

6. Host Computer Commands

This chapter describes the digital commands that the host computer must use to set up and control the RVP7 processor for recording data. Each command is described in detailed in a separate section of this chapter. Note that a command mnemonic, or shorthand reference name, is given in each section heading. These names are frequently used to refer to particular commands.

The write-up for each command includes a description of what the command does and a pictorial layout of the bits in the 16-bit command word. Commands consist of an initial command word containing an opcode in the low five bits. If additional arguments are required, they are listed as "Input 1", "Input 2", etc. Finally, if the command produces output, those words are listed as "Output 1", "Output 2", etc. Often each word is broken down into several independent fields, each consisting of one or more bits. In such cases, the pictorial layouts show the placement of the bit fields within the word, and each field is described individually. All data transferred to or from the RVP7 are in the form of 16-bit words.

Before attempting to program the RVP7, it is a good idea to at least skim through the descriptions of every command. The instruction set has been designed to be as concise and orthogonal as possible. User programs should always execute the IOTEST command on power-up to ensure that the interface connections are all intact. The diagnostic result registers from GPARM should also be checked initially to verify that the RVP7 passed all internal checks. Since all internal RVP7 tables and parameters are set to reasonable values on power-up, it is conceivable that PROC commands could be issued immediately to acquire and process radar data. More realistically, however, the default information is first modified to meet the users needs.

To set up for data acquisition and processing the following sequence of commands might be executed. Trigger and pulse width are first established using the SETPWF commands. Range bin placement and processor options are then chosen using LRMSK, and SOPRM, and receiver noise samples are taken with SNOISE. The noise levels are not automatically sampled on power-up, so SNOISE must be issued at least once by the user. LFILT is executed if clutter filters are needed. If data rays are to be synchronized with antenna motion, then LSYNC is used to specify a table of antenna angles. After all setups are complete, PROC commands are issued to actually collect, process, and output the data. Errors detected during the execution of commands are noted by the RVP7 and can be monitored using GPARM.

The RVP7 contains a 4096-word first-in-first-out (FIFO) buffer through which all output data flow. This buffer is included to simplify the requirements of the user's interface hardware. The FIFO holds each sequential word generated by the RVP7 until such time as the user is ready to accept it. Thus, when reading from the processor, it is permissible to fall behind by as many as 4096 words before any slowdown in performance occurs. The RVP7 writes to the FIFO at full speed as long as it is not full, and the internal processing is not affected by the exact speed at which user I/O actually occurs. This continues as long as the average I/O rate on, perhaps 10ms intervals, matches the average rate at which data are being produced.

The sequence of events described above is altered when the FIFO becomes completely full. Then, when the processor generates the next output word, it waits in an idle loop until the user makes room in the FIFO by reading out one or more words. Until this space becomes available, the RVP7 simply waits and does not proceed any further with its internal processing. This, of course, leads to a slowdown in performance, but it is not a disastrous one. The user always obtains correct data no matter how long it takes to read it. One could take advantage of this fact to synchronize the acquisition of data by the RVP7 with the post-processing and display of that data by the user. In this case, RVP7 would be instructed to output data at the maximum rate, the user would read these words at the user's maximum rate, and the overall system would automatically run at the slower of those two speeds.

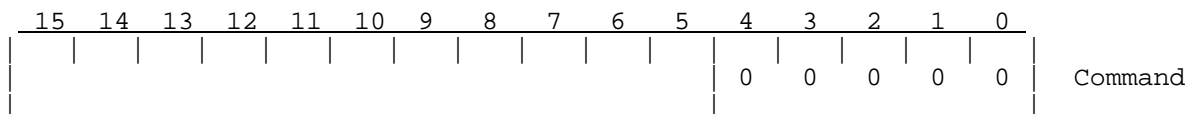
When the output FIFO is full and the RVP7 has the next word ready for output, there is another way that the idle wait loop can be exited, that is, if the processor detects that the user is performing a write I/O cycle. Since the user should have been reading data by now, the presence of a write cycle is taken to mean that some more important condition has arisen. As such, the wait loop is terminated and the RVP7 accepts the write data soon afterward. If the new data are commands, they are executed right away, but any output they try to produce may be lost in a similar manner. The net effect is that the processor continues to execute all commands correctly, but that their output is discarded.

The discarded output data are not in fact lost. Rather, the data are eventually replaced with an equal number of zeros. Each time the RVP7 discards an output word, it also increments an internal 24-bit count. When FIFO space becomes available in the future, the processor replaces all of the missing data with zero-valued placeholders.

Writing when the FIFO is full can be particularly useful if the new command is a RESET which calls for clearing of the output FIFO. When the RESET is processed, all past and present output data are discarded, leaving the RVP7 output section completely empty. This is useful whenever the processor has pending output data which the user wants to truly throw away.

6.1 No-Operation (NOP)

This single-word instruction is simply ignored by the the Signal Processor. The NOP is useful when a number of words are to be flushed through the RVP7 with no side effects.



6.2 Load Range Mask (LRMSK)

This command informs the signal processor of the ranges at which data are to be collected. An arbitrary set of range bins are selected via an 8192-bit mask. The Nth bit in the mask determines whether data are acquired and processed at a range equal to $RES \times (N-1)$. The Range resolution is specified by a TTY setup question (see section 3.3.5), in the range 50 through 133 meters. Any collection of ranges may be chosen from integer multiples of that distance. The example below is given for the default resolution of 125 meters. The range mask is passed to the RVP7

packed into 512 16-bit words. The least significant bit of each packed word represents the nearest range, and the most significant bit represents the furthest range in each group of 16. Because of memory constraints, the RVP7 uses only the first 5600 bits in the mask.

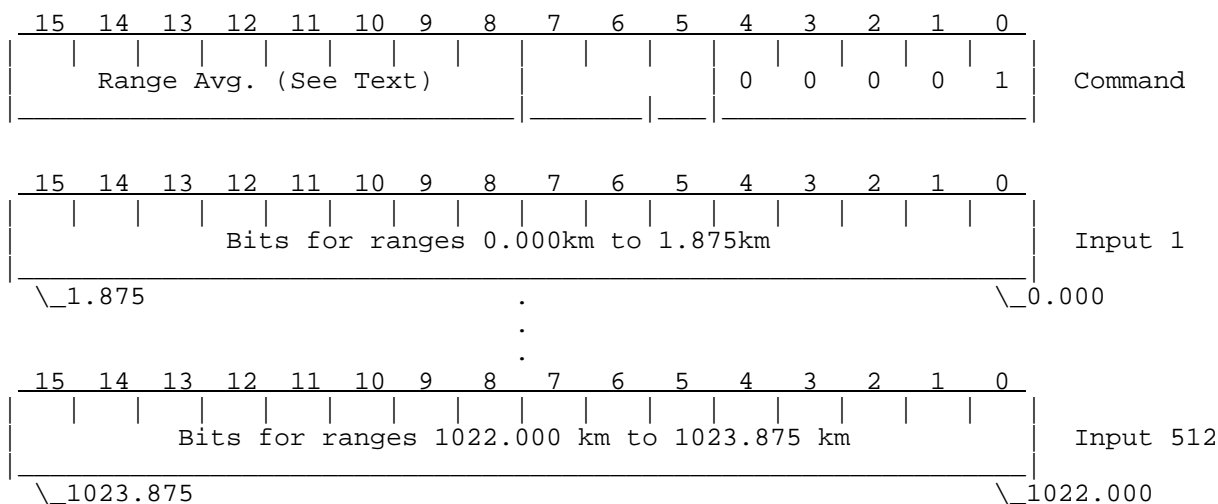
According to the range bins that are selected in the mask, the signal processor computes and stores internally a range normalization table which is later used to convert receiver intensity levels into reflectivity levels in dBZ. Note that the LRMSK command implicitly specifies the number of bins to be processed and output. The maximum bin count is 2048, though depending on the computational intensity of the configuration, the RVP7 may be able to compute fewer bins. If the number of bins selected in the bit mask exceeds this maximum, the trailing bins are truncated. If the new mask does not specify any active bins, then a single bin at range zero is forced on. The default power-up mask selects 256 bins equally spaced by 1.0km starting from zero range.

Range averaging is also determined by LRMSK. The upper byte of the command controls how many consecutive bins are grouped together. A value of zero means no averaging; one means that pairs of samples are averaged; 255 means that 256 terms are summed, etc. The individual samples that go into each average are still taken according to the bits that are set in the mask, except that they are now grouped together so that only one net bin results from the several data samples. Note that the limitation of 2048 sampled ranges applies to the bin count prior to averaging.

For example, suppose 100 bits are selected in the range mask and no averaging is elected. Then parameters are computed at those 100 ranges, and 100 bins of data are output. If the averaging were set to one, rather than zero, samples would still be taken at the same ranges, but pairs of bins would be averaged together and only 50 ranges would result. Note that the parameters are averaged by summing the autocorrelations for each bin. The range normalization value associated with the averaged bin is computed according to the midpoint of the first and last sample.

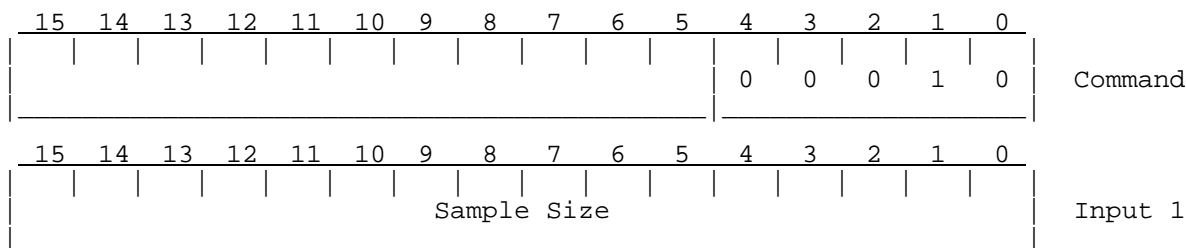
Incompletely averaged bins are discarded by the LRMSK command. In the above example, if the averaging were set to two so that triples of samples were summed, then only 33 bins would be output. This is because the 100-bit mask left a dangling 100th sample. In the extreme case where there are not enough mask bits to result in even one complete bin, the RVP7 forces the averaging to zero and turns on a single bin at zero range.

When the RVP7 is operating in fast-switching dual-polarization mode (See SOPPRM Command, word #2), the maximum number of bins that can be processed is half the usual maximum. This is because duplicate internal memory is needed to hold the states of the clutter filters separately for each polarization. If polarization switching is on and a range mask is loaded having more than 1024 bins, then an error bit is set (GPARM Command, word 9) and only the first 1024 bins are used. Conversely, if a range mask has already been loaded having more than 1024 bins and the user attempts to enter the switching polarization mode, then that request is denied and the RVP7 continues to operate in its prior fixed polarization manner. Whenever the number of range bins is less than 1024, then none of the above interactions ever arises.

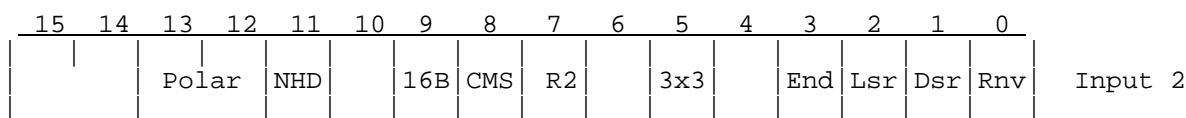


6.3 Setup Operating Parameters (SOPRM)

This command is used to configure the Signal Processor. The command should be issued whenever any of the parameters in the list change. The default parameter list consists of twenty 16-bit input words. These can be followed by optional XARG parameters as needed.



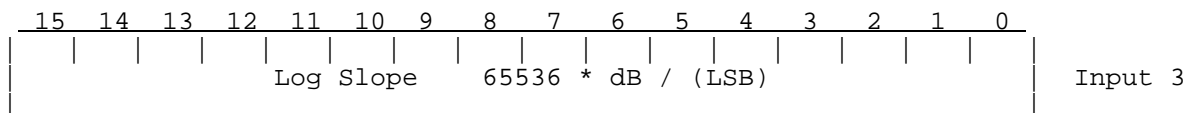
The sample size is continually adjustable from 1 to 256 pulses. However, during the alternating polarization mode, the sample size must be even. If an odd value is entered it is rounded up by one in that case.



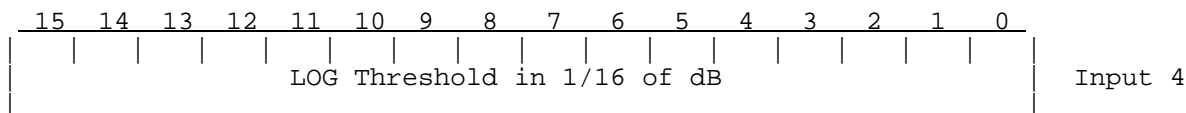
Each of the single-bit fields selects whether the given processing or threshold option is enabled (1) or disabled (0).

- Polar Configures transmit polarization and Zdr processing:
 - 00 – Fixed polarization, Horizontal
 - 01 – Fixed polarization, Vertical
 - 10 – Alternating polarization pulse-to-pulse
 - 11 – Dual simultaneous transmission
- NHD Disables inclusion of header words in the processed data that are output by the PROC command (See also, CFGHDR command).

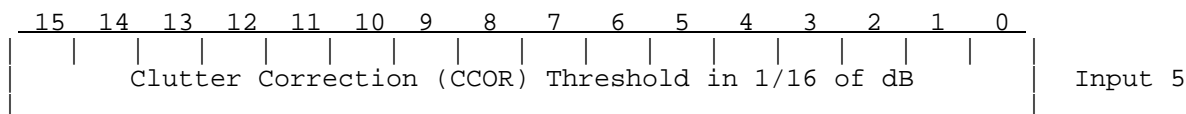
- 16B** Configures for 16-bit (rather than 8-bit) data output from the PROC command. This bit affects the single-parameter versions of Reflectivity, Velocity, Width, and Zdr data. However, the PROC command's archive format always holds 8-bit data, regardless of the setting of 16B. This gives the option of extracting both 8-bit and 16-bit data simultaneously from each ray.
- CMS** Enables Clutter Microsuppression, in which individual range bins are rejected (based on excessive clutter) prior to being averaged together in range.
- R2** Use three lag (R0/R1/R2) algorithms for width, signal power, and clutter correction.
- 3x3** Switches on the 3x3 output filter (See Section 5.3.3). The RVP7 automatically handles all of the pipelining overhead associated with running the 3x3 filter, i.e., valid output data are always obtained in response to every PROC command.
- End** Causes ENDRAY_ to pulse at the end of each ray.
- Lsr** Reflectivity speckle remover. When set, range speckles in the corrected and uncorrected reflectivity data are removed.
- Dsr** Doppler speckle remover. When set, range speckles in the velocity and width data are removed.
- Rnv** Range normalization of reflectivity data. This bit also enables intervening gas attenuation correction.



