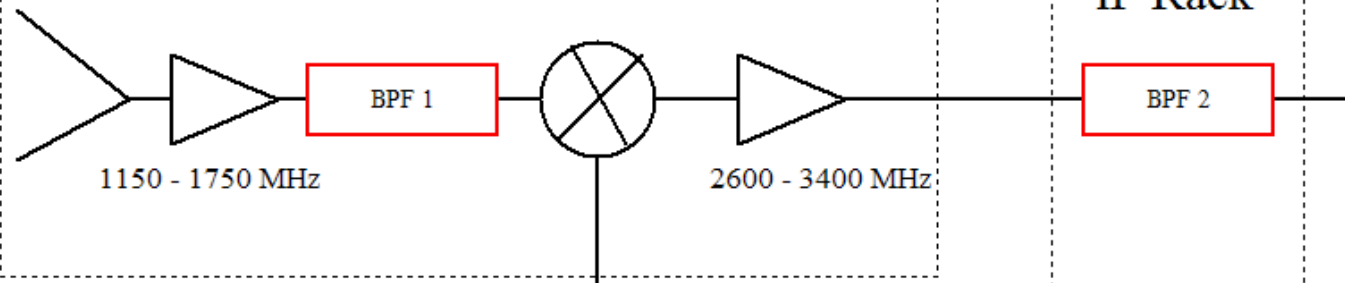




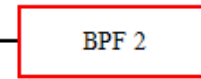
Tracing The Signal

Ron Maddalena
July 2015

Receiver



IF Rack

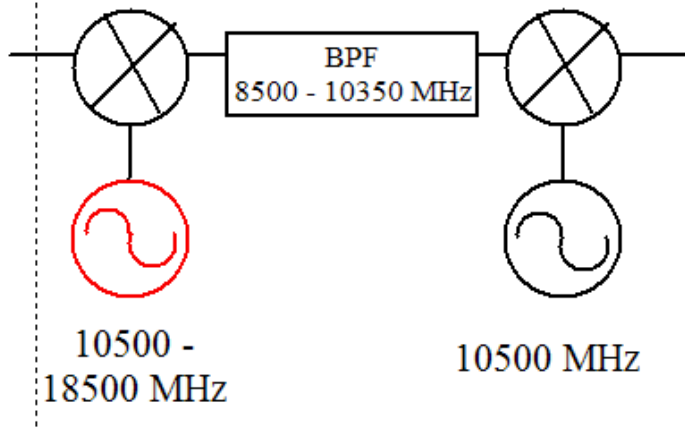


LO1

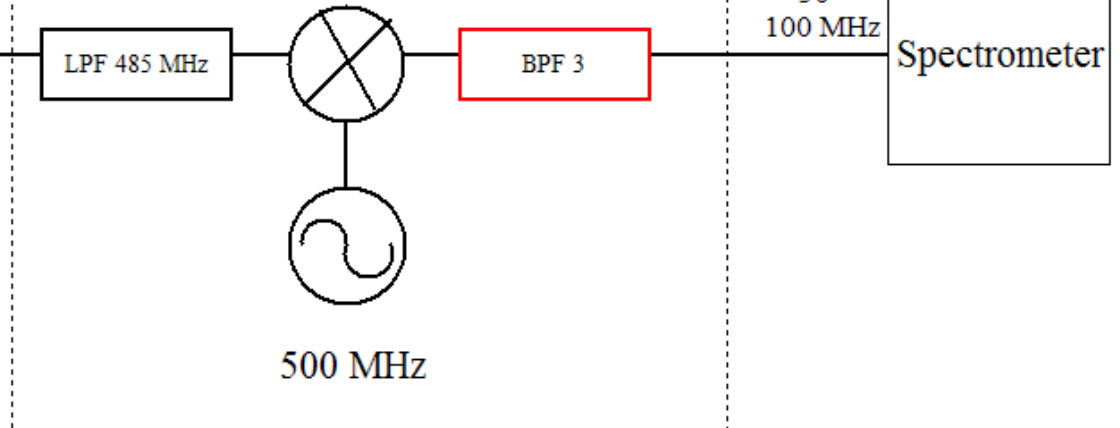


1000 - 10,000 MHz

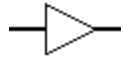
Converter Module



Analog Filter Module



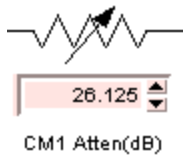
Typical Components



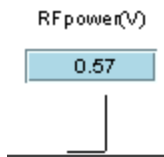
Amplifiers



Mixers



Attenuators



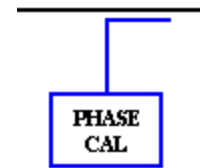
Power Detectors



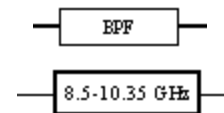
Synthesizers



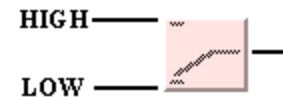
Splitters



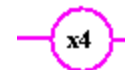
Couplers



Filters

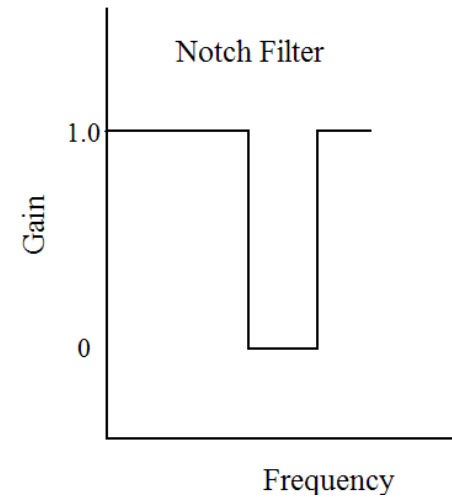
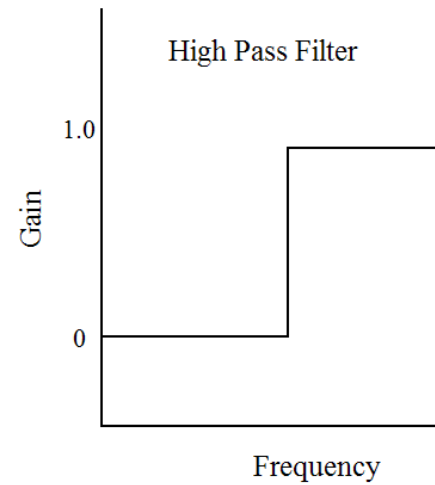
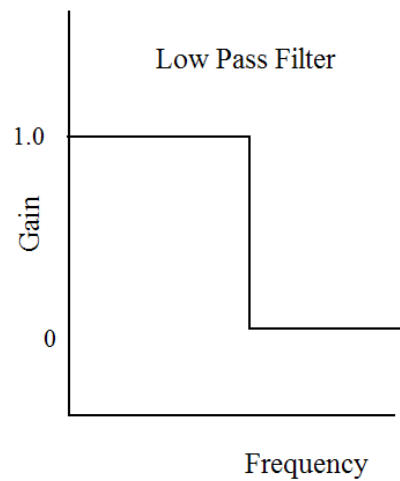
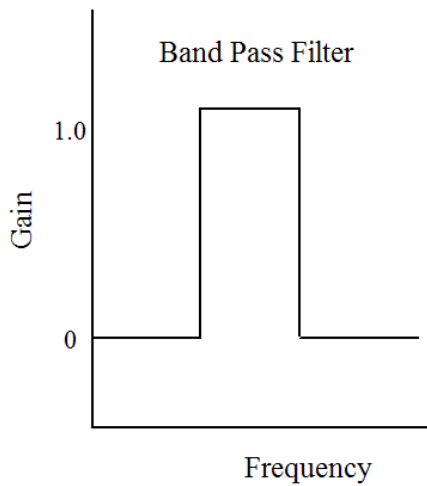


Switches



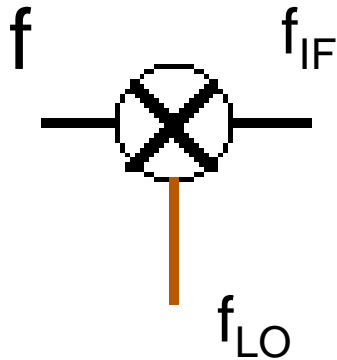
Multipliers

Types of Filters



Edges are smoother than illustrated

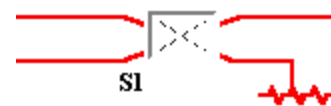
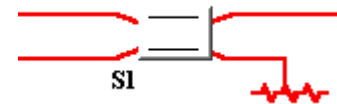
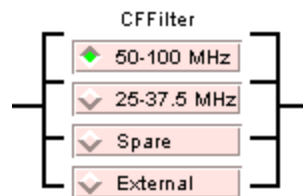
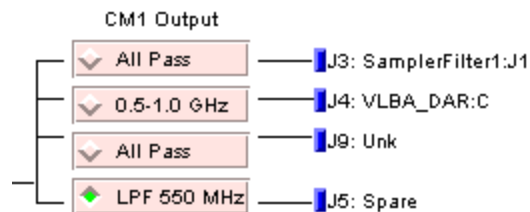
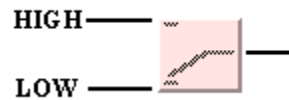
Types of Mixers



