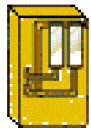


## 2. Hardware Installation

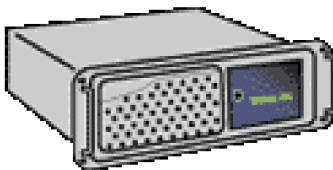
### 2.1 Overview and Input Power Requirements

This chapter describes how to install the RVP8 hardware. Topics include mechanical installation and siting, electrical specifications of the interface signals, system-level considerations and the standard connector panel that is provided.

There are three major modules supplied with the RVP8. These are:



**IFD (IF Digitizer)** Typically mounted in the radar receiver cabinet.  
**Input Power 47–63 Hz 100–240 VAC Auto-ranging**



**Main Chassis** Usually mounted in 19" EIA rack.  
**Input Power 60/50 Hz 115/230 VAC Manual Switches**



#### **I/O-62 Connector Panel**

Usually mounted in 19" EIA rack within 2 m of Main Chassis

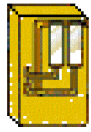
Much of the RVP8 I/O is configured via software. This makes the unit very flexible. Also, since there is virtually no custom wiring, it is very easy to insert spare modules and circuit cards. The software configuration of the I/O is described in **Appendix A**.

This section, in conjunction with **Appendix B**, describes the physical installation of the hardware.



**WARNING:** The Main Chassis redundant power supplies are **NOT** auto-ranging like the IFD. These are factory configured for the expected voltage, but should be **VERIFIED** by the customer before power is applied to the system.





## 2.2 IFD IF Digitizer Module Installation

### 2.2.1 IFD Introduction

The IFD IF digitizer is housed in an electrically sealed solid metal enclosure to achieve good immunity to external electrical noise. The internal circuitry has been designed to minimize the number of digital components, and it is carefully grounded and shielded to make the cleanest possible samples of the input IF signal. The unit is cooled by direct conduction of heat through the metal chassis; there are no openings required for airflow.

The IFD replaces all of the IF receiver components that are found in a traditional analog receiver system, i.e.,

- Band Pass Filters
- LOG Receiver
- AFC Circuit
- AGC or IAGC circuit
- Quad Phase Detector
- COHO (on magnetron systems)
- Line drivers for base band video

Indeed, one of the most time consuming parts of an upgrade is often the removal of old components. Many customers choose to simply bypass them and leave them in place. In some cases there will be other receiver modifications required to match the IFD signal input specifications. For example, IF attenuators or an IF amplifier are sometimes required.



**If you are doing an upgrade of an older system, you might want to consider purchase of a new STALO which can make significant improvements in Doppler performance.**

You should carefully document and red-line your system schematics to reflect any changes to the receiver.



## 2.2.2 IFD Revision History

There have been several hardware revisions of the IFD module since its introduction initially with the RVP7. Table 2–1 summarizes the differences among all of the versions that have been manufactured so far. The remainder of this chapter covers only the 14-bit units, although the previous generation 12-bit units are compatible with the RVP8 as well.

**Table 2–1: Differences Among Versions of the IFD**

	<i>Rev.B</i>	<i>Rev.C</i>	<i>Rev.D</i>	<i>Rev.E &amp; Higher</i>
<i>A/D Chip</i>	Analog Devices AD9042, 12–Bits		AD6644, 14–Bits	AD6645, 14–Bits
<i>Nominal IF Sample Rate</i>	36MHz			72MHz
<i>A/D Noise Density</i>	–76dBm/MHz		–82dBm/MHz	–85dBm/MHz
<i>Dynamic Range</i>	86dB at 0.5MHz		93dB at 0.5MHz	96dB at 0.5MHz
<i>Link to Rx</i>	Coax uplink, Fiber downlink			Integrated CAT-5E
<i>Upgradability</i>	FPGA chips must be manually reprogrammed			ReFlashable via Rx-Link
<i>Input Signal Level</i>	A/D saturation at +4.5dBm		A/D saturation at +6.0dBm	
<i>Ext-Clock</i>	No	Yes (shared with AFC connector)		
<i>Noise Generator</i>	None. The A/D dither power must be supplied from wideband thermal noise in the RF/IF chain.		Built-in noise source supplies A/D dither power in the 200–900KHz range.	
<i>Power Supplies</i>	+5.17V, +12V, –12V		+5.23V Primarily. ±12/15V required only for analog AFC output	+5.33V Primarily. +12/15V required for AFC, Hi-DAFC or stable VCXO (recommended). –12/15V required only for analog AFC output.
<i>Jumpers (Table 2–7)</i>	None	AFC/Clock I/O	AFC/Clock I/O, Dither and Config Selections	AFC/Clock I/O, JTAG, DAFC/Clock and Config Selections
<i>Uplink Protocols</i>	AFC-16	AFC-16 & PLL-16	Supports full set of protocols defined in Section 2.5.1	
<i>First Production</i>	March 1997	April 1998	December 2000	August 2004



### 2.2.3 IFD Power, Size and Physical Mounting Considerations

The IFD is a compact sealed module with dimensions 23.6 x 10.9 x 3.0 cm. (9.3 x 4.3 x 1.2 in). The unit is designed to be mounted on edge such that the 23.6 x 3.0 cm. surface is flush on the back of the receiver cabinet with 10.9 cm. protrusion into the cabinet. The unit is typically placed where a traditional LOG receiver would be installed. The IFD is cooled by direct conduction through its metal enclosure. It should be positioned so that air can freely convect around it, or bolted to a larger surface that will conduct the heat away.

The power supply module is separate and can be mounted nearby in the radar cabinet, or it can be attached directly to the IFD using a special mounting bracket. The power supply and bracket will add 3.3 cm. (1.3 in) of overall width to the receiver module.

The power supply is a low noise, low ripple, switching unit; the input voltage range is 100–240 VAC 47–63 Hz, autoranging. The IFD has an internal 3-stage power supply input filter to minimize interference from the power cable. Nonetheless, it is still good practice to insure that the four supply wires (+5V, –12V, +12V, and Ground) be kept short and twisted together. A ferrite choke around the supply wires near the terminal strip is also recommended.



**Important: The inductive filtering components inside the IFD introduce a voltage drop in the +5V supply. To produce the correct internal voltage, the supply voltage measured at the external terminal block should be 5.33V for Rev.E and later, 5.23V for Rev.D, and 5.17V for Rev.C and earlier boards.**



**Important: The voltage drop across the inductive filtering components causes the ground terminal of the power supply to float several tenths of a volt above chassis ground. For this reason, the IFD power supply should never be tapped to supply power to other nearby equipment.**

Mounting space should also be reserved for the external analog anti-alias filters. These filters can be mounted in the radar cabinet itself, or they can be attached directly to the IFD on the opposite side of the power supply. The filters and mounting bracket will add 2.0 cm. (0.8 in) of overall width.



## 2.2.4 IFD I/O Summary

The connectors on the IFD are labelled and described below for each hardware revision.

**Table 2–2: IFD Connectors (All Revisions)**

IFD I/O Summary			
Connector Label	Style	Description	Reference
J1 IF-IN	SMA	IF signal from LNA/mixer; via an anti-aliasing filter centered at IF (supplied by SIGMET). 50W, + 6.5 dBm max	2.2.6 2.2.7 2.2.8 2.2.10
J2 BURST (COHO)	SMA	IF Tx sample from waveguide tap and mixer; via an anti-aliasing filter centered at IF (supplied by SIGMET). 50W, +6.5 dBm max	2.2.6
J3 AFC (CLK)	SMA	AFC output (+ –10V) or reference clock input for coherent systems (2–60 MHz –10 to 0 dBm). The function of the connector is controlled by jumper selection within the IFD.	2.2.11 AFC 2.2.12 CLK

Since they share the same connector, analog AFC output and reference clock input can not be used simultaneously. However, this is a very rare requirement since an analog AFC output is used for magnetron systems and a reference clock input is typically used for fully coherent TWT and Klystron systems.

**Table 2–3: IFD Connectors (Rev.A–Rev.D)**

IFD I/O Summary			
Connector Label	Style	Description	Reference
J4 UPLINK	SMA/BNC	Connects to the RVP8/Rx PCI card by 75 Ohm shielded cable. The connector is SMA with an SMA/BNC adapter provided.	2.2.13
J5 FIBER-OUT	ST	62.5/125 micron multimode optical cable terminated in type ST connectors. IFD can be located up to 100m from the RVP8/Rx PCI card.	2.2.13

**Table 2–4: IFD Connectors (Rev.E & Greater)**

IFD I/O Summary			
Connector Label	Style	Description	Reference
J4 DAFC(CLK)	SMA	Synthesized legacy coax uplink stream for backward compatibility, or Expansion Clock input or output.	2.2.13
J5 Rx-Link	RJ-45	Connects to the RVP8/Rx PCI card via CAT-5E cable up to 100-ft in length.	2.2.13



## 2.2.5 IFD Adjustments and Test/Status Indicators

The IFD is packaged in a tight metal enclosure for maximum noise immunity. The only adjustments on the module are the internal gain and offset pots that adjust the AFC analog output. Two switches on the unit provide standalone test features to verify the proper functioning of the IFD and to assist with setting the voltage span of the AFC DAC.

**Table 2–5: IFD Toggle Switch Settings**

SW1	SW2	Function
A	A	AFC Test Low Voltage
A	B	AFC Test Midpoint Voltage
A	C	AFC Test High Voltage
B	A	Swap Burst and IF Input Signals
B	B	Normal Operation ( <i>also labeled as “run”</i> )
B	C	Reserved ( <i>downlink test pattern</i> )
C	A	Reserved
C	B	Reserved ( <i>downlink test pattern</i> )
C	C	Reserved ( <i>downlink test pattern</i> )

Two LEDs provide status information for the IFD itself, as well as status of the communication link(s) to the RVP8/Rx PCI card. These LEDs have the same interpretation across all revisions of the IFD. For Rev.B through Rev.D the words “uplink” and “downlink” refer to the physical coax uplink and fiber downlink cables. For Rev.E and higher, those words refer to conceptually similar uses of the four twisted pairs within the integrated CAT-5E link.

**Table 2–6: IFD LED Indicator Interpretations**

Red (Uplink)	Green (Ready)	Meaning
Blink	Blink	Reset sequence ( <i>powerup, or from uplink</i> )
Blink	Off	Uplink is dead ( <i>no uplink protocol from RVP8/Rx</i> )
On	Off	Uplink is alive, but downlink is dead
On	On	Normal Operation ( <i>IFD and Main are both okay</i> )

For IFDs at Rev.E and higher, the two LEDs on the RJ-45 connector also convey status about the CAT-5E link itself. Green indicates that valid clock and framing waveforms are present on the uplink. Yellow indicates that the RVP8/Rx card is receiving valid data from the IFD, including the IFD's report of the uplink being okay. These LEDs show valid status at all times (not just when the RVP8 software is running) and thus, both indicators should be illuminated whenever the CAT-5E cable is connected. Moreover, the Green/Yellow interpretation is consistent at both the IFD and RVP8/Rx ends: green indicates the reception of proper low-level electrical and



framing protocols, and yellow indicates that the green LED is ON at the other end, i.e., that the other end is receiving our transmissions correctly and is able to communicate that information back to us.

The internal jumper settings are summarized in the following table. Please also refer to Sections 2.2.11 and 2.2.12 for more information on setting up the AFC or External Clock options.

