Dataspeed Drive-by-Wire Kit FAQ

September 13$^{\text{th}}$, 2023

Ford U6 Platform (Lincoln Aviator)

Drive-By-Wire

Brakes

- **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?**
  Deceleration (m/s^2) with 0.001 resolution. The ACC and AEB interfaces are used.

- **What is the criteria for the DRIVER bit?**
  x>50Nm for 20ms

- **What is the criteria for the OVERRIDE bit?**
  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 'AllowIgnore' parameter via the DbwConfig GUI.

- **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.

- **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 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 0.2 per 20ms to prevent faults.

- **What is the interface? Units? Resolution?**
  Pedal position (%). 12 bit resolution.

- **What is the criteria for the DRIVER bit?**
  x>0.18 for 20ms

- **What is the criteria for the OVERRIDE bit?**
  x>0.30 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 'AllowIgnore' 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, but wheel torque and braking torque are reported.

- **Brake and throttle at the same time?**

  - To prevent faulting the OEM brake controller, accelerator pedal position is limited to about 10% when drive-by-wire braking is active

  - Due to overrides manual brakes win over drive-by-wire throttle, and manual throttle wins over drive-by-wire brakes

Steering

- **What is the report and expected control frequency?**
  100 Hz report, 50 Hz command, 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). The vehicle's response time is unknown, but it has not been an issue. The vehicle has an internal position control loop.

- **What is the interface? Units? Resolution?**
  Steering wheel angle and maximum angular rate: full range ($\pm 570°$), tenth of a degree resolution, maximum 1000°/s.

- **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?**
  Yes, lateral acceleration limit and angular acceleration limit parameters limit steering wheel angle and angular rate based on vehicle speed. These values can be changed via the DbwConfig GUI.

- **Is there a DRIVER bit to indicate activity on the steering wheel? (similar to the brake and throttle)**
  No.

- **Can I control torque instead of position?**
  No.

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

Gear/Transmission

- **What is the report and expected control frequency?**
  20 Hz report, control on-event

- **What is the interface?**
  Gear position (park/reverse/neutral/drive)

- **Are there any gear shift limitations?**

  - Gear shift commands will not be executed when there is an active driver override on brake/throttle/steering

- **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.

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.

Misc

- **What other vehicle sensors can I access?**

    - Vehicle speed is included in the steering report. (100 Hz)
    - Individual wheel speeds (100 Hz)
    - Roll and yaw rate (100 Hz) (pitch rate is not available)
    - 3-Axis acceleration (100 Hz)
    - Tire pressures (2 Hz)
    - Front and rear parking sonars (5 Hz) (only available at low speeds)
    - Rear side radars (5 Hz)
        Cross traffic alert boolean outputs (only available in reverse)
        Blind spot left/right boolean outputs (only available at high speeds)
        Raw radar data is not available
    - 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?**
  Front ACC radar is not available. Side radars are available as blind spot and cross traffic alert outputs only. Front radar is available as Forward Collision Warning (FCW) and Automatic Emergency Braking (AEB) statuses. Raw radar data is not available.

- **Can I have the documentation for the internal vehicle CAN buses?**
  No. That information is proprietary to the vehicle OEM 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).

- **How can I tell if the system is enabled/disabled?**
  The front and rear park assist warnings are activated when the driver takes control of the vehicle. This is both an audible chime and visual indication. At this time, there is no indication that the system is functioning/enabled/disabled.

- **Can I control any of the vehicle indicators/chimes/HMIs?**
  The override alert can be activated with the ALERT bit in the steering command message. No other 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.

Safety

- All modules prioritize driver input over drive-by-wire CAN bus input.

- All modules disengage control after 100ms if a new command is not received.

- All modules pass through vehicle signals unmodified when unpowered or disabled.

- There is an E-Stop button that restores OEM functionality by removing power. See above.

- There is an optional external brake input that can be used to apply a constant braking value with a physical button. 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 when the calibration is already valid. This prevents the calibration from updating when the drive-by-wire system is powered. To update the calibration, 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.

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_Kit.zip release from
  https://www.dataspeedinc.com/release-packages/

  - CAN bus documented in the Vector CAN DBC format: DataspeedByWire.dbc

  - Datasheets for each module (including CAN message definitions)

- ROS driver
  `https://bitbucket.org/DataspeedInc/dbw_mkz_ros`

Updating

- **Windows laptop and embedded modules**

  - Download the latest DriveByWire_Kit.zip release from
    `https://www.dataspeedinc.com/release-packages/`
  - Check the CHANGELOGs to see which modules need to be updated.
  - Update the firmware of required modules with DataspeedBootloader.exe by connecting to that module's USB cable. This process is documented in DataspeedBootloader.pdf.

- **Ubuntu Linux demo laptop**

  - ROS documentation can be found here:
    `https://bitbucket.org/DataspeedInc/dbw_mkz_ros/src/master/ROS_SETUP.md`
  - Run the 'One Line SDK Update' script at the link above.
  - The password for the provided laptop is 'password' (without quotes).

Troubleshooting

- **The only CAN messages from the drive-by-wire system are Version (0x07F) and License (0x07E)**
  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.

- **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 prevents vehicle steering calibration.

- **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.

- **My vehicle is not responding to commands and the passenger airbag light is flashing on/off.**
  These are the symptoms of a Watchdog Counter fault. To clear a watchdog counter event, press the OK button on the left side of the steering wheel or cycle power to the drive-by-wire system. If the Watchdog counter fault keeps triggering, set the COUNT field to zero in all command messages to disable this functionality.

- **My vehicle is making the override beeping noise continuously and engaging/disengaging control rapidly.**
  Most commands are expected every 20ms and timeout after 100ms. This sets TMOUT=1 and EN=0. 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 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.

- **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 and a USB cable using the laptop included with your vehicle. 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, and reset all values to default.
  - Test with a known working interface: Run the ROS joystick demo on the laptop included with your vehicle 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.

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	Modified[1]	Modified[1]
LDW (Lane Departure Warning)	Available	Disabled[2,3]	Disabled[2,3]
LKA (Lane Keep Assist)	Available	Disabled[2,3]	Disabled[2,3]
APA (Active Park Assist)	Available	Disabled[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	Modified[4]
Engine Start/Stop	Available	Modified	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]

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[1] Vehicle speed is set equal to zero for the steering motor. 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. This disables lane detection for systems that only activate above certain speeds.

[3] All steering actuation from assist systems is disabled.

[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.