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# Dataspeed Drive-by-Wire Kit FAQ

December 18th, 2024

Polaris RZR-XP 1000 Platform

## Drive-By-Wire

### Steering

- **What command types are available?**
  Torque, Angle, Curvature, YawRate, and Percent. Curvature and YawRate use Ackermann steering geometry to calculate an angle. Percent is simply ±270° scaled to ±100%. Percent is only intended to be used for demos that are unaware of the maximum angle.
- **Can I control torque instead of angle?**
  Yes. Set the SteerAllowTorqueCmd parameter via the DbwConfig GUI. Use extra caution when controlling steering wheel torque directly instead of angle. The steering wheel angle and angular rate limits do not apply in this control mode.
- **What is the report and expected control frequency?**
  100 Hz report, 50 Hz command, 10 Hz timeout. Commands >100Hz will be down-sampled.
- **What is the command delay?**
  Command messages are forwarded to the vehicle as soon as they are received to minimize delay.
- **What is the interface? Units? Resolution?**
  Steering wheel angle, angular rate limit, angular acceleration limit: full range (±270°), 0.1 degree resolution. Steering wheel torque: full range (20 Nm), 1/128 Nm resolution.
- **What is the relationship between steering wheel angle and road angle?**
  7.1:1
- **What is the steering wheel torque threshold for an override?**
  5 Nm filtered torque, and the value can be changed via the DbwConfig GUI
- **Are there any restrictions on engaging the steering wheel?**
  No.
- **Do any of the steering parameters or restrictions change with vehicle speed?**

  - Steering wheel angle limit vs speed with vehicle lateral acceleration threshold or arbitrary look-up table
  - Steering wheel angular rate limit vs speed with vehicle angular acceleration threshold or arbitrary look-up table
  - These values can be changed via the DbwConfig GUI.

- **Can I control the horn?**
  No. Status is also not available.

## Brakes

- **What command types are available?**
  Pressure and Percent. Percent is simply 0-80 bar pressure scaled to 0-100%. Percent is **not** pedal position.
- **What is the report and expected control frequency?**
  50 Hz report, 50 Hz command expected, 10 Hz timeout. Commands >100Hz will be down-sampled.
- **What is the command delay?**
  Command messages are forwarded to the actuator as soon as they are received to minimize delay.
- **What is the interface? Units? Resolution?**
  Brake pressure (bar) with 0.01 resolution.
- **What is the criteria for a driver override?**
  x>4 bar for 250 ms, and the values can be changed via the DbwConfig GUI
- **Can I press the brake without overriding the system?**
  Yes. Set the ignore bit in the command message and the corresponding BrakeAllowIgnore parameter via the DbwConfig GUI.
- **Can the drive-by-wire achieve full brake deceleration?**
  Yes, the brake actuator can build pressure to the same level as a physical brake pedal press.
- **How long can the brake actuator hold the vehicle stopped?**
  8 minutes, then the drive-by-wire executes a shift to park.
- **Can the brake lights be controlled separately?**
  No.

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## Throttle

- **What command types are available?**
  PedalRaw and Percent. PedalRaw is the raw pedal position sensor measurement. Percent is pedal position 0-100%, and is the recommended command type.
- **What is the report and expected control frequency?**
  50 Hz report, 50 Hz command expected, 10 Hz timeout. Interface to vehicle is analog, so >50Hz command is supported.
- **What is the command delay?**
  Command messages are forwarded to the vehicle as soon as they are received to minimize delay. The vehicle's response time is the same as a physical pedal press. Commands are ramp limited to prevent faults.
- **What is the interface? Units? Resolution?**
  Pedal position (%). 12 bit resolution.
- **What is the criteria for a driver override?**
  x>15% for 100ms, and the values can be changed via the DbwConfig GUI
- **Can I press the throttle without overriding the system?**
  Yes. Set the ignore bit in the command message and the corresponding ThrtlAllowIgnore parameter via the DbwConfig GUI.
- **Traction Control?**
  Traction Control can be enabled/disabled in the production vehicle. Status (enabled/disabled and active/inactive) is reported.
- **Is an engine torque measurement available?**
  No.

## Gear/Transmission

- **What is the report and expected control frequency?**
  10 Hz or on-event report, control on-event
- **Are there any gear shift limitations?**
  - The drive-by-wire prevents bad shifts at speed such as drive-to-reverse or into park, and either rejects the shift or replaces it with a shift to neutral.
  - By default, gear shift commands will not be executed when there is an active driver override on brake/throttle/steering. This behavior can be changed via the DbwConfig GUI.
- **What is the interface?**
  Gear position (park/reverse/neutral/low/high)

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## HMI (Human Machine Interface)

- **Can the steering wheel buttons be used to engage/disengage control?**
  Yes. Up to two buttons can be configured to be the system enable button(s). If two buttons are specified, both must be pressed to be considered a system enable button press. Up to two buttons can be configured to be the system disable button(s). If two buttons are specified, either press will be considered a system disable button press. See the parameter documentation for the SystemBtn group of parameters.