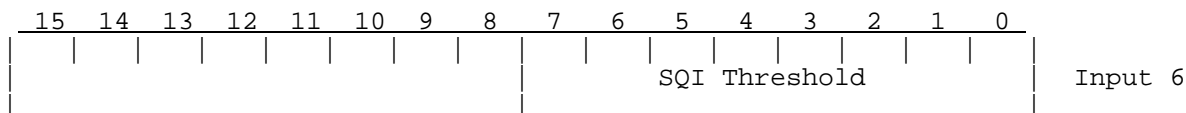
This number defines the multiplicative constant that converts the signal power in dB to the units of the 12-bit "Log of power in sample" time series outputs. One fourth of this slope is used to generate the "Log of Measured Noise Level" output from GPARM (word 6). The recommended value to use here is 0.03 (1966). This gives a dynamic range of 122 dB in 12 bits.



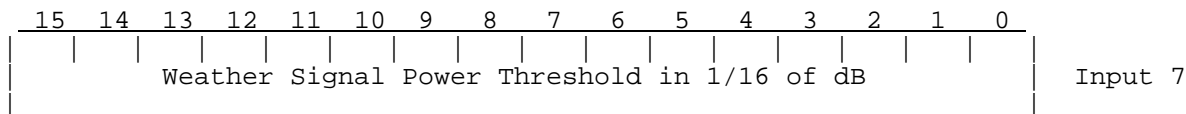
Reflectivity values below this level can result in thresholding of data, if the threshold control flags (see below) include LOG Noise bits. The threshold value is always non-negative, and the comparison test is described in Section 5.3.



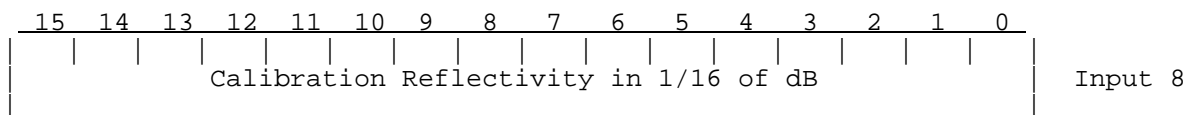
The clutter correction threshold is a bound on the computed log receiver adjustment for clutter. These corrections (in dB) are always negative. Any clutter correction which is more negative than the above value can result in thresholding of data.



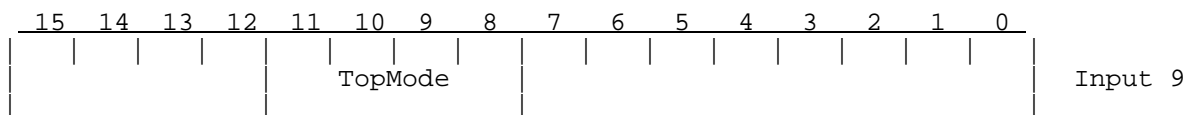
The Signal Quality Index (SQI) threshold is an unsigned binary fraction in the range 0 to 255/256. When the SQI for a range bin falls below the stated value it may result in thresholding of data.



Weather Signal Power (SIG) is an estimate of the SNR of the weather component of the received signal. When the SIG (see Section 5.2.10) falls below this comparison value it may result in thresholding of data.

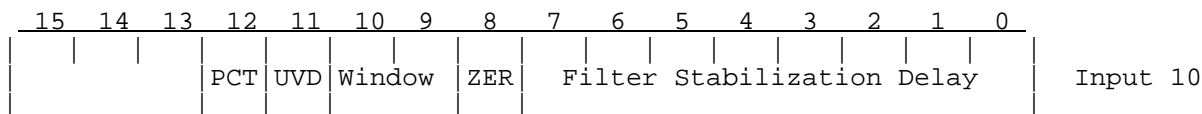


The calibration reflectivity is referenced to 1.0 kilometers.



The TopMode bits select the overall data acquisition and processing mode for the RVP7. Although the processing algorithms that are used in each top level mode are quite different, the RVP7 command set works in a uniform way in all modes.

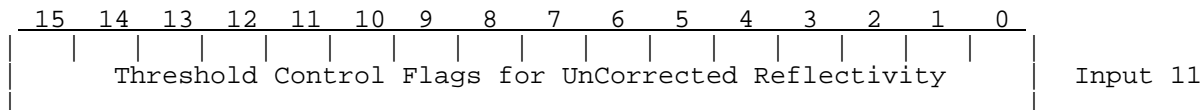
- 0000 Pulse Pair Processing Mode. Doppler clutter filters are 4th-order IIR high pass; data are processed one pulse at a time as each pulse arrives (see Section 5.2.3).
- 0001 FFT Processing Mode. Doppler clutter filters use nonlinear frequency-domain approach; data are processed in batches of pulses (see Section 5.8).
- 0010 Random Phase Processing Mode. Data from first and second trips are dealiased in range based on knowledge of the radar transmitter phase (see Section 5.9).
- 0100 DPRT-1 Processing Mode. The trigger generator produces alternate short and long pulses, and Doppler autocorrelations are computed using only the short pairs (see Section 5.5).
- 0101 DPRT-2 Processing Mode. The trigger generator produces alternate short and long pulses, and Doppler autocorrelations are computed using both pairs (see Section 5.5).



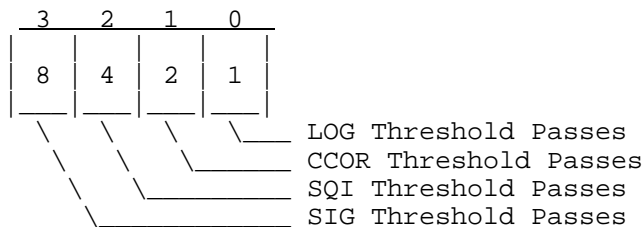
The RVP7 clutter filters are controlled by this word.

- Delay This delay is introduced prior to processing the next ray of data whenever Dual-PRF velocity unfolding is enabled or the RVP7 has been reconfigured by user commands. The delay permits the clutter filter transients to settle down following PRF and gain switches. The value is specified as the number of pulses, and hence, the number of filter iterations, to wait.

- ZER** If set, then the clutter filter's internal state variables are zeroed prior to waiting the delay time. For some signal conditions, this may give better results than allowing the filter to naturally flow into the new data.
- Window** Selects the type of window that is applied to time series data prior to computing power spectra via a DFT. Choices are: 0:Rectangular, 1:Hamming, 2:Blackman.
- UVD** Unfold velocities using a simple ($V_{high} - V_{low}$) algorithm, rather than the standard algorithm described in Section 5.6.
- PCT** If set, the RVP7 will attempt to run its standard processing algorithms even when a custom trigger pattern has been selected via the SETPWF command.



These flags select which threshold comparisons result in unCorrected reflectivity being accepted or rejected at each bin. There are four test comparisons that are made at each range, as described above for input words 4, 5, 6, and 7. Each test either passes and produces a code of 1, 2, 4, and 8 respectively, or fails and produces a code of zero. The sum of the codes for each of the four tests is a number between 0 and 15, which can also be interpreted as the following four-bit binary number:



The individual bits of the Threshold Control Flag word each specify whether data are to be accepted (1) or rejected (0) in each of the sixteen possible combinations of threshold outcomes. Thus, the pattern of bits in the flag word actually represents a truth table for a given logical function of the four threshold outcomes.

The following examples show actual values of the Flag word for the stated combinations of acceptance criteria:

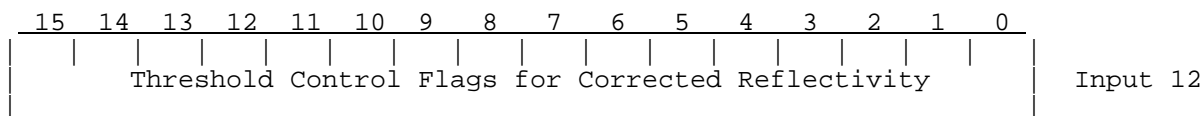
Value	Criteria
FFFF	All Pass (Thresholds disabled)
0000	All Fail (No data are passed)
AAAA	LOG
8888	LOG and CSR
A0A0	LOG and SQI
8080	LOG and CSR and SQI
F0F0	SQI
FAFA	SQI or LOG
C0C0	SQI and CSR
F000	SQI and SIG
C000	SQI and SIG and CSR
FFF0	SQI or SIG
CCC0	(SQI or SIG) and CSR

A simple way to generate these values is to imagine four 16-bit quantities having the following names and values: LOG=AAAA, CSR=CCCC, SQI=F0F0, SIG=FF00. The flag value needed to represent a given logical combination of threshold outcomes is obtained as the result when that same logical combination is applied to these special numbers.

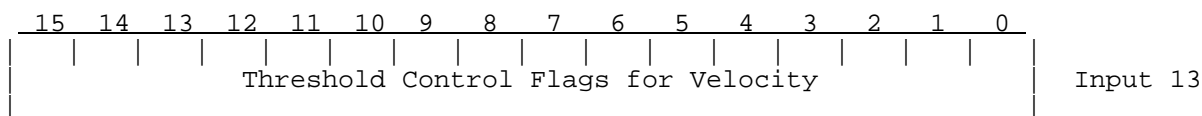
For example:

$$\begin{aligned} (\text{SQI or SIG}) \text{ and CSR} &= (\text{F0F0 or FF00}) \text{ and CCCC} \\ &= (\text{FFF0}) \text{ and CCCC} \\ &= \text{CCC0} \end{aligned}$$

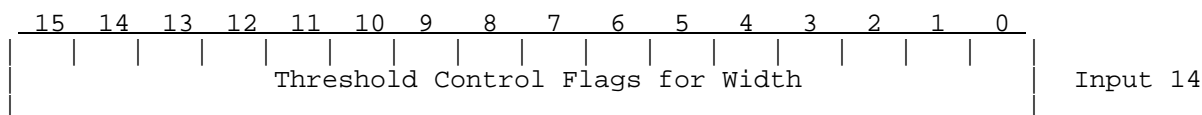
which corresponds with one of the examples given above.



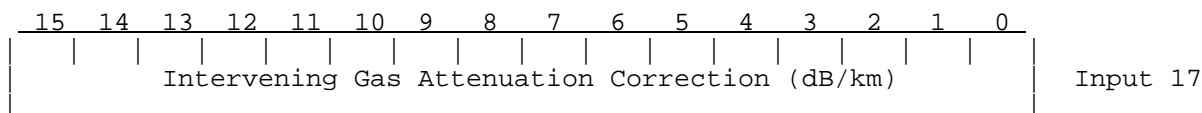
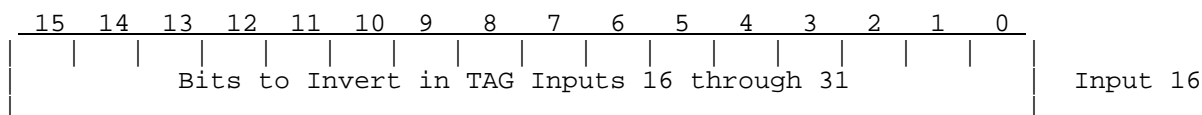
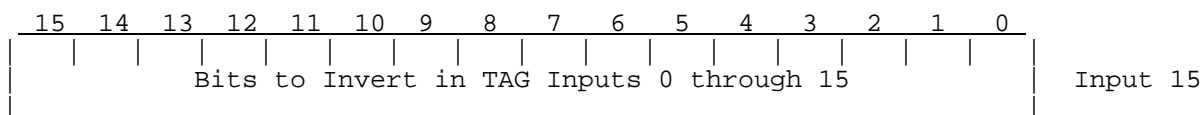
See Description for Input #11.



See Description for Input #11.



See Description for Input #11.

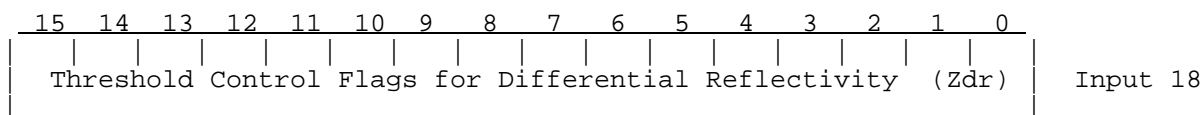


Gas attenuation correction attempts to compensate for overall (two-way) beam losses due to absorption by atmospheric gasses. The correction is linear with range, and is added to the data along with range normalization. Therefore, clearing the RNV bit in Word #2 above disables the correction. Of course, gas attenuation compensation can still be turned off even when RNV is on, simply by setting a slope of 0.0 dB/km.

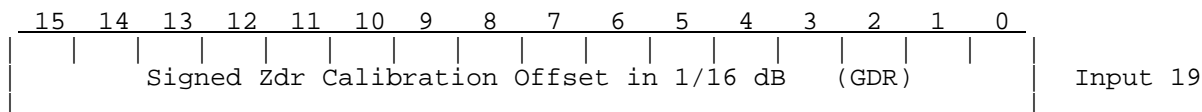
An attenuation of G db/km is encoded into the unsigned 16-bit word N as follows:

$$\begin{aligned} 0 \leq N \leq 10000 & \quad G = N / 100000 \\ \text{else} & \quad G = 0.1 + (N - 10000)/10000 \end{aligned}$$

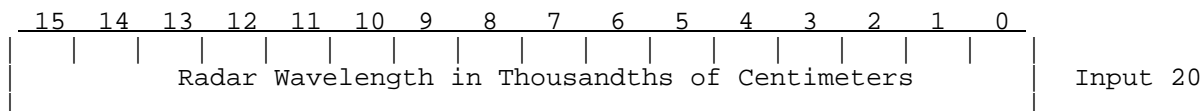
This format is backward compatible with the previous linear format for all values between 0.0 and 0.1dB/km; but it extends the upper range of values from 0.65535 up to 5.6535. These larger attenuation corrections are needed for very short wavelength radars.



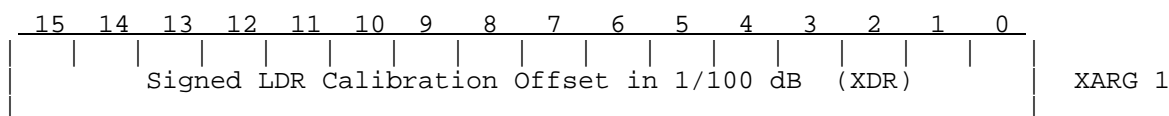
See Description for Input #11.



When differential reflectivity is computed there is a possibility that radar asymmetries will introduce a bias in the Zdr values, i.e., that Zdr will be non-zero even when observing purely spherical targets. This calibration offset permits nulling out this effect. The GDR offset accounts for the overall Tx/Rx gain imbalance between the two channels of the radar.



The radar wavelength is used in the calculation of 16-bit velocity and width data, to convert from Nyquist units to absolute physical units.



The XDR offset is used in the Linear Depolarization Ratio equations, and is the differential receiver gain between the two channels. Note that unlike the GDR offset (used for ZDR), the gain difference does not depend on differential transmit power.

