Brought to you by:
Jim Miller & Matt Petrie
2025, REV-7

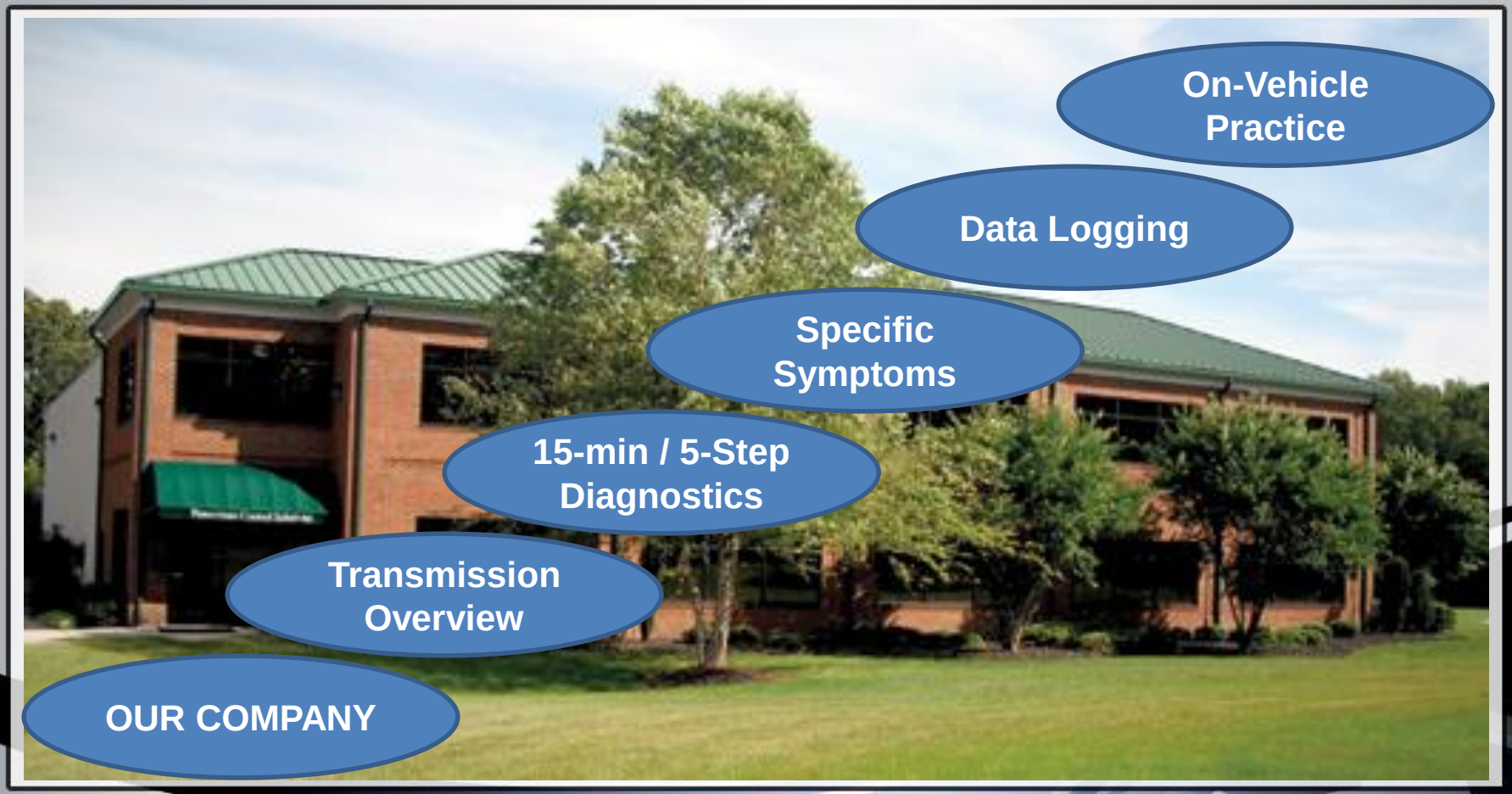
PCS

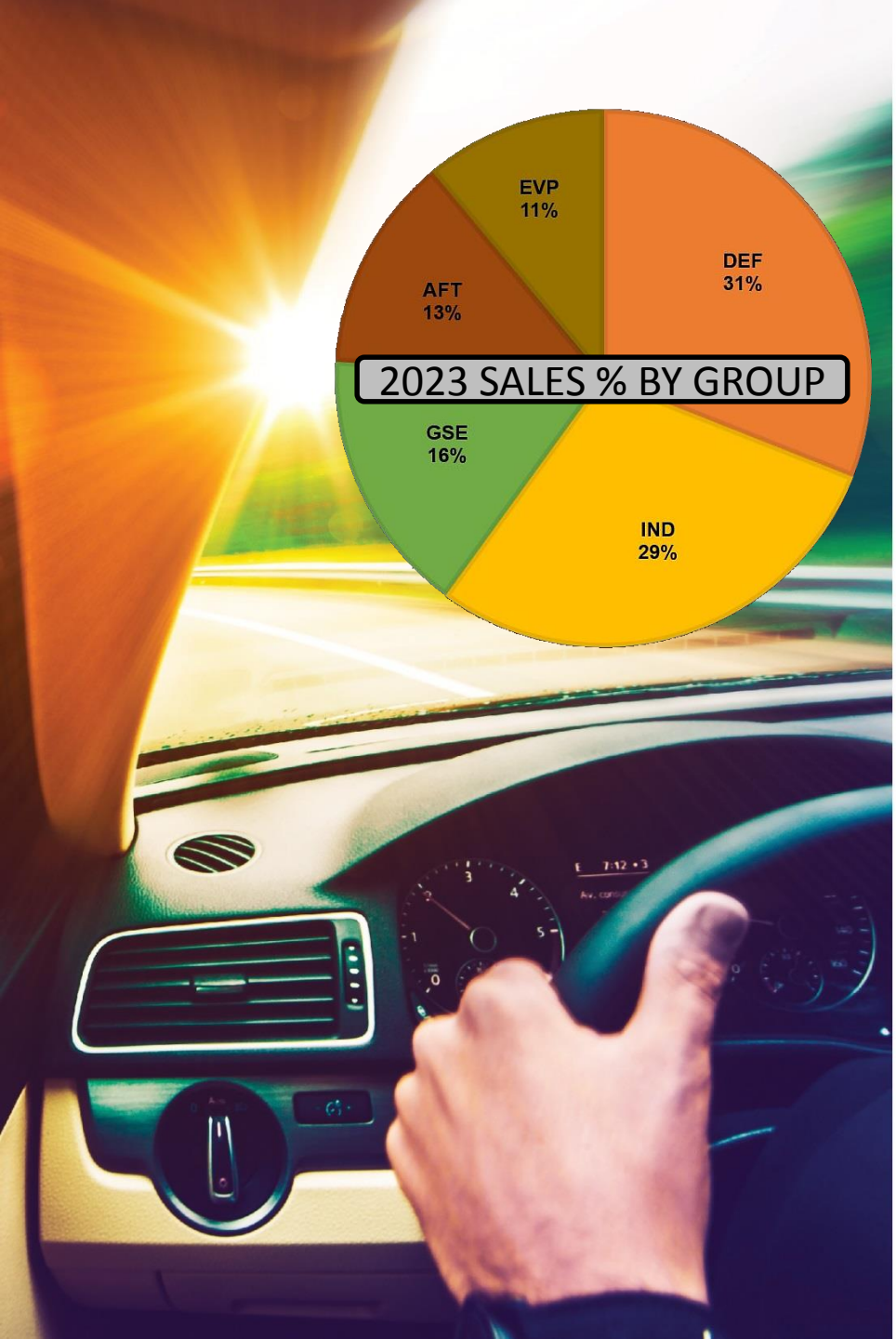
Powertrain Control Solutions.com

Engineering the future of driveline control

4LHD Operation and Diagnostics

Today's Objectives





PCS OVERVIEW

PCS is an engineering and production company specializing in automotive drive line control.

100% of each PCS product is designed in-house.

100% of 16,000+ PCS modules are full functionality tested.

100% of 7,400+ PCS wiring harnesses are fully tested with our automated point-to-point resistance process.

Richmond VA - Family Owned - <100 Team Members

Inventory and Quality Control:

- IPC / WHMA Certified
- IATF / AIAG Certified
- ISO-9001 Certified

MEMBER OF: Member of AIAG · IPC Member · SMTA

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Locations

ASHLAND ENGINEERING CENTER

- 38,000 ft^2 (3,530 m$^{2)}$
- Custom built ISO Class-6 Clean-Room:
  - 45 Panel PCB / PCA Production Line
  - 94K-CPH “2X JUKI RS-1R” Pick-and-Places
  - Inline 3D AOI for 100% panel inspection
  - X-Ray for QC and Root-Cause Analysis
  - Automated conformal coating, solder, & potting applicators
- High volume wire harness production including:
  - Automated crimp center
  - Wire twisting machine
  - Ultrasonic splicer
  - Computerized point-to-point test stands
- 3D Printers
- Two training rooms
- CNC Machining center and machine shop
- Valve body development machine
- High Voltage development stand
- Transmission Dyno
- AWD and 2WD Vehicle Dynos
- Hosts & Mentors local FIRST FRC Team

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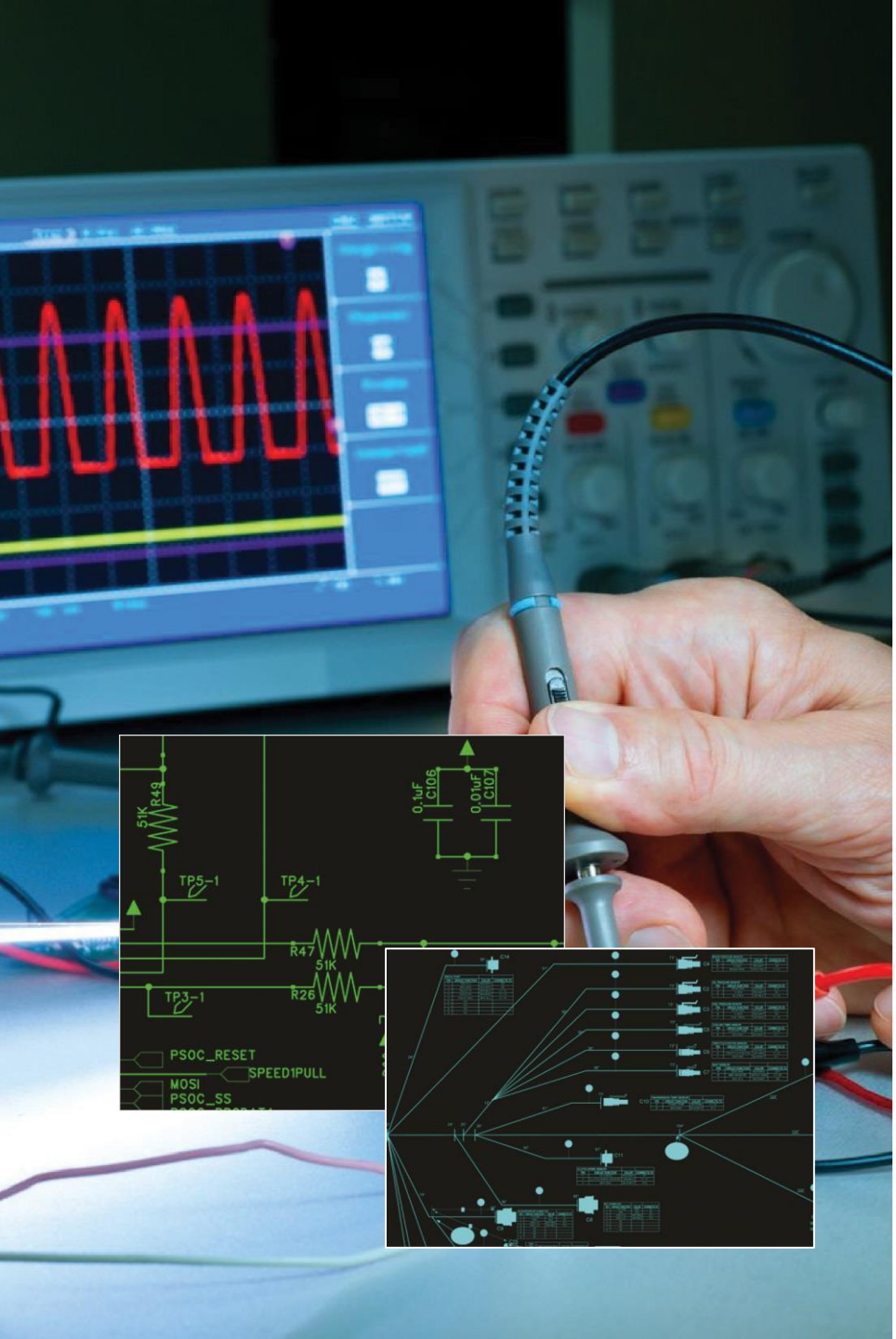

ENGINEERING

Mechanical & Electrical Design

PCS engineers help clients around the world solve challenging vehicle integration issues. We have extensive experience in driveline design, transmission design, and embedded control systems. We have the tools to assist with virtually every stage of vehicle design and development including FMEA, mechanical design, CAN architecture, EMI certification, and PPAP. Our engineers are available 24 hours, 7 days a week to provide on-site engineering support.

