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=====================================================================
 Arecibo Planetary Radar Cabling:  CW, Ranging, and PFS
        Rev 1; PTaylor, 2012
        Rev 2; JERichardson, SEP2014
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=====================================================================
I. Continuous Wave (CW) Spectra:  setup.cw (uses RI)
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Typically OC is always to the LEFT of SC as we cable and take
precedence in numbering, i.e., Channel 1 = OC, Channel 2 = SC

** For normal NEAs
            use 125 or 250 kHz Butterworth filters, set the
            K-H filter to 5.5 kHz, and use setup.cw

** For NEAs with Doppler uncertainties of order a few x 1000 Hz,
            use 250 or 500 kHz Butterworth filters, set the
            K-H filter to 30 kHz, and use setup.cw62khz

** For MBAs, use the 250 kHz or 500 kHz Butterworth filters,
            set the K-H filter to 30 kHz, and use setup.fs4


---------------------------------------------------------------------
| Begin with the Planetary Downconverter (260 Mhz --> 30 Mhz)
|       labeled 7-19 located in Rack #7
|       CH1 = SC signal  backwards since installation of new receiver
|       CH2 = OC signal   swap cables so OC stays on left though
---------------------------------------------------------------------
                                |       |
                                |       |       (OC, SC)
                                |       |       (30 MHz, 20 MHz BW)
                                |       |
---------------------------------------------------------------------
| Connect to Distribution Amplifiers 7-3/7-4 (OC) and 8-3/8-4 (SC)
|       (upper and lower are identical, each with 8 outputs)
|       This amplifies by 40 dB, with attenuators that follow:
|       for CW, set coarse dials to -40 dB
|     for CW, set fine dials to ~5 dB (for a total 45 dB attenuation)
|       (adjust as needed to get proper O-scope levels later)
|       any of the outputs can be used
---------------------------------------------------------------------
                                |       |
                                |       |       (OC, SC)
                                |       |       (30 MHz, 12 MHz BW)
```

SIGNAL IN

```
                                |       |
-------------------------------------------------------------------
| Filter with the Butterworth 125 kHz bandwidth filters, 7-6 and 8-6
|       OR:
| Filter with the Butterworth 30 MHz boxes, 7-7 and 8-7
|       use the 250 kHz bandwidth filter
-------------------------------------------------------------------
                                |       |
                                |       |
        _ (LO input)    |       |       (OC, SC)
        | (30 MHz)              |       |       (30 MHz, 125 or 250 kHz BW)
        |                       |       |
-------------------------------Reference Signal-------------------->
| Connect SBand LO to Ref In of baseband mixer 7-10/8-10
|       LO is from Synthesizer 5 or 6 on board 5-7
|       corresponds to 30 MHz box in Rack #3
|
| Connect the two Butterworth outputs to Signal In (left and right) of 7-10/8-10
-------------------------------------------------------------------
                        |       |       |       |
                        |       |       |       |       (OC Sin, OC Cos, SC Sin, SC Cos)
                        |       |       |       |       (0 Hz base, 125 or 250 kHz BW)
                        |       |       |       |
-------------------------------------------------------------------
| Sin/Cos outputs from OC/SC go to K-H filter, 8-15
|       connect OC Sin/Cos to inputs 1.1 and 1.2
|       connect SC Sin/Cos to inputs 2.1 and 2.2
|
| Panal settings (pressing a button once shows its setting,
|       pressing it again will adjust it:
|       * check that All Cannels button is GREEN (press if not)
|       * check that Mode is set to L.P. (low pass)
|       * check that Type is set to Bu. for Butterworth
|       * check that output gain is set to 20 dB
|       * press [5 . 5 KILO FREQ] to set to 5.5 kHz
|
|       There is an amber light in the upper left corner labelled
|       Remote.  If it is lit then you have to press the CE button
|       to allow changes to be made locally (with the buttons on the
|       face of the filter).  Otherwise pressing the buttons will not
|       have any effect.
-------------------------------------------------------------------
                        |       |       |       |
                        |       |       |       |       (OC Sin, OC Cos, SC Sin, SC Cos)
                        |       |       |       |       (0 Hz base, 5500 Hz BW)
                        |       |       |       |
-------------------------------------------------------------------
| Amplify signal with 8-13 (Op Amp)
|       4 outputs of K-H filters go to 4 "IN A" ports
|       set top dials to zero
|       set switches to msec (to the right)
|       set lower dials to small gains (1 to 5),
|         typically 1 is enough for CW
|       use these to amplify scope signal later
-------------------------------------------------------------------
                        |       |       |       |
                        |       |       |       |       (OC Sin, OC Cos, SC Sin, SC Cos)
                        |       |       |       |       (0 Hz base, 5500 Hz BW)
                        |       |       |       |
-------------------------------------------------------------------
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| Connect outputs to oscilloscope using 4 T-connectors
|       this splits the signal to the scope and RI
|       press Menu and recall Setup #9
|       adjust sampling timescale to just longer than
|         actual sampling frequency (400 us CW, 800 ns imaging)
|       adjust vertical scale to 2 Volts
|       adjust attentuations on 7-3, 8-3 and/or gains on 8-13
|         to get wiggles at about 300-400 mV
|       Menu Off button removes screen clutter
-------------------------------------------------------------------
                        |       |       |       |
                        |       |       |       |       (OC Sin, OC Cos, SC Sin, SC Cos)
                        |       |       |       |       (0 Hz base, 5500 Hz BW)
                        |       |       |       |
-------------------------------------------------------------------
| Outputs go to 4 RI channels: OC I and Q, SC I and Q
|       located on rack 10-9 (uses RI at 12.5 kHz data sampling rate)
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II. Ranging at 4 us:  setup.u4.8k or setup.u4.1k (uses RI)
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*** moving from CW to Ranging **

