



Jeep Grand Cherokee Steer-By-Wire

Steering by-wire in the Jeep Grand Cherokee

Features

- Computer control of steering
- Measure steering wheel position
- Driver override by grabbing the steering wheel
- CAN and USB interfaces
- No modifications to vehicle
- Signal passthrough on power off

Applications

- Driverless car research
- Advanced Driver Assist (ADAS) research

Description

The Dataspeed Inc. Steer-By-Wire interface enables computer control of the steering wheel in a safe and effective manner. This plug-in ready kit requires no modification to the factory harnessing and can be installed in minutes. Industry standard CAN and USB networks enable control and monitoring of the steering system.



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DISCLAIMER:

This product is intended for research purposes only. Steps have been taken to ensure function on power or communication loss. However, in no event shall Dataspeed Inc. be liable for any direct, indirect, punitive, incidental, special consequential damages, to property or life, whatsoever arising out of or connected with the use or misuse of its products.

1 Connector Pin Description

1.1 CAN/DB9 Connector

The CAN/DB9 connector is used for power and CAN communication. Short pins 1 and 6 together to activate the digital input.

Table 1: CAN/DB9 connector pin description.

Pin	Symbol	Description
1	DIGIN	Digital Input
2	CANL	CAN Low
3	GND	Ground
4	IGNITION	Ignition (12V)
5	NC	No Connect
6	GND	Ground
7	CANH	CAN High
8	NC	No Connect
9	POWER	Power (12V)

1.2 USB Connector

The USB connector is used for introspection and firmware upgrade.

2 Electrical Characteristics

Table 2: Electrical Characteristics.

Characteristic	Min	Typ	Max	Units	Conditions
VIGNITION ON	9	12	16	V	
VIGNITION OFF	-0.3	0	2	V	
VPOWER	9	12	16	V	
IPOWER		200		mA	VPOWER=12V, VIGNITION>9V
IPOWER			0.1	mA	VPOWER=12V, VIGNITION<2V
Temperature	-40		+85	°C	

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3 Mechanical Drawings

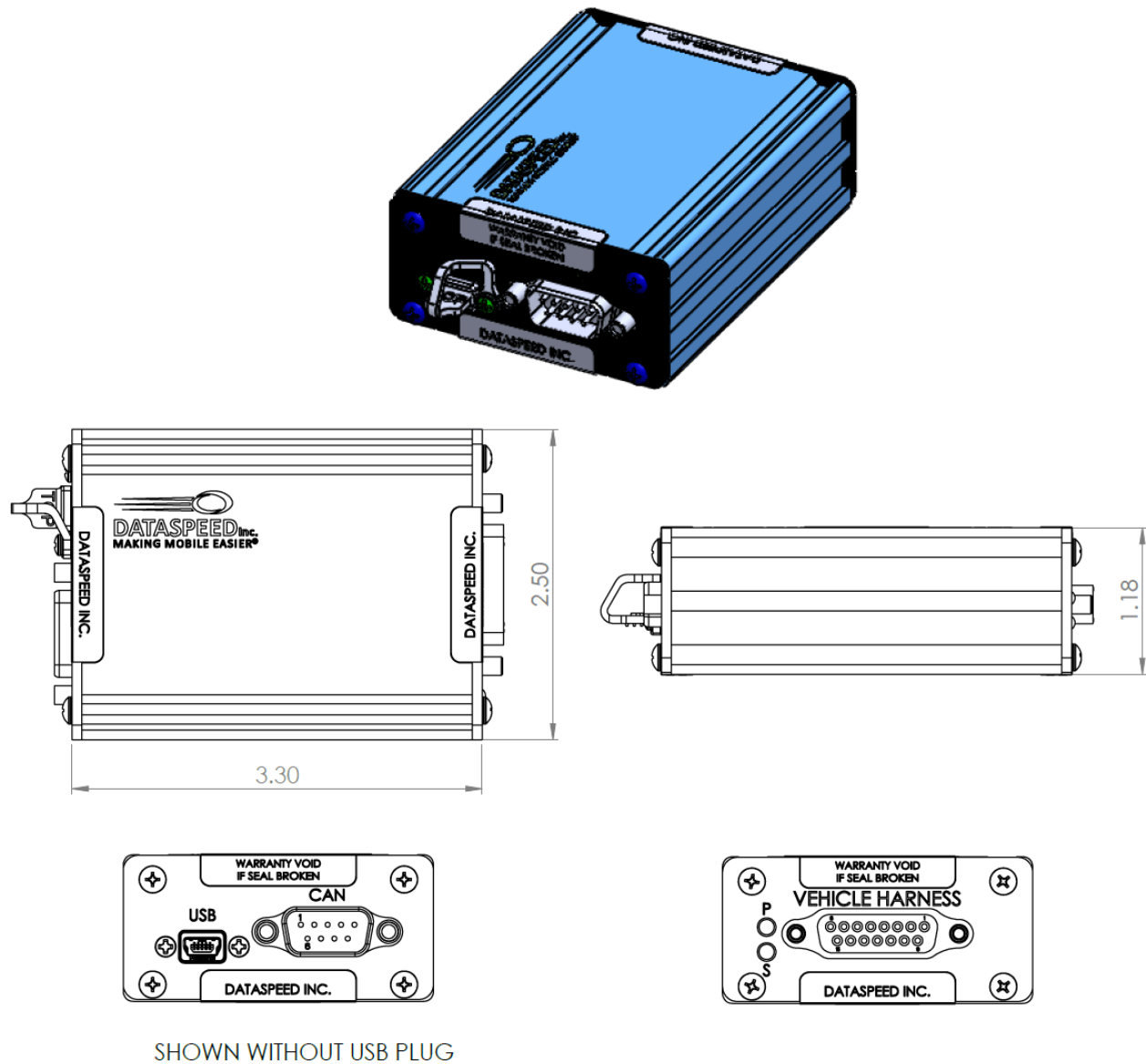


Figure 1: Mechanical Drawing

4 CAN Messages

Table 3: CAN bus configuration.

