

Section 1-3

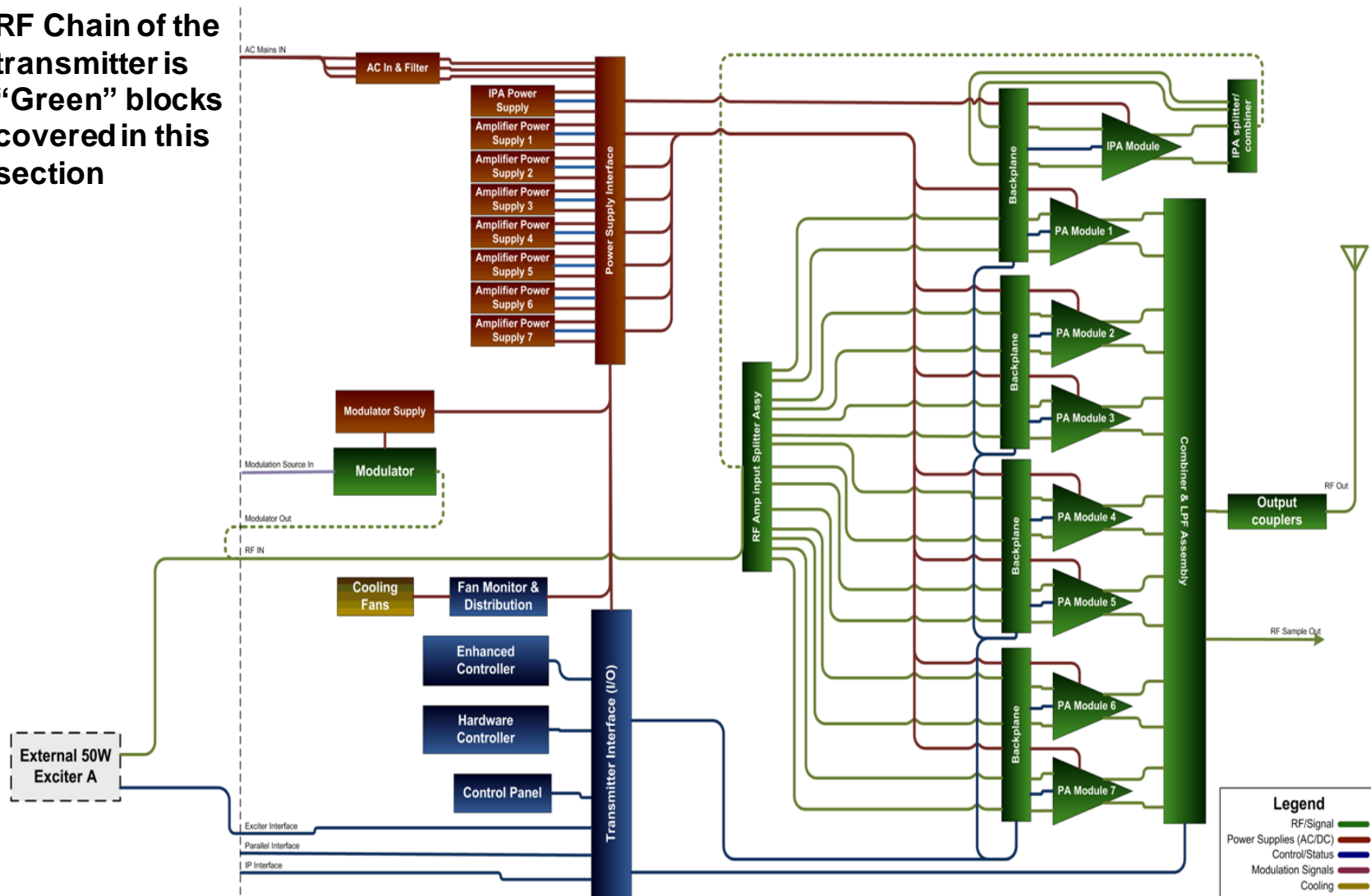
RF Chain

In this section of the class we will review the RF Chain.



FAX RF Chain

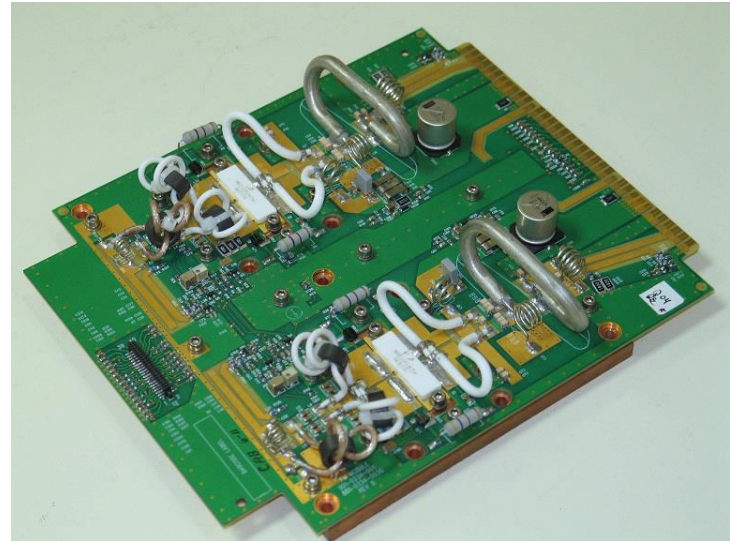
RF Chain of the transmitter is “Green” blocks covered in this section



FAX RF Chain

- Two identical RF pallets per amplifier module
- Two LDMOS devices per module (one per pallet)
- Broadband 87.5-108 MHz frequency range no tuning required
- Module Power rating:

| | |
|-----------|---------------|
| 1600 W FM | |
| @-20 dBc | 1300 W FM+HD |
| @-20 dBc | 600 W HD Only |
- All splitting and combing done external to the RF Module
- Lightweight, hot-pluggable and Interchangeable – See PA Edge Connector
- Weight: 4.5kg (9.9 lb)
- Size: 299mm x 191mm x 121mm (11.75" D x 7.5" W x 4.75" H)

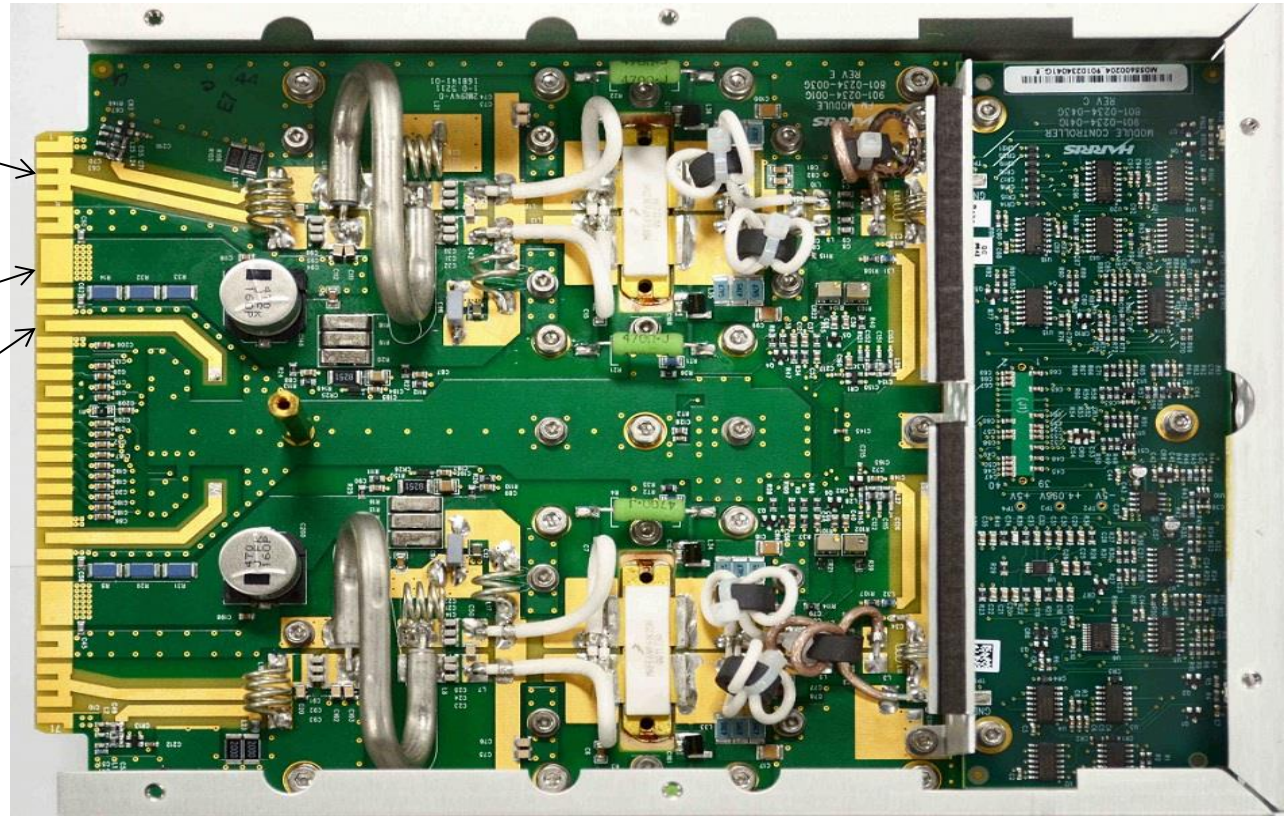


FAX RF Chain

RF Out Longest –
Ensures connection is
first going in and last
coming out

VDD – Next prior to RF IN

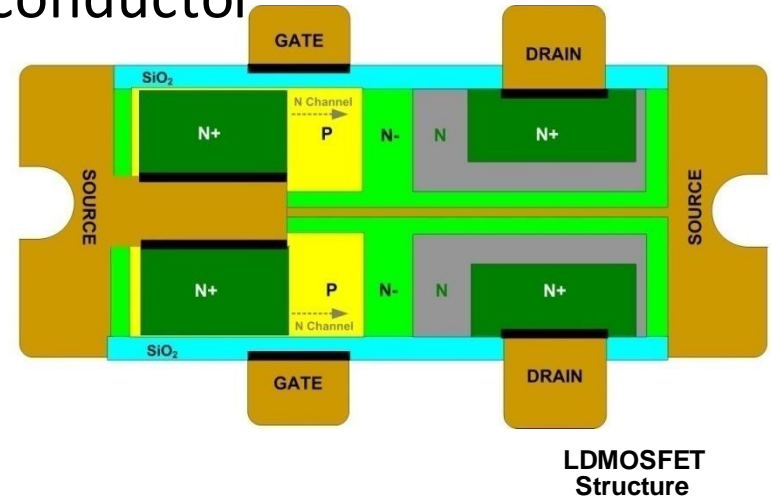
RF IN - Last



Edge connector line lengths make the Amplifier Hot-Pluggable



Laterally Diffused Metal–Oxide-Semiconductor Field-Effect Transistor (LDMOS-FET)



GatesAir has had a great deal of experience with LDMOS in Maxiva™ UHF and VHF television transmitters, as well as Platinum™ series L-band television transmitters.

Recent developments in 50-volt VHF Band II VHF LDMOS device technology have resulted in dramatic improvements in power density per device, and maximum power output as well as linearity and efficiency.



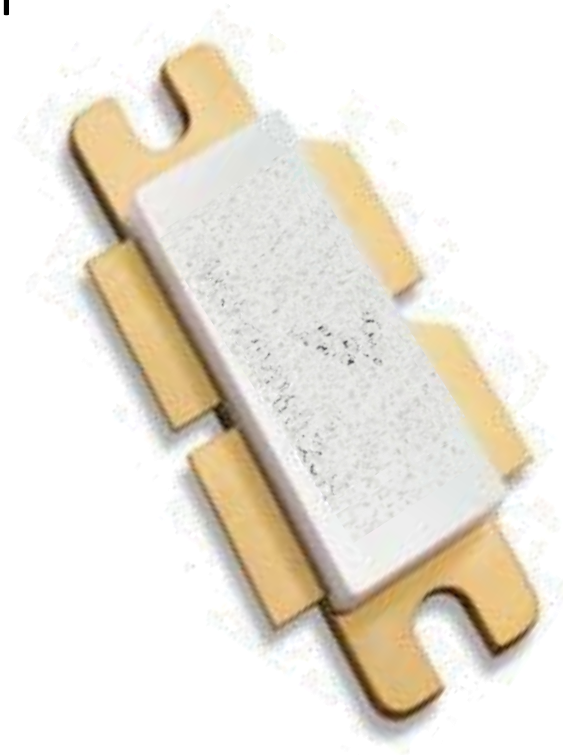
FAX RF Chain

Amplifier power density is the key to reducing both the size of the transmitter and the cost of manufacturing and purchase.