**Table 2–7: IFD Internal Jumper Settings**

	<i>Rev.B</i>	<i>Rev.C</i>	<i>Rev.D</i>	<i>Rev.E and Higher</i>
<b>JP1</b>	N/A	AB: AFC Voltage Output BC/Open: External Clock Input 50Ω/Open Termination		
<b>JP2</b>	N/A	Reserved	AB: Normal JTAG control BC: Factory reserved	
<b>JP3</b>	N/A	BC: External Clock Open: AFC Voltage Output	<i>Power Supply to Oscillator</i> <i>Use wirewrap, not jumper</i> AB: Regulated from +12V BC: Direct from +5V	
<b>JP4</b>	N/A	AB: Dither Applied to Burst BC: No Dither on Burst	AB: Oscillator is a VCXO BC: Oscillator is fixed XO	
<b>JP5</b>	N/A			Reserved for factory tests Must be left open
<b>JP6</b>	N/A			<i>J4 Protocol Selector</i> AB: Legacy DAFC output BC: Auxiliary CLK In/Out
<b>JP7</b>	N/A			<i>J4 DAFC Output Level</i> AB: +5V Signaling BC: +12V Signaling



## 2.2.6 IFD Input A/D Saturation Levels

There are two analog signals that must be supplied to the IFD:

- IF receiver signal
- IF Tx Sample (Burst Pulse) for magnetron, or COHO reference for klystron.

Both of these inputs are on SMA connectors. The IF signal should be driven by the front-end mixer/LNA/IF-Amp. components, similar to the way that a LOG receiver would normally be installed. The magnetron burst pulse or klystron COHO reference is also derived in the same manner as a traditional analog receiver.



**Note: Even for fully coherent Klystron and TWT systems, SIGMET recommends the use of an actual IF Tx sample. If this is not possible, then the COHO is used instead. If there is phase modulation, then the phase-shifted COHO should be input.**

The A/D input saturation level for both the IF-Input and Burst-Input is +6 dBm (4.5 dBm for Rev.C or earlier). In almost all installations an external anti-alias filter is installed on both of these inputs. These filters (if supplied by SIGMET) are mounted externally on one side of the IFD, and have an insertion loss of approximately 1–2dB. Thus, the input saturation level will be +8dBm measured at the filter inputs.

For the burst pulse or COHO reference it is important not to exceed the A/D saturation level. This reference signal should be strong enough so that most of the bits in the A/D converter are used effectively, but it should also allow a few decibels below the saturation level for safety. The recommended power level is in the range –12 to +1 dBm, measured as described in section D.14. This is important for making a precise phase measurement on each pulse.

In contrast, for the IF receiver input it is permissible (in fact desirable) to occasionally exceed the A/D input saturation level at the strongest targets. The RVP8 employs a statistical linearization algorithm to derive correct power levels from targets that are as much as 6dB above saturation. The actual IF signal level should be established by weak-signal and noise considerations (see below), rather than by working backwards from the saturation level.



## 2.2.7 IF Bandwidth and Dynamic Range

The RVP8 performs best with a wide bandwidth IF input signal. This is because a wideband signal can be made free of phase distortions within the (relatively narrow) matched passband of the received signal. The RVP8 uses an external analog anti-aliasing filter at each of its IF and Burst inputs. The purpose of these filters is to block frequencies that would otherwise alias into the matched filter passband. The anti-alias filters have a nominal passband width of 14 MHz centered at 30MHz, i.e. from 23MHz to 37MHz. This is the recommended operating bandwidth for the IF signal, although the RVP8 will still work successfully with lesser IF bandwidth.

At the 36MHz sampling rate the quantization noise introduced by LSB uncertainties is spread over an 18MHz bandwidth. For an ideal 14-bit A/D converter that saturates at +6dBm the effective quantization noise level would be:

$$+6dBm - 20\log_{10}(2^{14}) - 10\log_{10}\left(\frac{18MHz}{1MHz}\right) = -90\frac{dBm}{MHz}$$

If samples from this ideal converter were processed with a digital filter having a bandwidth of 1MHz, then an input signal at -90dBm would have a signal-to-noise ratio of 0dB. A narrower FIR passband (corresponding to a longer transmitted pulse) would decrease the quantization noise even further, so that 0dB SNR would be achieved at even lower input power.

In practice, the 14-bit A/D converter used inside the IFD does not behave quite this well. The Analog Devices AD6644 chip has been measured to have a wideband SNR of 76dB, i.e., 8dB less than the 84dB range expected for an ideal converter. The above calculation for noise density thus becomes:

$$+6dBm - 76dB - 10\log_{10}\left(\frac{18MHz}{1MHz}\right) = -82\frac{dBm}{MHz}$$

Indeed, the RVP8's receiver power monitor described in Section 4.5 will show a filtered power level of approximately -82dBm when the FIR bandwidth is 1MHz and the IFD inputs are terminated in 50-Ohms.

The inverse correspondence between filter bandwidth and the 0dB SNR signal level leads to an interesting and useful property of wideband digital receivers: they can operate over a dynamic range that is much greater than the inherent SNR of their A/D converter would imply. If this particular A/D chip were performing direct conversion at "base band" it would have a dynamic range of only 76dB. However, by utilizing the extra bandwidth of the converter, the RVP8 is able to extend the dynamic range to approximately 100dB.

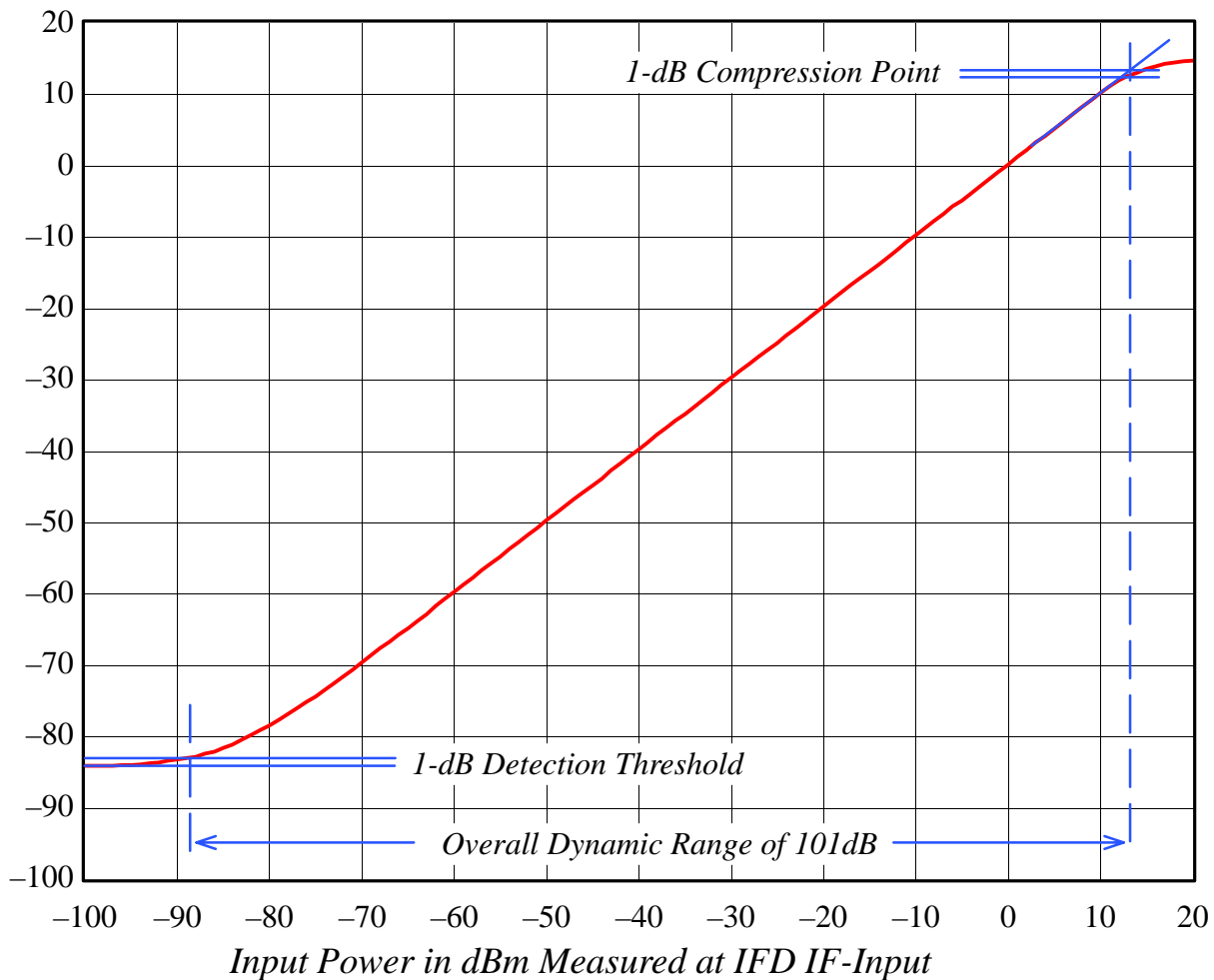
To understand this, begin with the 88dB interval between the converter's +6dBm saturation level and the -82dBm 0dB SNR level at 1MHz bandwidth. Add to this:

- 6dB for the statistical linearization that is performed on signals that exceed the saturation level. The RVP8 can recover signal power accurately even when the A/D converter is driven beyond saturation. Velocity data will also be valid, but spectral width may be overestimated.
- 4dB for usable dynamic range below the 0dB SNR level. In practice, a coherent signal at -4dB SNR can easily be measured when 25 or more pulses are used.



Thus, the overall dynamic range at 1MHz bandwidth (approx. 1  $\mu$ sec transmit pulse) is  $88+6+4 = 98\text{dB}$ . For a 0.5  $\mu$ sec pulse the dynamic range would be reduced to 95dB; but it would increase to 101dB for a 2.0  $\mu$ sec pulse. An actual calibration curve demonstrating this performance is shown in Figure 2–1, for which the RVP8's digital bandwidth was set to 0.53MHz and external signal generator steps of 1dB were used over the full operating range.

**Figure 2–1: Calibration Plot for a Stand-alone 14-Bit IFD**

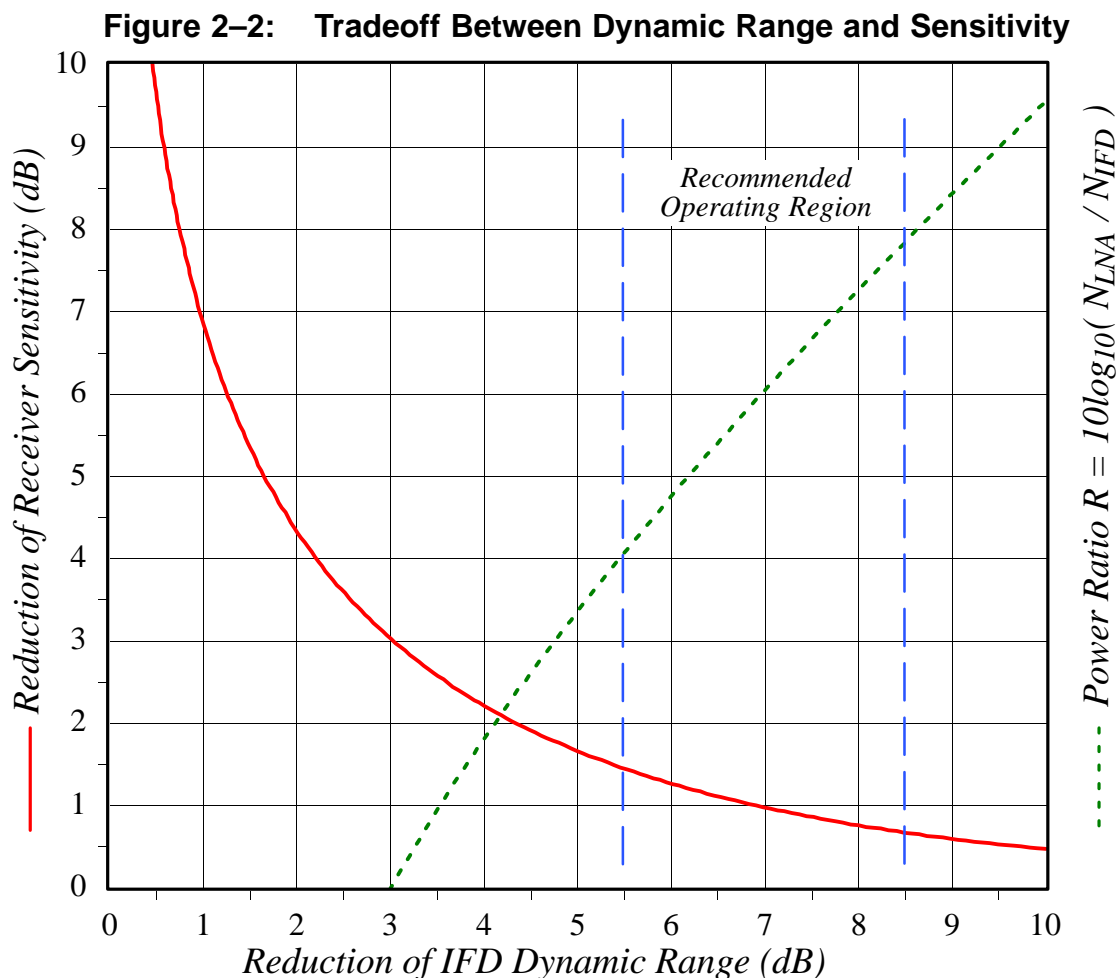




## 2.2.8 IF Gain and System Performance

The previous discussion was concerned with measuring the dynamic range of a stand-alone IFD. We will now examine how the unit performs in the context of a complete radar receiver. We assume that an LNA/Mixer has already been selected that offers an appropriate balance between price and noise figure. Having chosen these front-end components, the only parameter that remains to be determined is the total RF/IF gain between the antenna waveguide and the IFD.

