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BTR Transmission

The earlier series of Ford Australia's BTR transmissions for V8 powered cars incorporated a separate Transmission Control Module (TCM) to control the operation of the transmission in isolation to the engine management system (Ford's EEC4 and EEC5). The fitting of these earlier series 5.0L V8/BTR95LE combination, or upgrading a C4 or FMX to a four-speed auto behind the 302/351W and Cleveland engines into alternate vehicles has become a reasonably popular upgrade. BTR transmissions are cheap and plentiful, and can be built reasonably strong enough to withstand the rigours of high performance V8 engines. It is, therefore, the intention of this document to describe the required data inputs for the TCM to operate gear shifts and lock up effectively.

> Lock Up refers to the torque converter, which is a fluid coupling with an unlocked (or free spinning) mode and a locked (or engaged) mode. The TCM automatically controls when the torque converter is switched between these two modes.

BTR Types

The following is a list of BTR models and the cars in which they were fitted:

- Ford EA2/EB 1988-93 Ford 4.0/3.9L BTR 85LE (M85)
- Ford EB/EB2 1991-93 Ford 4.0L BTR 91LE (M91)
- Ford EB/EB2 1991-93 Ford 5.0L BTR 95LE (M95)
- Ford ED 1993-94 Ford 4.0L BTR 91LE (M91)
- Ford ED 5.0L 1993-94 Ford 5.0L BTR 95LE (M95)
- Ford EF 1994-96 Ford 4.0L BTR 93LE (M93)
- Ford EF 5.0L 1994-96 Ford 5.0L BTR 97LE (M97)

This document describes the application of the BTR 95LE as fitted throughout most of the 1990's, but is also applicable to the BTR 85LE, 91LE and 97LE.

> The BTR95LE and the BTR97LE have different shift points and stall, and are a V8 transmission

BTR Transmission Control Module

To retrofit a BTR transmission, you will need a controller from an EA Series 2, EB Series 1 6 Cyl, or EB 2, or ED V8. The controller is bolted to the pedal box. All other models integrated the TCM with the EEC4 and EEC5 Ford Engine Management System.

TCM Part Number		Trans Model	Car Model
BTRE	**Ford**		
0585-640030	90DA-7E453-AA	M85	EA2 (6 cylinder) MPEFI

0585-640031	90DA-7E453-BA	M85	EA2 (6 cylinder) EFI
0585-640033	90DA-7E453-CA	M85	EA2 (6 cylinder) High Series
0585-640037	90DA-7E453-AB	M85	EB (6 cylinder) MPEFI
0585-640038	90DA-7E453-CB	M85	EB (6 cylinder) EFI
0585-640039	90DA-7E453-CB	M85	EB (6 cylinder) High Series
0585-640040	91DA-7E453-AA	M95	EB2 (8 cylinder)

Note: You can use a 6-cylinder controller if you can't find a V8 one. The only difference is the shift points are slightly different.

Note: A 6-cylinder transmission (BTR85LE, BTR91LE, BTR93LE) will fit on to a V8 bellhousing and input shaft, but there are several internal differences.

Installation

In most applications, the 5L V8 and BTR 4 speed combo is the best way to go. You can, however, retro fit the BTR95LE V8 to Windsor and Cleveland 302/351. The bellhousing bolt pattern is the same as a C4/FMX, but the starter motor is on the left-hand side. Use the flex plate and torque converter that came with the BTR/5L donor car.

Note: Not every engine/transmission combination is covered here. Do your research into input shafts, flex plates, torque converters and tailshafts before proceeding.

The following components should be harvested from the donor vehicle.

- The Transmission Control Module (TCM).
- The TCM harness.
- The Transmission harness.

TCM Harness

The TCM harness is a long harness that plugs into the TCM with two plugs – a 12 pin plug and an 18-pin plug.

Figure 1 - TCM and Harness

The TCM Harness incorporates the following circuits:

- Solenoids. The round 12 pin plug.
- TPS. Three wires go to the engine bay to the TPS.
- VSS and Diagnostics. A rectangular 8 Pin plug.

Transmission Harness

The TCM Harness plugs in to the TCM at one end and the Transmission Harness at the other (either at the console or through the floor). The big round plug and the 8-Pin connector divides into the following circuits at the transmission end:

- Solenoid circuits. A round 12 pin plug.
- Gear Position Sensor. A two pin Denso plug (like an injector plug).
- The VSS socket (a three-pin socket).

There is also a 6-pin connector at the transmission end that originally supplied the link to Battery, Ignition and Grounds. You can use this or run your own power supply circuits.

Figure 2 - Transmission Harness

Most of the wiring is straightforward. The solenoid plugs are just fine as they are. The 8-Pin connector at the non-Transmission end of the Transmission Harness can be taken apart to connect the VSS in a non-factory setting.

Controller Inputs

The TCM relies on the following data inputs:

I/O Link. The transmission control module has an input and output serial communication link to the Powertrain Control Module (the original factory Ford EEC4 or EEC5 engine management system). This link communicates air conditioner status, engine temperature status, and T-bar selection. Torque reduction is enabled in reverse gear.

Throttle Position Sensor (TPS). The TPS is a potentiometer mounted in tandem with the Engine TPS.