Mechanical Design

Our engineers use SolidWorks® to create your 3D design into reality. Along with our rapid prototype tools, we also have a Milltronics VM20 CNC milling machine dedicated solely for research and design projects.

Circuit Schematic Design and Layout

Our engineers use Mentor Graphics PADS® to transform your idea to an electrical design. We will perform a complete electrical analysis of the system and make suggestions if improvements can be made. Our experience has taught us how to design a robust system and avoid common pitfalls. The best circuit schematic is only as good as the layout. Careful implementation is critical at this step. Our engineers will not only consider functional and EMI factors, but also perform a thorough design for manufacturing (DFM) review to insure the board can be built using the most reliable and cost effective process.

Wire Harness Design

An often overlooked component of a system is the wire harness. A properly designed wire harness not only provides superior reliability and performance but also minimizes costs in labor to manufacture and install, weight, and other considerations to improve the overall system implementation. PCS not only provides wire harness routing, but also performs an engineering review of the harness to ensure proper wire gauge, terminals and connectors for the application.

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Control Module Development

ENGINEERING

Driveline Integration & Validation

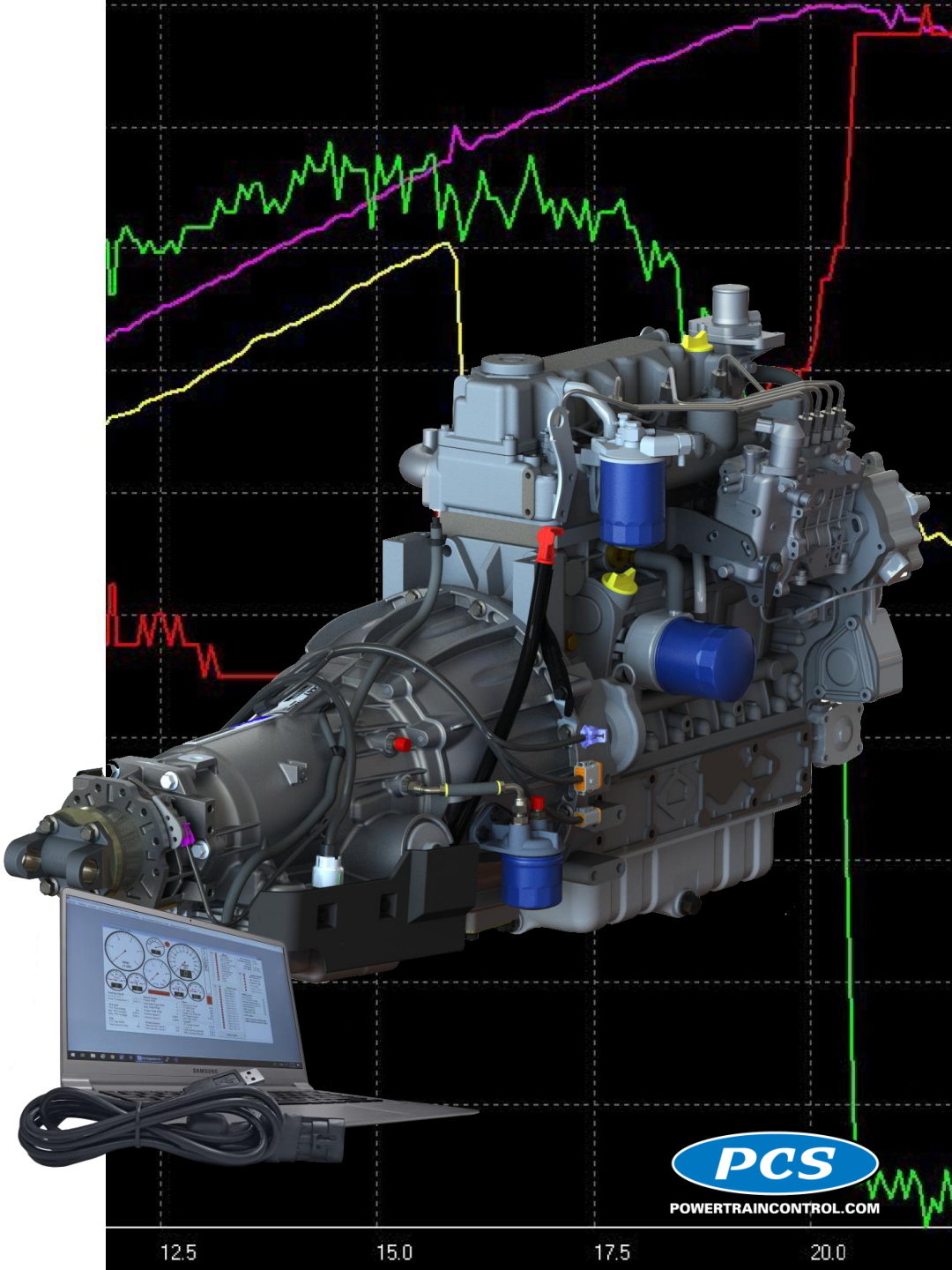
PCS provides complete driveline integration services for vehicle manufacturers. PCS can assist during the entire development cycle including component design, selection, validation, production procurement, and final assembly.

Transmission Simulation and Selection
Computer simulation of vehicle and transmission performance based vehicle specific parameters including GVW, engine, and final drive ratio. Several transmission options will be evaluated and compared. Factors also considered are cost, availability (new or reman), suitability for vehicle mission, and other implementation factors. For four-wheel-drive applications, the transfer case can be included in the analysis.

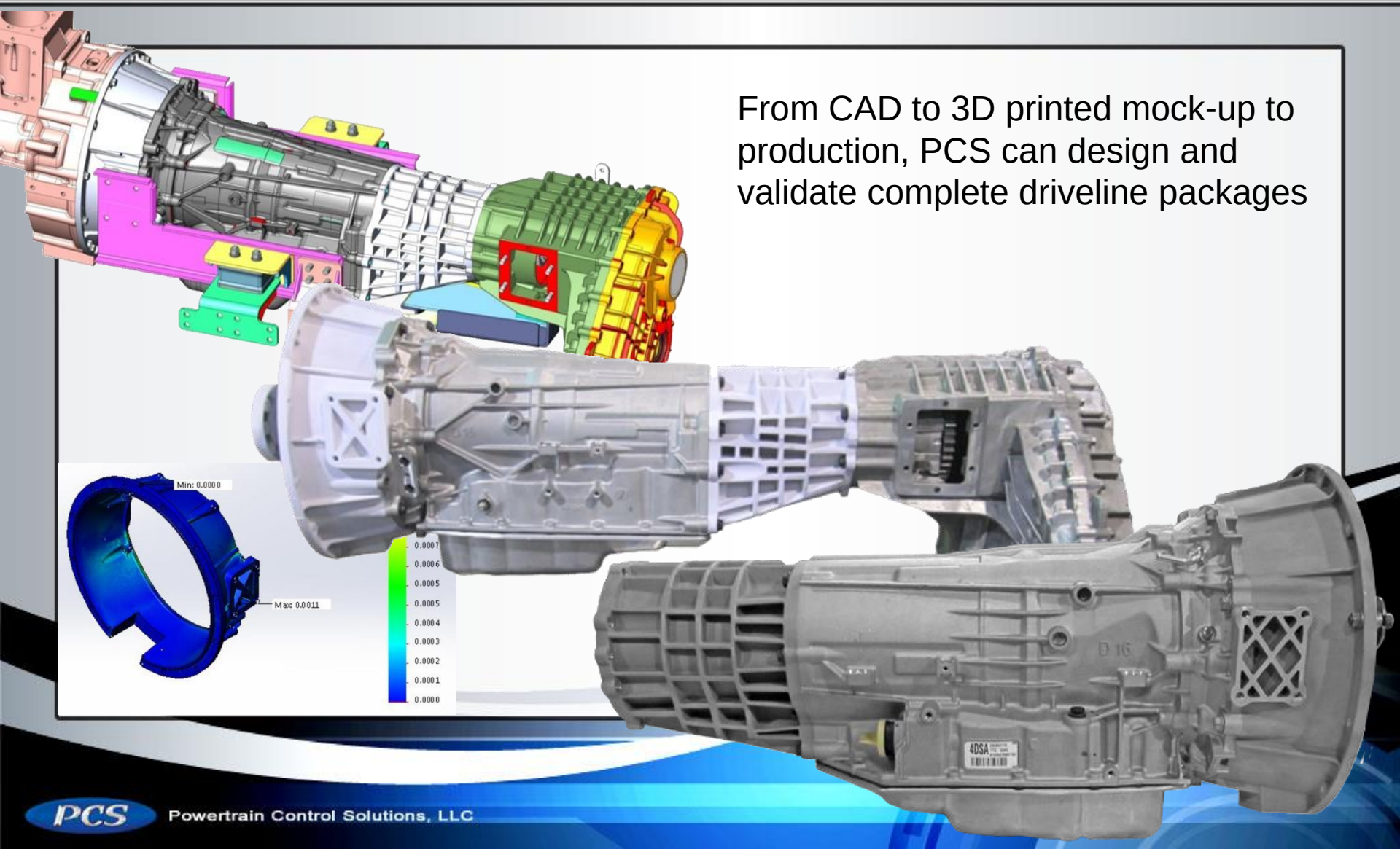
Engine to Transmission Interface
CAD design and analysis includes alignment, torque converter engagement, production feasibility, and costs. Custom bell housings can be designed to simplify installation and reduce production costs. PCS offers bell housings for popular engine/transmission combinations including SAE4 and SAE3 to GM 4L60/70.

Vehicle Fitment
CAD design and analysis of vehicle specific transmission mount loading capability, transmission field serviceability, driveline angle, transmission angle, maximum vehicle operation angle, driveshaft and axles, shift mechanism, cooling system, neutral safety, reverse indication, and parking brake.

Calibration, Validation, and Durability Testing
Transmission calibration and validation is offered to insure the transmission is properly integrated into the vehicle. While continuously monitoring transmission load, slip, cooling, and other variables, durability testing can be performed to verify the transmission will withstand the mission for the expected life of the vehicle.