Assume that the thermal noise ( $kT$ ) of the system is  $-114\text{dBm/MHz}$ , and that the noise figure of the LNA/Mixer is  $2\text{dB}$ . We wish to bring this  $-112\text{dBm/MHz}$  noise level up into the working range of the IFD so that the received echoes can be optimally processed. However, in trying to select the required gain, we realize that we must make a tradeoff between preserving the receiver sensitivity that has been established by the LNA, and preserving the overall dynamic range of the IFD. This is the exact same tradeoff that is made in traditional multi-stage analog receiver systems that include a wide dynamic range LOG receiver.



The solid red curve in Figure 2-2 shows that these two variables interact in a symmetric manner, so that any operating point  $(x,y)$  is always matched by a dual operating point at  $(y,x)$ . To understand the construction of this plot, let  $N_{IFD}$  represent the stand-alone (terminated input)



noise power of the IFD over some bandwidth. Similarly, let  $N_{LNA}$  represent the LNA/Mixer thermal noise power over that same bandwidth, and after amplification by all RF and IF stages. Note that  $N_{IFD}$  is primarily due to the quantization noise that is introduced by the A/D converter, whereas  $N_{LNA}$  has its origins in the fundamental thermal noise of the receiving system. The reduction of receiver sensitivity is the amount by which the LNA thermal noise is increased over the original level established by the front-end components:

$$\Delta Sensitivity = 10 \log_{10}(N_{LNA} + N_{IFD}) - 10 \log_{10}(N_{LNA}) = 10 \log_{10}\left(1 + \frac{N_{IFD}}{N_{LNA}}\right)$$

Likewise, the reduction of RVP8 dynamic range is the amount by which the IFD quantization noise is increased over its stand-alone value:

$$\Delta DynamicRange = 10 \log_{10}(N_{LNA} + N_{IFD}) - 10 \log_{10}(N_{IFD}) = 10 \log_{10}\left(1 + \frac{N_{LNA}}{N_{IFD}}\right)$$

Note that both of these quantities depend only on the ratio of the two powers; hence, the two equations define a parametric relationship in the dimensionless variable  $R = (N_{LNA} / N_{IFD})$ . Figure 2–2 was created by sweeping the value of  $R$  from 1/9 to 9. The solid red curve shows the locus of  $(\Delta DynamicRange, \Delta Sensitivity)$  points, and the dashed green curve shows  $R$  itself (expressed in dB) as a function of  $\Delta DynamicRange$ . For example, when the LNA noise power is equal to the IFD noise power,  $R$  is 1.0 (0dB) and there will be a 3dB reduction in both sensitivity and dynamic range.

The recommended operating region is the portion of the curve that limits the loss of sensitivity to between 1.4dB and 0.65dB. The attendant loss of dynamic range will fall between 5.5dB and 8.5dB respectively. Each axis of the plot has an important physical interpretation within the radar system.

- The horizontal axis is equivalent to the increase in the RVP8's report of filtered power when the IF-Input coax cable is connected versus disconnected. This is an easy quantity to measure, and thus provides a simple way to check the overall gain of the LNA/Mixer/IF components.
- The vertical axis is equivalent to a worsening of the LNA/Mixer noise figure. This can also be interpreted as the amount of transmit power that is, in some sense, "wasted" when observing very weak echoes. If you have installed an expensive LNA with a very low noise figure, then you will want to pick an operating point that makes the most of preserving that investment.

Figure 2–2 can be used to calculate the net gain that is required by the front-end components, and to predict the final system performance:

1. Choose an operating point that balances your need for sensitivity versus dynamic range. For this example, we will allow a 1dB loss of sensitivity from the theoretical limit of the LNA/Mixer, and will assume a bandwidth of 0.5MHz.
2. For a 1dB loss of sensitivity, the  $\Delta DynamicRange$  is first determined from the solid red curve as 7dB. The required noise ratio  $R$  is then read vertically on the dashed green curve as 6.1dB.



3. Thus, the RF/IF gain must bring the front-end thermal noise at  $-112\text{dBm/MHz}$  up to a level that is  $6.1\text{dB}$  higher than the IFD noise density of  $-82\text{dBm/MHz}$ . The gain is therefore  $(-82\text{dBm/MHz} + 6\text{dB}) - (-112\text{dBm/MHz}) = 36\text{dB}$ . Note that this gain does not depend on bandwidth, and therefore will be correct for all pulsewidth/bandwidth combinations.
4. The dynamic range for the complete system at  $0.5\text{MHz}$  bandwidth may now be calculated as  $101\text{dB} - 7\text{dB} = 94\text{dB}$ .
5. After assembling all of the RF and IF components we can check whether we achieved the correct gain by verifying a  $7\text{dB}$  rise (independent of bandwidth) in RVP8 filtered power when the IF-Input cable is connected versus disconnected.

Keep in mind when designing your RF and IF components that the final amplifier driving the IFD must be capable of driving up to, perhaps,  $+12\text{dBm}$ , so that signals above saturation can still be correctly measured.

### 2.2.9 IF Gain Based on System Noise Figure

The previous section described how to compute the front-end RF/IF gain based on the desired tradeoff of dynamic range versus sensitivity. Since arriving at the proper gain is so important, we present an alternate but equivalent approach based on system noise figure.

Every amplifier can be partially characterized by its gain “ $G$ ” and noise figure “ $F$ ”. Gain is measured quite simply by injecting a test signal at the mid-power range of the amplifier and measuring the ratio of Output/Input power. Noise figure is a little trickier, and is measured by terminating the input of the amplifier, measuring the output power within some prescribed bandwidth, and then dividing by the thermal noise power expected over that same bandwidth from an ideal amplifier having the same gain. For example, suppose that an amplifier with a gain of  $20\text{dB}$  delivers  $-90\text{dBm}$  of output power within a  $1\text{MHz}$  bandwidth when its input is terminated. We would expect the Boltzman thermal input noise at  $-114\text{dBm/MHz}$  to produce  $-94\text{dBm}$  from an ideal  $20\text{dB}$  amplifier under the same conditions. The noise figure of the real amplifier is therefore  $+4\text{dB}$ , i.e.,  $-90$  minus  $-94$ .

Although the above definitions are typically applied to linear analog amplifiers, these same terms can be applied to hybrid analog/digital systems such as the RVP8.

- To calculate the gain of the RVP8/IFD we apply a calibrated mid-power signal generator directly to its IF-Input and use the **Pr** plot (Section 4.5) to print the measured power. For a wide range of analog input power levels the RVP8 will report the exact same measured digital power; hence the overall analog/digital gain is  $1.0$  ( $0\text{ dB}$ ).
- To calculate the noise figure of the RVP8/IFD, we set the receiver bandwidth to  $1\text{MHz}$  (Section 4.4.2), terminate the IF-Input in  $50\text{-Ohms}$ , and again use the **Pr** plot, this time to examine the in-band thermal noise power. For the Rev.D IFD this measured noise level will be around  $-82\text{dBm}$ . Since an ideal unity gain amplifier would have produced a noise power of  $-114\text{dBm}$  in an equivalent bandwidth, the noise figure of the RVP8/IFD is  $32\text{dB}$ .



When two amplifiers are cascaded so that the output of the first drives the input of the second, the overall gain is the product of the two linear gains  $G_{lin}^1$  and  $G_{lin}^2$ , and the overall noise figure is computed from the two noise factors  $F_{lin}^1$  and  $F_{lin}^2$  as:

$$NoiseFigure = 10 \log_{10} \left[ F_{lin}^1 + \left( \frac{F_{lin}^2 - 1}{G_{lin}^1} \right) \right]$$

where the two noise factors are simply the linear representations of the noise figures that were expressed in deciBels:

$$NoiseFigure = 10 \log_{10} [ NoiseFactor ] .$$

Suppose that our first amplifier is an LNA/Preamplifier with a 2dB noise figure (noise factor 1.58), and we want to know what gain it must have such that, when cascaded into the RVP8/IFD, the overall noise figure will be 3dB. The 32dB noise figure of the IFD is equivalent to a noise factor of 1585, hence we have:

$$3dB = 10 \log_{10} \left[ 1.58 + \left( \frac{1585 - 1}{G_{lin}^1} \right) \right]$$

from which we solve  $G_{lin}^1 = 3771$ , i.e., 35.8dB. This agrees with the 36dB of gain that was computed in the example of the previous section for the same RF/IF components and desired overall performance.

## 2.2.10 Choice of Intermediate Frequency

The RVP8 does not assume any particular relationship between the A/D sample clock and the receiver's intermediate frequency. You may operate at any IF that is at least 2MHz away from any multiple of half the 35.9751MHz sampling rate (nominally 18, 36, 54, 72 MHz). The valid frequency bands are thus:

**6-16MHz, 20-34 MHz, 38-52 MHz, 56-70 MHz**

There are many reasons for staying clear of the Nyquist frequency multiples. Most of these considerations would apply to all types of digital processors, and are not specific to the RVP8.

As an example of what can go wrong at the Nyquist frequencies, suppose that an intermediate frequency of 35MHz was used. This is only 1MHz away from the (approximately) 36MHz sampling rate. The external anti-alias filter must now be designed much more carefully since a spurious input signal at 37MHz would be aliased into the valid 35MHz band. If the valid signal bandwidth were 2MHz, then the anti-alias filter would have the difficult task of passing 34–36MHz free of distortion while rejecting everything above 36MHz. The filter's transition zone would have to be very sharp, and this is difficult to achieve.

Another problem that would arise with a 35MHz IF on a magnetron system would be the RVP8's computation of AFC. If the processor can not distinguish 37MHz from 35MHz, then it can not tell the difference between the STALO being correctly on frequency, versus being 2MHz too high. The symmetric AFC tracking range would be reduced to the very small interval 34–36MHz.



For similar reasons (i.e., transition band width), the digital FIR filter itself also becomes difficult to design when its passband is near a Nyquist multiple. But there is an additional constraint that the digital filter should have a very large attenuation at DC. This is so that fixed offsets in the A/D converter do not propagate into the synthesized “I” and “Q” data. Since 36MHz is aliased into DC, we are left with the contradictory requirements of a zero very close to the edge of the filter’s passband.

### 2.2.11 IFD Analog AFC Output Voltage (Optional)

An analog AFC voltage is produced by a 16-bit DAC whose output limits are  $-10\text{V}$  to  $+10\text{V}$ . Gain and Offset potentiometers on the IFD module set the actual operating span within these limits. Use the switch settings described below to force the low, center, and high voltages to be output, and then adjust the two potentiometers so that the desired voltage span is achieved. The Offset adjustment is independent of the Gain adjustment. Hence, a good strategy is to first set the switches for the midpoint voltage, and adjust the Offset potentiometer so that the center IF frequency is produced by the STALO mixer. Then, adjust the Gain potentiometer for the desired tuning range around that center point. The midpoint voltage will not change as you vary the overall span.

