RVP7 V22 Release Notes

These notes cover changes made to the RVP7 code since release V21 of 21 April 2001. If you are upgrading from an earlier release, please read those notes also.

Bug Repairs

1. A bug was repaired in the reception of serial TAG angles, i.e., when the *SIO Usage* question in the **Mc** menu is set to *RCPrcv*. Incorrect AZ and EL angles would be received approximately once per minute, and would typically trigger the *DSP AZ Angles Exceed 30 Degrees* diagnostic message from IRIS/INGEST. This bug dates back to the very first RVP7 release; the RVP6 also may exhibit this same problem.
2. Some Rev.D (14-bit) RVP7/IFD's may show unstable **Pr** noise levels, as much as 7dB higher than the –81dBm/MHz level that is the theoretical limit for the AD6644 A/D chip operating at 36 MHz. The noise level may also fluctuate, sometimes appearing normal, depending on temperature. There is a software-only repair for this, but your RVP7/IFD must be returned to SIGMET for the new PLD code to be installed. Please see the *Alerts* page at *www.sigmet.com* for more details.
3. Two errors were repaired in the inheriting of the *Number of slave DSPs to use* setup parameter across reboots. 1) When a code upgrade was performed from V19 or earlier to V20 or later, the startup diagnostics would generally fail with an "Invalid DSP Count". This would happen even if all of the slave DSPs were present and working fine. Typing "*" in the RVP7 menus could be used to reboot with a clean DSP count. 2) When running perpetual diagnostics from the TTY with a reduced DSP count, e.g., with the command "* 12 +", the saved DSP count would incorrectly be restored after the first iteration.

New Features

1. Documentation has been added in Section 2.2.2 of the *RVP7 User's Manual* describing the procedure for installing RVP7 code upgrades under IRIS.
2. The RVP7's Perpetual Diagnostic Loop now maintains a histogram of receiver IF-Input noise levels in 1dB steps from –85dBm to –72dBm. You can view the accumulated noise distribution by typing "N" while the diagnostic loop is running. This feature is intended for use during factory burn-in and testing of RVP7/IFD units.
3. The RVP7 noise sampling procedure now 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. Previously, the algorithm would fail if the PRF exceeded approximately 1400Hz. Note that the PRF bound is equally well imposed for external triggers too, i.e., external triggers will be ignored for 800μsec following each one that is actually used.
4. The Doppler parameter modes (PPP, FFT, etc) now include an optional 3x3 interpolation and speckle removal filter that is applied to the final output rays. This 2-dimensional

filter examines three adjacent range bins from three successive rays in order to assign a value to the center point. Thus, for each output point, its eight neighboring bins in range and time are available to the filter. Only the *dBZ*, *dBT*, *Vel*, and *Width* data are candidates for this filtering step; all other parameters are processed as they always have, using the existing 1-dimensional (three bins in range) speckle remover.

The 3x3 filter has several subtleties and side effects built into it so that quite a few tasks can be accomplished.

- **Improved Speckle Removal** – When the LSR or DSR (Log & Doppler Speckle Removal) flags are set in the OPPRM flag word, data points will be removed whenever there are fewer than three (out of eight) neighbors present. This gives a much cleaner display than the previous 1-dimensional algorithm that merely checked for the presence of an adjacent bin in range.
- **Interpolation of Missing Bins** – When a data point is thresholded away, but six or more of its neighbors still have valid data, then an interpolated value will be supplied to fill in the missing bin. For *dBZ*, *dBT*, and *Width*, the interpolated value is computed as the arithmetic average of all available neighbors. For *Vel*, it is not possible to define a meaningful average in a simple way; so the “nearest” valid neighbor is simply filled in.
- **Dual-PRF Unfolding** – Dual-PRF velocity unfolding is computed within the 3x3 filter whenever both are enabled. A 3x3 cell of raw velocities is first examined to unfold the center point. That center point must be valid in order to proceed. However, all six neighbors from the two surrounding rays (at the alternate PRF) are candidates for performing the unfolding steps. This larger selection of alternate-PRF bins makes it more likely that the algorithm will find the pairs of Low/High PRF data that are required.