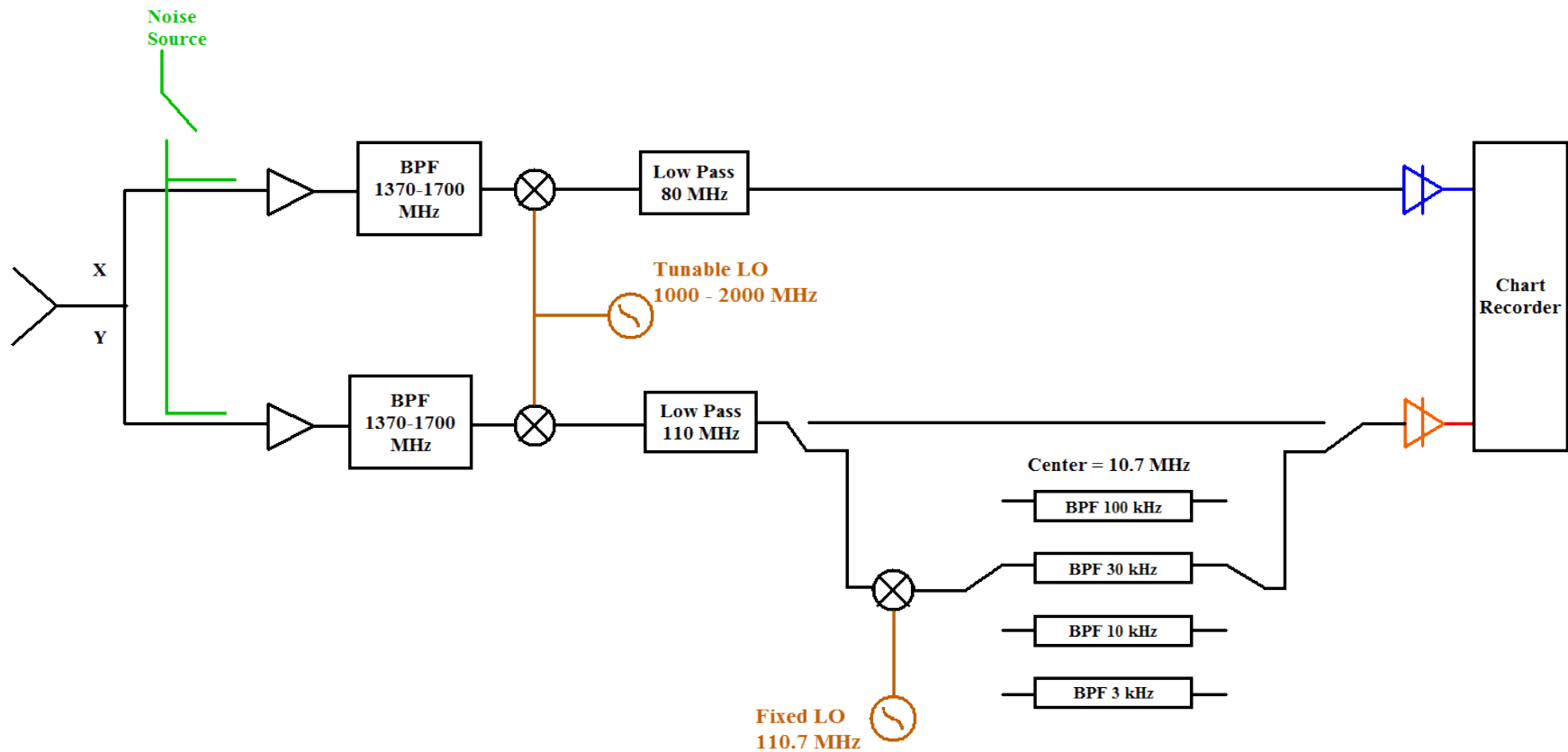
$$f_{IF} = n \cdot f_{LO} + m \cdot f$$

- n and m are positive or negative integers, usually 1 or -1
- Up Conversion : $f_{IF} > f$
- Down Conversion : $f_{IF} < f$
- Lower Side Band : $f_{LO} > f$
 - Sense of frequency flips
- Upper Side Band : $f_{LO} < f$

Example Switches



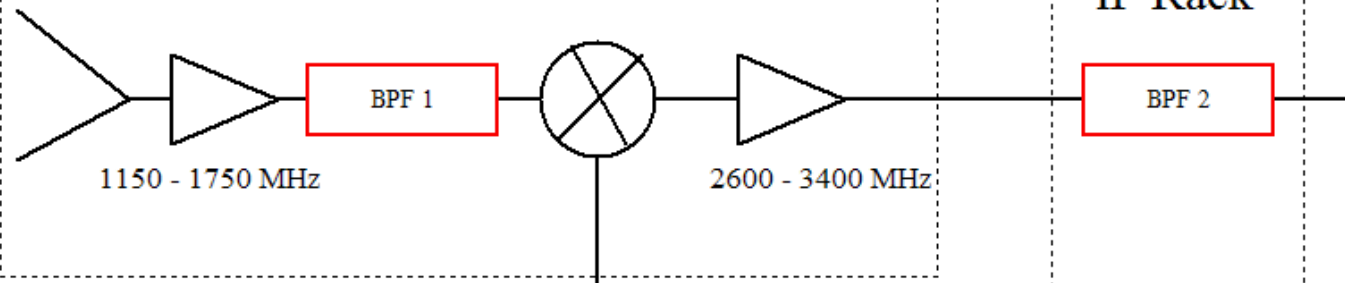
40-Ft System



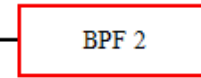
Quiz 1: Determine values for the first LO for the 40-ft when...

- Observing HI at 1420.41 MHz with a 30 kHz bandwidth
- Observing OH at 1665.6 MHz with a 10 kHz bandwidth