Contemporary solid-state 10kW FM transmitter designs can achieve about 625 Watts per cubic foot

50 Volt LDMOS makes possible fewer devices in a more compact transmitter package

New transmitter systems designed around these higher per-device power levels can now achieve 20 kW in the same 19" rack or around 1250W per cubic foot



PA Module I/O to PA Backplane Board

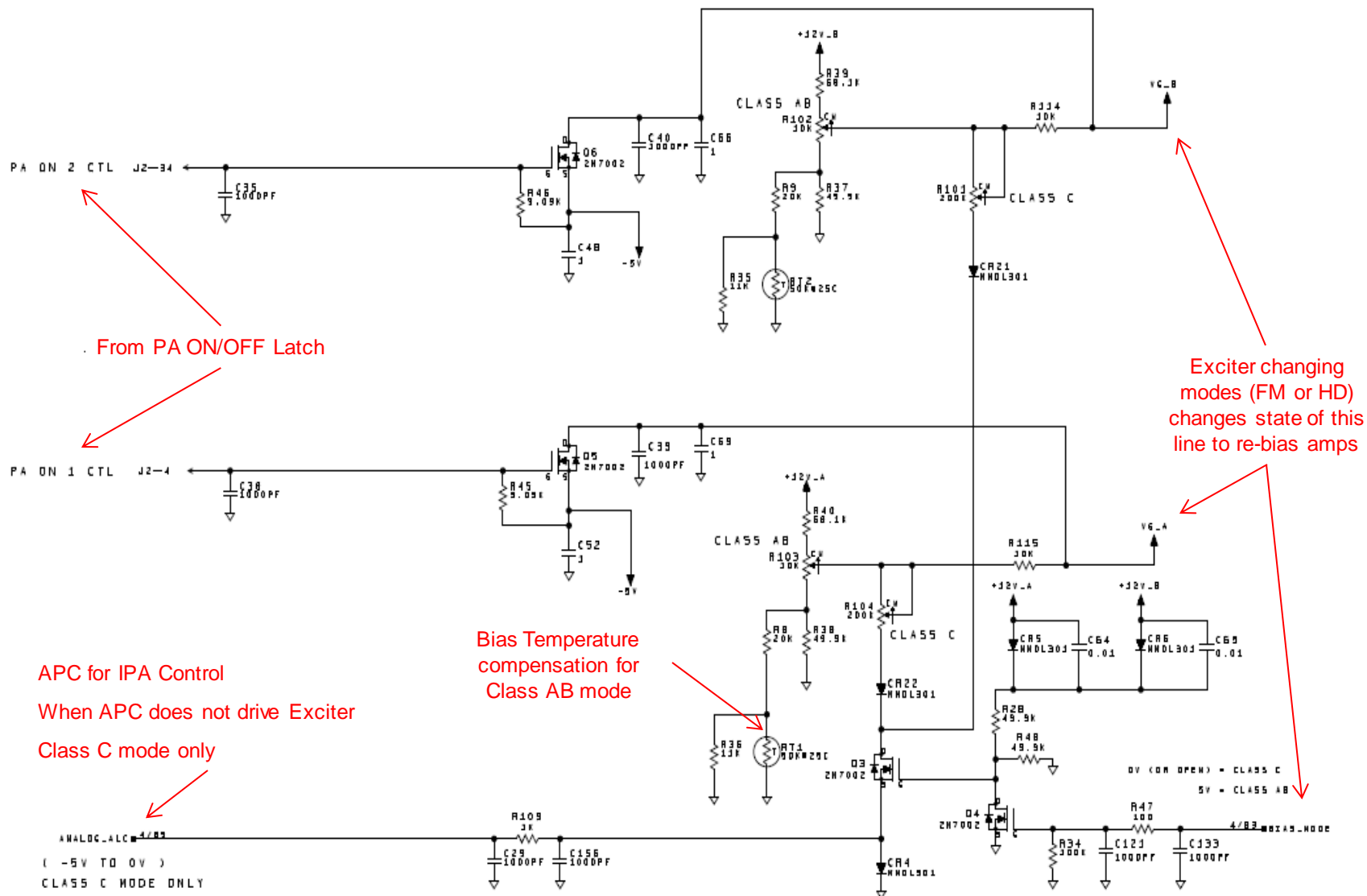
| Pin | Signal | Level | Notes |
|----------|-----------------------|---------------------|--|
| 1 | GND | | On Multiple Pins |
| 3,5,7 | RF OUT A | Up to 800 W FM Mode | Output mode dependant |
| 13-20 | VDD A | 44 - 50 VDC | From Main Power Supply |
| 23 | RF INPUT A | Up to 25 Watts | Drive to Pallet A |
| 27 | PA Enable | 0/5 VDC | ON= |
| 28 | ON COMMAND | 0/5 VDC | ON= |
| 29 | ANALOG ALC | -5 to 0 VDC | Used in Class C mode only |
| 30 | Bias Mode | 0/5 VDC | 0 VDC=Class C/5 VDC= Class AB |
| 31 | PA INTLK | GND | Indicates PA is installed in slot;if not installed activates PA SUMMARY FAULT via fet on Backplane |
| 32 | MUX SELECT | 0/5 VDC | Selects PA module to be read on MUX Bus |
| 33 | MUX AB SELECT | 0/5 VDC | Selects Pallet A or B readings that are applied to MUX Bus |
| 34 | +5 VDC SUPPLY | +5 VDC | From Main Power Supply |
| 35 | PA SUMMARY FAULT | 0/5 VDC | 0=Fault Indicates either A or B side has a fault of any kind |
| 36 | IPA CURRENT REFERENCE | Adds 1.2 k resistor | Reference when PA used as IPA for current overload; Dip sw setting on backplane bd |
| 37 | PA RFLD THD | | Not Used |
| 38 | PA OVERDRIVE FAULT | 0/5 VDC | Overdrive on A or B Pallet |
| 39 | PA CURRENT FAULT | 0/5 VDC | Overcurrent on A or B Pallet |
| 40 | PA VSWR FAULT | 0/5 VDC | Excess VSWR on A or B Pallet |
| 41 | PA TEMP FAULT | 0/5 VDC | PA TEMP Fault, Heatsink overtemp |
| 42 | PA CURRENT | I=10*V (±5 %) | Current Sense voltage scale factor shown |
| 43 | PA TEMP | 4.7 kΩ @25 °C | Heatsink temp thermistor output |
| 44 | VDD READY | 4.096 VDC | Indicates PA is installed in slot |
| 45 | SPARE | SPARE | |
| 49 | RF INPUT B | Up to 25 Watts | Drive to Pallet B |
| 53-60 | VDD B | 44 - 50 VDC | From Main Power Supply |
| 65,67,69 | RF OUT B | Up to 800 W FM Mode | Output mode dependant |

All other pins not listed are GROUND

Some signal names change nomenclature when they exit PA Module.



FAX RF Chain



From PA ON/OFF Latch

Exciter changing modes (FM or HD) changes state of this line to re-bias amps

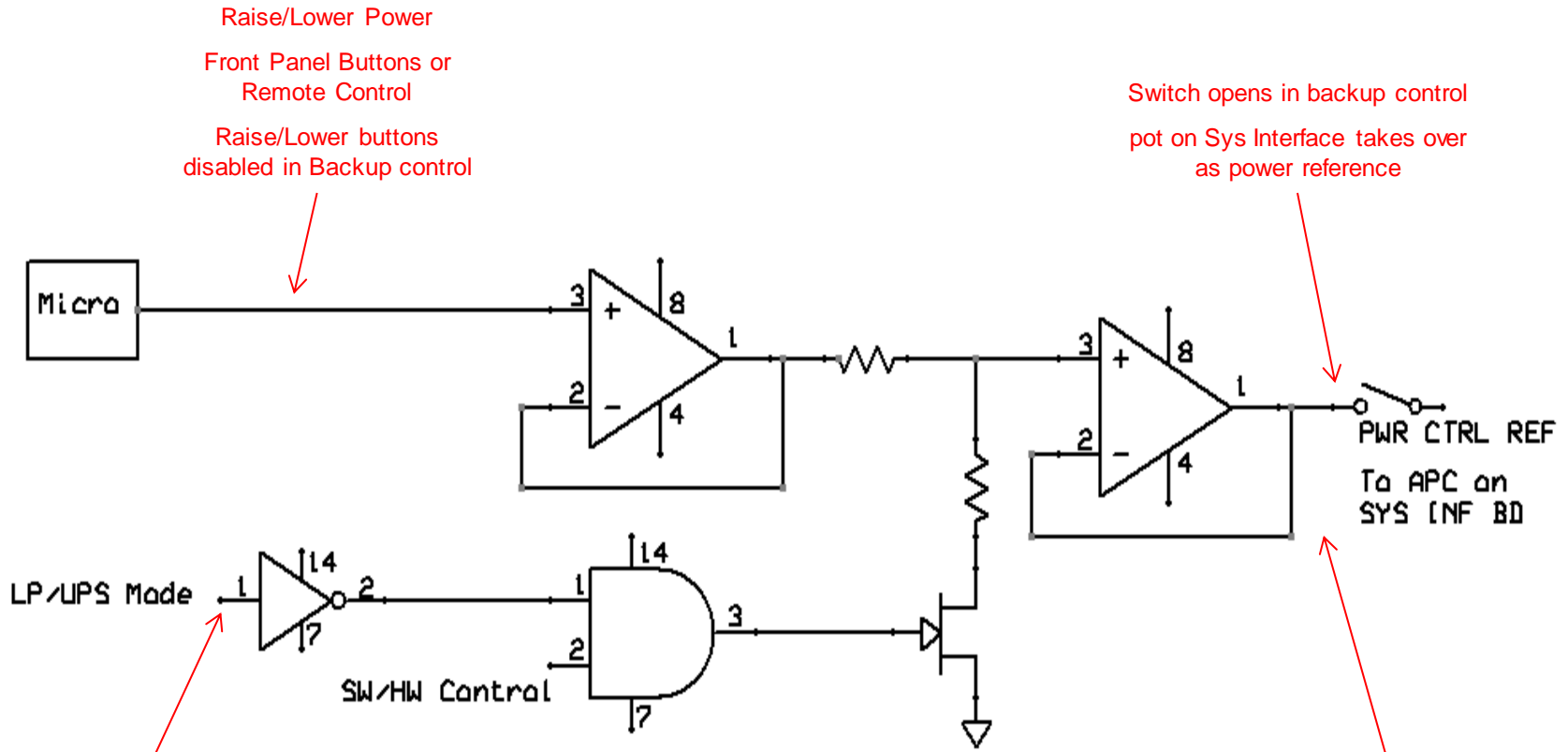
APC for IPA Control
When APC does not drive Exciter
Class C mode only

Bias Temperature compensation for Class AB mode

0V (OR OPEN) = CLASS C
5V = CLASS AB



FAX RF Chain



Raise/Lower Power
Front Panel Buttons or
Remote Control
Raise/Lower buttons
disabled in Backup control

Switch opens in backup control
pot on Sys Interface takes over
as power reference

LP/UPS Mode not LP
only J1-8 Remote I/O.
Also Reject Load Fault
will force TX to LP/UPS
Mode
Forces TX to user
preset power

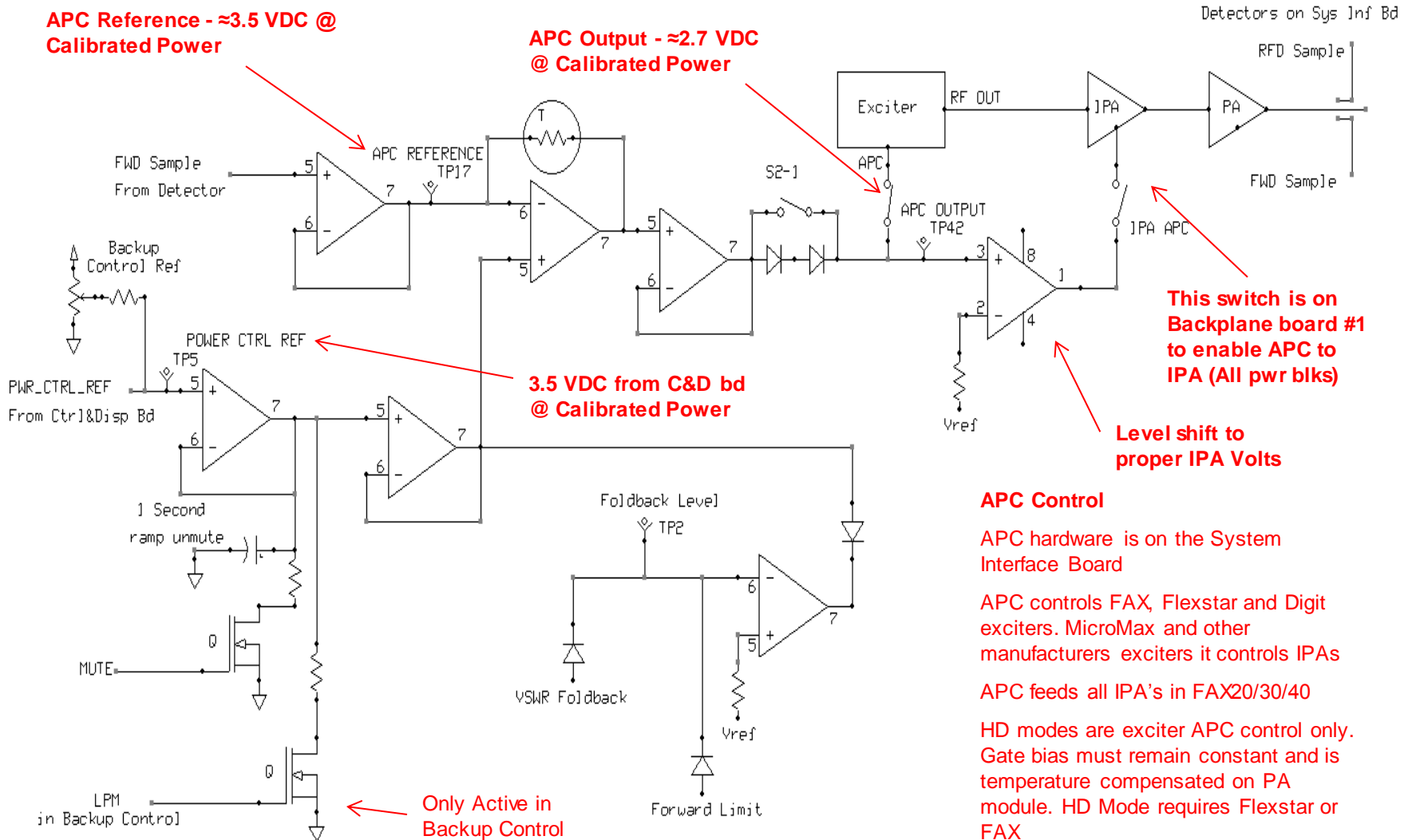
LP/UPS Modes active in Software Control Only