  The unfolded velocities are then applied to the same 3x3 filter that processes normal velocities at a single PRF, i.e., for speckle removal and interpolation as described above.
- **Dual-PRF, Random Phase Processing** – This now works properly at all ranges as a consequence of the 3x3 filtering steps. The velocity unfolding is performed seamlessly as a final pass on the combined first and second trip data. Moreover, the reflectivity and width data are likely to be interpolated across the “second bang” gap that hops in range at each PRF, i.e., the missing bins at the beginning of each second trip are interpolated from the six valid bins that surround it at the other PRF. The result is a reflectivity display that is free of missing data in either of the early portions of the second trip of each PRF.

  Note that the legacy Dual–PRF Random Phase behavior still appears when the 3x3 filter is disabled, i.e., velocities are unfolded as long as all of the range bins fit within the first trip; otherwise folded velocities are output.

The 3x3 filter is switched ON by setting Bit-5 of the OPPRM flag word. This bit was previously unused in the RVP7, and has historically been the “pipelined” bit for the

RVP6; so reusing it here for the additional 3x3 filtering stage makes sense. 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.

The maximum speed of the RVP7 is reduced to approximately 85000 bins/second when the 3x3 filter is ON — approximately 60% of its maximum throughput when the filter is OFF. This is still a rather large value, and should not affect most customers. For example, there would be no problem running a scan having 2048 bins at 1-degree resolution and a 40 deg/sec scan rate. However, if you really need to operate at the absolute upper limit of the RVP7's throughput, then the 3x3 filter should be disabled in the **Mp** menu.

5. An improvement has been made to the AFC Motor/Integrator feedback loop so that it works properly even if the motor has become stuck in a "cold start", i.e., after the radar has been turned off for a period of time. The problem is that the mechanical starting friction can sometimes be larger than normal, and additional motor drive is required to break out of the stuck condition. But once the motor begins to turn at all, then the normal AFC parameters (minimum slew, maximum slew, feedback slope) all resume working properly. The algorithm is changed as follows:

   - Whenever AFC correction is being applied, the RVP7 calculates how long it would take to reach the desired IF frequency at the present rate of change. For example, if we are 1MHz away from the desired IF frequency, and the measured rate of change of the IF burst frequency is 20KHz/sec, then it will be 50 seconds until the loop reaches equilibrium.

   - Whenever the AFC loop is in Track-Mode, but the time to equilibrium is greater than two minutes, then the "Minimum Slew" parameter will be slowly increased. The idea is to gradually increase the starting motor drive whenever it appears that the IF frequency is not actually converging toward the correct value, i.e., the motor is stuck.

   - As soon as the frequency is observed to begin changing, such that the desired IF would be reached in less than two minutes, then the "Minimum Slew" parameter is immediately put back to its correct setup value. The loop then continues to run properly using its normal setup values.

   Note that this solution requires no additional setup questions, i.e., this feature is now built in as a permanent part of the motor/integrator AFC loop. If your motor never becomes stuck, then you will never notice the change.

6. The RVP7 now supports two Dual-PRT processing modes that use a staggered PRT trigger sequence.

   - **DPRT-1 Mode** – The existing "DPRT" mode has been renamed "DPRT-1", but is otherwise unchanged. The trigger consists of a very short PRT from which Doppler data are obtained, followed by a much longer PRT whose purpose is to limit the average duty cycle of the transmitter. No information is extracted from the long PRT pair, but Dual-PRF techniques can still be used by varying the short period from ray to ray. The "-1" suffix in the new name for this mode is a reminder that Doppler parameters are computed from the short PRT only. The DPRT-1 mode is intended for millimeter wavelength radars that must run at a very high effective PRF (up to 20KHz) to get an acceptable unambiguous velocity, but which also have a much lower duty cycle constraint on the average number of pulses transmitted each second.

- **DPRT-2 Mode** – The V22 release introduces a new Dual-PRT mode named "DPRT-2". The trigger consists of alternating short and long period pulses, where the ratio of the periods is determined by the velocity unfolding ratio that has been selected. Doppler data are extracted from both the short and long pulse pairs (hence the "-2" suffix), and unfolded velocities are made available on each ray based on the combined PRT data from that ray alone. DPRT-2 mode is intended for rapidly scanning radars where the ray-to-ray spatial continuity assumptions of the traditional Dual-PRF algorithms do not apply.

  The DPRT-2 velocity unfolding algorithm uses a modified version of the standard Dual-PRF algorithm. Both start by computing a simple velocity difference as a first approximation of the unfolded result. The standard algorithm uses that difference to unfold the velocity from the most recent ray, which yields a lower variance estimate than the difference itself. The DPRT-2 algorithm is similar, except that the folded velocity from both PRTs are unfolded independently and then averaged together.

