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Dataspeed Drive-by-Wire Kit FAQ

December 18th, 2024

Ford U6 Platform (Lincoln Aviator)

Drive-By-Wire

Steering

- **What command types are available?**
  Angle, Curvature, YawRate, and Percent. Curvature and YawRate use Ackermann steering geometry to calculate an angle. Percent is simply ±570° 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?**
  No.
- **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 (±570°), 0.1 degree resolution.
- **What is the relationship between steering wheel angle and road angle?**
  The steering ratio is dynamically adjusted by an OEM system and cannot be directly observed. Experiments have shown a range between 14.0 and 21.0.
- **What is the steering wheel torque threshold for an override?**
  3.5 Nm filtered torque, and the value can be changed via the DbwConfig GUI. Higher thresholds are not attainable because the OEM vehicle enforces the 3.5 Nm threshold.
- **Are there any restrictions on engaging the steering wheel?**
  - Filtered torque must satisfy the following inequality to engage steering:
    -1.5 Nm $\leq$ TORQUE $\leq$ 1.5 Nm
  - Steering wheel angle velocity must satisfy the following inequality to engage steering:
    -50°/s $\leq$ VELOCITY $\leq$ 50°/s

  - These restrictions may make it difficult to engage steering while driving in a sharp turn
  - These values are set by the OEM, and cannot be changed.

- **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?**
  Accel, AccelAcc, AccelAeb, and Percent. Percent is simply 0-10 m/s^2 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 >50Hz will be down-sampled.

- **What is the command delay?**
  Maximum delay incurred from the drive-by-wire system forwarding to the vehicle is 20ms (50Hz).

- **What is the interface? Units? Resolution?**
  Negative acceleration (m/s^2) with 0.001 resolution using ACC/AEB. The interface to be used (ACC/AEB) can be specified.

- **What is the criteria for a driver override?**
  x>200Nm for 100ms, 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. However, brake deceleration via ACC will disengage while the brake pedal is pressed. Brake deceleration via AEB will remain active while the brake pedal is pressed.

- **Can the drive-by-wire achieve full brake deceleration?**
  Yes, the drive-by-wire uses the vehicle's AEB system to achieve full brake deceleration for a few seconds. After that, ACC is used to achieve up to 5 m/s^2.

- **How long can the ACC brakes hold the vehicle stopped?**
  5 minutes, then the electric parking brake is automatically applied.
- **Can the brake lights be controlled separately?**
  No.
- **ABS (Anti lock brakes)?**
  ABS is always enabled. Status (active/inactive) is reported.
- **Hill Start Assist (HSA)?**
  HSA can be enabled/disabled in the production vehicle. Status (enabled/disabled and active/inactive) is reported.
- **Stability Control?**
  Stability Control is always enabled. Status (active/inactive) is reported.

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.

- **Brake and throttle at the same time?**
  - To prevent faulting the OEM brake controller, the drive-by-wire accelerator pedal position command is limited to about 10% when drive-by-wire braking is active
  - Due to yielding and overrides, manual brakes win over drive-by-wire throttle, and manual throttle wins over drive-by-wire brakes

Gear/Transmission

- **What is the interface?**
  Gear position (park/reverse/neutral/drive)
- **What is the report and expected control frequency?**
  10 Hz or on-event report, control on-event
- **Are there any gear shift limitations?**
  - The OEM vehicle has mechanisms to prevent bad shifts at speed.
  - 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.
- **Is transmission gear ratio available?**
  No

Turn Signals

- **What is the report and expected control frequency?**
  20 Hz report, 20 Hz command, 5 Hz timeout
- **What is the interface?**
  Turn Signal state (none/left/right)
- **What are the limitations?**
  By default, turn signal commands are not executed when there is an active driver override on brake/throttle/steering. This behavior can be changed via the DbwConfig GUI.
- **Can I control the hazard lights?**
  No. Status is reported in the turn signal state enumeration.

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Electric Parking Brake

- **What is the report and expected control frequency?**
  20 Hz report, control on-event
- **What is the interface?**
  Parking brake command (none/on)
  To turn off parking brake: shift to reverse or drive, make sure the brakes are not pressed, command non-zero throttle pedal position.
- **What are the limitations?**
  Parking brake commands are not executed when there is an active driver override on brake/throttle/steering or vehicle speed is non-zero.

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?**
  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. The vehicle's parking alert actuates the beep. See the parameter documentation for the HmiBuzzer group of parameters.

  There is no indication that the system is functioning/enabled/disabled.

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.

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Misc

- **What other vehicle sensors can I access?**
  - Vehicle speed (100 Hz)
  - Individual wheel speeds (100 Hz)
  - Roll and yaw rate (100 Hz) (pitch rate is not available)
  - 3-Axis acceleration (100 Hz)
  - GPS (1 Hz)
  - 12V battery voltage and state-of-charge (10 Hz)
  - Tire pressures (2 Hz)
  - Fuel level (10 Hz)
  - Steering wheel buttons (20 Hz)
  - Door/Hood/Trunk open status (20 Hz)
  - Driver and passenger seat belt and airbag status. Rear seat belt statuses are not available.
- **Can I access the front and side radars?**
  Raw radar data is not available. Front radar is available as Forward Collision Warning (FCW) and Automatic Emergency Braking (AEB) statuses.
- **Can I have the documentation for the internal vehicle CAN buses?**
  No. That information is proprietary and cannot be distributed. If you need more than what is available on the drive-by-wire CAN bus, contact Dataspeed.
- **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. The shift-by-wire module remains powered on from a secondary vehicle power source to prevent an unintended shift when there is a mismatch between the gear selector and transmission, and does not execute new gear shift commands (software e-stop).
- **Can I control any of the vehicle indicators/chimes/HMIs?**
  No other vehicle indicators/chimes/HMIs are available at this time.
- **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 both near the battery on the passenger side in the trunk, and near the center console. See the wiring diagram.