Power Control Reference on Control & Display Board
Raise/Lower Power Adjusts this Ref
Circuit is disabled in Backup Control and trimmer pot acts as reference

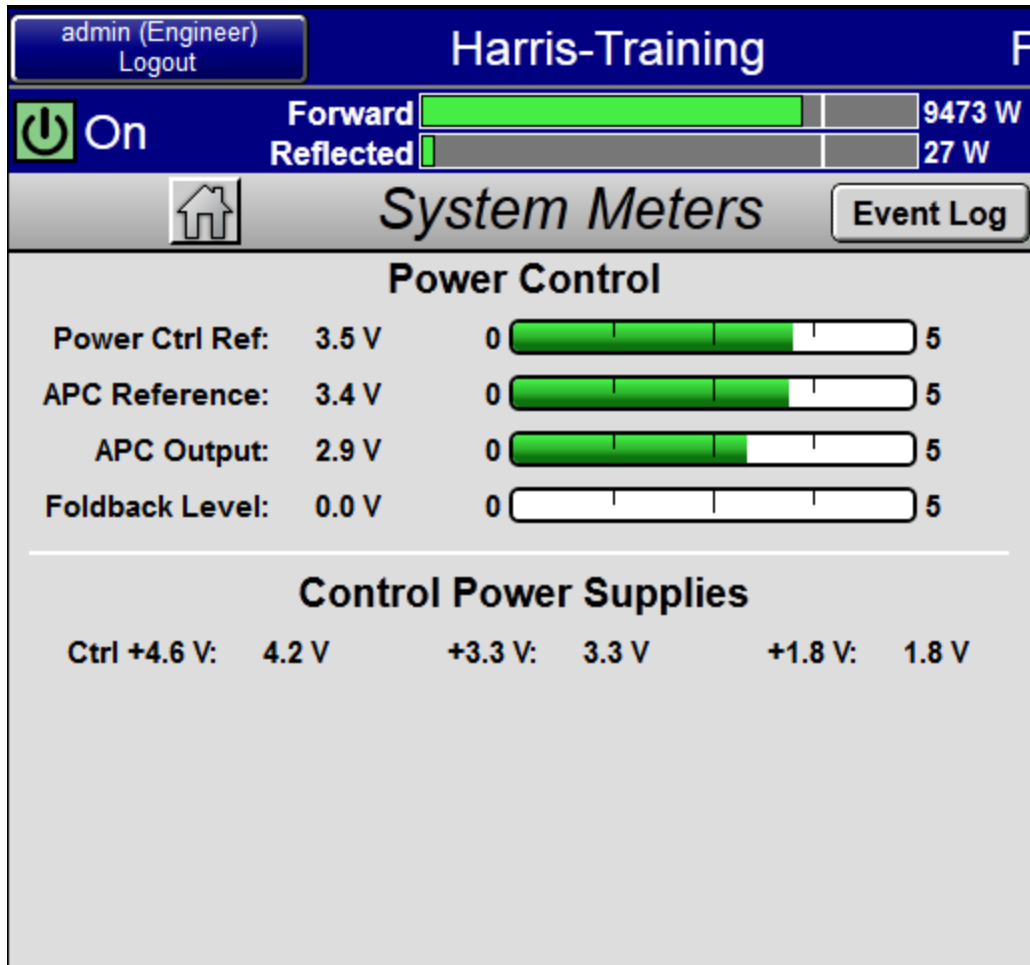
The PWR_CTRL_REF is 3.5
VDC @calibrated power and
is set during the calibration
process. This voltage is
used to setup forward
power limit and VSWR
fault/Foldback in Hardware



FAX RF Chain



FAX RF Chain



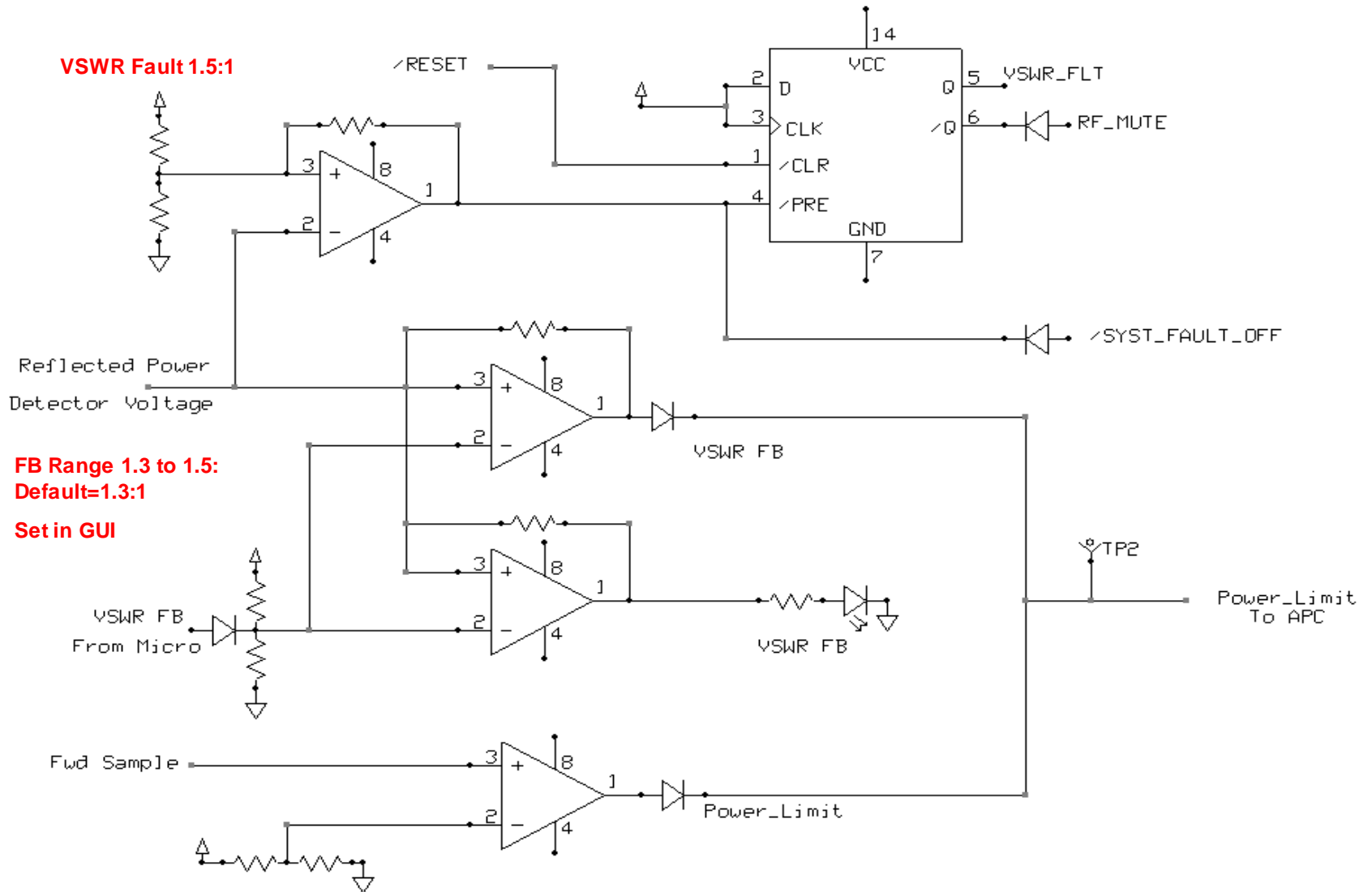
Power Ctrl Ref – TP5 from micro module. Set to 3.5 VDC during calibration. Varies only when raise/lower power button used.

APC Reference – TP17 detected RF sample from System forward power coupler. Should be approximately 3.5 volts at calibrated TPO.

APC Output – TP42 output to Exciter or to IPA level shifter

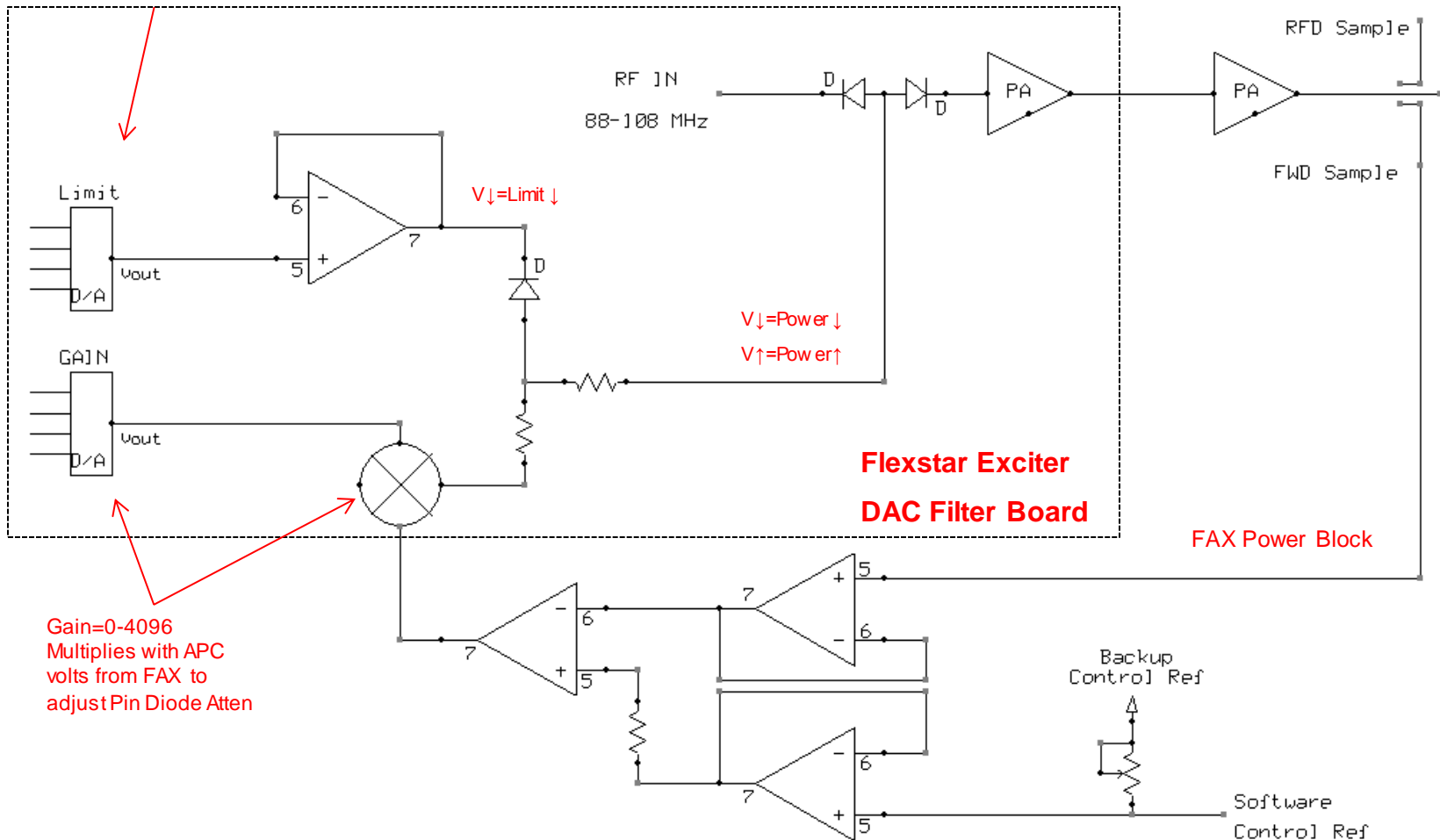
Foldback Level – TP2 – typically 0 volts, increases once 110 % forward power (from calibrated power) or VSWR Foldback Threshold is exceeded (1.3 – 1.5:1) set in GUI.

