



Rev. 910208

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SOURCE LOCKING FROM 110 GHz TO 170 GHz

A variety of applications, including radio astronomy, plasma physics, and interferometry systems, require stable signals between 110 GHz and 170 GHz. For frequencies up to 110 GHz, the EIP Model 578B Source Locking Microwave Frequency Counter is commonly used for stabilizing electronically tunable millimeter wave signal sources. There are two methods that enable the 578B to stabilize signals above 110 GHz.

One method is to use a tunable source with a fundamental frequency of 1/2 the desired frequency and then double the output to get the final frequency. Using this approach, the 578B could be used for source locking up to 220 GHz, but the source must provide an output at the fundamental frequency. A disadvantage to this method is the conversion loss of the millimeter wave doubler which significantly reduces output power.

Another approach, which is the primary focus of this application bulletin, is to combine the capabilities of the 575B, a 20 GHz version of the 578B, with the 588B, a pulse/CW counter that supports frequency measurement through 170 GHz. In the 575B/588B method, the 588B downconverts the 110 to 170 GHz millimeter wave signal to an IF. The 588B, shown in Figure 1, is modified to provide a prescaled IF output at rear panel. The 575B samples the IF and provides a control voltage to modulate the frequency of the millimeter wave source as required to hold the frequency of the IF constant. By holding the IF constant, the millimeter wave output of the source is stabilized. Figure 1 is a block diagram of the equipment setup required for source locking between 110 GHz and 170 GHz.

Using the setup described in Figure 1, millimeter signals can be stabilized to the accuracy of the 575B time base (typically 1×10^{-7} per month), and can be tuned in steps as small as 40 kHz. Also, the millimeter setup can be automated by putting the counters under GPIB control.

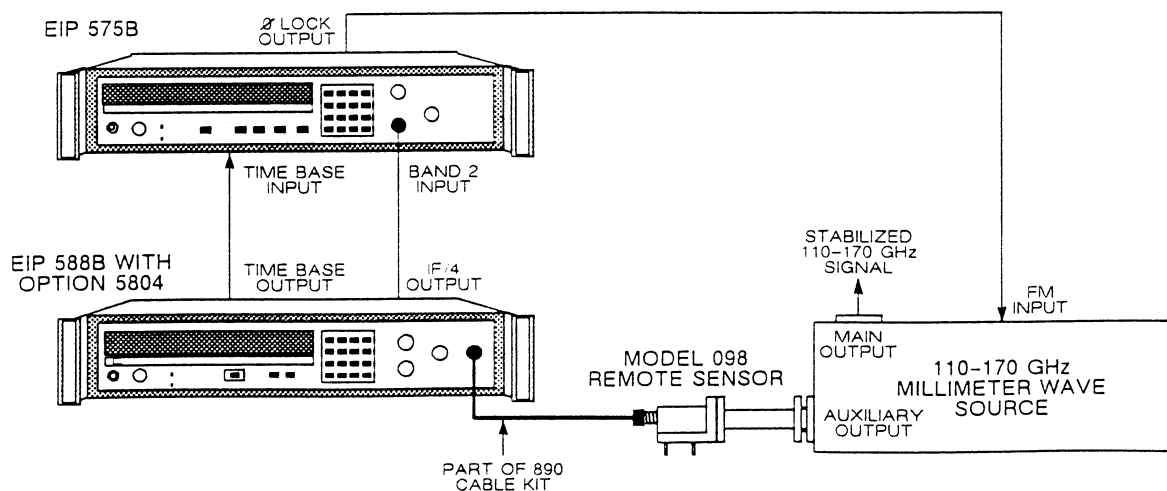


Figure 1. Equipment Setup for Source Locking 110 GHz to 170 GHz.

GENERAL INFORMATION ON SETUP

The IF output from the millimeter wave converter inside the 588B is approximately 675 MHz. This signal is first buffered and then prescaled by four prior to being routed to the rear panel of the 588B. Therefore, the frequency of the signal applied to the 575B is approximately 168.75 MHz (675 MHz/4).

Most millimeter wave sources have both electrical and mechanical tuning. Coarse frequency adjustment is performed by mechanical tuning. The FM input on the millimeter wave source allows electrical tuning, but only over a very limited frequency range. The phase lock output from the 575B also has a limited tuning range. Therefore, the millimeter wave source needs to be tuned as close as possible (typically within 40 MHz) to the desired phase lock frequency prior to attempting to phase lock.

PHASE LOCK PROCEDURE

1. Connect the equipment as shown in Figure 1.
2. Connect the time base output from the rear panel of the 588B to the time base input on the rear panel of the 575B and switch the INT/EXT time base select switch to EXT (external time base). This references both counters to the same time base.
3. On the 575B, select Band 2 to select the 10 MHz to 1 GHz frequency band.
4. On the 588B, select Band 3-8 to select the 110 GHz to 170 GHz frequency band.

At this point, the 588B will search for the millimeter wave signal (F_{mm}). Once the signal is found, the 588B will display the millimeter wave frequency and the 575B will display the frequency of the IF prescaled by four ($IF/4$).

5. Coarse tune the millimeter wave source as close as possible to the desired frequency.
 6. On the 588B, press the SPECIAL FUNC key and enter 61. This activates Special Function 61 which disables input signal tracking allowing the Band 3 IF in the 588B to vary over a range of approximately 150 MHz. Normally, the LO in the 588B is adjusted every gate to maintain a constant IF of 675 MHz.
 7. On the 588B, press the MIN PRF key and enter 0. This sets the minimum PRF on the 588B to 0 Hz which prevents it from dropping lock if IF threshold is lost.
 8. On the 588B, press the SPECIAL FUNC key and enter 75. This special function causes the 588B to display its internal IF by subtracting the LO frequency from the measured frequency. This is accomplished by loading the FREQ OFFSET register with: $(-1) \times \text{LO frequency}$. If the displayed frequency is negative, the counter is high side mixing with the input. If it is positive, the counter is low side mixing.
 9. On the 588B, press FREQ OFFSET. Disregarding the negative sign, record the LO frequency (F_{LO}) from the 588B display.
- $F_{LO} = \underline{\hspace{10em}}$
10. On the 588B, press CLEAR DATA to clear the offset frequency. The 588B will again display the frequency of the millimeter wave signal.
 11. Calculate the lock frequency (F_{LOCK}) for the 578B.

$$F_{LOCK} = \text{ABS}(F_{mm} - F_{LO})/4$$

Example: $F_{mm} = 130 \text{ GHz}$ (desired mm lock frequency)

$F_{LO} = 129.33 \text{ GHz}$ (recorded in step 9)

$$F_{LOCK} = \text{ABS}(130 \text{ GHz} - 129.33 \text{ GHz})/4 = 167.5 \text{ MHz}$$

12. On the 575B, press LOCK FREQ and enter the frequency, in MHz, calculated in step 11.

At this point, the 575B will determine the tuning sensitivity (MHz/V) and tuning polarity of the source by moving the phase lock control voltage while monitoring changes of input frequency. With this information, the 575B adjusts the phase lock circuitry and proceeds to lock the millimeter wave source to the desired frequency.

