

Ford F-150 Brake-By-Wire

Brake by-wire for non-hybrid Ford vehicle platforms with ACC/AEB

Features

- Computer control of braking
- Measure brake pedal positions
- Driver override by pressing the brake pedal
- 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. Brake By-Wire interface enables computer control of the braking system 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 brake 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. Optionally short both CD pins together.

Table 1: CAN/DB9 connector pin description.

Pin	Symbol	Description
1	CD	Connector Detect
2	CANL	CAN Low
3	GND	Ground
4	IGNITION	Ignition (12V)
5	NC	No Connect
6	CD	Connector Detect
7	CANH	CAN High
8	GND	Ground
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
V _{IGNITION ON}	9	12	16	V	
V _{IGNITION OFF}	-0.3	0	2	V	
V _{POWER}	9	12	16	V	
I _{POWER}		200		mA	V _{POWER} =12V, V _{IGNITION} >9V
I _{POWER}			0.1	mA	V _{POWER} =12V, V _{IGNITION} <2V
Temperature	-40		+85	°C	

3 CAN Messages

Table 3: CAN bus configuration.

Parameter	Value	Units
Terminated	No	
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

3.1 Brake

3.1.1 Command

Message ID: 0x060
 Receive Rate: 20ms
 Receive Timeout: 100ms

Table 4: Brake 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	PCMD<7:0>							
1	15:8	PCMD<15:8>							
2	23:16	CMD_TYPE				—	—	—	—
3	31:24	RES1	—	—	—	—	IGNORE	CLEAR	EN
4	39:32	—	—	—	—	—	—	—	—
5	47:40	—	—	—	—	—	—	—	—
6	55:48	—	—	—	—	—	—	—	—
7	63:56	COUNT							

bit 0-15 **PCMD:** Pedal Command
 0x0000 = 0%
 0xFFFF = 100%
 —
 0x0000 = 0.000 m/s²
 0x0001 = 0.001 m/s²
 0x2710 = 10.000 m/s²

bit 16-19 **Unimplemented:** Set to '0'

bit 20-23 **CMD_TYPE:** Command Type
 0 = NONE
 2 = PERCENT (percent of maximum deceleration)
 6 = DECEL (deceleration in m/s²)

bit 24 **EN:** Enable request
 1 = enable
 0 = disable

bit 25 **CLEAR:** Clear driver override flag
 1 = request clear of driver override
 0 = normal operation

bit 26 **IGNORE:** Ignore driver override
 1 = ignore
 0 = normal

bit 27-30 **Unimplemented:** Set to '0'

bit 31 **RESERVED:** Set to '0'

bit 32-55 **Unimplemented:** Set to '0'

bit 56-63 **COUNT:** Optional watchdog counter

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3.1.2 Report

Message ID: 0x061
Transmit Rate: 20ms

Table 5: Brake 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	PI<7:0>							
1	15:8	PI<15:8>							
2	23:16	PC<7:0>							
3	31:24	PC<15:8>							
4	39:32	PO<7:0>							
5	47:40	PO<15:8>							
6	55:48	WDCSRC				WDCBRK	—	BC	—
7	63:56	TMOUT	FLTPWR	FLT2	FLT1	FLTWDC	DRIVER	OVERRIDE	EN

- bit 0-15 **PI:** Pedal Input from the physical pedal
0 = 0.000 m/s²
1 = 0.001 m/s²
- bit 16-31 **PC:** Pedal Command from the command message
0 = 0.000 m/s²
1 = 0.001 m/s²
- bit 32-47 **PO:** Pedal Output is the maximum of PI and PC
0 = 0.000 m/s²
1 = 0.001 m/s²
- bit 48 **Unimplemented:** Set to '0'
- bit 49 **BC:** BOO Command¹²
1 = on, 0 = off
- bit 50 **Unimplemented:** Set to '0'
- bit 51 **WDCBRK:** Watchdog counter is applying brakes
- bit 52-55 **WDCSRC:** Watchdog counter source (See Table 7)
- bit 56 **EN:** Enabled
0 = disabled. PCMD 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 (PI ≤ 22% or ignored)
1 = Driver Override (PI > 22% for 100ms)
- bit 58 **DRIVER:** Driver Activity
0 = No Activity (PI ≤ 18%)
1 = Driver Activity (PI > 18% for 20ms)
- 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 **FLTPWR:** Power fault: 0 = No fault, 1 = Fault
- bit 63 **TMOUT:** Timeout
0 = Command is fresh
1 = Command timeout after 100ms