Parameter	Value	Units
Terminated	Yes	120 Ω
BitRate	500	k
t _q	200	ns
SyncSeg	1	t _q
PropSeg	3	t _q
PhaseSeg1	3	t _q
PhaseSeg2	3	t _q
SyncJumpWidth	2	t _q

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4.1 Steering

4.1.1 Command

Message ID: 0x064
Receive Rate: 20ms
Receive Timeout: 100ms

Table 4: Steering Command CAN Message Description.

Byte	Bits	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
0	7:0	SCMD<7:0>							
1	15:8	SCMD<15:8>							
2	23:16	CMD_TYPE	—	—	QUIET	—	IGNORE	CLEAR	EN
3	31:24	SVEL							
4	39:32	—	—	—	—	—	—	—	—
5	47:40	—	—	—	—	—	—	—	—
6	55:48	—	—	—	—	—	—	—	—
7	63:56	COUNT							

bit 0-15	SCMD: Steering Command
	Angle Mode (CMD_TYPE = 0):
	0x1450 = 520° left
	0x0001 = 0.1° left
	0x0000 = 0.0° center
	0xFFFF = 0.1° right
	Torque Mode (CMD_TYPE = 1):
	0x0280 = 5.0 N-m left
	0x0001 = 0.0078125 N-m left
	0x0000 = 0.0 N-m
	0xFFFF = -0.0078125 N-m right
	0xFD80 = -5.0 N-m right
bit 16	EN: Enable request
	0 = disable
	1 = enable
bit 17	CLEAR: Clear driver override flag
	0 = normal operation
	1 = request clear of driver override
bit 18	IGNORE: Ignore driver override
	0 = normal
	1 = ignore
bit 19	Unimplemented: Set to '0'
bit 20	QUIET: Disable driver override audible warning
	0 = normal
	1 = disable
bit 21-22	Unimplemented: Set to '0'
bit 23	CMD_TYPE: Steering command type
	0 = angle
	1 = torque
bit 24-31	SVEL: Steering Velocity
	0x00 = 0°/s = 500°/s
	0x01 = 4°/s
	0x02 = 8°/s
	0xFA = 1000°/s
bit 32-55	Unimplemented: Set to '0'
bit 56-63	COUNT: Optional watchdog counter

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4.1.2 Report

Message ID: 0x065
Transmit Rate: 20ms

Table 5: Steering Report CAN Message Description.

Byte	Bits	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
0	7:0	ANGLE<7:0>							
1	15:8	ANGLE<15:8>							
2	23:16	CMD<7:0>							
3	31:24	TMODE	CMD<14:8>						
4	39:32	SPEED<7:0>							
5	47:40	SPEED<15:8>							
6	55:48	TORQUE							
7	63:56	TMOUT	FLTCAL	FLT2	FLT1	FLTWDC	FLTPWR	OVERRIDE	EN

bit 0-15 **ANGLE:** Steering wheel angle
 0x1450 = 520° left
 0x0001 = 0.1° left
 0x0000 = 0.0° center
 0xFFFF = 0.1° right
 0xEBB0 = 520° right

bit 16-30 **CMD:** Reported steering wheel command
 Angle Mode (TMODE = 0): **Torque Mode** (TMODE = 1):
 0x1450 = 520° left 0x0280 = 5.0 N-m left
 0x0001 = 0.1° left 0x0001 = 0.0078125 N-m left
 0x0000 = 0.0° center 0x0000 = 0.0 N-m
 0x7FFF = 0.1° right 0x7FFF = -0.0078125 N-m right
 0xEBB0 = 520° right 0x7D80 = -5.0 N-m right

bit 31 **TMODE:** Steering torque mode: 0 = angle, 1 = torque

bit 32-47 **SPEED:** Vehicle speed
 0 = 0.00 kph
 1 = 0.01 kph
 65535 = 655.35 kph

bit 48-55 **TORQUE:** Steering column torque
 0x7F = 7.9375 Nm
 0x01 = 0.0625 Nm
 0x00 = 0.0000 Nm
 0xFF = -0.0625 Nm
 0x80 = -8.0000 Nm

bit 56 **EN:** Enabled
 0 = disabled. SCMD ignored.
 1 = enabled. No timeouts or overrides have occurred.

bit 57 **OVERRIDE:** Driver Override (Cleared on rising edge of EN bit in command message)
 0 = No Override (|TORQUE| < 3.5 Nm, or IGNORE == 1)
 1 = Driver Override (|TORQUE| ≥ 3.5 Nm) (configurable)

bit 58 **FLTPWR:** Power fault: 0 = No fault, 1 = Fault

bit 59 **FLTWDC:** Watchdog Counter fault: 0 = No fault, 1 = Fault

bit 60 **FLT1:** Channel 1 fault: 0 = No fault, 1 = Fault

bit 61 **FLT2:** Channel 2 fault: 0 = No fault, 1 = Fault

bit 62 **FLTCAL:** Calibration fault: 0 = No fault, 1 = Fault, Disconnecting the vehicle battery will cause the vehicle to lose steering calibration. Turn the wheel manually to recalibrate.

bit 63 **TMOUT:** Timeout: 0 = Command is fresh, 1 = Command timeout after 100ms

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4.2 Universal Lat/Lon Controller (ULC)

4.2.1 Command

Message ID: 0x076
 Receive Rate: 20ms
 Receive Timeout: 100ms

Table 6: ULC Command CAN Message Description.