Powertrain Integration



From CAD to 3D printed mock-up to production, PCS can design and validate complete driveline packages

Proudly Supporting

Supply Chevy Performance with control modules and wiring harnesses

GM GMC

Customer Care and Aftersales

Certificate of Excellence

PLATINUM

Supplier Status

is hereby granted to

POWERTRAIN CONTROL SOLUTIONS

ASHLAND, VIRGINIA

In Recognition for Outstanding On-Time Shipping Performance
to General Motors Customer Care and Aftersales

David Poole
General Director, Supply Chain

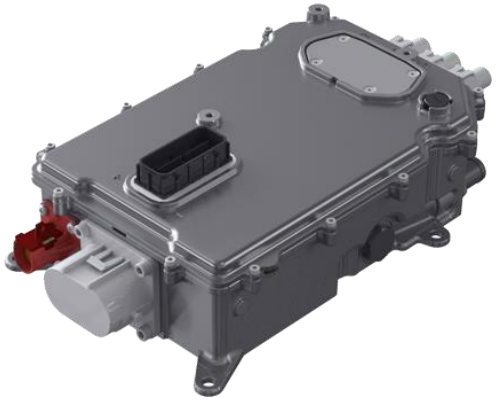
Wade Sheffer
Executive Director, Global Purchasing

PERFORMANCE

Aftermarket Products

- Simple Shift 13
- TCM2800 30+
- Paddle Shifters
- Push Buttons
- Gear Indicators
- Dataloggers
- Accelerometer / Gyro

450V CCS1 / CCS2 ELECTRIFICATION



INVERTERS

3-Phase Drive-Unit Control
225kW / 500A Peak / 250A Cont.
Optional 1200W 12 / 24V DC-DC
48 - 450V System Capable

DRIVE UNITS

Compact Designs
201 - 335 HP
265 - 962 FT-LBS
2,644 - 8,700 RPM

REMOTE DC-TO-DC

HV-to-12V 1400W DC Converter
12V and 24V Options
V-DC Output Configurable

IN-HOUSE HV-CABLE PRODUCTION!

GSE AIRPORT TRACTORS

Providing High-Voltage Electric-Vehicle powertrains for new and repowered airport bag-tractors, cargo-tractors, belt-loaders, and push-backs.

ROAD CONSTRUCTION

Developed drop-in powerplants for previously diesel / hydraulic asphalt pavers and powered-broom equipment.

UTV OFFROAD

Full 200HP AWD electric powertrain developed by PCS, providing highly versatile offroad performance for some of the worlds fastest UTVs.

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DEFENSE

HMMWV

In 2008 replaced Delphi as the supplier of the transmission control module for the HMMWV. Performed all calibration and validation using PCS produced tools. Currently the sole supplier for the TCM.

OSHKOSH JLTV

CAN based, military rated (MIL-STD-461E), control modules for accelerometer and gyro module, smart power distribution, and more.

BOEING BADGER

PCS engineered, calibrated, and validated driveline including TCM, transmission, and mil-spec transfer case module. PCS supplied transmission with custom VM Motori bellhousing and transfer case.

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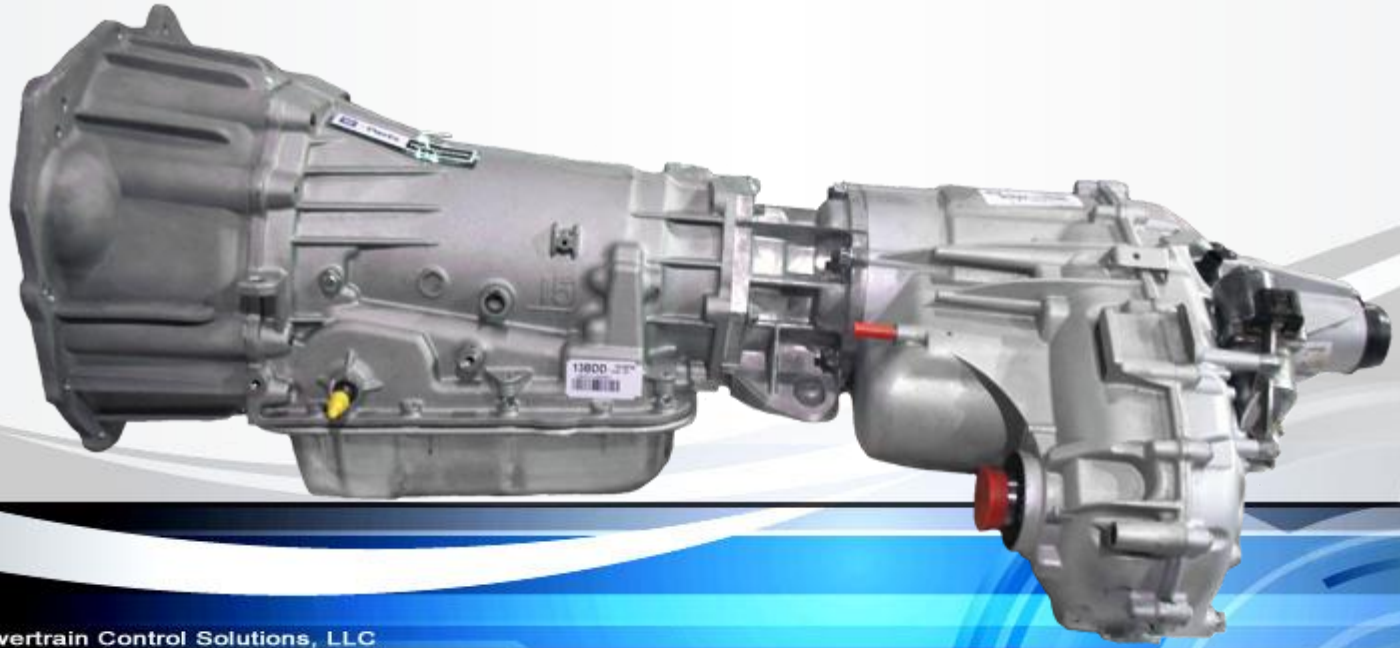
Boeing Badger

Military Integration

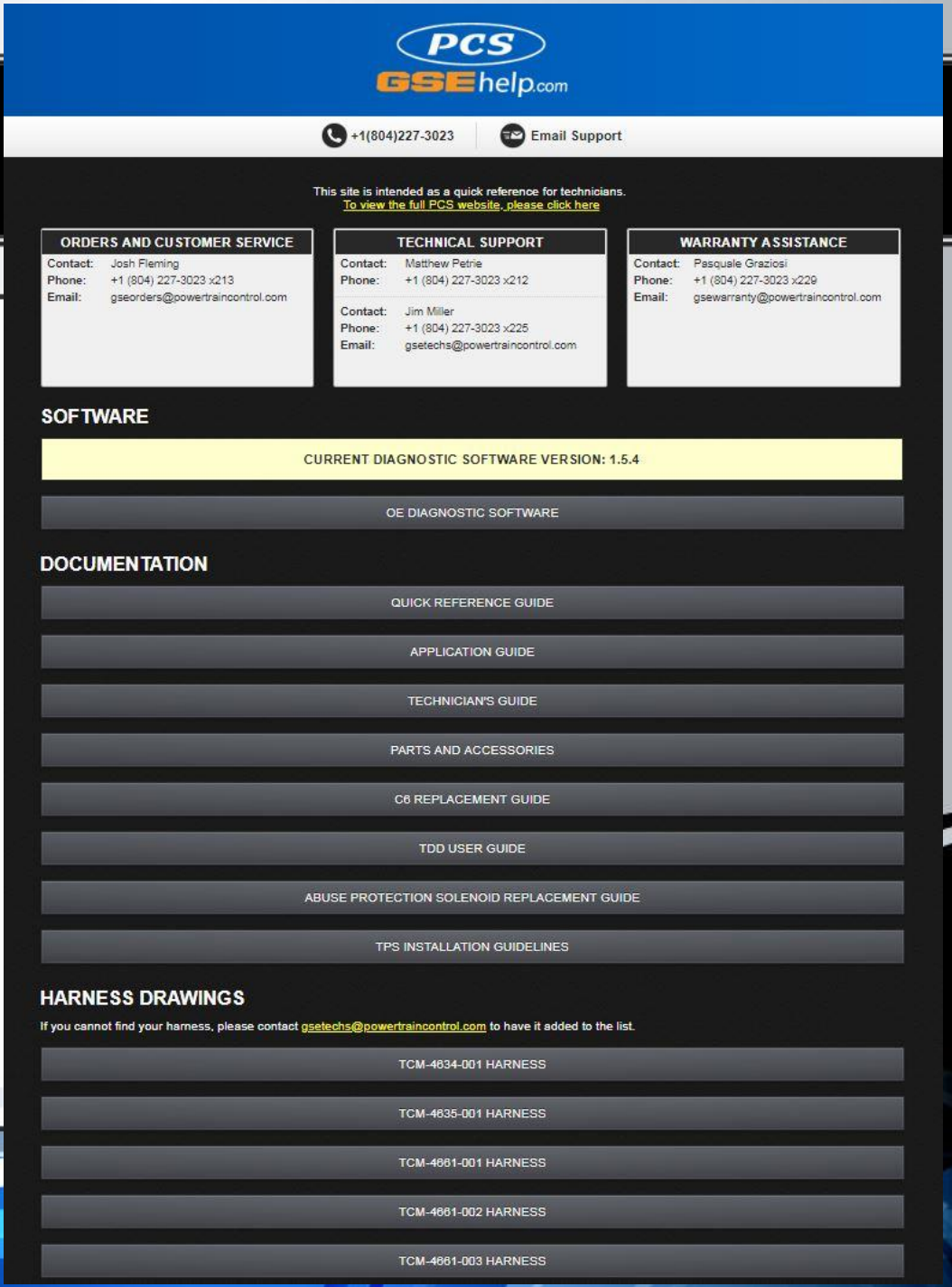
- Custom 4L70 bellhousing for VM Motori Engine
- Engineered, calibrated, and validated entire driveline; including our TCM and mil-spec transfer case module