FAX RF Chain



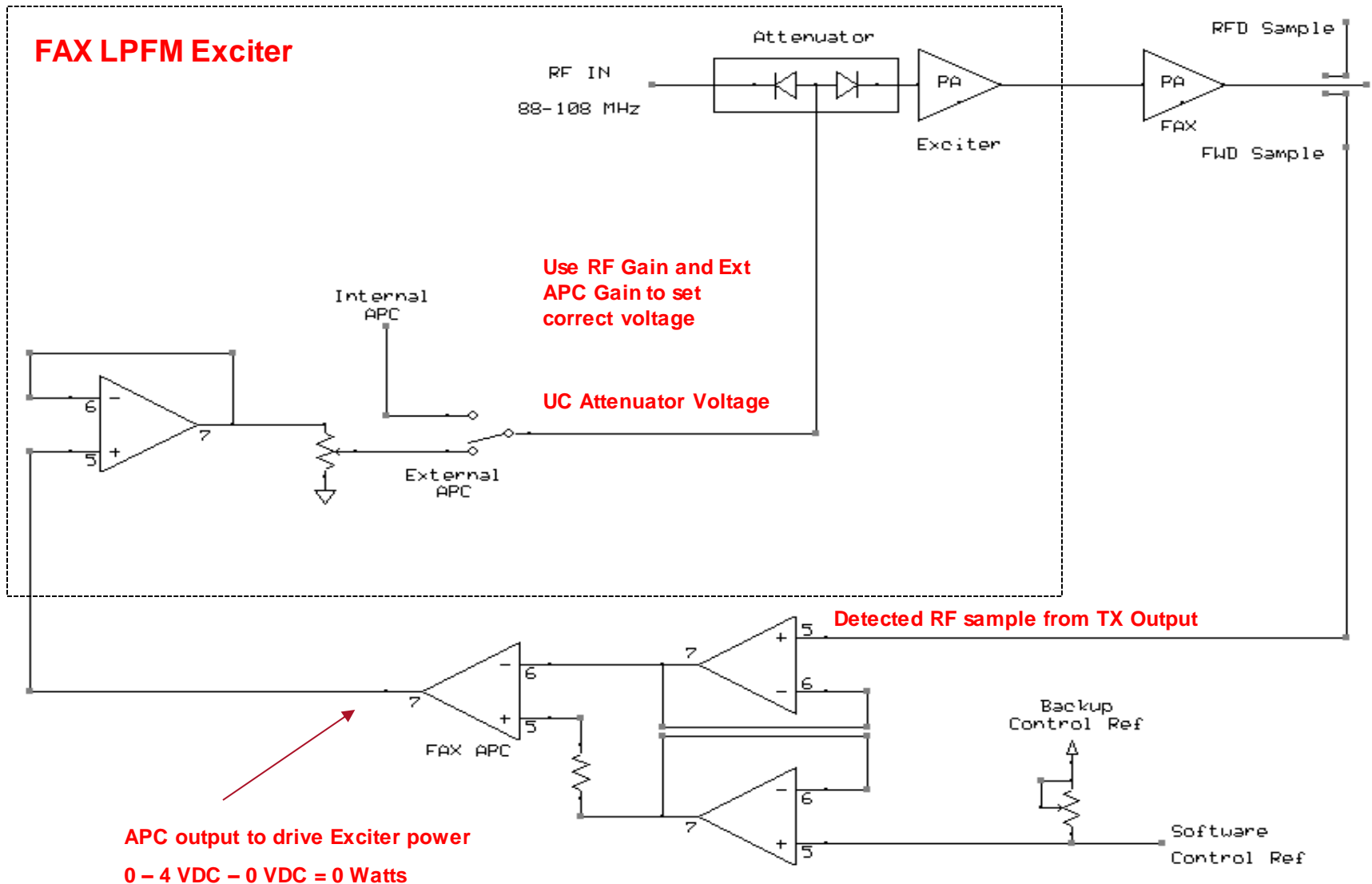
FAX RF Chain

Limit=0-4096
 Changes voltage where
 diode conducts to limit
 APC voltage to Pin Diode
 Atten



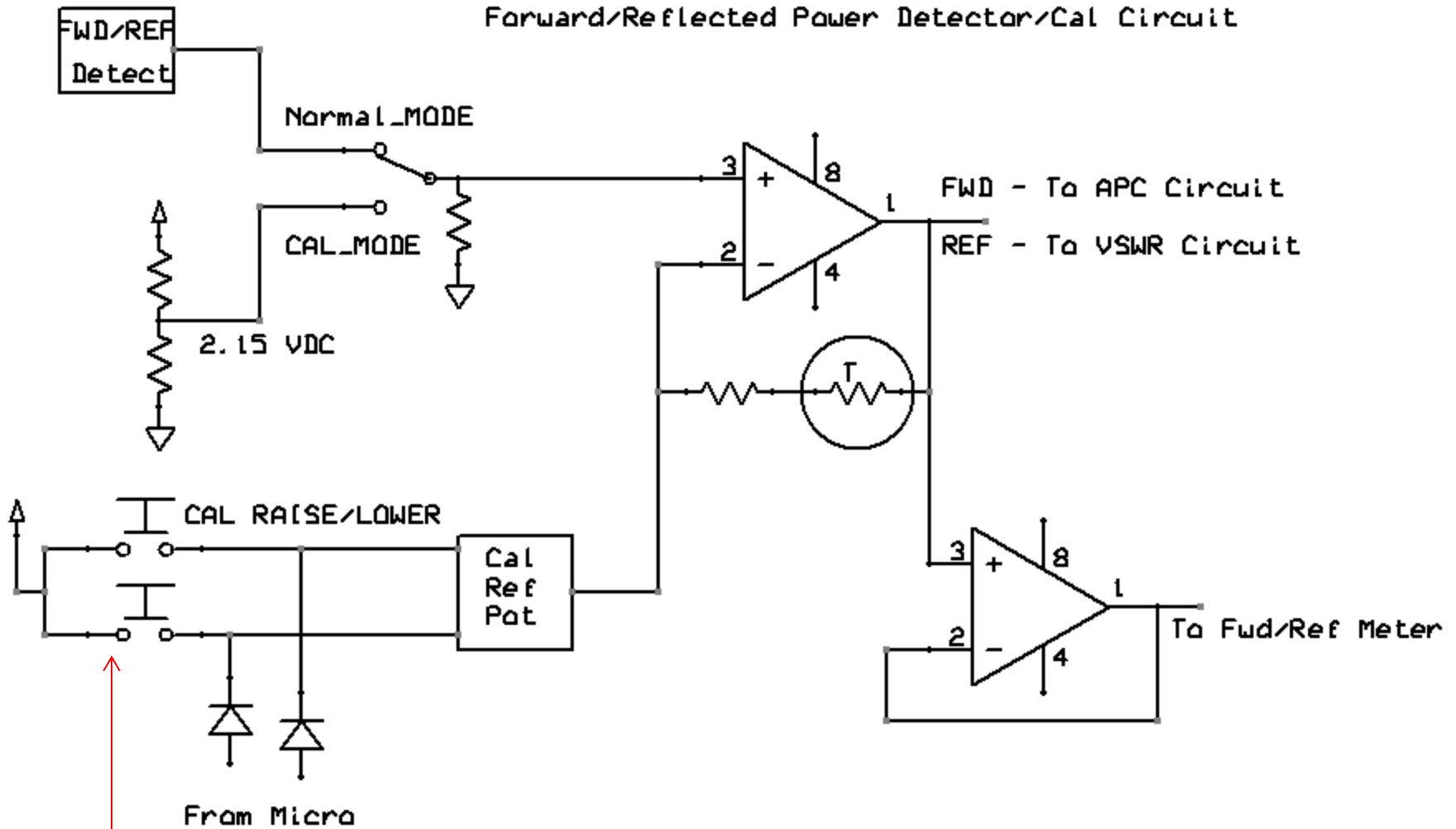
Gain=0-4096
 Multiplies with APC
 volts from FAX to
 adjust Pin Diode Atten

FAX RF Chain



FAX RF Chain

Forward/Reflected Power Detector/Cal Circuit



Buttons used only
for Power Block Cal

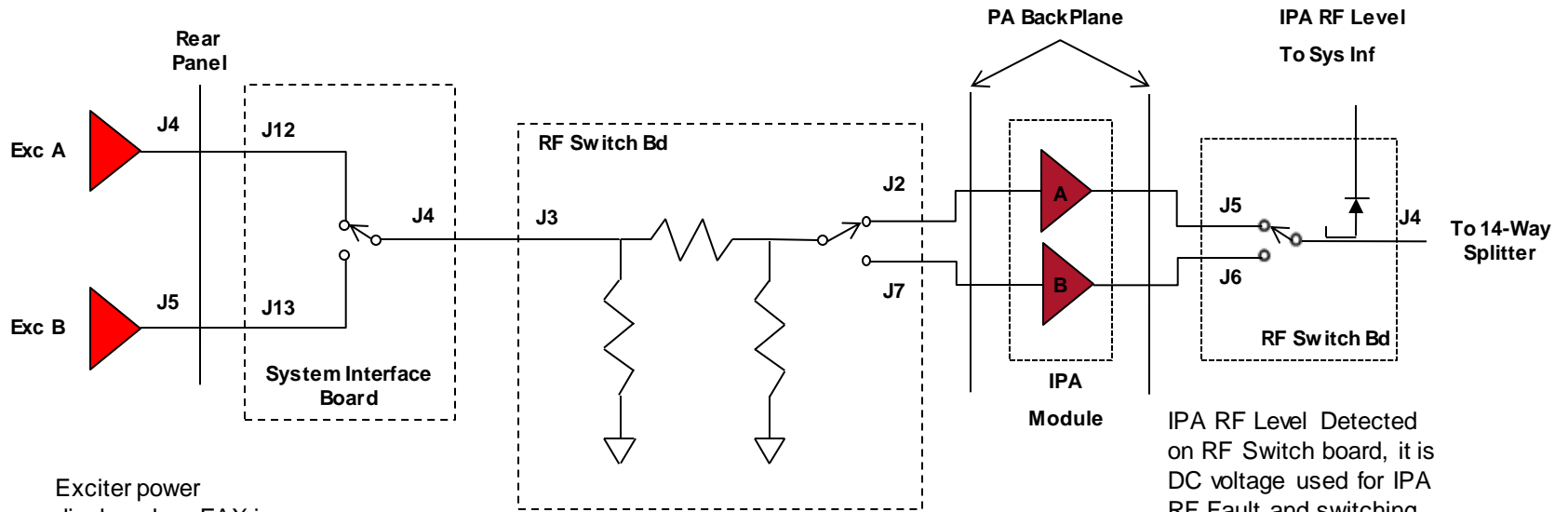
Forward/Reflected Power Calibration

The basic idea is that we use the forward and reflected sample from the same port on the directional coupler which means that the coupling factor for the forward and reflected power ports are pretty close to each other. Because of that, we can set the gains for the forward and reflected detector circuits such that when you calibrate the forward power to 3.5V for 100% using the adjustable gain stage after the detector, you just need to make the gain of the reflected power the same as the forward. This will give you 3.5VDC at the equivalent 1.5:1 VSWR.

When the calibration is entered, the first step is the AGC is set off and the gains are set to min. Phase I is done and then you set the exciter power out until the transmitter power matches your TPO. When you do phase II, the controller will adjust the gain of the forward power stage to get 3.5V for the forward power sample. Then the controller does the same as setting **S2-8 ON** which then puts a 2.15 VDC on each gain stage input. The micro measures the DC voltage of the forward power stage again and records that. It then adjusts the reflected gain stage to get the same voltage. Now both forward and reflected gains are the same. It opens **S2-8** and now sets the meter to indicate that 3.5V on forward sample is whatever the customer set up for the cal power. The reflected power detector generates about 2 times the voltage and the output at TP8 should be about 3.5 VDC at 1.5:1 VSWR (400 Watts at 10 kW output).



FAX RF Chain



Exciter power displayed on FAX is a DC Voltage from Exciter. There is no RF detector for Exciter Power

RF Switch Bd relays switch in tandem. For FAX20/30/40 All IPA's will be on A or B
 3 dB Pad provides isolation between Exciters and IPA and helps prevent overload of IPA

IPA RF Level Detected on RF Switch board, it is DC voltage used for IPA RF Fault and switching

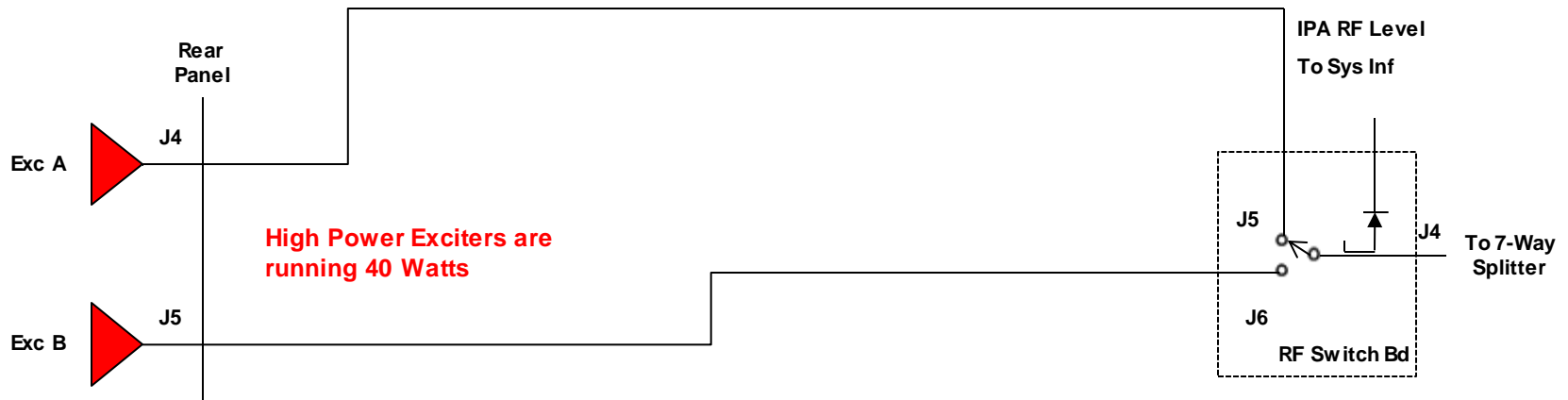
Gain=200W setting (Factory Setting)

$$W = ((V_{sample} * 3.84) - 1.46)^2$$

For IPA Bypass disconnect the coax at J4 and aux RF Power source should be connected to J4 on the at Interface Panel

FAX10/20/30/40 not FAX5

FAX RF Chain



Exciter power displayed on FAX is a DC Voltage from Exciter. There is no RF detector for Exciter Power