Receiver



IF Rack

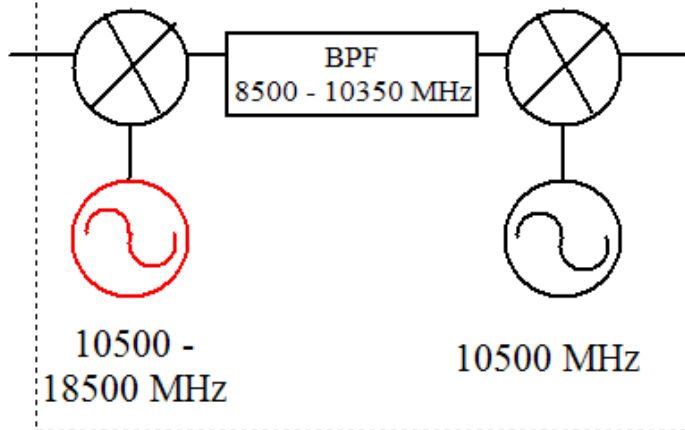


LO1

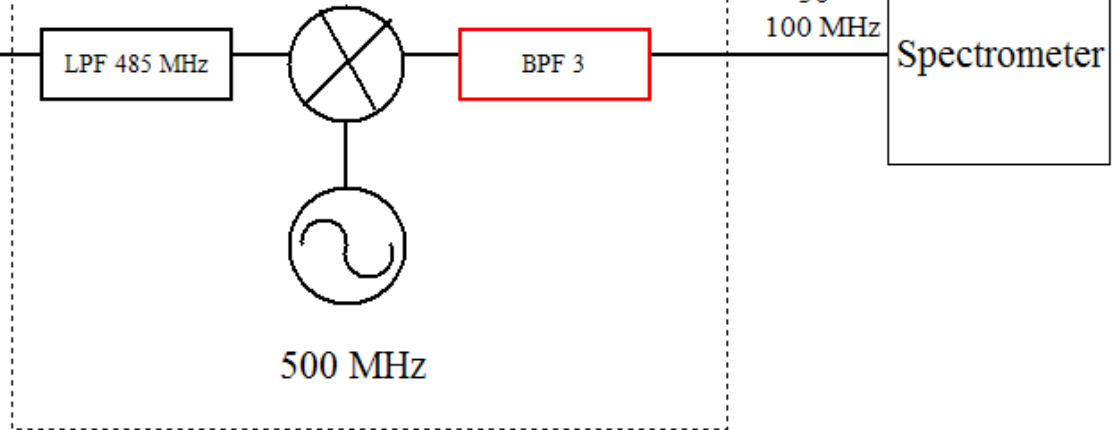


1000 - 10,000 MHz

Converter Module

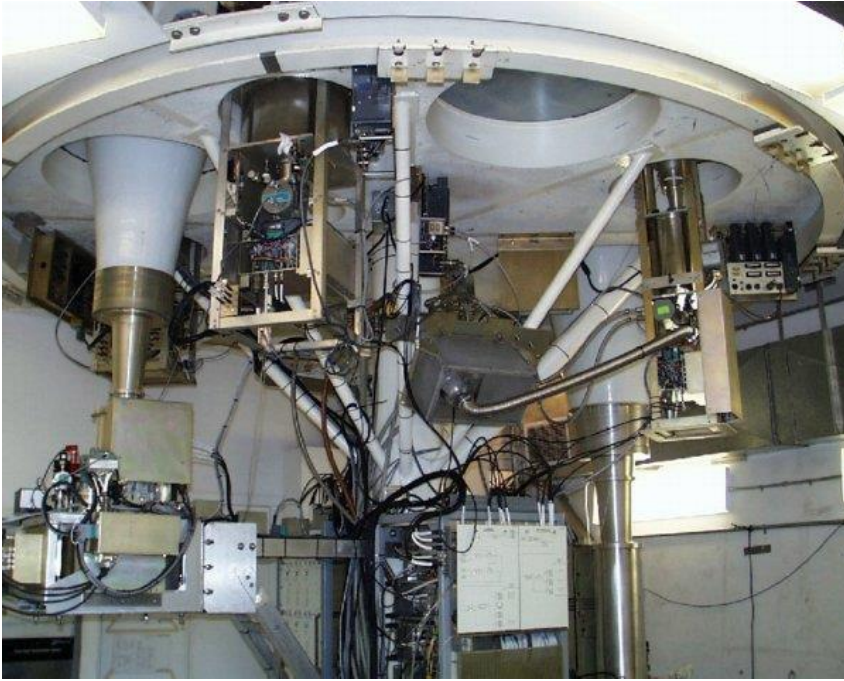


Analog Filter Module

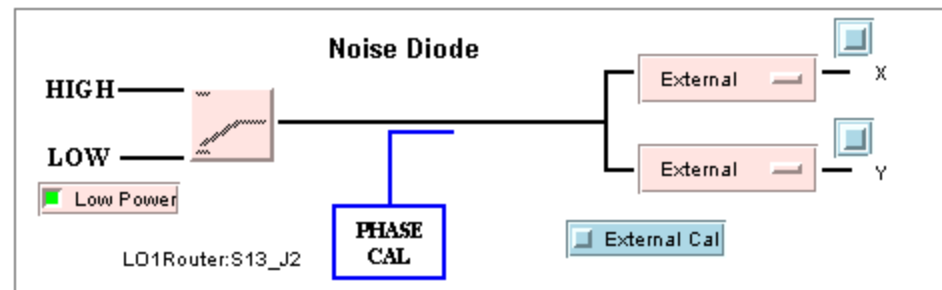
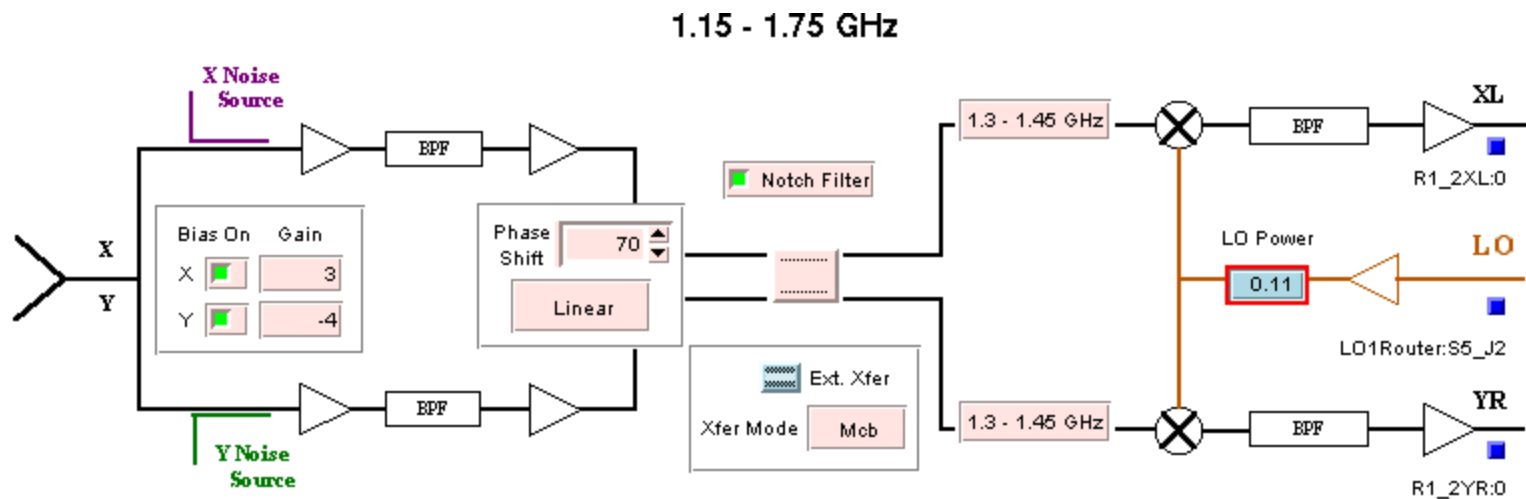