Engine Speed. The engine speed signal is taken from the tachometer signal line.

Road Speed. The road speed signal is taken from the speedometer transducer to speedometer line. This is commonly referred to as the Vehicle Speed Sensor (VSS).

Transmission Sump Temperature. This sensor is a thermistor in the solenoid wiring loom inside the transmission. When transmission sump temperature reaches 135 deg C the TCM will automatically select an *overheat* mode which applies lockup in 3rd and 4th gears except under very low speed and light throttle conditions, in both economy and normal modes.

Gear Position Sensor. The gear position sensor is incorporated in the inhibitor switch mounted on the side of the transmission case and provides discrete resistance values indicating the gear selected by the gear shift lever.

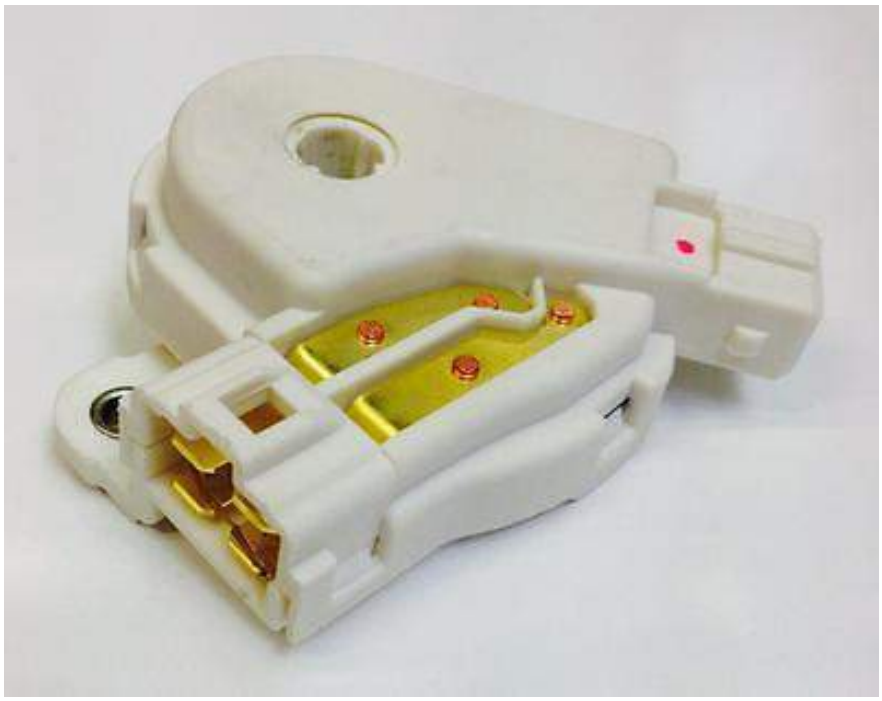


Figure 3 – Inhibitor Switch and Gear Position Sensor

Gear Position is coupled to the TCM via a two pin Denso connector (an injector connector). The other connections are for reversing lights and the neutral safety start switch.

Gear Position 97LE. The gear position signal from the transmission mounted inhibitor switch is sent to the PCM. The PCM processes this signal and sends the gear position status to the TCM and dashboard display.

VSS Wiring

The following table represents the wiring for the VSS. The original factory Ford item is no longer available, but the Bosch equivalent available from most auto parts stores is fine. The part number is F 005 S00 070 or Bosch VSS9004. However, they DO NOT match the colours depicted in the EF-EL workshop manual.

Pin	Bosch	Circuit	Diagram
999	White	This is the VSS signal to the speedo and to Pin 19 of the TCM. You should splice in a White wire for the electronic speedo. The Vicki has a Grey/Purple wire spliced in that goes to the console, and travels under dash.	 *Looking in at the end of the socket (female) or from the back of the plug (male)*
998	Blue	Ignition voltage.	
57	Black	Ground.	

The VSS is a Hall Effect Sensor and must be wired in a certain way. In the factory Ford installation, the VSS got its power and signal voltage from a regulated supply in the instrument cluster. To replicate this, you MUST include a resistance across the VSS signal so that the Hall Effect output has something to tie it to. My suggestion is to incorporate it in a plug and socket in the console.

