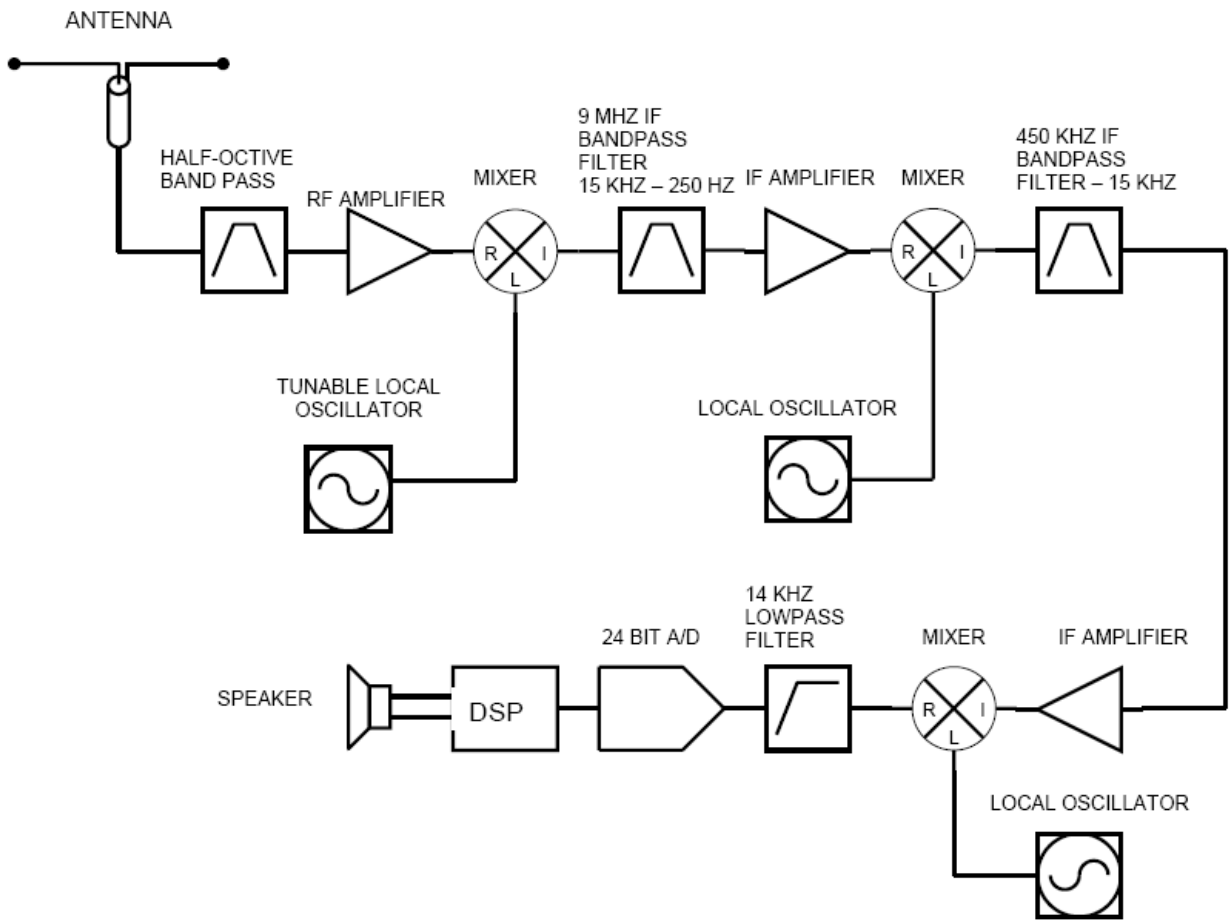
The 1990's Receiver



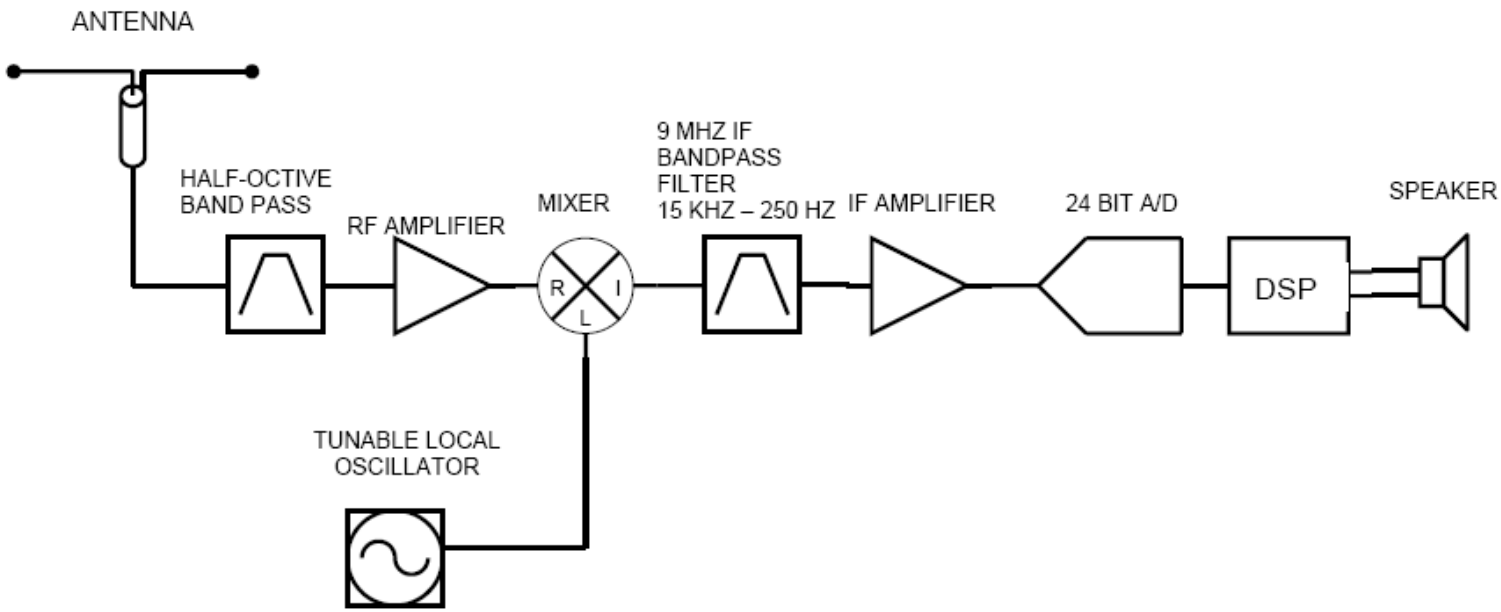
1990's Receiver

- General Coverage
- Easy PLL – less than 1 Octave.
- 70 MHz roofing filter can only be moderately narrow.
- Later versions had audio DSP, then IF DSP.
- Subject to problems of multiple-conversion receivers.

CA 2004 – TEN-TEC ORION



The Superhet of the Future



Why Crystal Filters?

- Why not just use DSP filters and get rid of the Crystal Filters?
- Crystal Filter Deficiencies.
- Is there a limit on A/D Dynamic Range?
- Is there a limit on Crystal Filter Performance?

Why do we still have multiple conversion receivers?

- Scott Robbins, W4PA of Ten-Tec
- Brian Wood, W0DZ of DZ Kits

WHAT IS IF DSP?

IF sampling receivers ("IF DSP" to Hams) have the A/D converter at the end of the IF chain. The IF signal is sampled directly by the A/D.

What is a Software Defined Receiver?

- IF sampling makes Digital Down-Conversion to base-band possible. DDC converters recover amplitude AND phase information from the signal.
- This in turn allows detection of ANY kind of modulation that will fit in the receivers pass-band – AM, FM, SSB, PSK, QPSK, etc.
- DSP processing recovers the modulation. Hence, software defines our receiver's capability.