Spectrometer

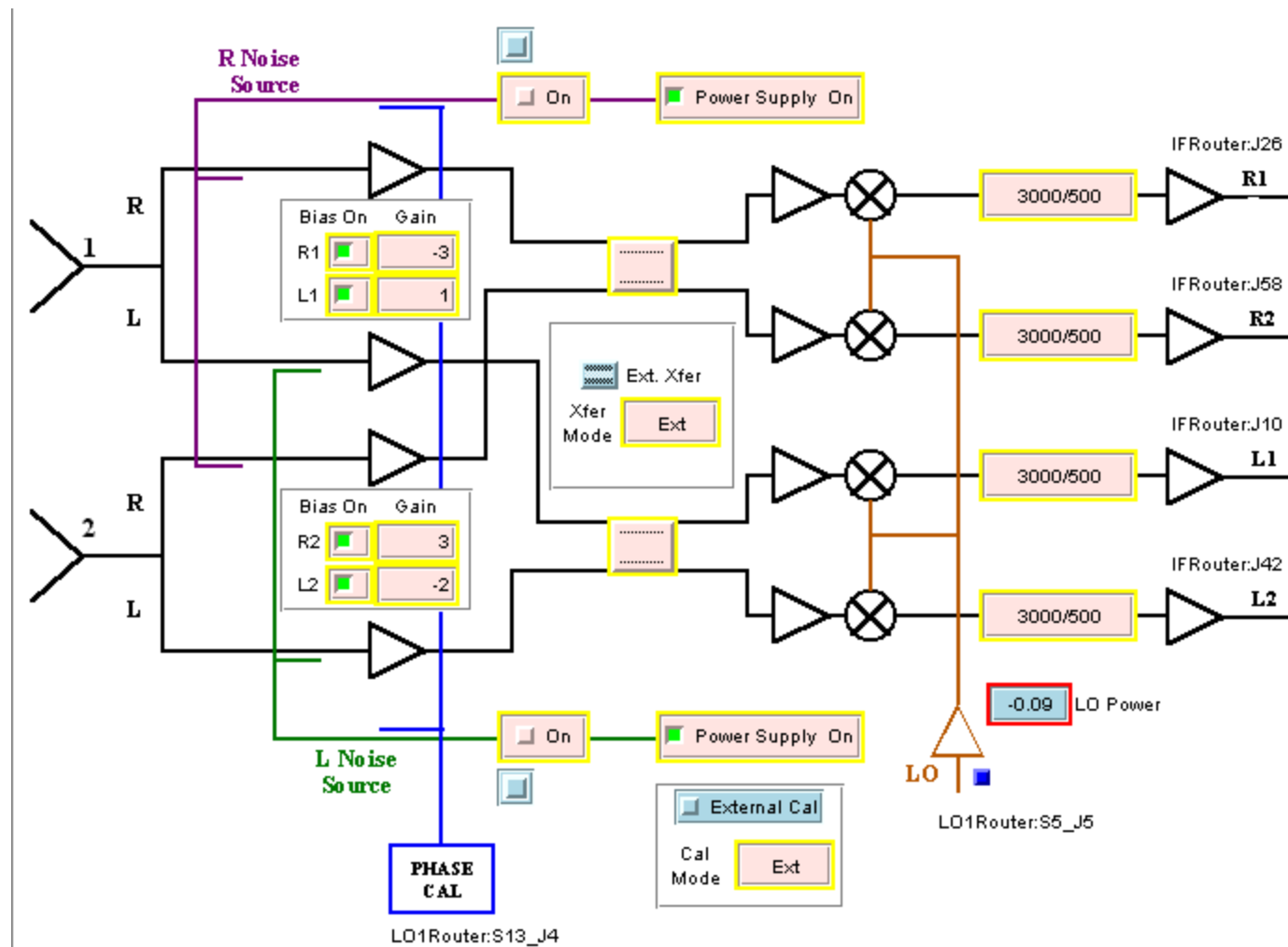
Receiver Room

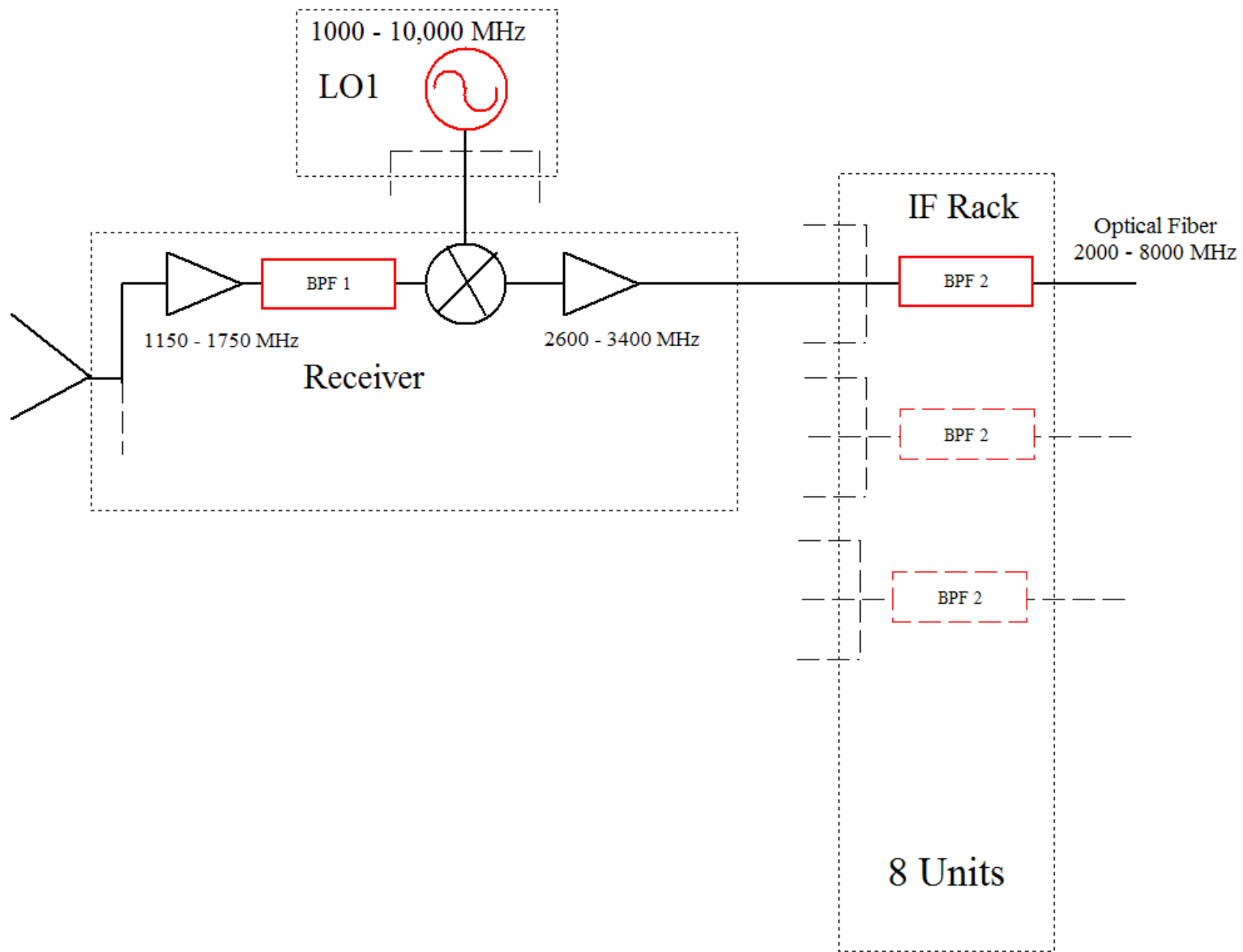


Typical Receiver

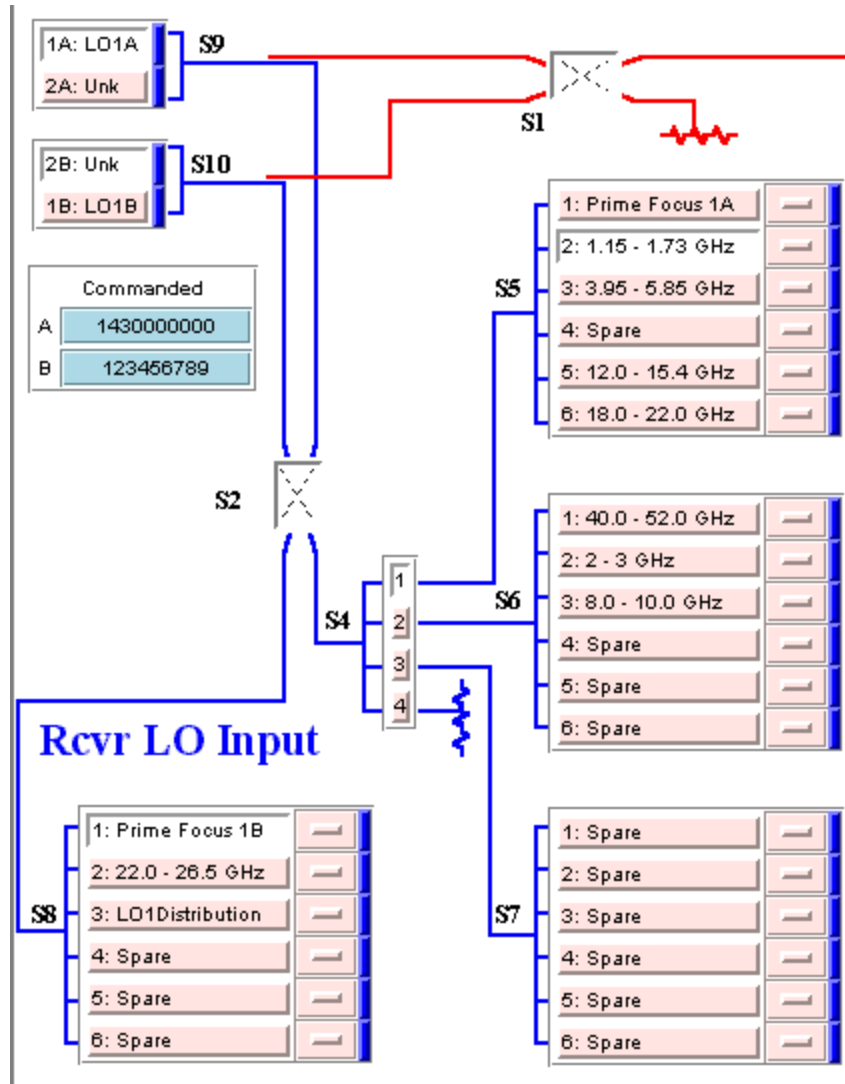


Multi-beam Receiver



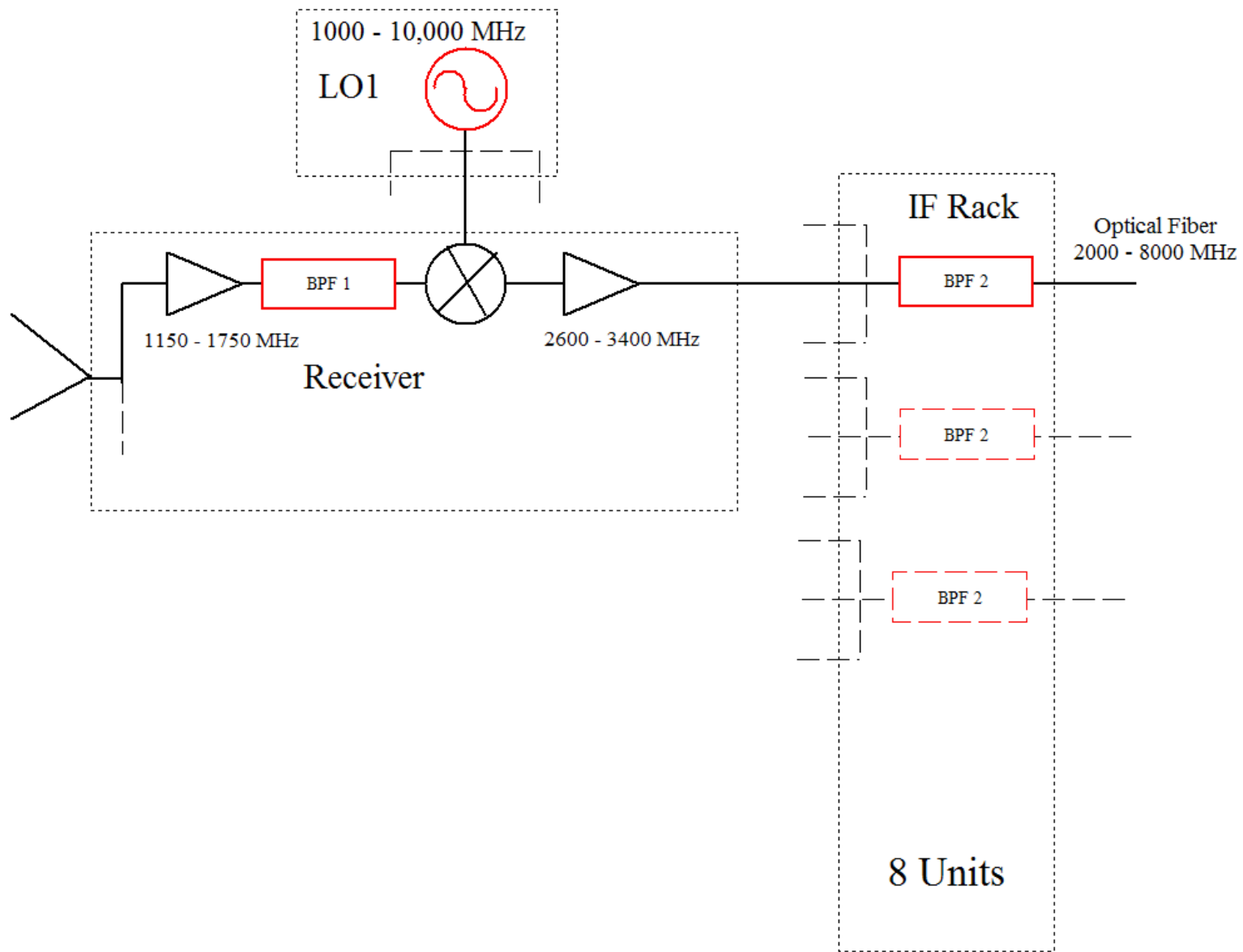


Local Oscillator and Switching Matrix

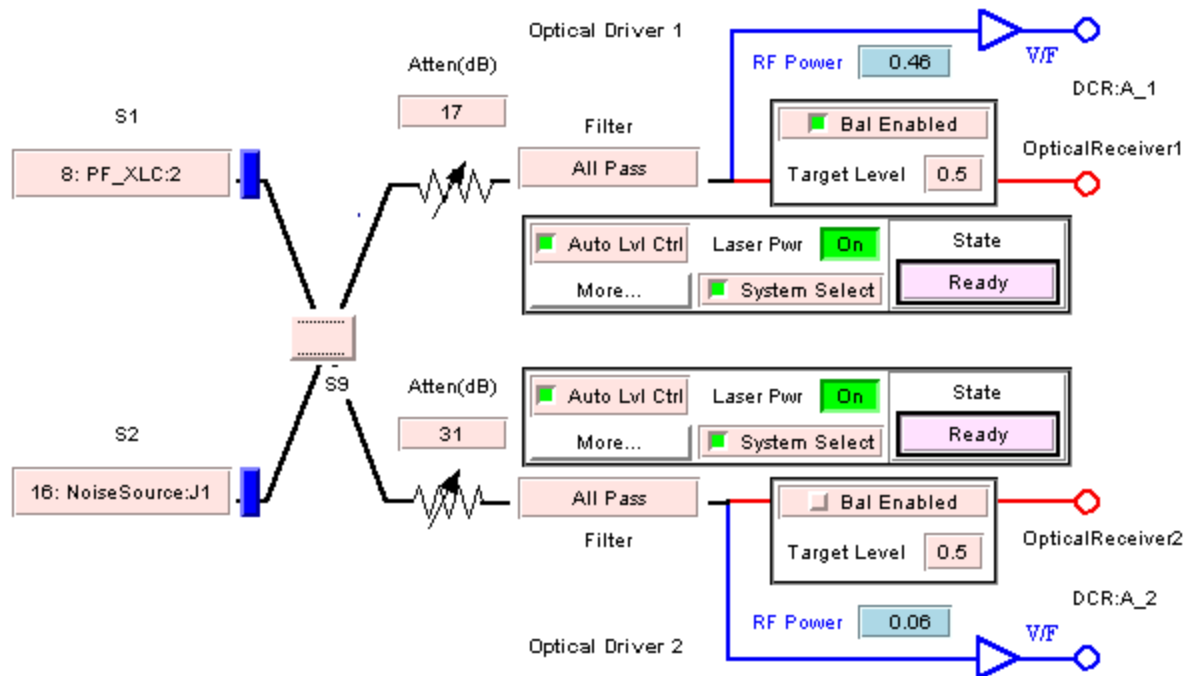


LO also used for:

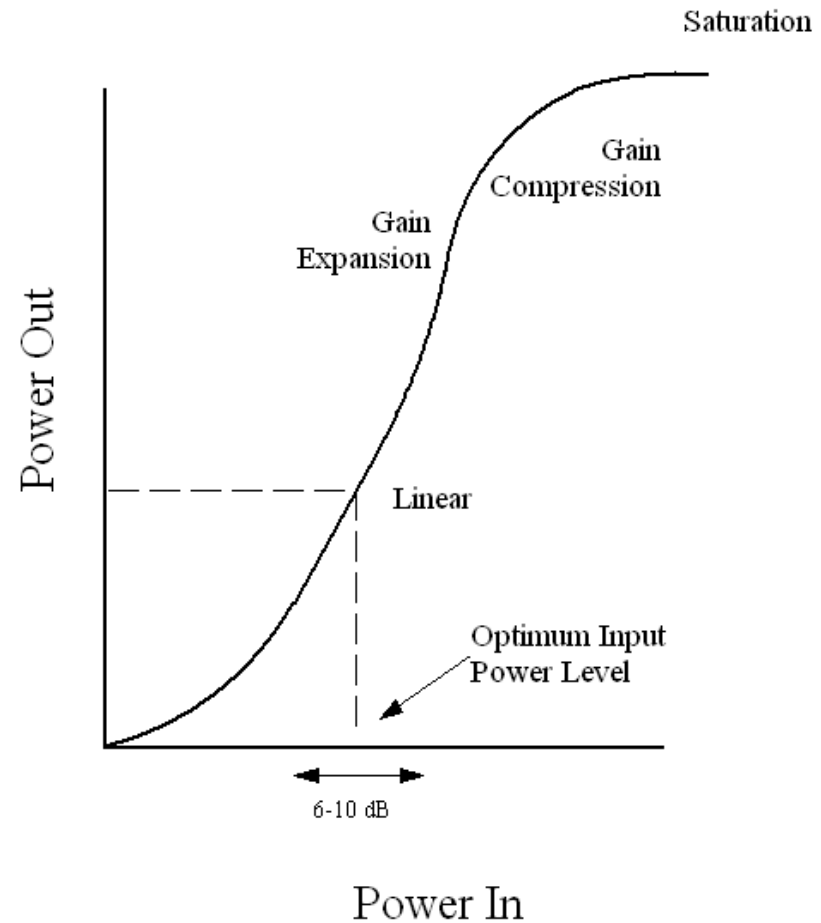
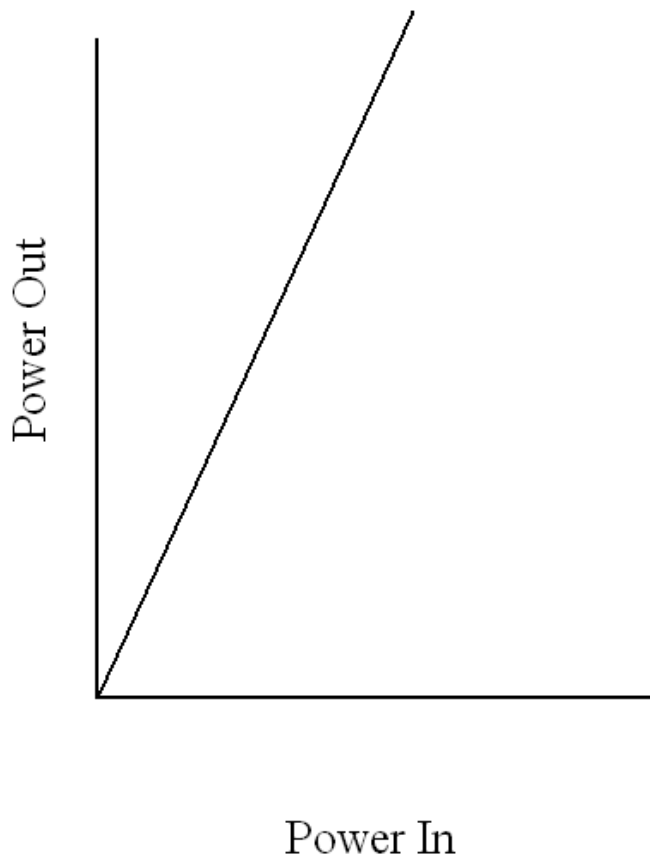
- Correcting for source velocity
 - wrt a chosen frame of rest
 - Heliocentric
 - LSR
 - Galactocentric
 - CMB
- And chosen approximation of Doppler shift
 - Relativistic
 - Radio
 - Optical
- Frequency Switching (optional tactic for removal of instrumental bandpass)
- Doppler Tracking for Earth rotation and revolution



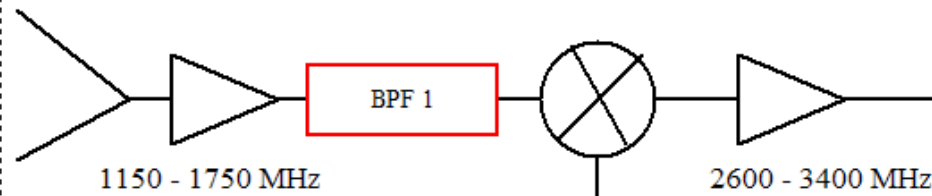
IF Rack – Input switching Matrix, IF Filters, Power Balancing Attenuators, and Drivers for 8 Optical Fibers