AFC voltage output is always enabled on Rev.B (and earlier) IFD boards. On Rev.C (and later) boards, the AFC function shares the same connector with the optional reference clock input (See Section 2.2.12). AFC can be enabled on a Rev.C board as follows:

- Remove U14
- Install U11, U12, U13
- Set JP1 to its AB position, which is also labeled “AFC”.
- Install fixed frequency stable 35.975MHz oscillator at U5.

The instructions are similar for a Rev.D board except that you do not need to remove U14, and you must check that no jumper has been placed on JP3/BC (See Table 2–7).

Additional information about using AFC can be found in Sections 2.4, 3.2.6, and 5.1.2.

### 2.2.12 IFD Reference Clock Input (Optional)

When the RVP8 is used in a klystron system, or in any type of synchronous radar, the radar COHO is supplied to the IFD so that the processor can digitally lock to it. The COHO phase is measured at the beginning of each transmitted pulse, and is used to lock the subsequent (I,Q) data for that pulse. The COHO phase is measured relative to the IFD’s own internal stable sampling clock, which is nominally 35.975MHz. The internal sampling clock itself is not affected by the application of the COHO. Rather, A/D samples of the COHO are obtained at the fixed sampling rate, and the (I,Q) data are digitally locked downstream in the RVP8 IF-to-I/Q processing chain (see Figure 1–3). The procedure is identical to the manner in which phase is recovered in a magnetron system, except that the COHO signal is used in place of a sample of the transmit burst.



There are two special concerns that may come up when the RVP8 is used in the above manner within a synchronous radar system. Both concerns are the result of the IFD's sampling clock being asynchronous with the radar system clock.

- ***RVP8 Generates the Radar Trigger***

The trigger signals supplied by the RVP8 are synchronous with the IFD data sampling clock. This is accomplished by a clock recovery PLL on the RVP8/Rx that provides on-board timing which is identical to the sampling clock in the IFD. However, since the IFD sampling clock is asynchronous with the radar clock(s), the RVP8 trigger outputs are likewise asynchronous. The result is that each transmitted pulse envelope will be triggered independently of the COHO phase. The transmitted pulse is still synchronous — but the precise alignment of the amplitude modulated envelope will vary.

In almost all cases, the exact placement of the transmitter's amplitude envelope does not affect the overall system stability, nor the ability of the RVP8 to reject ground clutter and to process multi-mode return signals. For this reason, a synchronous radar system that is triggered using the RVP8 triggers will still perform optimally using the standard digital COHO locking techniques. In spite of this, however, some system designers may still prefer that the amplitude envelope itself be locked to the COHO.

- ***RVP8 Receives the Existing Radar Trigger***

When an external trigger is supplied to the RVP8, the processor synchronizes its internal range bin selection circuitry to that external trigger. The placement of the range bins themselves, however, is always synchronous with the IFD's 35.975MHz acquisition clock. The result is that 27.8ns of jitter is introduced in the placement of the RVP8's range bins relative to the transmitted pulse itself.

The effect of this synchronization jitter is that targets appear to be fluctuating in range by approximately 4.2 meters. Although this is small relative to the range bin spacing itself, and thus does not affect the range accuracy of the data, the effect on overall system stability is more severe. Using both numerical modeling and actual field measurements, we have found that sub-clutter visibility of a  $\mu$ sec pulse may be limited to approximately 43dB as a result of this 27.8ns range jitter. This falls quite short of the usual expectations of a synchronous radar system in which clutter rejection of 55–60dB should be attainable.

The solution to either of the above concerns is to provide some means for the IFD's internal sampling clock to be phase locked to the radar system. If the RVP8 provides the radar triggers, then those triggers would become synchronous with the radar COHO; and if the RVP8 receives an external trigger, then its range bin clock would be synchronous with that external trigger, and thus, there will be no synchronization jitter in the range bins.

Beginning with Rev. C, the IFD offers the option of locking its sampling clock to an external system clock reference. This results in an RVP8 that is fully synchronous with the existing radar timing. Rather than being derived from a fixed-frequency oscillator, the phase locked IFD sampling clock is driven by a custom Voltage-Controlled-Crystal-Oscillator (VCXO). This



oscillator can have a center frequency in the 33.5 to 39.5MHz range, which is any rational multiple P/Q of twice the input reference frequency, where P and Q are integers between 1 and 128 (See also, Section 3.2.6). The tuning range of the VCXO is purposely kept very narrow (to improve the clock stability), and is restricted to approximately  $\pm 50$ ppm. Thus, the input reference clock frequency (range 2–60MHz) must be precisely specified so as to stay within these limits. The reference clock input power level should be between  $-10$  and  $0$ dBm.

Use the following configuration to allow a Rev.C IFD to lock its sampling clock to an external reference:

- Install U14
- Remove U11, U12, U13
- Set JP1 to its BC position to terminate the reference input in  $50\Omega$ , or leave the jumper open to achieve a high-impedance input (approx.  $5K\Omega$ ).
- Install custom Voltage-Controlled-Crystal-Oscillator (VCXO) at U5. Please contact SIGMET for assistance in specifying this device.

For a Rev.D board the instructions are similar except that you do not need to remove any components, and should place a jumper on JP3/BC (See Table 2–7).



**Note:** As described in the previous section, for Rev.C boards U14 *Must Be Removed* whenever the VCXO phase lock mode is not being used, i.e., when the normal free-running crystal is installed.

### 2.2.13 Communications Between the IFD and RVP8/Rx

In the Rev.A through Rev.D IFD modules there are two cable links between the IFD and the RVP8/Rx PCI card:

- Copper coax cable uplink from the RVP8/Rx board. Provides timing information for the burst pulse window, and 16-bit data for setting the AFC output level.
- Optical fiber downlink to the RVP8/Rx board. The receiver and burst pulse data samples are encoded into a 540MHz serial stream.

The uplink input from the RVP8 is an SMA input from a  $75\Omega$  shielded cable (e.g., RG59 cable).. This cable is electrically isolated from the receiver's ground ( $40K\Omega$  isolation) so that noise picked up by the cable will not be coupled into the receiver circuitry. The downlink uses a 62.5/125 micron multimode optical cable terminated in type ST connectors. The coax and fiber cables can be any length up to 100 meters apiece.

In the Rev.E and higher IFD modules there is a single CAT-5E (unshielded twisted pair) cable with RJ-45 connectors that links the IFD to the RVP8/Rx PCI card. This cable carries GigaBit rate data and should be of high quality construction. The cable length can be up to 100 feet, and a minimum length of six feet is also recommended. Electrical isolation at the IFD side is  $>2KV$ .

For all revisions of the IFD hardware, the RVP8 software measures the round trip cable delays each time it boots up and then uses that information to correct for range and timing offsets due to cable length.



## 2.2.14 Summary of Crystal and Filter Configurations

The RVP8/Rx, RVP8/Tx and IFD can operate in many different clocking and sampling configurations, depending on the requirements of the radar in which they are installed. The following summary describes how to setup the crystals and filters in your equipment.

### Step 1. Choose the Intermediate Frequency

Custom analog bandpass filters are installed in the RVP8/Tx and IFD to match to the radar's Intermediate Frequency. The RVP8/Tx filters are soldered directly onto the PCI card and are not really meant to be changed by the user. The IFD filters, however, attach via coax cables and are located on a serviceable mounting plate attached to the IFD.

Simply verify that the center frequency of all of your bandpass filters match the IF of your radar. Our standard filter frequencies are: 16MHz, 30MHz, 57.5MHz, and 60MHz.

### Step 2. Choose Clock Locking Options

The RVP8 acquisition and trigger clocks can operate as free-running oscillators, or they can be phase locked to an external reference signal.

- For simple magnetron radars there is generally no system reference clock, and the free-running clock mode is therefore appropriate. However, if a synthesized STALO is being used as the RF source, then you may want to lock your RVP8 to the STALO's own reference clock (generally 10MHz). For dual-pol magnetron systems you *must* lock the RVP8 in this manner to measure differential phase.
- For klystron and other synchronous radars there will always be some kind of reference clock in the system. In the simplest case of a single-pol radar in which the RVP8 fires the transmitter directly, you may be able to get away with using free-running clocks. However, in virtually all cases it is best to lock the RVP8 to (one of) the radar's existing timing reference(s).

The following table lists the different clock modes for the RVP8/Rx, RVP8/Tx, and IFD. The frequency of the required crystal oscillator is given, along with the type that is required. The VF155 oscillators are general purpose units, VFAC170 is low-jitter free-running, and VF940 is low-jitter Voltage Controlled Crystal Oscillator (VCXO).

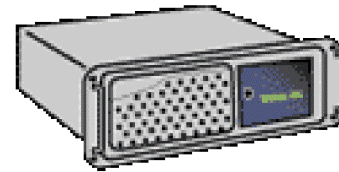


**Table 2–8: Clock Locking Component Options**

<i>Lock Mode</i>	<i>RVP8/Rx</i>	<i>RVP8/Tx</i>	<i>IFD</i>
Free-Running	U16: 26.983 (VF155)	U9 : 80.944 (VF940)	35.975 (VFAC170)
	The IFD is free-running, and the Rx and Tx cards lock to it. Use this mode for simple magnetron radars in which there is no system reference clock.		
N-MHz External Reference	U16: 26.983 (VF155)	U9 : 81.000 (VF940)	36.000 (VF940)
	A reference clock at some integer N-MHz is applied to both the IFD and Tx inputs, both of which lock directly to it. This is the recommended hookup for klystron radars or magnetron radars that use a synthesized STALO derived from, e.g., 10MHz.		
57.5491-MHz WSR88D COHO	U16: 26.983 (VF155)	U9 : 80.928 (VF940)	35.968 (VF940)
	For NEXRAD systems, the COHO is fed directly into both the IFD and Tx inputs. The IFD sampling rate is 5/8 of the COHO frequency, and the Tx rate is 45/32.		
31.0703-MHz ASR-9 COHO	U16: 27.186 (VF155)	N/A	36.248 (VF940)
	These special frequencies are used for the ASR-9 surveillance radars. The IFD locks to 7/6 times the COHO frequency of the radar.		



## 2.3 RVP8 Chassis



### 2.3.1 RVP8 Chassis Overview

The RVP8 main chassis can assume a variety of forms depending on the customer requirements. **Appendix G** describes a standard SIGMET system. A typical unit supplied by SIGMET contains at least the following:

- A dual CPU on either motherboard or SBC in a passive PCI backplane
- RVP8/Rx Card
- I/O-62 Card and Connector Panel

The system is also shipped with an integrated hard disk drive (HDD), 1.44 MB floppy (FDD) and CDRW unit. Note some installations may use a flash disk drive instead of an HDD. There is an LED display panel on the front of the chassis that is used to report system status.

### 2.3.2 Power Requirements, Size and Physical Mounting



**WARNING: The Main Chassis redundant power supplies are NOT auto-ranging like the IFD. These are factory configured for the expected voltage, but should be VERIFIED by the customer before power is applied to the system.**

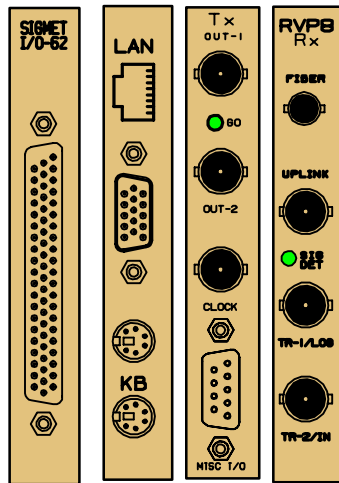
There are three redundant power supplies

The standard SIGMET chassis is a 19" EIA 4U rackmount unit, 17" (43 cm) deep. The chassis is usually mounted in a nearby equipment rack on rack slides (provided as standard). The connector panel is usually mounted on either the front or the rear of the same rack. The standard cable provided to connect the I/O-62 card in the main chassis to the connector panel is 6 feet long (1.8 m).