Byte	Bits	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
0	7:0	LIN_VEL<7:0>							
1	15:8	LIN_VEL<15:8>							
2	23:16	YAW_CMD<7:0>							
3	31:24	YAW_CMD<15:8>							
4	39:32	—	—	CLEAR	PEDALS	STEER	SHIFT	PARK	CURV
5	47:40	—	—	—	—	—	—	—	—
6	55:48	—	—	—	—	—	—	—	—
7	63:56	—	—	—	—	—	—	—	—

bit 0-15 **LIN_VEL:** Desired vehicle speed
 Units: m/s
 Resolution: 0.0025 m/s / lsb Type: int16
 Saturated Minimum: 0xF510 = -7 m/s Saturated Maximum: 0x4650 = 45 m/s
 bit 16-31 **YAW_CMD:** Desired steering (yaw rate or curvature, depending on the CURV bit setting)

CURV:		0	1
spec:			
Units		rads/sec	1/m
Resolution		2.5×10^{-4}	6.1×10^{-6}
Type		int16	int16
Min = 0x8000 (full right)		-8.192	-0.1999
Max = 0x7FFF (full left)		8.1915	0.1999

bit 32 **CURV:** Steering mode switch
 0 = Yaw rate mode
 1 = Curvature mode
 bit 33 **PARK:** Enable shifting out of Park
 0 = disable
 1 = enable
 bit 34 **SHIFT:** Enable control of the shifter
 0 = disable
 1 = enable
 bit 35 **STEER:** Enable control of steering
 0 = disable
 1 = enable
 bit 36 **PEDALS:** Enable control of the brake and throttle pedals to regulate speed
 0 = disable
 1 = enable
 bit 37 **CLEAR:** Clear driver override flag
 0 = normal operation
 1 = request clear of driver override
 bit 38-63 **Unimplemented:** Set to '0'

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4.2.2 Configuration

Message ID: 0x077
Receive Rate: 200ms
Receive Timeout: 1000ms

Table 7: ULC Configuration CAN Message Description.

Byte	Bits	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
0	7:0	LIN_ACCEL<7:0>							
1	15:8	LIN_DECEL<7:0>							
2	23:16	LAT_ACCEL<7:0>							
3	31:24	ANG_ACCEL<7:0>							
4	39:32	—	—	—	—	—	—	—	—
5	47:40	—	—	—	—	—	—	—	—
6	55:48	—	—	—	—	—	—	—	—
7	63:56	—	—	—	—	—	—	—	—

bit 0-7 **LIN_ACCEL:** Maximum linear acceleration
Units: m/s^2
Resolution: $0.025 \text{ m/s}^2 / \text{lsb}$
Type: uint8
Default: 0x00 = Use built-in speed-dependent LUT to limit acceleration
Saturated Minimum: 0x0C = 0.3 m/s^2
Saturated Maximum: 0x78 = 3.0 m/s^2

bit 8-15 **LIN_DECEL:** Maximum linear deceleration Units: m/s^2
Resolution: $0.025 \text{ m/s}^2 / \text{lsb}$
Type: uint8
Default: 0x00 = 1.5 m/s^2
Saturated Minimum: 0x0C = 0.3 m/s^2
Saturated Maximum: 0xF0 = 6.0 m/s^2

bit 16-23 **LAT_ACCEL:** Maximum lateral acceleration to limit steering angle
Units: m/s^2
Resolution: $0.05 \text{ m/s}^2 / \text{lsb}$
Type: uint8 Default: 0x00 = 4.0 m/s^2
Saturated Minimum: 0x14 = 1.0 m/s^2
Maximum: 0xFF = 12.75 m/s^2

bit 24-31 **ANG_ACCEL:** Maximum angular acceleration to limit steering rate
Units: rad/s^2
Resolution: $0.02 \text{ rad/s}^2 / \text{lsb}$
Type: uint8 Default: 0x00 = 1 rad/s^2
Saturated Minimum: 0x19 = 0.5 rad/s^2 Maximum: 0xFF = 5.1 rad/s^2

bit 32-63 **Unimplemented:** Set to '0'

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4.2.3 Report

Message ID: 0x078
Transmit Rate: 20ms

Table 8: ULC Report CAN Message Description.