  In addition to the above, the RVP7 also computes the DC average of the (I,Q) data within each bin. This is used as a simple estimate of clutter power, so that corrected reflectivities are available in DPRT-2 mode whenever a non-zero clutter filter is selected. DPRT-1 mode is the same in this respect. However, the DPRT-2 widths use an improved algorithm based on the two different PRTs, and which avoids the SNR sensitivity of the DPRT-1 width estimator.

The DPRT-2 mode is implemented as a new Major Mode (#5) in Word #9 of the SOPRM command. Bit #5 of GPARM Immediate Status Word #3 is also set to indicate that the mode is implemented in the signal processor. The new mode is supported in both the IRIS **ascope** utility and the Task Configuration Menu beginning with IRIS release 7.26 (August 2001). The **ascope** signal simulator has also been improved to work in all of the RVP7's Dual-PRF and Dual-PRT modes.

7. Several enhancements have been made to the Random Phase processing algorithms, all of which are likely to produce noticeable improvement in your RPH data:

   - In order for the adaptive whitening filter to remove coherent power from a raw trip, the SQI of the raw spectrum (after clutter filtering) must pass the normal SQI threshold. This change prevents the whitening filter from touching any spectral points unless we can be "pretty sure" that there is a coherent signal to remove.
   - The width of the whitening filter is now fixed when it is applied for the purpose of removing the clutter component of the raw trip signal, and when a fixed-width

clutter filter is also selected (See New Feature #10.). For variable-width clutter filters, the whitening filter is allowed to hunt for the edges of the clutter, just like it always would. The problem before was that a fixed-width clutter filter that was wide enough for normal spectral filtering would create a wider than optimum whitening filter when hunting was allowed.

- The final step in the RPH algorithm decides whether the original raw data for a given trip are better or worse than the whitened and recohered data from the other trip. This decision has been based solely on an SQI comparison of the two data sets, but can sometimes lead to a bad choice, e.g., when there is no signal in a given trip, both SQIs will be very low and scarcely meaningful. The new algorithm still uses the same SQI comparison, except that the SQI of the raw trip is scaled down by a function of the coherent signal power that was found and removed from the other raw trip.

8. The PRTs from the start and end of the last ray, which are reported in GPARM words #29 and #30, are now 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. In Rev.16 (when DPRT-1 was introduced) those GPARM words were redefined to always return the internal trigger generator's requested base PRT. That was unnecessarily restrictive, and now the two words once again convey more meaningful values, e.g., you will see alternating PRFs during the Dual-PRF modes in IRIS **ascope**.

9. A change was made in how the frequency-domain clutter filters interpolate across the zero velocity gap in the spectrum. Previously, the interpolated values were always substituted in place of the original spectral points, which could sometimes result in an overall increase in spectrum width and total power. Indeed, you could sometimes observe (dBZ > dBT) when using the spectral filters. The new filter algorithm only replaces a spectral point if the interpolated value is less than whatever was there already. The filters are much better behaved after making this change.

10. The RVP7 now supports variable-width frequency-domain clutter filters. These filters perform the same spectral interpolation as the fixed-width filters, except that their notch width automatically adapts to the clutter. The new filters are characterized by the same *Width* and *EdgePts* parameters in the **Mf** menu, except that the *Width* is now interpreted as a minimum width. An additional parameter *Hunt* allows you to choose how far to extend the notch beyond *Width* in order to capture all of the clutter power. Setting *Hunt=0* effectively converts a variable-width filter back into a fixed-width filter. See also Setup Change #8.

    The algorithm for extending the notch width is based on the slope of adjacent spectral points. Beginning *(Width–1)* points away from zero, the filter is extended in each direction as long as the power continues to decrease in that direction, up to adding a maximum of *Hunt* additional points. If you have been running with a fixed *Width=3* filter, you might try experimenting with a variable *Width=2* and *Hunt=1* filter. Perhaps the original fixed width was actually failing at times, but you were reluctant to increase it just to cover those rare cases. In that case, try selecting a variable *Width=2* and *Hunt=2* filter as an alternative. In general, make your variable filters “wider” by increasing *Hunt* rather than increasing *Width*. This will preserve more flexibility in how they can adapt to whatever clutter is present.

The variable-width clutter filters have performed very well in numerical simulations, and we are eager to hear how they work for you in practice. For now, the factory default filter settings have not been changed from the old fixed-width choices. This will, perhaps, be changed in the next release.