The power requirements are 100–240 VAC 47–63 Hz. The IFD is autoranging, i.e., there are no switches or jumpers that must be set. However, the main chassis is not. To check that the power supply is properly configured for your line voltage, follow the procedure in Section G.1.3.



## 2.3.3 Main Chassis Direct Connections



The direct connections to the RVP8 chassis are made either to the back of the unit to PCI cards (e.g., left) or to the remote connector panel. The direct connections are summarized in the table below.

Table 2–9: Direct Connections to RVP8 Main Chassis

IFD I/O Summary			
Connector Label	Style	Description	
Rx Card Connections			
Uplink	BNC	COAX uplink to IFD (75-Ohm shielded cable)	For IFD Rev.A-D
Fiber	ST	Fiberoptic downlink from IFD (orange cable)	
IFD-Link	RJ-45	CAT-5E (UTP) link between IFD and RVP8/Rx	For IFD Rev.E
Misc-I/O	DB9F	Four RS-422 I/O lines for future expansion	
TR-1 / LOG	BNC	Trigger outputs (5 or 12V, 75-Ohm) or pre-trigger input (1.8V threshold, 75-Ohm) Jumpers on the card select the function.	
TR-2 / PreTrigger In	BNC		
SBC or Motherboard Connections			
Network	RJ-45	10/100/1000 BaseT TCP/IP	
Keyboard	PS/2	Standard PC Keyboard	
Mouse	PS/2	Standard PC Mouse	
Monitor	VGA	Standard PC Video Monitor	
I/O-62 Connections			
<no label>	DB-62F	SIGMET-supplied cable to IO62/CP remote panel	
Optional Tx Card			
IF Out 1	BNC	Two independently synthesized IF output waveforms, up to +12dBm into 50-Ohm, 8-75MHz.	
IF Out 2	BNC		
CLK	BNC	Optional input or output reference clock (50-Ohm)	
Misc	DB-9F	Four optional RS-422 clocks or control lines	



Depending on the installation, the jumpers on the I-O 62, Rx and Tx Cards may require configuration. These are described in **Appendix G**.

### 2.3.4 External Pre-Trigger Input

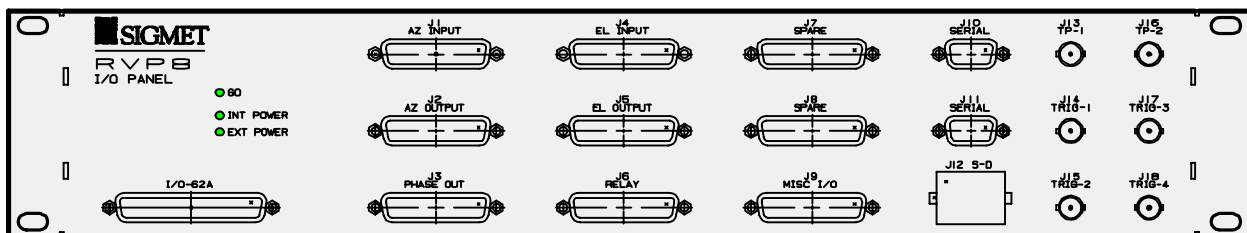
Users may supply the RVP8 with their own CMOS-Level pre-trigger for installations in which adequate trigger control already exists. The trigger input is provided directly on the Rx Card (bottom BNC connector on the card panel labeled "TR-2 / In). See **Appendix G** for instructions on how to set the Rx card jumpers to enable a pre-trigger input.

The trigger input uses CMOS levels (1.5V max low, 2.5V min high) for improved noise immunity. The trigger input may also be driven as high as +100V or as low as -100V without damage. This makes it easier to connect to existing high-voltage trigger distribution systems. The rising or falling edge of this external "TRIGIN" signal is interpreted by the RVP8 as the pretrigger point; the actual pulsewidth of the signal does not matter. The delay to range zero is configured via the TTY Setups. The other trigger outputs are then synchronized to the input trigger. The synchronization jitter between the user pretrigger and the other trigger outputs is less than 0.014 microseconds.

Trigger jitter can be improved in the case of coherent systems, by phase locking the IFD to the same reference clock used to generate the external triggers (typically the COHO). This provides approximately 10 dB of additional phase stability.

The RVP8's response to a missing external trigger is that the processor will insert fake (software) "triggers" at a rate of 250Hz whenever the trigger input is missing for more than 0.100 seconds. These fake triggers will keep the RVP8's internal code and external outputs running in spite of the missing input (the data values will all be zero, and the "no trigger" bit will be set in GPARM immediate status word #1). Normal operation automatically resumes as soon as the external trigger is restored.

### 2.3.5 Connector Panel I/O Connections



Most of the connections between the radar and the RVP8 are made using the RVP8 Connector Panel which connects to the I/O-62 by 1.8m (6 foot) cable. The panel is usually mounted on the front or the back of the same 19" EIA rack that contains the RVP8 chassis. The I/O-62 cable may be plugged into either the front or the back of the connector panel to optimize the cable run.

The Connector Panel uses a DC-DC converter to convert 12V unregulated input from the PCI card into regulated +5V, +3.3V, and +/-12V to run the main electronics on the panel. The LEDs on the panel are described below:



- **EXT LED** indicates that the 12V input power is present
- **INT LED** indicates that +3.3V is present
- **GO LED** indicates that the panel is properly communicating with the PCI card. It will blink slowly when communication is absent and very rapidly during the BRIEF times that the backpanel firmware are being updated with an rdaflash command. It will be solid when the panel is being used by the RCP8 software.

The table in **Section 1.9.5** provides a summary of the I/O for each connector. Detailed pin-out assignments are given in Appendix C. Descriptions of the various signals are provided below.

### **J1 & J4- AZ/EL Input: TTL parallel angles**

Thirty two TTL-Level input lines. These are sampled by the RVP8, and the bits accompany each processed output ray (See PROC command, Section 6.7). The inputs can also be read directly via the GPARM command (See Section 6.9). The RVP8 supports an antenna synchronizing mode and inserts the AZ and EL start and stop angles into the ray header of each radial (nominally 1 degree). Whenever antenna angle data are required, the processor reads the azimuth lines up to ten times in a row (spaced by 0.5  $\mu$ sec) until two successive values compare equal. This is done so that unsynchronized input data will be latched in a valid state. If after ten retries the lines were never observed in a consistent state, then the last observed state is used. Sampling for elevation is identical.

The format can be BCD or binary angle. Detailed pin assignments are given in Appendix B.

### **J2 & J5- AZ/EL Output: TTL parallel angles**

These provide output of the AZ and EL angles in TTL BCD or binary angle format. Detailed pin assignments are given in Appendix B. This feature could output the parallel angles to a separate antenna controller for example.

### **J3- PHASE OUT: 8-bit RS422 phase shifter control output**

Can be used as differential RS422 or as single-ended TTL. This is used to control a phase shifter for coherent systems that use phase modulation, but do not have a Tx card. This is typically used for legacy systems.

### **J6- RELAY: Control for external equipment**

Often, external equipment in the radar will require relay control (e.g., power on, radiate on, environmental systems, reset lines, slow polarization switch). This connector has connections for 3 internal relays that are on the connector panel itself. The maximum current through the relay contacts is 0.5 A continuous. The switching load is 0.25 A and 100V, with the additional constraint that the total power not exceed 4VA.



If larger current and voltage loads are required, then the connector panel relays can be used to switch external relays provided by the customer. Another alternative is to use the additional 4, 12V relay signals (up to 200mA) that are also supported on this connector.



**Hazard: External relays must be equipped with proper diode protection against back-EMF or damage to the I/O-62 and or the connector panel might result.**

### **J7 SPARE: Configurable 20 lines of TTL I/O**

This connector supports 20 lines of TTL each of which can be configured as either input or output via the softplane.conf file.

### **J8 SPARE: Analog Inputs**

10 differential analog inputs, up to  $\pm 20V$  max multiplexed into a single A/D convertor sampling each at  $>1000$  Hz. This can be used for monitoring environmental systems at the radar site.

### **J9- MISC: RS422 I/O, D/A and A/D**

7 additional RS422 lines, each configurable to be either input or output, and 2 each dedicated (non-multiplexed) A/D inputs ( $\pm 580V$  with pot adjust) and D/A outputs ( $\pm 10V$ ). The RS422 lines are convenient for high-speed polarization switch control.

### **J10-11: RS232C I/O**

These two connectors can be used for serial angle input. The most common format is the RCV01 format, although custom formats from antenna/pedestal manufacturers such as Orbit, Andrew and Scientific Atlanta are also supported.

### **J12: S-D- AZ and EL synchro input**

For systems that have synchros, the RVP8 can accept a direct synchro input from both AZ and EL. The nominal voltage and frequency are 100V @ 60 Hz. S/D conversion is performed in the I/O-62.

### **J13-14: TP1 & TP2: Programmable test point scope outputs**

An exciting feature of the RVP8 is the programmable test points. These are usually used to connect to an oscilloscope. The user can then specify what is output to the test points in the form of an analog voltage for display on the scope. Some examples are:

- “LOG” receiver power output (an old-time radar A-Scope)
- Burst pulse
- Analog input monitor

The advantage of using the test points is that technicians can leave them permanently connected to a rackmount oscilloscope and then select what is displayed. This saves time and reduces cabling errors when test switching cables.



## J15-18: TRIG1-4- Output triggers

The waveforms appearing on the four trigger outputs are programmed by the user to meet the radar's exact timing needs. These correspond to the trigger generators TGEN1, TGEN2, TGEN3 and TGEN4. More triggers can be configured on the "SPARE" connectors if they are required. All lines may be setup and used independently and can contain, for example, pre-trigger pulses, calibration gates, range strobes, scope triggers, etc. The triggers are driven at +12V into 75 $\Omega$  and can be independently-timed at rates between 50Hz and 20000Hz with better than 0.02% accuracy. For dual-PRF velocity unfolding applications, the RVP8 trigger generator must be used as opposed to an externally supplied pre-trigger (see next section).

The timing of the triggers is phase-locked to the sample clock in the IFD, which can be phase locked to the COHO of a coherent system. For coherent systems that do not sample the actual transmit pulse (for phase correction), this is recommended.

The trigger waveforms are configurable in software using the "mt" commands. This sets the trigger timing, trigger sense (active high or active low pulse) and the minimum and maximum PRF for each pulse width. See sections 3.2.4.



**It is sometimes useful to dedicate one of the TRIG outputs to trigger an oscilloscope.**

See **Section XXX** for a description of how to configure an input pre-trigger from an external source such as an existing radar trigger system.

## Selectable input pre-trigger

Users may supply the RVP8 with their own CMOS-Level pre-trigger for installations in which adequate trigger control already exists. The trigger input is provided directly on the Rx Card (bottom BNC connector on the card panel). The trigger input uses CMOS levels (1.5V max low, 2.5V min high) for improved noise immunity. The trigger input may also be driven as high as +100V or as low as -100V without damage. This makes it easier to connect to existing high-voltage trigger distribution systems. The rising or falling edge of this external "TRIGIN" signal is interpreted by the RVP8 as the pretrigger point; the actual pulsewidth of the signal does not matter. The delay to range zero is configured via the TTY Setups. The other trigger outputs are then synchronized to the input trigger. The synchronization jitter between the user pretrigger and the other trigger outputs is less than 0.014 microseconds.

Trigger jitter can be improved in the case of coherent systems, by phase locking the IFD to the same reference clock used to generate the external triggers (typically the COHO). This provides approximately 10 dB of additional phase stability.

The RVP8's response to a missing external trigger is that the processor will insert fake (software) "triggers" at a rate of 250Hz whenever the trigger input is missing for more than 0.100 seconds. These fake triggers will keep the RVP8's internal code and external outputs running in spite of the missing input (the data values will all be zero, and the "no trigger" bit will be set in GPARM immediate status word #1). Normal operation automatically resumes as soon as the external trigger is restored.



