



Date: June 6, 2022
Applicability: PowerDrive
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BACKGROUND INFORMATION

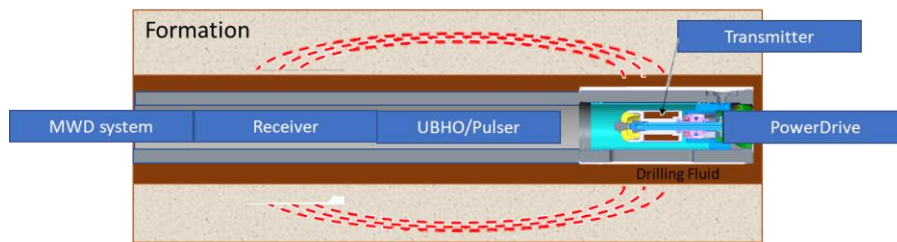
With the integration of the Babel Fish receiver into many MWD platforms in the last twelve months, the use of PowerDrive real-time information has dramatically increased. Nearly 50% of PowerDrive rental and sales runs in USLand utilized a real time receiver in May 2022.

With this increase, there have been several issues and complications identified. The purpose of this document is to educate users on the potential issues that can cause PowerDrive data to not be received and transmitted to surface by the MWD system.

E-MAG COMMUNICATIONS

PowerDrive communicates to the rest of the BHA via an RF transmitting antenna. This antenna is installed in the PowerDrive Control Unit at each service interval on request. PowerDrive broadcasts real time data at ~600 Hz @ 12 bps continually when the antenna is powered.

RF receivers (XHop, HHop, or Babel Fish) are mounted within the MWD string to receive transmission from PowerDrive. If the signal level at the receiver is significantly higher than the background noise, then the data is decoded, digitized, and provided to the MWD tool for transmission uphole with other MWD data.



POWERDRIVE TRANSMISSION

PowerDrive powers the antenna if nominal voltage from the PSPD (Power Supply and Distribution) to the iLink board is greater than ~32V. Nominal output when supplied in normal operation from the torquers is 42V.

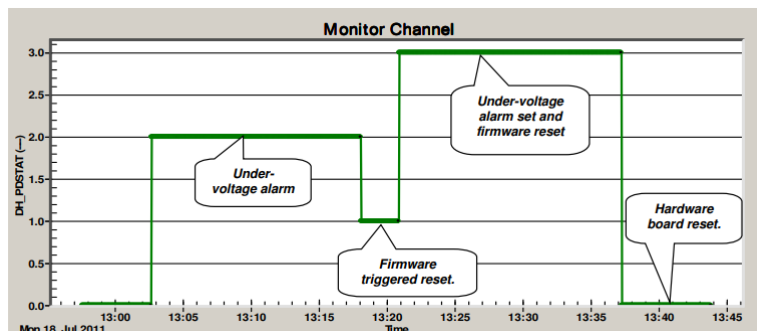
Voltage can be drawn below the ~32V transmission threshold in situations where the tool requires maximum power to maintain toolface control. This is known to happen with low flow, torquer friction, and positive pulse MWD. Any situation where the tool struggles to maintain toolface control (even instantaneously) can interrupt transmission.

PowerDrive recorded memory does not indicate whether the tool has successfully transmitted. Instantaneous torquer voltages and antenna transmission are not reported, controlled, or recorded by the CPU in the tool's memory.

If the DH_PD_STAT channel is being transmitted (it is also recorded by Babel Fish), it can be used to determine issues with PD transmission. Recorded memory from the Babel Fish can also be used to interpret issues with PowerDrive transmission from a variety of quality indicators after the run.

BIT	Meaning
0	System reset occurred under firmware control
1	This bit becomes set after an under voltage event occurred in P
2	Overcurrent alarm
3	The bit sets when ILink does not receive any data from PD controller board

Figure 14 shows example how DH_PDSTAT changes depending on PD control unit.



PD_STAT status word interpretation

SUCCESSFUL RECEPTION OF POWERDRIVE DATA

Signal is successfully received at the RF antenna if signal to noise ratio is higher than ~10 dB.