The default (power-up) values for the above parameters are listed below. Both the scientific units and the integer-input required by the command to set up that value are given. Most of these defaults will likely be reasonable for a wide variety of radars.

Table 6–1: Default Values For Operating Parameters

Parameter	Scientific Units	Input
Sample Size	25 pulses	25
Flag Word		0017 Hex
Log Slope	0.03 dB/LSB	1966
LOG Threshold	0.5 dB	8
CCOR Threshold	–25.0 dB	–400
Signal Quality Index Threshold	0.5 (dimensionless)	128
SIG Threshold	10.0 dB	160

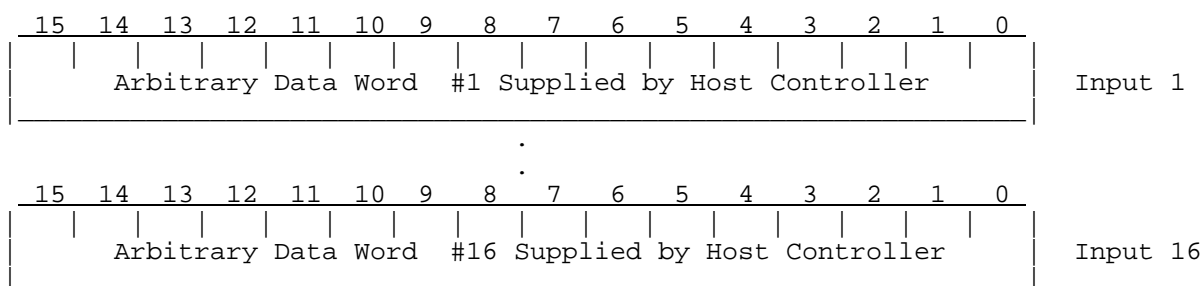
Table 6–1: Default Values For Operating Parameters (cont.)

Parameter	Scientific Units	Input
Calibration Reflectivity	–22.0 dBZ	–352
Gas Attenuation	0.016 dB/km	1600
Zdr Offset (GDR)	0.0 dB	0
LDR Offset (XDR)	0.0 dB	0
AGC Integration Period	8 pulses	8
Radar Wavelength	5.3 cm.	5300
Dual PRF Filter Stabilization	10 pulses	10
UnCor Refl. Thresh. Control Flag	LOG	AAAA Hex
Cor Refl. Thresh. Control Flag	LOG & CSR	8888 Hex
Velocity Thresh. Control Flag	SQI & CSR	C0C0 Hex
Width Thresh. Control Flag	SQI & CSR & SIG	C000 Hex
Zdr Refl. Thresh. Control Flag	LOG	AAAA Hex
TAG Bits to Invert	No Inversions	0000 Hex

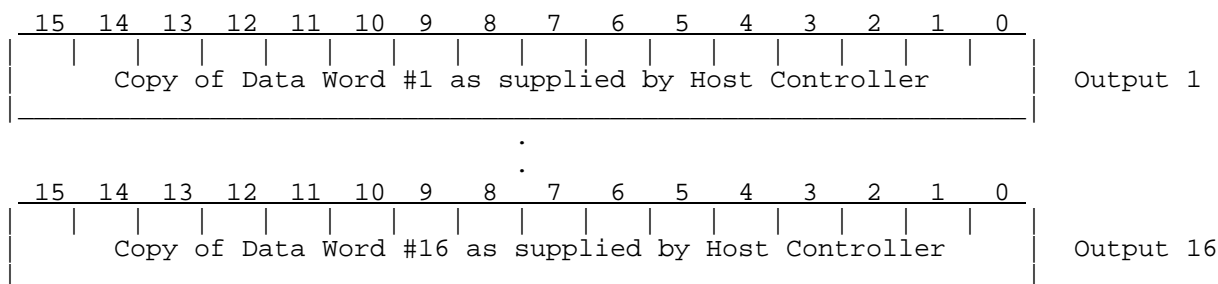
6.4 Interface Input/Output Test (IOTEST)

This command is used to test both the input and output data busses of the signal processor interface. When issued, the command causes sixteen words to be read from the host controller, after which those same sixteen words are written back out. Typically, the controller supplies a “barber pole” input sequence consisting, for example, of successive powers of two. If all of the output words are correct, one may conclude that there are no malfunctioning bits in the interface hardware.

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	
											0	0	0	1	1	Command

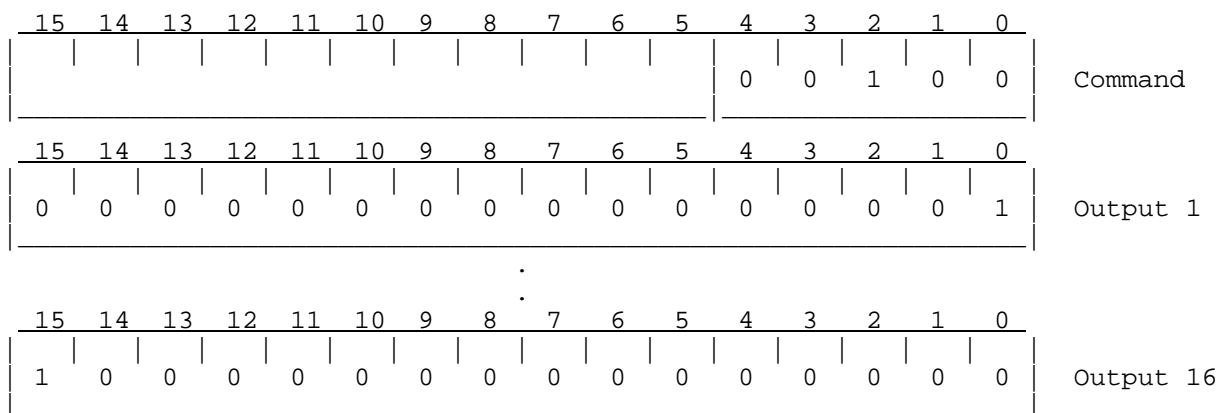


i **Note: The IOTEST command can also process and echo up to 128 additional XARGS data words (See Section 6.20).**



6.5 Interface Output Test (OTEST)

This command is used to test the integrity of the data being output by the signal processor. The command causes sixteen words to be output consisting of successive powers of two starting from one. By verifying whether each output word is correct, malfunctioning bits in the interface data bus can easily be isolated. This test is less stringent than the input/output test IOTEST, since the input data paths to the processor are not being checked. Typically, the OTEST is performed only when the IOTEST fails, and then to determine whether the fault was on input or output.



6.6 Sample Noise Level (SNOISE)

This command is used to estimate the current noise level from the receiver, so that the noise can be subtracted from subsequent measurements. Data are sampled for 256 pulses at 256 bins, beginning at a selectable range and spaced by 0.125 meters. The internal trigger generator is

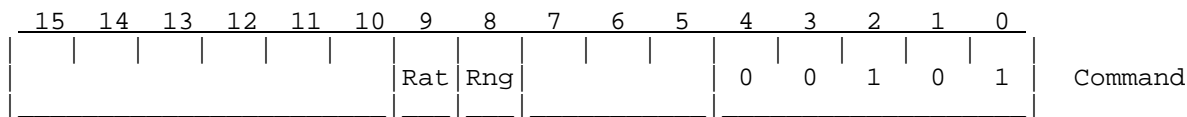
temporarily set to a special noise rate (usually much lower than the operating rate) during the process. It is ultimately the user's responsibility to insure that no returned power is present within the 32km sampling interval. In some cases it may be necessary to raise the antenna during the noise measurement to avoid thermal noise pickup from the ground, or from weather targets.

SNOISE has the option of setting up a new sampling range and trigger generator rate each time it is called. Two bits in the command word determine which (if any) of the new values overrides the current values stored in the RVP7. The power-up sampling range is 250km (input value of 250), and the power-up trigger rate is 200Hz (input value of 30000). These initial values persist until such time as they are altered here. Note that both input words must always be supplied after the command, even if the command calls for ignoring one or both of them. The range is supplied directly in kilometers up to a maximum of 992km. The trigger rate resulting from a given input is 6MHz divided by the input value, i.e. the input value is the trigger period in 0.1667 microsecond increments. Keep in mind that the given rate is bounded against the minimum PRT allowed for the current radar pulse width.

The SNOISE command bounds the requested starting range of the noise sampling interval. This is to insure that the noise samples will fit within the specified PRT, and within the range mask hardware RAM. The RVP7 sets an error bit when an improper range is requested. The noise sampling procedure also bounds the PRF to 1250Hz before making its measurements. This allows sufficient time for the algorithm to run properly on the 256 bins taken from 256 pulses. For a dual-receiver system the PRF bound is reduced to 625Hz (half) because there are twice as many samples to process. Note that the PRF bound is equally imposed for external triggers too, i.e., external triggers will be ignored for 800/1600µsec following each one that is actually used.

The SNOISE command should be re-issued now and then to compensate for drift in the RF and A/D systems. However, because DC offsets do not propagate into the "I" and "Q" values, reissuing the command is much less critical than with the RVP6. SNOISE must be executed at least once after power-up, before beginning to acquire and process data. The RVP7 does not automatically take a noise sample as part of its initialization procedure.

The measured offsets are stored internally for all subsequent uses inside the RVP7. The offset values may be inspected via the GPARM command, as may the current range and rate values themselves. Of course, whenever the range or rate are changed the user must ensure that the new trigger rate allows at least 32km following the new noise range. If this requirement is not met, or if other failures are detected during the noise measurement, appropriate bits are set in the GPARM latched status word. This word should generally be checked after SNOISE to make sure that everything worked properly.



Rng If 1, then the range in input word 1 is taken as the starting noise range for this and all subsequent SNOISE calls.

Rat If 1, then the trigger rate in input word 2 is taken as the noise rate for this and all subsequent SNOISE calls.

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	
Starting Range in km (Max 992km) of 32km Sampling Interval																Input 1
15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	
Internal Trigger Rate (6Mhz/N) to use During Noise Sampling																Input 2

6.7 Initiate Processing (PROC)

The PROC command controls the actual processing and output of radar data. The operating modes and types of data available from the RVP7 are described in detail in Chapter 1. That section also describes the proper use and application of the RVP7 to different radar environments.

PROC is a single-word command that specifies the type of processing to be performed, and the type of output to be generated. The two mode bits in the command word select either

- Synchronous mode — The processor acquires, processes, and outputs one ray in response to each PROC command. Processing is begun only after each command is actually received.
- Free running mode — A single PROC command is issued and rays are continually output as fast as they can be produced and consumed. This continues until any other command is written, e.g., a NOP could be used to terminate the free running mode with no other consequences.
- Time Series mode — Always produced in a synchronous manner, this mode require a new PROC command to initiate each new set of samples. Data are output as 8-bit time series, 16-bit time series, or 16-bit power spectra.

Optional Dual-PRF velocity unfolding is chosen by command bits eight and nine. For Doppler data either a 2:3, 3:4, or 4:5 PRF unfolding ratio may be selected. The RVP7 carries out all of the unfolding steps internally, so that mean velocity is now output with respect to the larger unambiguous interval. There is no additional velocity processing needed by the user, except of course, to change the velocity scale on any displays being generated. Furthermore, spectral widths are scaled consistently with respect to the higher PRF, and require no user modification before being plotted.

When unfolding is selected, the internal trigger generator automatically switches rates on alternate rays. The switch over occurs immediately after the last pulse of the current ray has been acquired; thus overlapping the internal post-processing and output time, with transmitter stabilization and data acquisition at the new rate.

Output data are selected by the upper six bits of the PROC command. Packed archive output is selected by setting the ARC bit. Individual byte or word display output is selected by setting any or all of the Z, T, V, W, Zdr, and KDP command word bits. When more than one of these bits is set, the output array consists of all of the bins for the leftmost selected parameter, followed by all of the bins for the next selected parameter, etc. Bits selected in XARG #1 behave the same way, except that the output order is right-to-left. Both archive and display formats can be selected

simultaneously, in which case the archive format is output first, followed by whichever individual display format values were also selected. The archive format is not recommended for use with new drivers because it can only handle four of the many possible output parameter types.

When time series mode is selected there are three output data formats available. For backwards compatibility, there is an 8-bit integer format in which the eight most significant bits from the I, Q, and LOG signals are represented in a byte. This format is not recommended because it will generally miss weak signals. We recommend the floating-point format that uses 16-bits per A/D sample. There is also a 16-bit power spectrum output that is accurate to 0.01dB. (See also GPARM output word #10).

In addition to the above output data, the first words of each ray optionally contain additional information about the ray itself. These header words are configured by the CFGHDR opcode, and are included only if the NHD (No-Headers) bit in SOPRM Input #2 is clear. For example, if TAG angle headers are requested, if the ARC, Z and V bits are all set, and if there are 100 bins selected in the current range mask, then each RVP7 output ray consists of the following:

```

1] TAG15 - TAG0      \ From Start of Acquisition
2] TAG31 - TAG16     /      Interval
3] TAG15 - TAG0      \ From End of Acquisition
4] TAG31 - TAG16     /      Interval
* 200 words of packed archive data,
* 100 words of Corrected Reflectivity data in low byte only.
* 100 words of Velocity data in low byte only,
```

The Command word format for Synchronous Doppler Mode is:

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	
ARC	Z	T	V	W	ZDR	Unfold		KDP	0	1	0	0	1	1	0	Command
_____	_____	_____	_____	_____	_____	_____	_____	_____	_____	_____	_____	_____	_____	_____	_____	

The Command word format for Free Running Doppler Mode is:

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	
ARC	Z	T	V	W	ZDR	Unfold		KDP	1	0	0	0	1	1	0	Command
_____	_____	_____	_____	_____	_____	_____	_____	_____	_____	_____	_____	_____	_____	_____	_____	

Either of these may be augmented by an optional XARG word (See Section 6.20)

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	
							(Tx Vert)			(Tx Horz)						
							Phi	Rho	Ldr	Phi	Rho	Ldr	SQI	RHV	PDP	XARG 1
_____	_____	_____	_____	_____	_____	_____	_____	_____	_____	_____	_____	_____	_____	_____	_____	

Unfold Selects Dual-PRF unfolding scheme:

00 : No Unfolding 01 : Ratio of 2:3
10 : Ratio of 3:4 11 : Ratio of 4:5

ARC Selects archive output format in which four data bytes (see 8-Bit descriptions below) are packed into two output words per bin as follows:

High Byte	Low Byte	
V	Z	First Word
W	T	Second Word

The remaining data parameters are available in both 8-Bit and 16-bit formats, according to SOPRM Command input word #2 (See Section 6.3). The same SOPRM word configures the RVP7 for Single or Dual polarization. The later is required for KDP, PDP, and RHV to be computed properly.

V Selects radial velocity data.