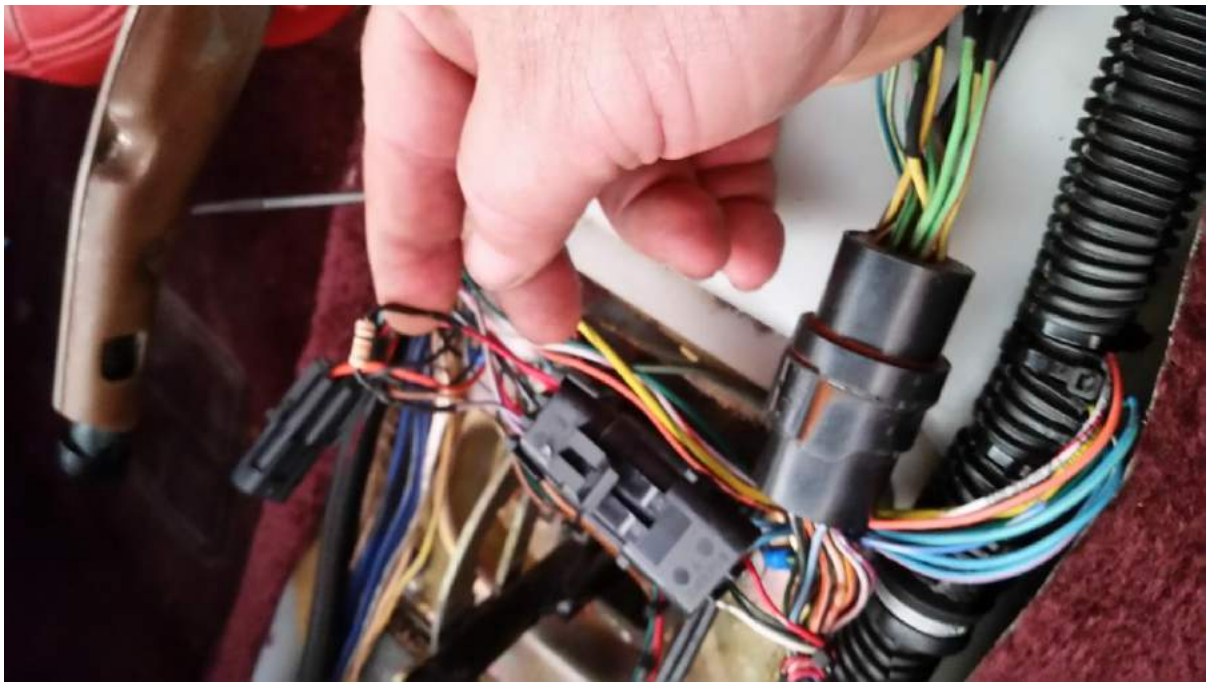


Figure 4 - Wiring in a Pull-Up Resistor in to the VSS Plug

WARNING: The VSS is VERY EASY to fry if you hook it up incorrectly!

The following is a diagram of a generic Hall Effect Sensor and how it should be wired in for your VSS:

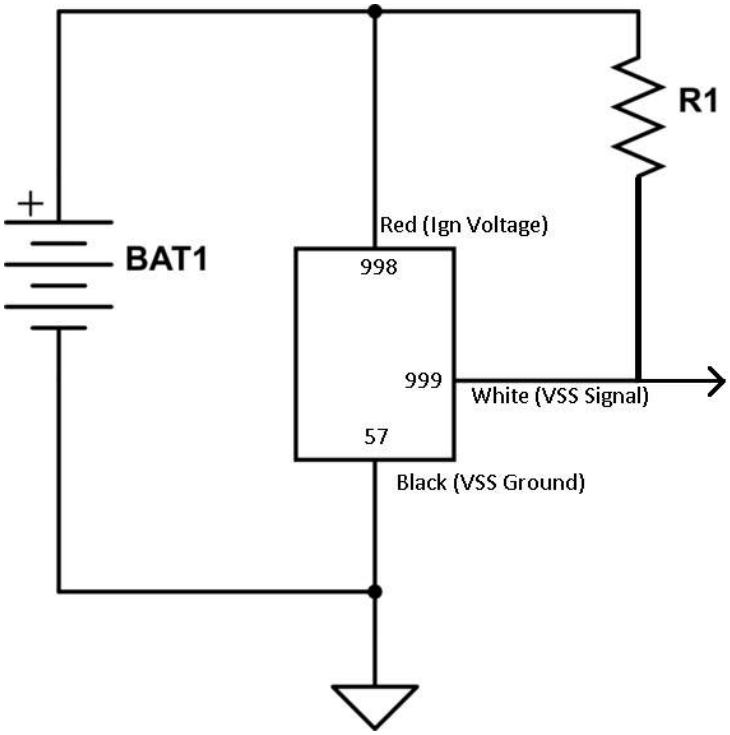


Figure 5 - Hall Effect Sensor Wiring

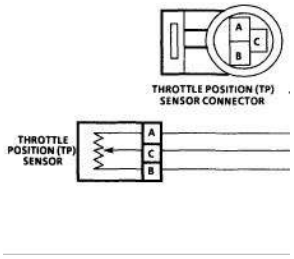
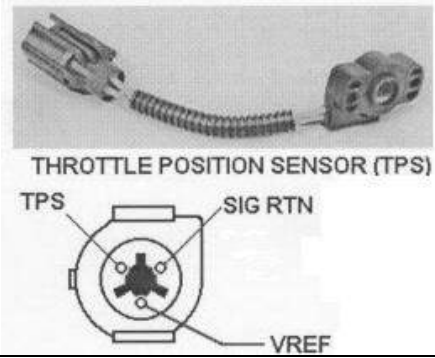
The value for R1 should be 10k ohms. If you leave out this resistor, the VSS signal will be a residual voltage of about 0.7V, which may be enough to drive a digital speedo, but not enough for the TCM.

> **Note**: If the voltage on the VSS signal is too low then the TCM won't get a valid speed signal and won't be able to correctly schedule the shifts.

TPS Wiring

The TPS can be the original Ford set-up that gangs two TPS together (one for the Engine Management System and one for the TCM). If you are using a non-Factory manifold, you need to incorporate the two TPS some way. A GM TPS will do just as well as the Ford one, but you CANNOT use one TPS for both!

