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## Shifting by-wire in the Ford Fusion/Mondeo

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### Features

- Computer control of shifting
- Measure gear positions
- Driver override by shifting manually
- 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. Shifter By-Wire interface enables computer control of gear shifting 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 shifting 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
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	

## 3 CAN Messages

Table 3: CAN bus configuration.

Parameter	Value	Units
Terminated	Yes	120 $\Omega$
BitRate	500	k
t <sub>q</sub>	200	ns
SyncSeg	1	t <sub>q</sub>
PropSeg	3	t <sub>q</sub>
PhaseSeg1	3	t <sub>q</sub>
PhaseSeg2	3	t <sub>q</sub>
SyncJumpWidth	2	t <sub>q</sub>

## 3.1 Shifting

### 3.1.1 Command

Message ID: 0x066  
Receive Rate: On Event

Table 4: Gear 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	CLEAR	—	—	—	—	GCMD		

bit 0-2      **GCMD:** Gear Command

0 = None

1 = Park

2 = Reverse

3 = Neutral

4 = Drive

5 = Low

bit 3-6      **Unimplemented:** Set to '0'

bit 7      **CLEAR:** Clear driver override flag

1 = request clear of driver override

0 = normal operation

Note: Gear commands will be rejected if OVERRIDE=1 for any of brake/throttle/steering. See the REJECT field on the next page for more information.

## 3.1.2 Report

Message ID: 0x067  
Transmit Rate: 50ms

Table 5: Gear 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	FLTBUS	CMD			DRIVER	STATE		
1	15:8	—	—	—	—	—	REJECT		

bit 0-2	<b>STATE:</b> Gear State 0 = None 1 = Park 2 = Reverse 3 = Neutral 4 = Drive 5 = Low
bit 3	<b>DRIVER:</b> Driver Override 0 = Last shift requested by-wire 1 = Last shift requested by driver
bit 4-6	<b>CMD:</b> Gear Command 0 = None 1 = Park 2 = Reverse 3 = Neutral 4 = Drive 5 = Low
bit 7	<b>FLTBUS:</b> CAN bus fault 0 = No Fault 1 = Fault
bit 8-10	<b>REJECT:</b> Gear rejected enumeration 0 = Not rejected 1 = Shift in progress 2 = Override (on brake/throttle/steering) 3 = Rotary shifter can't shift to Low 4 = Rotary shifter can't shift out of Park 5 = Rejected by vehicle (try pressing the brakes)
bit 10-15	<b>Unimplemented:</b> Set to '0'

## 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  
                  0x04 = Shifter module  
                  Other = Ignore, not this module  
 bit 8-15    **PLATFORM:** Vehicle platform enumeration  
                  0x00 = FORD\_CD4  
                  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 Shifting Signal:** The by-wire interface modifies the shifting signal when power is applied and the required CAN messages are received. The vehicle shifting 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, signals are not modified. This corresponds to GCMD = 0.
- **Power-up State:** The by-wire interface powers up in the disabled state. GCMD = 0.
- **Driver Override:** If the driver requests a shift, this is reported in the CAN shifting report message with DRIVER = 1. This is automatically cleared on the next by-wire shift request, but can also be cleared by setting CLEAR to 1 in the CAN shifting command message.

## 5 Supported Vehicles

The Shift By-Wire interface has been tested on the Ford Fusion/Mondeo for model years 2017-2018.



## APPENDIX A: REVISION HISTORY

### Revision A-01 (June 2018)

#### Modifications:

1. Initial release of this document.