Digital Modular Radio (DMR) AN/USC-61 (C)

Appendix W of the DMR External RF Control Interface: Ethernet Message Details for the 100W-A and 200W-A VHF/UHF RF Power Amplifiers

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Document Technical History

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-	3/02/2005	Initial Release	B Clark
A	12/16/2005	- updated 'Scope' and 'Effectivity' paragraphs - added MAC address range - added description of power control /display format - moved ALC slew rate from 'reset' to 'retained' - edited to pick up 'as-built' details of Power Resolution, RF Power Level, and Software Download messages	B Clark
B	03/08/2007	- corrected text for watchdog timer in status message description. Watchdog timer is required for the 100W-A PA	B Clark

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1 General Information

1.1 Scope

This document is a an appendix to the External RF Control Interface Control Document (ICD). It is an application-specific extension to Appendix C of the DMR External RF Control Interface, Ethernet Messages ICD. This document is intended for use by radio and power amplifier development teams.

The charter of this ICD is to provide details of selected Ethernet messages that define the software control interface between the DMR radio and two models of RF high power amplifiers (HPA): 100-A very high frequency (VHF) / ultra high frequency (UHF) HPA, and 200W-A VHF/UHF HPA. Except where specifically noted, document material applies to all three HPAs. Message formats and general message field descriptions are contained in the Ethernet message (Appendix C) document. This ICD also includes low-level details of selected control and indicator requirements, an extension of the 100W-A and 200W-A HPA specification.

This document represents remote (External RF Ethernet) control requirements for the 100W-A and 200W-A HPAs. The use of 'Shall' has been intentionally omitted from the text to improve document readability. However, all application-specific numerical values and text (identified by "quotes") contained in message field descriptions represent absolute requirements.

1.2 Effectivity

The original version of this document was the basis for the development of the 100W-A and 200W-A HPA. The document has evolved along with the continued development of HPAs, the DMR HPA specification, and the DMR external RF control Ethernet message ICD. A complete revision history is retained by DMR configuration management.

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1.3 Ethernet Network Overview

The DMR radio communicates with external RF network components, such as RF power amplifiers through a private, MAC layer (2) IEEE 802.3 compliant 100Base-TX External RF network (Figure 1). The network is labeled 'private' because only external RF (Ext RF) components use the network. The radio also has a TCP/IP Ethernet port that connects the radio to the remote human/machine interface (HMI). The TCP/IP network is not available to the power amplifiers. The radio is master of the External RF control network. All External RF network components are slaves to the radio. Other than specific noted exceptions (Table 3), the radio initiates all network communications.

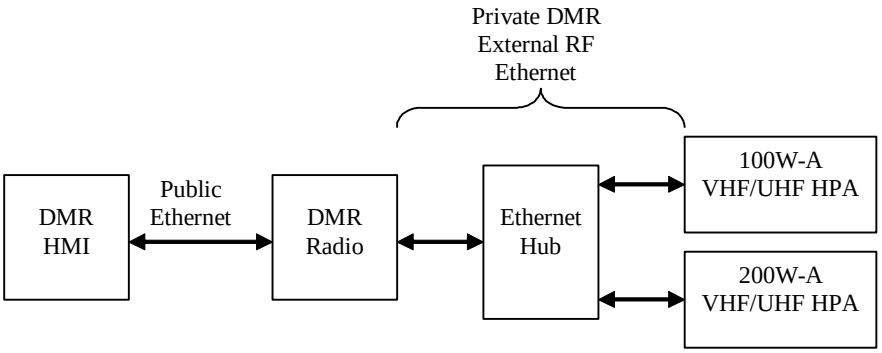

Figure 1 External RF Ethernet Context Diagram

1.4 Abbreviations and Acronyms

ALC	Automatic Level Control
BIT	Built-in-Test
CDC	Channel Discrete Control
DDC	Device Discrete Control
DMR	Digital Modular Radio
FPGA	Field Programmable Gate Array
GDC	Global Discrete Control
HPA	High Power Amplifier
I/O	Input / output
ICD	Interface Control Document
ITU	(DMR) Information Transfer Unit
MAC	Medium Access Control
PA	Power Amplifier
RF	Radio Frequency
RX	Receive
TX	Transmit
WPR	Waveform Power Ratio, a.k.a Peak Power Ratio (PPR)

2 Referenced Documents

The following documents form a part of this document to the extent specified herein. The listed documents are normally available from the organization that prepare or which distribute the documents. They may also be available through other informational services.

In the event of a conflict between the text of this document and the references cited herein, the text of the Requirements Specification document takes precedence.

IEEE-802.3/ (u, z)	Ethernet Physical Protocol Layer Specifications (IEEE-802.3u/100 Mbps, IEEE-802.3z/Full Duplex)
70-P41401M	Appendix C, DMR External RF Control Interface, Ethernet Messages, General Dynamics.

3 Ethernet Messages

3.1 Introduction

The External RF control network uses Ethernet MAC layer (2) packets for communication (Figure 1). The DMR-specific control message is embedded in the User Defined field of the packet. External RF Ethernet messages are custom designed to provide efficient control of the network components. Each packet contains a source address, destination address, message length, message ID, message data, and minimal required Ethernet overhead. External RF Ethernet packet details are contained in Appendix C of the DMR External RF Control, Ethernet Messages ICD.

3.2 Address Scope

External RF components monitor the network for control messages that contain one of three levels of destination address scope: 1) Global multicast, 2) Channel multicast, and 3) Device. Global multicast messages apply to all network components. Channel multicast messages apply to a group of network components assigned to the same (of multiple) DMR RF channel. Device messages apply to a single network component assigned to a matching (Ethernet) MAC address. Unique MAC addresses are assigned at time of product manufacture.

Message scope is listed in Table 3 , along with each message ID label. ‘Channel’ and ‘Device’ messages are essentially the same, differing only by the address (scope) and ID. ‘Channel’ and ‘Device’ (scope) messages contain a single set of control data. ‘Global’ messages, however, contain data sets for at least four DMR external RF channels. The radio-assigned RF channel number provides a pointer to HPA applicable ‘Global’ message data.

Except for specifically noted exceptions (Table 3), the HPA uses message address (scope) and ID in the following manner:

1. Determine message address is: a) global, b) same as assigned channel, c) same as unique device MAC
2. For messages addressed to the HPA, use message ID to determine radio-requested function
3. Use address (scope) to determine location of ‘Global’, ‘Channel’, or ‘Device’ message data

Each 100W-A and 200W-A HPA has a unique (Ethernet) MAC address. The addresses are located within a block having a specific prefix code – an Organizationally Unique Identifier (OUI/Company ID). DMR use of the External RF network OUI prefix “OA-00-3E” is authorized by the IEEE Registration Authority.

non-ALC capable 100W-A HPA MAC address range:
0A-00-3E-00-9C-40 through 0A-00-3E-00-EA-5F

ALC capable 100W-A HPA MAC address range:
0A-00-3E-03-00-00 through 0A-00-3E-03-FF-FF

200W-A HPA MAC address range:
0A-00-3E-05-00-00 through 0A-00-3E-05-FF-FF

3.3 Ethernet Message Timing

High-level event timing, such as transmit ON/OFF transitions, is contained in applicable HPA specification documents. Specified time intervals are referenced to receipt of the last bit of the applicable Ethernet command message. Waveform-to-device network timing was considered during creation of the HPA specifications. HPA Ethernet port/message timing addresses low-level monitoring of network activity.

The radio’s DMR External RF Ethernet port is capable of initiating network commands at a nominal 65K message/second rate. Although individual waveforms do not require this throughput rate, radio execution of multiple high-speed waveforms may load the network at its maximum rate for short durations. This means HPAs must be capable of monitoring network activity for matching address (Global, Channel, Device) messages at the maximum rate.

When the network is running at maximum rate, the predominant message type is Global Discrete Control (GDC). One message is generated for each transition of any of the message's (twenty+) data fields. GDC message data field transitions are determined by the radio's RF channel waveform – five data fields per RF channel. Some waveforms use none of the GDC message data fields, others may use all five. Each GDC message contains the most recent transition state along with the current state all other data fields. Depending on waveform timing, a single GDC message may contain new transitions from multiple waveforms.

The Global Discrete Control message performs another service, the combining of Channel Discrete Control (CDC) or Device Discrete Control (DDC) message data with GDC message data. This is possible because the GDC message picks up the most recent CDC or DDC message states for channels (waveforms) that are not using GDC controls. CDC and DDC messages are interlaced with GDC messages, but occur at very slow rates when compared to typical GDC message rates. As described in the Ethernet message ICD, CDC and DDC messages contain a single-channel set of GDC message fields. The combining capability of the GDC message means the HPA is always set to the correct Duplex, Transmit Keyline, or Strobe state, whether the device is controlled by a high-speed or low-speed waveform.

All DMR Ethernet control messages contain a priority field, which indicates the urgency of processing the message. Nearly all of the control messages are set to 'Setup' priority (00 hex), which indicates the message is processed in a first in – first out order. Assuming the HPA received message queue is empty, the HPA should start processing a new message within 100 micro-seconds (nominal) of receipt. An 'Immediate' priority (03 hex) message must be processed as soon as possible because the message contains a control parameter(s) that has significant impact on waveform performance. The HPA must interrupt its current task to process an 'Immediate' priority message. The GDC message is always transmitted with an 'Immediate' priority.

3.4 HPA Ethernet Message Vocabulary

The radio communicates with the HPA through the message vocabulary listed in Table 3. Each table entry lists the generic message name, the message ID (hex number), scope (global, channel, device), direction (to / from HPA), and HPA response to the message. The message table is arranged by functional groups such as HPA startup (reset, query request and response, and status request and response), rather than by numeric order.

The numeric references in the Message Name/ID column of are the message ID listed in the DMR External RF Ethernet message ICD. General message functionality and data fields are described in the ICD. Table 3 of this document describes how the HPA processes the message. HPA Type is listed for selected messages and data field descriptions to indicate HPA-specific applications.

Refer to the applicable HPA requirement documents and the External RF Control Ethernet Message ICD for data field tolerances, and thresholds (Section 2).

3.5 Terminology Applicable to HPA Control

3.5.1 RF Power Notes

The following terms are used throughout the message description portion of this document (Table 3).

The terms 'keyOFF' and 'keyON' apply to the power-producing state of the HPA RF transmit path, independent of the application of RF power at the HPA transmit path input (J1). 'KeyOFF' indicates the transmit path is disabled. The HPA transmit path input is isolated from the transmit path output while the HPA is set to 'keyOFF'. 'KeyON' indicates the HPA transmit path is enabled. RF power applied to the HPA transmit path input is amplified and passed through to the transmit path output while the HPA is set to 'keyON'.

The terms 'amplitude modulated' and 'non-amplitude modulated' describe general RF performance of DMR waveforms. 'Amplitude modulated' (AM) indicates the waveform modulates the RF carrier with an amplitude-varying signal. Amplitude modulation affects transmitted signal power. 'Non-amplitude modulated' (constant amplitude) indicates the modulated waveform has relatively constant amplitude. Non-amplitude modulation has little or no effect on transmitted signal power. The terms 'Non-amplitude modulated' and 'constant amplitude' are used interchangeably throughout this document. Some DMR 'constant amplitude' waveforms may contain small AM components.

The terms ‘peak’ power, ‘average’ power, and ‘peak-to-average power ratio’ characterize HPA RF power control and power measurements (Figure 2). The terms apply to all DMR amplitude modulated and non-amplitude modulated (constant amplitude) waveforms.

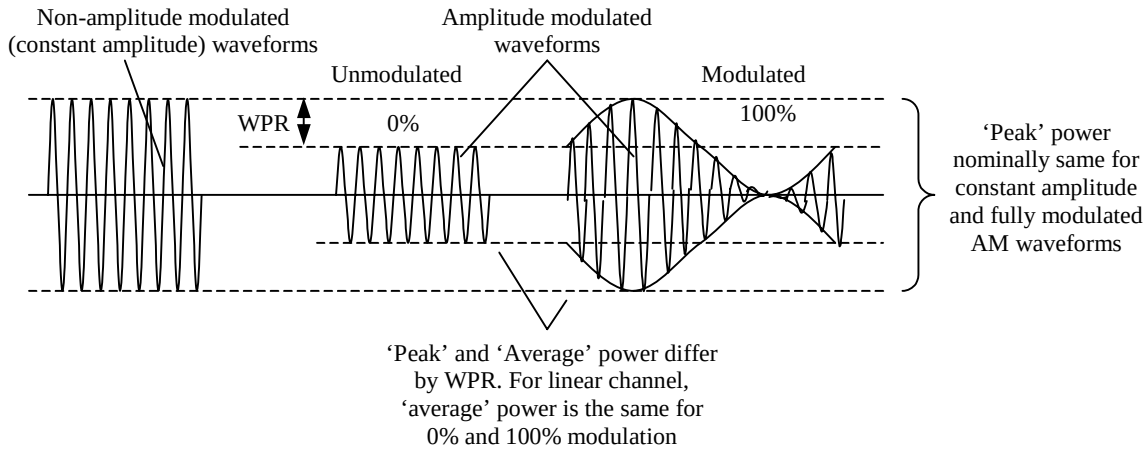

Figure 2 DMR Waveform Power Ethernet Message Descriptions

‘Peak’ power, as used in this document, represents instantaneous waveform power, measured at the waveform’s largest voltage excursions. For an amplitude-modulated (AM) signal, ‘peak’ power represents the instantaneous power measured at (full modulation) signal maxima (Figure 2). For a non-amplitude modulated (constant amplitude) signal, ‘peak’ power represents the power measured at any point in time. All DMR waveforms – either constant amplitude or amplitude-modulated – are designed to output the same nominal ‘peak’ power for any operator-selected power, as measured at the radio and the HPA RF outputs.

HPA input and output power controls are set to waveform ‘peak’ power levels. The input power control represents ‘peak’ waveform power measured at the radio output (HPA input). The output power control represents ‘peak’ waveform power measured at the HPA output, assuming the RF power applied to the HPA input is within the specified operating range of the (HPA) input power control setting. For DMR, all commanded input and output power control settings are reported in the Ethernet status response message are ‘peak’ values.

‘Average’ power, as used in this document, represents the long-term integrated average of measured modulated or unmodulated RF signal power. Lab style RF power meters normally measure and display ‘average’ power. In a linear system, ‘average’ power represents basic carrier power, independent of the (< 100%) percentage of amplitude modulation applied to the carrier or the waveform’s peak-to-average power ratio (next paragraph). For DMR, all power values measured at HPA input and output sensors are displayed on the (HPA) operator panel and reported in the Ethernet status response message as ‘average’ (long-term integrated) power.

‘Peak-to-average power ratio’, expressed in dB, represents the difference between ‘peak’ and ‘average’ power of a signal having an amplitude-modulated component. For DMR, the term ‘waveform power ratio’ (WPR) is equivalent to the term ‘peak-to-average power ratio’, and is used throughout this document as such. WPR information is contained in the (output) Power Set message.

A WPR value of 6 dB indicates the waveform’s full-modulation ‘peak’ power is 6 dB greater than its unmodulated power. DMR constant-amplitude waveforms typically have a WPR of 0 dB, which means signal power is essentially the same whether the waveform is modulated or unmodulated.

WPR affects HPA operation in two ways: 1) display of commanded power settings, and 2) output power control range. WPR effect on output power control range is applicable only to the 100W-A HPA.

The HPA-displayed value of commanded (‘peak’) input and output power control settings are reduced by the most recent commanded WPR to correlate the values displayed on the HPA operator panel with those displayed on the radio operator panel. The WPR offset applied to (HPA) displayed data has no affect on HPA operation or on data contained in the Ethernet status response message. Examples of WPR effect on commanded and displayed power control settings are listed in Table 1.

The 100W-A HPA uses WPR to select the range of available output power. The (100W-A) HPA has an available output power range of 43 to 53 dBm (‘peak’, 37 to 47 dBm ‘average’) when the radio-supplied WPR indicates the HPA is operating with an amplitude-modulated waveform. The (100W-A) HPA has an available output power range of 40 to 50 dBm (‘peak’ or ‘average’) when the WPR indicates the HPA is operating with a non-amplitude (constant amplitude) waveform. All Ethernet power controls are ‘peak’ values.

Table 1 WPR Affect on Displayed Power Controls

WPR	Commanded Input Power Control (‘peak’)	Displayed Input Power Control (‘average’)
0	0	0
0	5	5
6	0	-6
6	5	-1

WPR	Commanded Output Power Control (‘peak’)	Displayed Output Power Control (‘average’)
0	43	43
0	53	53
6	43	37
6	53	47

3.5.2 Power Control and Indicator Display Formats

The following notes apply to the display of measured input power, measured output power, and power controls on the HPA operator panel. All DMR power amplifiers display power controls and indicators in the same manner.

The DMR RF power amplifiers are required to display power controls and indicators with 0.1 dB or 1 watt resolution. The following provides additional details for the recommended implementation of the requirement. The notes assume the HPA measures power with a fractional (i.e 0.1 dB, 0.25 dB) resolution.

Customer direction requires all power values are to be displayed with a max of two decimal places. Doing so improves the readability of power controls and indicators when the PA is configured for watt (power display) format. DMR further decomposed customer direction by adding ‘watt’, ‘mW’, ‘µW’ labels to displayed watt-format power values. The use of labels allows the display of all watt power values as integers, i.e.: '1 W', '10 mW', '950 uW'. Even though '0.25 W' is the same as '250 mW’, DMR recommends displaying the value as an all-integer value (‘mW’).

Power controls are ‘constant’. Input and output power control ranges are listed in Table 2. The HPA Maximum output power limiter range (not shown) is the same as the Output Power control range

Table 2 HPA Power Control Ranges

Power Control	100W-A	200W-A
Input Power	-20 through +15 dBm	-20 through +15 dBm
Output Power AM waveform mode	37 through 47 dBm	40 through 53 dBm
Output Power non-AM waveform mode	40 through 50 dBm	40 through 53 dBm

Measured power is variable. When the PA is configured to display measured power in dB units, simply display the measured value. When the PA is configured to display measured power in watt units, the PA needs to either calculate the watt equivalent of the measured dB value or display a value stored in a look-up table.

3.6 Ethernet Message Descriptions

HPA-specific DMR External Control Ethernet messages are listed in Table 3. Applicable command message fields are specifically listed (**bold labels**) in the message descriptions. Specific response message fields are addressed in message descriptions when additional implementation details are available or necessary.

Table 3 Power Amplifier Ethernet Message Vocabulary

Message Name / ID (hex) / Scope / HPA Type	**Direction**	**HPA Action**
Reset Complete (1F - device)	from HPA	The HPA spontaneously outputs this message through the Ethernet port to indicate completion of a power-on-reset sequence. The message is output without solicitation from the DMR radio, regardless of Talk Mode state. The Reset Status field indicates the reason for transmission of the message. The ALC-capable 100W-A HPA and the 200W-A HPA report the following codes during restart. The code descriptions provide additional detail to the reset complete message: Status — Description 00 — boot and application programs OK 01 — application program error 02 — boot program error A reset event is apparent on the HPA operator panel by a momentary blanking of the display during the startup process.
Reset (1C – global) (1D – channel) (1E – device)	to HPA	**Reset field:** Restarts the HPA, the same as power-on-reset. The following tables list HPA parameters, and their reset state. The (**Value** column) 'retained' value indicates the parameter retains the commanded state prior to the most recent power cycle or reset. **Controls** — **Value** — **Description/State** Channel ID — retained — remote ITU channel select Control Mode — retained — selects REMOTE, LOCAL control Duplex — retained — selects HALF, FULL TX path Frequency — retained — operating frequency Input Power — retained — input RF power control Output Power — retained — output RF power control Mute — retained — (remote) mute state WPR — retained — waveform power ratio ALC slew rate — retained — selects FAST, SLOW slew rate ALC mode — reset — ALC ON/OFF: ON Operator panel lock — reset — operator panel: ENABLED Power resolution — reset — reported power resolution: 1 dB Talk mode — reset — Talk Mode: DISABLED Test - loop-back — reset — loop-back: DISABLED TX keyline — reset — TX path: keyOFF (RX enabled)

Message Name / ID (hex) / Scope / HPA Type	Direction	HPA Action
		(Continued from previous page) **Indicators** / **Value** / **Description/State** Ethernet Address / retained / HPA MAC address data indicators / reset / displays current data fault monitors / reset / displays current state **Discrete Inputs** / **Value** / **Description** TX Enable / reset / discrete input: DISABLED TX Inhibit / reset / discrete input: ENABLED Displayed ALC mode and ALC slew rate shown for 200W-A and ALC-capable 100W-A HPA. Non-ALC capable 100W-A HPA (sets) and reports ALC mode as OFF, and ALC slew rate as 'not selected'. Retained or reset values are reported in applicable fields in the Status Response message, and displayed in applicable fields of the HPA operator panel. 'Discrete Inputs' are momentarily reset during a commanded reset or power-on-reset. When (retained) Control Mode is set to LOCAL, discrete TX Enable and TX Inhibit controls assume the state of their applicable input.
Query Request (30 – global) (2E – device)	to HPA	**Response Message Type field:** Per value contained in the Response Message Type field, the HPA outputs one of the following messages (data values in () are hex constants) : 01 = Device Query Response – Long message (ID 31) 02 = Device Query Response – Short message (ID 32) 03 = Device Query Response – ASCII message (ID 33) To accommodate legacy DMR RF control implementation, the HPA must respond to a Global Query Request message when it contains a Global multicast destination address or a Device destination address. The HPA responds to a Device Query Request message only when it contains a Device destination address, but not when it contains a Global multicast destination address. An HPA operator panel indication of a Query Request/Response sequence is not required.
Query Response – Long (31 - device)	from HPA	The HPA reports the following information when the (Query message) Message Type Field set is to '1'. Field data is left-justified, (right) padded with space (0x20) characters. Offsets are decimal. Data values in () are hex constants. **100W-A HPA** **Field Name** / **Offset (bytes)** / **Values/Labels** Device Type / 2 / (01) 100W, 200W HPA BIT Status / 3 / 1-byte latest HPA status Frequency Limit – High / 4 / (0190) 400 MHz max freq Frequency Limit - Low / 6 / (001E) 30 MHz min freq Max (peak) Power In / 8 / (0F) 15 dBm max input Max (peak) Power Out / 9 / 1-byte, max output capability* Number of Channels / 10 / (01) single channel device Command Speed Type / 11 / (00) full command speed

Message Name / ID (hex) / Scope / HPA Type	Direction	HPA Action
		(Continued from previous page) Reserved 12 (00) not used PA serial number 16 8-ASCII characters PA Title 24 “DMR 100-A Power Amp ” PA part number label 48 “Part Number: ” PA part number: 64 8-ASCII characters PA hardware version label 72 “Hardware Ver: ” PA hardware version: 88 8-ASCII characters PA software version label 96 “PA Software Ver: ” PA software version: 112 MM-FF-RR PA boot version label 120 “PA Boot Ver: ” PA boot version: 136 MM-FF-RR PA FPGA version label 144 “PA FPGA Ver: ” PA FPGA version: 160 MM-FF-RR E-net part number label 168 “E-net Part Num: “ E-net part number 184 16-ASCII characters E-net serial number label 200 “E-net Ser Num: “ E-net serial number 216 8-ASCII characters E-net hardware version label 224 “E-net HW Ver: “ E-net hardware version 240 MM-FF-RR E-net software version label 248 “PA E-net Ver: ” E-net software version: 264 MM-FF-RR E-net boot version label 272 “E-net Boot Ver: “ E-net boot version 288 MM-FF-RR E-net FPGA version label 296 “E-net FPGA Ver: ” E-net FPGA version 312 MM-FF-RR Device Type is always reported as ‘01’ (hex) for the 100W-A and 200W-A PA This is so the ‘A’ PAs are interchangeable with legacy 100W and 200W PAs *Max Power Output field indicates CW power. 100W-A PA reports 50 dBm (32 hex) as max power capability 200W-A PA reports 53 dBm (35 hex) as max power capability Note: the 100W-A HPA is capable of 52.5 dBm peak when configured for AM, but always reports CW value of 50 dBm as max power capability PA Part numbers are vendor-specific 100200-1 100W-A ALC capable HPA 10390A 100W-A non-ALC capable HPA 26000-2 200W-A HPA HPA Hardware Version is vendor-specific, and is subject to change Software Version format is MM-FF-RR, where: MM = major release, indicates not compatible with previous versions FF = functional release, new feature, compatible with prior HW, SW RR = (minor) defect repair. ‘MM-FF-RR’ label is listed for all HPA software components. Change labels to “N/A” for software components not used in the production unit.

Message Name / ID (hex) / Scope / HPA Type	Direction	HPA Action
		(Continued from previous page) Ethernet (E-net) and FPGA software field entries are included in the response message when applicable to the HPA design. An HPA operator panel indication of a Query Request/Response sequence is not required.
Query Response – Short (32 - device)	from HPA	The HPA reports the following information when the (Query message) Message Type Field set is to ‘2’. Field data is left-justified, (right) padded with space (0x20) characters. Offsets are decimal. Data values are hex. Field Name — Offset — Description, label Device Type — 2 — (01) 100W, 200W HPA BIT Status — 3 — (hex) latest HPA status Device Type is always reported as ‘01’ (hex) for the 100W-A and 200W-A PA This is so the new PAs are interchangeable with older 100W and 200W PAs An HPA operator panel indication of a Query Request/Response sequence is not required.
Query Response – ASCII (33 - device)	from HPA	The HPA reports the following information when the (Query message) Message Type Field set is to ‘3’. Field data is left justified, (right) padded with space (0x20) characters. Offsets are decimal **Field Name — Offset (bytes) — Description, label** PA serial number: — 2 — 8-ASCII characters PA Title — 10 — 24 chars, same as ‘Long’ msg PA part number label — 34 — “Part Number: ” PA part number: — 50 — 8-ASCII characters PA hardware version label — 58 — “Hardware Ver: ” PA hardware version: — 74 — 8-ASCII characters PA software version label — 82 — “PA Software Ver: ” PA software version: — 98 — MM-FF-RR** PA boot version label — 106 — “PA Boot Ver: ” PA boot version: — 122 — MM-FF-RR** PA FPGA version label — 130 — “PA FPGA Ver: ” PA FPGA version: — 146 — MM-FF-RR** E-net part number label — 154 — “E-net Part Num: “ E-net part number — 170 — 16-ASCII characters E-net serial number label — 186 — “E-net Ser Num: “ E-net serial number — 202 — 8-ASCII characters E-net hardware version label — 210 — “E-net HW Ver: “ E-net hardware version — 226 — MM-FF-RR E-net software version label — 234 — “PA E-net Ver: ” E-net software version: — 250 — MM-FF-RR E-net boot version label — 258 — “E-net Boot Ver: “ E-net boot version — 274 — MM-FF-RR E-net FPGA version label — 282 — “E-net FPGA Ver: ” E-net FPGA version — 298 — MM-FF-RR

Message Name / ID (hex) / Scope / HPA Type	Direction	HPA Action
		(Continued from previous page) PA Part numbers are vendor-specific 100200-1 100W-A ALC capable HPA 10390A 100W-A non-ALC capable HPA 26000-2 200W-A HPA HPA Hardware Version is vendor-specific, and is subject to change Software Version format is MM-FF-RR, where: MM = major release, indicates not compatible with previous versions FF = functional release, new feature, compatible with prior HW, SW RR = (minor) defect repair. 'MM-FF-RR' label is listed for all HPA software components. Change labels to "N/A" for software components not used in the production unit. Ethernet (E-net) and FPGA items are included in the response message only when applicable to the HPA design. An HPA operator panel indication of a Query Request/Response sequence is not required.
Status Request (36 – device)	to HPA	**BIT Request field:** Requests recent HPA status and/or execution of HPA BIT. The HPA generates one Status Response message for each Status Request message. The HPA executes BIT upon request. Operational parameters may be altered during BIT. The Status Request message, along with any radio-generated command message, provides a refresh for the Ethernet port watchdog timer. The HPA performs the following actions when a command (Status Request) message has not been received during the previous 10 second (nominal) period: - sets the transmit path to keyOFF state - sets Transmitter State field of Status Response message to keyOFF - discards discrete input or Ethernet commands to keyON - allows use of transmit path commands after Status Requests resume 100W-A HPA The watchdog timer is optional for the 100W-A HPA. When implemented, performs the same as the 200W-A HPA. A text message, such as "Testing", is displayed on the operator panel while the HPA is executing commanded BIT. A Status Response message is transmitted upon completion of BIT.

<table>
<tr><th>Message Name / ID (hex) / Scope / HPA Type</th><th>Direction</th><th>HPA Action</th></tr>
<tr><td>Status Response
(37 - device)</td><td>from HPA</td><td>
The HPA reports the most recent measured performance data in the Status Response message. Data may be measured upon receipt of the Status Request message. The following notes provide specific details applicable to the HF HPA Status Response message. Field IDs are decimal offsets. Data values are hex. Numbers in () are decimal message field locators.

The following fields are constant:
<table>
<tr><th>Field ID</th><th>Description</th><th>Value</th><th>Notes</th></tr>
<tr><td>(2)</td><td>Device Type</td><td>01</td><td>100W, 200W HPA</td></tr>
<tr><td>(4)</td><td>BIT LRU</td><td>00</td><td>serviced as single LRU</td></tr>
<tr><td>(17)</td><td>Blocking Mode</td><td>00</td><td>N/A, constant value</td></tr>
<tr><td>(19)</td><td>Extended Message</td><td>FF</td><td>N/A, constant value</td></tr>
<tr><td>(26)</td><td>SYSCAL Status</td><td>hex</td><td>100W-A non-ALC HPA</td></tr>
<tr><td>(27)</td><td>SYSCAL Offset</td><td>hex</td><td>100W-A non-ALC HPA</td></tr>
</table>

Device Type is always reported as ‘01’ (hex) for the 100W-A and 200W-A PA This is so the ‘A’ PAs are interchangeable with legacy 100W and 200W PAs

The SYSCAL Status field (26) and SYSCAL Offset field (27) are used only by the 100W-A non-ALC HPA. ALC capable HPAs set these fields to ‘00’.

The Fault Class field (15) reports ‘SERIOUS’ for all HPA (BIT) detected faults: High Temp (23), Low Power Supplies (24, 35), Excessive VSWR (25).

Warning event fields: Low Output Power (22), High Input Power (33), and High Output Power (34), are reported in the status message, but not included in the Fault Class field (15) status. For the non-ALC capable 100W HPA, the ALC ON/OFF field (16) is always reported as OFF ‘00’ and the ALC Slew Rate field (27) is always reported as ‘not selected’ ‘00’.

Measured data tolerances, alert thresholds, and warning thresholds are listed in the HF HPA specification.

Power measurements are reported with fixed and programmable resolution, and as signed and unsigned numbers. Status message fields are described in the DMR External RF Control Ethernet message ICD.

Commanded input and output power control settings are reported in the Status Response message as ‘peak’ (paragraph 3.5).

HPA measured input and output RF power is reported in Status Response message and displayed to operator on HPA control panel as ‘average’ power (paragraph 3.5).

The Status Request/Response sequence is exclusive to Ethernet port (remote) operation, and is not directly displayed on the HPA operator panel.

The current state of all HPA controls, whether set through the Ethernet port or operator panel, is reported in applicable fields of the status response message.
</td></tr>
</table>

Message Name / ID (hex) / Scope / HPA Type	Direction	HPA Action
Power Resolution (63 – device)	to HPA	**Power Resolution field:** Configures reporting resolution of Status Response message RF power data fields, including: **Field ID** / **Field Name** / **Description** 8 / Power In / measured HPA input power 9 / Power Out / measured HPA output power 10 / Power Reflected / power reflected into HPA output port 11 / VSWR / variable, calculated portion of VSWR ratio Power Out, Power Reflected, and VSWR data fields contain unsigned number values. Although values less than 0 dBm may be measured for these fields, the HPA limits the reported power value at 0 dBm. Power Resolution is exclusive to the measured input and output power fields of the Status Response message. An HPA operator panel indication of Power Resolution state is not required. Power Resolution is not retained during power cycles, and defaults to 1 dB resolution during power-on-reset.
Channel Assignment (34 – device)	to HPA	Assigns a radio RF channel ID to the HPA. Once assigned to a DMR RF channel, the HF HPA also responds to all Channel multicast messages having the same (channel) MAC address as previously assigned to the PA. By default, the HPA responds to all Device (Ethernet) messages addressed to the HPA's unique factory-installed MAC address, and to all Global multicast messages. A block of unique MAC addresses is provided with the HPA purchase order. The Channel Assignment message used with the HF HPA contains only one Channel Number/Channel Address pair, located in the First/Self Channel Number fields. **Channel Number field**: defines where HPA applicable data is located inside Global multicast messages. The HPA discards Global multicast control messages such as Discrete Control, Frequency Set, and Power Set when assigned to channel '0'. The HPA always responds to Global Query request messages. **Channel Address field**: contains the specific channel multicast (MAC) address of the logical group of DMR RF components containing the HPA. Commanded Channel Assignment is reported in the Channel Number field of the Status Response message, and displayed in the DMR RF Channel ID field of the HPA operator panel. The most recent RF Channel assignment is retained during power cycles.

Message Name / ID (hex) / Scope / HPA Type	Direction	HPA Action
RF Power Level Set (62 – device)	to HPA	Sets the Input Power component of transmit path gain. HPA output power is determined by the combination of input power and output power controls, and RF power applied to the HPA TX input. Message data values are hex. Equivalent RF power values are decimal. **ITU Output Power field** 100W-A HPA all WPR: D8 through 28 (-20 through +15 dBm), 0.5 dB resolution 200W-A HPA all WPR: D8 through 28 (-20 through +15 dBm), 0.5 dB resolution The ITU Output Power field value has 0.5 dB resolution. Therefore, the ITU Output Power data field contains a value twice the magnitude of the HPA Input Power setting. For example, to set the HPA Input Power control to +5 dBm, the ITU Output Power field contains a value of +10 (0A hex). To set the Input Power control to -5 dBm, set the ITU Output Power field to -10 (F6 hex). ITU Output Power is always commanded as 'peak' (paragraph 3.5). The commanded ITU Output Power value is reported in the Commanded Input Power field of the Status Response message as 'peak'. The HPA Input Power Control is always set to the value contained in the ITU Output Power field. The Input Power Control setting is displayed on the HPA operator panel as 'peak' power, decreased by the WPR (paragraph 3.5) contained in the most recent Power Set message. The most recent Input Power control setting is retained during power cycles.
Power Set (0A – global) (0B – channel) (0C – device)	to HPA	Sets the Output Power component of transmit path gain. HPA output power is determined by the combination of input power and output power controls, and RF power applied to the HPA TX input. The 100W-A HPA has a dual power range: one for AM waveforms, and another for non-AM waveforms. The waveform type is defined by the Waveform Power Ratio (WPR) field. Message data values are hex. **RF Power Level field** 100W-A HPA non-AM WPR: 28 through 32 hex (40 through 50 dBm), 1 dB resolution AM WPR: 2B through 35 hex (43 through 53 dBm), 1 dB resolution 200W-A HPA all WPR: 28 through 35 hex (40 through 53 dBm), 1 dB resolution RF Power Level data sets the HPA output power control. RF Power Level data is always commanded as 'peak' (paragraph 3.5). Commanded RF output power is reported in the Commanded Output Power field of the Status Response message as 'peak'. The HPA Output Power control setting is always the same as the RF Power Level field value. The Output Power Control setting is displayed on the HPA operator panel as 'peak' power, decreased by the WPR (paragraph 3.5) contained in this message. The most recent Output Power control setting is retained during power cycles.

Message Name / ID (hex) / Scope / HPA Type	Direction	HPA Action
		(Continued from previous page) **Waveform Power Ratio (WPR) field** 100W-A HPA 00, 01, 03, 04, 05: configures HPA for non-AM waveform operation 02: configures HPA for hopping waveform operation 06, 07, 0A: configures HPA for AM waveform operation 200W-A HPA 02: configures HPA for hopping waveform operation Commanded WPR power is reported in the Commanded Waveform Power Ratio field of the Status Response message, and displayed on the HPA operator panel as "AM" for AM waveforms, "Non-AM" for non-AM waveforms, and "Hopping" for hopping waveforms. Paragraph 3.5 provides additional details of how WPR affects HPA operation. The Waveform Power Ratio control setting is retained during power cycles.
ALC ON/OFF (0D – channel) (0E – device)	to HPA	Non-ALC capable 100W-A PA: Message not applicable to this device ALC capable 100W-A PA, and 200W-A PA Configures HPA ALC ON/OFF and slew rate operation. **Automatic Level Control field** data sets the HPA ALC function to either ON/OFF (track/hold). HPA gain controls 'track' commanded output power when ALC is set to ON. HPA gain controls 'hold' at the values used to hold commanded output power at the time ALC is set to OFF. Commanded ALC ON/OFF state is reported in the ALC ON/OFF field of the Status Response message, and displayed in the ALC ON/OFF field of the HPA operator panel. **ALC Slew Rate field** data sets the HPA ALC function for either 'fast' or 'slow' attack (slew) rate. 'Fast' slew rates are used with peak waveforms. 'Slow' slew rates are used with waveforms having significant AM component. Commanded ALC Slew Rate state is reported in the ALC Slew Rate field of the Status Response message, and displayed in the ALC Slew Rate field of the HPA operator panel. For ALC-capable 100W-A and 200W-A HPAs, the ALC ON/OFF control is not retained during power cycles. ALC ON/OFF defaults to ON during a power-on-reset. ALC Slew Rate is retained during power cycles. ALC controls are not applicable for the non-ALC capable 100W-A HPA, and therefore always (set) report ALC ON/OFF as OFF and ALC Slew Rate as 'not selected'.
XALC ON/OFF (0F – channel) (10 – device)	to HPA	The HPA processes XALC ON/OFF messages the same as ALC ON/OFF messages.

Message Name / ID (hex) / Scope / HPA Type	Direction	HPA Action
Frequency Set (04 – global) (05 – channel) (06 – device)	to HPA	Configures HPA TX path and RX path frequency. **Effectivity Command field**: Values 0x00, 0x02, 0x04 – HPA immediately tunes to the frequency contained in the message. The HPA may cycle the transmit path output state (keyON / keyOFF / keyON), if necessary, to accomplish this task. Values 0x01, 0x03, 0x05 – HPA retains the received frequency for later use. The HPA tunes to the stored frequency upon receipt of the next low to high transition of the Discrete Control message STROBE field. The HPA overwrites a previously stored frequency with the new frequency, even if the HPA had not been tuned to the old frequency. **Frequency Resolution field**: per Appendix C of the DMR External RF Control Interface, Ethernet Messages ICD **Frequency Base field**: per Appendix C of the DMR External RF Control Interface, Ethernet Messages ICD Commanded Frequency is reported in the Frequency/Channel/Band Set field of the Status Response message, and displayed in the Frequency field of the HPA operator panel. The frequency value displayed on the HPA operator panel is replaced with a “Hopping” label while the HPA is configured to operate with a hopping waveform, described in the Power Set message. The most recent tuned frequency is retained during power cycles. A previously stored (but not tuned) frequency is not retained, and is replaced by the most recent tuned frequency during power-on-reset.
Frequency and Power Set (07 – global) (08 – channel) (09 – device)	to HPA	The HPA processes Frequency and Power Set messages as though receiving back-to-back Frequency Set and Power Set messages.
Discrete Control (01 – global) (02 – channel) (03 – device)	to HPA	Controls HPA transmit path operation when the HPA is set for remote control, and tunes the HPA to a previously stored frequency. Data values are hex. **Duplex field:** 100W-A, 200W-A HPA 00 – sets TX path to full duplex FF – sets TX path to half duplex Commanded Duplex state is reported in the Duplex field of the Status Response message, and displayed in the Duplex field on the HPA operator panel. Duplex is retained during power-on-reset. **Transmit Key field:** 100W-A, 200W-A HPA available only when: -- Discrete TX Inhibit (Deny/Permit) input set to ‘Permit’ -- Discrete Hardwire Option (message) is set for Ethernet control -- HPA HMI TX Mode is set for REMOTE operation

Message Name / ID (hex) / Scope / HPA Type	Direction	HPA Action
		(Continued from previous page) FF sets HPA transmit path to keyON 00 sets the transmit path to keyOFF The HPA transmit path is set to keyOFF, regardless of Transmit Key field value, when either: -- Discrete TX Inhibit (Deny/Permit) input is set to 'Deny' -- the Ethernet MUTE Set (message) is asserted (set to Mute) Commanded Transmit Key state, or EXT I/O TX Keyline state, is reported in the Transmitter State field of the Status Response message, and displayed as a Transmit indicator on the HPA operator panel. The HPA may limit display of the operator panel transmit indicator at a nominal 100mS ON/50mS OFF period when keyON/keyOFF activity exceeds this rate. Transmit Key is set to keyOFF during power-on-reset. **Strobe field:** 100W-A, 200W-A HPA - low to high transition tunes the HPA to the most recent stored (Frequency Set message) frequency. The transition may be discarded when no Frequency has been stored since the most recent reset. - transmit path must be in keyOFF state while the HPA tunes to new frequency. The HPA may set the transmit path to keyOFF state while tuning, and return to keyON state if the Transmit Key field was asserted (keyON state) at the time of Strobe transition. Strobe is a transition-only field, and is not affected by power cycles. Due to its transitory nature, Strobe state is not reported in the Status Response message or displayed on the operator panel. **Spare fields**: not used with the 100W-A / 200W-A HPAs. Discard these fields.

Message Name / ID (hex) / Scope / HPA Type	Direction	HPA Action
Discrete Hardwire Option (44 – device)	to HPA	Selects source of transmit path (keyline) control. The Discrete Hardwire Option message always sets all fields values to the same state. **Transmit/Receive Input Select field**: also known as Duplex 100W-A, 200W-A HPA 00 selects the Ethernet port (REMOTE mode) for Duplex control 0F selects the EXT I/O port (LOCAL mode) for Duplex control **Transmit key Input Select field**: 100W-A, 200W-A HPA 00 selects the Ethernet port (REMOTE mode) for keyline control 0F selects the EXT I/O port (LOCAL mode) for keyline control **Strobe Input Select field**: 100W-A, 200W-A HPA - not applicable to the HPAs. Frequency Strobe is always controlled through the Ethernet port. **Slow Command Priority field**: 100W-A, 200W-A HPA - not applicable to the HPAs. Discard field data. Commanded Discrete Hardwire state is reported in the Control Mode field of the Status Response message, and displayed in the TX Mode field of the HPA operator panel with a label similar to “CONTROL: LOCAL” or “CONTROL: Remote”. Transmit Key source selection is not retained during power cycles, and defaults to Ethernet (REMOTE) control during power-on-reset.
Mute Set (19 – global) (1A – channel) (1B – device)	to HPA	Qualifies the use of (Ethernet) Discrete Control message Transmit Key or EXT I/O (input) transmit path Keyline controls. This control is logically combined with the EXT I/O Transmit Inhibit input such that the assertion of either control disables the transmit path output. Data values are hex. Mute is also known as ‘Permit’/’Deny’. ‘Permit’ allows, and ‘Deny’ inhibits the use of Ethernet or EXT I/O Transmit Keyline controls.. **Mute Enable field:** 00 – allows (permits) the use of Ethernet Transmit Key or EXT I/O Transmit Keyline, providing the EXT I/O Transmit Inhibit signal is not asserted. FF – disables (denies) transmit path operation (no output), regardless of Ethernet Transmit Key or EXT I/O Transmit Keyline state. The HPA tracks transmit path Keyline control states while muted, and then sets the transmit path to the most recent commanded state when mute is set to non-asserted (permit) state. **Talk Mode field:** Commanded Mute state, or EXT I/O TX Inhibit state, is reported in the Mute State field of the Status Response message, and displayed the Mute field of the HPA operator panel The Mute Set state is retained during power cycles, to prevent unintentional keyON operation after a power-on-reset in which the HPA was muted (deny state) at the time of reset.

Message Name / ID (hex) / Scope / HPA Type	Direction	HPA Action
Talk Mode Set (3F – device)	to HPA	Controls spontaneous generation of Command Complete Response, Fault Response, and Command Error messages. Data values are hex. **Talk Mode field:** 01 disables generation of spontaneous response messages 02 enables generation of all spontaneous response messages 03 enables spontaneous generation of detected fault messages Talk Mode is exclusive to Ethernet communications. An HPA operator panel indication of Talk Mode state is not required. Talk Mode is not retained during power cycles, and defaults to 'PUPIL' (hex 01) during power-on-reset.
Command Complete Response (2F - device)	from HPA	When enabled by the Talk Mode Set message, the HPA outputs one Command Complete message after the processing associated with each command message has been completed. The HPA does not generate Command Complete Responses for messages that already solicit a response, such as Status Request. The Talk Mode/Command Complete Response message sequence is exclusive to Ethernet communications. An HPA operator panel indication of Talk Mode / Command Complete Response activity is not required.
Fault Response (3E – device)	from HPA	When enabled by the Talk Mode Set message, the HPA outputs 'real time' reports of detected faults. One message is generated for each fault event. A Fault Response message is not generated to indicate a cleared fault. Items reported in the Fault Response message include: **Fault Event** — **Description** Excessive Temperature — combined status of all temperature monitors Low Power Supply — combined status of all power supplies Excessive VSWR — VSWR load on HPA output is excessive All faults are reported as serious in the Status Response message. The Talk Mode/Fault Response message sequence is exclusive to Ethernet communications. An HPA operator panel indication of Talk Mode/Fault Response activity is not required.
Command Error Response (40 - device)	from HPA	When enabled by the Talk Mode Set message, the HPA outputs this message when an error has been detected in the most recent command message. The response returns the ID of the faulted message. The Talk Mode/Command Error message sequence is exclusive to Ethernet communications. An HPA operator panel indication of Talk Mode/Command Error activity is not required.

Message Name / ID (hex) / Scope / HPA Type	Direction	HPA Action
Local Lockout (43 – device)	to HPA	**Local Lockout field:** Controls access to the HPA operator panel. Data values are hex. FF inhibits the use of HPA operator panel controls 00 enables the use of HPA operator panel controls Commanded Local Lockout state is reported in the Operator Lockout field of the Status Response message. A text message, such as "Lockout", is displayed on the HPA operator panel while access to the panel is inhibited. The Local Lockout state is not retained during power cycles, and defaults to allow use of operator panel controls during power-on-reset.
Software Download (FF – device)	to HPA	Provides the means to update HPA software through the Ethernet port. The HPA transmits one Software Download Status message for each Software Download message. Receipt of a complete program package is reported in the final status message. The download function is capable of detecting errors during the download. The status of each message status is reported in the subsequent status message. The HPA validates the contents of the complete package prior to transferring the program into permanent memory. Upon successful validation of the downloaded package, the HPA proceeds with the programming of memory devices without any prompting from the radio. A self-induced reset may be performed upon during programming operations. The HPA transmits a Reset Complete message to indicate the completion of download tasks. The HPA must be capable of downloading a new application program regardless of the operational condition of the previously loaded program. The Software Download message sequence is interactive with the radio, and is therefore not reported in the Status Response message. A text message, such as "Download", is displayed on the HPA operator panel during a software download operation. **Packet Count field:** Refer to External RF Ethernet Message ICD for other message field details **Packet Count – Max field:** Refer to External RF Ethernet Message ICD for other message field details **Download Type field:** All of the 100W-A and 200W-A HPAs have multiple downloadable software components, listed in the following table. Non-ALC capable 100W-A HPA software components Type ID — Software Component 00 — PA controller module application 02 — PA controller module boot/loader

Message Name / ID (hex) / Scope / HPA Type	Direction	HPA Action
		(Continued from previous page) ALC capable 100W-A HPA and 200W-A HPA software components Type ID — Software Component 00 — Ethernet port module application 01 — Ethernet port module FPGA 02 — Ethernet port module boot/loader 03 — PA controller module application 04 — PA controller module boot/loader **Vendor Download field:** The 100W-A and 200W-A HPA loadable (executable) files have several formats, listed in the following paragraphs. The Non-ALC capable HPA application and boot/loader components are contained in separate 'S' record text files. To download either of the components, the radio parses the applicable loadable file into multiple download messages, each containing a single 'S' record. The 'S' records are copied directly from the loadable file into the download messages. The radio transfers all records from the decomposed loadable file in the same order as presented in the file. The HPA re-assembles the downloaded records into a copy of the original loadable file, performs validation tests, and then programs internal permanent memory with the 'validated' program. The ALC capable HPA Ethernet port application and boot/loader components, and PA controller application and boot/loader components are contained in separate 'S' record text files. The Ethernet port FPGA circuit image file is stored as a binary format. To download the application or boot/loader components, the radio parses the applicable loadable file into multiple download messages, each containing a single 'S' record. Download message data is 'compressed' from the original from the original loadable file format. The radio converts each two-byte 'S' record ASCII character into a single hex byte prior to storing into the download messages. The ALC HPA 'compressed' download message data field is effectively half the size as the 'direct-copy' format used by the non-ALC HPA. The radio transfers all records from the decomposed (and 'compressed') loadable file in the same order as presented in the file. The HPA re-assembles the downloaded records into a copy of the original loadable file, performs validation tests, and then programs internal permanent memory with the 'validated' program. To download an FPGA image, the hex-format file is decomposed into a contiguous series of Software Download messages. The message series must be transferred to the HPA in the same order as extracted from the original loadable file. Each download message has a unique ID (Packet Count field). The Vendor Download field contains loadable file data only. The HPA reassembles the original loadable file from the Software Download messages.

Message Name / ID (hex) / Scope / HPA Type	Direction	HPA Action
Software Download Status Response (FE - device)	from HPA	The HPA outputs one Download Status message for each received Software Download message. Packet Status field and Vendor Download Status field contents are listed: **Packet Status** — **Vendor Download Status** 00 — Download OK, flash completed OK 01 — reserved 02 — reserved 03 — Packet rejected, repeat packet – optional 04 — Packet OK, continue download 05 — Download contained error – repeat download 06 — Download OK, flash not completed or contained errors 07-FF — reserved The Software Download message sequence is interactive with the radio download feature, and is therefore not reported in the Status Response message. A text message, such as “Download”, is displayed on the HPA operator panel during a software download operation. The final response message reports the results of download checks and flash operations. The HPA may perform validity checks only after all packets have been received. Therefore, all progressive status download messages may report an “Packet OK” status. The final Software Download Status message may trail the final Software Download message by as much as 10 seconds. The following Packet Status codes are typical for the final 100W-A / 200W-A HPA Software Download Status message: ‘00’ – download OK and flash OK ‘05’ – download corrupted, flash not attempted ‘06’ - download OK, flash not OK The HPA transmits a Reset Complete message within 30 seconds after reporting successful download and flash operations (code ‘00’).