(1) Connect OC (SC) Distribution Amplifier 7-3 (8-3) to 2 MHz Gaussian filter
        in 7-9 (8-9) and continue to mixer in 7-10/8-10

(2) Connect Sin/Cos Baseband Mixer outputs to the inputs of the 4 us matched filters
        in 7-20 or 8-18 (only one polarization required)

(3) Connect outputs of matched filters to Op amplifier 8-13
        continue to oscilloscope and adjust levels to 700-800 mV

Flowchart:

-------------------------------------------------------------------
| Begin with the Planetary Downconverter (260 Mhz --> 30 Mhz)
|       labeled 7-19 located in Rack #7
|       CH1 = SC signal  backwards since installation of new receiver
|       CH2 = OC signal   swap cables so OC stays on left though
-------------------------------------------------------------------
                            |       |
                            |       |       (OC, SC)
                            |       |       (30 MHz, 20 MHz BW)
                            |       |
-------------------------------------------------------------------
| Connect to Distribution Amplifiers 7-3/7-4 (OC) and 8-3/8-4 (SC)
|       (upper and lower are identical, each with 8 outputs)
|       This amplifies by 40 dB, with attenuators that follow:
|       for ranging, set coarse dials to -20 dB
|     for ranging, set fine dials to ~5 dB (for a total 25 dB attenuation)
|       (adjust as needed to get proper O-scope levels later)
|       any of the outputs can be used
-------------------------------------------------------------------
                            |       |
                            |       |       (OC, SC)
```