Ground Support Equipment

Website

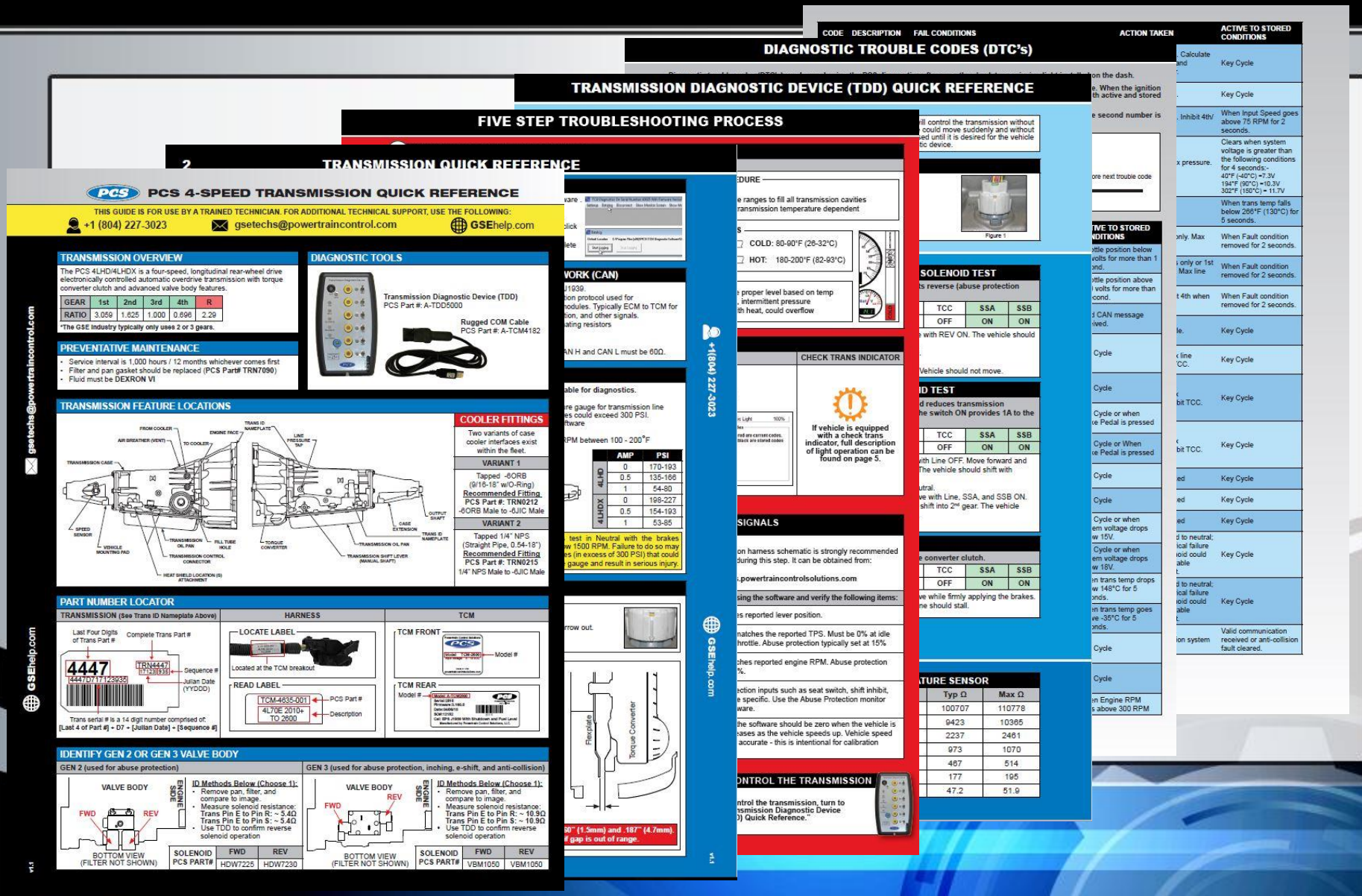
- Easy URL
- No Advertisements
- Smartphone Friendly
- Easy Contact Info
- Latest Tech Guides
- Latest TSB’s
- All GSE Harnesses



Available Reference Material

- *Parts and Accessories* *(Full Catalog)*
- *Application Guide* *(Engineering Reference)*
- *Technician's Guide* *(Standard Maintenance Procedures)*
- *Torque Specs* *(Transmission & Trans Systems)*
- *Datalog Guide* *(As explained later)*
- *Training Powerpoint* *(For your later reference)*
- *Disc Brake Adjustment* *(As requested by field techs)*
- *All old and new TSB's and Tips & Tricks!!*

Quick Reference



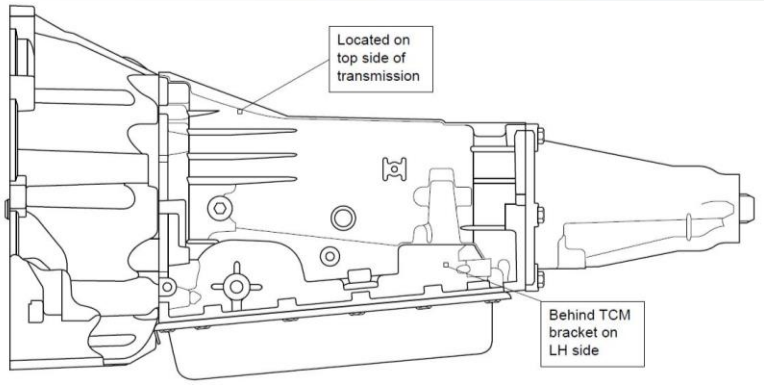
For Technical Help

gsetechs@powertraincontrol.com

GSEhelp.com

+1 (804) 227-3023

Transmission ID



Last Four Digits of Trans Part #

Complete Trans Part #

4447

4447D717123935

TRN4447

17123 935

Sequence #

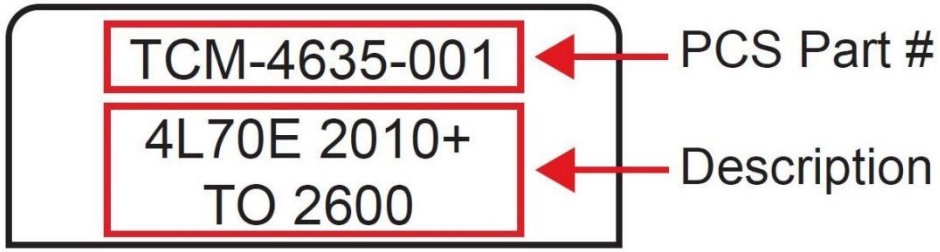
Julian Date (YYDDD)

Trans serial # is a 14 digit number comprised of:

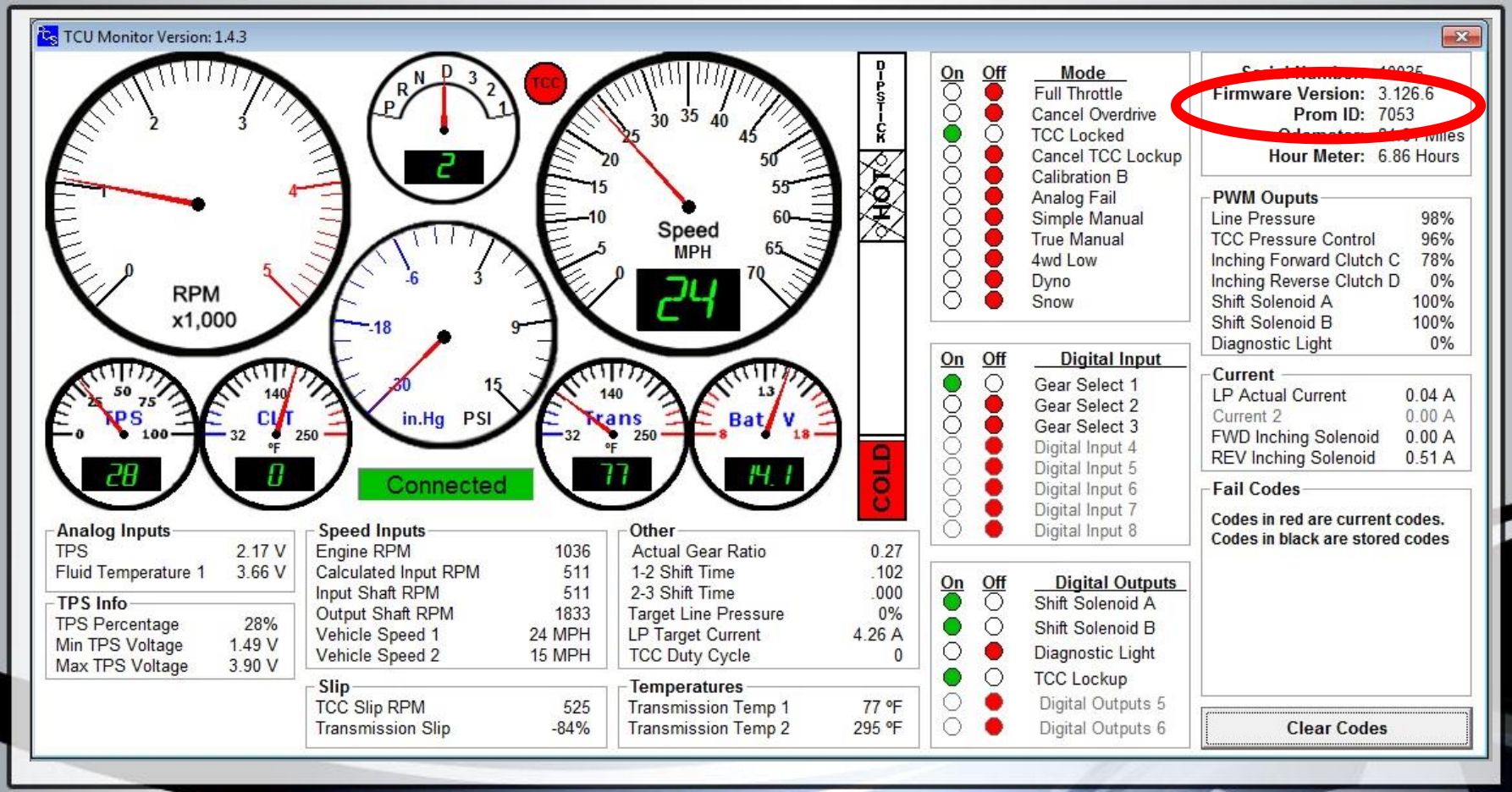
[Last 4 of Part #] + D7 + [Julian Date] + [Sequence #]

Harness ID

Located at the TCM breakout

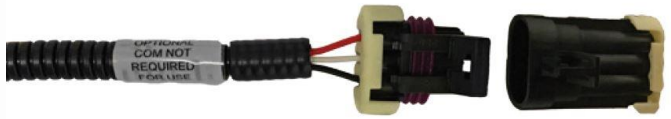


TCM2600 / 2800, Firmware, Calibration



Check for Codes – PCS Software

- Transmission controller is accessed via a serial data interface and a laptop
- The serial data interface cable kit is available from PCS, part number TCM4640
- The Diagnostic Software is available from GSEhelp.com



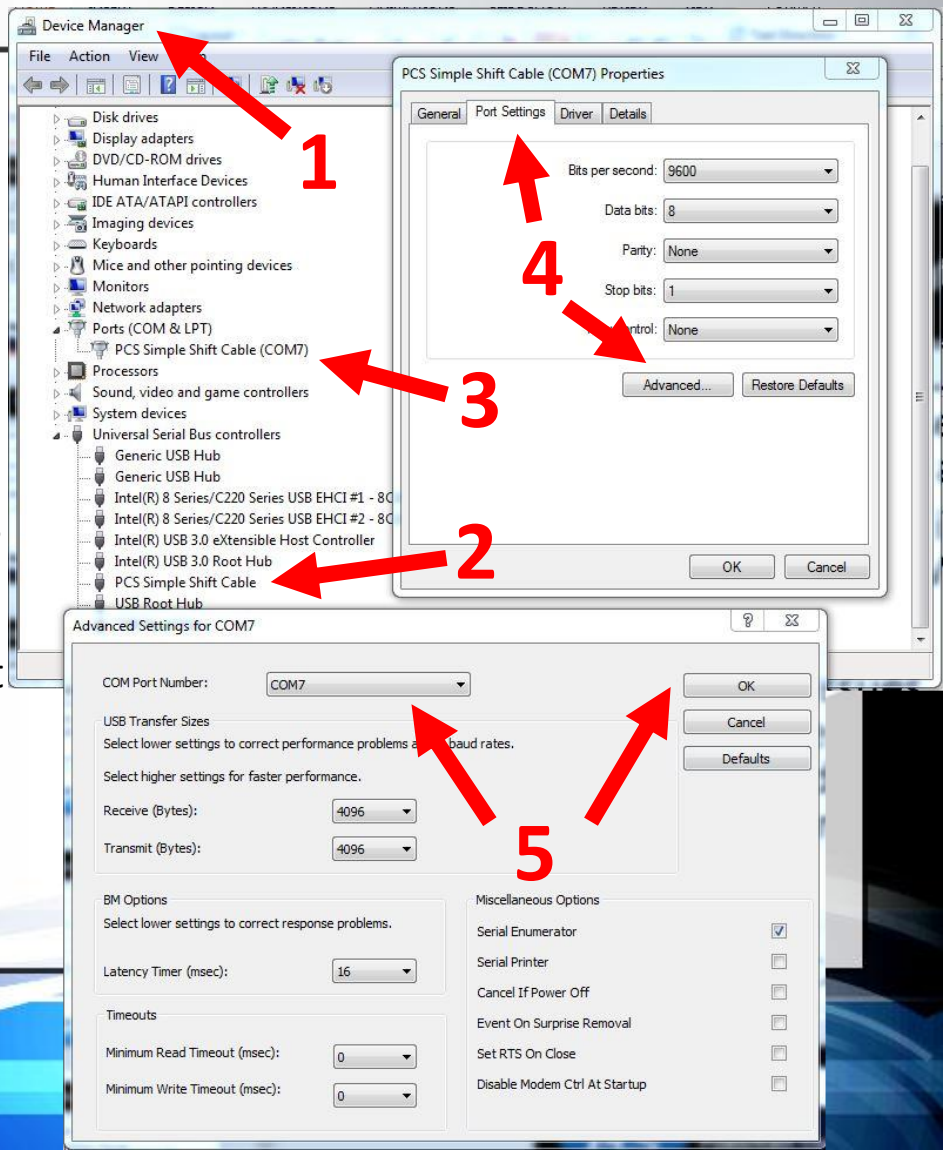
Labeled **"OPTIONAL COM NOT REQUIRED FOR USE."**

When not in use cap is required.

