

# Microwave and Satellite Modems with AFC

6/1/04

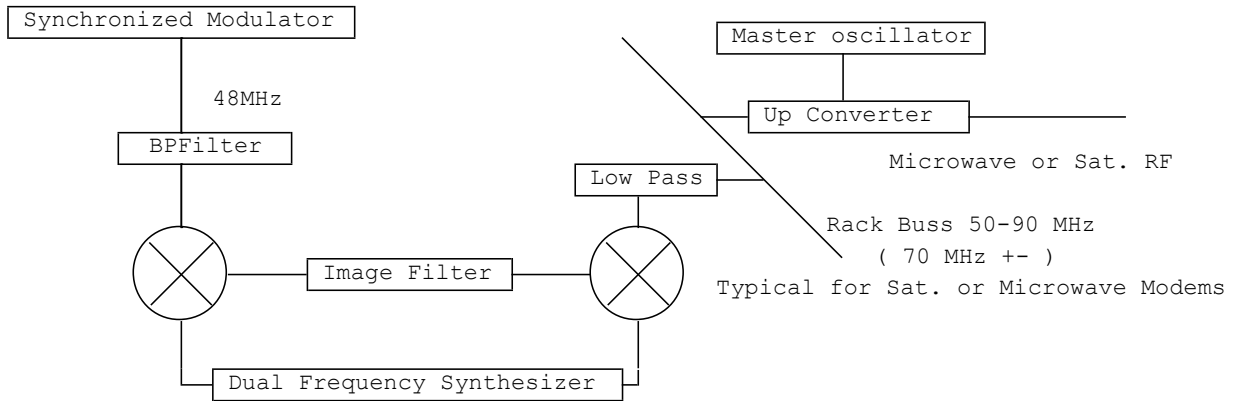


Fig. 1. Assuming the typical Microwave or Sat. feed has an IF frequency of 70+- MHz, the circuit of Figure 1 converts a fixed 48 MHz MSB signal to a frequency that can be placed anywhere within the modem band. The Image filter should be above 600 MHz. A Cellular diplexer at 835 MHz has been used satisfactorily. More than 12 cycles of converted frequency are required per cycle of 48 MHz IF frequency.

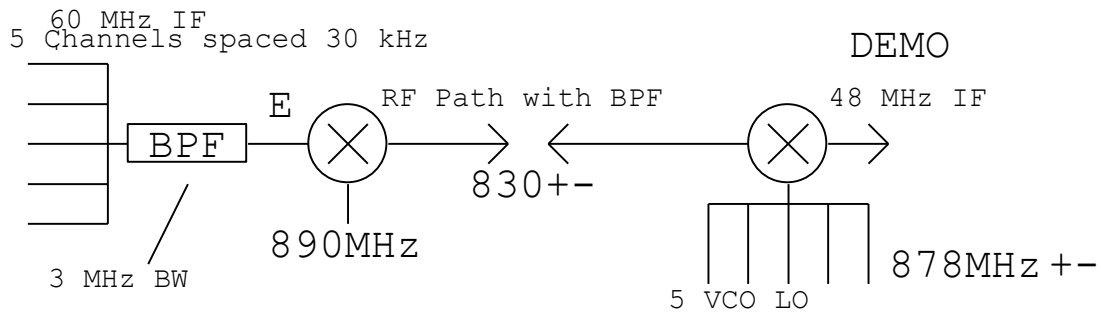


Figure 2. The receiver modem will have the desired signal somewhere between 50 and 90 MHz. This needs to be converted to a fixed IF frequency for detection. A dual frequency synthesizer is required. This circuit makes no provision for temperature or Doppler shift. There are other circuits that broaden the range for Doppler.

Figure 3 shows a method that will lock the receiver to the incoming frequency. This can be as much as 300 kHz off after a stage or two of Microwave repeaters, or over 100 kHz for some Doppler shifts. Voltage tunable TCXO blocks are available for the synthesizer reference.