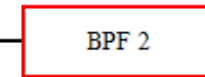
Power Balancing/Leveling and Non-Linearity



Receiver



IF Rack

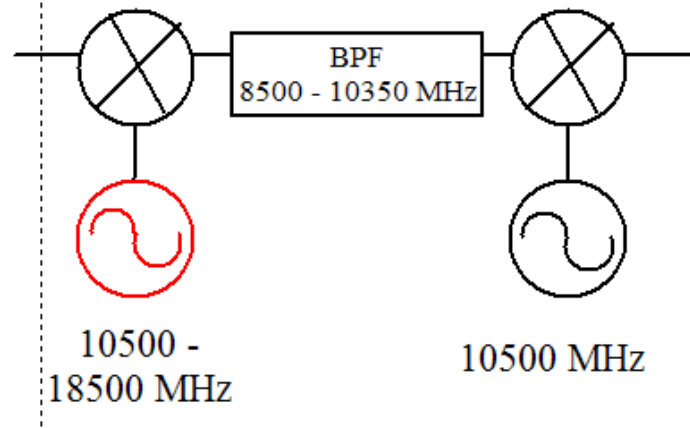


LO1

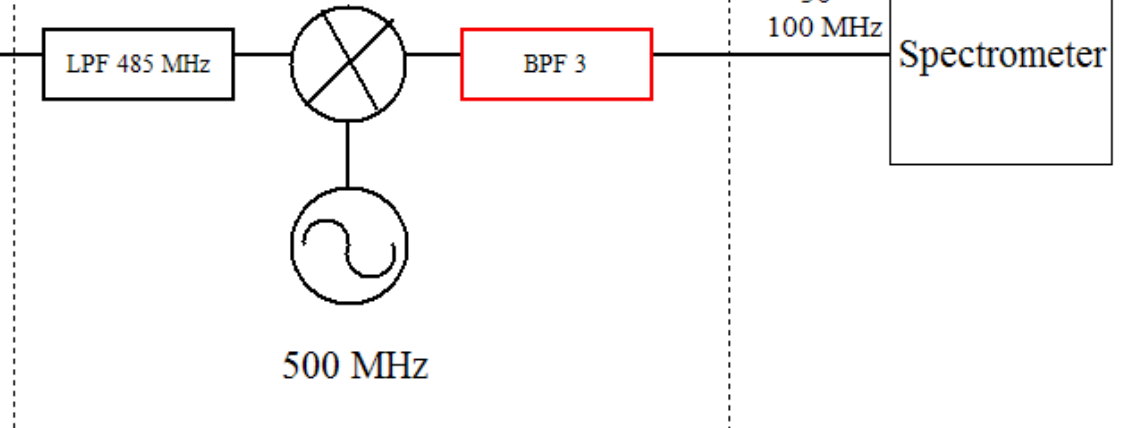


1000 - 10,000 MHz

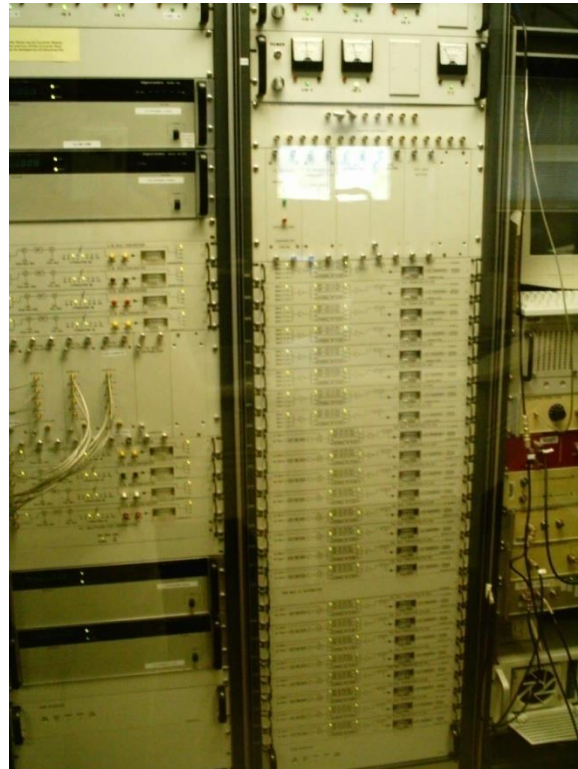
Converter Module



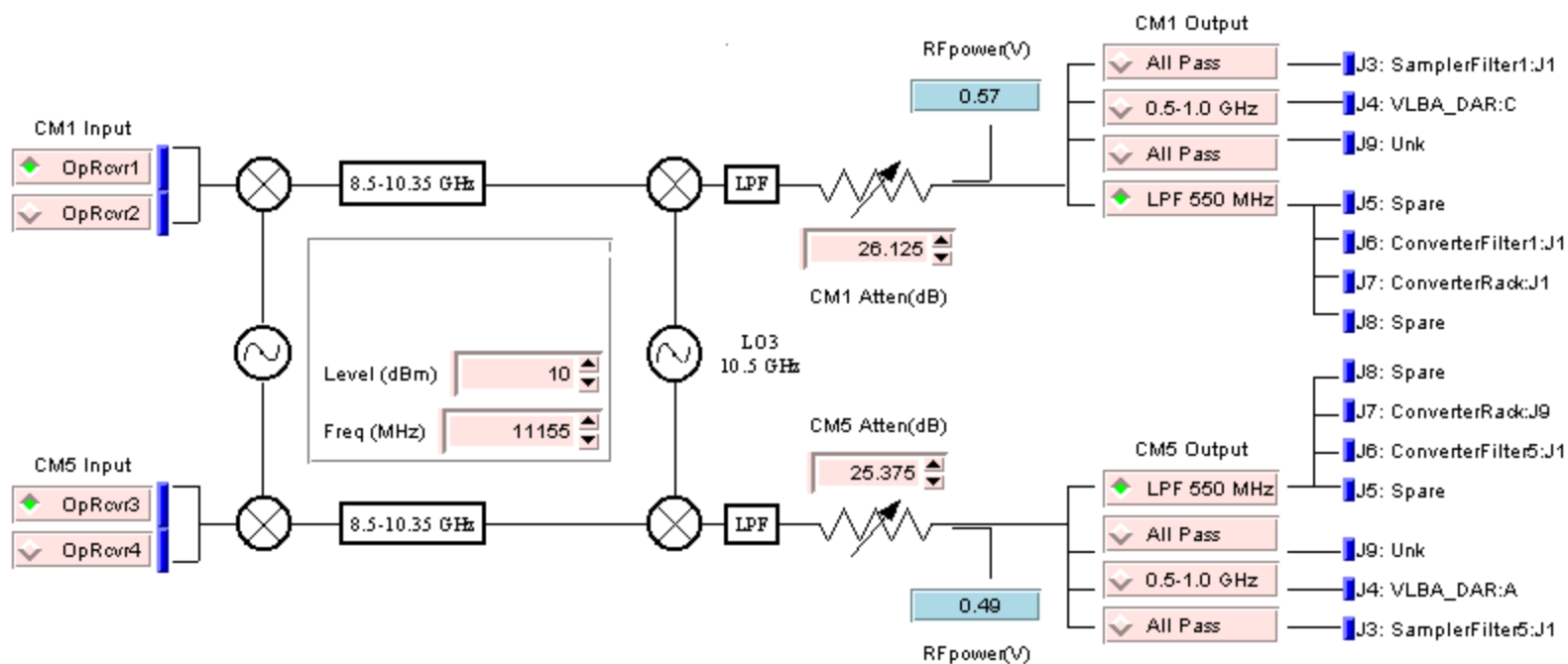
Analog Filter Module



Converter and Analog Filter Racks, Spectrometer

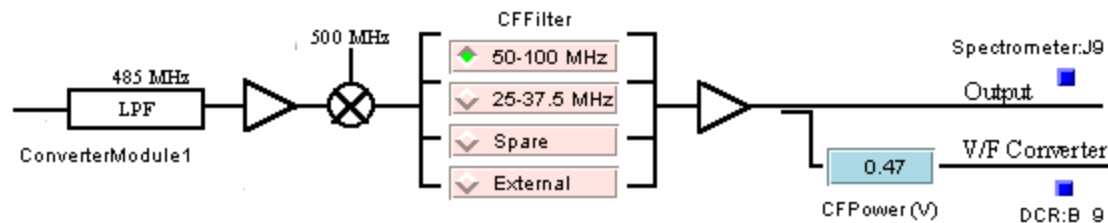


Converter Rack – Receivers for Optical Fibers, LO2 and LO3, Power Balancing Attenuators, Output Switches to Backends and AFR

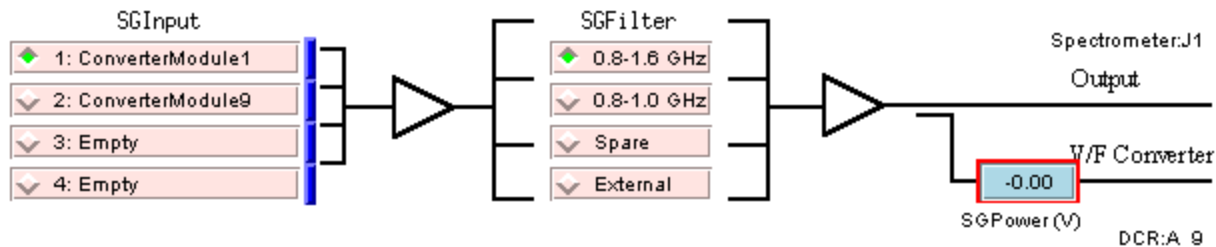


Analog Filter Rack

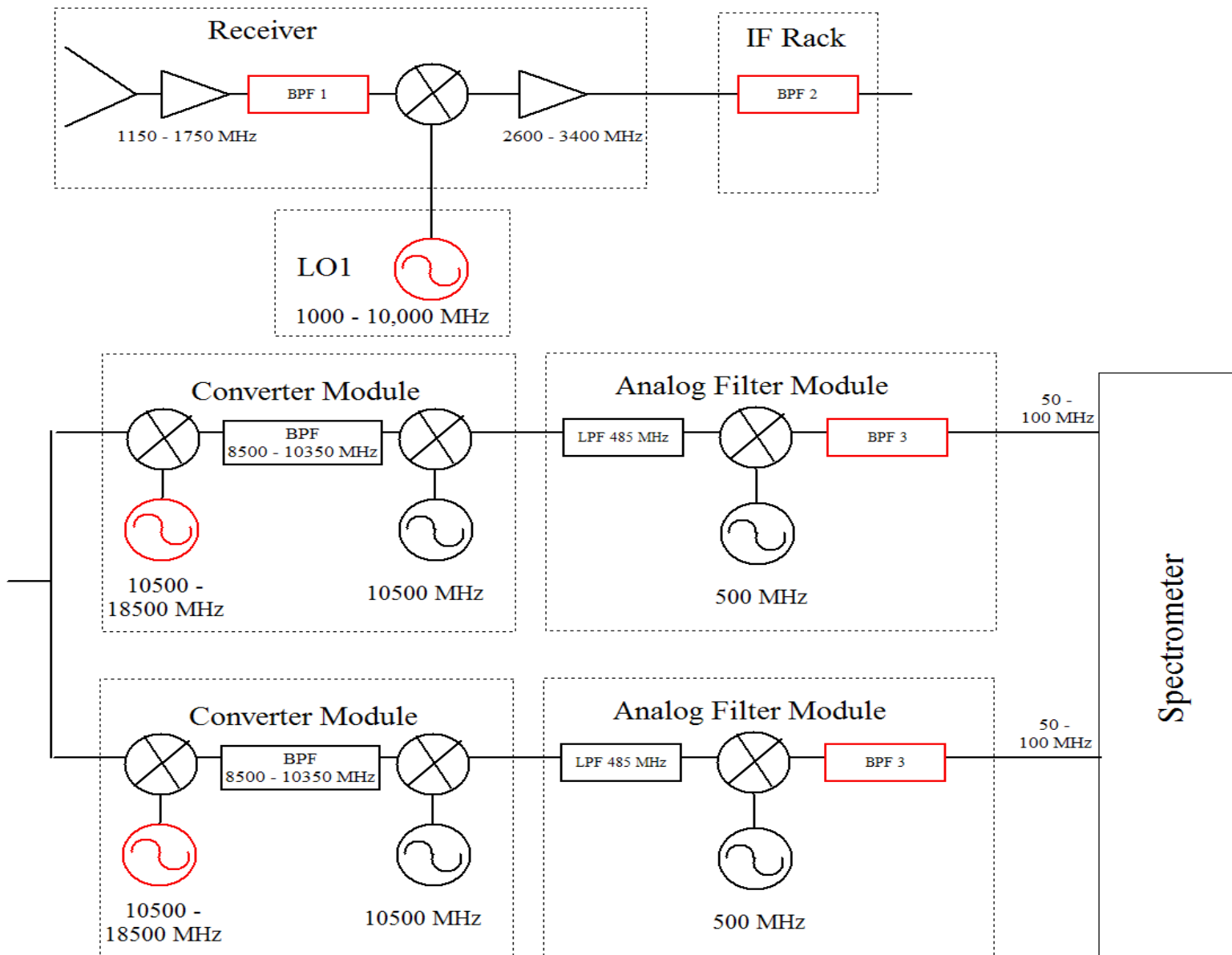
For 12.5 and 50 MHz Slow-Speed Spectrometer Samplers : LO4 and Filters



For 200 and 800 MHz High-Speed Spectrometer Samplers : Input Switches and Filters.



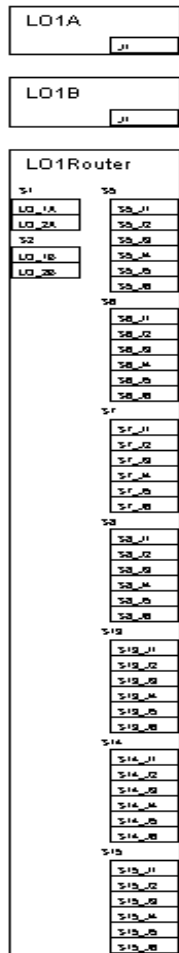
Quiz 3: Determine values for red components



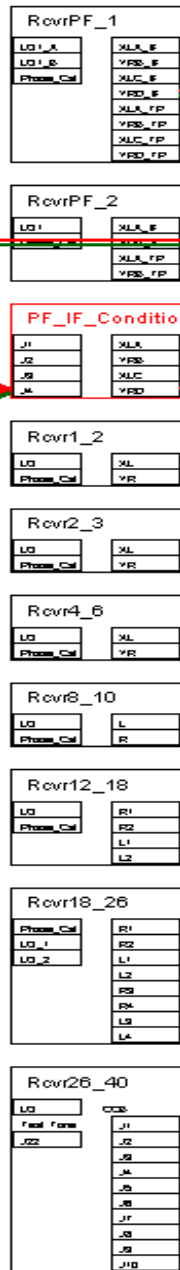
Quiz 3: Determine values for red components

- Goal : Observe simultaneously 1420 MHz and 1665 MHz with the 50 MHz wide (75 MHz center frequency) mode of the Spectrometer
- Parameters:
 - BPF1 can be: 1100–1800, 1600-1750, 1300-1450, or 1100-1450 MHz
 - All mixers are LSB. Hint: first two mixers up convert, the last two down convert.
 - BPF2 can be : 2990-3010, 2960-3040, 2840-3160, 2360-3640, 5960-6040, 5840-6160, or 5360-6640 MHz
 - BPF3 can be : 50-100 or 25-37.5 MHz
 - See block diagram for other parameters
- Hint: Work from the receiver down the chain until you get stuck, then from Spectrometer up. Try 1420 MHz first, then add in 1665 MHz.
- Record values for LO1 and both LO2's; settings for BPF1, 2, and 3; and values for all Intermediate Frequencies.

