CW/SSB Rig Frequency

By G8MNY   (Correction Sep 13)
(8 Bit ASCII graphics use code page 437 or 850, Terminal Font)

Rigs frequency readouts are not all what they seem. Here is an explanation of
why they can be wrong. With the older pre PLL rigs, tiny frequency errors of a
few 100Hz was considered irrelevant, but with 10Hz digital readouts it looks so
bad. A rig should be warmed up before any re-calibration is done!

MASTER OSCILLATOR
On modern PLL rigs there is an oscillator that is used to lock the VFO to.
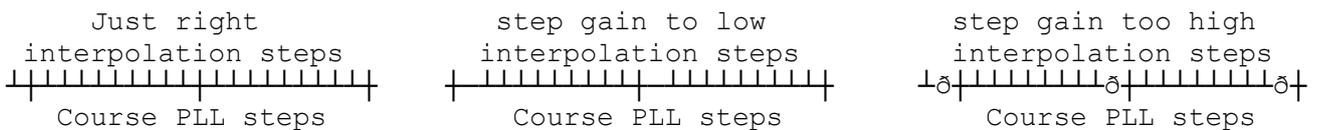Changing this will alter all the Tx/Rx frequencies.
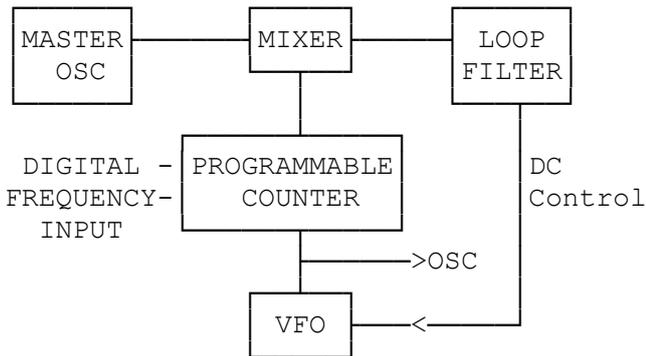
```
 ┌─────────┐      ┌───────┐        ┌────────┐       The PLL needs to do the whole
 │ MASTER  │──────│ MIXER │────────│  LOOP  │       of HF down to say 10Hz for
 │  OSC    │      │       │        │ FILTER │       good tuning, however correcting
 └─────────┘      └───────┘        └────────┘       a VFO only 10 times a second
                      │                             to get 10Hz loop steps is not
 DIGITAL ─     ┌──────────────┐   DC    │           a good strategy, as there is
 FREQUENCY-    │ PROGRAMMABLE │  Control │           slow tuning response & higher
   INPUT       │   COUNTER    │                      noise sidebands (wobble)
               └──────────────┘                      than a faster loop.
                      │   ────>OSC
                  ┌───────┐
                  │  VFO  │   <────
                  └───────┘
```

To solve this problem another method is used...

INTERPOLATION
This is a pre calibrated offsets of a crystal oscillator (often the master one)
Sometimes used for just a 5kHz FM rig shift, but more sophisticated may be up
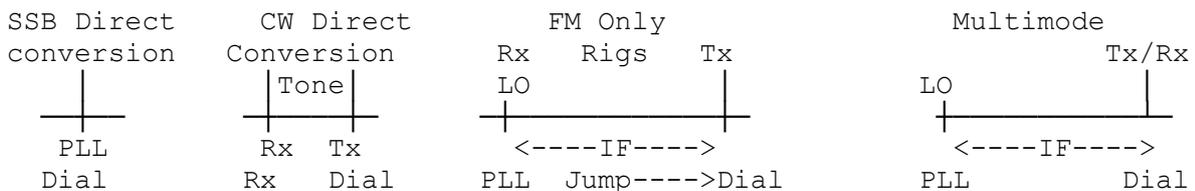to 256 fine steps.

More typically 100x 10Hz steps to fill in frequency gaps of a 1kHz PLL step
oscillator. Correctly set up the result can be perfect, but incorrect it will
give uneven jumps for each PLL step.

```
      Just right              step gain to low          step gain too high
  interpolation steps        interpolation steps        interpolation steps
 ┬┼┼┼┼┼┼┼┼┼┼┼┼┼┼┼┼┼┼┬        ┬ ┼┼┼┼┼┼┼┼┼ ┬ ┼┼┼┼┼┼┼┼┼ ┬    └ō┼┼┼┼┼┼┼┼┼ō┼┼┼┼┼┼┼┼┼ō┼
  Course PLL steps           Course PLL steps           Course PLL steps
```

So the gain of the interpolation offset steps needs to be just right, so that
at the PLL step exactly equals the interpolation frequency jump. An error here
may CORRUPT the PLL Master Oscillator calibration!