```
                                |       |       (30 MHz, 12 MHz BW)
                                |       |
-------------------------------------------------------------------------
| Filter with the 2 MHz bandwidth Gaussian filters, 7-9 and 8-9
| These have a diagonal Input / Output arrangment
-------------------------------------------------------------------------
                                |       |
                                |       |
        _ (LO input)    |       |       (OC, SC)
        | (30 MHz)              |       |       (30 MHz, 2 MHz BW)
        |                       |       |
-------------------------------------------------------------------------
| Connect SBand LO to Ref In of baseband mixer 7-10/8-10
|       LO is from Synthesizer 5 or 6 on board 5-7
|       corresponds to 30 MHz box in Rack #3
|
| Connect the two Gaussian outputs to Signal In (left and right) of 7-10/8-10
-------------------------------------------------------------------------
                        |       |       |       |
                        |       |       |       |       (OC Sin, OC Cos, SC Sin, SC Cos)
                        |       |       |       |       (0 Hz base, 2 MHz BW)
                        |       |       |       |
-------------------------------------------------------------------------
| Filter with the 4 us Matched Filters, 7-20 or 8-18
|    typically, only one polarization is required
| These have a vertical Input / Output arrangment
-------------------------------------------------------------------------
                        |       |       |       |
                        |       |       |       |       (OC Sin, OC Cos, SC Sin, SC Cos)
                        |       |       |       |       (0 Hz base, 250 kHz / 4 us BW)
                        |       |       |       |
-------------------------------------------------------------------------
| Amplify signal with 8-13 (Op Amp)
|       4 outputs of Matched filters go to 4 "IN A" ports
|       set top dials to zero
|       set switches to msec (to the right)
|       set lower dials to small gains (1 to 5),
|         typically 2 is enough for Ranging
|       use these to amplify scope signal later
-------------------------------------------------------------------------
                        |       |       |       |
                        |       |       |       |       (OC Sin, OC Cos, SC Sin, SC Cos)
                        |       |       |       |       (0 Hz base, 250 kHz / 4 us BW)
                        |       |       |       |
-------------------------------------------------------------------------
| Connect outputs to oscilloscope using 4 T-connectors
|       this splits the signal to the scope and RI
|       press Menu and recall Setup #9
|       adjust sampling timescale to just longer than
|         actual sampling frequency (400 us CW, 800 ns imaging)
|       adjust vertical scale to 2 Volts
|       adjust attentuations on 7-3, 8-3 and/or gains on 8-13
|         to get wiggles at about 700-800 mV
|       Menu Off button removes screen clutter
-------------------------------------------------------------------------
                        |       |       |       |
                        |       |       |       |       (OC Sin, OC Cos, SC Sin, SC Cos)
                        |       |       |       |       (0 Hz base, 250 kHz / 4 us BW)
                        |       |       |       |
-------------------------------------------------------------------------
```

```
| Outputs go to 4 RI channels: OC I and Q, SC I and Q
|       located on rack 10-9 (uses RI at 250 kHz data sampling rate)
-------------------------------------------------------------------------


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III. Imaging at 0.05:  setup.p05 (uses PFS)
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Flowchart:

-------------------------------------------------------------------------
| Begin with the Planetary Downconverter (260 Mhz --> 30 Mhz)
|       labeled 7-19 located in Rack #7
|       CH1 = SC signal  backwards since installation of new receiver
|       CH2 = OC signal   swap cables so OC stays on left though
-------------------------------------------------------------------------
                                |       |
                                |       |       (OC, SC)
                                |       |       (30 MHz, 20 MHz BW)
                                |       |
-------------------------------------------------------------------------
| Connect to 260 MHz IF Amplifiers 7-19 (OC) and 8-19 (SC)
|       set to ~ 10 + 8.2 on dials
-------------------------------------------------------------------------
                                |       |
                                |       |       (OC, SC)
                                |       |       (30 MHz, 20 MHz BW)
                                |       |
-------------------------------------------------------------------------
| Connect to PFS patch panel (20 MHz data sampling system)
|       located on bottomost right corner of rack #9
|       labelled with "googly eyes" stickers
-------------------------------------------------------------------------
```

7-17, 8-16 → 9-17

] (9-17)

Notes:

Disconnect cable to patch panel if not in use

Typically run at 20 MHz sampling (1 spb for 0.05 us, 2 spb for 0.1 us, and 4 spb for 0.2 us)

In the back room the OC and SC signals come out of the patch panel at the bottom of the PFS rack and go into the Signal In of the BB mixer at the top of the rack

Sin/Cos outputs go to the PFS I and Q ports

IPPS port connects to the bottom left port on the time tick panel

Clock connects to buffer panel at 5, 10, or 20 MHz depending on the desired sampling rate [0.05 us -> 20 MHz, 0.1 us -> 10 MHz, 0.2 us -> 5 MHz, but now use 20 MHz for all]

To test levels, put in sbrxmode and collect some data:

```
pfs_radar -m # -d . -s 2
pfs_hist -m # *000
rm *000
```

Levels should be roughly 1 to 3 to 3 to 1 for -m 5
 and barely using outermost channels for -m 6

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IV. Imaging at 0.1, and 0.2 us: setup.p1, setup.p2pfs (uses PFS)
==========
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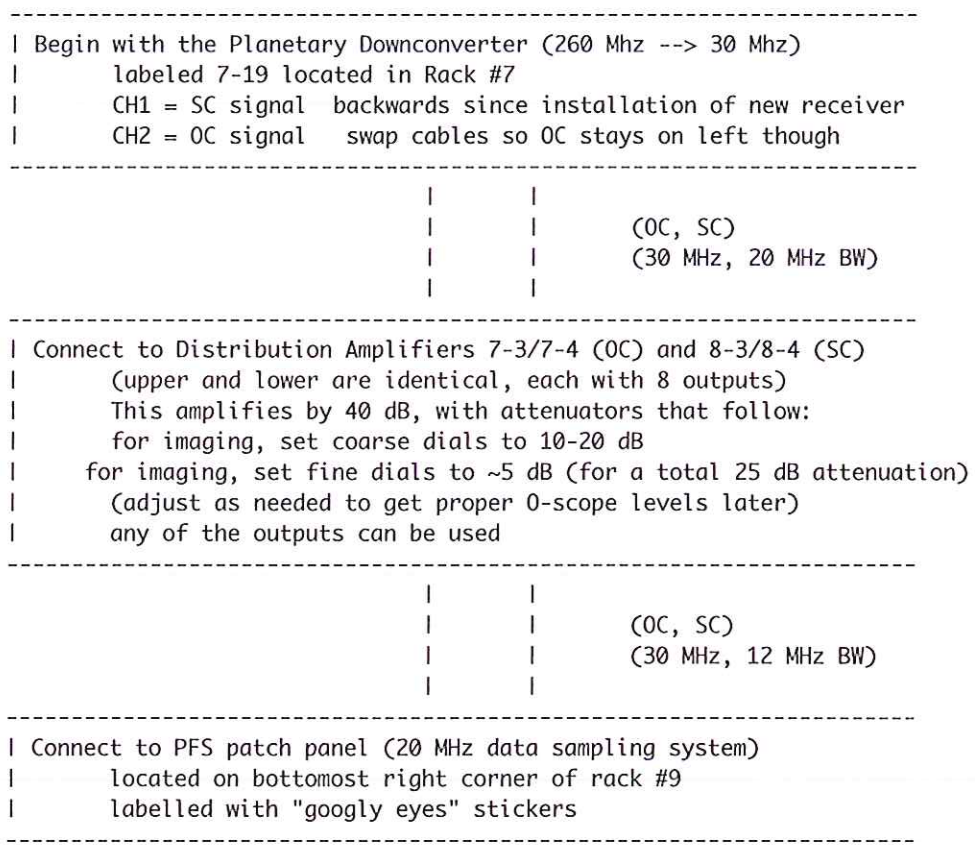
Flowchart:



Notes:

Disconnect cable to patch panel if not in use

Typically run at 20 MHz sampling (1 spb for 0.05 us, 2 spb
for 0.1 us, and 4 spb for 0.2 us)

In the back room the OC and SC signals come out of the patch
panel at the bottom of the PFS rack and go into the
Signal In of the BB mixer at the top of the rack

Sin/Cos outputs go to the PFS I and Q ports

IPPS port connects to the bottom left port on the time tick panel

Clock connects to buffer panel at 5, 10, or 20 MHz depending on
the desired sampling rate [0.05 us -> 20 MHz, 0.1 us ->
10 MHz, 0.2 us -> 5 MHz, but now use 20 MHz for all]

