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INTERFACE CONTROL DOCUMENT
FOR THE
RECEIVER SIGNAL PROCESSOR/ARCHIVE I

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DOCUMENT REVISION RECORD FORM

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1 SCOPE

1.1 Identification

This document defines the WSR-88D RDA Level I raw In-Phase and Quadrature (I&Q) data (hereafter, Level I data) format structure for output from a standard WSR-88D NEXRAD system.

1.2 Purpose

The University of Oklahoma, National Severe Storms Laboratory (NSSL), National Center for Atmospheric Research (NCAR), MIT Lincoln Labs, and the Radar Operations Center (ROC) use Level I data to support engineering analysis of Radar Data Acquisition (RDA) processes and new science algorithms. Level I recording and the playback capability within the ROC are essential to evaluate the impact of the changing RDA algorithm parameters on the performance of hydrometeorological and severe weather identification and tracking algorithms. It is also used as a vital component in the process of interference source identification and mitigation.

1.3 Document Overview

This document defines the WSR-88D RDA Level I data format, how to read and interpret data files, and describes the pulse data. This ICD is not intended to serve as a document concerning the applicable standards. That is, the reader is assumed to be generally knowledgeable of the contents, terminology, etc., of the standards. Distribution of this document is unrestricted.

2 REFERENCE DOCUMENTS

2.1 Government Documents

Reference Number	Title
2810000 Rev. J	WSR-88D System Specification
2830013 Rev. B	WSR-88D System/Subsystem Design Description
2830009A Pt. 1	Prime Item Development Specification for RDA Equipment (B1, CI-09)
Source:	Radar Operations Center (ROC) 1313 Halley Circle, Norman, OK Phone (local): 1 (800) 643-3363

2.2 Non-Government Documents

Reference Number	Title
RVP900	Digital Receiver and Signal Processor User's Manual
None	IRIS Programmer's Manual
Source:	Vaisala Inc. 10-D Gill Street, Woburn, MA 01801, USA Phone (local): 1 888 VAISALA (824 7252) Phone (international): +1 781 933 4500 Fax: +1 (781) 933-8029

3 STANDARD FORMAT

3.1 Data Files

Level I (also referred to as time series or TS) files come packaged in a default format based on hardware specifications. In particular, this document covers Level I data from a WSR-88D system that uses a Vaisala RVP900™ Digital Receiver and Signal Processor. The default format includes many fields NEXRAD does not need/use – they will be denoted as “Not Used” in Tables 1 and 2. This document will cover the specifics of fields/data used by the WSR-88D. Please refer to the RVP900™ User’s Manual for details on items not discussed in this document.

3.2 File size

Level I data files typically range in size from 40 MB to 420 MB in size. Some files can be smaller due to incomplete cuts or termination of data volumes or larger depending upon the scanning settings.

3.3 File naming convention

Data files have the following naming convention*:
<site info>.<date>.<time>.<milliseconds>.<volume coverage pattern>.<volume cut number>.<polarization>.<max range in km>

<site_info>: The 4-letter ICAO site identifier are the first four characters. Anywhere from 0-4 characters may follow the ICAO before the first "." in the filename as SSSS_CCC. The SSSS represents the ICAO, and CCC represents something such as the archive format or channel number. Examples: SSSS., SSSS_CH1., SSSS_RVP., etc.
<date>: Represented in the format of yyyymmdd; 4-digit year, 2-digit month, and 2-digit day
<time>: In the format of HHMMSS; 2-digit hour, 2-digit minute, and 2-digit second
<milliseconds>: Milliseconds digits of the associated time
<volume coverage pattern>: The first 3 characters are "vcp" followed immediately by the 2-3 digit vcp number. Examples: vcp32, vcp121, vcp215, etc.
<volume cut number>: 1-2 digit number representing the associated cut of the volume coverage pattern
<polarization>: Tag identifying which polarization is used in the file. Options are "H" (horizontal-only), "V" (vertical-only), or "H+V" (horizontal and vertical)
<max range in km>: Number of digits representing the max range in km of data available in the file. For WSR-88D data, this is normally a 3-digit value.

Example filenames:
- FOP1_RVP.20090520.194927.413.vcp212.9.H.460
- KFTG.20180421.225619.608.vcp32.6.H+V.460
- KFWS_RVP.20130411.194953.459.vcp12.13.H+V.137
- FOP1_CH1.20191223.143343.272.vcp32.2.H+V.460

*Some files during test or calibration cuts may have different properties.

4 READING LEVEL I DATA FILES

4.1 Data Structure

Level 1 data files are packaged with ASCII and binary data. The first thing in a file is the PulseInfo structure in ASCII. This is followed by all of the pulses associated with the info structure. The info structure is related to processing mode, so each file is generally a single cut of WSR-88D data. Pulses consist of an ASCII PulseHdr structure followed by 16-bit words of I&Q data. None of these structures/pulses have a consistent length in ASCII or binary because some fields have various lengths and the number of I&Q pairs varies based on processing mode.
The PulseInfo and PulseHdr structures are demarcated by “start” and “end” lines that can be used to determine where each block is and where binary pulse data begins. Both the Info and Hdr block consists of key = value pairs in ASCII. Formats of the values for each key (field) can be found in Table 1 and Table 2.

Table 1. Pulse Info

Field Name	Description	Format
iVersion	Version number of PulseInfo structure	String
iMajorMode	Processing Mode in use at time of data acquisition. Values used by WSR-88D: 12 = Batch mode or Staggered PRT 13 = Standard FFT 14 = Noise power measurement 15 = SZ-2	Integer
iPolarization	Transmit Polarization type - always set to "3" on the WSR-88D. Not used.	Integer
iPhaseModeSeq	Not used.	Integer
taskID.iSweep	Sweep number - typically the same as the cut number in WSR-88D data	Integer
taskID.iAuxNum	Auxiliary Number - set to 0 on WSR-88D	Integer
taskID.iScanType	Scan Geometry. Generally equals 4 to represent full PPI scan. Not used.	Integer
taskID.sTaskName	Generally, the VCP used to collect the data. For example: vcp32, vcp212	String
sSiteName	Site Name - typically the 4-letter ICAO	String
iAqMode	Not used.	Integer
iUnfold Mode	Not used.	Integer
iPWidthCode	Pulse Width Code used internally. 0 for short pulse, 1 for long pulse	Integer
fPWidthUSec	Pulse Width in microseconds. (Associated with iPWidthCode)	Floating Point
fBandWidthMHz	Bandwidth in MHz. (Associated with iPWidthCode)	Floating Point
fDBzCalib	dBZ0 for H channel, in dBZ	Floating Point
fDBzCalibCx	dBZ0 for V channel, in dBZ	Floating Point
fNoiseCalib	Not used.	Floating Point Array[2]
fBurstCalib	Not used.	Floating Point Array[2]
iSampleSize	Not used.	Integer
iMeanAngleSync	Not used.	Integer
iFlags	Not used.	Integer

Field Name	Description	Format
iPlaybackVersion	Not used.	Integer
fGdrOffset	Gain ratio of the two channels in dB. When computing Zdr, this value should be added to the H/V ratio to correct for the system bias.	Floating Point
fXdrOffset	Not used.	Floating Point
fSyClkMhz	IFD system clock rate in MHz. Needed to convert PulseHdr fields iNextPRT and iPrevPRT to seconds	Floating Point
fWavelengthCM	Wavelength of the radar in cm.	Floating Point
fSaturationDBM	Denotes the scaling factor of IQ vectors relative to dBm. This is the power in dBm for a IQ vector the magnitude with a magnitude of 1.0.	Floating Point
fRangeMaskRes	Spacing between range bins in m - set to 250 for WSR-88Ds.	Floating Point
iRangeMask	Bitfield representing which bins were enabled. For each 16 bins of data per pulse, a 16-bit integer is output with a bit set for each bin of data selected. Readers of WSR-88D produced data can safely ignore this field and assume that IQ vectors for each pulse are contiguous in range.	Integer Array [variable length]
fNoiseDBm	Noise samples in dBm for both H and V channels	Floating Point Array [2]
fNoiseStdvDB	Not used.	Floating Point Array [2]
fNoiseRangeKM	Not used.	Floating Point
fNoisePRFHz	Not used.	Floating Point
iGparmLatchSts	Not used.	Integer
iGparmImmedSts	Not used.	Integer Array [6]
iGparmDiagBits	Not used.	Integer Array [4]
sVersionString	The rvp9 software version number	String
iAntStatusMask	Not used.	Integer

Table 2. Pulse Header

Field Name	Description	Format
iVersion	Version number of PulseHdr structure	Integer
iFlags	Integer representation of a bitfield of trigger control flags: Bit 0 = Header and all associated data valid Bit 1 = One or more pulses missing prior to this Bit 2 = First pulse within trigger bank Bit 3 = Last pulse in trigger bank Bit 4 = Trigger bank just beginning (could be same bank Bit 5 = Triggers were blanked on this pulse More than one bit may be set if multiple conditions are met. Bits pertaining to trigger banks (2, 3, and 5) may be set but are unused by processing.	Integer
iMSecUTC	Milliseconds field of data acquisition time. See iTimeUTC.	Integer
iTimeUTC	Data acquisition time in seconds since 0:00 January 1, 1970	Integer

Field Name	Description	Format
	UTC.	
iBtimeAPI	Time in ms on internal clock when pulse arrived. Clock values range from 0 to 2^32-1 and are not relative to any external timesource.	Integer
iSysTime	IFD system clock time of pulse acquisition (see also fSyClkMHz in the PulseInfo structure)	Integer
iPrevPRT	IFD system clock ticks elapsed since previous pulse (for conversion to seconds, see fSyClkMHz in the PulseInfo structure)	Integer
iNextPRT	IFD system clock ticks until the next pulse (for conversion to seconds, see fSyClkMHz in the PulseInfo structure)	Integer
iSeqNum	Sequence number assigned to this pulse.	Integer
iAqMode	Not used.	Integer
iPolarBits	Not used.	Integer
iTxPhase	Phase angle of transmit data (16-bit binary angle)	Integer
iNanoUTC	Nanoseconds related to iTimeUTC	Integer
iAntStatus	Not used.	Integer
iPedAz	Azimuth relative to the pedestal (16-bit binary angle)	Integer
iPedEl	Elevation relative to the pedestal (16-bit binary angle)	Integer
iAzV	Not used.	Integer
iElV	Not used.	Integer
iAz	Azimuth relative to the Earth (16-bit binary angle)	Integer
iEl	Elevation relative to the Earth (16-bit binary angle)	Integer
iNumVecs	Total number of I&Q vectors in this pulse per channel	Integer
iMaxVecs	Not used.	Integer
iVIQPerBin	Number of receiver channels (2 for Dual-pol WSR-88D)	Integer
iTgBank	Not used.	Integer
iTgWave	Not used.	Integer
uiqPerm.iLong	User-specified Tag bits that would appear in all following pulse headers once set. One value for each channel.	Integer Array[2]
uiqOnce.iLong	User-specified Tag bits that appear in one pulse header once set. One value for each channel	Integer Array[2]
RX[0].fBurstMag	Not used.	Floating Point
RX[0].iBurstArg	Not used.	Integer
RX[1].fBurstMag	Not used.	Floating Point
RX[1].iBurstArg	Not used.	Integer
iUTags	Not used.	Integer
inu.iRoll	Not used.	Integer
inu.iPitch	Not used.	Integer
inu.iHead	Not used.	Integer
inu.RollV	Not used.	Integer
inu.PitchV	Not used.	Integer
inu.HeadV	Not used.	Integer
inu.iLatitude	Not used.	Integer
inu.iLongitude	Not used.	Integer
inu.iHeight	Not used.	Integer
inu.iVelEast	Not used.	Integer
inu.iVelNorth	Not used.	Integer
inu.iVelUp	Not used.	Integer

5 PULSE DATA

5.1 Description

WSR-88D I&Q data are packaged in "High SNR" format style to capture more Signal-to-Noise Ratio (SNR) detection compared to Vaisala "Legacy" packaging.
Each 16-bit floating point word (similar to binary16) is packaged in little-endian format such that:

- Mantissa (bits 0-10)
  - 12-bit signed integer
- Sign (bit 11)
  - Binary
- Exponent (bits 12-15)
  - 4-bit unsigned integer

The packaging interpretation differs depending on the Exponent. Use the following rules to determine the unpacked value (y).

- If the Exponent equals 0:
  - y = Mantissa * (2^(Exponent-25))
- Else (Exponent is non-zero):
  - If S = 0
    - x = [01][Mantissa] à a 13-bit signed integer
  - If S = 1
    - x = [10][Mantissa] à a 13-bit signed integer
    - y = x * (2^-24)

Formatted by I, Q pairs, the entry order is: I_{H1}, Q_{H1}, I_{H2}, Q_{H2},… I_{Hm}, Q_{Hm}, where *m* is the total number of I&Q vector pairs (as listed in iNumVecs in the PulseHdr). On a dual-polarization system, vertical channel pairs immediately follow after *m* Horizontal pairs: I_{V1}, Q_{V1}, I_{V2}, Q_{V2},… I_{Vm}, Q_{Vm}. There are the same number of pairs in H and V for a dual-polarization system. The next PulseHdr block follows the last I&Q pair unless it is the end of a file. There is not a specific line to mark the end of a file.

APPENDIX A. GLOSSARY

Acronym/Abbreviation	Description
ASCII	American Standard Code for Information Interchange
ICAO	International Civil Aviation Organization
ICD	Interface Control Diagram
IFD	Intermediate Frequency Digitizer
IQ	In-Phase and Quadrature
FFT	Fast Fourier Transform
NCAR	National Center for Atmospheric Research
NSSL	National Severe Storms Laboratory
PPI	Plan Position Indicator
PRT	Pulse Repetition Time
RCP	Radar Control Processor
RDA	Radar Data Acquisition
RFC	Request For Comment
ROC	Radar Operations Center
RPG	Radar Product Generator
RVP	Radar Signal Processor
RxRN	Radial by Radial Noise
SAILS	Supplemental Adaptive Intra-Volume Low-Level Scan
SNR	Signal to Noise Ratio
SZ-2	Sachidinanda-Zrnić – 2
TS	Time Series
VCP	Volume Coverage Pattern
WSR-88D	Weather Surveillance Radar-1988 Doppler
UTC	Universal Coordinated Time
Zdr	Differential Reflectivity