UVLBI MEMO #017

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Subject: Special version of integrator for P8 maser

A special version of the integrator assembly has been built to optimize the Allan standard deviation (SAO assembly A6A6) of the oscilloquartz 8607-BM BVA crystal oscillator when locked to the P8 hydrogen maser. The modified circuit is shown in figure 1 along with the original in Figure 2. The new circuit was built on a "vector" prototype board using an aluminum box and connectors compatible with the assembly in P8 used to lock a Wenzel crystal. The new assembly can be switched into the maser receiver assembly by, first removing power, unscrewing the cover plate on which the electronics is mounted, disconnecting the cables and switching them over to the new module.

The new module was designed assuming a voltage tuning sensitivity K_v of 53 radians/volt derived from a measured turning curve with slope 6×10^{-9} per volt. The detector sensitivity $K_0$was assumed to be 0.2 volts/radian. The loop natural frequency, w_n, and damping, ζ are given by

$$w_n = \sqrt{K_0 K_v / \tau_2}$$

$$\zeta = w_n \, \tau_1 / 2$$

where $\tau_2 = cr_1$ and $\tau_1 = cr_2$. For the choice of $c = 10\mu F$, $\tau_2 = 10s$, $\tau_1 = 1.5s$

$$r_1 = 1M\Omega$$
$$r_2 = 150k\Omega$$
$$w_n = 1\,radian/\text{sec}$$
$$\zeta = 0.75$$

Some flexibility was incorporated allowing r, to be changed to 90 $K\Omega$ and 3 $K\Omega$ to increased the loop natural frequency to 3 and 20 radians/sec respectively via 2 toggle switches. The 20 radians/sec (~3 Hz loop bandwidth) being used to provide a quick lock-up when setting up the maser receiver.

Numerous addition changes were made to the original circuit to insure the lowest possible noise from the phase detector and loop operational amplifier. In order to test the circuit which the maser the integrator module was used to lock the Oscilloquartz crystal to the Applied Physics Lab super crystal using the set-up in figure 3.

Table of results:		Loop BW Hz		
τ	Open loop	1/6	½	3
0.1s	1×10^{-12}	1×10^{-12}	1×10^{-12}	2×10^{-12}
1S	3×10^{-13}	2×10^{-13}	3×10^{-13}	3×10^{-13}
10S	1×10^{-13}	8×10^{-14}	8×10^{-14}	8×10^{-14}
100S	1×10^{-13}	8×10^{-15}	8×10^{-15}	5×10^{-15}
0.1 Hz	-100	-100	-100	-100
1	-130	-130	-120	-120
10	-142	-145	-142	-135
Table 1. * The Allen Std. Dev. And phase noise in dBc/Hz were read off the timing solutions screen and were NOT divided by $\sqrt{2}$.				

The optimum loop bandwidth, when the crystal is locked to the maser, is expected to be between 1/6 and ½ Hz. The table shows that when the loop bandwidth is increased to 3 Hz the short term stability is degraded as a result of some phase noise in the HP8648B synthesizer. The performance is also expected to degrade at 3 Hz, when the oscilloquartz is locked to the maser, as a result of the white noise from the maser.