```
To test levels, put in sbrxmode and collect some data:
        pfs_radar -m # -d . -s 2
        pfs_hist -m # *000
        rm *000
Levels should be roughly 1 to 3 to 3 to 1 for -m 5
 and barely using outermost channels for -m 6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V. Imaging at 0.5 us or 1.0 us: setup.p5 or setup.u1 (uses GIO/aeron5)
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Description:

Connect OC (SC) attenuator 7-3 (8-3) directly to mixer 7-10/8-10
        bypass Butterworth and Gaussian filters
        set attenuation to ~25 dB

Connect Sin/Cos outputs to the 0.5 us matched filters in 8-18
        avoid 4 us filters in the same panel!
        skip the K-H filter for this setup

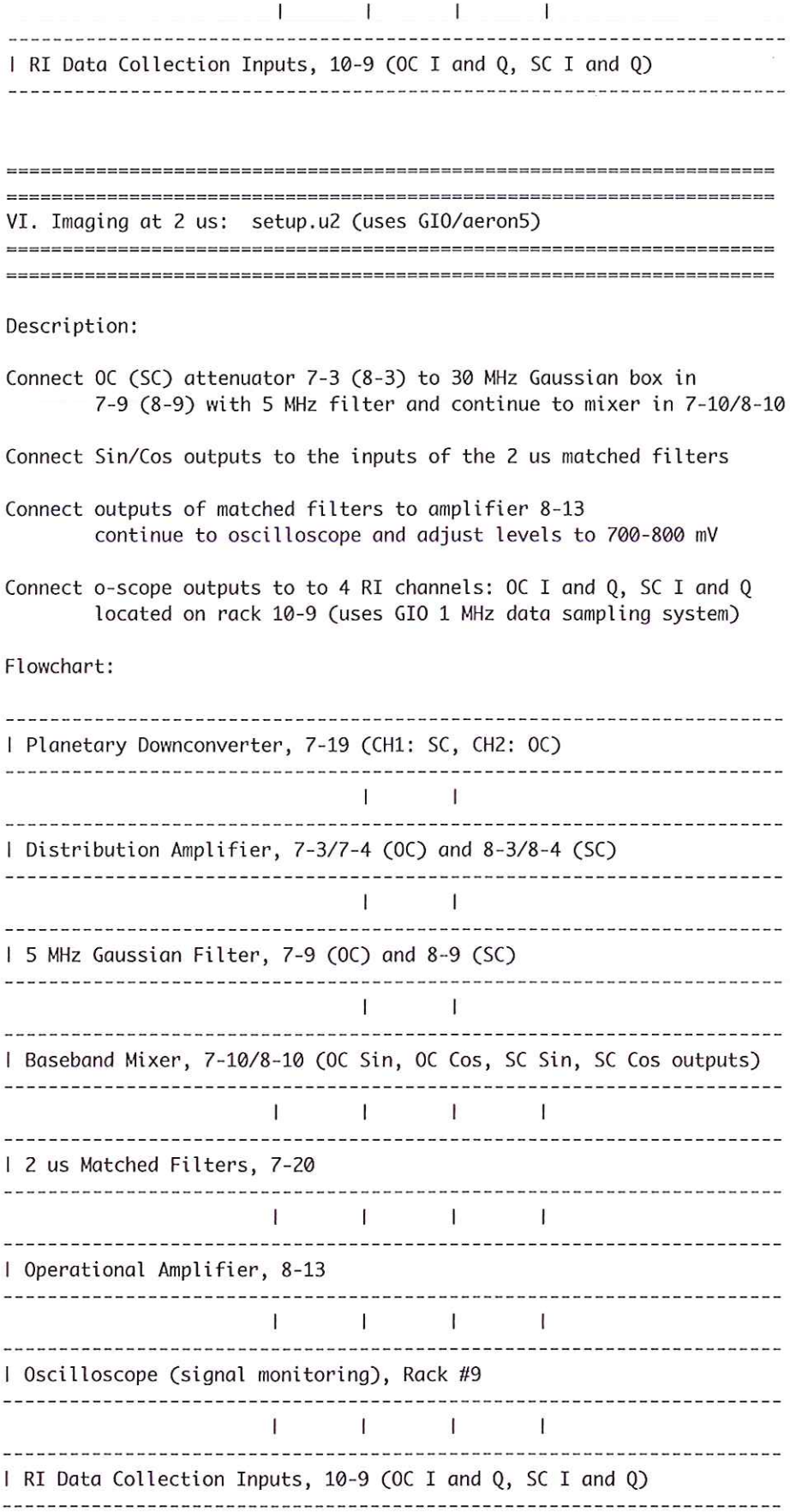
Connect outputs of matched filter to amplifier 8-13
        set lower dials to about 2 on op-amp (lower knobs)
        continue to oscilloscope with levels 700-800 mV