Byte	Bits	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
0	7:0	SPEED_REF<7:0>							
1	15:8	MODE	PEDALS	TMOUT	SPEED_REF<12:8>				
2	23:16	SPEED_MEAS<7:0>							
3	31:24	CURV	STEER	OVERRIDE	SPEED_MEAS<12:8>				
4	39:32	ACCEL_REF							
5	47:40	ACCEL_MEAS							
6	55:48	—	MAX_ANG						
7	63:56	PRE_SP	PRE_ST	MAX_RATE					

- bit 0-12 **SPEED_REF:** Internal speed reference being tracked
Units: m/s Resolution: 0.02 m/s / lsb Type: int16
- bit 13 **TMOUT:** Command timeout status
0 = Command being received
1 = Command timed out after 100 ms
- bit 14 **PEDALS:** Status of throttle and brake signals being sent by the speed control system
0 = Throttle and brake signals are not being sent
1 = Throttle and brake signals are being sent
- bit 15 **MODE:** Input tracking mode currently active (see ULC User's Guide for details)
0 = Loose Tracking Mode
1 = Tight Tracking Mode
- bit 16-28 **SPEED_MEAS:** Speed control feedback value
Units: m/s Resolution: 0.02 m/s / lsb Type: int16
- bit 29 **OVERRIDE:** Driver override status
0 = No driver overrides latched
1 = One or more driver overrides latched
- bit 30 **STEER:** Status of steering angle signal being sent by the steering control system
0 = Steering signals are not being sent
1 = Steering signals are being sent
- bit 31 **CURV:** Steering mode status
0 = Yaw rate mode
1 = Curvature mode
- bit 32-39 **ACCEL_REF:** Internal acceleration reference being tracked
Units: m/s² Resolution: 0.05 m/s² / lsb Type: int8
- bit 40-47 **ACCEL_MEAS:** Acceleration control feedback value
Units: m/s² Resolution: 0.05 m/s² / lsb Type: int8
- bit 48-54 **MAX_ANG:** Maximum allowed steering angle given LAT_ACCEL signal in command
Units: degrees Resolution: 5 degrees / lsb Type: uint8
- bit 55 **Unimplemented:** Set to '0'
- bit 56-61 **MAX_RATE:** Maximum allowed steering velocity given ANG_ACCEL signal in command
Units: deg/s Resolution: 8 deg/s / lsb Type: uint8
- bit 62 **PRE_ST:** Steering preemption status
0 = Not being preempted
1 = Steering control would otherwise be active, but is being preempted
- bit 63 **PRE_PD:** Pedal preemption status
0 = Not being preempted
1 = Speed control would otherwise be sending pedal commands, but is being preempted

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4.3 Turn Signal Command

Message ID: 0x068
Receive Rate: 50ms
Receive Timeout: 200ms

Table 9: Turn Signal Command CAN Message Description.

Byte	Bits	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
0	7:0	—	—	—	—	—	—	TRNCMD	

bit 0-1 **TRNCMD:** Turn Signal Command

0 = None

1 = Left

2 = Right

3 = Not Used

bit 7-2 **Unimplemented:** Set to '0'

Note: The turn-signal command will be rejected if OVERRIDE=1 for any of brake/throttle/steering. This is silent, there is no signal to report that the command was rejected.

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4.4 Miscellaneous Report

Message ID: 0x069
Transmit Rate: 50ms

Table 10: Miscellaneous Report CAN Message Description.

Byte	Bits	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
0	7:0	—	—	—	—	—	—	TRNSTAT	
1	15:8	—	CNCL	RES	—	—	—	—	—
2	23:16	FLTBUS	—	GDEC	GINC	SDEC	SINC	—	ONOFF
3	31:24	—	—	—	—	—	—	—	—
4	39:32	—	LDRHT	LDLFT	LDDWN	LDUP	LDOK	—	—
5	47:40	—	—	—	—	—	—	—	CCMODE

bit 0-1 **TRNSTAT:** Turn signal status

0 = None
1 = Left
2 = Right
3 = Not Used

bit 2-12 **Unimplemented:** Set to '0'

bit 13 **RES:** ACC resume button: 0 = Not pressed, 1 = Pressed

bit 14 **CNCL:** ACC cancel button: 0 = Not pressed, 1 = Pressed

bit 15 **Unimplemented:** Set to '0'

bit 16 **ONOFF:** ACC on/off button: 0 = Not pressed, 1 = Pressed

bit 17 **Unimplemented:** Set to '0'

bit 18 **SINC:** ACC increment set speed button: 0 = Not pressed, 1 = Pressed

bit 19 **SDEC:** ACC decrement set speed button: 0 = Not pressed, 1 = Pressed

bit 20 **GINC:** ACC increment following gap button: 0 = Not pressed, 1 = Pressed

bit 21 **GDEC:** ACC decrement following gap button: 0 = Not pressed, 1 = Pressed

bit 22 **Unimplemented:** Set to '0'

bit 23 **FLTBUS:** CAN bus fault: 0 = No Fault, 1 = Fault

bit 24-33 **Unimplemented:** Set to '0'

bit 34 **LDOK:** Left D-Pad OK button: 0 = Not pressed, 1 = Pressed

bit 35 **LDUP:** Left D-Pad Up button: 0 = Not pressed, 1 = Pressed

bit 36 **LDDWN:** Left D-Pad Down button: 0 = Not pressed, 1 = Pressed

bit 37 **LDLFT:** Left D-Pad Left button: 0 = Not pressed, 1 = Pressed

bit 38 **LDRHT:** Left D-Pad Right button: 0 = Not pressed, 1 = Pressed

bit 39 **Unimplemented:** Set to '0'

bit 40 **CCMODE:** ACC mode button: 0 = Not pressed, 1 = Pressed

bit 41-47 **Unimplemented:** Set to '0'

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4.5 Wheel Speed

Message ID: 0x06A
Transmit Rate: 10ms

Table 11: Wheel Speed CAN Message Description.