8-Bit Velocity Format — Mean velocity, expressed as a fraction of the unambiguous velocity interval, is computed from the unsigned byte N as:

$$V_{\text{m/sec}} = V_{\text{Nyquist}} \times (N-128) / 127.5$$

0 : Indicates velocity data is not available at this range

1 : Maximum velocity towards the radar

128 : Zero velocity

255 : Maximum velocity away from the radar

When velocity unfolding is selected, the output is still interpreted as above, except that the unambiguous interval is increased by factors of 2, 3, and 4 for 2:3, 3:4, and 4:5 unfolding.

16-Bit Velocity Format — Mean velocity in meters/second is computed from the unsigned word N as:

$$V_{\text{m/sec}} = (N-32768) / 100$$

The overall range is from -327.67m/sec to +327.66m/sec in one centimeter/second steps as follows:

0 : Indicates velocity data is not available at this range

1 : -327.67 m/sec (towards the radar)

32768 : 0.00 m/sec

65534 : +327.66 m/sec (away from the radar)

65535 : Reserved Code

W Selects spectral width data.

8-Bit Width Format — Spectral width is computed from the unsigned byte N as:

$$W_{\text{Nyquist}} = N / 256$$

The overall range is a fraction between 1/256 to 255/256 of the unambiguous interval. The code of zero indicates that width data was not available at this range.

16-Bit Width Format — Spectral width in meters/second is computed from the unsigned word N as:

$$W_{\text{m/sec}} = N / 100$$

The overall range is from 0.01m/sec to 655.34m/sec in one centimeter/second steps as follows:

0 : Indicates width data is not available at this range
1 : 0.01 m/sec
65534 : 655.34 m/sec
65535 : Reserved Code

Z Selects clutter corrected reflectivity data.

8-Bit deciBel Format — The level in decibels is computed from the unsigned byte N as:

$$\text{dBZ} = (N-64)/2.$$

The overall range is therefore from -31.5 dBZ to +95.5 dBZ in half-dB steps as follows:

0 : Indicates no reflectivity data available at this range
1 : -31.5 dBZ
64 : 0.0 dBZ
128 : 32.0 dBZ
255 : +95.5 dBZ

16-Bit deciBel Format — The level in decibels is computed from the unsigned word N as:

$$\text{dBZ} = (N-32768) / 100$$

The overall range is from -327.67dB to +327.66dB in 1/100dB steps as follows:

0 : Indicates no reflectivity data available at this range
1 : -327.67 dBZ
32768 : 0.00 dBZ
65534 : +327.66 dBZ
65535 : Reserved Code

T Selects total reflectivity. Same 8-bit and 16-bit coding formats as for clutter corrected reflectivity above.

ZDR Selects differential reflectivity data.

8-Bit ZDR Format — The level in decibels is computed from the unsigned byte N as:

$$\text{dB} = (N-128) / 16$$

The overall range is from -7.935dB to +7.935dB in one-sixteenth dB steps as follows:

0 : Indicates no reflectivity data available at this range
1 : -7.9375 dB
128 : 0.0000 dB
255 : +7.9375 dB

16-Bit ZDR Format — Same as 16-bit deciBel format.

KDP Selects dual polarization specific differential phase data.

8-Bit KDP Format — Values are coded into an unsigned byte using a logarithmic scale. The KDP angles are multiplied by the wavelength in cm. (to reduce dynamic range) and then converted to a log scale separately for both signs. The minimum value is 0.25 deg*cm/km, and the maximum value is 150.0 deg*cm/km. A code of zero represents no data, and a code of 128 represents 0 deg*cm/km. The conversion equation for positive values (codes from 129 to 255) is:

$$KDP \times \lambda = 0.25 \times 600^{\left[\frac{N-129}{126}\right]}$$

The conversion equation for negative values (codes from 1 to 127) is:

$$KDP \times \lambda = -0.25 \times 600^{\left[\frac{127-N}{126}\right]}$$

16-Bit KDP Format — Same as 16-bit deciBel format, except that the units are hundredths of degrees per kilometer. No weighting by wavelength is introduced.

PDP Selects dual polarization differential phase Φ_{DP} data.

8-Bit Φ_{DP} Format — The phase angle in degrees is computed on a 180-degree interval from the unsigned byte N as:

$$\Phi_{DP} (mod\ 180) = 180 (N - 1) / 254$$

- 0 : Indicates no Φ_{DP} data available at this range
- 1 : 0.00 deg
- 254 : 179.29 deg
- 255 : Reserved Code

16-Bit Φ_{DP} Format — The phase angle in degrees is computed on a 360-degree interval from the unsigned word N as:

$$\Phi_{DP} (mod\ 360) = 360 (N - 1) / 65534$$

- 0 : Indicates no Φ_{DP} data available at this range
- 1 : 0.000 deg
- 65534 : 359.995 deg
- 65535 : Reserved Code

RHV Selects dual polarization correlation coefficient ρ_{HV} data.

8-Bit ρ_{HV} Format — The correlation coefficient is computed on the interval 0.0 to 1.0 using a square root weighting of the unsigned byte N as:

$$\rho_{HV} = \sqrt{\frac{(N - 1)}{253}}$$

- 0 : Indicates no ρ_{HV} data available at this range
- 1 : 0.0000 (dimensionless)
- 2 : 0.0629
- 253 : 0.9980

254 : 1.0000
255 : Reserved Code

16-Bit ρ_{HV} Format — The correlation coefficient is computed on the interval 0.0 to 1.0 linearly from the unsigned word N as:

$$\rho_{HV} = (N - 1) / 65533$$

0 : Indicates no ρ_{HV} data available at this range
1 : 0.0 (dimensionless)
65534 : 1.0
65535 : Reserved Code

SQI Selects Signal Quality Index data. This dimensionless parameter uses the same 8-bit and 16-bit data formats as RHV (ρ_{HV}).

LDR Selects Linear Depolarization Ratio, measured either on the horizontal receive channel while transmitting vertically, or on the vertical receive channel while transmitting horizontally.

8-Bit LDR Format — The level in decibels is computed from the unsigned byte N as:

$$\text{dB} = -45.0 + (N-1) / 5$$

This spans an asymmetric interval around zero decibels, and allows for cross channel isolation as large as 45dB. The overall range is from -45.0dB to +5.6dB in 0.2dB steps as follows:

0 : Indicates no LDR data available at this range
1 : -45.0 dB
226 : 0.0 dB
254 : +5.6 dB
255 : Reserved Code

16-Bit LDR Format — Same as 16-bit deciBel format.

RHO Selects the cross channel correlation coefficient. This dimensionless parameter uses the same 8-bit and 16-bit data formats as RHV (ρ_{HV}).

PHI Selects the cross channel differential phase. This parameter uses the same 8-bit and 16-bit angular data formats as PDP (ϕ_{DP}).

The Command word format for Time Series Mode is:

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	
TSOUT			Spec	Type		Unfold			1	1	0	0	1	1	0	Command

TSOUT Selects type of data to be output.

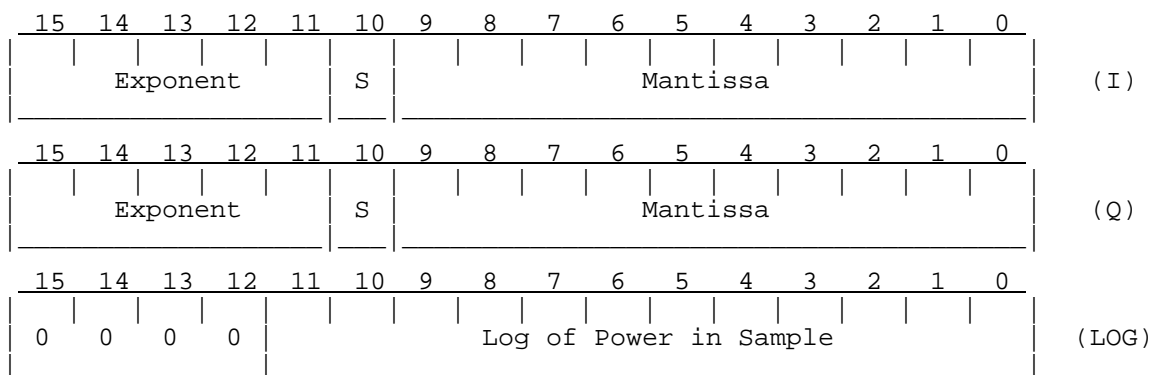
00 : 8-bit Time Series 01 : Power Spectrum
10 : 16-bit Time Series 11 : Unused

When the TSOUT bits select "Power Spectrum" then, depending on the current major mode, a further choice may be needed to select one of several spectral view points. For the Random Phase major mode the possible values of "Spec Type" are:

- | | |
|------------------------|-------------------------|
| 0: Raw First Trip | 4: Raw Second Trip |
| 1: Whitened First Trip | 5: Whitened Second Trip |
| 2: Cleaned First Trip | 6: Cleaned Second Trip |
| 3: Final First Trip | 7: Final Second Trip |

When time series output is selected the output data consist either of (3xBxN) or (2xBxN) words, depending on the output format, where B is the number of bins in the current range mask, and N is the number of pulses per ray. Data samples for each bin of pulse #1 are output first, followed by those for each bin of pulse #2, etc. up to pulse #N. In other words, the data are output in the same time-order that they were acquired.

In the floating point format, three words are used for each bin:



To convert the floating I and Q samples to voltages: First create a 12-bit signed integer in which bits zero through 9 are copied from the Mantissa field, and bits ten and eleven are either 01 or 10 depending on whether S is 0 or 1. Then, multiply this number by $2^{(exponent-40)}$, where the exponent field is interpreted as an unsigned 5-bit integer. Finally multiply by the maximum voltage. The resulting value has 12-bits of precision and a dynamic range of approximately 190dB. The large dynamic range is necessary to cover the full range of data. In summary:

$$Voltage = V_{MAX} \times (Sign, Mantissa) \times 2^{[Exponent - 40]}$$

Note that the resulting voltage span is actually $\pm 4 \times V_{MAX}$. The extra factor of four is built into the format so that transient excursions above the full scale input voltage can still be encoded properly. These may arise for time series data that have been processed by an IIR clutter filter.

The "Log of Power in Sample" is provided mainly for backwards compatibility. It can be calculated from the I and Q numbers. To convert to dBm it requires a slope and offset as follows:

$$dBm = P_{MAX} + Slope \times [Value - 3584]$$

Where:

$$P_{MAX} = +4.5dBm \text{ for 12-bit IFD, } +6.0dBm \text{ for 14-bit IFD}$$

$$V_{MAX} = 0.5309 \text{ Volts for 12-bit IFD, } 0.6310 \text{ Volts for 14-bit IFD}$$

Slope = “Log Power Slope” word 3 of SOPRM command. 0.03 recommended.

For backwards compatibility the RVP7 produces a 8-bit fixed point time series format. Because of the limited dynamic range available, this will only show strong signals, and is not recommended for use. The I, Q, and Log power triplets are packed into two 16-bit output words as follows:

High Byte	Low Byte	
Q Sample	I Sample	First Word
Zero	Log Power	Second Word

The “Log Power” value is the upper 8 bits of the long format. The other numbers are produced by the equation:

$$Voltage = V_{MAX} \times \left[\frac{Sample}{128} \right]$$

When Power Spectrum output is selected, the spectrum size is chosen as the largest power of two (N2) that is less than or equal to the current sample size (N). When the sample size is not a power of two, a smaller spectrum is computed that by averaging the spectra from the first N2 and the last N2 points. The data format is one word/bin/pulse, in the same order as for time series output. Each word gives the spectral power in hundredths of dB, with zero representing the level that would result from the strongest possible input signal. Thus, the spectral output terms are almost always negative.

The time series that are output by the RVP7 are the filtered versions of the raw data, when available. If a non-zero time-domain clutter filter is selected at a bin, then the I and Q data for that bin show the effects of the filter. Whenever you need to observe the raw samples, make sure that no clutter filters are being applied.

In pulse pair time series mode with dual receivers, selecting (H+V) will produce data in one of two formats according to the “Sum H+V Time Series” question in the **Mp** setup section:

- Answering “Yes” will result in summed time series from both channels, but spectra from the DSP will be the averaged spectra from each channel individually. This allows the **IRIS ascope** utility to display either the spectrum-of-sum or sum-of-spectra according to whether the “Spectra from DSP” button is pressed in the *Processing/Gen-Setup* window.
- Answering “No” will still produce the usual (BxN) time series output samples, except that the first half of these samples will be the first half of the “H” data in their normal order. This will be followed by a zero sample if (BxN) is odd; followed by the first half of the “V” data, also in their normal order.

In other words, only the first halves of the individual “H” and “V” sample arrays are output by the RVP7. As an example, if you select 25 bins and 100 pulses, then the output data will consist of 1250 “H” samples (from all bins in the first 50

pulses), followed by 1250 “V” samples from the exact same set of bins and pulses. This is the more useful option when custom algorithms are being run on the data from the two separate receivers.

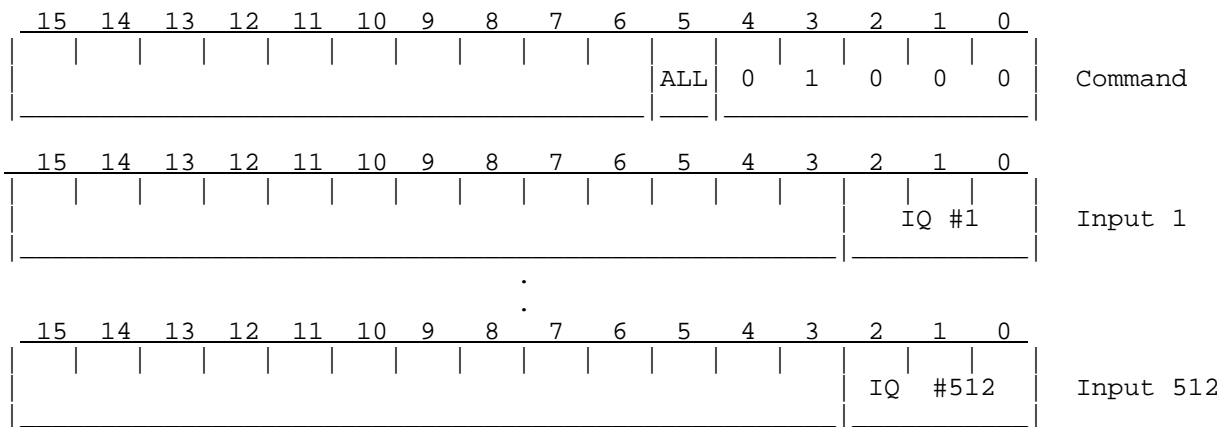
When the number of output words is large there is a possibility that the internal buffering within the RVP7 may overflow and data may be lost. Due to internal memory limitations, the product (BxN) must be less than 12000. A bit in the latched status word (See GPARM) indicates when time series overflows occur. In such cases, the correct number of words are still output, but they are all zero after the point at which overflow was detected.