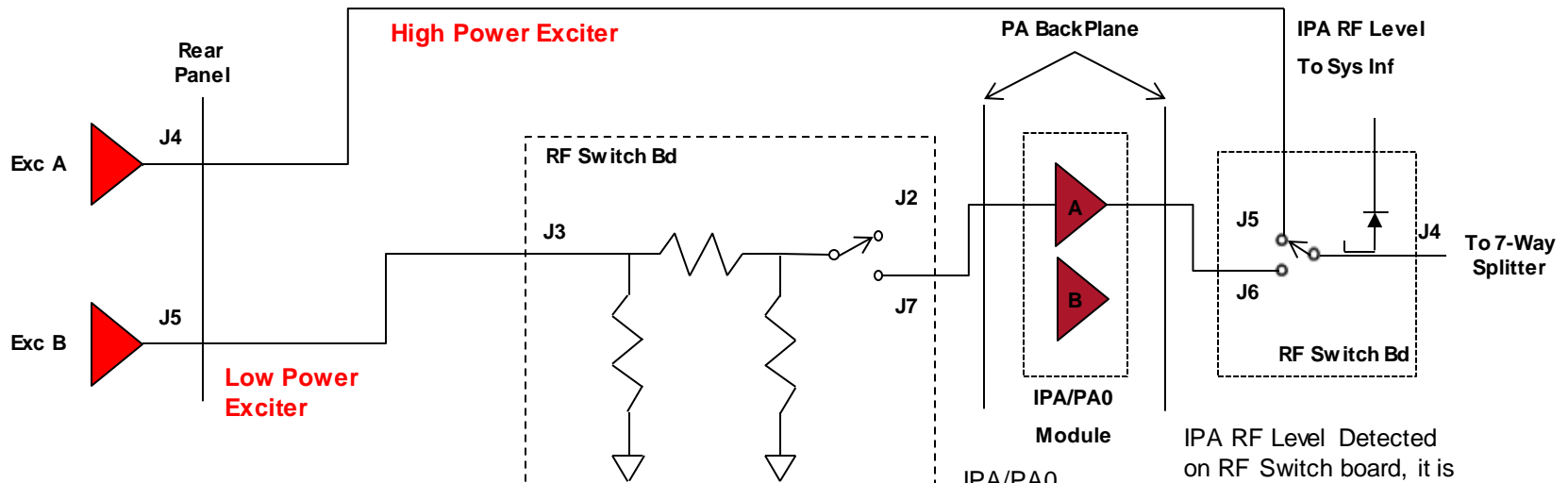
IPA RF Level Detected on RF Switch board, it is DC voltage used for IPA RF Fault and switching

Gain=200W setting (Factory Setting)

$$W = ((V_{\text{sample}} * 3.84) - 1.46)^2$$

FAX5 ONLY (New versions)

FAX RF Chain



Exciter power displayed on FAX is a DC Voltage from Exciter. There is no RF detector for Exciter Power

RF Switch Bd relays switch in tandem. For FAX20/30/40 All IPA's will be on A or B
3 dB Pad provides isolation between Exciters and IPA and helps prevent overload of IPA

IPA/PA0 Module uses one FET as a IPA and one as PA.

IPA RF Level Detected on RF Switch board, it is DC voltage used for IPA RF Fault and switching

Gain=200W setting (Factory Setting)

$$W = ((V_{\text{sample}} * 3.84) - 1.46)^2$$

For IPA Bypass disconnect the coax at J4 and aux RF Power source should be connected to J4 on the at Interface Panel

FAX5 ONLY (Older versions)

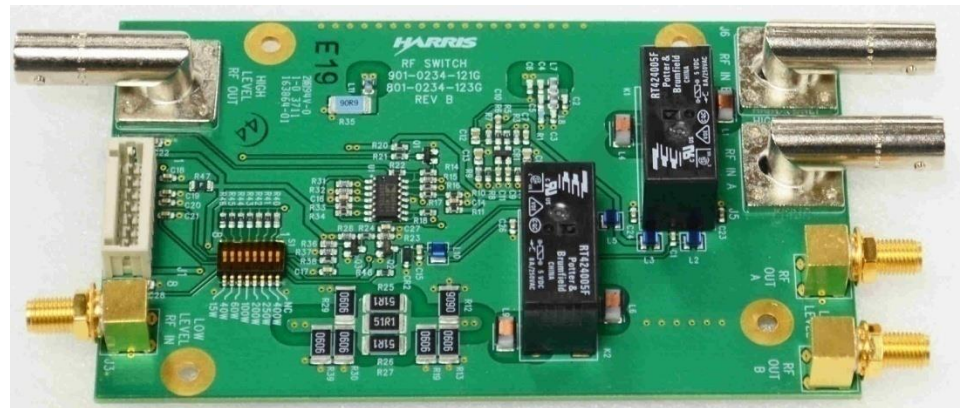


FAX RF Chain

System Interface Board – Performs exciter switching. Will be the Multi-Unit Interface Board in FAX20/30/40. Not used in FAX5.

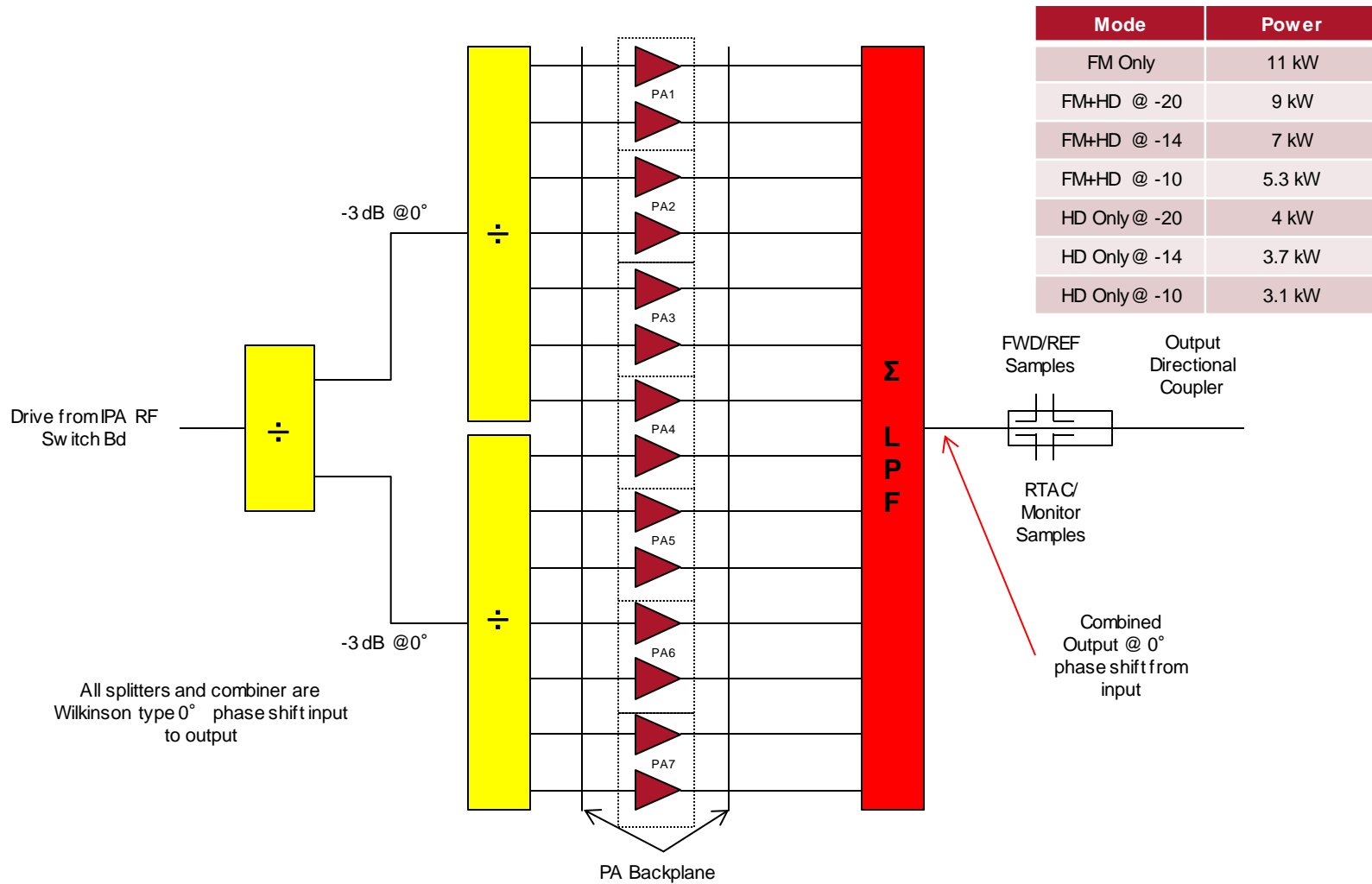


RF Switch Board – Exciters IN/OUT on SMA connectors
IPA IN/OUT on BNC Connectors (Higher Power)



PA Backplane Board – RF IN on SMA connectors; RF OUT on Type N connectors
Dipswitch sets up board ID for multiplexing and IPA setup