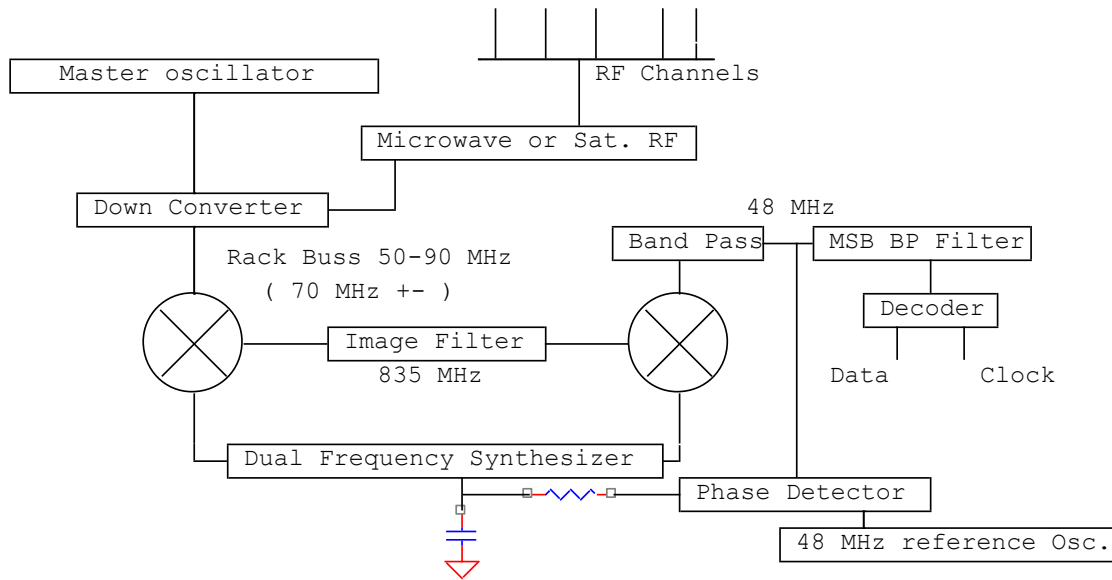


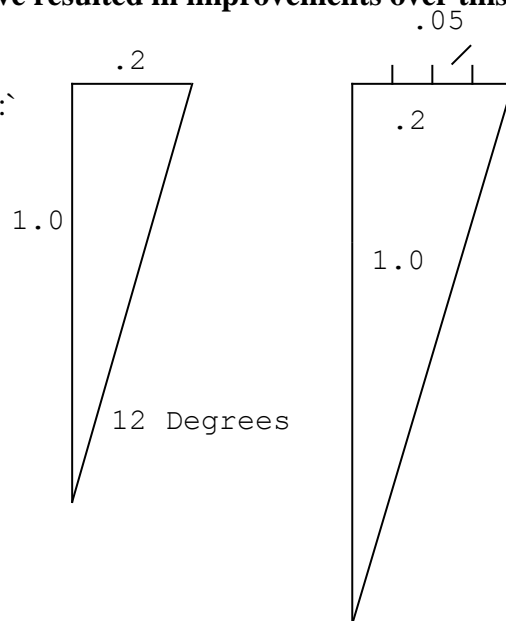
Figure 3. Automatic Frequency tracking to compensate for Doppler and temperature drift.

**6/9/05 note:**

**Recent developments have resulted in improvements over this earlier method.**

Interference Note:

Multichannel Interference:



To put the 5 channel interference problem in perspective.

Most of the zero group delay filters are also phase change devices, with loss. For example, at 48 MHz, the half lattice bridge filter has 1/2 the input phase remaining after each stage. Thus 3 stages will have +45, +22, +12 degrees. Only +12 degrees remains after 3 stages. The Sine 12 degrees is 0.2.

Any interference greater/stronger than 14 dB will cause an error. Now assume there are 4 interferers. Each can have only  $.05 \times 1.0 = -26$  dB level before an error appears, since the vectors sum.

Assume 12dB per stage, then the system holds up ( total -36 dB for 3 stages on the shoulders.) Two stages will not do it.