6.8 Load Clutter Filter Flags (LFILT)

A special feature of the RVP7 processor is that any of the eight available clutter filters may be chosen independently at each selected range. This range-dependent clutter removal is useful when the clutter characteristics vary with increasing range. Typically, clutter interference is most severe in the immediate vicinity of the radar. Thus, a highly rejective filter might be chosen for near ranges, and a less rejective or perhaps no filter could be used at far ranges.

The input words following the LFILT command specify the choice of filter to be applied at each of the (up to 2048) selected range bins. A fixed size filter table is always loaded, regardless of whether the range mask (See LRMSK) is using the full number of bins. In such cases, the later filter codes are simply be ignored for the current range mask. However, if a longer range mask is loaded in the future, then those later codes would apply to the appropriately numbered bins. Put another way, each filter code is associated with a particular bin number, not with a particular range. The correspondence between bin numbers and actual ranges is made only through the range mask.

Only the low three bits are used in each word to specify the filter number. The correspondence between filter codes and filter characteristics is given in Appendix A. If the ALL bit is set in the Command, then 2048 words are loaded, corresponding to the maximum number of range bins that are allowed. Otherwise only 512 words are loaded, and the 512th filter choice is replicated for all bins further in range.



6.9 Get Processor Parameters (GPARM)

This command is used to access status information from the RVP7 processor. Sixty-four words are always transferred, some later words are reserved for future compatibility and are read as zeros. For convenience, a shorthand table of the output words is given in Table 6–2.

Table 6–2: RVP7 Status Output Words

Word	Description	Word	Description
1	Revision / Serial number	33	LOG Threshold
2	Number of Range Bins	34	CCOR Threshold
3	Current trigger period	35	SQI threshold
4	Current TAG00 – TAG15	36	SIG Threshold for Width
5	Current TAG16 – TAG31	37	Calibration Reflectivity
6	Log of Measured Noise Level	38	— Reserved —
7	“I” Channel DC Offset	39	— Reserved —
8	“Q” Channel DC Offset	40	Range Averaging Choice
9	Latched Processor Status	41	— Reserved —
10	Immediate Status Word #1	42	— Reserved —
11	Diagnostic Register A	43	Header configuration of PROC data
12	Diagnostic Register B	44	I-Squared Noise (Low 16-bits)
13	Number of Pulses / Ray	45	I-Squared Noise (High 16-bits)
14	Trigger count (Low 16-bits)	46	Q-Squared Noise (Low 16-bits)
15	Trigger Count (High 8-bits)	47	Q-Squared Noise (High 16-bits)
16	No. of Properly Acquired Bins	48	Log of Measured Noise Level
17	No. of Properly Processed Bins	49	LOG-Exponential Noise Std. Dev.
18	Immediate Status Word #2	50	Horizontal/Vertical Noise Ratio
19	Noise Range in Km	51	AFC/MFC Control Value
20	Noise Trigger Period	52	Interference Filter Select
21	Pulse Width 0 min. Trig. Period	53	Interference Filter C1 Constant
22	Pulse Width 1 min. Trig. Period	54	Interference Filter C2 Constant
23	Pulse Width 2 min. Trig. Period	55	Immediate Status Word #3
24	Pulse Width 3 min. Trig. Period	56	Burst Tracking Slew
25	Pulse Width Bit Patterns	57	Polarization Algorithm Choices
26	Current /Pulse Width	58	— Reserved —
27	Current Trigger Gen. Period	59	— Reserved —
28	Desired Trigger Gen. Period	60	— Reserved —
29	PRT at Start of Last Ray	61	— Reserved —

Word	Description	Word	Description
30	PRT at End of Last Ray	62	— Reserved —
31	Processing/Threshold Flags	63	— Reserved —
32	Log Slope	64	— Reserved —

The revision and serial numbers of the particular RVP7 board are accessible here. This information is useful when computer software is being designed to handle a variety of signal processor revisions. The revision number is seven bits total; four of which are still in the high four bits of the word for compatibility with an older format.

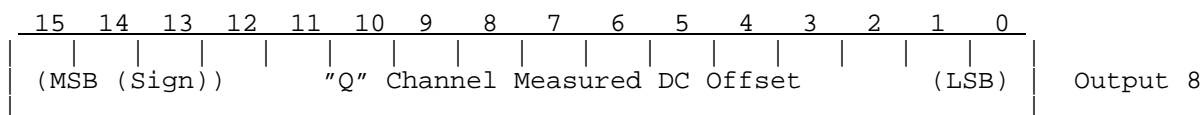
15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0		0		(MSB)		Log of Measured Noise Level								(LSB)	

Output 6

$$dBm = P_{MAX} + Slope \times [(Value/4) - 3584]$$

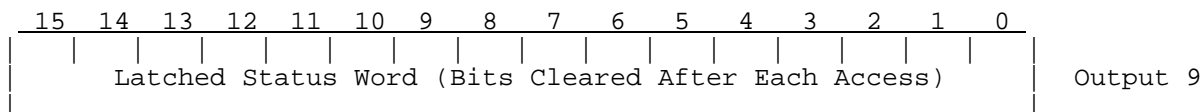
15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
(MSB (Sign))				"I" Channel Measured				DC Offset				(LSB)			

Output 7

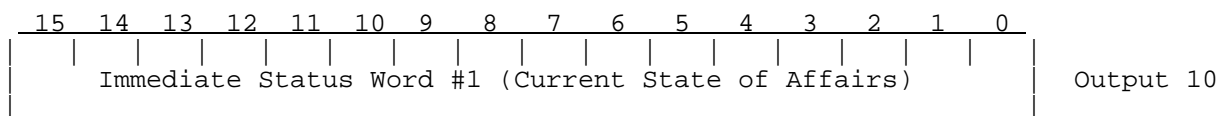


The "I" and "Q" values are stored in a linear format, similar to the short form time series. See the discussion in Section 6.7. These numbers should always be very close to zero, because the FIR filter that creates them is designed to reject DC. To convert to voltage, use the equation:

$$\text{Voltage} = V_{MAX} \times \left[\frac{\text{Value}}{32767} \right]$$

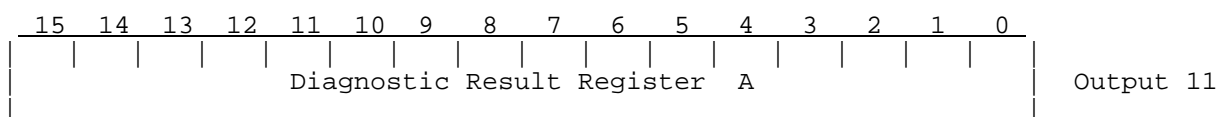


- Bit 0 No Trigger during noise measurement.
- Bit 1 Trigger too fast during noise measurement, i.e., some of the noise sample bins were positioned past the trigger range.
- Bit 2 No trigger during PROC command.
- Bit 3 PRF varied by more than 10 microseconds from the beginning to the end of a processing interval.
- Bit 5 FIFO overflow during last PROC command.
- Bit 6 Command received while waiting for output FIFO space. The command was processed but some output data has been lost (zeroed).
- Bit 7 Error detected during last SNOISE command.
- Bit 9 Error in last Load Range Mask (LRMSK) Command. This generally means that too many range bins were selected.
- Bit 10 Error in LSIMUL command protocol.
- Bit 11 Measured phase sequence is incorrect.
- Bit 15 Invalid processor configuration. This bit is set if the last PROC command called for an illegal combination of parameters. The possible causes are:
 - Spectrum size greater than 128 or less than 4
 - More than 342 bins/slave in FFT modes
 - (bins/slave) x (4 + sample size) exceeds 26200 in FFT modes
 - (bins/slave) x (sample size) exceeds 3000 for Time Series or Spectra output
 - Odd number of bins selected during fast polarization switching
 - Bad combination of polarization parameters

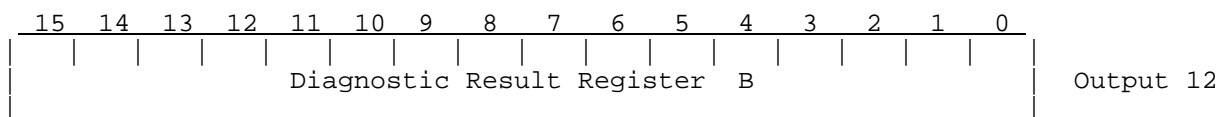


- Bit 0 No trigger, or, more than 50ms. since last trigger.
- Bit 1 Error in loading trigger angle table (See LSYNC Command).
- Bit 2 PWINFO command is disabled.
- Bit 3 Angle sync input is BCD (Else binary angle).
- Bit 4 Angle sync is on elevation axis (Else azimuth axis).

- Bit 5 Angle sync is enabled.
- Bit 6 Angle sync is not interruptible.
- Bit 7 Angle sync is dynamic (else rays begin on sync angles).
- Bit 8 DSP has full IAGC hardware and firmware configuration.
- Bit 9 DSP supports 16-bit floating time series.
- Bits 11,10 Current unfolding mode.
- Bits 13,12 Number of AUX boards attached.
- Bit 14 DSP supports Power Spectrum output



- Bit 0 No fiber downlink signal detected
- Bit 1 16-Bit AFC level read/write
- Bit 2 IF Receiver reset request not sent
- Bit 3 I/O FIFO full before 4096 writes
- Bit 4 I/O FIFO not full after 4096 writes
- Bit 5 Transmit phase latch bits
- Bit 6 Downlink local counter test
- Bit 7 Receiver status bits & switches
- Bit 8 Test byte pattern from receiver
- Bit 9 Test word pattern from receiver
- Bit 10 Non-Volatile RAM 0x00 and 0xFF flags
- Bit 11 UART read/write check
- Bit 12 External RAM check
- Bit 13 SCSI controller chip error
- Bit 14 Range mask RAM and addressing
- Bit 15 I&Q FIFO interrupt & trigger flags



- Bit 0 I&Q FIFO data bits
- Bit 1 FIR processing of ramp pattern
- Bit 2 Boot words not accepted by first slave
- Bit 3 No reply slave DSP count
- Bit 4 Invalid count of slave DSPs
- Bit 5 Global communication port tests
- Bit 6 Internal tests failed on some slave
- Bit 7 Trigger Generator RAM and addressing

- Bit 8 Excessive coax/fiber round trip jitter
- Bit 9 No sync found in round trip test
- Bit 10 Internal error in compile/link
- Bit 11 ROM checksum error
- Bit 12 Invalid count of slave DSPs

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	
Number of Pulses Being Integrated																Output 13
15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	
Trigger Count (Low 16-bits)																Output 14
15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	
								Trigger Count (high 8-bits)								Output 15

The trigger count is a running tally of the number of triggers received by the RVP7 on the TRIGIN line. It is a full 24-bit counter.

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	
Number of Properly Acquired Bins for Current Range Mask & PRT																Output 16
15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	
No. of Valid Bins in Initial Part of Ray From Last PROC Cmd																Output 17
15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	
Immediate Status Word #2 (Current State of Affairs)																Output 18

- Bit 0 Processor supports FFT algorithms
- Bit 1 Processor supports Random Phase algorithms
- Bit 3 Processor supports DPRT (Dual-PRT) algorithms
- Bit 4 Problem in UpLink COAX cable from RVP7/Main —> RVP7/IFD
- Bit 5 Problem in DownLink fiber cable from RVP7/IFD —> RVP7/Main
- Bit 7 RVP7/IFD PLL is not locked to external user-supplied clock reference
- Bits 8–10 Status of burst pulse and AFC feedback
 - 1: AFC Disabled
 - 2: Manual Frequency Control
 - 3: No burst pulse detected
 - 4: AFC is waiting for warm-up
 - 5: AFC is locked
 - 6: AFC is tracking
- Bit 11 RVP7/IFD test switches are not in their normal operating position
- Bit 12 Set according to whether the RVP7 is performing trigger blanking. This allows the host computer to decide whether to interpret the End-TAG-0 bit in the output ray header as a blanking flag, or as a normal TAG line.

- Bit 13 Missing signal at RVP7/IFD Burst Input
- Bit 14 Slave DSP count may be less than the number of available chips
- Bit 15 Set when valid burst power is detected but the center-of-mass lies outside of the aperture sub-window that defines the portion of the pulse used for AFC analysis. This error bit effectively flags when the burst pulse has drifted out of its optimal placement within the sampling window.

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	
Starting Range in Km at Which Noise Sample Data are Taken																Output 19
15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	
Trigger Period (0.16667usec Increments) During Noise Sampling																Output 20
15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	
Min Trig Period (0.16667usec Increments) for Pulse Width 0																Output 21
15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	
Min Trig Period (0.16667usec Increments) for Pulse Width 1																Output 22
15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	
Min Trig Period (0.16667usec Increments) for Pulse Width 2																Output 23
15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	
Min Trig Period (0.16667usec Increments) for Pulse Width 3																Output 24
15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	
Four 4-bit Control Bit Patterns for Each Pulse Width																Output 25

See PWINFO command, input word #1, for definition of these bits.

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	
						Window		TopMode						P.W.		Output 26
P.W. Currently selected radar pulse width																
TopMode Major Mode (See SOPRM Input #9)																
Window Spectral Window Choice (See SOPRM Input #10)																
15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	
Current Trigger Generator Period (0.16667usec Increments)																Output 27
15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	
Desired Trigger Generator Period (0.16667usec Increments)																Output 28

The desired trigger generator rate is that which was selected in the most recently issued SETPWF command (or power-up rate if SETPWF was never issued). The current rate may be different from the desired rate due to bounding against limits for the current pulse width, or being in an odd ray cycle during dual-PRT processing. The measured PRT's are forced to 0xFFFF (the maximum unsigned value) whenever the external trigger is expected but missing.

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	
TRIGIN Period at Start of Last PROC Acquisition Time																Output 29

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	
TRIGIN Period at End of Last PROC Acquisition Time																Output 30

The PRTs from the start and end of the last ray are the actual measured values whenever possible, i.e., when non-simulated data are being processed, and we either have an external trigger, or an internal trigger that is not in any of the Dual-PRT modes. The units are the same as for the measured current trigger period in Output #3.

Outputs 31 through 37 are the current processing and threshold parameters set by SOPRM. See Section 6.3 for additional notes on each of these parameters.