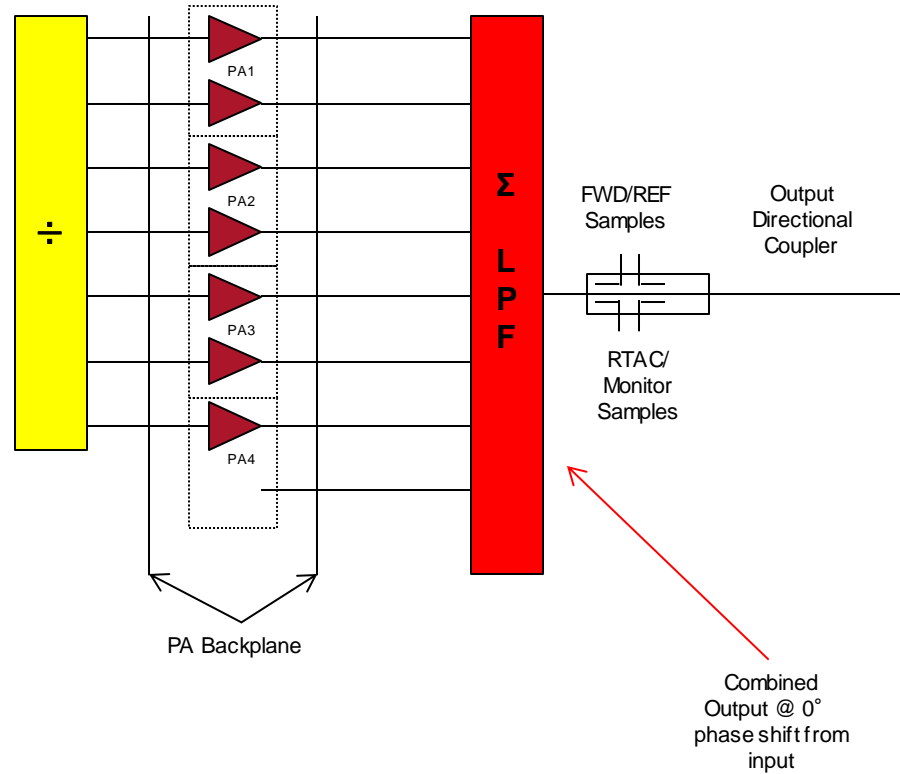
FAX RF Chain



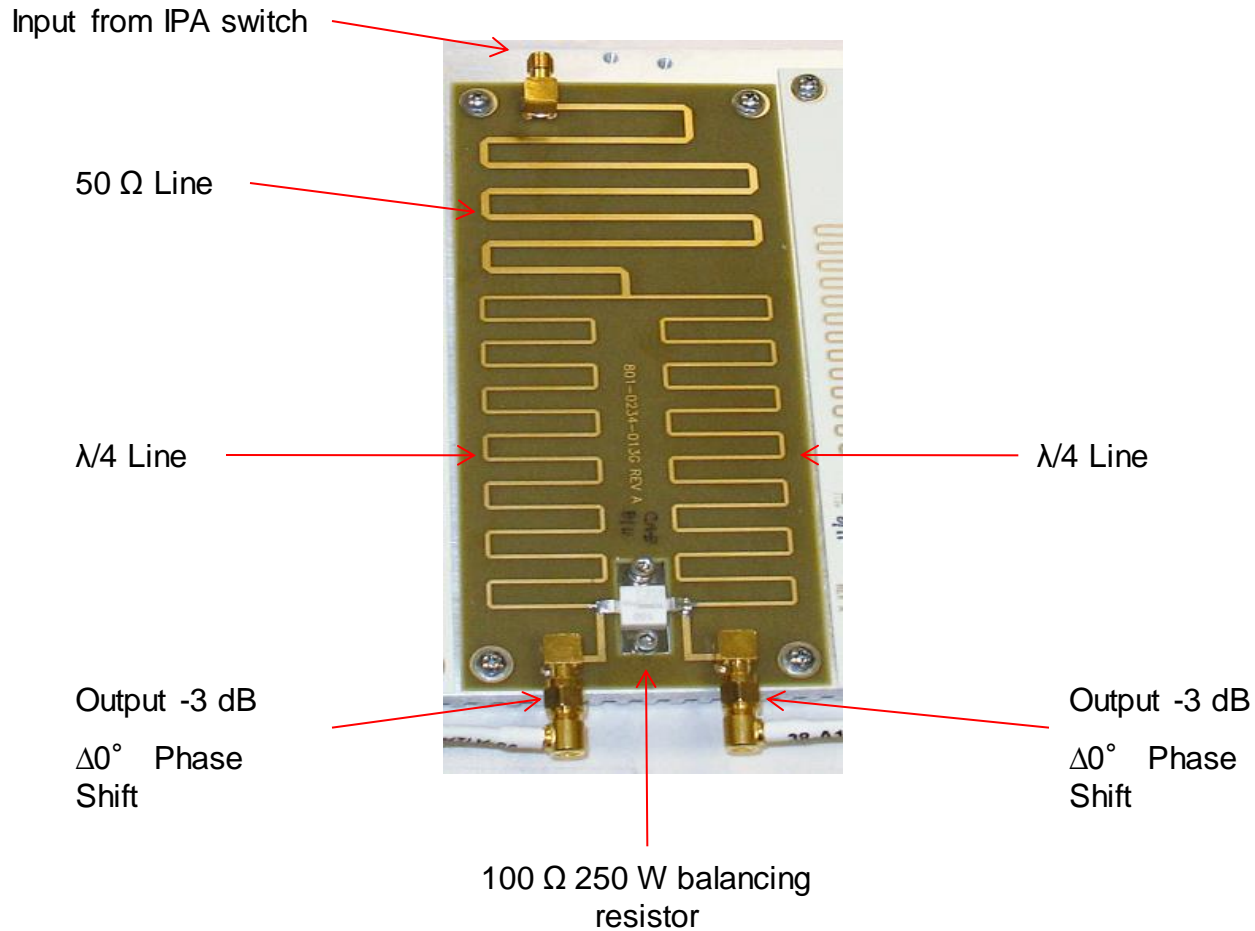
FAX RF Chain

| Mode | Power |
|---------------|---------|
| FM Only | 5.5 kW |
| FM+HD @ -20 | 4.5 kW |
| FM+HD @ -14 | 3.5 kW |
| FM+HD @ -10 | 2.67 kW |
| HD Only @ -20 | 2 kW |
| HD Only @ -14 | 1.85 kW |
| HD Only @ -10 | 1.55 kW |

All splitters and combiner are Wilkinson type 0° phase shift input to output



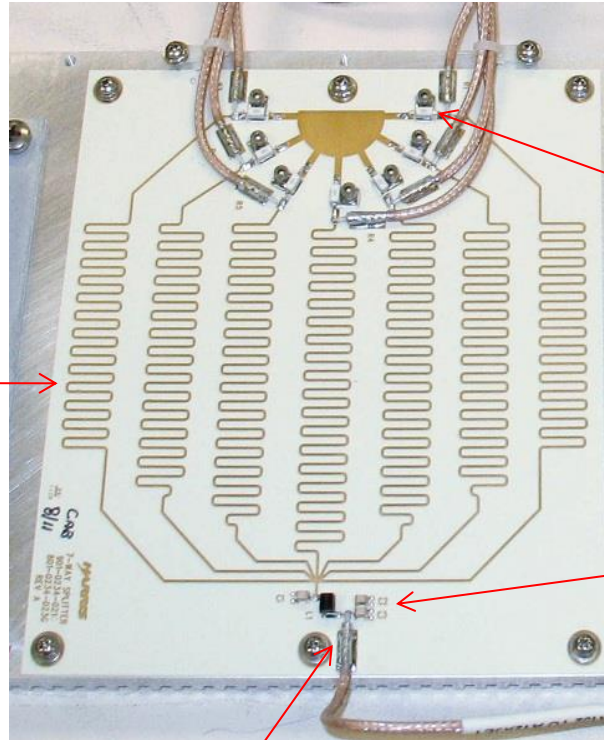
FAX 2-Way Splitter



FAX 7-Way Splitter

Output from to PA Modules

Outputs -8.45 dB
 $\Delta 0^\circ$ Phase shift
(between outputs)



100 Ω 10 W
balancing
resistors

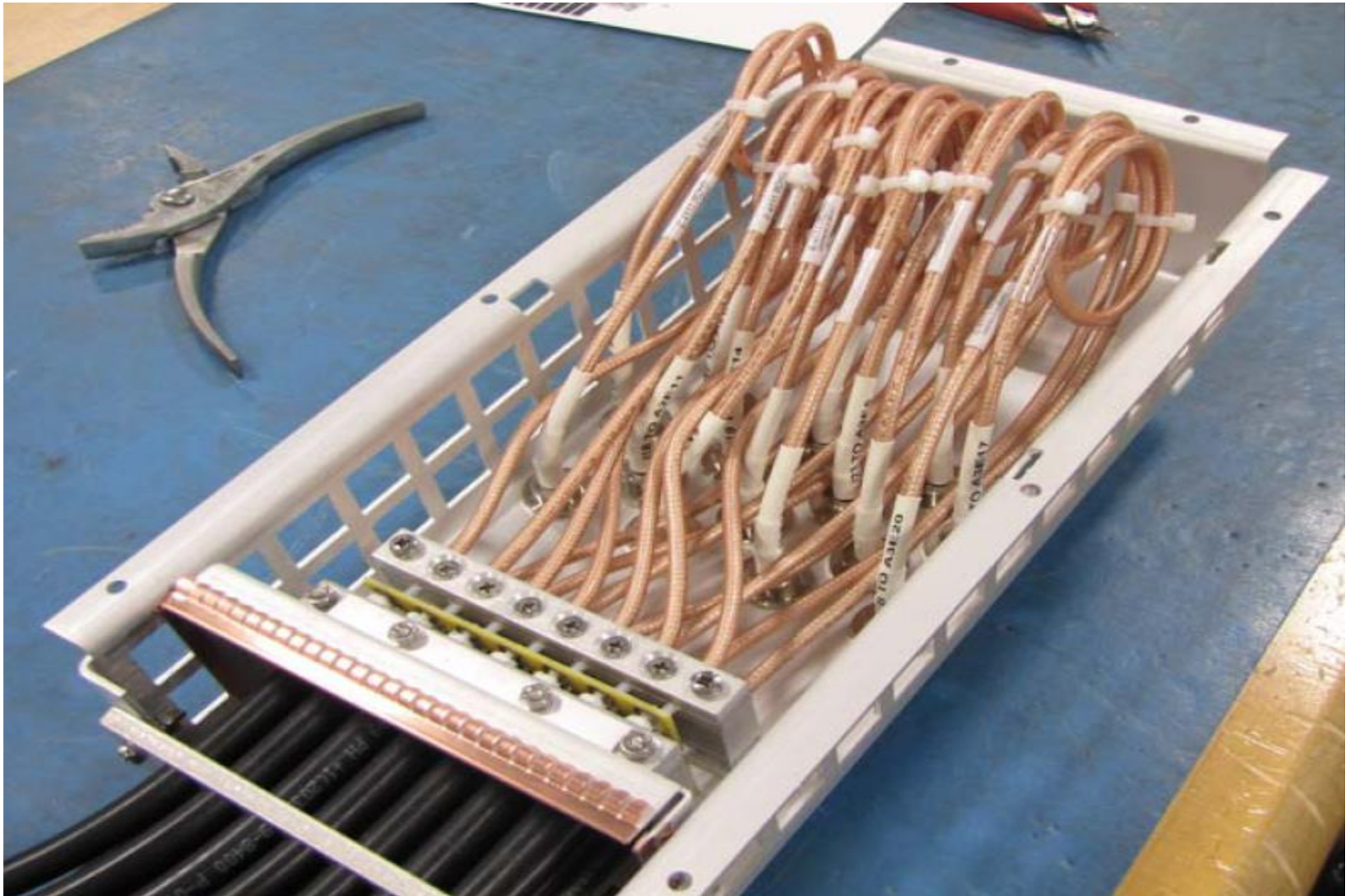
$\lambda/4$ Lines

50 Ω
Matching
Network

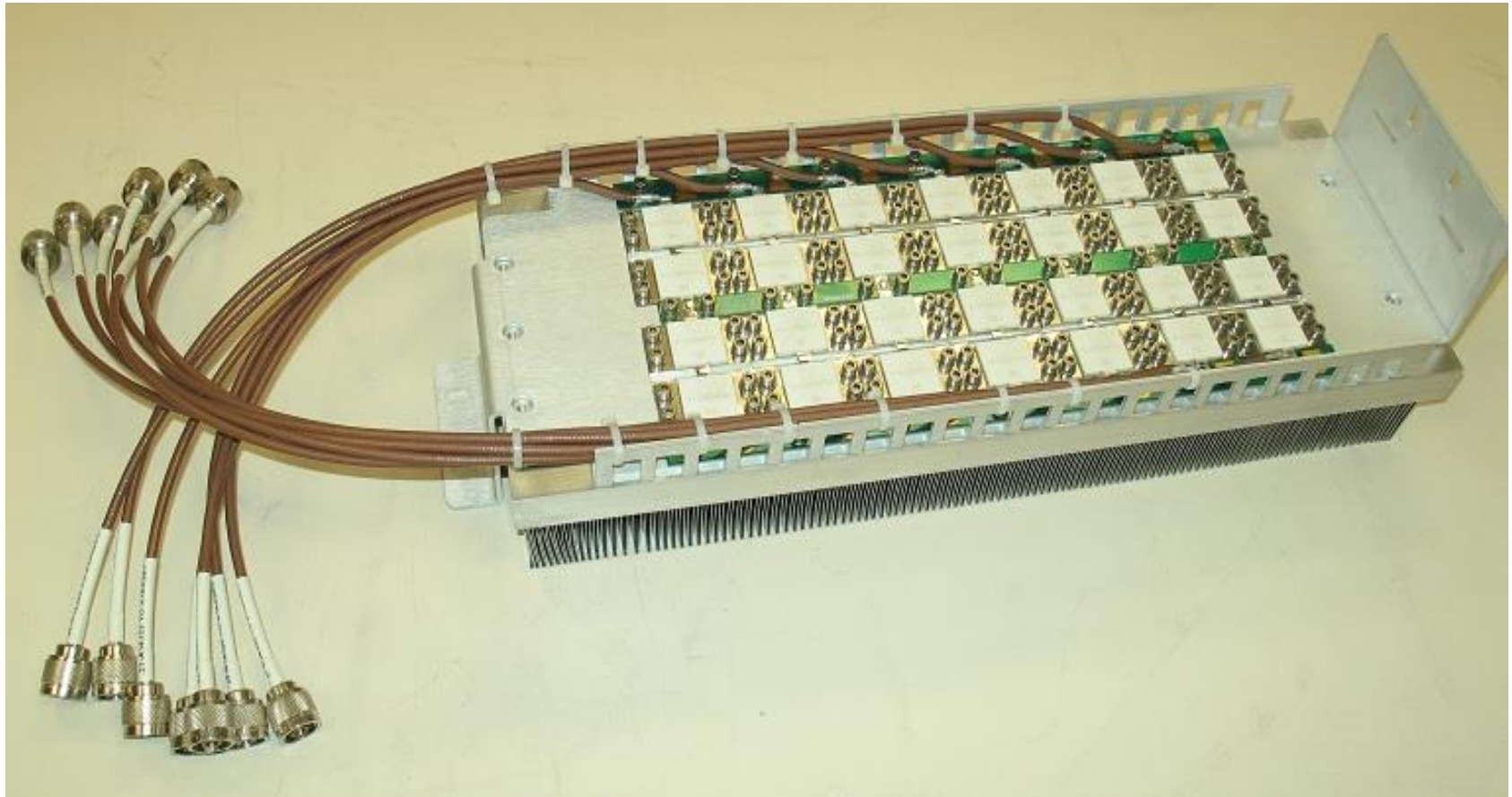
Input from 2-Way Splitter



FAX RF Chain



FAX RF Chain



FAX RF Chain



FAX RF Chain

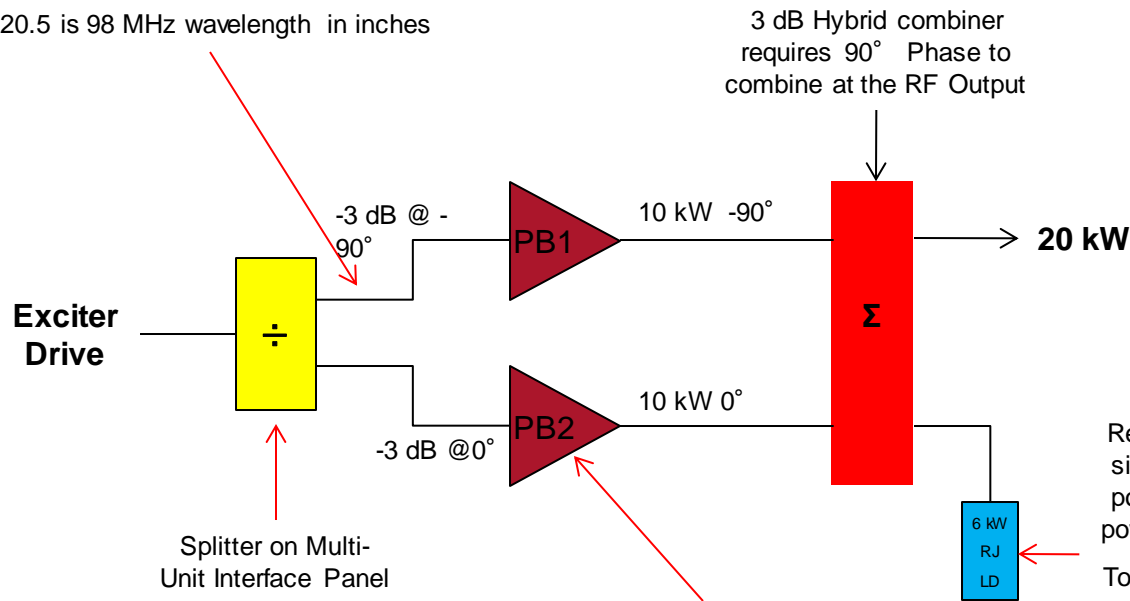
Cable length is 21" longer than other side to provide (1/4 wavelength) 90° phase shift at center of band

$$(120.5 * 1/4) * 0.7 = 21"$$

0.7=Velocity factor of RG316

98=center frequency

120.5 is 98 MHz wavelength in inches



| Mode | Power |
|---------------|-----------|
| FM Only | 22 kW |
| FM+HD @ -20 | 20.2 kW |
| FM+HD @ -14 | 18.25 kW |
| FM+HD @ -10 | 14.132 kW |
| HD Only @ -20 | 8 kW |
| HD Only @ -14 | 7.4 kW |
| HD Only @ -10 | 6.2 kW |