- **How can I tell if drive-by-wire control is active?**
  A digital low-side driver output can be used to electrically drive a buzzer. The system will beep one time when control is activated and two beeps two times when control is disengaged. The beep patterns can be configured or disabled. See the parameter documentation for the HmiBuzzer group of parameters.

  A digital low-side driver output can be used to electrically drive an LED to indicate status. Blink patterns for the status LED can be configured for each state (active / ready / manual / fault). See the parameter documentation for the HmiStatus group of parameters.

## System Synchronization

- **Can I command steering without brake and throttle?**
  Yes. The default SystemSyncMode parameter value of None allows the steer/brake/throttle subsystems to operate independently.

- **Can I command brake and throttle without steering?**
  Yes. The default SystemSyncMode parameter value of None allows the steer/brake/throttle subsystems to operate independently.

- **Can I require all subsystems (steer/brake/throttle) to be active or revert to manual?**
  Yes. See the parameter documentation for the SystemSyncMode parameter.

- **Can I require a human button press to engage the system?**
  Yes. See the parameter documentation for the SystemSyncMode parameter.

## Misc

- **What other vehicle sensors can I access?**
  - Vehicle speed (100 Hz)
  - Steering wheel buttons (20 Hz)
  - Driver seat belt status

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- **How does the E-Stop button function?**
  The E-Stop button removes power from all drive-by-wire modules, forcing vehicle connections back to hardware pass-through configuration. This will NOT stop the vehicle. Taking control with the steering wheel or brake pedal is a much smoother transition.
- **How do I access the drive-by-wire CAN network to send commands?**
  If using ROS, a USB-CAN tool is provided and works with the ROS driver. Otherwise, there are CAN/power taps under the dash. See the wiring diagram.

## Safety

- All systems prioritize driver input over drive-by-wire CAN bus input.
- All systems disengage control after 100ms if a new command is not received.
- All systems disengage control on driver override unless specifically disabled with a USB parameter and CAN message flag.
- All systems pass through vehicle signals unmodified when unpowered or disabled.
- E-Stop button restores OEM functionality by removing power. See above.
- CRCs and rolling counters with validation in command messages and important report messages.
- Steering wheel angle and angular rate limits vs vehicle speed. See the parameters document for more information.
- Optional brake and throttle limits vs vehicle speed. See the parameters document for more information.
- Optional external brake input that can be used to apply a constant braking value with a digital input. See the parameters document for more information.
- Options to brake at a preconfigured value and shift to park on loss of CAN command messages. See the parameters document for more information.
- Options to brake at a preconfigured value and shift to park and lockout control when vehicle speed or acceleration exceeds threshold. See the parameters document for more information.
- Contact Dataspeed for more for a more detailed discussion of safety.

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### Calibration

- **Steering Wheel Angle**: The user must provide the steering wheel angle calibration. Send a steering command CAN message with the Calibration command type and the desired value in the command field. The calibration is stored in flash, persists across firmware updates, and only needs to be done one time. Raw steering wheel angle sensor and calibration offset are available in a separate message. This can be used to have a consistent angle measurement when the calibration offset changes.
- **Shift Lever Positions**: The drive-by-wire module automatically moves the shift lever to observe and calibrate the positions corresponding to specific gears. The process takes approximately 10 seconds. This happens automatically when the vehicle speed is zero, the engine is off, and the throttle pedal is not pressed. Send a gear command CAN message with Calibration as the gear command to manually recalibrate. The calibration is stored in flash, persists across firmware updates, and only needs to be done one time.

### Vehicle Parameters

- Steering ratio: 7.1:1
- Ackerman wheelbase: 118 inches

## Power Distribution

- **How can I turn power distribution channels on and off?**
  Touchscreen display in a cup holder mount, startup/shutdown scripts, CAN message, Ethernet/LCM message
- **How can I configure the power distribution?**
  Use PowerDistributionGUI.exe and its documentation.
- **What is the power rating?**
  9-18 volts, 15 Amps per channel continuous, 180 Amps total continuous
- **Can I view the current of the 120V power inverter?**
  No. The current consumption of the inverter is not available.
- **Can I connect a higher wattage power inverter instead of the 600W model?**
  Yes. See the Power Distribution Panel datasheet for a list of supported part numbers.
- **What is the default mode change pin number?**
  1234