Byte	Bits	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
0	7:0	FL<7:0>							
1	15:8	FL<15:8>							
2	23:16	FR<7:0>							
3	31:24	FR<15:8>							
4	39:32	RL<7:0>							
5	47:40	RL<15:8>							
6	55:48	RR<7:0>							
7	63:56	RR<15:8>							

bit 0-15 **FL:** Front Left Wheel Speed
0x7FFF = 327.67 rad/s
0x0001 = 0.01 rad/s
0x0000 = 0.00 rad/s
0xFFFF = -0.01 rad/s
0x8000 = -327.68 rad/s

bit 16-31 **FR:** Front Right Wheel Speed
0x7FFF = 327.67 rad/s
0x0001 = 0.01 rad/s
0x0000 = 0.00 rad/s
0xFFFF = -0.01 rad/s
0x8000 = -327.68 rad/s

bit 32-47 **RL:** Rear Left Wheel Speed
0x7FFF = 327.67 rad/s
0x0001 = 0.01 rad/s
0x0000 = 0.00 rad/s
0xFFFF = -0.01 rad/s
0x8000 = -327.68 rad/s

bit 48-63 **RR:** Rear Right Wheel Speed
0x7FFF = 327.67 rad/s
0x0001 = 0.01 rad/s
0x0000 = 0.00 rad/s
0xFFFF = -0.01 rad/s
0x8000 = -327.68 rad/s

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4.6 Wheel Position

Message ID: 0x070
Transmit Rate: 20ms

Table 12: Wheel Position CAN Message Description.

Byte	Bits	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
0	7:0	FL<7:0>							
1	15:8	FL<15:8>							
2	23:16	FR<7:0>							
3	31:24	FR<15:8>							
4	39:32	RL<7:0>							
5	47:40	RL<15:8>							
6	55:48	RR<7:0>							
7	63:56	RR<15:8>							

bit 0-15 **FL:** Front Left Wheel Position Counts
 0x7FFF = 32767
 0x0001 = 1
 0x0000 = 0
 0xFFFF = -1
 0x8000 = -32768

bit 16-31 **FR:** Front Right Wheel Position Counts
 0x7FFF = 32767
 0x0001 = 1
 0x0000 = 0
 0xFFFF = -1
 0x8000 = -32768

bit 32-47 **RL:** Rear Left Wheel Position Counts
 0x7FFF = 32767
 0x0001 = 1
 0x0000 = 0
 0xFFFF = -1
 0x8000 = -32768

bit 48-63 **RR:** Rear Right Wheel Position Counts
 0x7FFF = 32767
 0x0001 = 1
 0x0000 = 0
 0xFFFF = -1
 0x8000 = -32768

The conversion factor was experimentally determined to be 125.5 counts per revolution. It is recommended to experimentally calculate the conversion factor for a particular vehicle by comparing wheel position counts over time with wheel speeds.

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4.7 Fuel Level

Message ID: 0x072
Transmit Rate: 100ms

Table 13: Fuel Level CAN Message Description.

Byte	Bits	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
0	7:0	FUEL<7:0>							
1	15:8	—	—	—	—	—	FUEL<10:8>		
2	23:16	—	—	—	—	—	—	—	—
3	31:24	BATTERY_12V							
4	39:32	ODOMETER<7:0>							
5	47:40	ODOMETER<15:8>							
6	55:48	ODOMETER<23:16>							
7	63:56	—	—	—	—	—	—	—	—

bit 0-10 **FUEL:** Fuel Level
 0x398 = 100.0000%
 0x001 = 0.108696%
 0x000 = 0.000000%
 0x7FF = -0.108696%

bit 11-23 **Unimplemented:** Set to '0'

bit 24-31 **BATTERY_12V:** 12V battery voltage
 0x00 = 0.0000V
 0x01 = 0.0625V
 0xFF = 15.9375V

bit 32-55 **ODOMETER:** Vehicle odometer
 0x000000 = 0.0 km
 0x000001 = 0.1 km
 0xFFFFFFFF = 1677721.5 km

bit 56-63 **Unimplemented:** Set to '0'

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4.8 Brake Info

Message ID: 0x074
Transmit Rate: 20ms

Table 14: BrakeInfo CAN Message Description.

Byte	Bits	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
0	7:0	BRKTRQR<7:0>							
1	15:8	BRKTRQA<3:0>				BRKTRQR<11:8>			
2	23:16	BRKTRQA<11:4>							
3	31:24	BPEDPC							
4	39:32	BRKPRSR<7:0>							
5	47:40	—	—	—	—	STATNRY	BRKPRSR<10:8>		
6	55:48	—	—	—	—	—	—	—	—
7	63:56	—	—	—	—	—	—	—	—

bit 0-11 **BRKTRQR:** Braking Torque Request

0x000 = 0 N-m

0x001 = 3 N-m

0xFFE = 12282 N-m

0xFFF = Invalid

bit 12-23 **BRKTRQA:** Braking Torque Actual

0x000 = 0 N-m

0x001 = 3 N-m

0xFFE = 12282 N-m

0xFFF = Invalid

bit 24-31 **BPEDPC:** Brake pedal percentage

0x00 = 0.0%

0x01 = 0.4%

0xFA = 100.0%

bit 32-42 **BRKPRSR:** Brake pressure

0x000 = 0 bar

0x001 = 0.1 bar

0x7D0 = 200 bar

bit 43 **STATNRY:** Vehicle Stationary

0 = Moving, 1 = Stationary

bit 44-63 **Unimplemented:** Set to '0'

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4.9 Throttle Info

Message ID: 0x075
Transmit Rate: 10ms

Table 15: ThrottleInfo CAN Message Description.