11. The RVP7’s automatic hunt for the burst pulse (which optionally occurs immediately after startup) will now always run at least once whenever the feature is enabled. The automatic hunting ceases as soon as any activity is detected from the host computer. Previously, if that activity had occurred very quickly after RVP7 startup, then no hunting would be attempted at all. This change insures that at least one attempt will always be made.

Setup Changes

1. A 6dB error has been corrected in the **Mp** setup menu values of the RVP7/IFD noise dither power. The available choices are 6dB higher than they were before, i.e., { Off, –57dBm, –37dBm, –32dBm, –27dBm, –22dBm, –19dBm }. The “Total Power” levels reported in the **Pr** plots will now match the selected dither power when no other input signals are present. Note that the higher dither values are used during factory testing, and are not intended for operational use.

2. The factory default value for the RVP7/IFD noise dither power in the **Mp** menu has been changed from –37dBm to –57dBm. We also recommend that you make this same change to your customized settings for routine operation. Adequate A/D dither power will still be present even at the –57dBm setting.

   The problem with the –37dBm dither level is that, for certain choices of (I,Q) FIR filter, the stopband of the filter may not give enough attenuation to preserve the RVP7/IFD’s inherent noise level. For example, the factory default 1MHz bandwidth Hamming filter has a stopband attenuation near DC of approximately 43dB. You can see this graphically at the right edge of the **Ps** menu. The in-band contribution of dither power is therefore approximately (–37dBm) – 43dB = –80dBm, which exceeds the A/D converter’s 1MHz bandwidth noise of –81.5dBm.

3. A new setup question: *2D Final Speckle/Unfold– 0:Never, 1:User, 2:Always*, now appears in the **Mp** menu. See New Feature #4.

4. The question *Rx-Fixed Triggers* in the **Mt** menu now uses “Y” and “N” for the printed list of Yes/No answers. Previously a blank had been used to represent the “N”, and that was confusing.

5. The *Real Time TTY Monitor* section of the **M+** menu now contains an additional question to request that the Burst Pulse tracking slew (in microseconds) be monitored. The format

is *BPT:0.00*, which is the same format that is used in the TTY printout of the **Pb** plotting command.

6. A new setup question: *Unfold Velocity (Vh–Vl) – 0:Never, 1:User, 2:Always,* now appears in the **Mp** menu. This question allows you to choose whether the RVP7 will unfold velocities using a simple $(V_{high} - V_{low})$ algorithm, rather than the standard algorithm described in Section 5.6 of the *RVP7 User's Manual*. Bit-11 of OPPRM word #10 is the host computer's interface to this function when the "1:User" case is selected.

i **Note: This setup question is included for research customers only. The standard unfolding algorithm should still be used in all operational systems because of its lower variance. For this reason, the factory default value of this parameter is "0:Never".**

7. The factory defaults for the whitening filter parameters in the **Mf** menu now match the settings shown in the manual:

   Noise threshold for replacing a point: 1.20
   Replacement value multiplier: 0.5000
   SNR in tails, for determining width: 0.25

   Also, the *SNR in tails...* parameter can now be set as low as 0.05 (used to be 0.1).

8. The RVP7 now supports variable-width spectral clutter filters. An example of the text from the **Mf** menu is shown below. For details, please see New Feature #10.

```
Spectral Clutter Filters
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Filter #1 – Type:0(Fixed)    Width:1   EdgePts:2
Filter #2 – Type:0(Fixed)    Width:2   EdgePts:2
Filter #3 – Type:0(Fixed)    Width:3   EdgePts:3
Filter #4 – Type:0(Fixed)    Width:4   EdgePts:3
Filter #5 – Type:1(Variable) Width:1   EdgePts:2   Hunt:2
Filter #6 – Type:1(Variable) Width:2   EdgePts:2   Hunt:2
Filter #7 – Type:1(Variable) Width:3   EdgePts:3   Hunt:3
```

9. A new setup question: *Process w/custom trigs – 0:Never, 1:User, 2:Always,* now appears in the **Mp** menu. This question allows you to choose whether the RVP7 will attempt to run its standard processing algorithms even when a custom trigger pattern has been selected via the SETPWF command. Generally it does not make sense to do this, so the default setting is "0:Never". Bit-12 of OPPRM word #10 is the host computer's interface to this function when the "1:User" case is selected.