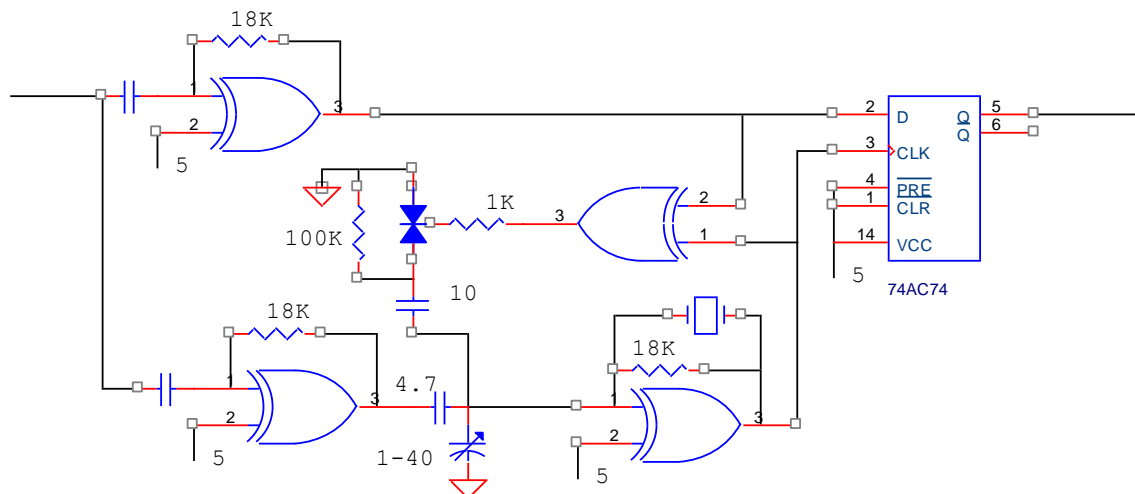
Some of the filters degrade in performance as frequency increases. ( circuit parameters, LCRZ etc.). One of the filter circuits will preserve a 180 degree equivalent, but makes a conversion from 3PRK to MCM. The following stages must then be zero group delay MCM filters, not zero group delay phase filters. There is a difference, and the signal cannot be limited.

If one stage at  $\pm 90$  is obtainable, then a second stage with  $\pm 45$  will tolerate a much higher level of interference. Needed is a phase loss ratio better than  $\frac{1}{2}$ .

I have resurrected the flywheel bridge filter from some time back. I have found a way to keep about 150 degrees of phase shift per stage. This means I can keep at least 90 degrees of phase shift total after 3 stages, so the interference has almost no effect. The shoulders are only 10 dB down per stage. I am rewiring the receivers to embody this filter. This filter can be limited, so it works with the iMeter.

The work at the moment ( after conversion to this filter ) is to come up with the best three stage combination that works with both fundamental as well as overtone crystals.

This basic analysis assumes there is no cross modulation in the circuits.

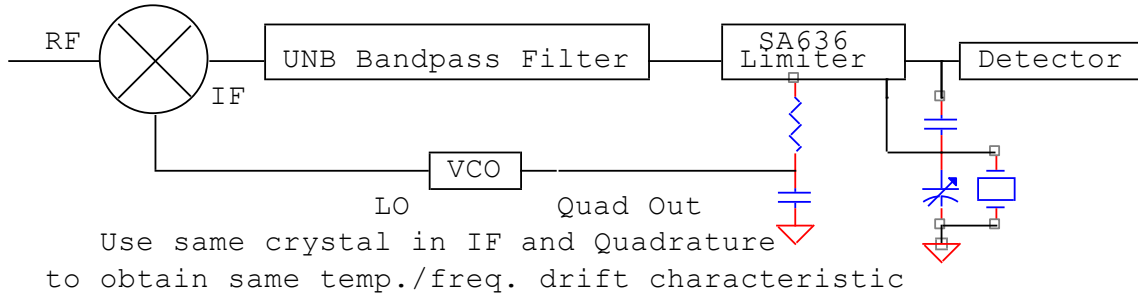


AFC ckt for Pliats det.

No cap on osc. out. Can add res and cap to varactor. May need series cap with crystal to tune in range.

The varactor feedback IS NOT REQUIRED BUT MAY BE EXPERIMENTED WITH.. Did not work well with Varactor alone.