Splitter on Multi-Unit Interface Panel

3 dB Wilkinson type same as 2-Way in power block; has 0° Phase shift

Cable length on output can be changed slightly for minimum power into reject load

0° Phase shift through power blocks, all splitters and combiners are Wilkinson type

Reject load sized to 1/2 power of 1 power block

To calibrate shut off 1 power block for 100 %

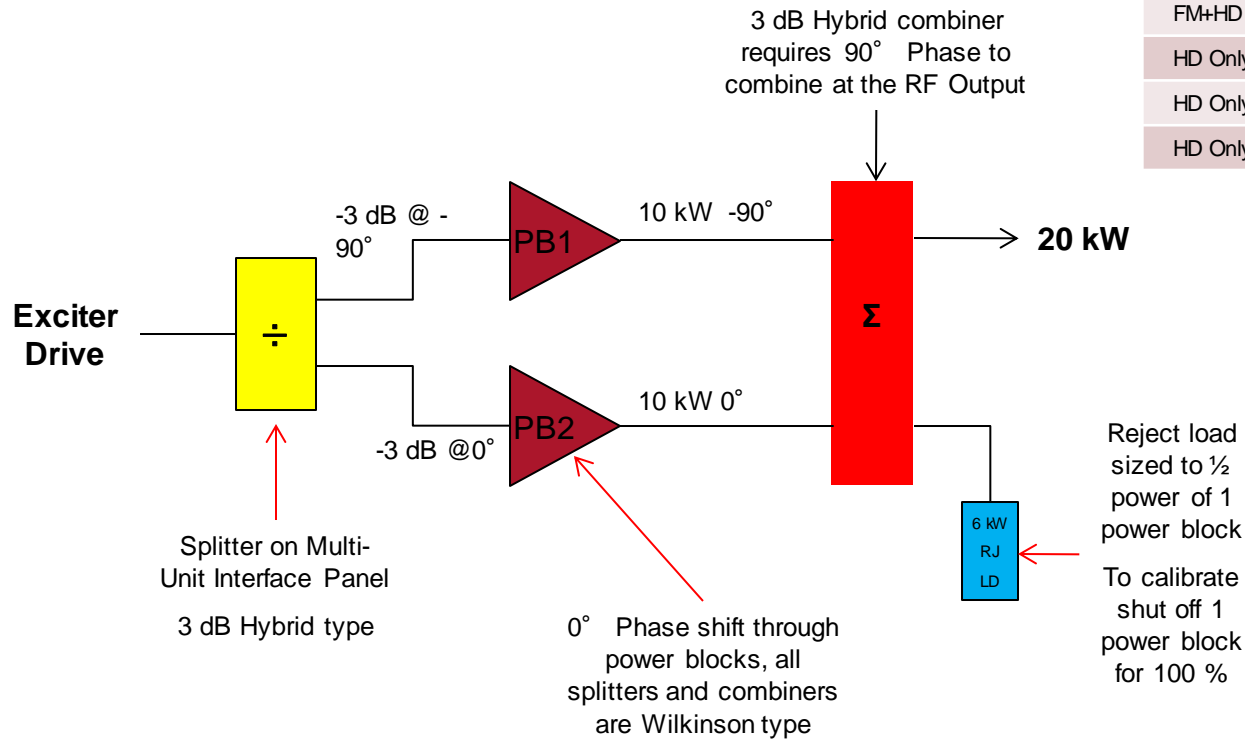
Older Model FAX20's



FAX RF Chain



| Mode | Power |
|---------------|-----------|
| FM Only | 22 kW |
| FM+HD @ -20 | 20.2 kW |
| FM+HD @ -14 | 18.25 kW |
| FM+HD @ -10 | 14.132 kW |
| HD Only @ -20 | 8 kW |
| HD Only @ -14 | 7.4 kW |
| HD Only @ -10 | 6.2 kW |



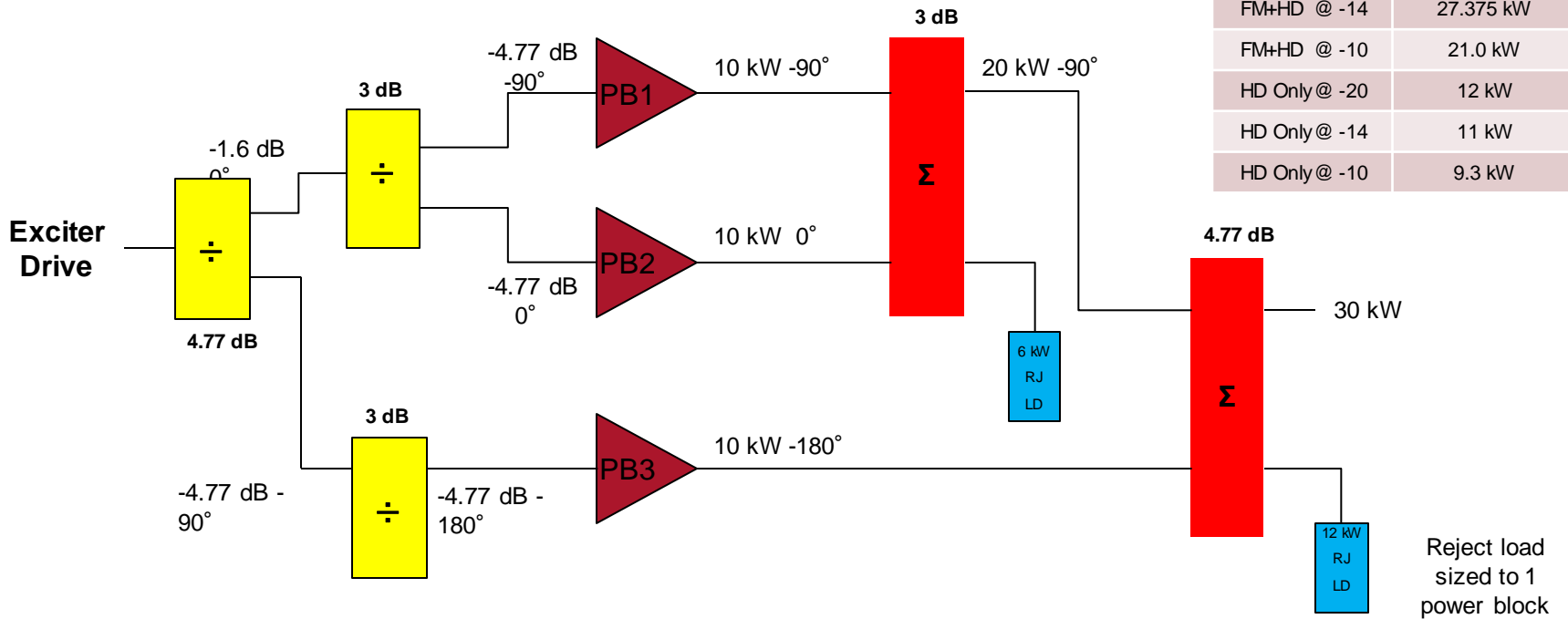
Newer Model FAX20's



FAX RF Chain



All splitters and combiners external to the power blocks are Hybrid type

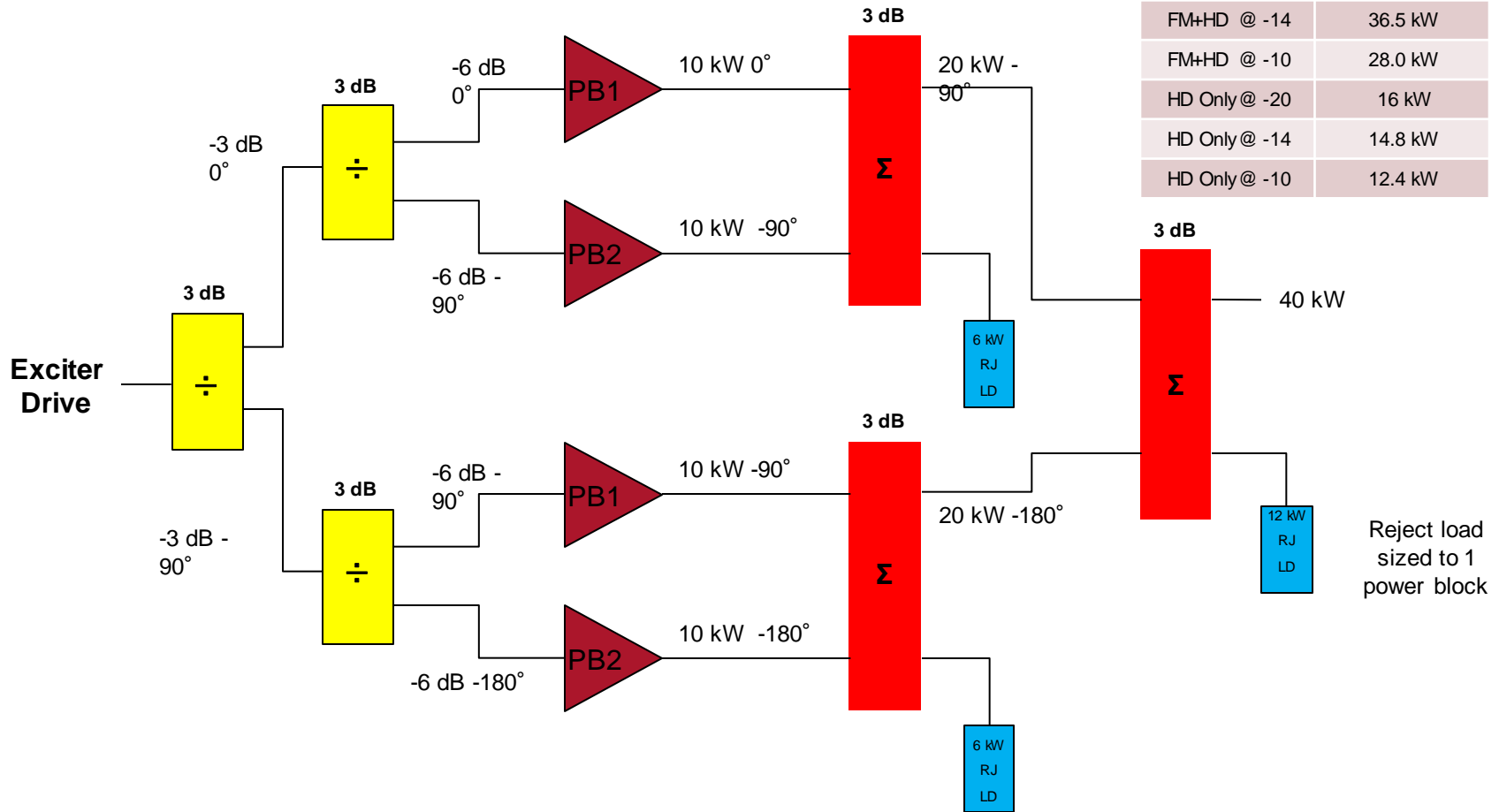


| Mode | Power |
|---------------|-----------|
| FM Only | 33 kW |
| FM+HD @ -20 | 30.3 kW |
| FM+HD @ -14 | 27.375 kW |
| FM+HD @ -10 | 21.0 kW |
| HD Only @ -20 | 12 kW |
| HD Only @ -14 | 11 kW |
| HD Only @ -10 | 9.3 kW |