Byte	Bits	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
0	7:0	AXLTRQ<7:0>							
1	15:8	—	AXLTRQ<14:8>						
2	23:16	APEDPC							
3	31:24	—	—	—	GEARNUM				
4	39:32	—	—	—	—	—	—	—	—
5	47:40	—	—	—	—	—	—	—	—
6	55:48	—	—	—	—	—	—	—	—
7	63:56	—	—	—	—	—	—	—	—

bit 0-14 **AXLTRQ:** Driver Intended Axle torque

0x3FFF = 25598.4375 Nm

0x0001 = 1.5625 Nm

0x0000 = 0.0000 Nm

0x7FFF = -1.5625 Nm

0x4000 = -25600 Nm

bit 15 **Unimplemented:** Set to '0'

bit 16-23 **APEDPC:** Accelerator Pedal Percent

0x00 = 0.0 %

0x01 = 0.4 %

0xFA = 100.0 %

bit 24-28 **GEARNUM:** Transmission gear number

0x00 = Unknown

0x01 = Drive (1st)

0x02 = Drive (2nd)

0x03 = Drive (3rd)

0x04 = Drive (4th)

0x05 = Drive (5th)

0x06 = Drive (6th)

0x07 = Drive (7th)

0x08 = Drive (8th)

0x10 = Neutral

0x11 = Reverse (1st)

0x12 = Reverse (2nd)

0x1F = Park

bit 29-63 **Unimplemented:** Set to '0'

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4.10 License

See the Dataspeed License Manager (DataspeedLM) for more information.
The bits 16-63 in the License CAN message are multiplexed with the MUX field.

MUX	Description
0x00	Feature 'Base' (base functionality)
0x80	MAC Address
0x81	Build Date string (characters 0-5)
0x82	Build Date string (characters 6-9)
0x83	VIN string (characters 0-5)
0x84	VIN string (characters 6-11)
0x85	VIN string (characters 12-16)

4.10.1 Feature: Base

Message ID: 0x07E
Transmit Rate: 250ms

Table 16: License CAN Message Description.

Byte	Bits	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
0	7:0	MUX							
1	15:8	—	—	—	—	—	EXPIRED	TRIAL	READY
2	23:16	—	—	—	—	—	—	TRIAL	ENABLED
3	31:24	—	—	—	—	—	—	—	—
4	39:32	TRIALS USED<7:0>							
5	47:40	TRIALS USED<15:8>							
6	55:48	TRIALS REMAINING<7:0>							
7	63:56	TRIALS REMAINING<15:8>							

bit 0-7	MUX: Multiplexer field, determines representation bits 16-63 0x00 = Feature: Base
bit 8	READY: License Manager ready 0 = Waiting to resolve VIN 1 = Ready
bit 9	TRIAL: Trial license 0 = No features licensed as a trial 1 = One or more features licensed as a trial
bit 9	EXPIRED: Expired license 0 = No feature licenses expired (past firmware build date) 1 = One or more feature licenses expired (past firmware build date)
bit 10-15	Unimplemented: Set to '0'
bit 16	ENABLED: Feature enabled 0 = This feature not licensed 1 = This feature successfully licensed
bit 17	TRIAL: Feature trial 0 = This feature not licensed as a trial 1 = This feature licensed as a trial (regardless of remaining trial counts)
bit 18-31	Unimplemented: Set to '0'
bit 32-47	TRIALS USED: Number of trial counts used for this feature
bit 48-63	TRIALS REMAINING: Number of trial counts remaining for this feature

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4.10.2 MAC Address

Message ID: 0x07E
Transmit Rate: 250ms

Table 17: License CAN Message Description.

Byte	Bits	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
0	7:0	MUX							
1	15:8	—	—	—	—	—	EXPIRED	TRIAL	READY
2	23:16	MAC0							
3	31:24	MAC1							
4	39:32	MAC2							
5	47:40	MAC3							
6	55:48	MAC4							
7	63:56	MAC5							

bit 0-7 **MUX:** Multiplexer field, determines representation bits 16-63
 0x80 = MAC Address

bit 8 **READY:** License Manager ready
 0 = Waiting to resolve VIN
 1 = Ready

bit 9 **TRIAL:** Trial license
 0 = No features licensed as a trial
 1 = One or more features licensed as a trial

bit 9 **EXPIRED:** Expired license
 0 = No feature licenses expired (past firmware build date)
 1 = One or more feature licenses expired (past firmware build date)

bit 10-15 **Unimplemented:** Set to '0'

bit 16-23 **MAC0:** MAC Address byte 0

bit 24-31 **MAC1:** MAC Address byte 1

bit 32-39 **MAC2:** MAC Address byte 2

bit 40-47 **MAC3:** MAC Address byte 3

bit 48-55 **MAC4:** MAC Address byte 4

bit 56-63 **MAC5:** MAC Address byte 5

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4.10.3 Build Date (part 0)

Message ID: 0x07E
Transmit Rate: 250ms

Table 18: License CAN Message Description.