Connect o-scope outputs to to 4 RI channels: OC I and Q, SC I and Q
        located on rack 10-9 (uses GIO 2 MHz data sampling system)

To switch between CW and 0.5 us quickly, skip the BW filter,
move all K-H filter inputs/outputs to 0.5 matched filter
inputs/outputs below, and adjust levels on 7-3, 8-3, and 8-13

Flowchart:

-------------------------------------------------------------------
| Planetary Downconverter, 7-19 (CH1: SC, CH2: OC)
-------------------------------------------------------------------
                                |       |
-------------------------------------------------------------------
| Distribution Amplifier, 7-3/7-4 (OC) and 8-3/8-4 (SC)
-------------------------------------------------------------------
                                |       |
-------------------------------------------------------------------
| Baseband Mixer, 7-10/8-10 (OC Sin, OC Cos, SC Sin, SC Cos outputs)
-------------------------------------------------------------------
                        |       |       |       |
-------------------------------------------------------------------
| 0.5 us Matched Filters, 8-18
-------------------------------------------------------------------
                        |       |       |       |
-------------------------------------------------------------------
| Operational Amplifier, 8-13
-------------------------------------------------------------------
                        |       |       |       |
-------------------------------------------------------------------
| Oscilloscope (signal monitoring), Rack #9
-------------------------------------------------------------------
```



VI. Imaging at 2 us: setup.u2 (uses GIO/aeron5)

Description:

Connect OC (SC) attenuator 7-3 (8-3) to 30 MHz Gaussian box in
7-9 (8-9) with 5 MHz filter and continue to mixer in 7-10/8-10

Connect Sin/Cos outputs to the inputs of the 2 us matched filters

Connect outputs of matched filters to amplifier 8-13
continue to oscilloscope and adjust levels to 700-800 mV

Connect o-scope outputs to to 4 RI channels: OC I and Q, SC I and Q
located on rack 10-9 (uses GIO 1 MHz data sampling system)

Flowchart:

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VII. Imaging at 40 or 70 us:  setup.u40l, setup.u70l
                              (main belt, long code, uses RI)
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Connect OC (SC) attenuator 7-3 (8-3) to 125/250 kHz Gaussian filter

Connect Sin/Cos outputs from 7-10/8-10 to 40/70 us matched filters in
        7-21, 7-22 and continue to 8-13

Set attenuation dials on 7-4 and 8-4 to ~25 dB

Set lower dials on 8-13 op-amps to 10 and check levels

Connect o-scope outputs to 4 RI channels: OC I and Q, SC I and Q
        located on rack 10-9 (uses RI data sampling system, at
        20 us / 50 kHz or 35 us / 28.6 kHz sampling rate)

Flowchart:

---------------------------------------------------------------------
| Planetary Downconverter, 7-19 (CH1: SC, CH2: OC)
---------------------------------------------------------------------
                                ↓     ↓
---------------------------------------------------------------------
| Distribution Amplifier, 7-3/7-4 (OC) and 8-3/8-4 (SC)
---------------------------------------------------------------------
                                ↓     ↓
---------------------------------------------------------------------
| 125/250 MHz Gaussian Filter, 7-9 (OC) and 8-9 (SC)
---------------------------------------------------------------------
                                ↓     ↓
---------------------------------------------------------------------
| Baseband Mixer, 7-10/8-10 (OC Sin, OC Cos, SC Sin, SC Cos outputs)
---------------------------------------------------------------------
                          |     |     |     |
---------------------------------------------------------------------
| 40/70 us Matched Filters, (40: 8-19/8-20, 70: 7-21/7-22)
---------------------------------------------------------------------
                          |     |     |     |
---------------------------------------------------------------------
| Operational Amplifier, 8-13
---------------------------------------------------------------------
                          |     |     |     |
---------------------------------------------------------------------
| Oscilloscope (signal monitoring), Rack #9
---------------------------------------------------------------------
                          |     |     |     |
---------------------------------------------------------------------
| RI Data Collection Inputs, 10-9 (OC I and Q, SC I and Q)
---------------------------------------------------------------------
```