¹ Brake On Off (BOO), turn on brake lights, enable shift out of park, and cancel cruise control

² Brake On Off (BOO) is actuated by the external brake pedal emulator module to enable shifting out of park

3.2 Version

Message ID: 0x07F
Transmit Rate: 1000ms

Table 6: 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
 0x05 = ACC/AEB Brake module
 Other = Ignore, not this module

bit 8-15 **PLATFORM:** Vehicle platform enumeration
 0x01 = FORD_P5
 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

4 Function

- **Modifying the Braking Signal:** The brake-by-wire module uses the Adaptive Cruise Control and Automatic Emergency Braking (ACC/AEB) interfaces to decelerate the vehicle. The physical pedal will function normally regardless of the CAN messaging and applied power.
- **Power-off State:** Without power applied, the hardware passes signals through unaltered.
- **Disabled State:** In the disabled state, the emulator passes the pedal input to the output. This corresponds to PCMD = 0 or EN = 0. The emulator does not respond to any PCMD until the enable bit (EN) is set to 1.
- **Power-up State:** The emulator powers up in the disabled state. PCMD = 0 and EN = 0.
- **Watchdog Timer:** If the emulator does not receive a command message within 100ms, the emulator enters the disabled state.
- **Driver Override:** If the driver presses either pedal, both pedals enter the driver override state. This corresponds to OVERRIDE = 1 and EN = 0 in the CAN report messages. If the pedals are enabled when the driver presses either pedal, the driver override state is latched. This can be cleared by toggling EN from 0 to 1 in the CAN command messages. The driver override state can also be cleared by setting the CLEAR bit to 1 in either CAN command message.

5 Supported Vehicles

The Brake By-Wire interface has been tested on the Ford F-150 for model year 2018 and 2019. The Adaptive Cruise Control with Stop-and-Go package is required for braking.

6 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.

6.1 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)
- Vehicle must be out of park or moving for any of these conditions to set off an alert

6.2 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 0.25, which corresponds to 925 Nm of braking torque.
- 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

6.3 Fault Source Enumeration

Table 7: Enumeration values of the **WDCSRC** signal

Value	Enum	Description
0	NONE	None
1	OTHER_BRAKE	Determined by brake module
2	OTHER_THROTTLE	Determined by throttle module
3	OTHER_STEERING	Determined by steering module
4	BRAKE_COUNTER	Brake command counter failed to increment (user error)
5	BRAKE_DISABLED	Brake module disabled without override when in gear or moving
6	BRAKE_COMMAND	Brake command timeout (CAN bus overload or user error)
7	BRAKE_REPORT	Brake report timeout (CAN bus overload or module failure)
8	THROTTLE_COUNTER	Throttle command counter failed to increment (user error)
9	THROTTLE_DISABLED	Throttle module disabled without override when in gear or moving
10	THROTTLE_COMMAND	Throttle command timeout (CAN bus overload or user error)
11	THROTTLE_REPORT	Throttle report timeout (CAN bus overload or module failure)
12	STEERING_COUNTER	Steering command counter failed to increment (user error)
13	STEERING_DISABLED	Steering module disabled without override when in gear or moving
14	STEERING_COMMAND	Steering command timeout (CAN bus overload or user error)
15	STEERING_REPORT	Steering report timeout (CAN bus overload or module failure)

APPENDIX A: REVISION HISTORY

Revision A-01 (August 2018)

Modifications:

1. Initial release of this document.

Revision A-02 (August 2018)

Modifications:

1. Changed CMD_TYPE DECEL from 5 to 6.

Revision A-03 (August 2018)

Modifications:

1. Updated supported vehicle model year range to 2019.