Byte	Bits	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
0	7:0	MUX							
1	15:8	—	—	—	—	—	EXPIRED	TRIAL	READY
2	23:16	DATE0							
3	31:24	DATE1							
4	39:32	DATE2							
5	47:40	DATE3							
6	55:48	DATE4							
7	63:56	DATE5							

bit 0-7 **MUX:** Multiplexer field, determines representation bits 16-63
 0x81 = Date part 0

bit 8 **READY:** License Manager ready
 0 = Waiting to resolve VIN
 1 = Ready

bit 9 **TRIAL:** Trial license
 0 = No features licensed as a trial
 1 = One or more features licensed as a trial

bit 9 **EXPIRED:** Expired license
 0 = No feature licenses expired (past firmware build date)
 1 = One or more feature licenses expired (past firmware build date)

bit 10-15 **Unimplemented:** Set to '0'

bit 16-23 **DATE0:** Date string (character 0)

bit 24-31 **DATE1:** Date string (character 1)

bit 32-39 **DATE2:** Date string (character 2)

bit 40-47 **DATE3:** Date string (character 3)

bit 48-55 **DATE4:** Date string (character 4)

bit 56-63 **DATE5:** Date string (character 5)

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4.10.4 Build Date (part 1)

Message ID: 0x07E
Transmit Rate: 250ms

Table 19: License CAN Message Description.

Byte	Bits	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
0	7:0	MUX							
1	15:8	—	—	—	—	—	EXPIRED	TRIAL	READY
2	23:16	DATE6							
3	31:24	DATE7							
4	39:32	DATE8							
5	47:40	DATE9							
6	55:48	—	—	—	—	—	—	—	—
7	63:56	—	—	—	—	—	—	—	—

bit 0-7 **MUX:** Multiplexer field, determines representation bits 16-63
0x82 = Date part 1

bit 8 **READY:** License Manager ready
0 = Waiting to resolve VIN
1 = Ready

bit 9 **TRIAL:** Trial license
0 = No features licensed as a trial
1 = One or more features licensed as a trial

bit 9 **EXPIRED:** Expired license
0 = No feature licenses expired (past firmware build date)
1 = One or more feature licenses expired (past firmware build date)

bit 10-15 **Unimplemented:** Set to '0'

bit 16-23 **DATE6:** Date string (character 6)

bit 24-31 **DATE7:** Date string (character 7)

bit 32-39 **DATE8:** Date string (character 8)

bit 40-47 **DATE9:** Date string (character 9)

bit 48-63 **Unimplemented:** Set to '0'

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4.10.5 VIN (part 0)

Message ID: 0x07E
Transmit Rate: 250ms

Table 20: License CAN Message Description.

Byte	Bits	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
0	7:0	MUX							
1	15:8	—	—	—	—	—	EXPIRED	TRIAL	READY
2	23:16	VIN00							
3	31:24	VIN01							
4	39:32	VIN02							
5	47:40	VIN03							
6	55:48	VIN04							
7	63:56	VIN05							

bit 0-7 **MUX:** Multiplexer field, determines representation bits 16-63
 0x83 = VIN part 0

bit 8 **READY:** License Manager ready
 0 = Waiting to resolve VIN
 1 = Ready

bit 9 **TRIAL:** Trial license
 0 = No features licensed as a trial
 1 = One or more features licensed as a trial

bit 9 **EXPIRED:** Expired license
 0 = No feature licenses expired (past firmware build date)
 1 = One or more feature licenses expired (past firmware build date)

bit 10-15 **Unimplemented:** Set to '0'

bit 16-23 **VIN00:** VIN string (character 0)

bit 24-31 **VIN01:** VIN string (character 1)

bit 32-39 **VIN02:** VIN string (character 2)

bit 40-47 **VIN03:** VIN string (character 3)

bit 48-55 **VIN04:** VIN string (character 4)

bit 56-63 **VIN05:** VIN string (character 5)

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4.10.6 VIN (part 1)

Message ID: 0x07E
Transmit Rate: 250ms

Table 21: License CAN Message Description.

Byte	Bits	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
0	7:0	MUX							
1	15:8	—	—	—	—	—	EXPIRED	TRIAL	READY
2	23:16	VIN06							
3	31:24	VIN07							
4	39:32	VIN08							
5	47:40	VIN09							
6	55:48	VIN10							
7	63:56	VIN11							

bit 0-7 **MUX:** Multiplexer field, determines representation bits 16-63
 0x84 = VIN part 1

bit 8 **READY:** License Manager ready
 0 = Waiting to resolve VIN
 1 = Ready

bit 9 **TRIAL:** Trial license
 0 = No features licensed as a trial
 1 = One or more features licensed as a trial

bit 9 **EXPIRED:** Expired license
 0 = No feature licenses expired (past firmware build date)
 1 = One or more feature licenses expired (past firmware build date)

bit 10-15 **Unimplemented:** Set to '0'

bit 16-23 **VIN06:** VIN string (character 6)

bit 24-31 **VIN07:** VIN string (character 7)

bit 32-39 **VIN08:** VIN string (character 8)

bit 40-47 **VIN09:** VIN string (character 9)

bit 48-55 **VIN10:** VIN string (character 10)

bit 56-63 **VIN11:** VIN string (character 11)

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4.10.7 VIN (part 2)

Message ID: 0x07E
Transmit Rate: 250ms

Table 22: License CAN Message Description.