The transmission TPS must be wired in according with the following table:

Pin	TPS Conn	Ford	TCM Pin	GM TPS	Ford TPS
A	5V Ref	Blu/Gn	25		
B	TPS Ground	Blu/Wht	9		
C	TPS Signal	Blu/Rd	16		

The TPS Reference Voltage is a 5V supply that comes from Pin 25 of the TCM (see TCM Wiring Schematics and Pinouts on page 15).

Other Inputs

The following inputs are also required:

- **Tacho**. Pin 6 (Pink wire) of the TCM expects a coil Negative signal as the Engine Speed reference. If you are using the Tacho signal from an aftermarket Engine Management System, the Tacho signal may not be strong enough, especially if you are running a Tacho as well. You may need to incorporate a 1k ohm pull-up resistor connecting this wire to a 12V Ignition source.
- **Gear Position Sensor**. The 2 Pin Denso plug connects the TCM to the Gear Position Sensor (GPS) to tell the TCM which gear has been selected by the shifter. The GPS is readily available from auto parts stores and eBay.

Post Installation Tests

When you have installed the engine and transmission, wired up the TCM and all the required inputs, carry out a continuity test on the Solenoid connections to make sure there are no breaks in any of the wires. Use your Voltmeter on Continuity (it makes the BEEP sound when you touch the probes together) and test every wire from the plug on the transmission to the plugs on the TCM. Refer to TCM Wiring Schematics and Pinouts on Page 15.

Voltage Tests

These Initial checks are to confirm that you have all the required signals to run the TCM. Refer Figure 9 - Auto Trans Controller Wiring and TCM Wiring Schematics and Pinouts on Page 15.

Signal Name	Pin	Colour	Should be
Constant power on	Pin 15	Yellow/Black Stripe.	12V
Ignition power on	Pin 30	Yellow / Red.	12v
Varying voltage (TPS)	Pin 16	Blu/Red	Approx 0.5 to aprox 4.5 dependant on throttle position.
Voltage and Frequency (VSS)	Pin 19	White wire	The speed signal should swing from about 6-8 volts to 0 volts as you slowly roll the car in neutral, in KOEO mode, or turn the back wheel if it's up on jacks. A digital voltmeter or good multimeter will measure the voltage if you roll it slow enough.
Voltage and frequency (Tacho)	Pin 6	Pink	Voltage with engine off and voltage with engine running.
Voltages, Gear Position Sensor	Between pin 10 and pin 17	violet/white (10), violet (17)	0.5 volt steps from park to 1st. from 4.5 to 0.5.

Diagnostics

The TCM incorporates a Diagnostics function that enables you to troubleshoot problems that may arise with the transmission. Most commercial workshops use a Scan Tool to connect with a Diagnostic Port in the car, but we are only concerned with the TCM.

Make Your Own TCM Scan Tool

Making your own Scan Tool is very easy. All you need is a 10k ohm resistor, a 12V LED, an On/Off switch and a small box to put them in. It will cost you less than $5 at Jaycar.

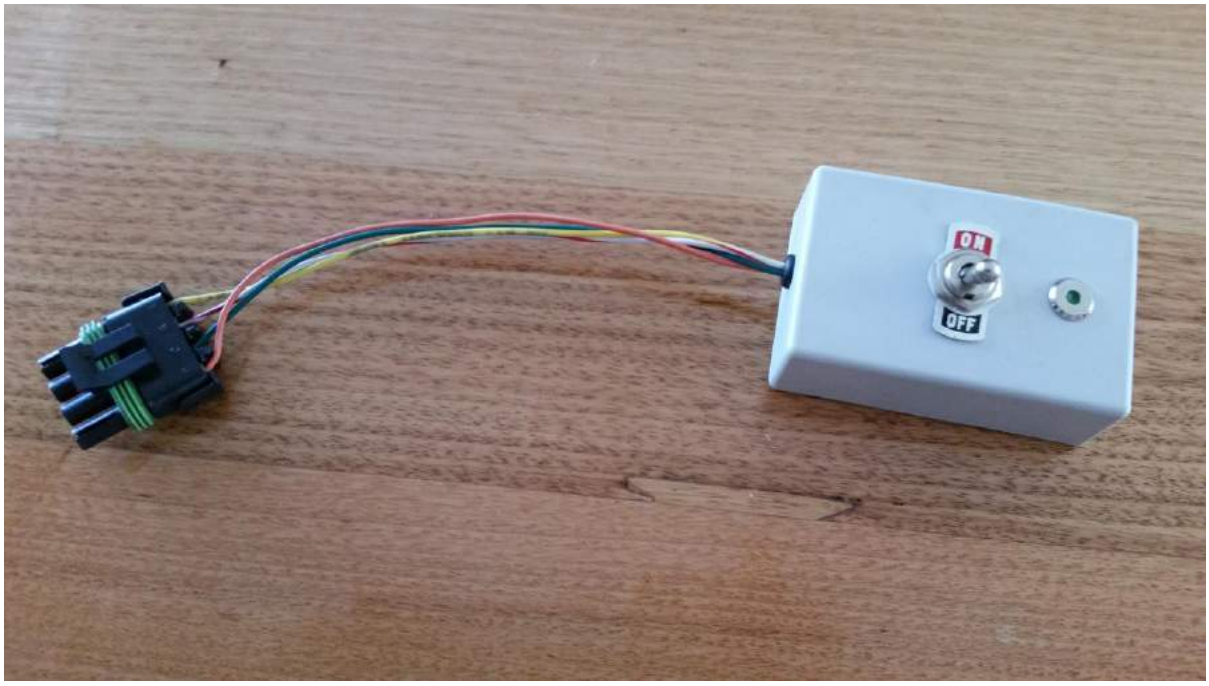


Figure 6 - TCM Scan Tool

- Solder the 10k resistor to the Positive leg of the LED (you can't just connect a LED directly to 12V, you need to limit the current with a resistor). Connect the other end of the resistor to a 12V Battery source.

  Note: There are a handful of identifiers for finding the positive and negative pins on an LED. Usually, the LED has a longer leg, which should indicate the positive (anode). If someone's trimmed the legs, the flat edge on the LED's outer casing points to the negative (cathode).

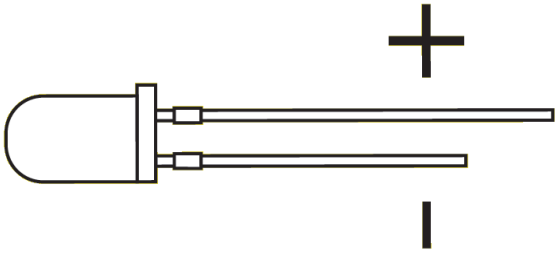


Figure 7 - LED Polarity

- Connect the Dark Green wire from Pin 20 of the TCM to the other leg of the LED.
- Connect the switch to Pin 2 (Orange) and Pin 8 (White/Red).
- Stuff it all in a box.

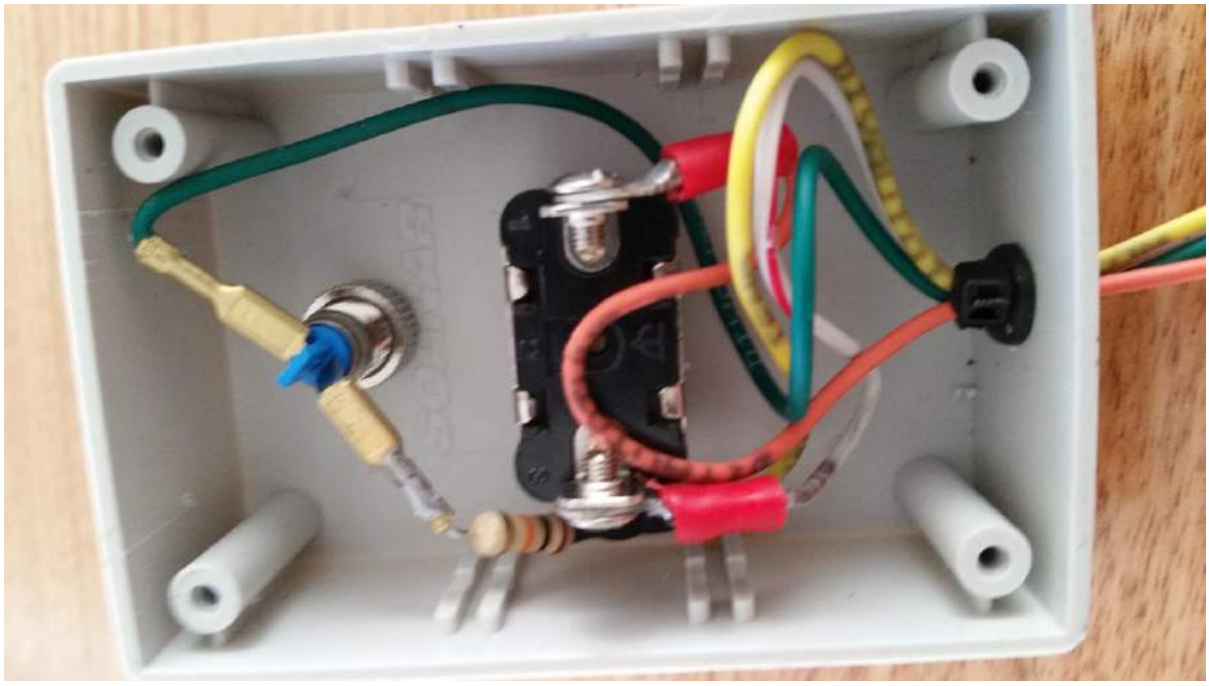


Figure 8 - Scan Tool (Internal Wiring)

Your Scan tool works by flashing the LED. Pin 20 of the TCM normally floats high(12v) and goes low to output a code, so the led will flash.

Fault Codes

This document only deals with the Transmission Control Module. Any reference to the factory Ford EEC4 or EEC5 is only for the purposes of comparison or explanation.

The Fault Codes are organised into two groups.

- One Set of Fault Codes are displayed in the Key On, Engine Off (KOEO) Mode.
- The Other Set of Fault Codes are displayed in the Key On, Engine Running (KOER) Mode.

If the car has the Battery disconnected for a period, OR If any of the TCM components are replaced, the Keep Alive Memory (KAM) WILL be affected and will have incorrect settings. The TCM will need its KAM reassigned to relearn its program. See Intermittent Fault Codes

For checking of intermittent faults that may be hard to identify:

1. Connect Scan Tool to the diagnostic connector.

   Do NOT switch ON.
2. Switch Ignition ON.
3. Wiggle all Connectors.
4. Wiggle all associated Wiring Harnesses.
5. Operate all Moving Sensors (Shifter, Mode Switc h, VSS).

If a Fault is detected by the TCM the LED will flash and the Fault Codes will be written to the ECM.

Throttle Learn Clearing and Throttle Learn Procedure on Page 14.

Fault Code Identification

There are five fault code types.

- **Fast Codes**. These appear very fast and are of NO value unless you are using a Data Scanner. Fast codes contain the fault information output in the normal slow codes but are output about 100 times faster. These are the first things output on a Key On Engine Off test.
- **ECM Identification Code**. Tells you which TCM is being tested.
- **Hard Codes** (Current Faults). Hard codes are problems that the computer has located RIGHT NOW. Examples are a sensor out of range or a broken wire (open circuit). Hard codes are the FIRST set of slow codes output in a Key On Engine Off test BEFORE the SEPARATOR pulse.
- **Separator Codes**. The separator code is a single pulse that indicates the END of hard codes and the BEGINNING of memory codes. It will show up as a code 10 on most digital testers.
- **Memory Codes**. These are faults stored in memory from the previous 20 Engine Warm-up / Run Cycles. If for example there was a loose wire to a solenoid that only lost contact while driving but was making contact while testing the system there would be NO HARD FAULT CODE. The code would show up IN MEMORY. The same would happen for a sensor that only went out of range occasionally. Memory codes come out AFTER the separator pulse.

NOTE: The TCM will erase the memory after a certain number of engine re-starts if the problem does not repeat itself. The number of re-starts varies from 20 to 80 depending on the model. The later models keep memory longer.

Extracting Codes

The output codes are all the same (numbers) from the combined/separate computers (early models are 2 digit and later ones are 3 digit, for example 99 or 099). This document will only deal with the Transmission codes.

The Fault Codes are read as pulses, or flashes, of the LED. Each Pulse is 0.5 seconds long. The Interval between Tens and Single Units is 2.0 Seconds. The Interval between Fault Codes is 4.0 Seconds. The Fault Codes will appear in this Sequence:

KOEO Mode:

- Fast Codes
- Hard Codes

After the Hard Codes have been displayed, there is an Interval of 6.0 Seconds, followed by:

- Separator Code (10) or a single flash.

After the Separator Code, there is an Interval of 6.0 Seconds, followed by:

- Memory Codes

KOER Mode:

- ECM ID Code
- Fast Codes
- Hard Codes

To extract codes, proceed as follows:

1. Connect Scan Tool. The LED will come ON.
2. Switch ignition ON.
3. Switch Scan Tool ON.
4. Read KOEO Codes.
5. Switch Scan Tool OFF.
6. Start Engine.
7. Switch Scan Tool ON.
8. Read KOER Codes.

Note: The Hard Codes and Memory Codes will ONLY be flash once. To re-start the Self-Test, switch Ignition OFF for more than 15 Seconds.

Fault Code Erasure

1. Switch off your Scan Tool.
2. Turn Ignition OFF for 10 Seconds
3. Turn Ignition ON.
4. Switch your Scan Tool ON.
5. While Fault Codes are Flashing, switch Scan Tool OFF.
6. Retest Codes for successful erasure.

Fault Codes List

The following table is an abbreviated list of fault codes for the BTR TCM. References and codes for the Ford engine management system (EEC4 and EEC5) have been omitted.

Code	Model	Meaning
EA and EB Series 1 Transmission Controller ID Codes:		
30	KOEO	MPEFI 6 cyl. Low Series
50	KOEO	EFI 6 cyl.
80	KOEO	MPEFI 6 cyl High series.
EB – ED Trans Controller ID Code:		
40	KOEO	SEFI 8 cyl All.
M91 Codes		
11	KOEO	System Pass.
23	KOEO and KOER	TPS Out of range
26	KOEO	Trans Oil Temp Sensor out of range
27	KOEO	Gear Lever Position s/w fault/fail
36	KOEO	Speedo signal fault/fail
57	KOEO	Power/Econ switch fault
63	KOEO	TP Voltage Low
67	KOEO	NDS or AC is On
78	KOEO	Trans Battery Fault
95	KOEO	VPS Solenoid Fault/Fail
96	KOEO	PCS Solenoid Fault S6
98	KOEO	ON/OFF Solenoid Fault/Fail
99	KOEO	Throttle not learned
M93 Codes (these are the later model three digit codes)		
111	All Tests	System Pass
513/578	KOEO	Trans Oil Temp out of range
634	KOEO	Gear Lever Position s/w Fault/fail
452	KOEO	Speedo Signal Fault/Fail
628	KOEO	Power/Econ Switch Fault

522	KOEO	NDS or a/c is ON
513/578	KOEO	Trans Battery Fault
691	KOEO	Solenoid 1
692	KOEO	Solenoid 2
693	KOEO	Solenoid 3
694	KOEO	Solenoid 4
695	KOEO	Solenoid 5
696	KOEO	Solenoid 6
697	KOEO	Solenoid 7

Intermittent Fault Codes

For checking of intermittent faults that may be hard to identify:

7. Connect Scan Tool to the diagnostic connector.

   Do NOT switch ON.

8. Switch Ignition ON.
9. Wiggle all Connectors.
10. Wiggle all associated Wiring Harnesses.
11. Operate all Moving Sensors (Shifter, Mode Switc h, VSS).

If a Fault is detected by the TCM the LED will flash and the Fault Codes will be written to the ECM.

Throttle Learn Clearing and Throttle Learn Procedure

Code 99 – Throttle Not Learnt – means the closed throttle position has not been learnt. In the factory Ford setting, this may be caused by the following:

- Transmission hasn't reached normal operating temperature.
- Engine idle speed incorrect.

The TCM will learn the closed throttle position automatically when the transmission reaches normal operating temperature and the engine is allowed to idle in drive with the 'basic idle' set and a/c off. When retro-fitting the BTR Transmission, however, you will need to do the Throttle Learn procedure to clear the error 99 code:

Throttle Learn Clearing:

1. Select Power Mode
2. KOEO
3. 100% Throttle
4. Select Econ
5. 0% Throttle

Throttle Learn Procedure

1. Idle engine for 60 seconds.
2. KOEO, trans in Drive.
3. 100% Throttle for 60 Seconds.
4. Select Park, turn ignition OFF.

TCM Wiring Schematics and Pinouts

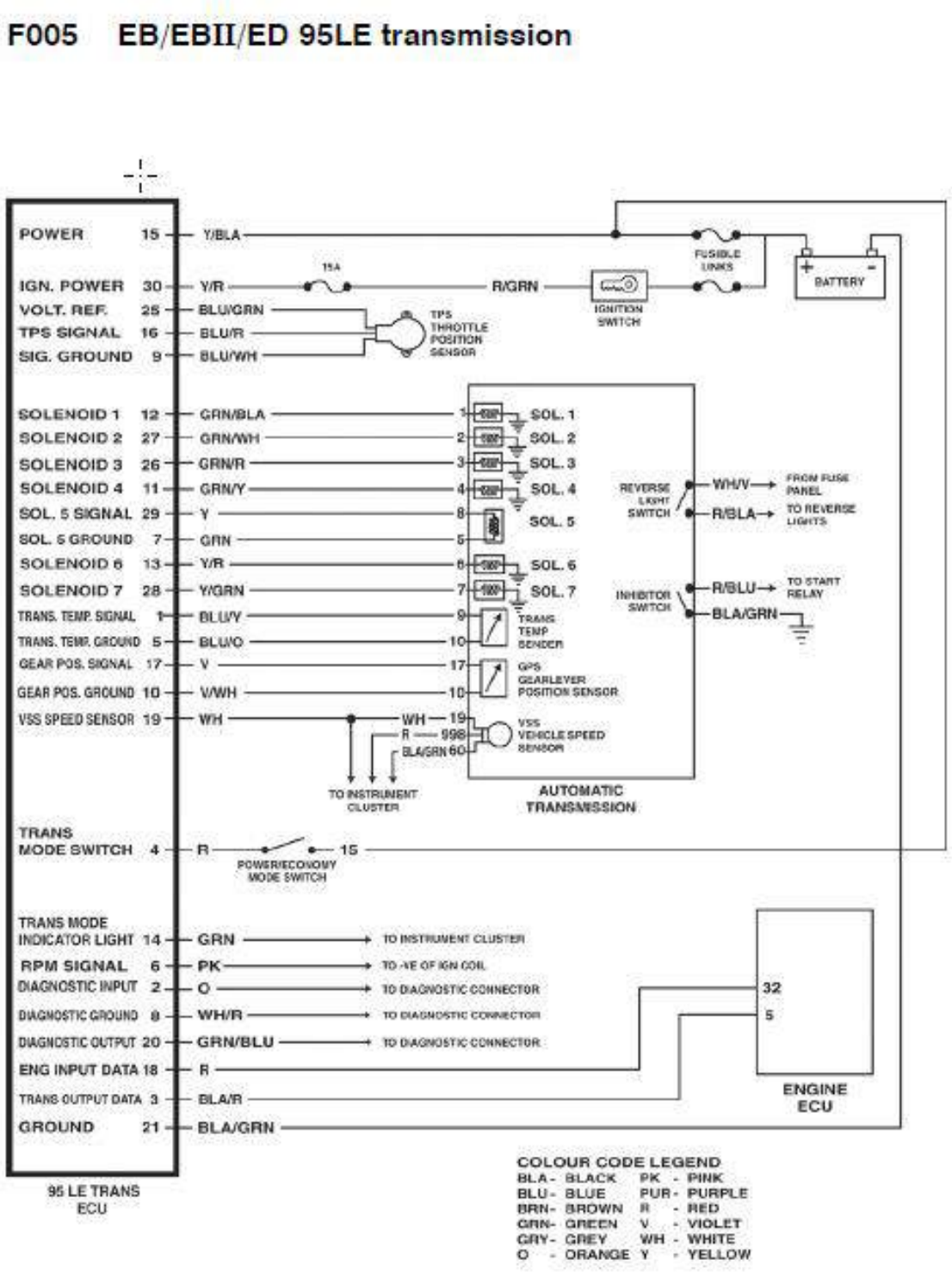
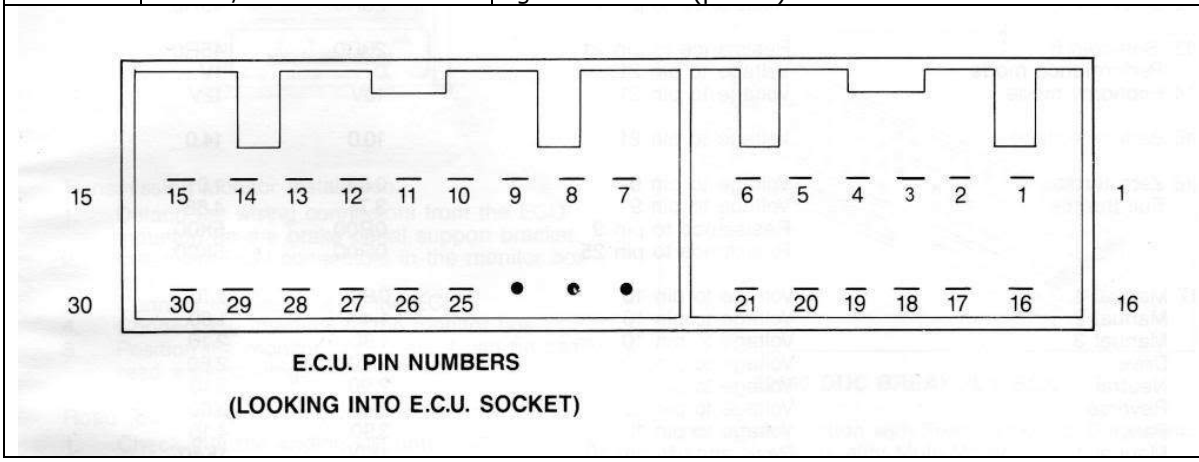


Figure 9 - Auto Trans Controller Wiring

TCM Wiring Table		
PIN	**Wire Colour**	**Description**
1	Blue/Yellow	Temp Sensor (input)
2	Orange	Diagnostics (input). This pin is grounded to initiate self-test. Normally floats high (+5V).
3	Black(?)	Trans Output Data. Indicate to ECM that reverse has been engaged (engine torque cut-off).
4	Red	(V8) Econ/Performance Mode switch (input). 0v (Econ), 12V (Power). (6 cyl) Air Con status (input) A/C On (12V) or Off (0V).
5	Blue/Orange	Temp Sensor ground
6	Pink	Tacho Input
7	Green (Lt Green?)	Solenoid 5 return (input)
8	White/Red	Diagnostics (ground). This pin connects to STI (Pin 2) to initiate self-test.
9	Blue/White	Throttle Position (ground)
10	Violet/White	Shift Lever Position (ground). Ref for PRNDL switch input.
11	Green/Yellow	Solenoid 4 (input)
12	Green/Black	Solenoid 1 (output)
13	Yellow/Red	Solenoid 6 (output)
14	Green (Dk Green)	Mode indicator dash light (output)
15	Yellow/Black	Battery Positive (power)
16	Blue/Red	Throttle Position (input)
17	Violet	Shift lever (input)
18	Red	(V8) I/O Data. (6 cyl) Econ/Performance Mode switch (input). 0v (Econ), 12V (Power)
19	White	Shaft Speed Sensor (input)
20	Dk Gn	Diagnostics (output). The self-test diagnostic codes are output here. Voltage level is +12V, switched to Ground by the TCM to output the codes.
21	Black (Blk/Gn?)	Ground
25	Blue/Green	Throttle position sensor reference 5v (power)
26	Green/Red	Solenoid 3 (input)
27	Green/White (Gn/Yell?)	Solenoid 2 (input)
28	Yellow/Green	Solenoid 7 (output)
29	Yellow	Solenoid 5 Power (splice?)
30	Yellow/Red	Ignition switch (power)



Fully Programmable Aftermarket Controller

In the process of putting this document together, I contacted Jamie from Shiftkits Australia (shiftkits.com.au) who was only too happy to help me out with loads of information, technical

assistance and advice. I had seen his manual controller referred to on various Ford forums, but had not heard of the fully programmable automatic controller.

Jamie's advice was to make sure all was working as it should with the factory controller before investing in his fully programmable unit. For those of you who want to use a BTR 4 speed auto in your project but can't find a factory controller (they are rare, to say the least) then this may be your answer. Here's some of the features of the Shiftkits BTR Fully Programmable Controller:

- Map shift points and downshift points for each gear.
- Map Line pressure for each gear.
- Control Torque converter lock and unlock parameters.
- RPM based shift mode to allow consistent shifting at the selected RPM per gear for drag racing.
- Switchable Automatic or Full Manual mode, with optional inputs for upshift and downshift paddle switches.
- Programmable speedo output.

What you need to provide is the following:

- Vehicle speed signal
- Throttle position signal
- Engine RPM signal
- Factory (or duplicate) transmission harness (1x round transmission plug and 1x 2 pin gear position switch connector).

The kit comes with a wire-in harness, installation instructions, software CD and programming cable.