## 2.3.6 Power-Up Details



**WARNING:** The Main Chassis redundant power supplies are **NOT** auto-ranging like the IFD. These are factory configured for the expected voltage, but should be **VERIFIED** by the customer before power is applied to the system.

When the RVP8 is powered-up or reset, the host Linux PC goes through an automated boot process that ultimately starts the RVP8 application. The RVP8 then runs extensive internal diagnostics. In most cases, there is no display connected to the RVP8 to monitor the boot sequence. For troubleshooting it is useful to connect a display to view any error messages.

The RDA front panel display shows the status of the Linux boot sequence and summary status of the diagnostic self-tests. During the Linux boot stage, the front panel shows the following which indicates how much time has elapsed since the start of the boot process.

```
-----  
| SIGMET Inc.                Open RDA |  
| Boot < 00:24 >             |  
-----
```

After the Linux boot process is complete, the RVP8 runs its internal self-tests during which the front panel display appears as follows.

```
-----  
| RVP8 V4.3                  Starting |  
| Running Diagnostics        |  
-----
```

After successful completion of the self-tests, the display will show the following,

```
-----  
| RVP8 V4.3                  Starting |  
| Diagnostics Pass           |  
-----
```

and then switch to the standard operational display which shows the current azimuth and elevation, the major mode, the number of range bins, the PRF and XXX:

```
-----  
| 179.23    AZ/EL          14.96    |  
| FFT      1646    1800 Hz    x1    |  
-----
```

In the event that the diagnostics do not pass, then the display will indicate the number of tests that “Fail”. Note that the “dspcx –nochat” utility “gparm” command or the “v” command in the TTY setups can be used to learn the details of the failures.



### 2.3.7 Socket Interface

The RVP8 as shipped is configured to listen on a network port. It is ready to interface to a host computer via the network using a program called **DspExport**. It is also ready to run some commands on the RVP8 itself. The RVP8 comes with some built-in SIGMET supplied utilities such as **setup**, **dsp**x and **ascope**. These utilities are described in the *IRIS Utilities Manual*. Because the RVP8 can only have one program controlling it at a time, use of a local program like **dsp**x will block network access, and vice versa.

#### How DspExport Works

**DspExport** is a daemon program which is normally configured to run all the time. When it receives a socket connection request it will establish a connection to the RVP8. At this point, multiple connections are allowed. It will only handle the "INFO", "SETU" and "OPEN" commands. Once the "OPEN" command is sent, an exclusive connection for I/O to the RVP8 is established. If a second OPEN request comes in while the first is still active, it will fail, and return the message "Device allocated to another user". To see if it is running on your RVP8, try typing

```
$ ps -aef | grep DspExport
```

During development, it can always be started up manually by typing "DspExport" at a shell prompt. It can be started with the "-v" option for more detailed logging. It defaults to using port 30740. If you wish to use another port, start it with an option such as "-port:12345". The command line option "-help" lists these options.

#### Source Examples

The source code for **DspExport** and for the dsp library is supplied on the RVP8 release cdrom. This can be optionally installed as part of the upgrade procedure as discussed in *Software Installation manual*. You will find **DspExport** in \${IRIS\_ROOT}utils/dsp, and you will find the dsp library in \${IRIS\_ROOT}libs/dsp. In the library, you will find example code which talks to **DspExport** in file OpenSocket.c, dsp\_read.c and dsp\_write.c. Search for the string "SOCKET", and you can see how the code differs between SCSI interface and socket interface.

#### Socket protocol

The socket interface basically supports all the "Host Computer Commands" in chapter 6. There are a few layers of formatting on top of that. All messages going both ways consist at the lowest level of an 8-character decimal ASCII number, followed by a block of data. The decimal number indicates how many bytes follow. Generally, all data transfers are initiated by the host computer by sending a block of data which consists of a command word followed by the "|" character, followed by optional data.

It will respond to all commands with either an "Ack|" indicating acknowledgment that the command was OK, or "Nak|" indicating that there was an error. For Nak, the reply will always include a string indicating what the error was. For Ack there is optional data following.

On initial socket connection request **DspExport** will provide a response of either Nak indicating the connection failed, and why, or Ack followed by some connection information. This Ack string is in the form of name/value pairs, and will look something like:



**Ack|CanCompress=1,Model=RVP8,Version=7.32**

Your program can choose to evaluate or ignore any of these keywords. “CanCompress=1” indicates that the **DspExport** computer supports compression. The host computer can then choose to use compression if it wants to. When you first connect, you are in the “info only” mode. That means that the server will only respond to INFO and OPEN commands. **DspExport** supports only the 6 commands discussed individually below:

### **Read command (READ)**

Example: “READ|100|” means read 100 bytes from the RVP8. Since the RVP8 interface is a 16-bit word interface, these read sizes should always be even. It will always reply with a “Ack|” followed by 100 bytes of binary data, or with a “Nak|”, in other words there can be no partial reads.

### **Write command (WRIT)**

Example: “WRIT|<data>” Where <data> is some binary data. This data is written to the RVP8. Again, the data size should be even.

### **Read Status command (STAT)**

Example: “STAT|” This reads the status bits back from the RVP8. This is a 1 bit value, set to 1 if the RVP8 has data available in its output buffer. It will return either “Ack|0”, or “Ack|1”, or a “Nak”. This is the equivalent of the `dspr_status()` call in the dsp library.

### **Set Information command (INFO)**

Example: “INFO|ByteOrder=LittleEndian,WillCompress=1,Version=7.32”. This command can be used to inform RVP8’s **DspExport** about the host computer. Current options available are:

**ByteOrder** to inform **DspExport** of the byte order of the host computer. This is needed because all the data read or written to/from the RVP8 is in 16-bit words. If the host computer has a different byte order from the RVP8, **DspExport** will byte swap the data.

**WillCompress** to inform **DspExport** to use compression or not. Compression is only used if both sides agree to use it. The host computer should only set this to 1 if it received a “CanCompress” of 1 on initial connection. The only thing compressed is the data from normal READ commands. If it is compressed, it will reply with the acknowledge compressed string of “AkC”. The compression program is the zlib compress and uncompress. The uncompress function requires that the caller know the expected uncompressed size. This is true for RVP8 reads, because the reader always specifies the read size.

**Version**, send the IRIS version.

### **Read data available command (RDAV)**

Example: “RDAV|100|2|” This means read up to 100 bytes of data from the RVP8 in individual DMA transfers of 2 bytes each. Before each read, the status is checked to see if there is more data available. If not, the read stops, and the number of bytes read is returned. This is merely a performance enhancing command since the same feature is available by using the READ command and the STAT command.



## Open the connection for I/O (OPEN)

Example: "OPEN" This means switch from open for "info only" mode to open for I/O. If the signal processor is in use by another device, you will get an error in response to this command. Multiple clients are allowed to connect for info only, but only one can do I/O. Note that if you run **DspExport** with the -803 command line option, you will get the legacy behavior which means that every connection will automatically send the OPEN command. There is no reverse command to switch back to open for info only. There is also no such library call in the driver.

## Read Setup information (SETU)

Example: "SETU" This means read the dsp\_manual\_setup structure from the RVP8 machine and send it back in an ASCII name=value pair format. This is the structure configured in the RVP section of **setup**. That configuration is served out to all clients who wish to use the RVP8.

## Reset Kernel FIFOs (RKFF)

Example: "RKFF|2|" This means reset the kernel FIFOs on the RVP8. The argument specifies which direction FIFOs to reset.

## Notes on migrating from the SCSI interface

Here are suggestions for customers who are converting an existing program which used a SCSI interface to the RVP7 to the socket interface to the RVP8. First take a look at our source code which handles either SCSI or socket. In `OpenSocket.c` you can see the code which replaces the SCSI device open call. The SCSI inquiry command is replaced by reading the string returned after the socket is opened. The SCSI read command is replaced by the "READ|.." command. The SCSI mode sense command is replaced by the "STAT|" command. The SCSI write command is replaced by the "WRIT|.." command. You should get your code working first without using the RDAV command or using compression.

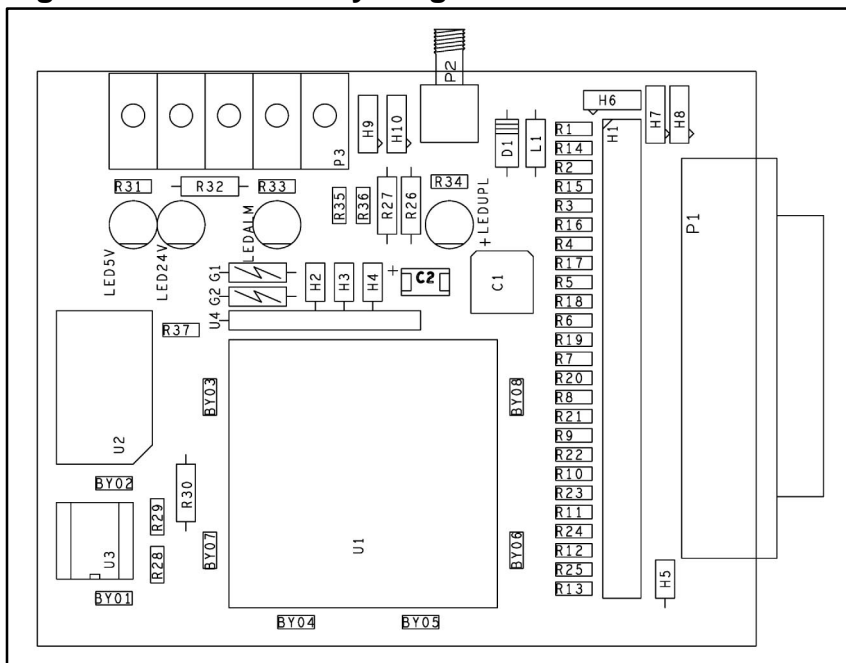
There is a significant difference between the RVP7 and RVP8 in regards to the FIFO reset command. This is the RVP8 command 0x008C (see section 6.11). The RVP8 is unable to read incoming commands if the output FIFO is entirely full. Therefore, if you put the RVP8 into continuous output mode, then issue the FIFO reset command to return to interactive mode, it may hang. We have added special dsp library support to solve this. To see how we have handled this problem, look in the source file `DspResetFifo.c`.



## 2.4 Digital AFC Module (DAFC)

The DAFC is a small self-contained circuit board which can passively “eavesdrop” on the RVP8’s serial uplink transmissions. Its purpose is to generate a set of digital AFC control lines that could be applied, for example, to a custom STALO frequency synthesizer. A full size (3”x3.75”) assembly diagram of the board is shown in Figure 2–3. It can be installed in the radar system either as a bare board, or packaged into a small metal enclosure.

**Figure 2–3: Assembly Diagram of the DAFC**



SIGMET recommends that the DAFC board be used in new system designs whenever AFC is required, as it offers these advantages over other methods of frequency control:

- 1) The use of a digital frequency synthesizer is superior to using analog AFC because the stability of a synthesized STALO can be made much greater than that of a tunable cavity oscillator. Also, noise on the AFC control voltage directly contributes to phase noise in the received weather targets in analog AFC systems, so cabling of the control signal can become tricky.
- 2) The RVP8 Connector Panel can also be made to output 8-bit AFC (TTL or RS422). However, this is not in general recommended because of the potential for noise on the cable which is typically run >2m into a radar cabinet. Using the DAFC module is preferable because the board can be physically located very close to the STALO. The length of the control cable and its susceptibility to noise and ground loops are therefore reduced. Also, the DAFC board can supply up to 24 output control lines, rather than just eight.

The digital output lines are made available as TTL levels on a 25-pin female “D” connector (P1). There are 130Ω resistors (R1–R25) in series with each output line to help protect the board against momentary application of non-TTL voltages on its external pins. However, these resistors do impose a restriction on the input line configuration of the receiving device. To



assure a valid TTL low level of 0.6V max. requires that the STALO inputs be pulled up to +5 with nothing less than (approx.) 1.2K $\Omega$ . Put another way, the low level input current of the receiving device should not exceed 4.5mA. Most STALOs that we have seen use 5-20K $\Omega$  pull-up resistors, so this should not be a problem.