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# Documentation

- Download the latest DriveByWire release package from https://www.dataspeedinc.com/release-packages/
  - CAN bus documented in the Vector CAN DBC format: DataspeedByWire.dbc
  - CAN bus messages implementation in C++: DataspeedByWire.hpp
  - Parameter documentation for each module with configuration application
  - Firmware for each module with bootloader application
- ROS driver and demo software https://bitbucket.org/DataspeedInc/dbw_ros/

# Updating

- **Windows**
  - Download the latest DriveByWire release package from https://www.dataspeedinc.com/release-packages/
  - Check the CHANGELOGs to see what has changed.
  - Update the firmware of each module with DataspeedBootloader.exe by connecting to that module's USB cable. This process is documented in DataspeedBootloader.pdf.
  - Optionally check and/or change module parameters with DbwConfig.exe by connecting to that module's USB cable. This process is documented in DbwConfig.pdf.
- **Linux**
  - Download the latest DriveByWire release package from https://www.dataspeedinc.com/release-packages/
  - Check the CHANGELOGs to see what has changed.
  - Update the firmware of each module with dataspeed_boot_usb by connecting to that module's USB cable. This process is documented in dataspeed_boot_usb.html.
  - Optionally check and/or change module parameters with dbw_config_cli by connecting to that module's USB cable. This process is documented in dbw_config_cli.html.
- **ROS demo software on Ubuntu Linux**
  - Use the system package manager to update packages: 'sudo apt update && sudo apt upgrade'

dataspeedinc.com • (248) 243-8889
2736 Research Dr. • Rochester Hills, MI • 48309

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# Troubleshooting

- **The only CAN messages from the drive-by-wire system are EcuInfo messages (0x6C0-0x6C7)**
  The embedded firmware requires a valid license. See LicenseManager\DataspeedLM.exe to view and modify the license in the steer-by-wire module. Contact Dataspeed to receive your license.

- **My vehicle is not responding to commands or generating reports and the drive-by-wire power usage is 100mA or less.**
  Check that the red E-Stop button located near the cup-holders is not pressed.

- **My vehicle is not responding to commands or generating reports and the drive-by-wire power usage is 900mA or greater.**
  There may be a hardware or wiring problem. Contact Dataspeed to help debug the problem.

- **Steering is not working and reporting a calibration fault.**
  Send a steering command CAN message with the Calibration command type and the desired value in the command field to calibrate steering wheel angle.

- **Steering is not working and reporting an unsupported actuator configuration fault.**
  Contact Dataspeed to fix this issue.

- **Shifting is not working and reporting an unsupported actuator configuration fault.**
  Contact Dataspeed to fix this issue.

- **Shift lever control is erratic.**
  The shift lever calibration could contain incorrect values. Send a gear command CAN message with Calibration as the gear command to manually recalibrate.

- **My vehicle is making the disengage beeping noise continuously and engaging/disengaging control rapidly.**
  Most commands are expected every 20ms and timeout after 100ms. This sets Timeout=1 and Enabled=0 in the report message. If the timeout causes control to disengage, the audible warning is triggered. Verify that your software sends commands every 20ms using an external CAN tool. One common problem is for some other process on the computer sending the drive-by-wire commands to take all the processing power and delay other processes for longer than the 100ms timeout. Make sure that the vehicle control software is separate from perception and other processing that could take a large amount of resources, and try assigning a higher priority to the process running the control software.

- **My vehicle is generating reports but not responding to commands**

Check the SystemReport message for the reason for the last disengage and the reason the system is not ready for control

- **The thermocouple on the Power Distribution Panel is reporting wild values.** There is a known hardware issue with the Power Distribution Panel thermocouple sensor where the value is prone to noise from nearby equipment such as the inverter remote cable. It is not recommended to trust the temperature reading from the thermocouple sensor.
- **Steering, braking, throttle, shifting, turn signals, or something else is not working.**
  - Check that all subsystems have the latest firmware with DataspeedBootloader.exe (Windows) or dataspeed_boot_usb (Linux) and a USB cable. There may be unexpected issues if the firmware versions of each drive-by-wire modules do not match.
  - Check the configurable parameters with DbwConfig.exe (Windows) or dbw_config_cli, and reset all values to default or known working values.
  - Test with a known working interface: Run the ROS joystick demo on a Linux laptop and test the problem.
  - If the issue still persists, contact Dataspeed. Dataspeed may ask you to extract a recording of the problem from the USB cable of the GATEWAY module, which shows up as a read-only flash drive. The active log file number is reported in the EcuInfoGateway CAN message.