Serial Communication Cable

- TCM is accessed via a serial data interface and a Windows laptop
- Replacement is available from PCS. PN# TCM4180

- Comm issues
  - Step-1: Hit the Windows button and type “Device Manager”.
  - Step-2: Verify that the device & driver is installed and no errors.
  - Step-3: Ports (Com & LPT) 5-15… Windows often defaults to com-3. If not 5-15, right-click & Properties.
  - Step-4: Port-Settings, Advanced
  - STEP-5: Select an available com 5-15.



4-Speed Offerings

- 4L60E / 4L70E Hybrid Core:
  - 4LHD (258mm), 4LHDX (300mm)
  - 4-Speed Transmission w/ Lockup Converter
    - 4L60/70 GM Transmission with upgrades for industrial use and abuse protection valvebody.
    - GSE typically only uses 2 or 3 speeds.

GEAR	1st	2nd	3rd	4th	R
RATIO	3.059	1.625	1.000	0.696	2.29

Great Lakes ferry story!

4L60E Legacy Upgrades

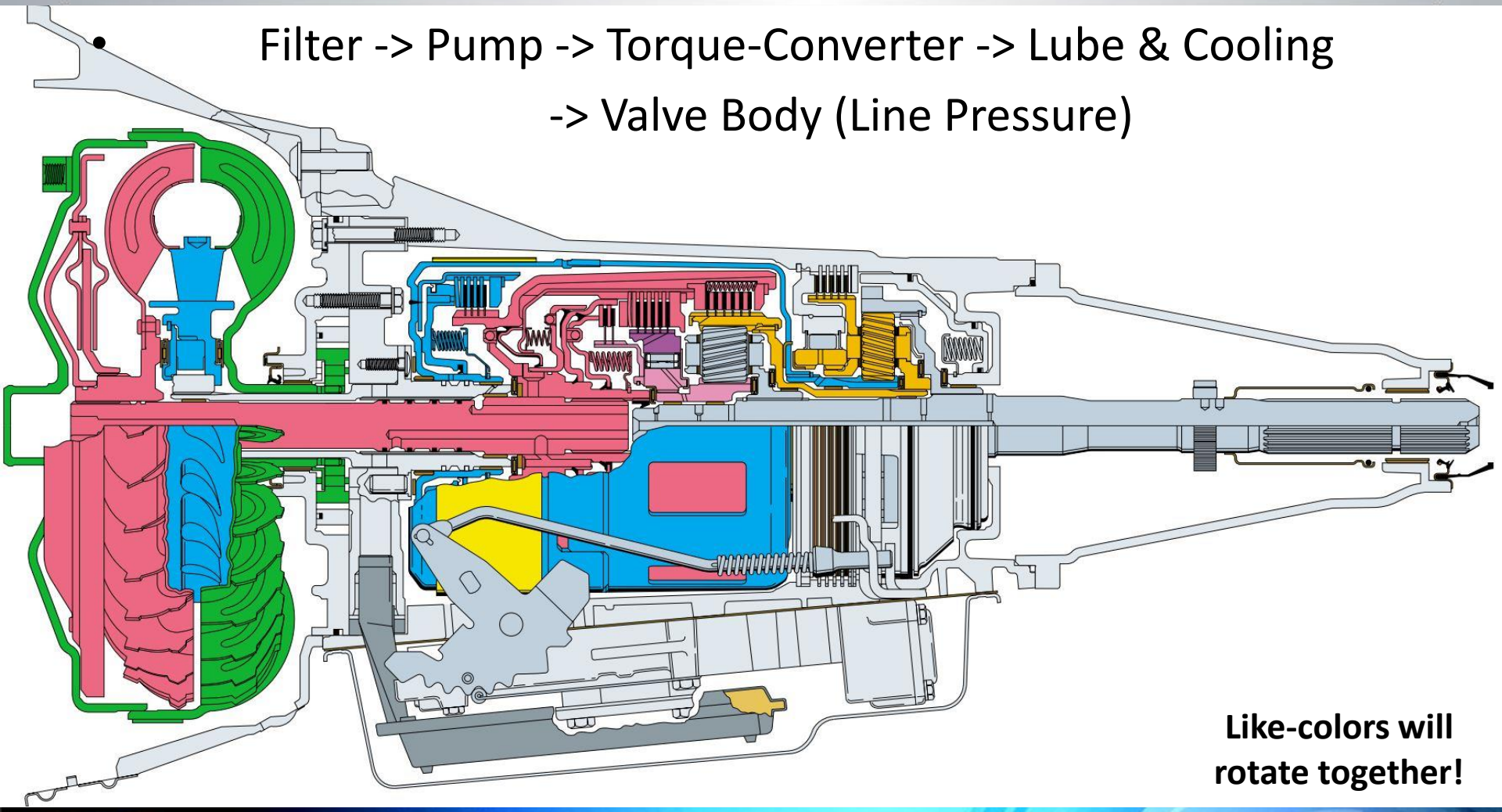
- GM oversight on all Production Processes & Quality Control
- 100% Full functionality tested on trans-dyno test stands
- GM/PCS 2yr or 2,000hr warranty
  - Does not cover shipping damages, improper installation, improper operation / maintenance
- Heat Treated input / output shafts
- Induction hardened input / output shaft splines
- Latest 4L70E electronics for diagnostics & control
- 7-plate 3-4 Clutch
- Heavy-Duty low/reverse roller clutch
- Heavy-Duty needle-type thrust bearings
- Five pinion rear planets
- Hardened reaction sun gear shell

Standard 4L60E, with PCS Options

- Bellhousings:
  - GM/LS, SAE4, C6 (SAE3 and SAE5 adapters available)
- Torque Converters:
  - 300mm, 258mm, C6-258mm
- Output:
  - 2WD Slip Yoke, FFO w/ Disc, C6 w/Drum, and 4WD
- Valve body:
  - Gen 2 (Abuse protection), Gen 3 (Electronic range, inching, anti-collision)
- New or Reman
- 72 unique transmission part numbers (Transmission Listing on website)

Transmission Systems & Operation 1

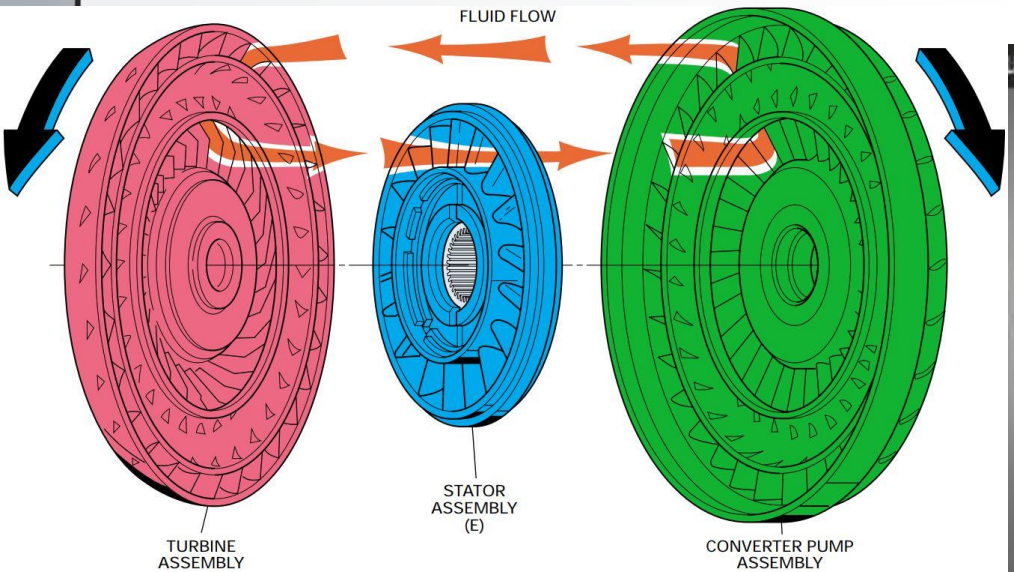
- Filter -> Pump -> Torque-Converter -> Lube & Cooling -> Valve Body (Line Pressure)

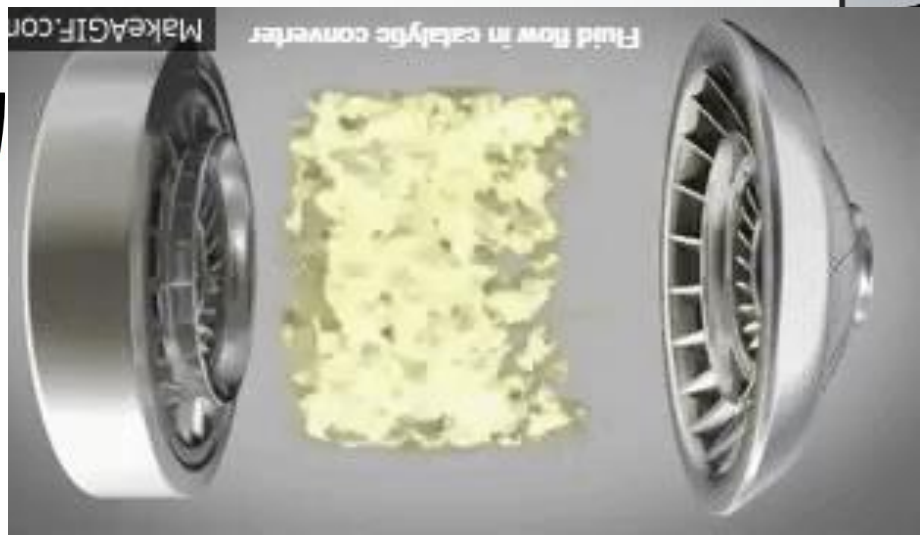


Like-colors will rotate together!