IF OFFSET
For direct conversion rigs the PLL is used directly as the Rx & Tx frequency in
SSB, but there is a Rx offset to generate a CW tone on Tx.

```
  SSB Direct      CW Direct       FM Only                  Multimode
  conversion      Conversion    Rx    Rigs   Tx                      Tx/Rx
                     │Tone│      LO               │           LO              │
        │               │  │     ├─────────────────┤          ├──────────────┤
      ──┼──         ──┼──┼──     ├──                          ├──
       PLL          Rx   Tx       <────IF────>                 <────IF────>
       Dial         Rx   Dial    PLL  Jump────>Dial           PLL           Dial
```

For superhets the Rx LO frequency is offset from the Tx frequency by the IF, so
the PLL is setup to do that.
In an FM only system, the PLL will be asked to jump to the Tx frequency on Tx.

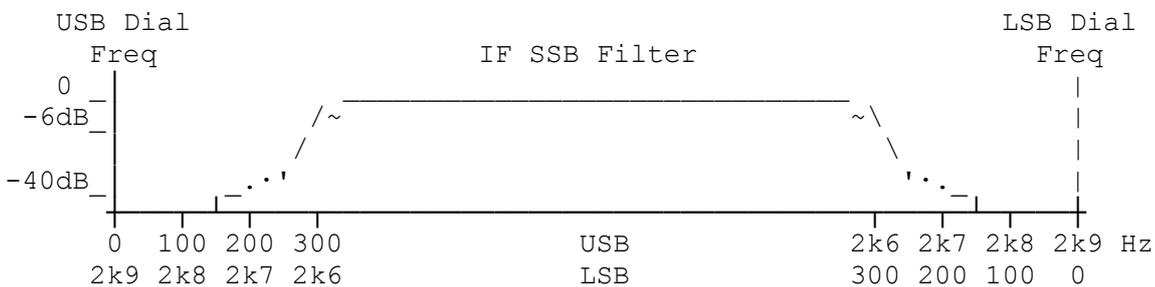(N.B. it must not Tx while jumping frequency!).
In a multimode the Tx signals are made at the IF frequency & may share the IF
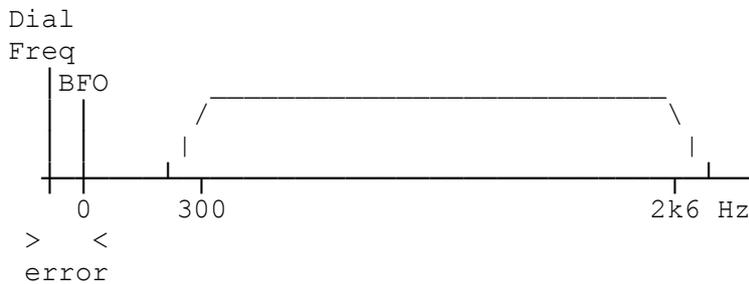filter for bandwidth limiting.

AM & FM
With these modes the Tx frequency is the same as the dial. If the rig uses a Tx
IF for these, it's frequency will need setting up to generate the dial
frequency. If this is not done after the PLL is set up, & the Tx freq used for
PLL calibration a frequency scaling error will occur & the PLL will be out at
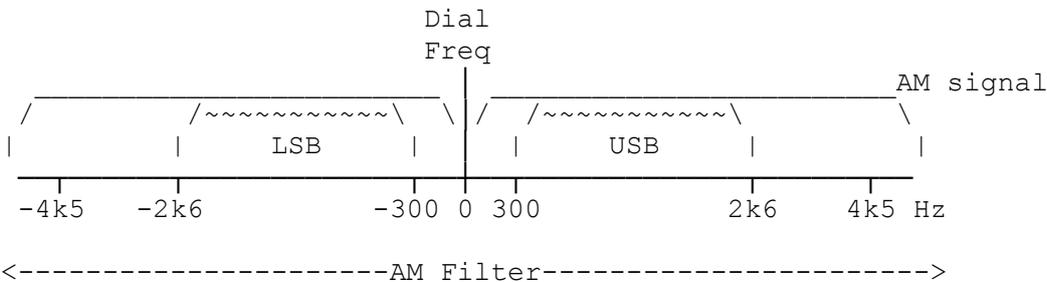other frequencies!