Digital Down-Converter

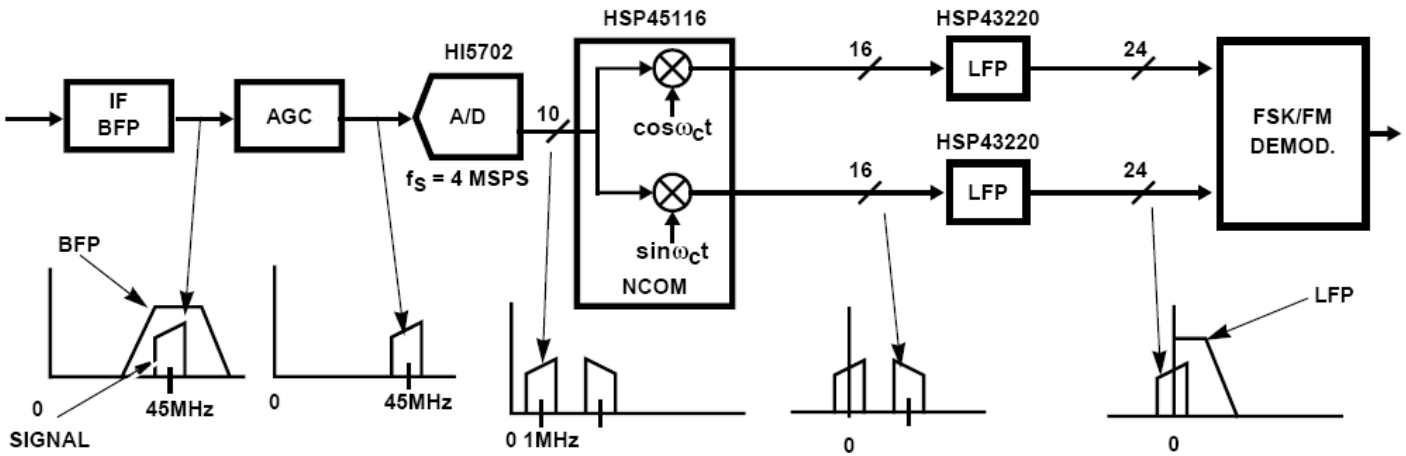


FIGURE 2. DIGITAL IF BASEBAND DOWNCONVERSION BLOCK DIAGRAM

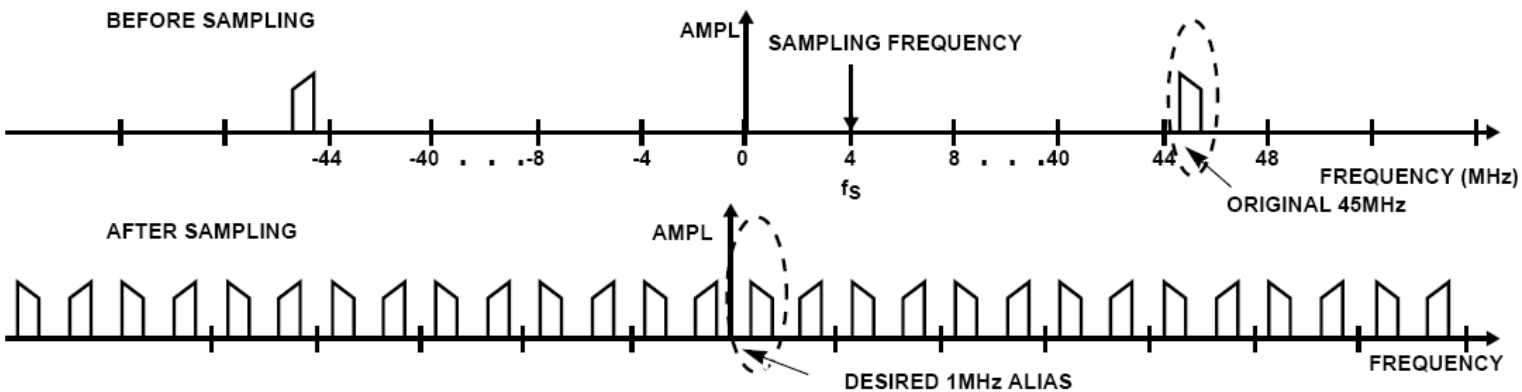


FIGURE 3. UNDERSAMPLING FREQUENCY PLAN

Under-Sampling

- If the ADC sample-and-hold is fast enough, we don’t need to sample at the carrier frequency, e.g. a 9 MHz IF can be sampled by an A/D with a 1 MHz clock and a Nyquist band of 0 – 500 kHz.
- The Nyquist band must be wide enough to contain the modulation bandwidth.
- The Sampling Clock must be low-jitter.

Over-Sampling

- If the Nyquist band is much wider than the modulation bandwidth, we get a free improvement in Signal-to-Noise Ratio (SNR) of 10 log (BW_N/BW_M)
- Over-sampling does not help Spurious-Free Dynamic Range (SFDR).

The Bottom Line

- Single-Conversion is the goal.
- DSP cannot replace Crystal Filters anytime soon.
- Get the narrow selectivity as far forward in the receiver as possible.
- Byron Goodman was right!