All receivers currently in use are probe-based. If they are mounted more than a few inches away from the transmitter, then the RF signal must travel through the PowerDrive collar, mud annulus, formation, and MWD collar to the receiver. All of these attenuate the signal. Thicker collars (675/900) attenuate signal levels more than thinner collars (475/525). Conductive mud (WBM) and conductive formation can also attenuate signal to some extent.

Axial distance also attenuates the signal. Signal levels reduce with axial distance squared. Relatively small distance changes (of receiver to PowerDrive) can have large effects on signal levels at the receiver. Recut length on stabilizers, UBHO's, and other components can vary and cause issues with reception.

Noise levels at the receiver are dominated by three main factors:

- Electrical noise from other EM sources. Other electrical equipment in the drilling system (no matter the carrier frequency) generates wide band noise on collars and MWD housings. This can be seen as in-band noise to the PowerDrive transmission. Even rig surface noise has been observed to cause reduction in signal/noise ratios.
- Electrical noise from power/signal running through the receiver in the MWD system. All bottom mounted systems have some effect on receiver noise regardless of filtering.
- Mechanical vibration. Lateral vibration on the antenna generates noise in the receiver. Centralization is important to both minimize vibration of the receiving antenna and movement within the collar.

Each MWD system passes different power and signal below the receiver in bottom-mounted pulser configurations. It is the responsibility of the MWD system owner to minimize the noise level induced on the receiver. Extreme can provide experimental test setup and consult as required.

Receiver data is plotted from every run when returned to maintenance. This data is correlated to the associated PowerDrive data. Any gaps in reception that cannot obviously be explained by PowerDrive transmission cause an upgrade to the receiver service level.

All outgoing tools from Extreme's maintenance facility are screened for minimum SNR at a fixed distance in air from a PowerDrive transmitter.

TRANSMISSION OF POWERDRIVE DATA TO SURFACE

PowerDrive data is provided from the receiver to the MWD system. There are over 10 commercial platforms that are now capable of integration with a receiver. All have different schemes for processing this data through the system to surface display.

PD receivers do not record successful transmission to the MWD system. Recorded data is entirely based on independent receiver operation. Signal/Noise ratio and other quality metrics for the transmission are recorded, but differ between XHop, HHop, and Babel Fish.

APPENDIX: RECENT ISSUES IDENTIFIED WITH POWERDRIVE TRANSMISSION

In some specific, confirmed instances, PowerDrive real-time transmission has stopped with increase in flow rate during operation. This has been shown through precise alignment of PD recorded data to receiver recorded data. This is contrary to the expected design intent, where more power supplied in operation (via mud flow) can help ensure that voltages remain above cutoff thresholds.

This has been observed in multiple hole sizes and tool configurations. These instances are repeatable in field operation, but have not yet been reproduced in the flow loop. Tools with this issue pass outgoing transmission testing through all flow rates on outgoing and incoming tests from the Extreme facility. In some cases RT transmission was only recorded during pipe fill, downlink, or other low flow periods.

Fully characterized instances are being provided to the global engineering team for analysis. These instances must be vetted to ensure that other factors may not be causing transmission issues. These factors include:

- Positive pulse toolface instability
- Low flow rates
- High receiver noise levels from EM, vibration, etc
- Distance from transmitter to receiver
- Mechanical/Electrical issues with transmitter or receiver

A very small percentage of Babel Fish runs are eventually confirmed to be associated with this specific issue after full evaluation.

There are several recent changes to the PowerDrive assembly that could potentially affect real time transmission, but none is confirmed thus far:

- MKII revision PSPD board. These now make up over 50% of the sales/rental fleet. All confirmed instances are MKII. The board revision is intended to engineer out known failure modes with previous revisions.
- iLink board revisions. These are less than half of the fleet and more difficult to track. Revisions mitigate procurement issues, while keeping a very similar design.
- CPU board revisions. A new controller with associated firmware was introduced to the fleet to mitigate supply chain issues. It now makes up over 50% of the fleet.

Each identified instance is added evidence in the ongoing investigation. If you identify a drilling run where real time data stops with increased flow rate, please indicate this in failure report requests for both PowerDrive and the receiver. If possible, please include the estimated threshold flow rate for data reception.