SSB FREQUENCY
As well as the LO being offset by the IF frequency the modulation &
demodulation uses an IF BFO in the product detector/mixer. So there is another
frequency to set up. With USB & LSB modes it is placed above or below the IF
filter. The PLL system is programed with these mode offsets....

```
    USB Dial                                          LSB Dial
       Freq               IF SSB Filter                  Freq
      0 _|                _____     |
   -6dB_|        /~      /                          ~\         |
        |       /                                      \       |
        |      /                                        \      |
  -40dB_|   _..'                                        '.._   |
        |__|_____|__|
         0  100 200 300              USB         2k6 2k7 2k8 2k9 Hz
         2k9 2k8 2k7 2k6             LSB         300 200 100  0
```

On non PLL rigs the BFO is normally set up to place the IF filter at it's best
place for good communications frequencies e.g. 300-2600Hz. But with a PLL
design a BFO frequency error will put the dial out!

```
     Dial
     Freq
       |  BFO        _____
       |  |         /                            \
       |  |        |                              |
       |__|_____|_____|___
          0       300                            2k6 Hz
       >   <
       error
```
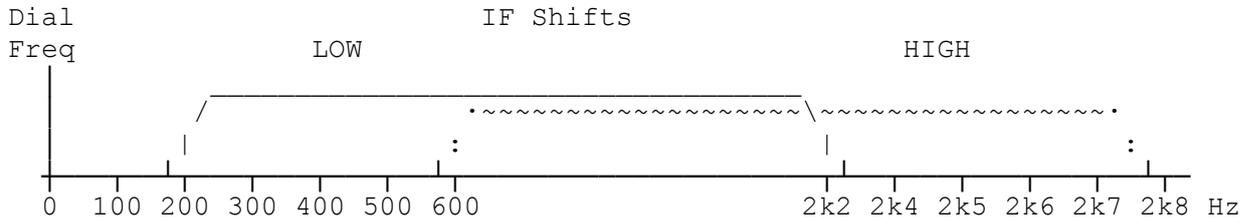
An exacting way of checking this is to tune into an accurate AM broadcast
signal & select AM, USB, & LSB modes, & see if there is any pitch difference,
there should be none. (If the rig display is one that jumps in frequency
between modes, it will need resetting to the station's frequency when U change
mode.)

```
                              Dial
                              Freq
    _____      |_____AM signal
   /          /~~~~~~~~~~~\     \ |/    /~~~~~~~~~~~\              \
   |          |     LSB     |     ||   |     USB     |             |
   |_____|_____|____ |_|__|_____|_____|___
  -4k5      -2k6          -300  0 300              2k6           4k5 Hz

       <--------------------AM Filter-------------------->
```
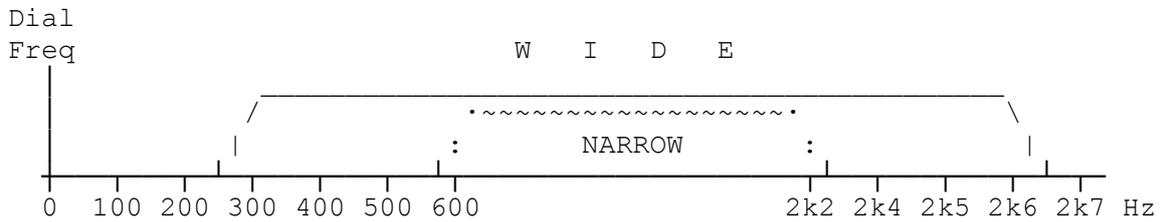
Use the RIT to eliminate USB/LSB pitch difference. Fixed RIT difference may
indicate the PLL is off, a different amount of RIT for USB than LSB indicates
the IF BFOs are off.