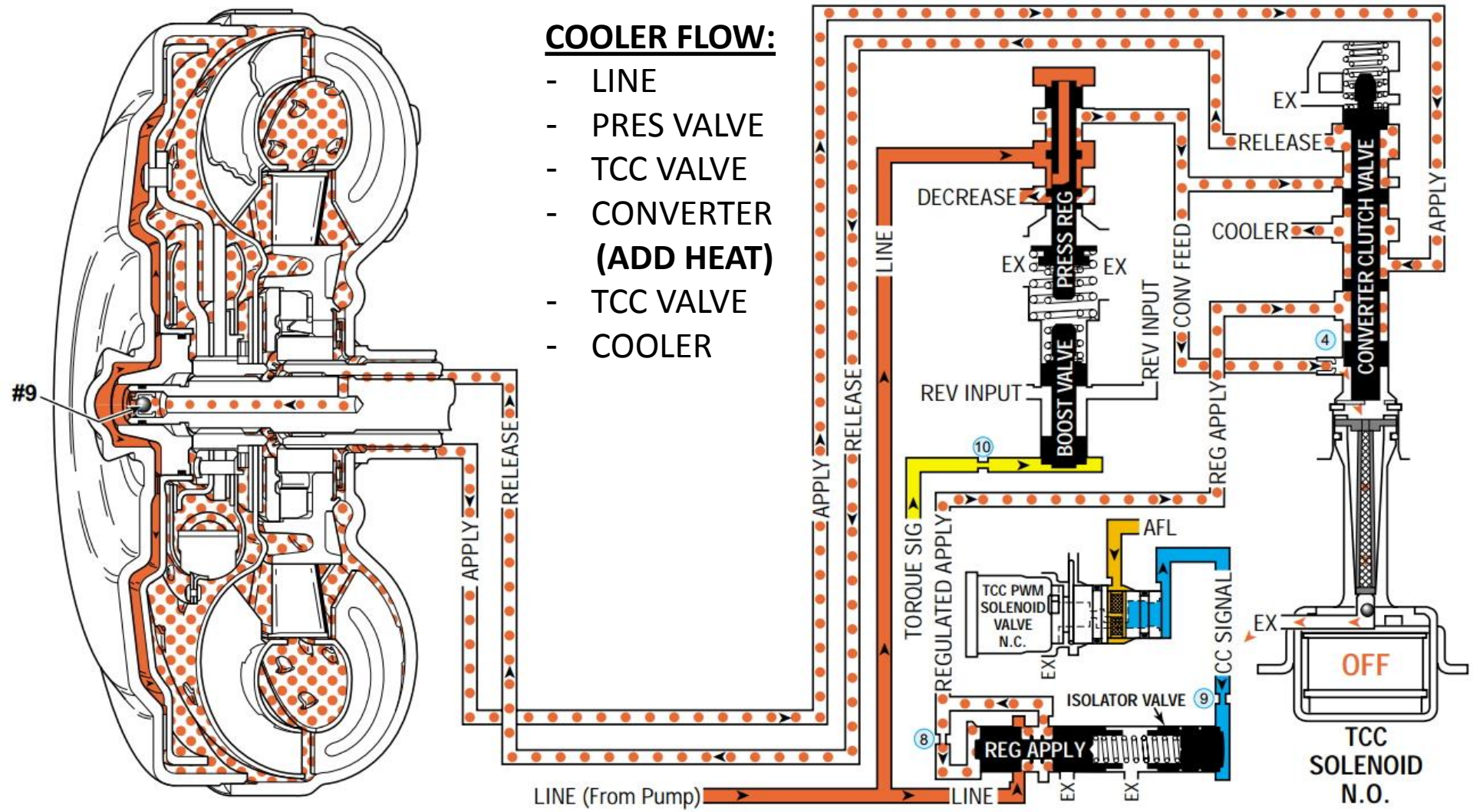
TORQUE CONVERTER

- FLUID COUPLING.
- ALLOWS ENGINE TO SLIP / RUN AT IDLE WHILE IN GEAR.
- ~2X TORQUE MULTIPLICATION.
- LOWER EFFICIENCY; GENERATES HEAT THROUGH FRICTION.
- PUMP DESIGNED TO FILL IMMEDIATELY ON ENGINE STARTUP.
- PHYSICALLY DRIVES THE PUMP, OUTER CASE AT ENGINE-RPM.
- INTEGRATED LOCKUP CLUTCH FOR GEAR 3 / 4.





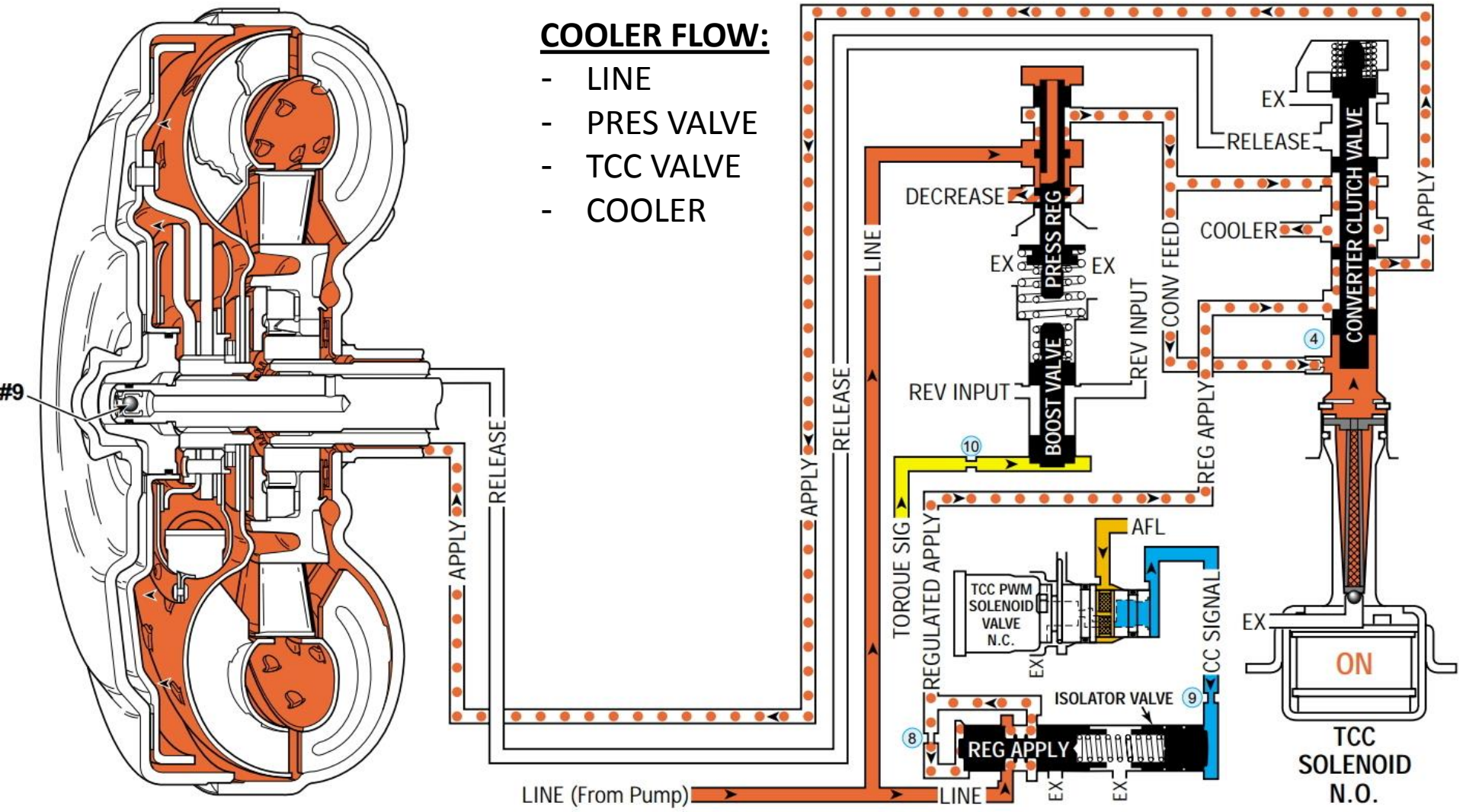
CONVERTER – UNLOCKED / RELEASED



COOLER FLOW:

- LINE
- PRES VALVE
- TCC VALVE
- CONVERTER **(ADD HEAT)**
- TCC VALVE
- COOLER

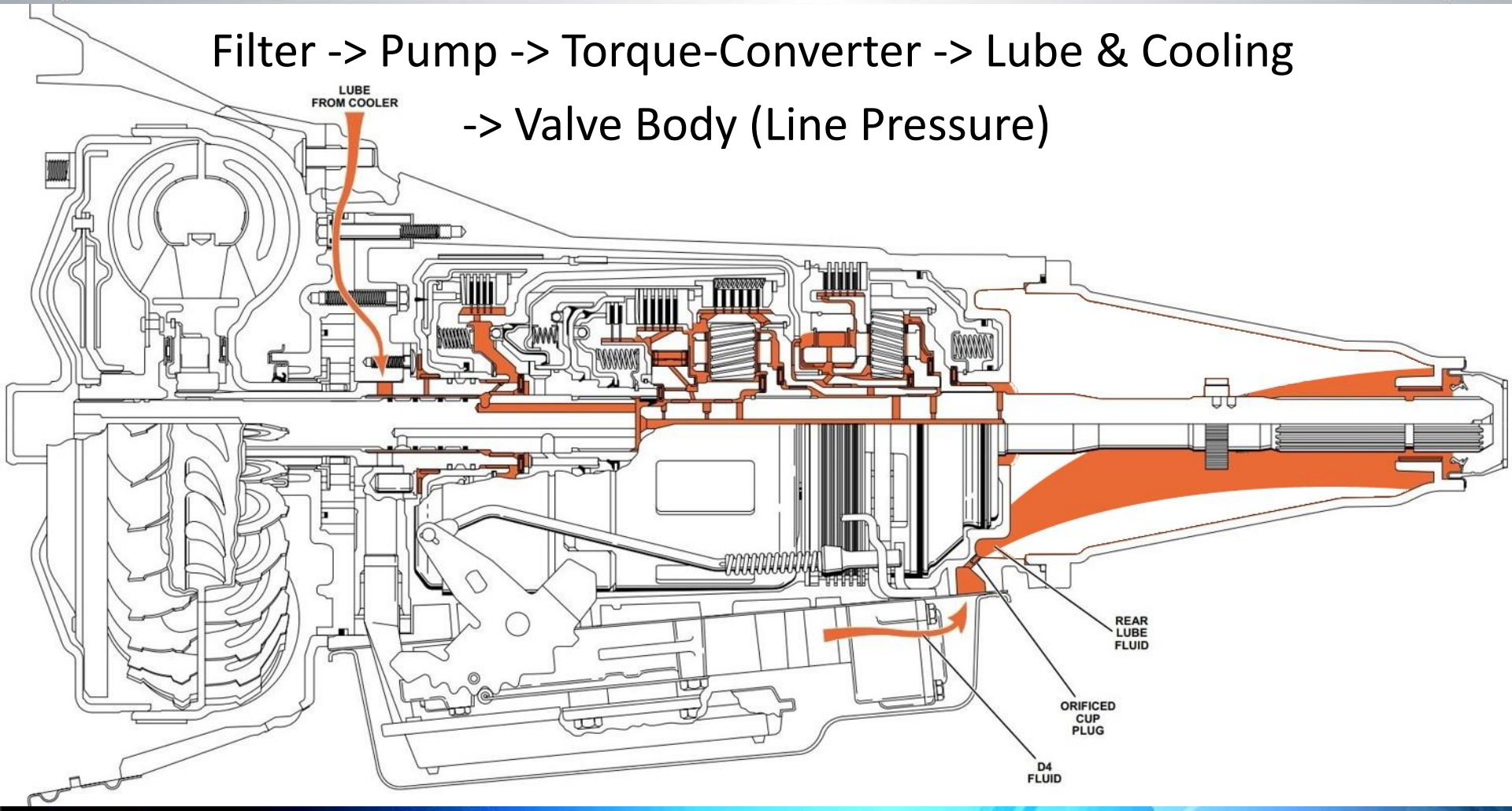
CONVERTER – LOCKED / APPLIED



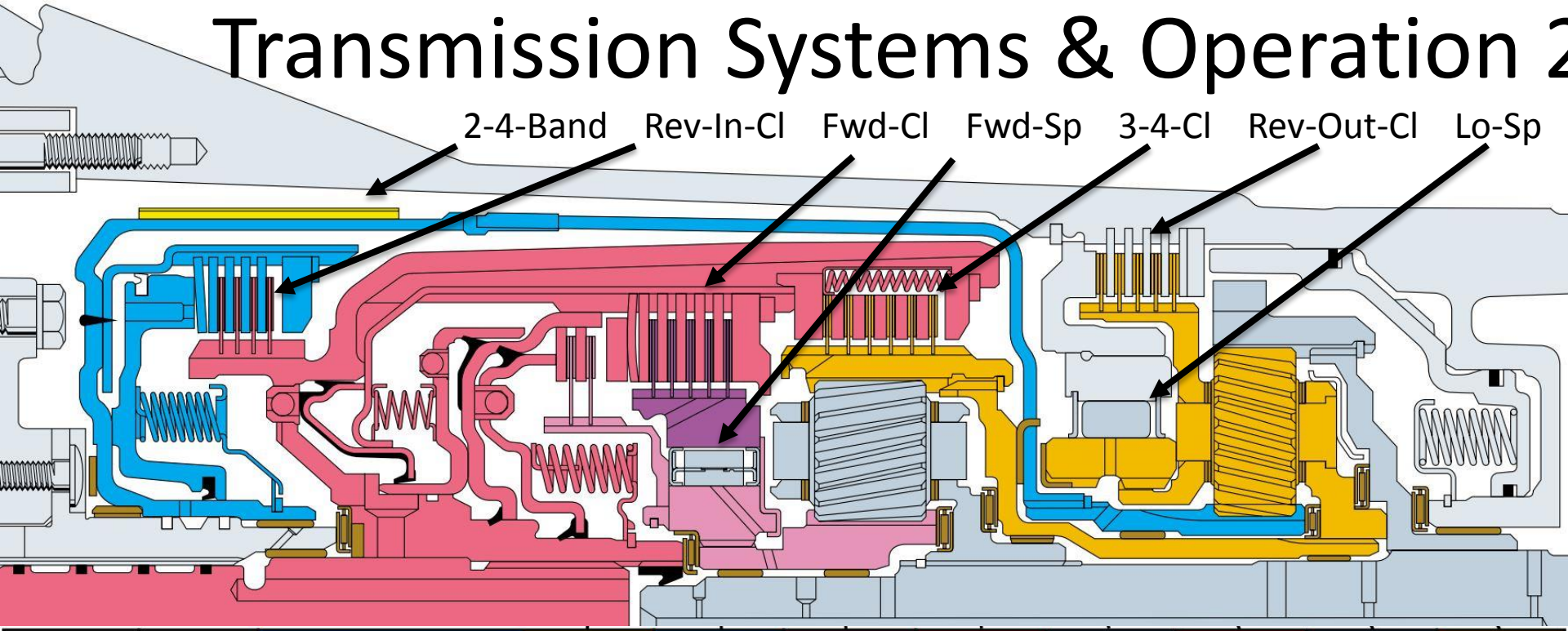
COOLING AND LUBRICATION CIRCUIT

Filter -> Pump -> Torque-Converter -> Lube & Cooling

-> Valve Body (Line Pressure)

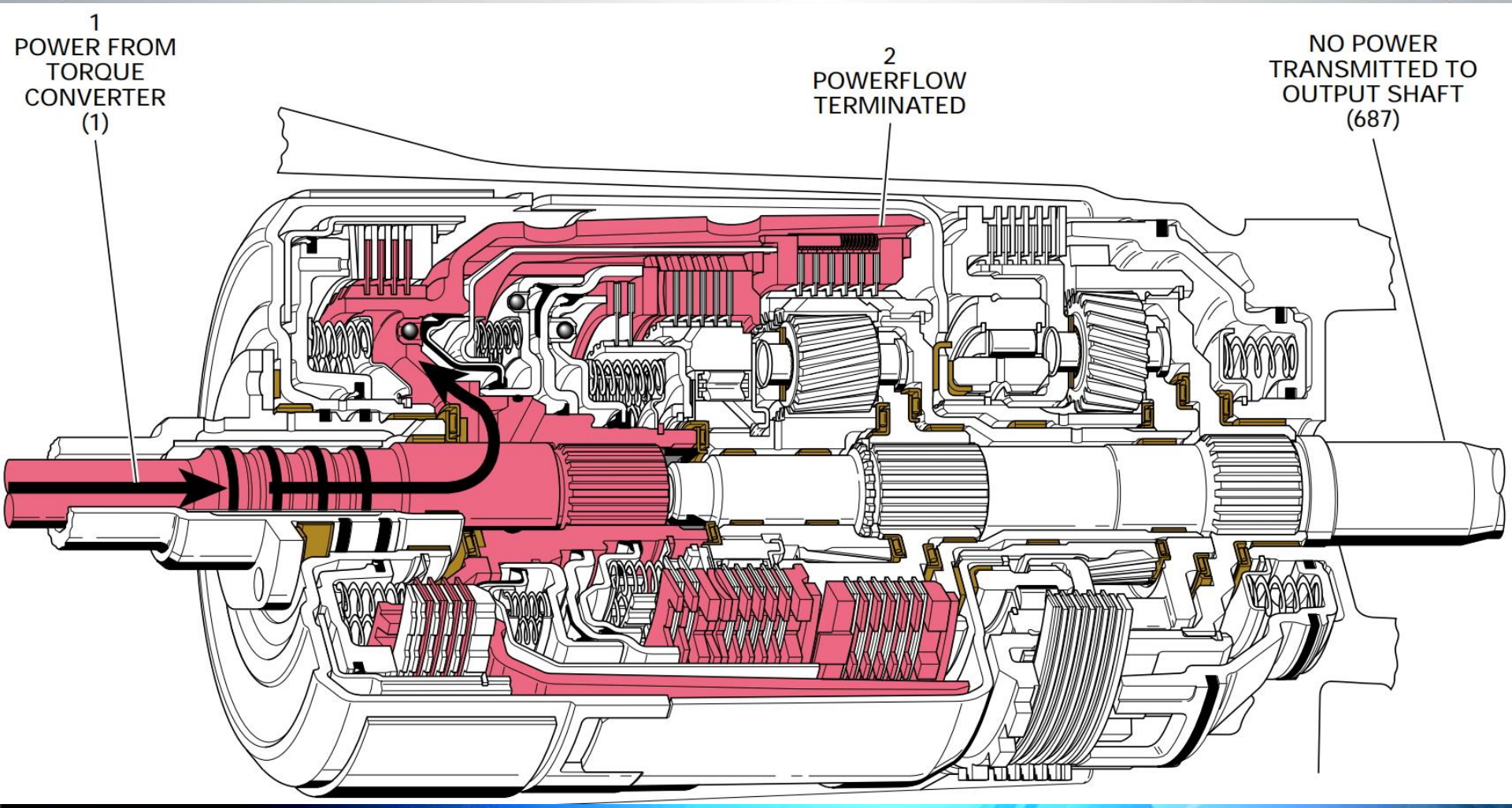


Transmission Systems & Operation 2

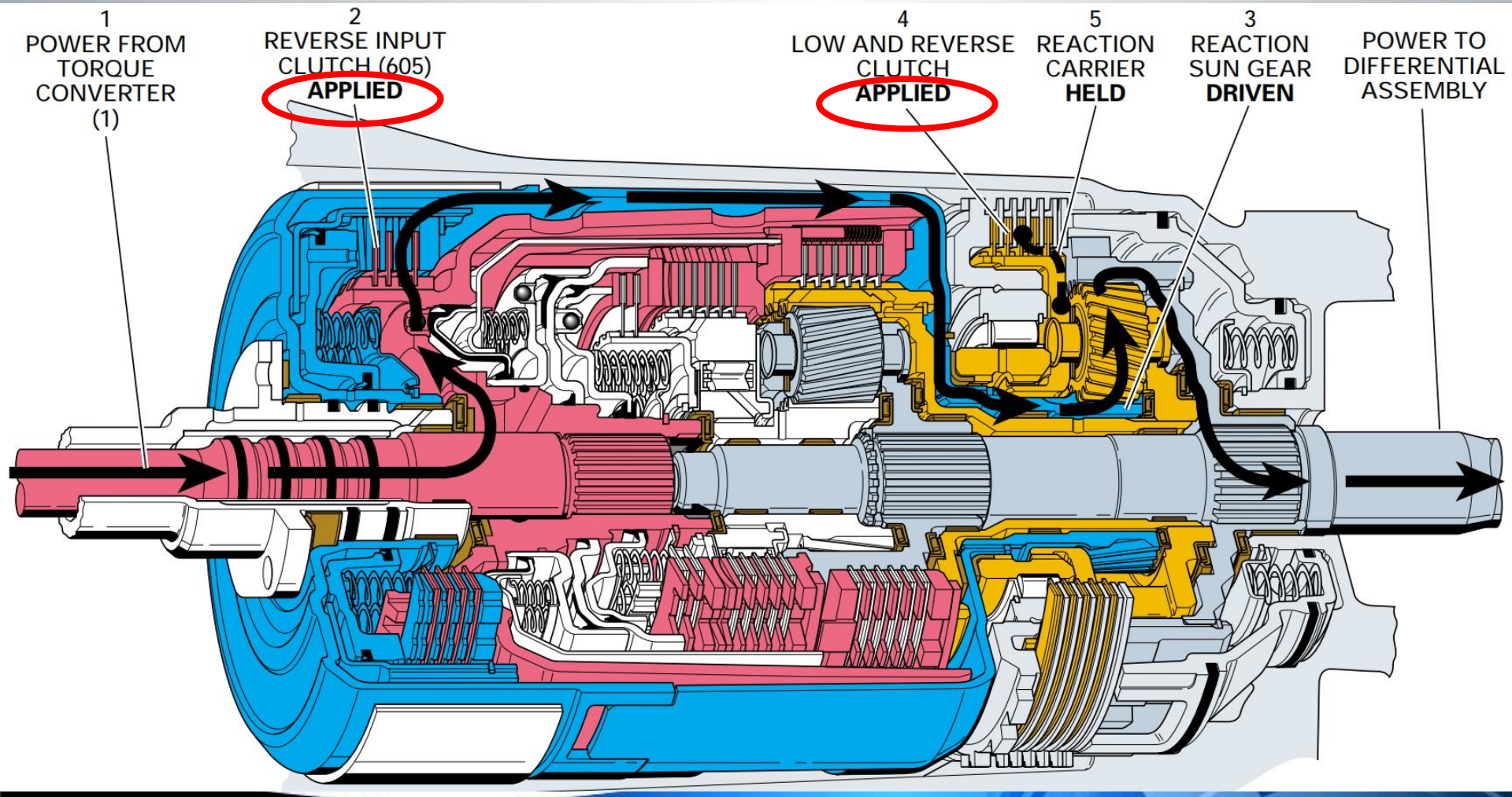


RANGE	GEAR	SHIFT SOLENOID VALVES		2-4 BAND	REVERSE INPUT CLUTCH	OVERRUN CLUTCH	FORWARD CLUTCH	FORWARD SPRAG CL. ASSEMBLY	3-4 CLUTCH	LO ROLLER CLUTCH	LO/REV. CLUTCH
		1-2	2-3								
PARK		ON*	ON*								APPLIED
REVERSE		ON*	ON*		APPLIED						APPLIED
NEUTRAL		ON*	ON*								
D	1st	ON	ON				APPLIED	HOLDING		HOLDING	
	2nd	OFF	ON	APPLIED			APPLIED	HOLDING			
	3rd	OFF	OFF				APPLIED	HOLDING	APPLIED		
	4th	ON	OFF	APPLIED			APPLIED		APPLIED		