FAX RF Chain



All splitters and combiners external to the power blocks are Hybrid type

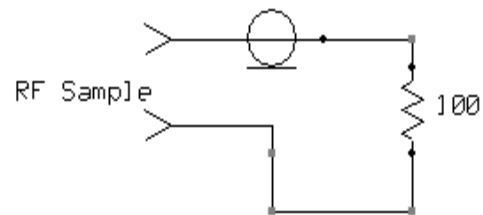
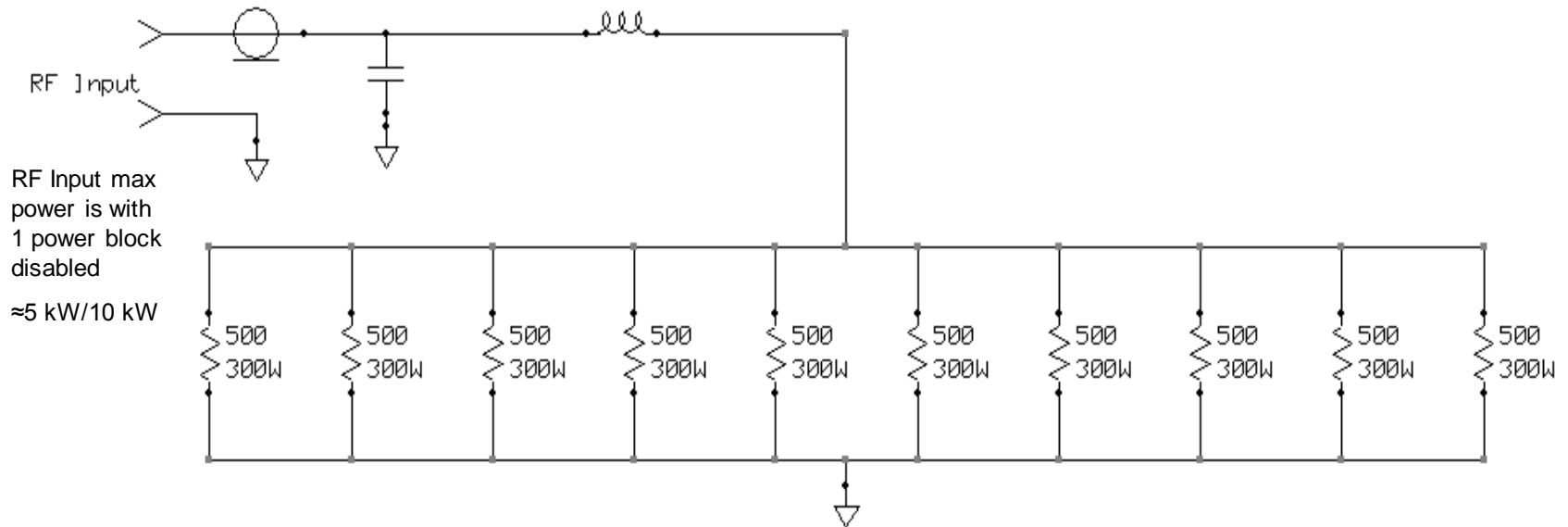


| Mode | Power |
|---------------|---------|
| FM Only | 44 kW |
| FM+HD @ -20 | 40.4 kW |
| FM+HD @ -14 | 36.5 kW |
| FM+HD @ -10 | 28.0 kW |
| HD Only @ -20 | 16 kW |
| HD Only @ -14 | 14.8 kW |
| HD Only @ -10 | 12.4 kW |

Reject load sized to 1 power block



FAX RF Chain



Reject load design is the same for 6 kW or 12 kW load.

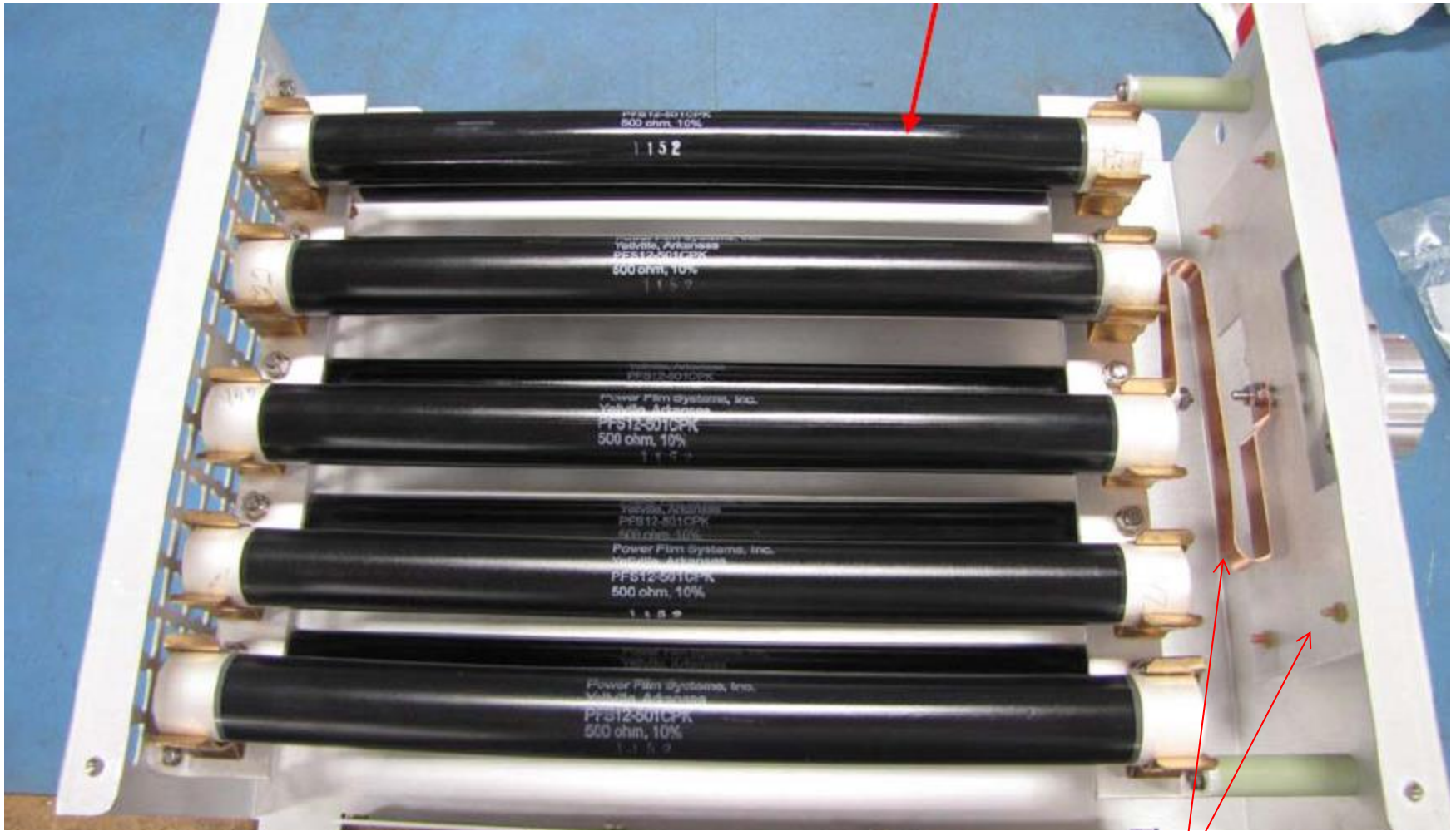
12 kW has 20 resistors

6 kW has 10 resistors

RF Sample fed to Detector on Fan Board then to controller for reject load power calibration

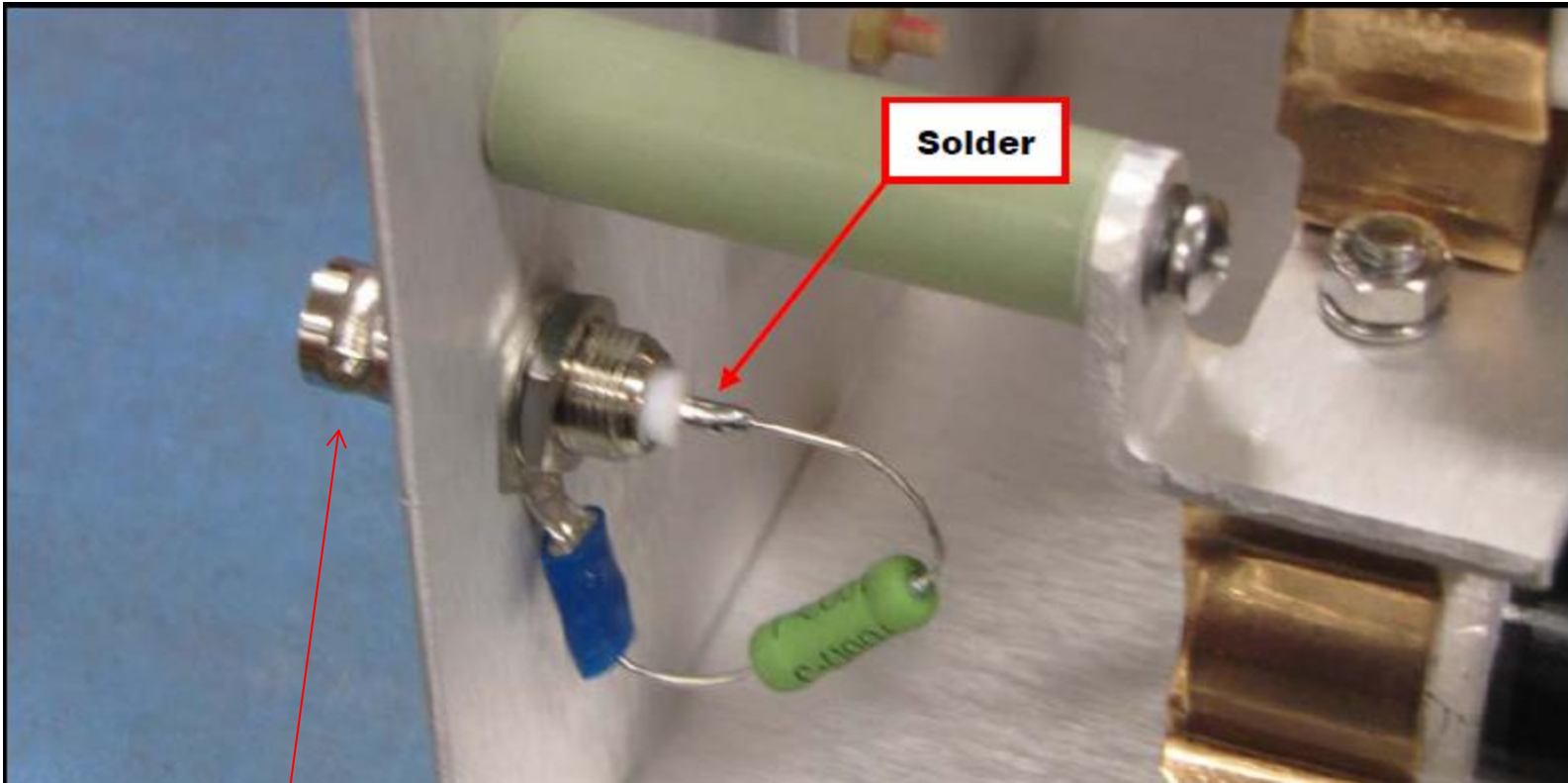


FAX RF Chain



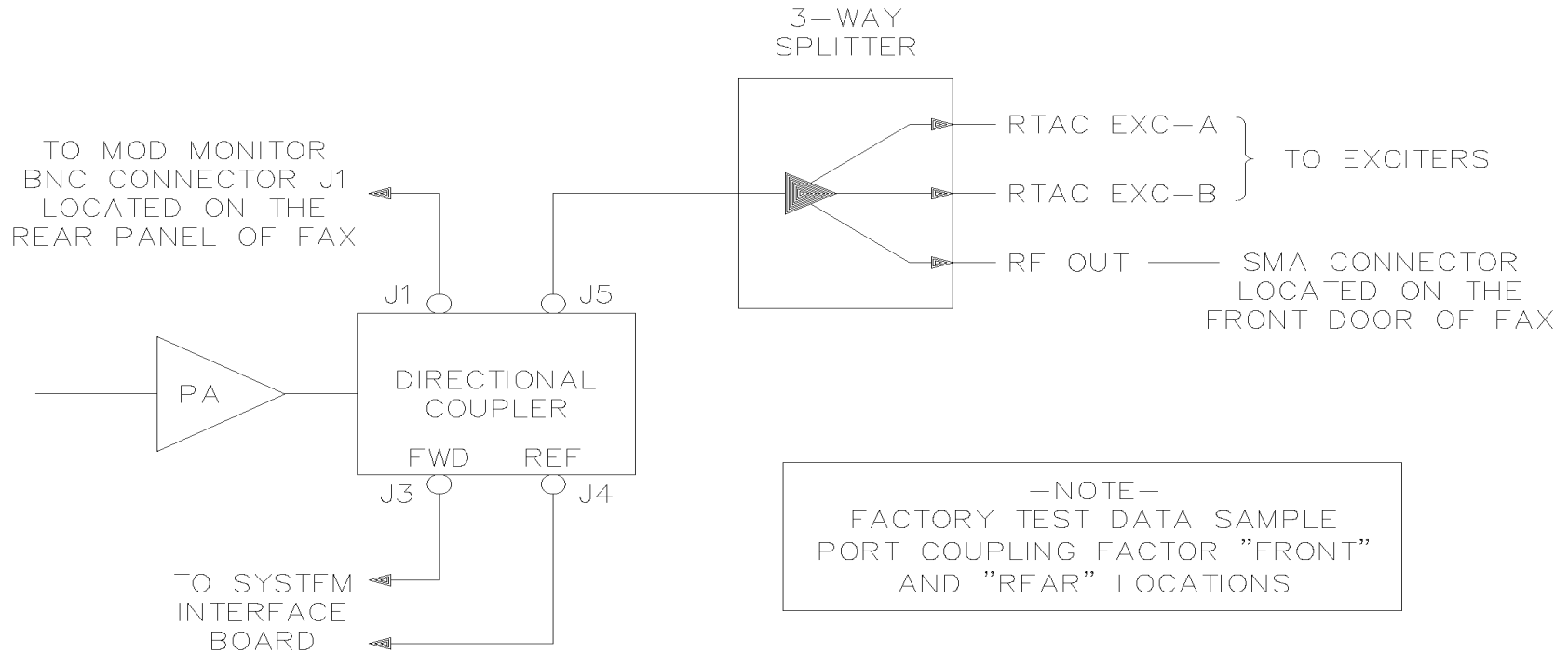
Tuning network; Inductor and capacitor

FAX RF Chain



RF Sample to Fan board detector

FAX RF Chain



FAX RF Chain