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	
		Polar		NHD			16B	CMS	R2			End	Lsr	Dsr	Rnv	Output 31

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	
Log Slope								65536 * dB / LSB								Output 32

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	
LOG Noise Threshold in 1/16 of dB																Output 33

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	
Clutter Correction (CCOR) Threshold in 1/16 of dB																Output 34

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	
								SQI Threshold								Output 35

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	
SIG Threshold in 1/16 of dB																Output 36

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	
Calibration Reflectivity in 1/16 of dB																Output 37

15 14 13 12 11 10 9 8 7 6 5 4 3 2 1 0	Reserved (Zero)	Output 38
15 14 13 12 11 10 9 8 7 6 5 4 3 2 1 0	Reserved (Zero)	Output 39
15 14 13 12 11 10 9 8 7 6 5 4 3 2 1 0	Range Avg (From LRMSK Command)	Output 40
15 14 13 12 11 10 9 8 7 6 5 4 3 2 1 0	Reserved (Zero)	Output 41
15 14 13 12 11 10 9 8 7 6 5 4 3 2 1 0	Reserved (Zero)	Output 42
15 14 13 12 11 10 9 8 7 6 5 4 3 2 1 0	Header Configuration of PROC data (Copy of CFGHDR Input #1)	Output 43
15 14 13 12 11 10 9 8 7 6 5 4 3 2 1 0	Noise Sum of I Squared MSB=2** -16 LSB=2** -31	Output 44
15 14 13 12 11 10 9 8 7 6 5 4 3 2 1 0	Noise Sum of I Squared MSB=1 LSB=2** -15	Output 45
15 14 13 12 11 10 9 8 7 6 5 4 3 2 1 0	Noise Sum of Q Squared MSB=2** -16 LSB=2** -31	Output 46
15 14 13 12 11 10 9 8 7 6 5 4 3 2 1 0	Noise Sum of Q Squared MSB=1 LSB=2** -15	Output 47

To compute the noise power in dBm from Words 44-47, first calculate:

$$N_I = (\text{Word 45}) \times 2^{-15} + (\text{Word 44}) \times 2^{-31}$$

$$N_Q = (\text{Word 47}) \times 2^{-15} + (\text{Word 46}) \times 2^{-31}$$

From which we obtain:

$$dBm = P_{MAX} + 10 \log_{10} (N_I + N_Q) - 3dB$$

Note that the four integer values become rather small and severely quantized when the noise power drops to low values. Historically, these four words were used to balance the individual gain of the “I” and “Q” channels in the RVP6 in the presence of a strong test signal. Since “I” and “Q” are inherently balanced in the RVP7, these output words are no longer of much value.

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	
Log of Measured Noise Level (same as word 6)																Output 48
15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	
Exponential-LOG Noise Standard Deviation (8000hex)																Output 49
15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	
Ratio of Horizontal/Vertical Noise Power in Hundredths of dB																Output 50
15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	
16-Bit AFC/MFC Value (-32768 through +32767)																Output 51
15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	
				IFD Sat.Power				MinRev				Inter.F				Output 52

Inter.F Specifies which interference filter is running. Zero means “none”; see Section 5.1.4 for a description of the interference filter algorithms.

MinRev Minor revision level of the RVP7 code that is currently running.

IFD Sat.Power (P_{MAX})

Input power required to saturate the IF-Input A/D converter for the RVP7/IFD receiver that is currently attached.

0: +4.5dBm

1: +6.0dBm

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	
Interference Filter Parameter “C1” in Hundredths of deciBels																Output 53
15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	
Interference Filter Parameter “C2” in Hundredths of deciBels																Output 54
15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	
Immediate Status Word #3 (Current State of Affairs)																Output 55

Bit 0 Burst pulse timing adjustments can be made

Bit 1 Burst pulse frequency adjustments can be made

Bit 2 Burst pulse hunting is enabled

Bit 3 Burst pulse hunt is running right now

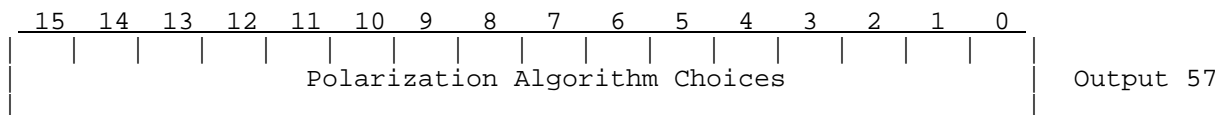
Bit 4 Last burst pulse hunt was unsuccessful

Bit 5 Dual PRT Type 2 is supported

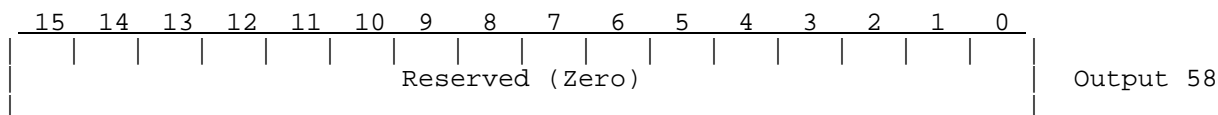
Bit 6 Could not generate the requested phase sequence

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	
Signed trigger slew in hundredths of microseconds																Output 56

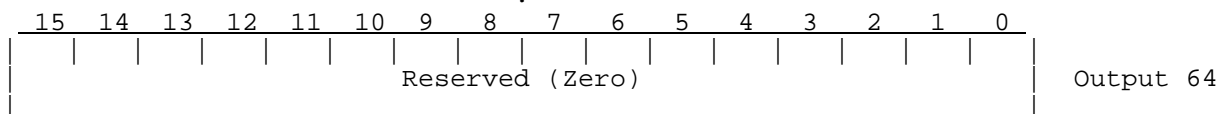
This is the same format that is used by the SETSLEW command to set the current trigger slew (See Section 6.26)



- Bit 0 Use H transmissions for (T,Z,V,W)
- Bit 1 Use V transmissions for (T,Z,V,W)
- Bit 2 Use Co-Pol reception for (T,Z,V,W)
- Bit 3 Use Cross-Pol reception for (T,Z,V,W)
- Bit 4 Correct all polar params for noise
- Bit 5 Use filtered data for all polar params
- Bit 6 Sign convention for PHIdp



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6.10 Load Simulated Time Series Data (LSIMUL)

This command is provided as a diagnostic for proper functioning of the RVP7 algorithms. It permits arbitrary simulated data samples to be input to the processing routines, rather than sampled data from the A/D converters as is ordinarily the case. Since the properties of the simulated data are known exactly, it is possible to verify that the calculations within the RVP7 are proceeding correctly.

The LSIMUL command (with operation=1) should be issued prior to the PROC command which is being tested. This enables the simulated data mode. The next PROC command will then wait for N (N = sample size) LSIMUL commands (with operation=2) prior to outputting each ray. The arrival of any other command during that time will cause the simulated data mode to be exited, and error bit #10 will be set in the GPARM latched status word. The error bit is also set if an LSIMUL command with operation=2 is received while simulated data mode is disabled.

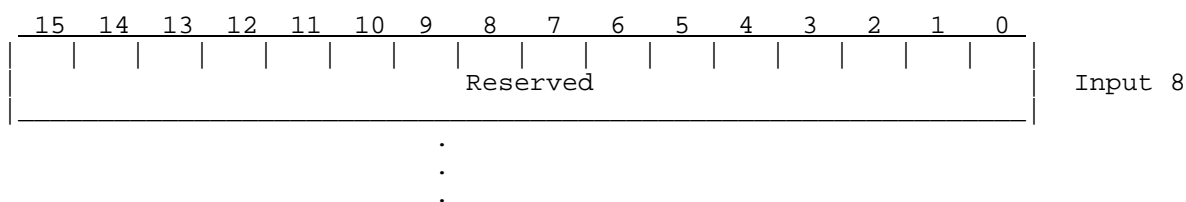
You may specify a single simulated data sample for every range bin, or a pattern or simulated samples to be replicated over the range of bins. Most RVP7 algorithms are independent of range, and can be tested with identical data at every bin. Notable exceptions, however, are the “pop” clutter filter, and range bin averaging procedures. In its full generality, the LSIMUL command permits independent I and Q samples to be simulated at every bin of every pulse. If this results in more host computer I/O than is practical, then specify fewer simulated bins and allow the RVP7 to replicate them internally.

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	
					Operation						0	1	0	1	0	Command

The available operations are:

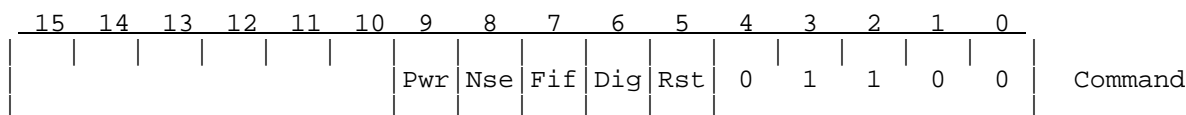
- 0 Disable the use of simulated data. RVP7 returns to acquisition and processing of live data from the A/D converters.
- 1 Enable processing of simulated data. Subsequent PROC commands will use the data supplied in the next N (N = sample size) LSIMUL commands with Operation=2.
The receiver noise and offset levels which are internally maintained by the RVP7 are zeroed by this command. This is because the measured offsets are not relevant to the simulated data, and must not be used in the subsequent computations. Thus, it is important to issue the SNOISE command before resuming the acquisition and processing of live radar data.
- 2 Load one pulse of data samples. Each bin within the pulse is represented by four 16-bit words which represent a single instantaneous sample. You may specify one or more bins to be loaded; the RVP7 will replicate these data as necessary in order to fill out the entire count of acquired bins. Thus, the total number of words loaded is $(4+4B)$, where B is the bin count specified in Word #1. This takes account of the four "header" words, plus four words for every bin being defined. If B is zero, then a zero-valued sample is applied for all channels.

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	
																Input 1
Number of Bins of Simulated Data Which Follow																
15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	
																Input 2
Transmit Phase of This Pulse (16-bit Binary Angle)																
15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	
																Input 3
Transmit Power in Hundredths of dB (Zero dB Nominal)																
15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	
																Input 4
Reserved																
15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	
																Input 5
Reserved																
15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	
																Input 6
Signed "I" A/D Sample (F16.12 Format)																
15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	
																Input 7
Signed "Q" A/D Sample (F16.12 Format)																



6.11 Reset (RESET)

The RESET command permits resetting either the entire RVP7 processor, or selected portions thereof. Flags within the command word determine the action to be taken.



- Pwr** Performs a power-up reset. The RVP7 is rebooted from the contents of the on-board ROM.
- Nse** Reset the sampled receiver noise level to the default value defined in the **M*** setup questions (See Section 3.3.7).
- Fif** Remove any data currently in the output FIFO's. This permits flushing output data that was left from a previous command, so that new output can be read from scratch. See notes in the *Introduction* to this chapter concerning actions taken by the RVP7 when the output FIFO becomes full.
- Dig** Forces RVP7 to execute its built-in diagnostic tests and most of the power-up sequence. This bit is identical to "Rst", except that the initial one-second blinking of the board's LED is not done. This permits the host computer to continually execute the diagnostics at the maximum rate, e.g., for burn-in testing.
- Rst** Restart the processor using the current version of loaded code.

6.12 Define Trigger Generator Output Waveforms (TRIGWF)



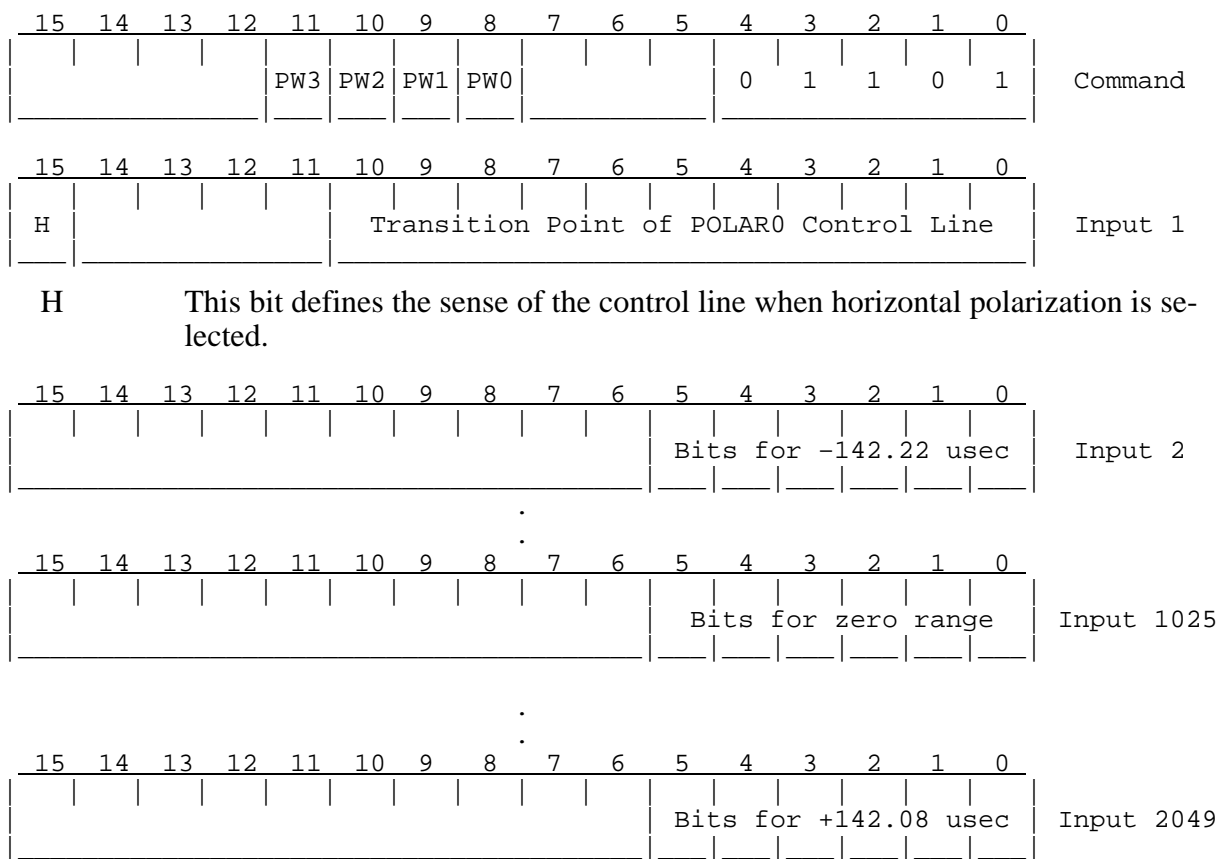
Note: This opcode is obsolete, and is included only for backward compatibility with the RVP6. The opcode is disabled by default (See Section 3.3.1), because the interactive trigger setup procedure described in Section 4.4 is the preferred method of defining all RVP7 triggers and timing. TRIGWF should not be used in any new code applications that drive the RVP7.

The RVP7 has a built-in trigger generator that can synthesize six independent digital output waveforms, each having arbitrary shape and being active anywhere in a window centered around zero-range. The six trigger outputs can be defined by a 2048-word by 6-bit table which is loaded from the user computer. The patterns are automatically read from the table and output to the six trigger lines during each radar pulse. The six outputs can be used for transmitter triggers, scope triggers, range strobes, PLL gates, etc. The writable waveform table makes the RVP7 unique, in that the detailed timing of trigger and related control signals can be easily adjusted in software, without having to resort to reprogramming PROMs. This makes it possible for user software to edit the trigger timing in a convenient interactive manner.