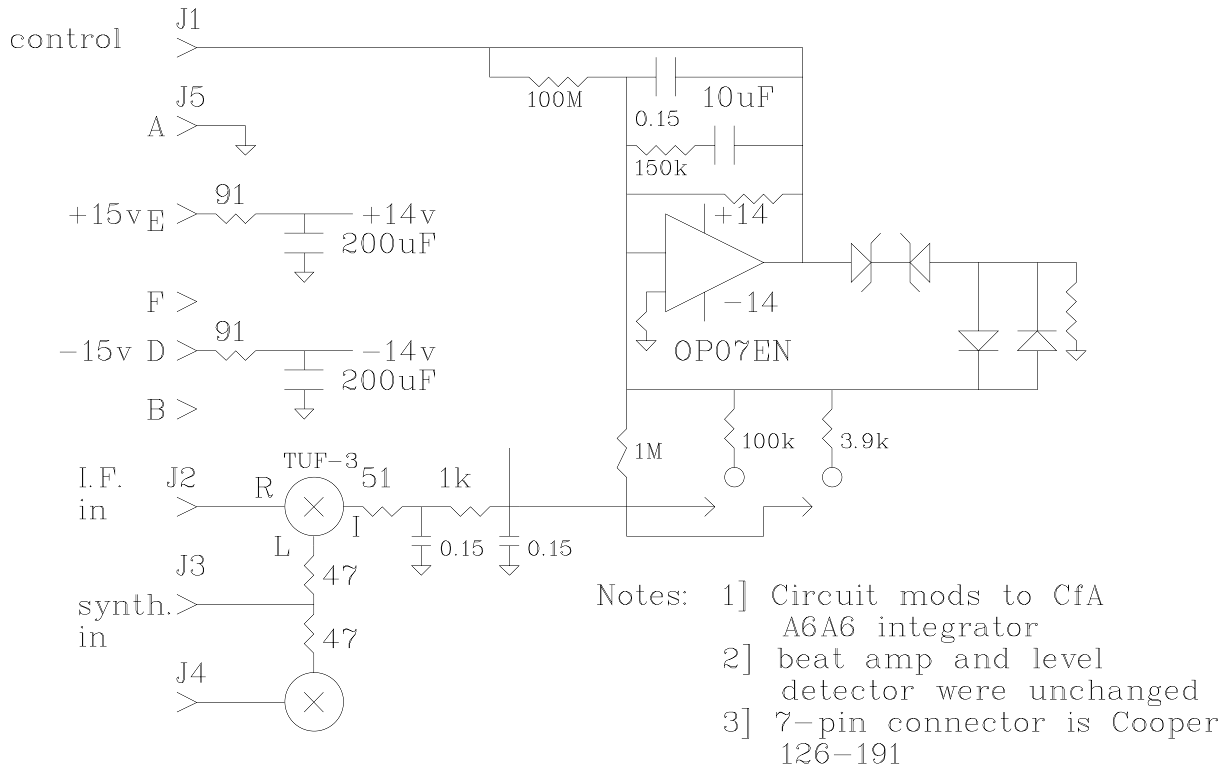
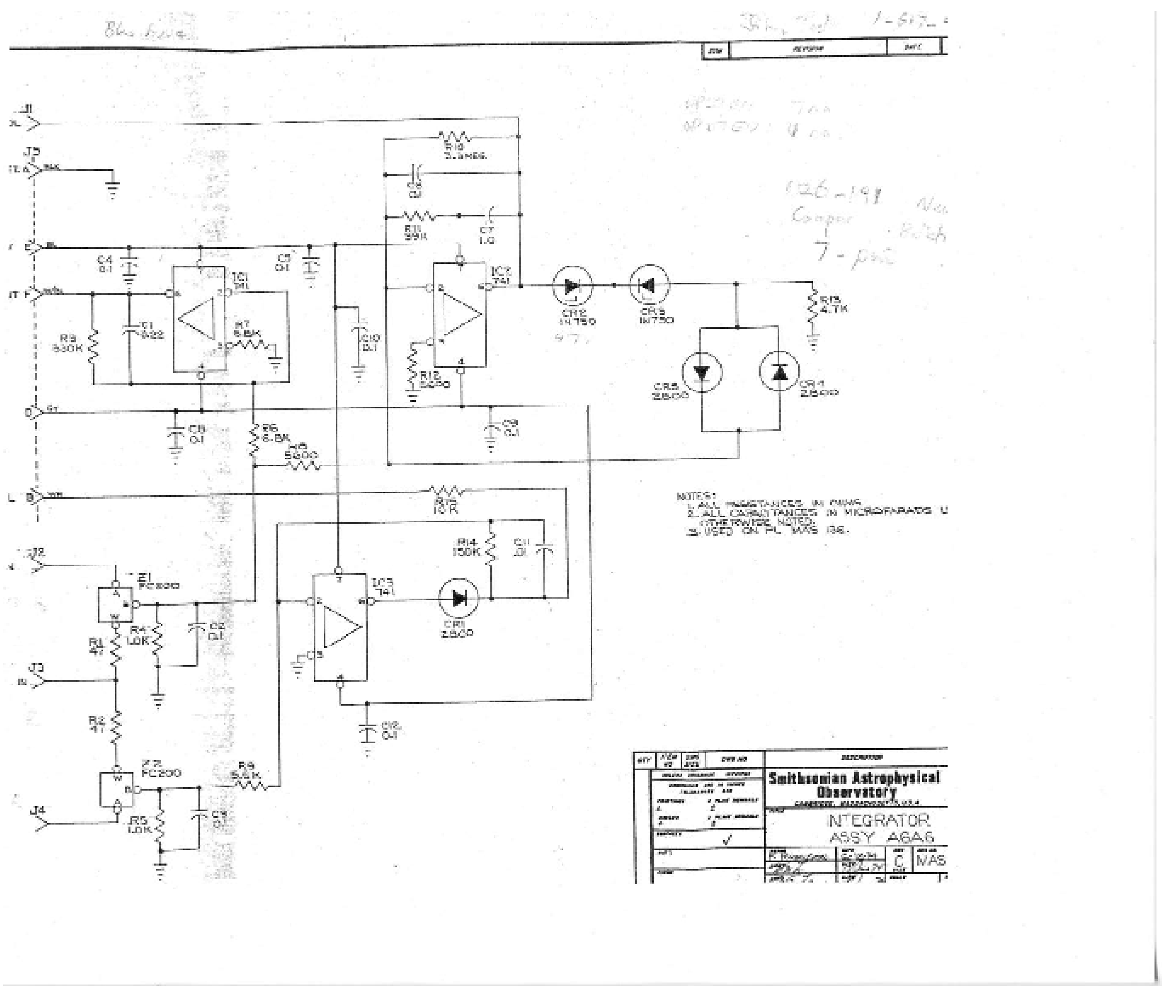
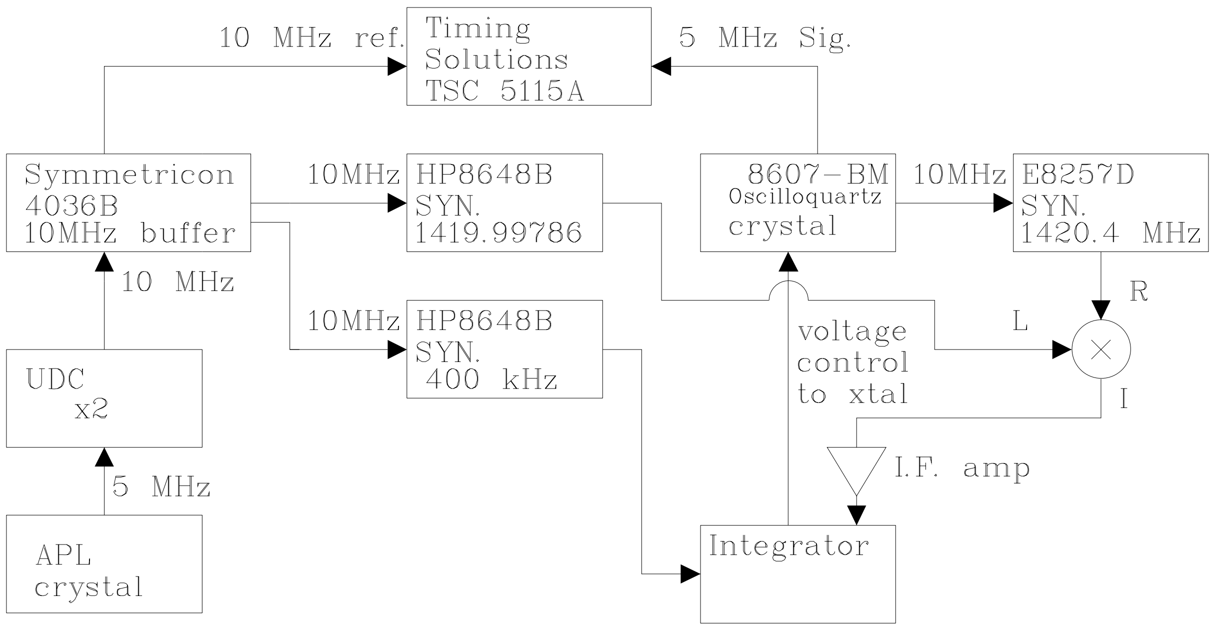

control
J1
J5
A
100M
0.15
10uF
150k
+15v E
91
+14v
200uF
+14
F
-14
-15v D
91
-14v
200uF
OP07EN
B
1M
100k
3.9k
I.F. in
J2
R
TUF-3
51
1k
I
L
0.15
0.15
J3
47
synth. in
47
J4
Notes: 1] Circuit mods to CfA A6A6 integrator
2] beat amp and level detector were unchanged
3] 7-pin connector is Cooper 126-191

Figure 1.



NOTES:
1. ALL RESISTANCES IN OHMS
2. ALL CAPACITANCES IN MICROFARADS U
OTHERWISE NOTED.
3. USED ON PL MAS 136.
Smithsonian Astrophysical Observatory
INTEGRATOR
ASSY A6A6
MAS

Figure 2.



Test setup for checking phase lock loop

Figure 3.