**Does not consider Crystal Temp. stability.**



**If same crystal and circuit are used expect same freq./Temp change so filter and input should track.**

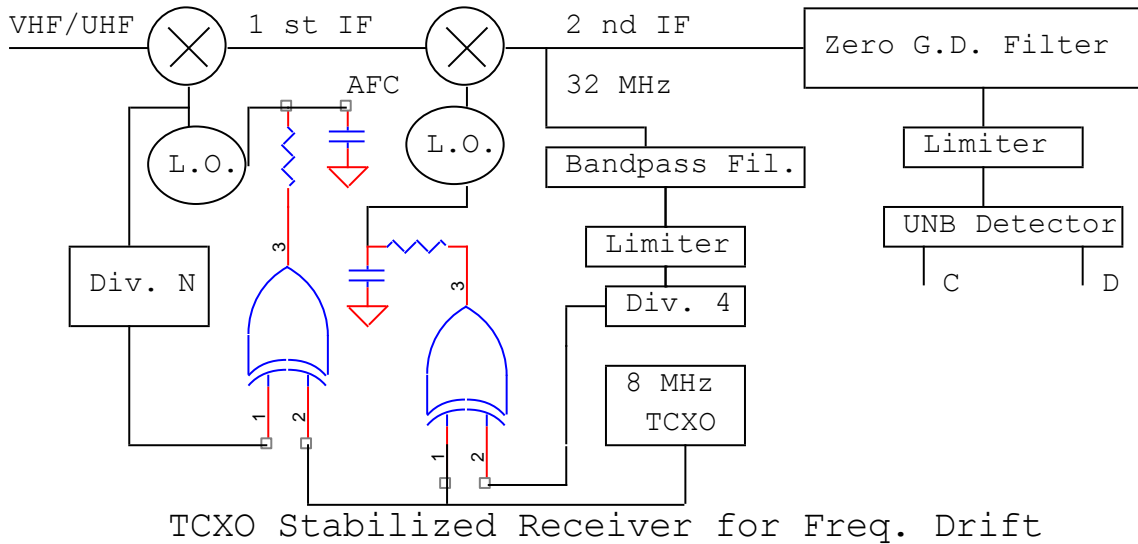


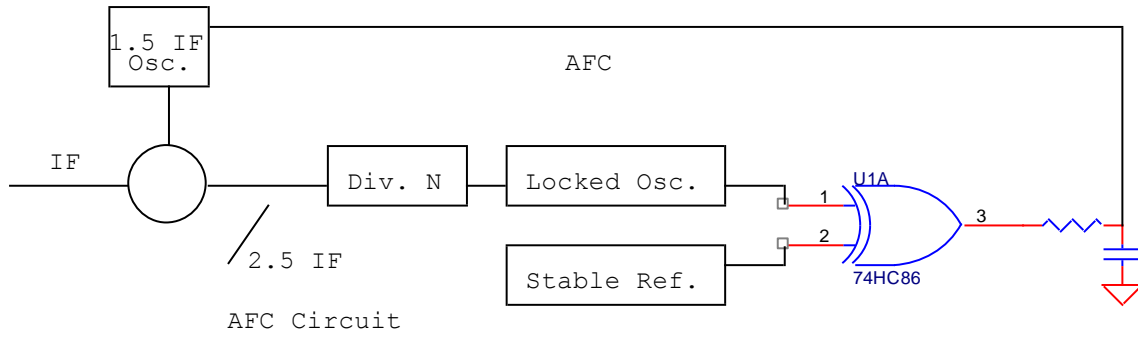
Figure 16.3. Dual conversion concept to obtain stable fixed IF for UNB detection.

In figure 16.3 an off the air signal that is not exactly at the desired frequency can be converted to the desired frequency by dual conversion. Assume the incoming signal is at 1,000 MHz, but is 10 kHz off from the exact desired frequency. The first conversion could result in a first IF of 100 MHz +/- 10kHz. The second conversion would be off 10 kHz unless the second local oscillator can correct it to be exactly at the desired 32 MHz. Dividing the 32 MHz by 4 yields 8 MHz +/- 2.5 kHz. This is compared to the TCXO at exactly 8 MHz and an error voltage corrects the local oscillator frequency to cause the IF to be exactlay at 32 MHz.

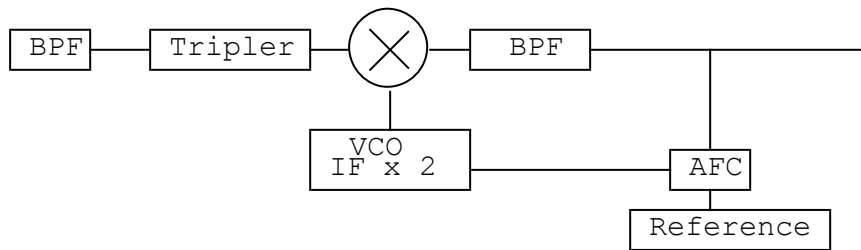
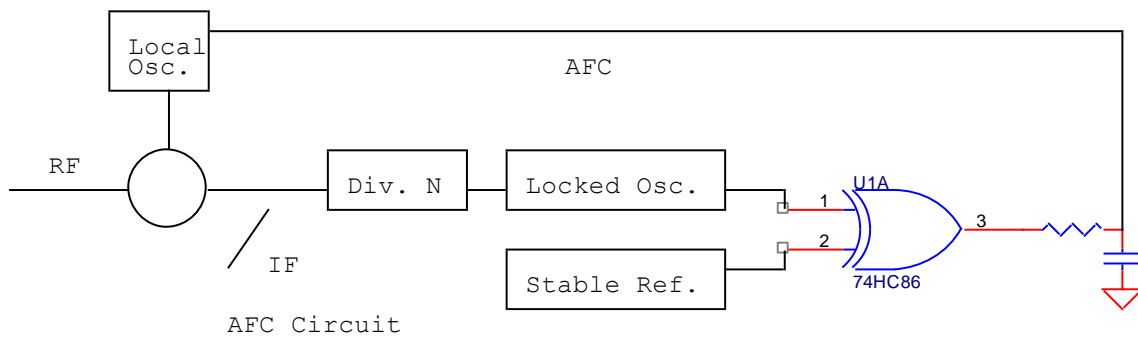
A locked oscillator between the limiter and the divide by 4 may be necessary to obtain the necessary stability and exact phase relationship.