All twenty five pins of the “D” connector are wired identically on the DAFC board, i.e., each pin connects to one end of a 2-pin jumper (2x25 header H1), the other end of which connects to a Programmable Logic Device (PLD) chip. The PLD lines can be configured either as inputs or outputs, and this single chip handles all of the decoding and driving needs for the entire board. For each “D” connector pin that is to be used as an AFC output or Fault Status input, you should install the corresponding jumper to connect that pin through to the PLD, or use a wirewrap wire if the pin must go to a different PLD line. The “D” connector pin numbers are printed next to each of the jumper locations. Because of the ordering of the pins in the connector housing, jumpers 1 through 13 are interleaved with jumpers 14 through 25.

The uplink protocol that the board should be expecting is selected by jumpers H3 and H4, as summarized in Table 2–10. The first three table entries describe three fixed mappings of the traditional AFC-16 uplink format onto various pins of the 25-pin “D” connector. One of these choices must be used whenever the DAFC is interfaced to an RVP8 system whose uplink uses the older style 16-bit AFC uplink format. In this case you will have to make most or all of the pin assignments using wirewrap wire to connect each bit to its corresponding pin. This will be somewhat tedious, but hopefully one of the three formats will be a reasonable starting point for doing the wiring. By far the most preferable solution, however, is to use the Pinmap uplink protocol (available since Rev.19) which allows for complete software mapping of all 25 external pins.

**Table 2–10: DAFC Protocol Jumper Selections**

H4	H3	Function
On	On	AFC-16 format, Bits<0:15> on Pins<1:16>, Fault input on Pin 25
On	Off	AFC-16 format, Bits<0:15> on Pins<25:10>, Fault input on Pin 3
Off	On	AFC-16 format, Bits<0:15> on Pins<18, 19, 6, 7, 21, 22, 23, 11, 10, 9, 20, 8, 12, 25, 13, 24>, Fault input on Pin 4
Off	Off	Pinmap format, software assignment of all pins

Ground, +5V, and +24V power supply pins on the “D” connector should be connected with wirewrap wire to the nearby power and ground posts H6, H7, and H8. The PLD jumpers for these power supply pins must not be installed. Two 3K/6K resistive terminators are also available at H5 for pulling pins up to approximately +3.3V when that is appropriate. Unused “D” connector pins should remain both unwired and not jumpered.



**Warning: It is important that the jumpers only be installed for pins that carry TTL inputs or outputs destined for the on-board PLD. The jumpers must be removed for all power supply pins, and for unused and reserved pins of the external device.**



The DAFC board runs off of a single +5V power supply which can be applied either from the STALO through the “D” connector, or externally through the terminal block. There are also provisions for supplying +24V (approx.) between the terminal block and the “D” connector, which is handy for cabling power to a STALO that requires the second voltage. Two green LEDs indicate the presence of +5V and +24V. Terminal block Pin #1 is +5V, Pin #2 is +24V, and Pin#3 is Ground. Pin #1 is the one nearest the corner of the board.

There is an option for having a “Fault Status” input on the “D” connector of the DAFC. Since the board is completely passive in its connection to the uplink, the fault status bit will not affect the uplink in any way. Rather, the bit is simply received by the board (with optional polarity reversal) and driven onto the terminal block (P3) from whence it can be wired to some other device, e.g., a BITE input line of an RCP02. A yellow LED is included to indicate the presence of any external fault conditions.

The “AB” position of the 3-pin “Alarm” jumper (H9) connects the Fault Status signal to Pin #4 of the terminal block, whereas the “BC” position grounds that terminal block pin. A second ground can be made available at Pin #5 of the terminal block by installing a jumper in the “BC” position of the “Spare” 3-pin jumper (H10). This second ground could be used as a ground return when the Fault Status line is driven off of the terminal block. The “AB” position of the “Spare” jumper is reserved for some future input or output line on the terminal block.

Both the shield and the center conductor of the uplink SMA input connector (P2) are electrically isolated ( $> 100K\Omega$ ) from the rest of the DAFC board. Moreover, the SMA connector pins themselves are high-impedance and unterminated. What this means is that the board can be TEE'd into the uplink cable anywhere in the cable run from the RVP8/Rx board to the IFD. Since the cable is driven by the RVP8/Rx, it must be at one end of the cable; and since termination is provided by the IFD, it must be at the other end. The DAFC can be anywhere in the middle. Be sure, however, that the TEE is located right at the DAFC itself so that an unterminated cable stub is not created. A red LED is included to indicate that a valid uplink data stream is being received.

A crystal oscillator is used to supply the operating clock for the on-board logic, and there are two choices of frequency to use. If jumper H2 is “Off” then the crystal frequency should be equal to the IFD's sampling clock  $f_{aq}$ , and if H2 is “On” the frequency should be  $(0.75 \times f_{aq})$ .

Additional information about using AFC can be found in Sections 2.2.11, 3.2.6, and 5.1.2.

## 2.4.1 Example Hookup to a CTI “MVSR-xxx” STALO

Here is a complete example of what would need to be done in hardware and software to interface the DAFC to a Communication Techniques Inc. digital STALO. The electrical interface for the STALO is via a 26-pin ribbon cable which carries both Control and Status, as well as DC power. This cable can be crimped onto a mass-terminated 25-pin “D” connector (with one wire removed) and plugged directly into the DAFC. The resulting pinout is shown in Table 2–11.

The STALO frequency is controlled by a 14-bit binary integer whose LSB has a weight of 100 KiloHertz. In addition, the “Inhb” pin must be low for the STALO to function. Power is supplied on the +5V and +24V pins, and two grounds are provided. An “alarm” output is also available.



**Table 2–11: Pinout for the CTI “MVSR-xxx” STALO**

<u>Ribbon Pin</u>	<u>"D" Pin</u>	<u>Function</u>	<u>Ribbon Pin</u>	<u>"D" Pin</u>	<u>Function</u>
1	1	Ground	2	14	--
3	2	+5V	4	15	--
5	3	+24V	6	16	--
7	4	Alarm	8	17	--
9	5	--	10	18	Bit-0
11	6	Bit-2	12	19	Bit-1
13	7	Bit-3	14	20	Bit-10
15	8	Bit-11	16	21	Bit-4
17	9	Bit-9	18	22	Bit-5
19	10	Bit-8	20	23	Bit-6
21	11	Bit-7	22	24	Ground
23	12	Bit-12	24	25	Bit-13
25	13	Inhb	26	--	--

First configure the IFD pins themselves. Pins 1 and 24 are power supply grounds, and are connected with wirewrap wire to the nearby ground posts. Pins 2 and 3 supply +5V and +24V to the STALO, and should be wire wrapped to the internal power posts. The STALO power, as well as the DAFC power, is then supplied externally via the terminal block on the DAFC itself.

Sixteen jumpers should be installed to connect the Control and Status lines, i.e., pins 4, 6–13, 18–23, and 25. We will use pinmap uplink protocol, so H3 and H4 are removed; and a x1 on-board crystal, so H2 is also removed.

The STALO has an output frequency range from 5200–6020MHz in 100KHz steps. In this example we will assume that we need an AFC frequency span of 5580–5600MHz. This can be done with the following setups from the **Mb** section:

```
AFC span- [-100%,+100%] maps into [ 3800 , 4000 ]
AFC format- 0:Bin, 1:BCD, 2:8B4D: 0, ActLow: NO
AFC uplink protocol- 0:Off, 1:Normal, 2:PinMap : 2
  PinMap Table (Type '31' for GND, '30' for +5)
  -----
  Pin01:GND  Pin02:GND  Pin03:GND  Pin04:GND  Pin05:GND
  Pin06:02   Pin07:03   Pin08:11   Pin09:09   Pin10:08
  Pin11:07   Pin12:12   Pin13:GND  Pin14:GND  Pin15:GND
  Pin16:GND  Pin17:GND  Pin18:00   Pin19:01   Pin20:10
  Pin21:04   Pin22:05   Pin23:06   Pin24:GND  Pin25:13
  FAULT status pin (0:None): 4, ActLow: NO
```

We map the AFC interval into the numeric span 3800–4000, and choose the “Bin” (simple binary) encoding format. The actual frequency limits therefore match the desired values:

$$5200\text{MHz} + (3800 \times 100\text{KHz}) = 5580\text{MHz}$$

$$5200\text{MHz} + (4000 \times 100\text{KHz}) = 5600\text{MHz}$$

The “Inhb” line is held low, and fault status is input on Pin 4. Note that all pins that are not directly controlled by the software uplink (e.g., power pins, and unused pins) are merely set to “GND” in the setup table.



## 2.4.2 Example Hookup to a MITEQ “MFS-xxx” STALO

The electrical interface for this STALO uses a 25-pin “D” connector with the following pin assignments

- GROUND on pins 1 and 2.
- Four BCD digits of 1KHz, 10KHz, 100KHz, and 1MHz frequency steps, using Pins <25:22>, <21:18>, <17:14>, <13:10>.
- Seven binary bits of representing 10MHz steps, Bits<0:6> on Pins<9:3>.

First configure the IFD pins themselves. Pins 1 and 2 are ground, and are connected with wirewrap wire to the nearby ground posts. Pins 3 through 25 all are signal pins, so we plug in a jumper for each of these 23 pins. We will use pinmap uplink protocol, so H3 and H4 are removed; and a x1 on-board crystal, so H2 is also removed.

In this example we will assume that we wish to control the STALO in 20KHz steps from 1.350GHz to 1.365GHz. This can be done with the following setups from the **Mb** section:

```
AFC span- [-100%,+100%] maps into [ 1350000 , 1365000 ]
AFC format- 0:Bin, 1:BCD, 2:8B4D: 2, ActLow: NO
AFC uplink protocol- 0:Off, 1:Normal, 2:PinMap : 2
  PinMap Table (Type '31' for GND, '30' for +5)
  -----
  Pin01:GND  Pin02:GND  Pin03:22  Pin04:21  Pin05:20
  Pin06:19  Pin07:18  Pin08:17  Pin09:16  Pin10:15
  Pin11:14  Pin12:13  Pin13:12  Pin14:11  Pin15:10
  Pin16:09  Pin17:08  Pin18:07  Pin19:06  Pin20:05
  Pin21:GND  Pin22:GND  Pin23:GND  Pin24:GND  Pin25:GND
  FAULT status pin (0:None): 0, ActLow: NO
```

We map the AFC interval into a numeric span from 1350000 to 1365000, and choose the “8B4D” mixed-radix encoding format. The STALO itself has 1KHz frequency steps, but the AFC servo will be easier to tune if we intentionally degrade this to 20KHz. This is done simply by grounding all four of the 1KHz BCD input lines, plus the LSB of the 10KHz BCD digit. A more creative use for one of these unused pins would be to remove the pin 25 jumper, wirewrap pin 25 to ground (so the STALO still reads it a logic low), and assign pin 25 as a fault status input. That pin could then be connected to an external fault line, if the STALO has one.



## 2.5 RVP8 Custom Interfaces

This section describes some additional points of interface to the RVP8. These hookups are less conventional than the “standard” interfaces described earlier in this chapter, but they sometimes can supply exactly what is needed in exactly the right place. For the most part, these custom interfaces are merely taps into existing internal signals that would normally not be seen by the user.