Δ 7-4 to 7-17
7 8-16

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VIII.  Matched Filter Cabinet Diagrams
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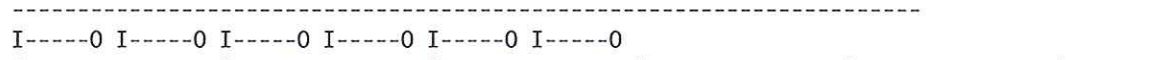
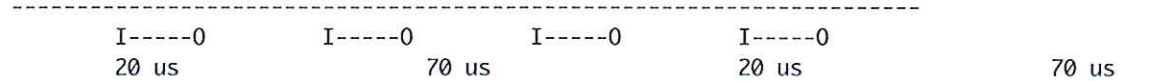
I = input, O = output

RACK #7:

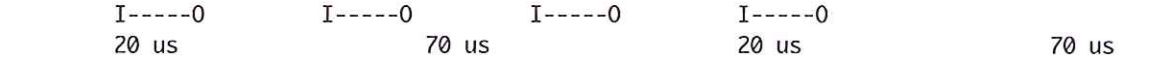
7-20:



7-21:

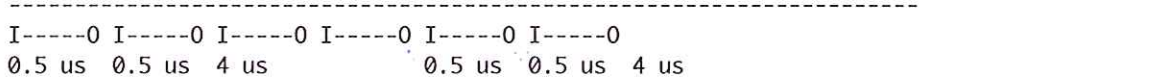


7-22:

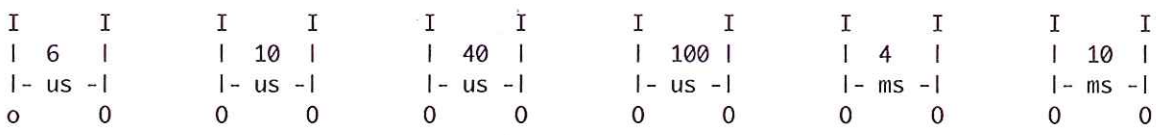


RACK #8:

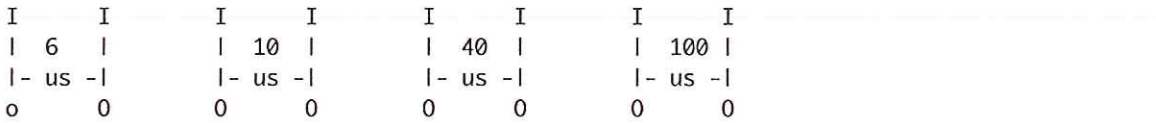
8-18:



8-19:



8-20:



8-21: