Extreme Equipment Sales & Rentals
PowerDrive Real-Time Data Points Overview & Prioritization
Revision 3.0

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Applicability: PowerDrive
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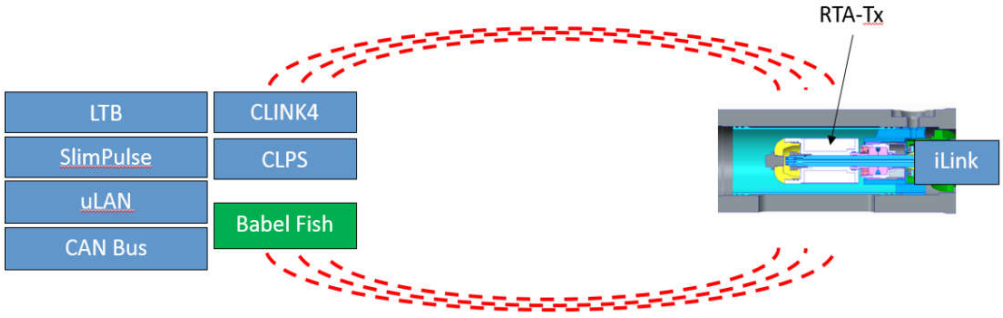
BACKGROUND INFORMATION

With the introduction of PowerDrive version 4.1 firmware and the recent successful field trails of Babel Fish in North America Lane, it is becoming more desirable to have real-time data from the PowerDrive tool in order to help improve operations. While the 4.1 firmware increases the number of available downlinks, it also uses multi-page operation. Due to the risk of downlinking on the wrong page, it is not recommended to run the multi-page without real-time feedback from the tool. The goals of this Technical Bulletin are to provide a brief overview of E-mag communications and to serve as a guide for the D-Points available as well as give a brief description as to how they can be useful. The D-points are grouped according to need/service and presented in order of priority to help optimize frames when space is limited.

E-MAG COMMUNICATIONS:

The PowerDrive tool communicates to the rest of the BHA via an E-Mag link. The tools are fitted with either an iLink or ShortHop board. This board connects to the PowerDrive antenna and sends a uni-direction data stream to a receiver.



Choosing a modulation type depends on the capabilities of the receiver. The ShortHop uses a FSK signal at 575 Hz and 595 Hz with a baud rate of 10 bit/s. The iLink uses a BPSK signal at 586 Hz with a baud rat of 12 bit/sec. The iLink modulation provides a higher signal-to-noise ration and can transmit over longer distances.

E-Mag Receiver	Modulation	Communications Protocol	Theoretical Range (ft)
Babel Fish 475/675	iLink	Standard, Extended, Flexible	18+*
XHOP	Shorthop	Standard, Extended, Flexible	3 to 6

* depends on many environmental factors

In addition to the type of modulation, the tool can also be configured to use three types of data communication to a receiver.

- Standard → CU only sends standard data points. This is Legacy and only required for the PDCU-BB tool.
- Extended → Enables more data to be sent which includes both the standard and extended data points. This is the second option.
- Flexible → Optimizes the E-Mag bandwidth and enables the PowerDrive to send any future data point in its real-time catalog without a change of firmware on the receiver side. This is the preferred option, if this is available.

RECOMMENDED DATA POINTS:

The following recommended data points should be used in most applications. They are listed in order of priority. If there is not enough room for all of them, start removing from the bottom up.

Priority	PowerDrive Data Points					Protocol			Meaning	Comments
	Name	Size (bits)	Scale	Offset	Unit	Std	Ext	Flex		
1	RTSTAT	12	1	0	--				PD Real-Time Status Word	Can be decoded using the Downlink Timing Sheet. Gives you current tool mode, ROP index, health flags, FDL bit period, steering mode (MTF/GTF), etc.
2	SHKRSK	2	1	0	-				Shock Risk/Severity	See shock risk definition chart on page 6. The definitions were modified from 3.2 firmware onwards to factor in vibration (rms) too.
3	INCL	12	0.05	0	deg				Inclination (continuous survey)	Continuous PD Inc
4	AZIM	12	0.1	0	deg				Azimuth (continuous survey)	Continuous PD Azi
5	POSSUM	7	2	-100	%				Integral Control Term, PosSum	PWM demand on torquers used as an indicator of jamming or improper tool functionality. Use to troubleshoot when PROPEFF is below PRDS. Negative values reflect lower torquer load, positve reflects upper torquer load. -30 to -70 is the normal range.
6	DLNK	9	1	0	-				Last Received Fast Downlink Cmd	Use for dowlink confirmation. DLINK is preferred b/c provides downlink source (rpm/flow), but STEER is also available. Both should be decoded using the Downlink Timing Sheet.
7	TF	6	6	0	deg				Measured TF (MTF or GTF) - low res	Effective TF being held. Should match TFDS unless seeing high shocks or possible tool issue.
8	TFDS	6	6	0	deg				Desired Toolface	Toolface the PD is trying to hold. Used in addition to DLNK/STEER for steering confirmation. Should be placed immediately before PRDS.
9	PROPEFF	4	10	0	%				Effective Steering Proportion	Percentage of drill cycle the PD is actually steering. Should match PRDS unless seeing high shocks or possible tool issue.
10	PRDS	4	10	0	%				Desired Proportion	Percentage of drill cycle the PD is attempting to steer. Used in addition to DLNK/STEER for steering confirmation. Should be placed immediately after TFDS.
11	IH_TRGT	12	0.05	0	deg				Inclination Target	Shows the inclination the PD is trying to hold in IH / HIA.
12	AZI_TRGT	12	0.1	0	deg				Azimuth Target	Shows the azimuth the PD is trying to hold in HIA.
13	UTRPM	6	100	0	rpm				Upper Torquer RPM	Useful for detecting jamming and washouts. Can also be used to estimate flow rate through tool.
14	LTRPM	6	100	0	rpm				Lower Torquer RPM	Useful for detecting jamming.

OPTIONAL DATA POINTS:

The following D-Points may prove useful in certain situations and can be included if desired.

Priority	PowerDrive Data Points					Protocol			Meaning	Comments
	Name	Size (bits)	Scale	Offset	Unit	Std	Ext	Flex		
Opt	GT	6	0.5	984	mG				Total G	
Opt	BT	11	48	0	nT				Total B	
Opt	TFHI	12	0.1	0	deg				Measured TF (MTF or GTF) - high res	Effective TF being held. Should match TFDS unless high shocks or possible tool issue.
Opt	STKSLP	4	1	0	-				SnS amplitude & frequency severity	Combined stick-slip amplitude and frequency levels 0-3.
Opt	STEER	8	1	0	-				Steer D-point	Use for dowlink confirmation. Should be decoded using the Downlink Timing Sheet.
Opt	IH_TURN	6	4	-100	%				Inclination Hold Turn Setting	Displays current % of IH turn setting.
Opt	RTTOTSHK	2	1	0	-				RT Total Shock	Real-time total shock; 0 = 0 to 50K shks above 50G, 1 = 50K to 100K, 2 = 100K to 200K, 3 = >200K
Opt	PCNTSTCK	2	1	0	-				Percent Stuck	Pecentage of time that the collar RPM is lower than 5 RPM; 0 = none, 1 = 0% to 25%, 2 = 25% to 50%, 3 = > 50% of time
Opt	CCRPM	8	2	0	rpm				Control Collar RPM	Useful if running Vortex and motor rev/gallon is questionable.
Opt	SS_AMPL	7	4	0	rpm				Stick-Slip Amplitude	Stick-slip peak amplitude relative to average collar RPM; 0 = amplitude <= 25%, 1 = 25% < Amp <= 50%, 2 = 50% < Amp <= 100%, 3 = Amp > 100%
Opt	SHK_AMPL	6	80	0	m/s2				Shock Amplitude	Will give the peak shock in any direction (axial or radial). The benefit of having SHK_Ampl together w/ SHKRSK is that the new SHKRSK definitions include rms so could start to trigger level 2-3's if your're seeing high vibration too rather than just peak shocks. Having the SHK_Ampl will help distinguish if any high SHKRSK values are being caused by high peak values if SHK_Amp also peaks at the same time or if not it could be high levels of vibration.
Opt	RTSTAT2	12	1	0	-				PD Real-Time Status Word #2	Useful in utility frame so that PD survey quality can be confirmed before engaging HIA; 0 = Good survey, 8 = bad survey based on GTOT. Decoded using the Downlink Timing Sheet.
Opt	RTSTAT3	6	1	0	-				PD Real-Time Status Word #3	
Opt	RTSTAT4	6	1	0	-				PD Real-Time Status Word #4	
Opt	PDTEMP	8	1	-40	deg				PDCU Temp	Useful if high temperatures are expected (>130 deg C).
Opt	LatShkPeak	6	5	25	Gs				Lateral Shock Peak	New shk data point for flexible protocol; Lateral Shk Pk, range 25 – 345
Opt	LatVib	6	1	5	Grms				Lateral Vibration	New shk data point for flexible protocol; Lateral Vibration, range 5 – 67
Opt	AxiShkPeak	5	1	3	Gs				Axial Shock Peak	New shk data point for flexible protocol; Axial Shk Peak, range 3 - 33
Opt	AxlVib	5	1	3	Grms				Axial Vibration	New shk data point for flexible protocol; Axial Vibration, range 3 - 33

GAMMA RAY DATA POINTS:

There are 2 options for average and quadrant Gamma Ray, but extended D-points are the usual default configuration. There is also a new Gamma 8 D-point if both space in the frame is available and running flexible D-points.

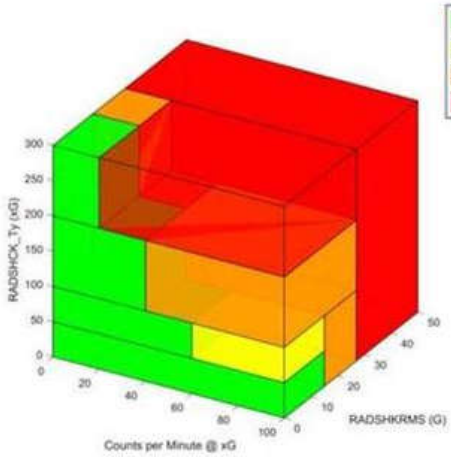
PowerDrive Data Points					Protocol			Meaning	Comments
Name	Size (bits)	Scale	Offset	Unit	Std	Ext	Flex		
GRAV	7	1	0	cps				Gamma Ray Average	Conventional data point often used due to smaller size unless gamma values are expected to exeed 256 cps.
GRUP	7	1	0	cps				Gamma Ray Up	Conventional data point often used due to smaller size unless gamma values are expected to exeed 256 cps.
GRLF	7	1	0	cps				Gamma Ray Left	Conventional data point often used due to smaller size unless gamma values are expected to exeed 256 cps.
GRDN	7	1	0	cps				Gamma Ray Down	Conventional data point often used due to smaller size unless gamma values are expected to exeed 256 cps.
GRRT	7	1	0	cps				Gamma Ray Right	Conventional data point often used due to smaller size unless gamma values are expected to exeed 256 cps.
GRAV_ext	9	1	0	cps				Extended Gamma Ray Average	Extented data point which can measure gamma values up to 1000 cps which necessary in some shale formations in NAL.
GRUP_ext	9	1	0	cps				Extended Gamma Ray Up	Extented data point which can measure gamma values up to 1000 cps which necessary in some shale formations in NAL.
GRLF_ext	9	1	0	cps				Extended Gamma Ray Left	Extented data point which can measure gamma values up to 1000 cps which necessary in some shale formations in NAL.
GRDN_ext	9	1	0	cps				Extended Gamma Ray Down	Extented data point which can measure gamma values up to 1000 cps which necessary in some shale formations in NAL.
GRRT_ext	9	1	0	cps				Extended Gamma Ray Right	Extented data point which can measure gamma values up to 1000 cps which necessary in some shale formations in NAL.
GAMMA8	24	1	0	-				8 Bin Gamma Scan Line	New Gamma data point for flexible protocol

Table A-3: Definition of DLNK

Bit no.	Name	Comment
8	Precursor correlation	0 = Correlation < T + 0.05 1 = Correlation >= T + 0.05
7	Command correlation	0 = Correlation < T + 0.05 1 = Correlation >= T + 0.05
6	Downlink source	0 = Flow 1 = Collar
5	Precursor	Received precursor number: 0 = Precursor 1 1 = Precursor 2
4 to 0	Command	Received command number (commands 0 to 31)

Table A-4: Definition of RTSTAT

Bit no.	Name	Comment
11 to 9	Tool mode	Tool current operating mode: 000 = Manual TF 001 = PowerV 010 = IH 100 = Auto TFDS 110 = HIA
8	ROP index	ROP index used for IH and HIA: 0 = ROP index 1 (20 to 100 ft/hr) 1 = ROP index 2 (80 to 400 ft/hr)
7	Valve seized	This is set when the control unit is not rotating with respect to the control collar
6	Servo saturated	PosSum exceeds normal range. This is set when the control unit is at + or – 100 % PWM demand, and is unable to keep up with rotational requirements. It indicates that the control unit is not steering properly
5 to 4	Fast downlink bit period	01 = 18 seconds 10 = 36 seconds
3	Bxy low	Magnitude of BxBy too small (less than 15 000 nT) for roll estimation and CRPM downlink
2	High temperature	Temperature > 140 degC
1	Steering mode	0 = Gravity 1 = Magnetic
0	Stick-slip	Tool has detected stick-slip above the theshold: (Amplitude + Frequency) > 3 (Amplitudue) = 3 (Frequency) = 3



PowerDrive			
Bit No# 1-0	**SHKR SK**	**Current Definition (Countsper minute)**	**New Definition (Counts per minute)**
00	0	RADSHK_T1 (50G) < 60	RADSHK_T1 (50G) < 60
01	1	60 ≤ RADSHK_T1 (50G) < 300	60 ≤ RADSHK_T1 (50G)
10	2	300 ≤ RADSHK_T1 (50G) < 600	40 ≤ RADSHK_T2 (100G) **OR** 15 ≤ RADSHKRMS <27
11	3	600 ≤ RADSHK_T1 (50G)	20 ≤ RADSHK_T3 (200G) **OR** 27 ≤ RADSHKRMS

Table A-6: Definition of STKSLP

Bit no.	Name	Comment (bit order 3,2 or 1,0)
3 to 2	SS_AMPL	Stick-slip peak amplitude[1] relative to average collar RPM 00 = 0 Amplitude <= 25% 01 = 1 25% < Amplitude <= 50% 10 = 2 50% < Amplitude <= 100% 11 = 3 Amplitude > 100%
1 to 0	SS_FREQ	Stick-slip frequency[2] in cycles per minute (cpm) 00 = 0 cpm <= 7.5 01 = 1 7.5 < cpm <= 30 10 = 2 30 < cpm <= 60 11 = 3 cpm > 60

[1] The amplitude is derived from calculations of collar speed in rpm, using the formula: Amplitude = $(\omega_{c\ max} - \omega_{c\ min}) / (2 * \omega_{c\ average})$ over a survey interval.

[2] The frequency is the average number of stick-slip cycles where the collar speed exceeds a window of 25% above or below the average collar speed

Table A-8: Definition of STEER

Bit no.	Name	Comment
7	Steer mode	0 = Magnetic 1 = Gravity (inverse of RTSTAT bit 1)
6 to 5	Precursor	Received precursor number: 01 = Precursor 1 10 = Precursor 2
4 to 0	Command	Received command number (commands 0 to 31)

Table A-9: Definition of RTTOTSHK

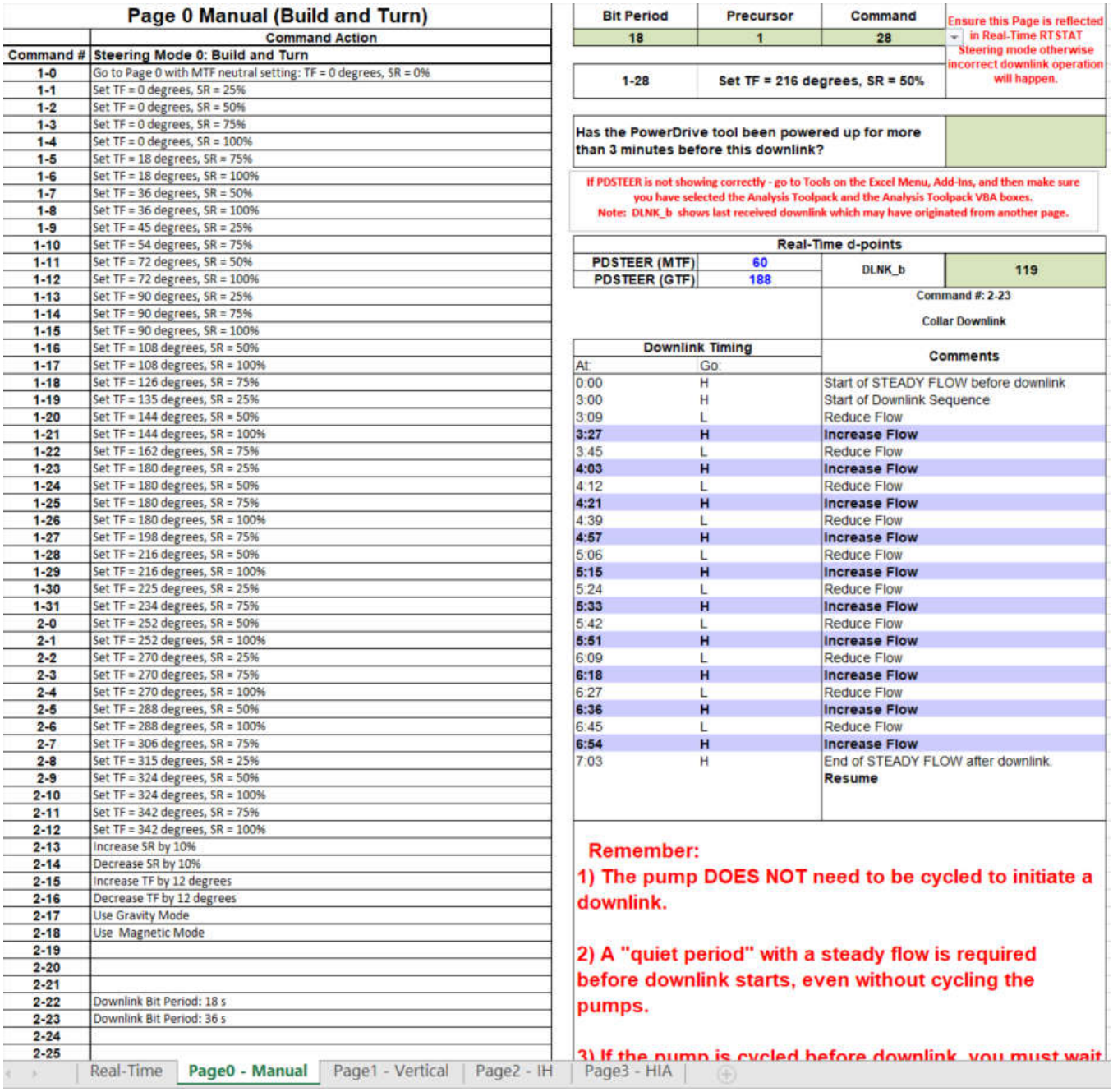
Bit no.	Name	Comment (bit order 3,2 or 1,0)	
1 to 0	RTTOTSHK	Real time total shock	
		00 = 0	0 < Number of shocks above 50G <= 50,000
		01 = 1	50,000 < Number of shocks above 50G <= 100,000
		10 = 2	100,000 < Number of shocks above 50G <= 200,000
		11 = 3	Number of shocks above 50G > 200,000[1]

[1] This is the contractual limit for all tools.

Table A-10: Definition of PCNTSTCK

Bit no.	Name	Comment (bit order 3,2 or 1,0)	
1 to 0	PCNTSTCK	Percent stuck: Percentage of time that the collar RPM is lower than 5 rpm.	
		00 = 0	percentage of time = 0%
		01 = 1	0% < percentage of time < 25%
		10 = 2	25% <= percentage of time < 50%
		11 = 3	percentage of time >= 50%

Fast Downlink Timing Sheet:
Below are some snapshots of a few tabs of the Fast Downlink Timings Sheet. One of the recommended data points used for downlink confirmation is DLINK. DLINK is preferred because it also provides the downlink source (rpm/flow), but the STEER data point is also available. Both data points can be decoded on any of the downlink pages of the Fast Downlink Timing Sheet. Several status word data points can also be decoded on the real-time tab of the Fast Downlink Timing Sheet.



Page 0 Manual (Build and Turn)

Command #	Command Action Steering Mode 0: Build and Turn
1-0	Go to Page 0 with MTF neutral setting: TF = 0 degrees, SR = 0%
1-1	Set TF = 0 degrees, SR = 25%
1-2	Set TF = 0 degrees, SR = 50%
1-3	Set TF = 0 degrees, SR = 75%
1-4	Set TF = 0 degrees, SR = 100%
1-5	Set TF = 18 degrees, SR = 75%
1-6	Set TF = 18 degrees, SR = 100%
1-7	Set TF = 36 degrees, SR = 50%
1-8	Set TF = 36 degrees, SR = 100%
1-9	Set TF = 45 degrees, SR = 25%
1-10	Set TF = 54 degrees, SR = 75%
1-11	Set TF = 72 degrees, SR = 50%
1-12	Set TF = 72 degrees, SR = 100%
1-13	Set TF = 90 degrees, SR = 25%
1-14	Set TF = 90 degrees, SR = 75%
1-15	Set TF = 90 degrees, SR = 100%
1-16	Set TF = 108 degrees, SR = 50%
1-17	Set TF = 108 degrees, SR = 100%
1-18	Set TF = 126 degrees, SR = 75%
1-19	Set TF = 135 degrees, SR = 25%
1-20	Set TF = 144 degrees, SR = 50%
1-21	Set TF = 144 degrees, SR = 100%
1-22	Set TF = 162 degrees, SR = 75%
1-23	Set TF = 180 degrees, SR = 25%
1-24	Set TF = 180 degrees, SR = 50%
1-25	Set TF = 180 degrees, SR = 75%
1-26	Set TF = 180 degrees, SR = 100%
1-27	Set TF = 198 degrees, SR = 75%
1-28	Set TF = 216 degrees, SR = 50%
1-29	Set TF = 216 degrees, SR = 100%
1-30	Set TF = 225 degrees, SR = 25%
1-31	Set TF = 234 degrees, SR = 75%
2-0	Set TF = 252 degrees, SR = 50%
2-1	Set TF = 252 degrees, SR = 100%
2-2	Set TF = 270 degrees, SR = 25%
2-3	Set TF = 270 degrees, SR = 75%
2-4	Set TF = 270 degrees, SR = 100%
2-5	Set TF = 288 degrees, SR = 50%
2-6	Set TF = 288 degrees, SR = 100%
2-7	Set TF = 306 degrees, SR = 75%
2-8	Set TF = 315 degrees, SR = 25%
2-9	Set TF = 324 degrees, SR = 50%
2-10	Set TF = 324 degrees, SR = 100%
2-11	Set TF = 342 degrees, SR = 75%
2-12	Set TF = 342 degrees, SR = 100%
2-13	Increase SR by 10%
2-14	Decrease SR by 10%
2-15	Increase TF by 12 degrees
2-16	Decrease TF by 12 degrees
2-17	Use Gravity Mode
2-18	Use Magnetic Mode
2-19	
2-20	
2-21	
2-22	Downlink Bit Period: 18 s
2-23	Downlink Bit Period: 36 s
2-24	
2-25	

Bit Period	Precursor	Command	Ensure this Page is reflected in Real-Time RTSTAT Steering mode otherwise incorrect downlink operation will happen.
18	1	28	
1-28	Set TF = 216 degrees, SR = 50%		

Has the PowerDrive tool been powered up for more than 3 minutes before this downlink?	

If PDSTEER is not showing correctly - go to Tools on the Excel Menu, Add-Ins, and then make sure you have selected the Analysis Toolpack and the Analysis Toolpack VBA boxes.
Note: DLNK_b shows last received downlink which may have originated from another page.

Real-Time d-points			
PDSTEER (MTF)	60	DLNK_b	119
PDSTEER (GTF)	188		

Command #: 2-23
Collar Downlink

Downlink Timing		Comments
At:	Go:	
0:00	H	Start of STEADY FLOW before downlink
3:00	H	Start of Downlink Sequence
3:09	L	Reduce Flow
3:27	**H**	**Increase Flow**
3:45	L	Reduce Flow
4:03	**H**	**Increase Flow**
4:12	L	Reduce Flow
4:21	**H**	**Increase Flow**
4:39	L	Reduce Flow
4:57	**H**	**Increase Flow**
5:06	L	Reduce Flow
5:15	**H**	**Increase Flow**
5:24	L	Reduce Flow
5:33	**H**	**Increase Flow**
5:42	L	Reduce Flow
5:51	**H**	**Increase Flow**
6:09	L	Reduce Flow
6:18	**H**	**Increase Flow**
6:27	L	Reduce Flow
6:36	**H**	**Increase Flow**
6:45	L	Reduce Flow
6:54	**H**	**Increase Flow**
7:03	H	End of STEADY FLOW after downlink. **Resume**

Remember:
1) The pump DOES NOT need to be cycled to initiate a downlink.

2) A "quiet period" with a steady flow is required before downlink starts, even without cycling the pumps.

3) If the pump is cycled before downlink, you must wait

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Decode RTSTAT_b

Input decimal value	1125
Hexadecimal value	465
Binary value	010001100101

Description	Current State	bit number	bit value
Manual Mode = 000, PowerV = 001, IH = 010, HIA=011	IH mode	11 10 9	0 1 0
ROP Index	ROP1	8	0
Valve Seized	Ok	7	0
Possum Saturated	PosSum exceeding normal range	6	1
FDL bit period (01=18, 10=36 sec)	Bit Period = 36 sec	5 4	1 0
Bxy Low	Ok	3	0
High Temp	CU Temperature > 140°C	2	1
ToolFace Mode	GTF	1	0
Stick-Slip	Stick-Slip above threshold	0	1

Encode RTSTAT_b

Encoded decimal value of RTSTAT_b: 1398

Description	bit number	bit weight	Input bit value		State
Manual TF = 000, PowerV = 001, IH = 010, HIA=011	11 10 9	2048 1024 512	0 1 0	===> ===> ===>	IH mode
ROP Index (ROP1 = 0, ROP2=1	8	256	1	===>	ROP2
Valve seized = 1	7	128	0	===>	Ok
Possum saturated = 1	6	64	1	===>	PosSum exceeding normal range
FDL bit period (01=18, 10=36 sec)	5 4	32 16	1 1	===>	Bit Period = N/A sec
BXY small = 1	3	8	0	===>	Ok
HI Temp >140degC = 1	2	4	1	===>	CU Temperature > 140°C
ToolFace Mode: GTF = 0, MTF = 1	1	2	1	===>	MTF
Stickslip amp=3 or frq=3 or both=2	0	1	0	===>	Ok

RTSTAT2 (Extended dpoint) — 9

The tool is detecting a divergence between single & all axis azimuth values

RTSTAT4 (Extended dpoint) — 32

DZM is Enabled.
PROPEFF_b should match PRDS.
Unless POSSUM_b maxes out and Tool is jammed.

AZIMQ_b (Standard dpoint) — 10

Lower Torquer minimum RPM = 550

LTRPM = (unscaled AzimQ)*25 + 300

AzimQ decodes minimum Lower Torquer RPM since last survey frame.

The calculation above requires raw, unscaled AzimQ as seen on the HSPM frame decoding display! The scaled AzimQ to be divided by 1.6

BT_b (Standard dpoint) — 2

IH Target Inclination = 0.2 Deg.

In order to compute target inclination, simply input the raw value displayed on the HSPM demodultation panel for BT_b in the box above. The computed value is the actual target inclination calculated by the tool (IH Mode use only).

INCLQ_b (Standard dpoint) — 2

Effective Steer Proportion = 20 %

D-Point Name	Default Values (non-scaled)								Good/Expected Values (decimal)		D-Point Size (bits)
	No Comms between receiver and MWD		No Comms between receiver and CU *2		Short-Hop seed *3		Short-Hop Timeout *4				
	Hex	Decimal	Hex	Decimal	Hex	Decimal	Hex	Decimal	Non-scaled	Scaled	
RTSTAT_b	FFF	4095	EFE	3838	DFD	3581	CFC	3324	-	-	12
AzimQ_b	F	15	E	14	D	13	C	12	0 - 14	300 - 650	4
InclQ_b	F	15	E	14	D	13	C	12	0 - 10	0 - 100	4
Bt_b	7FF	2047	6FE	1790	5FD	1533	4FC	1276	0 - 1800	0 - 180.0	11

*1 **No Comms between receiver and MWD** is the value set by the MWD tool when it has no communication with (no reply from) the PD receiver
*2 **No Comms between receiver and CU** is the LTB modem default value. It is set when the receiver powers up.
*3 **Short-Hop seed** is the value set by the receiver board if a d-point is not received in a frame. Partially received frames will have d-points with this
*4 **Short Hop Timeout** is the value set by the receiver board if no short hop frames have been received from the CU for 11 minutes.

Note:
- Refer to the PDX6 Operations Manual, Real-Time Data section, for a comprehensive list of PD d-points, d-point interpretation and default value
- Some d-points have default values which fall in the range of valid values.
- Bit 8 should indicate ROP index regardless of the current steering mode.

The following should be noted for PDX6 DHS version X.XX:
- Continuous azimuth (Azim_b) and continuous inclination (Incl_b) are no longer affected by low steering proportion settings.
- Some real time d-points (AzimQ_b, InclQ_b, Bt_b) have been redefined/borrowed, and are now being used to transmit values that are different to their original function.
- The first Short-Hop message is sent at start of the first drilling survey, approximately 30 seconds earlier than older DHS versions.
- TFHI_b, TF_b and INCLQ_b will have zero values in the first Short-Hop survey frame after a power-up.
- SHKRSK_b and STKSLP_b will have zero values in the first two Short-Hop survey frames after a power-up.

Schlumberger GeMS 103293379 Revision: 01

IMPORTANT:

If any computed values are not showing correctly - go to Tools on the Excel Menu, Add-Ins, and then make sure you have selected the Analysis Toolpack and the Analysis Toolpack VBA boxes.

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