Trigger waveforms are loaded using the TRIGWF command. Four bits in the command word (PW0 through PW3) select which pulsewidths will receive the new waveforms. On power-up, all four pulsewidths are initialized to user-selected waveforms.

The first word following the TRIGWF command specifies the transition point of the POLAR0 polarization control signal. This control signal is either held low or high for the cases of fixed horizontal or vertical polarization, or it alternates from pulse to pulse for fast-switching polarization measurements such as Zdr. The transition point is specified as a value between 0 and 2047, where 1024 represents range zero. These units are the same as the time units for the waveforms which follow, i.e., a 2048-word array holding 6-bit trigger patterns. Bit 0 in each of these words affects the TGEN0 digital output line, bit 1 affects TGEN1, etc. The bits are output at a 7.195MHz rate, and the beginning of the 1024th array word (1025th word following the command) corresponds exactly to the instant at which data at range zero are sampled by the RVP7. Note that the output rate can also be interpreted as a new bit coming every 1/48 km. In some cases this is a more useful view.

As an example, suppose we wish to make the TGEN0 output be a 0.42 microsecond pretrigger pulse, with a rising edge exactly five microseconds prior to range zero. This would be done by setting bit 0 in input words 988, 989, and 990 following the TRIGWF command, and leaving all other bit 0's clear. Further, if TGEN1 was to be a 0.14 microsecond marker strobe at 20km, we would simply set bit 1 of input word 1984.



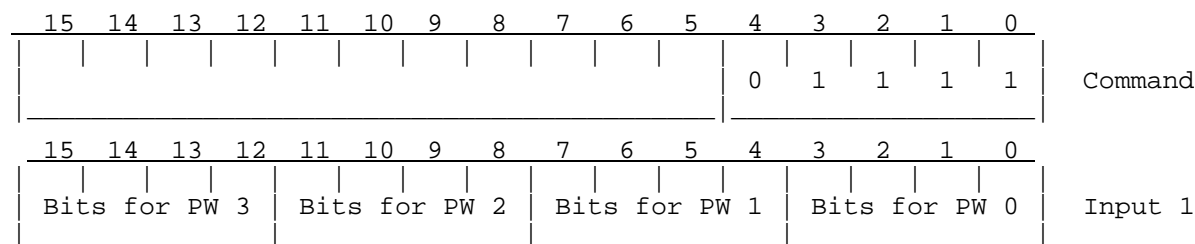
6.13 Define Pulse Width Control Bits and PRT Limits (PWINFO)

The RVP7 is equipped to control the radar transmitter's pulse width and corresponding receiver bandwidth. There are four pulse/bandwidth codes, numbered simply 0 through 3. The association between codes and pulse widths is completely determined by the needs and capabilities of the particular radar on hand. In some cases, the zero code might represent 0.25 microsecond pulse width, and in other cases it may represent 2.0 microseconds. Likewise, some radars may use all four codes, whereas others have fewer options from which to choose. The PWINFO command defines what happens for each of the four possible codes, but does not actually select which code is being used. The later function is performed by SETPWF.

The RVP7 drives four TTL output lines (PWBW0 – 3) which are intended to control the radar pulse/bandwidth hardware. Typically this control is via relays or solid-state switches in the transmitter and receiver. The user decides what state the four lines assume for each pulse width code. This is done using word #1 following the command, which contains four codes packed into one 16-bit word. The power-up default is to drive output line N low for a code of N, keeping all other lines high (Input of 7BDE Hex). The flexibility in defining the output bits usually makes the radar hardware connections very simple. For example, if pulsewidth selection relied on choosing one of four relays, then each PWBWn line could serve directly as a relay driver using the default pattern.

For each pulse width there is a corresponding minimum trigger PRT permitted. This bound is intended to limit the transmitter duty cycle to a safe value under all conditions. PWINFO sets up these minimum PRT's using words 2 through 5 following the command. The maximum frequency of the internal trigger generator is then constrained at each pulse width to the indicated rate. This protection applies at all times, i.e., during noise sampling, during ray processing, and during the standby time between rays. The default PRT bounds are 2000, 1000, 750, and 500 Hertz (Inputs of 3000, 6000, 8000, and 12000). If your radar does not use all four pulse width codes, it is still a good idea to set the unused PRT limits to reasonable values. This way protection is still provided in the event that SETPWF accidentally selects one of the unused states. If the internal trigger generator is not being used, then the PRT limits no longer affect the actual trigger rate and transmitter protection becomes the responsibility of the the user hardware. Finally, note that the entire pulse/bandwidth mechanism can be effectively turned off by setting the four bit patterns and the four PRT limits all to the same value.

The PWINFO command can be disabled (for transmitter safety), so that PRT limits cannot accidentally be changed by the host computer. When this is one, the RVP7 still reads the five input words, but no changes are made to the pulse width and PRT information. Thus, the command I/O behaves the same way, whether enabled or disabled.



15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	
Min Trig Period (0.16667usec Increments) for Pulse Width 0																Input 2
15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	
Min Trig Period (0.16667usec Increments) for Pulse Width 1																Input 3
15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	
Min Trig Period (0.16667usec Increments) for Pulse Width 2																Input 4
15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	
Min Trig Period (0.16667usec Increments) for Pulse Width 3																Input 5

6.14 Set Pulse Width and PRF (SETPWF)

This command selects the pulsewidth and trigger rate. A 2-bit pulse width code is passed in bits 8 and 9 of the command word, and selects one of four pulse widths as described under PWINFO. The new radar PRT is passed in word #1. For all processing modes that use a fixed trigger rate, this value defines the trigger period that is output at all times except during noise measurements. For Dual-PRF applications, this word defines the short period (high PRF) rate. The long period is internally computed as either 3/2, 4/3, or 5/4 the short period, and the trigger generator alternates between the short and long rates on each successive ray.

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	
				(Rsv)	P.W.						1	0	0	0	0	Command
15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	
Desired Trigger Generator Period (0.16667usec Increments)																Input 1

When Input #1 is zero, then the arguments take on an alternate form that allows an array of N (up to 64) trigger periods to be specified, and also gives much finer time resolution in the choice of each period. The XARGS command is first used to load an array of N 32-bit words that define the trigger period(s) in nanoseconds. The RVP7 will then generate triggers whose shapes (relative starts and widths) are identical for each pulse, but whose periods follow the selected sequence. Trigger patterns such as these are intended to support research customers who use the real-time (I,Q) data stream directly.

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	
Lower 16-Bits of 32-Bit Trigger Period in Nanoseconds																XARG 1
15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	
Upper 16-Bits of 32-Bit Trigger Period in Nanoseconds																XARG 2
:																

6.15 Load Antenna Synchronization Table (LSYNC)

The RVP7 can operate in a mode wherein radar data are acquired in synchronization with the antenna motion along either the azimuth or elevation axis. This special feature frees the user computer from having to separately monitor the antenna angles and request each data ray individually. To use this mode, it is assumed that TAG0-15 are wired to receive azimuth angles, and that TAG15-31 are wired to receive elevation. Angle input may be in the form of either 16-bit binary angles, or four-digit BCD. This synchronization mode is the only one which ascribes any meaning to the TAG inputs; ordinarily they are merely passed on to the user computer as ancillary information.

Antenna synchronization is accomplished by way of a table of trigger angles. This table, which contains between three and 1024 angles, is used to define the angle boundaries for each processed ray. The trigger angles need not be uniformly spaced, nor must they span the full 360-degrees of rotation. This gives considerable flexibility in the choice of angles. For example, if local obstructions cause shadows in the radar image, then those regions can be skipped merely by omitting table entries in their vicinity. Likewise, as the antenna rotates data can be acquired within one or more sectors by simply specifying the appropriate sets of contiguous bearings at whatever angular resolution is desired. Note that on power-up the angle table is initialized to 360 values corresponding to integer-valued degrees from zero to 359.

The synchronization algorithm works automatically with either clockwise or counterclockwise antenna rotation, and can tolerate any sequence of changes in direction, e.g., if the antenna itself is scanning a sector, or if it is turning erratically. Moreover, the trigger angles do not have to be hit exactly in order to start each new ray — the antenna need only move across them. This minimizes the possibility of losing data due to missing codes in the angle encoders. The RVP7 will automatically produce an output ray after one second of waiting, even if no trigger angles have been crossed. This is to avoid timeouts with the host computer when the antenna is not moving at all.

To use the synchronization mode, the trigger angle table is first loaded using the LSYNC command. The user chooses the number of table entries and then writes the required number of words to the RVP7. The angles must be supplied in a clockwise strictly increasing order, and they must neither reach nor pass zero degrees by the table's end. The first value, however, may be zero. Binary angle representation is used wherein Bit 15 represents 180 degrees, Bit 14 represents 90 degrees, etc. The Ld bit must be set in the command word to indicate that a new table size and set of angles are being loaded. A flag bit is to be set (See GPARM) if errors are detected when loading the table of angles.

To actually enable synchronized operation the Ena command bit must eventually be set, and EL and BCD should be either set or cleared according to the user's needs. These bits may be used independent of reloading the actual table values. Thus, antenna synchronization may be turned on and off without having to reload the table each time. However, if there were errors when the table was last loaded, the processor ignores the Ena bit and synchronization is forced off. Once enabled, PROC commands are then issued in the usual manner to acquire and process the radar data. Either the single-cycle or free-run PROC mode may be used. Data collection proceeds as usual, except that the rays are now automatically aligned with the trigger angles.

The angle sync algorithm is dynamic and works as follows. Each ray begins immediately upon the user's request, or upon completion of the previous ray when in continuous processing mode. At the start of the ray, the RVP7 finds the pair of sync angles that enclose the previous trigger angle. The current ray then runs until the antenna passes outside of either limit, at which point processing for that ray is terminated. Once this happens, a new trigger angle is assigned based on which limit was crossed.

The maximum number of pulses that will be present in each ray during angle syncing is still given by the Sample Size field of the SOPRM command. The actual number of pulses will be less only if a trigger angle is crossed before the full pulse count is reached. In general, you should set the Sample Size somewhat larger than the expected pulse count so that the trigger angle crossings make the best use of every available pulse when the antenna is scanning at the expected rate.

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	
			NoI	Ena	El	BCD	Ld				1	0	0	0	1	Command

- NoI** Ordinarily, the potentially lengthy sync wait loop is terminated if the user writes additional words to the RVP7. Setting this bit prevents such interrupts. Beware that the processor loop can not be broken in this case except by moving the antenna across a trigger angle, or cycling the RESET_ line.
- Ena** Enables antenna synchronization.
- El** Synchronization is based on TAG15–31 (Elevation) inputs, else TAG0–15 (Azimuth) is used.
- BCD** Specifies that TAG angle input is in the form of 4-digit Binary Coded Decimal; otherwise, a 16-bit binary angle is assumed.
- Ld** Indicates that a new table size and array of values follow the command. If Ld = 0, then LSYNC is a one-word command only.

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	
																Input 1
Number of Trigger Angles that Follow (3 - 1024)																

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	
																Input 2
(Ignored)																

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	
																Input 3
First Trigger Angle (16-Bit Binary Angle)																

⋮

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	
Last Trigger Angle (16-Bit Binary Angle)																

6.16 Set/Clear User LED (SLED)

This command simply turns the red user LED on and off under program control. The LED is on during the initial running of internal diagnostics, and then remains off unless changed by this command. Note that the red LED can be configured to serve as an internal activity indicator (see TTY setups), in which case this command has no effect.

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	
							LED				1	0	0	1	0	Command

6.17 TTY Operation (TTYOP)

This command controls the TTY “chat mode” interface to the host computer. The command can simulate the typing of characters on the RVP7’s setup TTY. Characters entered in this manner are indistinguishable from those typed on the actual TTY; hence, whatever one can do via the TTY, one can also do via this command. The RVP7 sends all TTY output to whichever stream (TTY, or host computer) provided the most recent input character. This command is also used to monitor the graphical data from the special scope plotting modes.

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	
								Operation			1	0	0	1	1	Command

The operation codes are as follows:

- 0 Sends the ASCII character in the upper byte of the word to the RVP7 as if it had been typed on the setup TTY’s keyboard.
- 1 Allow scope plotting data to be output whenever a plot is being drawn. All relevant status and data words are output once upon each receipt of this command. Subsequently, status and data will be output only when a change has taken place.
- 2 Disable the scope plotting output data.

Any of the following types of data may be output by the RVP7 while the TTY monitor is running. The order of arrival of each data type is indeterminate, but all multi-word sequences will always be output as contiguous words.

Individual “TTY” characters generated by the RVP7 are output in the low byte of the word, with the upper byte set to zeros.

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	
0	0	0	0	0	0	0	0									TTY Char

The status of the plotting modes is given in the following word.

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	
1	0	0	0													PLT Status

PLT Indicates that a scope plot is being drawn now.

The 2-bit intensities of each of 16 possible strokes of data is given in the following 4-word sequence. An intensity of zero represents “OFF”; one, two and three are successively brighter.

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	0	0	1	0	0	0	0	Int 3		Int 2		Int 1		Int 0	
15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	0	0	1	0	0	0	1	Int 7		Int 6		Int 5		Int 4	
15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	0	0	1	0	0	1	0	Int 11		Int 10		Int 9		Int 8	
15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	0	0	1	0	0	1	1	Int 15		Int 14		Int 13		Int 12	

The data for each stroke of the plot is given by the following sequence of 501 words.

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	
1	0	1	0													Plot Data
15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	
1	0	1	1													Word #1
15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	
1	0	1	1													Word #500

6.18 Load Custom Range Normalization (LDRNV)

Reflectivities computed by the RVP7 are ordinarily corrected for range effects by adding an offset in deciBels equal to $20 \log(R / 1\text{km})$, where R is the range in kilometers. This correction is based on a simple filled beam geometry, and is sufficiently accurate for most meteorological observations. The LDRNV command is provided for applications in which an alternate custom range correction is required, for example, if the radar receiver's LNA were to be driven by an external user-supplied STC waveform.

LDRNV loads a 251-word custom correction table holding values in hundredths of deciBels over five decades of $\log(\text{range})$ from 0.01km to 1000km. There are 50 table entries per decade of range. Thus, the range in kilometers corresponding to an input word #N is $10^{\left[\frac{N-1}{50}-2\right]}$, and the default correction table (automatically used on power-up) is simply $40(N - 101)$. The table

values are stored and interpolated whenever the RVP7 loads a new range mask (See LRMSK), at which point custom values for the actual user ranges are computed. The LDRNV command need be issued only once, but it must be done prior to choosing the working set of range bins.

The linear intervening gas attenuation correction (See SOPRM) is always added to the reflectivity data, regardless of whether default or custom range normalization is in effect. If this is undesirable, the intervening gas slope should be set to zero.

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	
											1	0	1	0	1	Command

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	
																Input 1
Signed Hundredths dB of Range Normalization for Range 0.01 km																

.