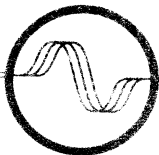
The following sample program simplifies source locking between 110 and 170 GHz by automatically performing the required calculations. It was written for an HP-85 instrument controller. It could be used as written on a HP85 or modified to run on other controllers or to suit a particular application.

```
10 CLEAR
20 DISP
30 DISP "*****"
40 DISP " EIP MICROWAVE INC."
50 DISP " 110 GHZ THRU 170 GHZ "
60 DISP " SOURCE LOCKING PROGRAM "
70 DISP
80 ! WRITTEN ON HP-85 INSTRUMENT
90 ! CONTROLLER
100 ! REQUIRED EQUIPMENT
110 ! EIP 575B AND EIP 588B
120 ! DATE: 1 FEBRUARY 1990
130 DISP " REV DATE: 2/1/1991"
140 DISP "*****"
150 ! INIT VARIABLES
160 ! *****
170 F=719 ! 575B GPIB ADDR 19
180 P=718 ! 588B GPIB ADDR 18
190 ! *****
200 !INITIALIZE COUNTERS
210 ! *****
220 OUTPUT F;"RSB2R0FA"
230 OUTPUT P;"INIT"
240 WAIT 5000 ! WAIT FOR 588B TO INIT
250 OUTPUT P;"BA 3,SUB 8"
260 ! *****
270 ! GET DESIRED LOCK FREQ
280 ! *****
290 CLEAR
300 DISP
310 DISP "ENTER LOCK FREQUENCY"
320 DISP "IN GHZ BETWEEN 110
330 DISP "GHZ AND 170 GHZ"
340 INPUT L
350 ! RANGE CHECK
360 IF L<110 THEN 370
370 IF L>170 THEN 370
380 GOTO 450 ! NO RANGE ERROR
390 BEEP@BEEP@BEEP ! ERROR BEEP
400 CLEAR ! CLEAR SCREEN
410 DISP "RANGE ERROR"
420 WAIT 1000
430 GOTO 290
440 ! *****
450 ! ADJ TO 40 K RESOL
460 ! *****
470 L=L * 1000000
480 L1=INT(L/1000) * 1000
490 D1=L-L1
500 D1=INT(D1/40) * 40
510 L=L1+D1 * 1000
520 ! *****
530 ! DISPLAY COARSE FREQ ADJ MSG
540 ! *****
550 DISP
560 DISP "COARSE TUNE THE SOURCE AS"
570 DISP "CLOSE AS POSSIBLE TO"
580 DISP "THE DESIRED FREQUENCY"
590 DISP
600 DISP "PRESS [CONT] WHEN READY"
610 PAUSE ! WAIT HERE TIL READY
620 ! *****
630 ! GET LO FREQUENCY FROM 588B
640 ! *****
650 OUTPUT P;"SP 61,MI 0 HZ"
660 WAIT 500 ! WAIT .5 SEC
670 OUTPUT P;"SP 75" ! LOAD LO
680 WAIT 500
690 OUTPUT P;"OUTPUT OFFSET"
700 WAIT 500
710 ENTER P;L3
720 OUTPUT P;"OFFSET 0 HZ"
730 ! CALCULATE ACTUAL LOCK FREQ
740 I=ABS(ABS(L3)-L/4
750 ! *****
760 ! LOCK ROUTINE
770 ! *****
780 OUTPUT F;"PF",I,"H"
790 S=SPOLL(F)
800 WAIT 100 ! WAIT .1 SEC
810 IF BIT(S,3)<>1 THEN 790
820 ! *****
830 ! DISP LOCK INFORMATION
840 ! *****
850 CLEAR
860 DISP
870 DISP "***LOCK COMPLETE***"
880 DISP "LOCK FREQ = ";L/1E9);" GHz"
890 DISP "LO FREQ = ";ABS(L3/1E9);" GHz"
900 DISP "IF/4 = ";I/1000000);" MHz"
910 DISP
920 DISP "PROGRAM END"
930 END ! PROGRAM END
940 ! *****
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EIP's Counter Line at a Glance

Model	CW or Pulse	Max. Freq.	Optional Max. Freq.	Damage Level	Microwave Amplitude Discrimination	Freq. Limits	Power Meter Option	Source Locking	VXIbus
625A 628A	CW CW	20 GHz 26.5 GHz		200W Peak 200W Peak	X X				
535B 538B	CW CW	20 GHz 26.5 GHz	50 GHz	200W Peak 200W Peak	X X				
545B 548B	CW CW	20 GHz 26.5 GHz	110 GHz	200W Peak 200W Peak	X X	X X	X X		
575B 578B	CW CW	20 GHz 26.5 GHz	110 GHz	200W Peak 200W Peak	X X	X X	X X	X X	
585B 588B	CW & Pulse CW & Pulse	20 GHz 26.5 GHz	170 GHz	200W Peak 200W Peak	X X	X X			
1230A 1231A	CW & Pulse CW & Pulse	26.5 GHz 20 GHz	170 GHz	200W Peak 200W Peak	X X	X X			X X

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