The amount of off frequency that can be tolerated is dependent upon the bandpass filter bandwidth and the the absence of interference within that bandwidth.

This circuit is not an unusual concept. The first local oscillator, with its frequency synthesizer, is availble in off the shelf frequency synthesizer chips [1]. The second AFC circuit is the commonly used AFC circuit with the TCXO substituted for the usually used crystal or LC discriminator reference [2].



Detect from 2.5 IF. Could use other values ( 1.2 / 1.5 etc.)



- [1] Example --- National LMX2330L.
- [2] "Google" on Automatic Frequency Control.

**Doppler circuitry could also be added. See Chapter 16 of Textbook.**

## Doppler Circuitry:

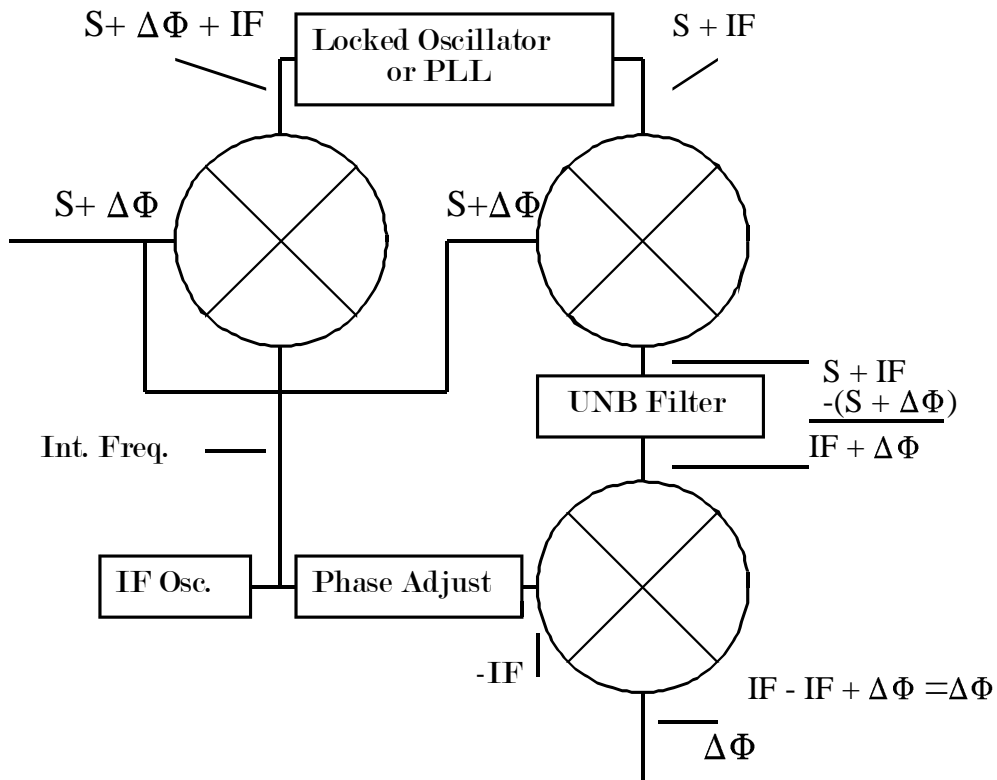


Figure 16.1. This concept functions with amplitude modulated systems such as RADAR and MCM, and with some degree of success with 3PRK. [ Ref. 3 ]

3PSK and NRZ-MSB are also end to end amplitude pulse methods, so it should function equally well.

The block diagram above shows how it is possible to overcome Doppler shift, or frequency drift, and provide a broader tolerance between transmitted and received signal frequencies. The carrier frequency  $S$  should be 12 or more times  $IF$ .

The purpose of the PLL, or locked oscillator, is to remove the phase shift  $\Delta\Phi$  by using a large  $T_g$ . The PLL with a long loop filter time will not pass the abrupt modulation changes. This is used to establish a reference in phase detector circuits. The PLL needs to track the Doppler shift, which is not an instantaneous phase jump.