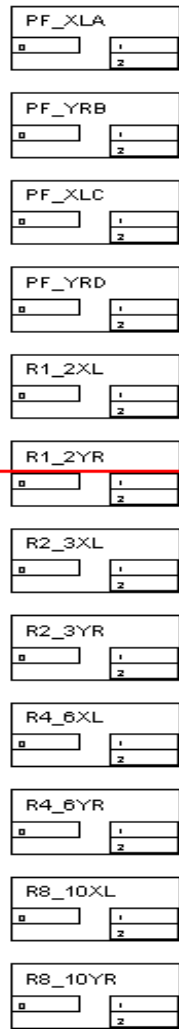
L.O. 1



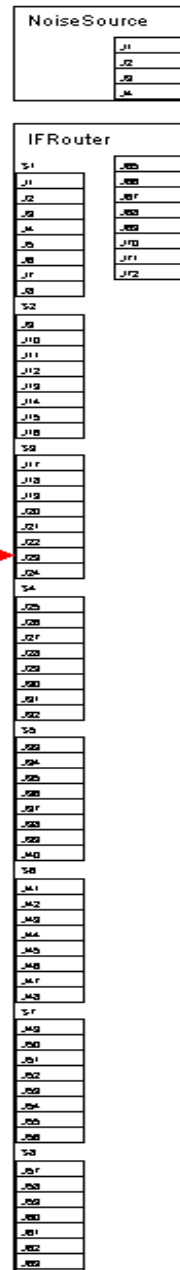
RECEIVERS



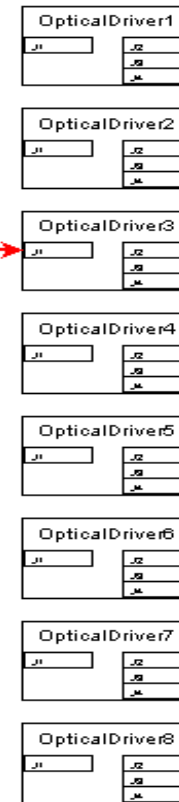
SPLITTERS



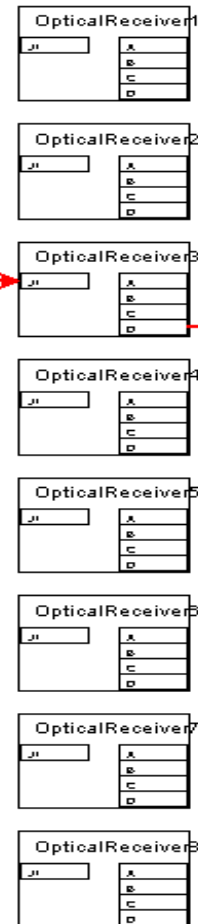
I.F. ROUTER

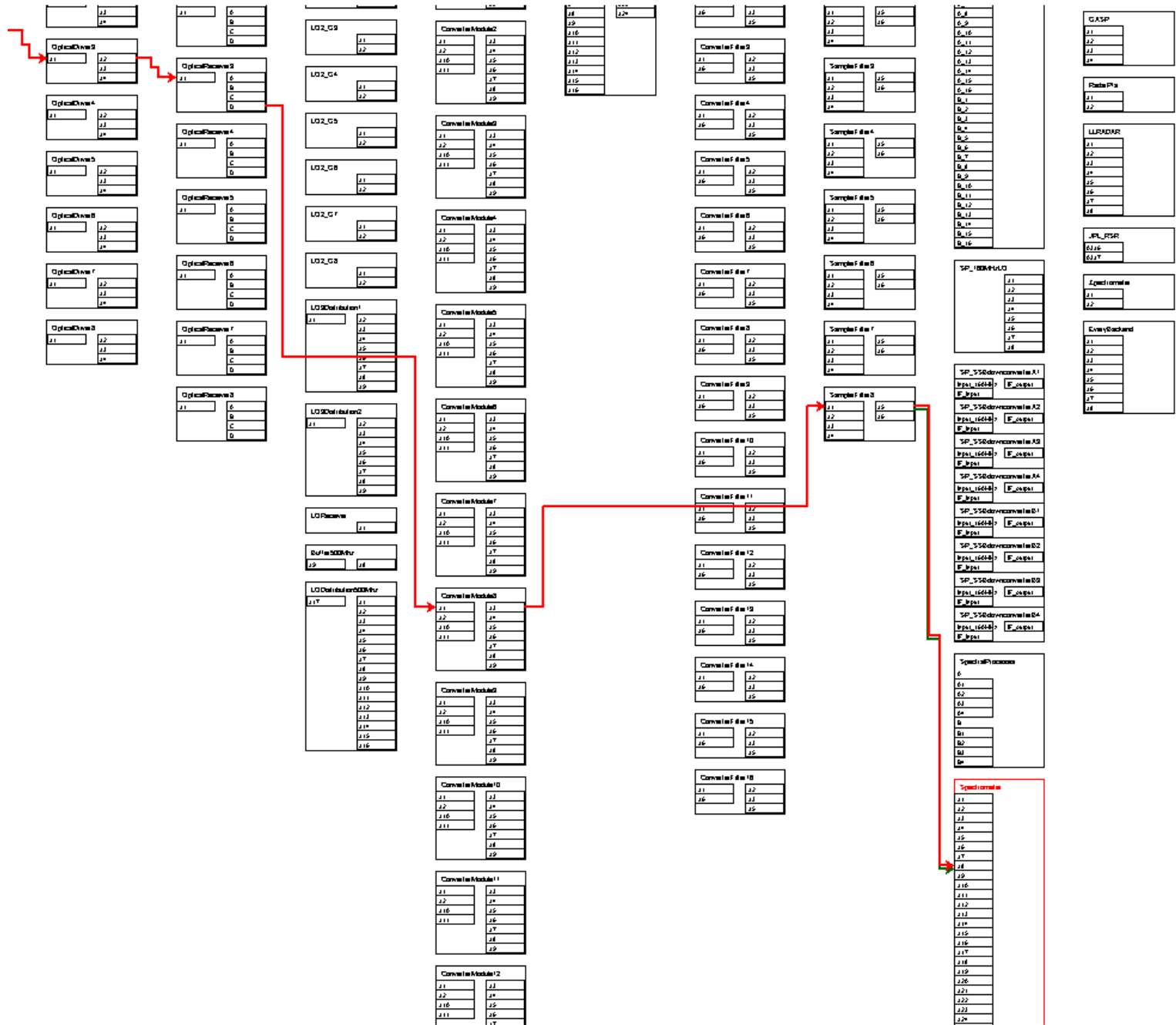


OPT. DRIVERS



OPT. RECEIVERS





Spectrum

Sideband	lower
IF	1200
Sky	-2770
Bandwidth	0
Polarization	linear_y
Noise Diode	lowCal

Sinusoid

IF	0
At LO	0

From: SamplerFilter8:J5

```

Feed: RcvrPF_1:YRD_342
      Freq: 270 to 420 MHz
      Polarization: linear_y
      Horn: 1
Tone: RcvrPF_1:C342Y
      Freq: 0 MHz
Filter: RcvrPF_1:FL342_5Y
      Freq: 270 to 420 MHz
Mixer: RcvrPF_1:MXYRD
      LO: 1430 MHz
      Component -- LO1A:synthesizer
      Lower Sideband: IFo = 1430 - IFi
Filter: RcvrPF_1:FLYRD3
      Freq: 1040 to 1120 MHz
Filter: RcvrPF_1:FLYRD
      Freq: 960 to 1200 MHz
Attenuator: RcvrPF_1:ifChannelD
Output Port: RcvrPF_1:J4
Input Port: PF_IF_Conditioner:J4
Output Port: PF_IF_Conditioner:J8
Input Port: IFRouter:J23
Output Port: IFRouter:J67
Input Port: OpticalDriver3:J1
Attenuator: OpticalDriver3:attenuator
Output Port: OpticalDriver3:J2
Input Port: OpticalReceiver3:J1
Output Port: OpticalReceiver3:J5
Input Port: ConverterModule8:J1
Mixer: ConverterModule8:MX2
      LO: 13500 MHz
      Component -- LO2_G4:synthesizer
      Lower Sideband: IFo = 13500 - IFi
Filter: ConverterModule8:FL1
      Freq: 8500 to 10350 MHz
Mixer: ConverterModule8:MX3
      LO: 10500 MHz
      Component -- LO3Distribution1:synthesizer
      Lower Sideband: IFo = 10500 - IFi
Filter: ConverterModule8:FL2
      Freq: 0 to 2200 MHz

```

Spectrum

Sideband	lower
IF	1200
Sky	-2770
Bandwidth	0
Polarization	linear_y
Noise Diode	lowCal

Sinusoid

IF	0
At LO	0

From: SamplerFilter8:J5

```

Mixer: RcvrPF_1:MXYRD
      LO: 1430 MHz
      Component -- LO1A:synthesizer
      Lower Sideband: IFo = 1430 - IFi
Filter: RcvrPF_1:FLYRD3
      Freq: 1040 to 1120 MHz
Filter: RcvrPF_1:FLYRD
      Freq: 960 to 1200 MHz
Attenuator: RcvrPF_1:ifChannelD
Output Port: RcvrPF_1:J4
Input Port: PF_IF_Conditioner:J4
Output Port: PF_IF_Conditioner:J8
Input Port: IFRouter:J23
Output Port: IFRouter:J67
Input Port: OpticalDriver3:J1
Attenuator: OpticalDriver3:attenuator
Output Port: OpticalDriver3:J2
Input Port: OpticalReceiver3:J1
Output Port: OpticalReceiver3:J5
Input Port: ConverterModule8:J1
Mixer: ConverterModule8:MX2
      LO: 13500 MHz
      Component -- LO2_G4:synthesizer
      Lower Sideband: IFo = 13500 - IFi
Filter: ConverterModule8:FL1
      Freq: 8500 to 10350 MHz
Mixer: ConverterModule8:MX3
      LO: 10500 MHz
      Component -- LO3Distribution1:synthesizer
      Lower Sideband: IFo = 10500 - IFi
Filter: ConverterModule8:FL2
      Freq: 0 to 2200 MHz
Attenuator: ConverterModule8:AT1
Output Port: ConverterModule8:J3
Input Port: SamplerFilter8:J1
Filter: SamplerFilter8:FL1
      Freq: 800 to 1600 MHz
Output Port: SamplerFilter8:J5
Input Port: Spectrometer:J8

```

GBT – Configure command in Astrid program does all the hard work for you.....

```
configLine = ""  
receiver = "Rcvr1_2"  
beam     = "B1"  
obstype  = "Spectroscopy"  
backend  = "VEGAS"  
nwin     = 2  
restfreq = 1420.4058., 1666.0  
deltafreq = 0, 0  
bandwidth = 11.72  
swmode   = "tp"  
swtype   = "none"  
swper    = 1.0  
swfreq   = 0.0, 0.0  
tint     = 30
```

```
vlow     = 0  
vhigh    = 0  
vframe   = "lsrk"  
vdef     = "Radio"  
noisecal = "lo"  
pol      = "Linear"  
nchan    = "low"  
""
```