### 2.5.1 Using the Legacy IFD Coax “Uplink”

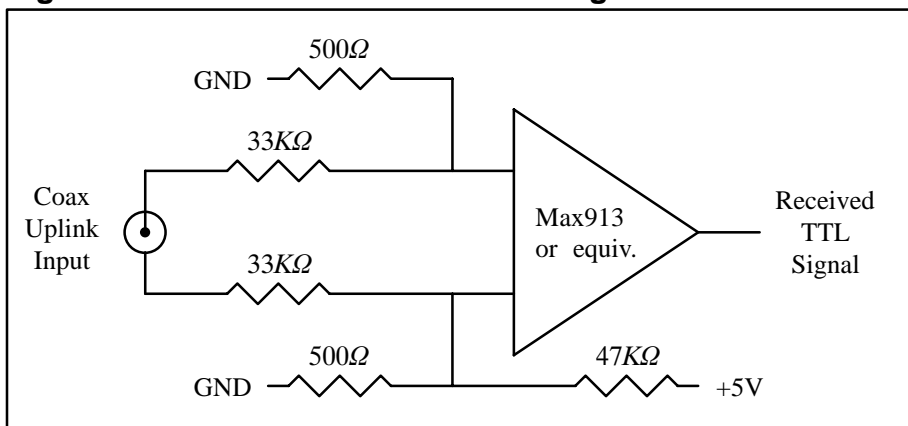
In the previous RVP7 processor the Coax Uplink was the IFD's single line of communication from the main processor board. All of the information that was needed by the IFD would arrive through this uplink; and as such, it contained information that might also be useful for other parts of the radar system. In particular, it is a convenient source of digital AFC.

The RVP8 uses a single CAT-5E Uplink/Downlink cable between the IFD and RVP8/Rx PCI card. The legacy coax uplink protocol is no longer used directly; but to help with backward compatibility, the waveform is now synthesized as an *output* from the IFD. Any hardware that used to be attached to the RVP7 coax uplink can still be driven from this new IFD port.

The uplink is a single digital transmission line that carries a hybrid serial protocol. The two logic states, “zero” and “one” are represented by 0-Volt and +12-Volt (open circuit) electrical levels. The output impedance of the uplink driver is approximately  $55\Omega$ . When the cable is terminated in  $75\Omega$  the overall positive voltage swing will be approximately 8.6-Volts.

The electrical characteristics of the uplink have been optimized for balanced “groundless” reception. The recommended eavesdropping circuit is shown in Figure 2–4, and consists of a high speed comparator (Maxim MAX913, or equivalent) and input conditioning resistors. Both the shield and the center conductor of the coax uplink feed the comparator through  $33K\Omega$  isolation resistors; no direct ground attachment is made to the shield itself. The  $500\Omega$  resistors provide the local ground reference, and the  $47K\Omega$  resistor supplies a bias to shift the unipolar uplink signal into a bipolar range for the comparator.

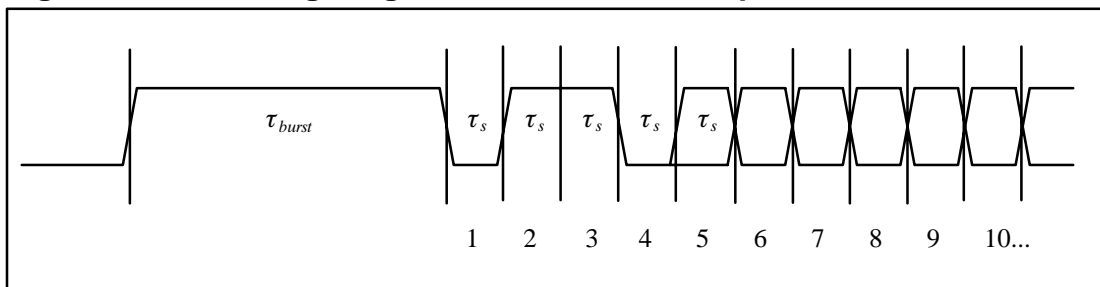
**Figure 2–4: Recommended Receiving Circuit for the Coax Uplink**





The uplink signal, shown in Figure 2–5, is periodic at the radar pulse repetition frequency, and conveys two distinct types of information to the IFD. The signal is normally low most of the time (to minimize driver and termination power), but begins a transition sequence at the beginning of each transmitted pulse.

**Figure 2–5: Timing Diagram of the IFD Coax Uplink**



The first part of each pulse sequence is a variable length “burst window” which is centered on the transmitted pulse itself, and which has a duration  $\tau_{burst}$  approximately 800ns greater than the length of the current FIR matched filter. The burst window defines the interval of time during which the IFD transmits digitized burst pulse samples, rather than digitized IF samples, on its downlink. The exact placement and width of the burst window will depend on the trigger timing and digital filter specifications that the user has chosen, usually via the **Pb** and **Ps** plotting setup commands.

Following the burst window is a fixed-length sequence of 25 serial data bits which convey information from the RVP8/Rx board. The first four data bits form a characteristic (0,1,1,0) marker pattern. The first zero in this pattern effectively marks the end of the variable length burst window, and the other three bits should be checked for added confidence that a valid bit sequence is being received. Table 2–12 defines the interpretation of the serial data bits.

**Table 2–12: Bit Assignments for the IFD Coax Uplink**

Bit(s)	Meaning
1–4	Marker Sequence (0,1,1,0). This fixed 4-bit sequence identifies the start of a valid data sequence following the variable-length burst window.
5–20	16-bit multi-purpose data word, MSB is transmitted first (See below)
21	Reset Request. This bit will be set in just one transmitted sequence whenever an RVP8 reset occurs.
22	If set, then interpret the 16-bit data word as 4-bits of command and 12-bits of data, rather than as a single 16-bit quantity (See below)
23–24	Diagnostic select bits. These are used by the RVP8 power-up diagnostic routines; they will both be zero during normal operation.
25	Green LED Request; 0=Off, 1=On. The state of this bit normally follows the “Downlink Detect” LED on the RVP8/Rx board.



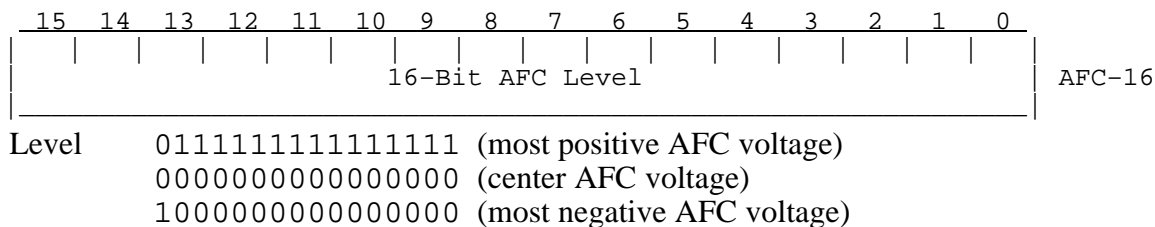
The period  $\tau_s$  of the serial data is  $(128/f_{aq})$ , where  $f_{aq}$  is the acquisition clock frequency given in the **Mc** section of the RVP8 setup menu. For the default clock frequency of 71.9502MHz, the period of the serial data will be 1.779 $\mu$ sec. The logic that is receiving the serial data should first locate the center of the first data bit at  $(0.5 \times \tau_s)$  past the falling edge at the end of the burst window. Subsequent data bits are then sampled at uniform  $\tau_s$  intervals.

The actual data sampling rate can be in error by as much as one part in 75 while still maintaining accurate reception. This is because the data sequence is only 25-bits long, and hence, the last data bit would still be sampled within  $\pm 1/3$  bit time of its center. Having this flexibility makes it easier to design the receiving logic. For example, if a 5MHz or 10MHz clock were available, then sampling at 1.8 $\mu$ sec intervals (1:85 error) would be fine. Likewise, one could sample at 1.75 $\mu$ sec based on a 4MHz or 8MHz clock (1:61 error), but only if the first sample were moved slightly ahead of center so that the sampling errors were equalized over the 25-bit span.

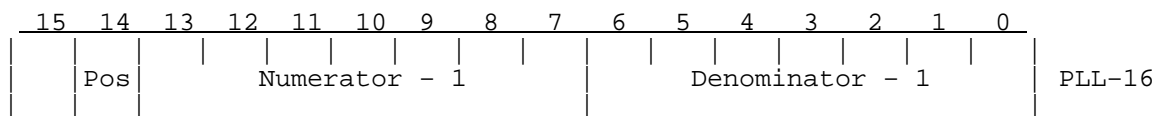
### Interpreting the Serial 16-bit Data Word

The serial 16-bit data word has several different interpretations according to how the RVP8 has been configured, and whether Bit #22 of the uplink stream is set or clear. The evolution of these different formats has been in response to new features being added to the IFD (Section 2.2), and the production of the DAFC Digital AFC Module (Section 2.4).

The original use of the uplink data word was simply to convey a 16-bit AFC level, generally for use with a magnetron system. Bit #22 is clear in this case, and the word is interpreted as a linear signed binary value. The use of this format is discouraged for new hardware designs, but it will remain available to guarantee compatibility with older equipment.



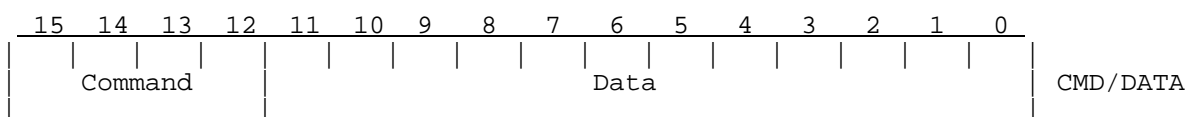
When the IFD is jumpered for phase locking to an external reference clock, then Bit #22 will be clear and the data word conveys the PLL clock ratio, and the Positive/Negative deviation sign of the Voltage Controlled Crystal Oscillator (VCXO). This format is commonly used with klystron systems, especially when the RVP8 is locking to an external trigger.



Note that the AFC-16 and PLL-16 formats can never be interleaved for use at the same time, since there would be no way to distinguish them at the receiving end.

Finally, an expanded format has been defined to handle all future requirements of the serial uplink. Bit #22 is set in this case, and the data word is interpreted as a 4-bit command and 12-bit data value. A total of  $16 \times 12 = 192$  auxiliary data bits thus become available via sequential transmission of one or more of these words. The CMD/DATA words can also be used along with *one* of the AFC-16 or PLL-16 formats, since Bit #22 marks them differently.





Commands #1, #2, and #3 control the 25 output pin levels of the DAFC board. These transmissions may be interspersed with the PLL-16 format in systems that require both clock locking and AFC, e.g., a dual-receiver magnetron system using a digitally synthesized COHO. Note that the entire 25-bits of pin information are transferred synchronously to the output pins only when CMD=3 is received. This assures that momentary invalid patterns will not be produced upon arrival of CMD=1 or CMD=2 when the output bits are changing.

CMD=1	Data<0>	DAFC output pin 25
	Data<6>	Fault Input is active high
	Data<11:7>	Which pin to use for Fault Input (0:None)
CMD=2	Data<11:0>	DAFC output pins 24 through 13
CMD=3	Data<11:0>	DAFC output pins 12 through 1

These three digital AFC pinmap commands are recommended as a replacement for the original AFC-16 format in all new hardware designs. If you only need 12-bits of linear AFC, then map the AFC range into the -2048 to +2047 numeric span, and select binary coding format (See Section 3.2.6); the 12-bit data with CMD=3 will then hold the required values. To get a full 16-bit value, use a -32768 to +32767 span and extract the full word from both CMD=2 and CMD=3. Of course, other combinations of bit formats and number of bits (up to 25) are also possible.

Command #4 is used to control some of the internal features of the IFD. Bits <4:0> configure the on-board noise generator so that it adds a selectable amount of dither power to the A/D converters. This noise is bandlimited using a 10-pole lowpass filter so that most of the energy is within the 150KHz to 900KHz band, with negligible residual power above 1.4MHz. Each of the five bits switch in additional noise power when they are set, with the upper bits making successively greater contributions. Bits <6:5> permit the IF-Input and Burst-Input signals to be reassigned on the downlink.

CMD=4	Data<4:0>	Built-in noise generator level
		IF-Input and Burst-Input selection
	Data<6:5>	00 : Normal                      01 : Swap IF/Burst
		10 : Burst Always              11 : IF Always
	Data<7>	0 : Normal                      1: Swap Pri/Sec IF
	Data<8>	Downlink IF data stream format
		0 : Normal 72MHz single channel
		1 : Halfband 36MHz dual channel
	Data<9>	0 : Low Halfband              1: High Halfband