Byte	Bits	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
0	7:0	MUX							
1	15:8	—	—	—	—	—	EXPIRED	TRIAL	READY
2	23:16	VIN12							
3	31:24	VIN13							
4	39:32	VIN14							
5	47:40	VIN15							
6	55:48	VIN16							
7	63:56	—	—	—	—	—	—	—	—

bit 0-7 **MUX:** Multiplexer field, determines representation bits 16-63
 0x85 = VIN part 2

bit 8 **READY:** License Manager ready
 0 = Waiting to resolve VIN
 1 = Ready

bit 9 **TRIAL:** Trial license
 0 = No features licensed as a trial
 1 = One or more features licensed as a trial

bit 9 **EXPIRED:** Expired license
 0 = No feature licenses expired (past firmware build date)
 1 = One or more feature licenses expired (past firmware build date)

bit 10-15 **Unimplemented:** Set to '0'

bit 16-23 **VIN12:** VIN string (character 12)

bit 24-31 **VIN13:** VIN string (character 13)

bit 32-39 **VIN14:** VIN string (character 14)

bit 40-47 **VIN15:** VIN string (character 15)

bit 48-55 **VIN16:** VIN string (character 16)

bit 56-63 **Unimplemented:** Set to '0'

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4.11 Version

Message ID: 0x07F
Transmit Rate: 1000ms

Table 23: Version CAN Message Description.

Byte	Bits	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
0	7:0	MODULE							
1	15:8	PLATFORM							
2	23:16	MAJOR<7:0>							
3	31:24	MAJOR<15:8>							
4	39:32	MINOR<7:0>							
5	47:40	MINOR<15:8>							
6	55:48	BUILD<7:0>							
7	63:56	BUILD<15:8>							

bit 0-7 **MODULE:** Module enumeration
 0x03 = CAN Steering Module
 Other = Ignore, not this module
bit 8-15 **PLATFORM:** Vehicle platform enumeration
 0x11 = FCA_WK2
 Other = Ignore, not this vehicle platform
bit 16-31 **MAJOR:** Firmware version major increment
bit 32-47 **MINOR:** Firmware version minor increment
bit 48-63 **BUILD:** Firmware version build increment

5 Function

- **Modifying the Steering Signals:** The by-wire interface modifies the steering signals when power is applied and the required CAN messages are received. The vehicle steering system will function regardless of the CAN messaging and applied power to the by-wire interface.
- **Power-off State:** Without power applied, the hardware passes signals through unaltered.
- **Disabled State:** In the disabled state, steering signals are not modified. This corresponds to EN = 0. The by-wire interface does not respond to any SCMD until the enable bit (EN) is set to 1.
- **Power-up State:** The by-wire interface powers up in the disabled state. EN = 0.
- **Watchdog Timer:** If the by-wire interface does not receive a steering command message within 100ms, the by-wire interface enters the disabled state.
- **Driver Override (Steering):** If the system senses torque on the steering wheel from the driver, control is given to the driver by entering the driver override state. This corresponds to OVERRIDE = 1 and EN = 0 in the CAN steering report message. This can be cleared by toggling EN from 0 to 1, or by setting CLEAR to 1 in the CAN steering command message.
- **Audible Warning:** The steering module simultaneously activates the front and rear parking proximity warning chimes for one second to indicate an unintentional transition from computer control back to manual control. This is defined as a transition of the EN bit from 1 to 0 in any of the report messages for brake/throttle/steering/shifting, without a corresponding transition in the command message. An unintentional transition could be caused by an override, timeout, fault, or any other unexpected behavior. The brake and throttle report messages are received on the CAN bus from the external throttle/brake module.

6 Supported Vehicles

The Steering By-Wire interface has been tested on the Jeep Grand Cherokee for model years 2018 and 2019. The "Parallel and Perpendicular Park Assist" package is required for steering.

7 Watchdog Counter

The watchdog counter is an optional feature enabled by incrementing the COUNT bits to assist in compliance with California autonomous vehicle requirements. This is separate from the 100ms watchdog timeout always present for each command message. Each module monitors its own state and the state of all other modules for error conditions. To clear a watchdog counter event, press the OK button on the left side of the steering wheel or cycle power to all modules.

7.1 Fault Conditions

- Count is not incremented, or count is incremented more than 3 (this allows up to 2 dropped messages)
- Command timeout after 100ms (catches main computer crash, power loss, or disconnect)
- Report timeout after 100ms (catches failure of embedded firmware)
- Transition from enabled to disabled (catches unexpected transfer of control to the driver)
 - This fault condition can be disabled with the DbwConfig GUI.
- Vehicle must be out of park or moving for any of these conditions to set off an alert

7.2 Fault Actions

- Normal driver override audible and visual alert for one second (sets off the front park aid warning)
- Apply small amount of braking until the driver takes control with the brake pedal, throttle pedal, but not the steering wheel. The applied braking value is 1 m/s². The braking value can be changed with the DbwConfig GUI.
- Flash the passenger airbag ON and OFF lights until the alert is cleared to show that the watchdog is faulted
- All commands to all subsystems are ignored until the alert is cleared

APPENDIX A: REVISION HISTORY

Revision A-01 (October 2018)

Modifications:

1. Initial release of this document.

Revision A-02 (November 2018)

Modifications:

1. Added ULC messages.
2. Added notes about parameters (overrides and watchdog counter).
3. Added mechanical drawing.
4. Updated product photo.

Revision A-03 (March 2019)

Modifications:

1. Fixed CAN termination resistance that was mistakenly changed to false.
2. Changed SVEL scale factor.
3. Updated Watchdog Counter braking value.

Revision A-04 (August 2019)

Modifications:

1. Changed SVEL default from 1000 to 500.
2. Added Fuel Level message with odometer and battery voltage.
3. Added transmission gear number enumeration to Throttle Info message.
4. Added ULC messages.