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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.

Calibration

- **Steering Wheel Angle**: The OEM vehicle automatically compares steering wheel angle with a calculated angle based on vehicle speed and a yaw rate gyro sensor to calibrate the angle offset for center. This calibration is constantly updating when vehicle speed is above approximately 25 mph. However, the drive-by-wire system sets vehicle speed to zero for the steering module in order to be ready for steering angle control when the calibration is already valid and a steering command CAN message has been received in the last 2 seconds. This prevents the calibration from updating when the drive-by-wire system is powered and receiving steering command CAN messages. The SteerPreventCalibration parameter can be used to set vehicle speed to zero for the steering module all the time to prevent calibration updates. To update the calibration, stop sending steering wheel command CAN messages or power off the drive-by-wire

system and drive relatively straight. Calibration accuracy goes up with vehicle speed. The calibration is reset when power to the OEM steering module is removed, so it is necessary to drive above 25 mph to calibrate steering wheel angle after disconnecting or draining the battery. 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.

Vehicle Parameters

- Maximum braking deceleration: 10 m/s^2
- Maximum horse power: 250 to 450 hp
- Vehicle mass: 2150 to 2550 kg
- Steering ratio: The steering ratio is dynamically adjusted by an OEM system and cannot be directly observed. Experiments have shown a range between 14.0 and 21.0.
- Ackerman wheelbase: 119.1 inches.
- Ackerman track width: 66.9 inches

Power Distribution

- **How much power can I draw from the vehicle?**
  - The recommended auxiliary continuous power draw limit on the Lincoln Aviator vehicle is 75A at 14V, which is 1050W. Large bursts for several minutes will be handled by the lead-acid battery.
  - The limit comes from the alternator power rating at idle to charge the 12V battery. If the continuous load is more than the charging, eventually, the battery will be unable to support critical vehicle subsystems such as power steering and others.
- **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

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'

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.**
  Disconnecting the vehicle battery will cause the production vehicle to lose steering calibration. To calibrate, drive at least 25 mph for at least 10 seconds in a straight line. This may require all sensors to be plugged in (front camera, front radar, side radar, trunk open sensor).

- **The steering wheel is not calibrated well.**
  Try driving at least 50 mph in a straight line with the drive-by-wire system unpowered. When powered, the drive-by-wire system sometimes prevents vehicle steering calibration.

- **Steering is not working and reporting an unsupported actuator configuration fault.**
  Redo the installation procedure to change the configuration of the Ford PSCM (Power Steering Control Module).

- **Steering is not ready for control and there are no faults or warnings.**
  Turn the steering wheel all the way left and right, then back to center.

- **My wheel speed report and wheel position report always report positive speeds and increasing positions, even while in reverse.**
  Some vehicles do not report the sign of wheel speeds and the direction of wheel position ticks. This is dependent on the OEM vehicle and possibly trim level.

- **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 create a recording using the Drive-By-Wire Logger program located at DbwLogger\DbwLogger.exe. See DbwLogger.pdf for documentation on this procedure.

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ADAS Features

The following table lists vehicle features that may be affected when the drive-by-wire is unpowered/powered/active.

Production Vehicle Feature	Unpowered	Powered	Active
Air bags	Available	Available	Available
ABS (Anti-Lock Brakes)	Available	Available	Available
ESC (Electronic Stability Control)	Available	Available	Available
Traction Control	Available	Available	Available
EPAS (Electric Power Assisted Steering)	Available	Available[1]	Modified[1]
LDW (Lane Departure Warning)	Available	Available[2][3]	Disabled[2][3]
LKA (Lane Keep Assist)	Available	Available[2][3]	Disabled[2][3]
APA (Active Park Assist)	Available	Available[3]	Disabled[3]
HSA (Hill Start Assist)	Available	Available	Available
BLIS (Blind Spot Information System)	Available	Available	Available
CTA (Cross Traffic Alert)	Available	Available	Available
TPMS (Tire Pressure Monitoring System)	Available	Available	Available
Backup Camera	Available	Available	Available
Engine Idle Shutdown	Available	Modified[4]	Modified[4]
Engine Start/Stop	Available	Modified[5]	Modified[5]
ACC (Adaptive Cruise Control)	Available	Available	Modified[6][7]
Forward Collision Warning	Available	Available	Available
Pre-Collision Assist	Available	Available	Modified[8][9]
AEB (Automatic Emergency Braking)	Available	Available	Modified[8][9]

[1] Vehicle speed is set equal to zero for the steering motor when the steering command CAN message is present. This results in parking levels of steering torque assist at all vehicle speeds.

[2] Vehicle speed is set equal to zero for the steering motor when the steering command CAN message is present. This disables lane detection for systems that only activate above certain speeds.

[3] All steering actuation from assist systems is disabled when the steering command CAN message is present.

[4] Engine Idle Shutdown can optionally be disabled with a parameter. The default is false.

[5] Engine Start/Stop can optionally be disabled with a parameter. The default is false.

[6] Cruise control can optionally be disabled with a parameter when brake or throttle control is enabled. The default is true.

[7] Brake control either takes the maximum of user ACC commands and vehicle ACC commands, or replaces the vehicle's ACC commands (selectable with a parameter).

[8] Brake control either takes the maximum of user AEB commands and vehicle AEB commands, or replaces the vehicle's AEB commands (selectable with a parameter).

[9] Many automatic braking systems do not activate when the driver is actively pressing the throttle. The drive-by-wire throttle emulates human input, so drive-by-wire commands could affect automatic braking in the same way.

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