IF SHIFTS/WIDTHS
Rigs using double conversion & 2 IFs it is possible to overlap filters of
different frequencies to change the BFO to IF frequency without an apparent
frequency shift or to get variable IF widths.

```
    Dial                        IF Shifts
    Freq                LOW                           HIGH

                         _____
                        /          .~~~~~~~~~~~~~~~~~~\~~~~~~~~~~~~~~~~~·
                        |          :                 |                 :
         ┬───┬───┬───┬───┬───┬───┬───────────────────┬───┬───┬───┬───┬───┬
         0  100 200 300 400 500 600                  2k2 2k4 2k5 2k6 2k7 2k8 Hz
```

To do this the BFOs/LO are mixed together so that the overall IF difference is
nil.

```
    Dial
    Freq                        W   I   D   E
                    _____
                   /          .~~~~~~~~~~~~~~~~~~·                \
                   |          :     NARROW       :                |
         ┬───┬───┬───┬───┬───┬───┬───────────────────┬───┬───┬───┬───┬
         0  100 200 300 400 500 600                  2k2 2k4 2k5 2k6 2k7 Hz
```
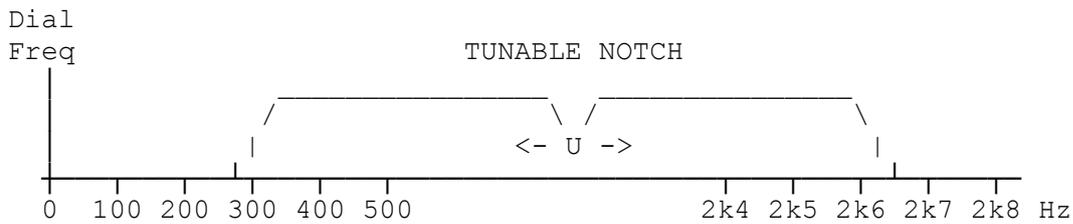
Different makers use different controls for these functions. Simple ones let
you narrow the width by removing top or bottom bandwidth in a single control,
more complex ones use 2 controls to give a full combination of the 2 functions.

When set up properly IF shift & bandwidth should not affect calibration, but
they will need calibration in them selves, so that the filters do overlap fully
for the widest IF, say when the control is in the middle. This may have
consequences for the Tx IF/SSB tone.

NOTCH FILTER
This is a crystal that is tunable across the IF to filter out unwanted signals
on spot frequencies.

```
    Dial
    Freq                     TUNABLE NOTCH
                        _____   _____
                       /              \ /              \
                       |         <- U ->|              |
         ┬───┬───┬───┬───┬───┬───┬───────────────┬───┬───┬───┬───┬
         0  100 200 300 400 500              2k4 2k5 2k6 2k7 2k8 Hz
```

It will not affect frequency calibration, except to itself so the centre of
control is centre of IF.

CW MODE
Note this is a split frequency mode! In Rx the offset PLL or IF frequency is
set up to produce a CW tone ideally equal to the CW Tx sidetone say 700Hz.
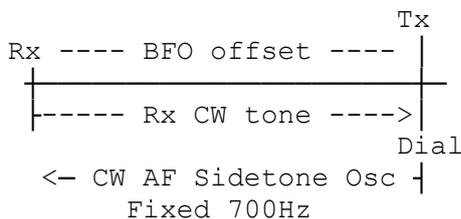
```
                          Tx
   Rx ---- BFO offset ---- |          Like the SSB mode to do
   |------------------------|          this the PLL or IF BFOs
   |------ Rx CW tone ---->|          are shifted between Tx
                         Dial          & Rx & the 2 frequencies
      <- CW AF Sidetone Osc |          will need setting up if the
          Fixed 700Hz                  rig is being calibrated.
```

Then tuning in to a CW station at the same pitch has your CW Tx sidetone you will be able to Tx EXACTLY on the same frequency & not a few 100Hz out!

If there is a narrow CW IF filter then the BFO will need to be calibrated for that to do the same.

CONCLUSION
Of course the above is all true for DSP as well, except that all the calibrations are in the software, so if the master PLL is OK all should be OK.

But generally to calibrate a Rig's frequency there are several BFO oscillators to set up.. USB, LSB, CW Tx, CW Rx, AM Tx & FM Tx, as well as the PLL master oscillator. VHF/UHF sets may have other up mixer oscillators as well.

See also my TECH buls on "Calibrating Frequency", & "Off air lock ref osc".

Why don't U send an interesting bul?

73 de John G8MNY @ GB7CIP