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	
																Input 251
Signed Hundredths dB of Range Normalization for Range 1000 km																

6.19 Read Back Internal Tables and Parameters (RBACK)

This command permits some of the RVP7 internal tables to be read back for confirmation and diagnostic purposes. This command would not generally be used during normal data acquisition and processing.

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	
												1	0	1	1	0
				Data to Show												Command

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	
																Input 1
Number of words to output																

The data that can be returned are:

- 0 Full operational parameter table from last SOPRM command.
- 1 Ray history array consisting of six words per ray for the last 40 rays (in reverse time order) that were processed. Each six-word group holds
 - a. Actual number of samples that went into the ray
 - b. Time since the last ray (in tenths of ms)
 - c. Ending azimuth TAG bits
 - d. Ending elevation TAG bits
 - e. Starting azimuth TAG bits
 - f. Starting elevation TAG bits
- 2 Angle sync table from last LDSYNC command.

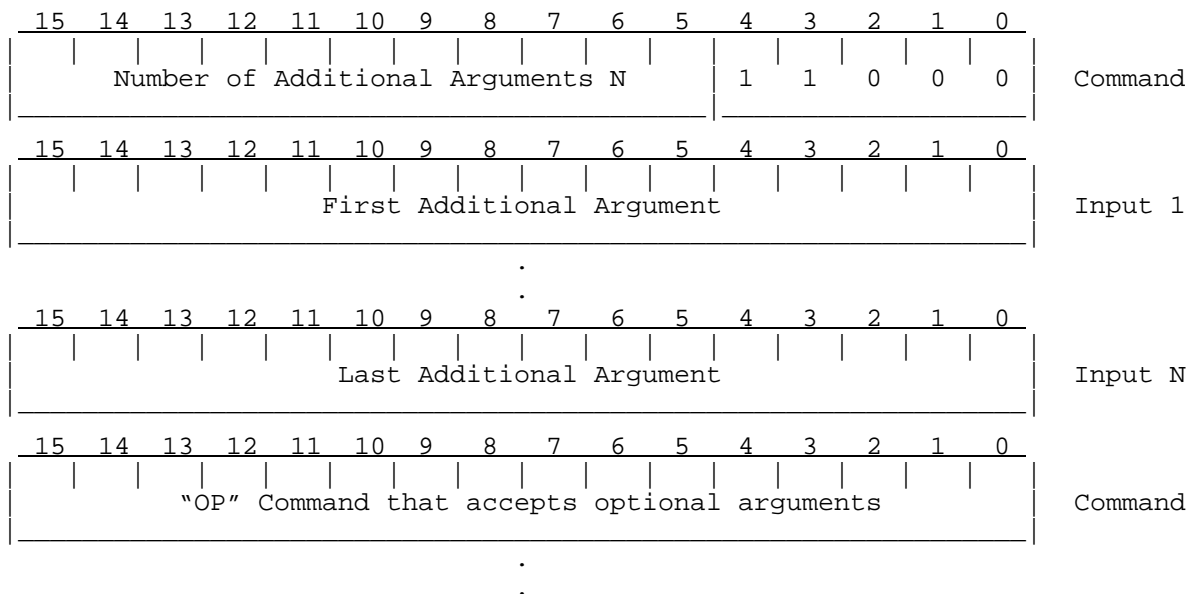
- 4 Filter selection array from the last LFILT command.
- 6 Custom range normalization from last LDRNV command.
- 7 Samples of the TAG input lines at 4ms intervals. The sampling begins at the moment the RBACK command is received, and continues until the output count is reached. Each 32-bit sample is output as a pair of 16-bit words:
 - a. Azimuth (TAG bits 0 – 15)
 - b. Elevation (TAG bits 16 – 31)
- 8 Doppler clutter filter coefficients (Same format as for LFCOEFS command)
- 10 Range mask spacing in cm for each pulsewidth

6.20 Pass Auxiliary Arguments to Opcodes (XARGS)

This command provides a backward compatible mechanism for supplying additional (optional) arguments to other opcodes. The command may be used freely in the RVP7's instruction stream, even if the opcode being modified does not expect any optional arguments. XARGS will be a NOP in that case.

To supply optional arguments to another opcode "OP", the XARGS command is first executed with the additional argument count encoded in its upper 11-bits. This is followed by the array of between 0 and 2047 additional arguments. At this point the XARGS command is finished and the "OP" command is fetched as the next instruction. "OP" will execute normally, except that the additional arguments from XARGS can be picked up after its own input list has been read to completion.

XARGS affects only the opcode that immediately follows it. The entire list of optional arguments is discarded after "OP" executes, even if "OP" did not use some or all of the list. However, if "OP" is yet another XARGS command, then the additional arguments that it supplies will be appended to the first set. In this way, XARGS can supply an arbitrarily large number of additional arguments.



6.21 Load IIR Clutter Filter Coefficients (LFCOEFS)

The RVP7 is shipped with a default set of Chebyshev high pass clutter filters. For most radar applications, these defaults provide a sufficiently wide range of filter choices to meet the signal processing needs. However, if it is deemed desirable to run with other types of IIR filters, this command is used to define the new filter designs.

The tables in Appendix “A” list the coefficient values for the default filters. The LFCOEFS command serves to redefine a single row of table values, i.e., all coefficients for a single filter within an overall set of filters. The Doppler filters are fourth-order and thus are defined by nine coefficients; the LOG filters are third-order and require seven coefficients.

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	
				0	0	0	0	0	0	0	1	1	1	1	1	Command
15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	
											LOG				Filter #	Input 1

LOG If this bit is set, then one of the LOG filters is being modified and 14 words are assumed to follow; if clear, then a Doppler filter is being modified and 18 words are assumed to follow. The LOG filters are obsolete, and are not implemented in the RVP7; this bit is included only for backward opcode compatibility with the RVP6.

Filter # Selects one of the filters to modify. To avoid confusion, the all-pass filter (000) can not be altered by this command. If the all-pass filter is selected, the coefficient input words will still be loaded, but no changes will take place to the filters.

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	
																Input 2
																Low Bits of First Coefficient
15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	
																Input 3
																High Bits of First Coefficient

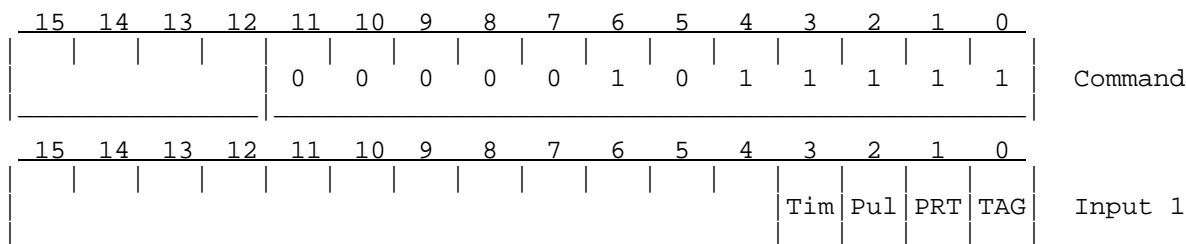
⋮

Each real valued coefficient is represented by a 32-bit signed fixed point quantity ranging from -16.0 to $+15.99999999$. The highest of the 32 bits has a weight of -16 ; successively lower bits have weights $8, 4, 2, 1, 0.5, \dots, 2^{-27}$.

6.22 Configure Ray Header Words (CFGHDR)

The processed data that are output by the PROC command may contain optional header words that give additional information about each ray. This command configures the set of words that makeup each header. There are (up to) thirty two different choices of words or groups of words to include, as indicated by the bit mask following the command. Setting a bit requests that those

words be included in the header, and be placed in the order implied by the sequence of the bits. Leaving all bits clear will suppress the header entirely; though this can also be done without changing the configuration via the NHD (No-Headers) bit in SOPRM Input #2.



TAG Four words containing two 32-Bit TAG samples, one from the beginning and one from the end of the ray:

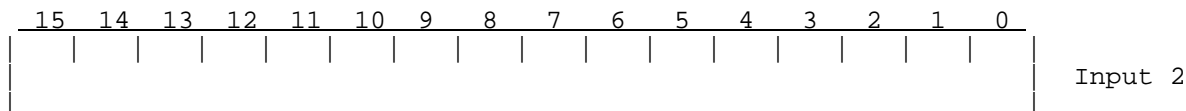
Word #1	TAG15–0	Start of Ray
Word #2	TAG31–16	Start of Ray
Word #3	TAG15–0	End of Ray
Word #4	TAG31–16	End of Ray

- When the RVP7 is operating in dual PRF mode, bit zero of the “start” TAG word is replaced with a flag indicating that the ray’s PRF was low (0) or high (1).
- When trigger blanking is enabled, bit zero of the “end” TAG word is replaced with a flag indicating that the trigger was blanked (0) or normal (1). Note that the data within a ray are considered to be invalid if any of the pulses that were used to compute the ray were blanked. Also, the RVP7 will output all zeroed data whenever a ray contains any blanked pulses.

PRT PRT (Pulse Repetition Time) measured at the end of the ray. Same format as GPARM Word #30. The measured PRT’s are forced to 0xFFFF (the maximum unsigned value) whenever the external trigger is expected but missing.

Pul Number of pulses that were used to compute the ray.

Tim Time stamp. Sixteen-bit counter incrementing at a rate of 1000 counts/sec, and sampled at the end of the ray.



6.23 Configure Interference Filter (CFGINTF)

The RVP7 can optionally apply an interference filter to its incoming (I,Q) data stream, with the goal of rejecting occasional and sparse interference from other (usually man-made) signal sources. The CFGINTF command is used to choose which filtering algorithm will be applied, and to configure its operation via additional XARGS parameters (See Section 6.20).

If the XARGS are not supplied, then the filter parameters will simply retain their previous values. Thus, CFGINTF with no XARGS can be used to turn the interference filters On/Off without making any other changes to their threshold constants. Likewise, if only XARG 1 is supplied, then that single threshold value will be used for both C1 and C2.

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	
				0	0	0	0	0	1	1	1	1	1	1	1	Command

Filter Chooses which interference algorithm should be run. See Section 5.1.4 for a description of the available algorithms.

- 0: None (Interference filtering is disabled)
- 1: Alg.1 (Traditional JMA Algorithm)
- 2: Alg.2 (Alg.1 optimized for additive interference)
- 3: Alg.3 (Alg.2 with better statistics)

We recommend that you choose Alg.3 for general operational use. The other algorithms are included mostly for historical reasons.

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	
																XARG 1

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	
																XARG 2

6.24 Load ROM Image and Reboot (BOOT)

The RVP7 is capable of rebooting from a ROM image that is supplied by the host computer. This makes it possible to install and run new versions of code without having to replace the ROM on the RVP7/Main board. Unattended remote sites can be upgraded in this manner via a network.

When the RVP7 is first powered up, it will always boot from the on-board ROM (nothing else would be possible). But the ROM is also considered the most trusted source of code, and therefore will also be used for all “hard” resets:

- External hardware $\overline{\text{RESET}}$ line (parallel interface reset)
- SCSI Bus reset sequence
- RVP7 “RESET” command with “Pwr” option selected

When the BOOT command has been used to install a new version of code, that new code will persist across all of the following types of “soft” resets:

- Autoreset performed by the internal Watchdog
- Any type of reset invoked using the “*” local TTY command
- The power sequencing reboot that occurs when the RVP7/IFD is turned on after the RVP7/Main board has already powered up.
- RVP7 “RESET” command with “Rst” or “Dig” options selected

The following command initializes for loading a complete ROM image. An internal 512KB memory array is allocated and initialized for receiving the subsequent ROM data. This command defines the beginning of a ROM Load/Reboot sequence, and must always be first.

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	
1	0	0	0	0	0	0	0	1	0	0	1	1	1	1	1	Command

The actual ROM image is too large to be loaded in a single I/O transfer, so it is broken into smaller segments of up to 128 32-bit words in length. Each segment is loaded by specifying its 17-bit starting longword address, i.e., the ROM byte address divided by four. This address is followed by the array of 32-bit data that are to be loaded there. The data are supplied using a previous call to the XARGS command. Note that two extra upper address bits (19 rather than 17) are defined to permit future code expansion.

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	
0	High Addr			0	0	0	0	1	0	0	1	1	1	1	1	Command
15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	
Low Bits of Starting ROM Address																Input 1
15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	
Low 16-Bits of first 32-Bit ROM Word																XARG 1
15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	
High 16-Bits of first 32-Bit ROM Word																XARG 2
:																

The loaded image can be tested for internal consistency using the following command. The “OK” bit will only be set if the ROM image has been completely loaded, and the built-in CRC check matches exactly. The “OK” bit must be set in order for the RVP7 to boot the new code.

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	
1	0	0	1	0	0	0	0	1	0	0	1	1	1	1	1	Command
15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	
															OK	Output 1

Finally, the following command is used to boot a properly loaded ROM image. You should allow approximately four seconds for the reboot to occur before performing any further I/O with the signal processor. This command will do nothing if the ROM image is invalid.

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	
1	0	1	0	0	0	0	0	1	0	0	1	1	1	1	1	Command

6.25 Set AFC level (SETAFC)

This command sets the AFC level to a given value. The signed 16-bit span is identical to GPARM Output #51 which shows the present AFC level, i.e., corresponding to the –100% to +100% AFC range that is defined in the **Mb** menu. The RVP7 will automatically convert the new level into whatever analog or digital AFC output format has been configured. The only exception is for the Motor/Integrator type of AFC loop, in which case this command does nothing.

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	
				0	0	0	0	1	0	1	1	1	1	1	1	Command

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	
																Input 1
16-Bit AFC/MFC Value (–32768 through +32767)																

6.26 Set Trigger Timing Slew (SETSLEW)

The **Mt** menu allows you to select a subset of triggers that can be slewed “left” and “right” in order to place the burst pulse accurately at range zero. This command allows you to manually set the present amount of slew. The input argument is in hundredths of microseconds, i.e., ranging from –327.68μsec to +327.67μsec. The actual span permitted by the RVP7 is ±20μsec. This is the same format used in GPARM Output #56 which shows the present slew value.

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	
				0	0	0	0	1	1	0	1	1	1	1	1	Command

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	
																Input 1
Signed trigger slew in hundredths of microseconds																

6.27 Hunt for Burst Pulse (BPHUNT)

This command starts up the internal procedure to hunt for a missing burst pulse when we are uncertain of both its time and frequency. Depending on how the hunting process has been configured in the **Mb** menu, the whole procedure may take several seconds to complete. The RVP7's host computer interface remains completely functional during this time, but any acquired data would certainly be questionable. GPARM status bits in word #55 indicate when the hunt procedure is running, and whether it has completed successfully.

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	
			Now	0	0	0	0	1	1	1	1	1	1	1	1	Command

Now Forces the hunt procedure to be started even if the burst pulse is already present. Normally the procedure will only be started when the burst pulse is missing at the time BPHUNT is given.