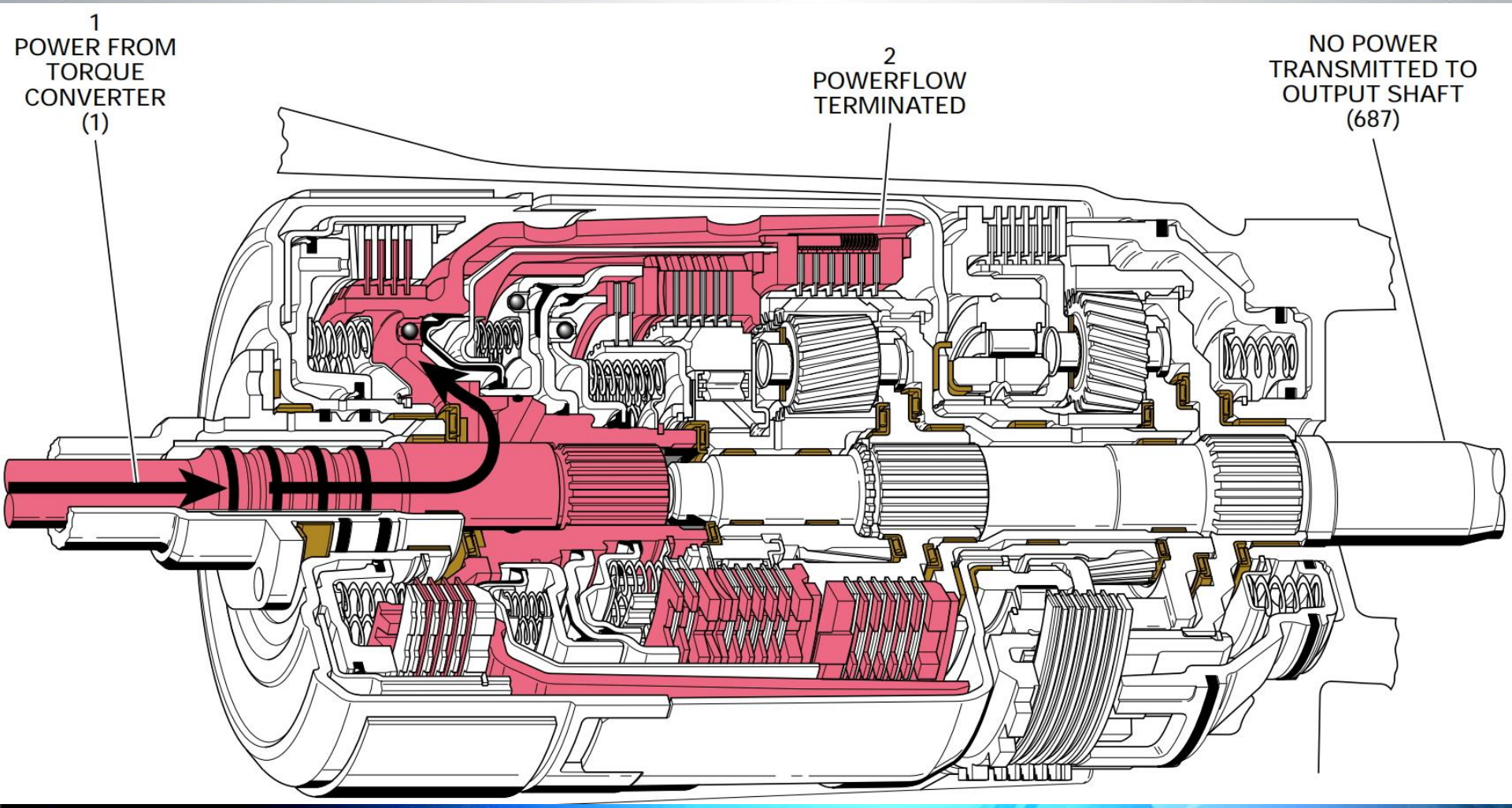
STARTUP, PARK / NEUTRAL



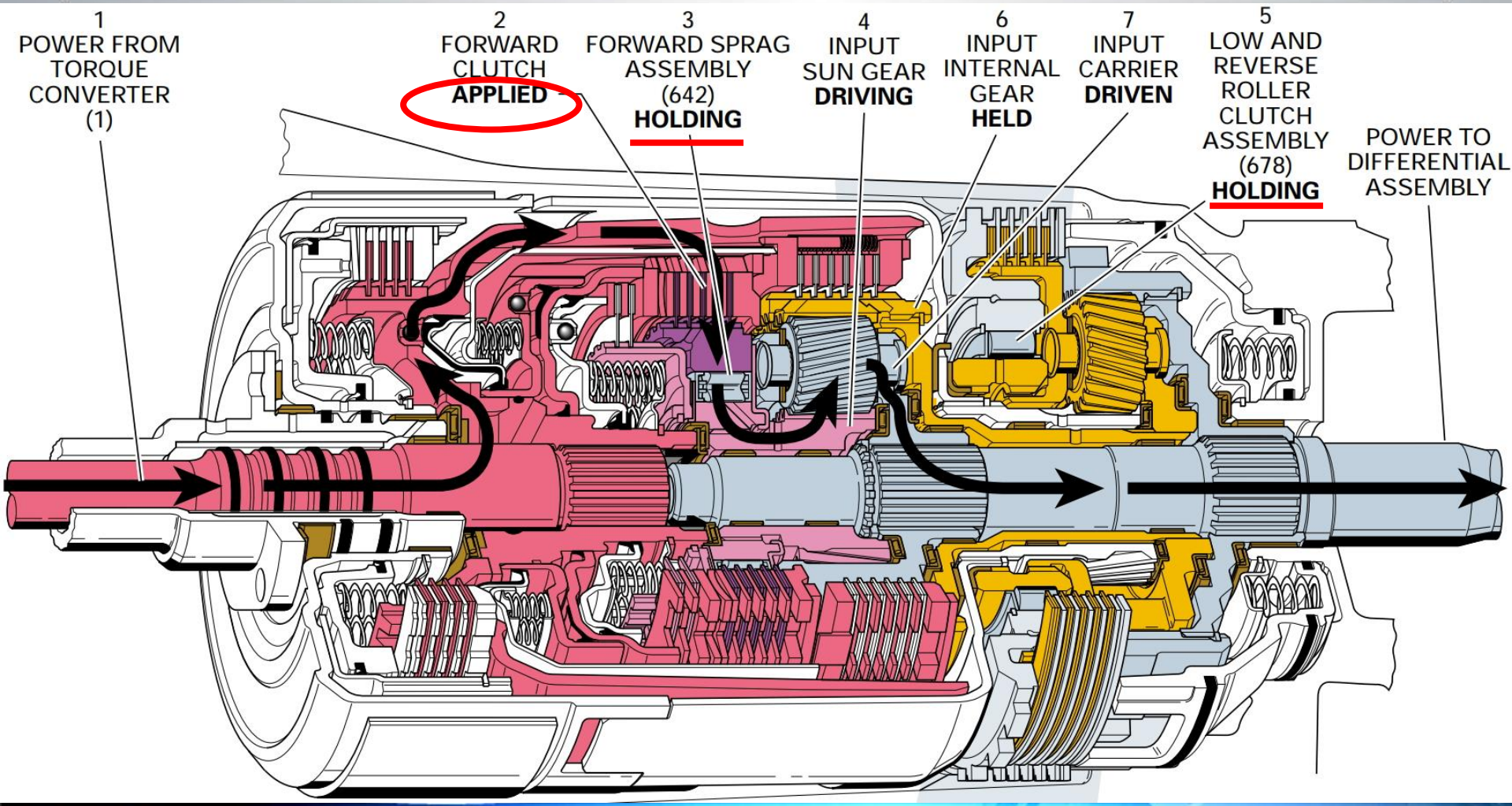
REVERSE “REV” – 2.29:1



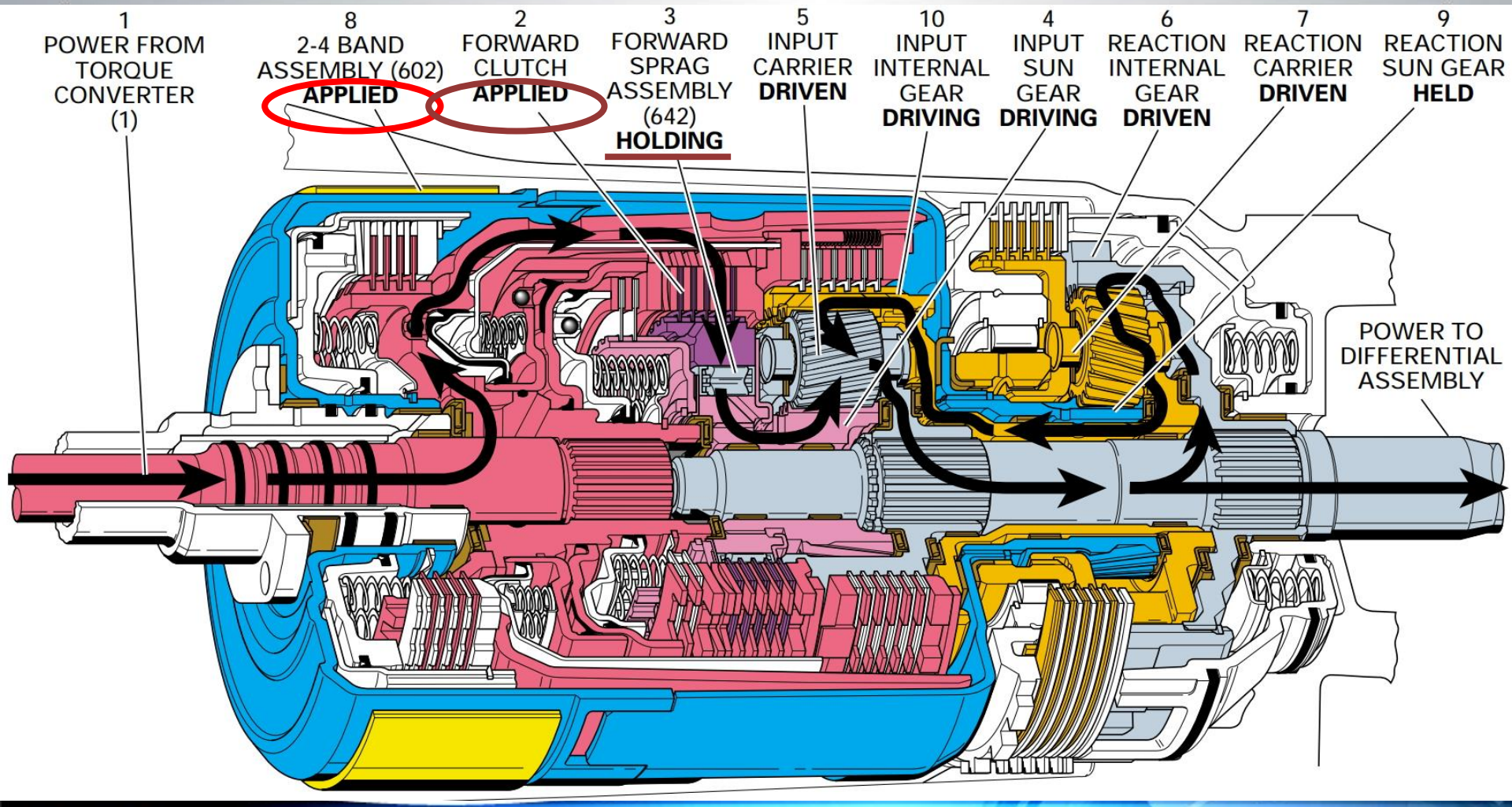
STARTUP, NEUTRAL



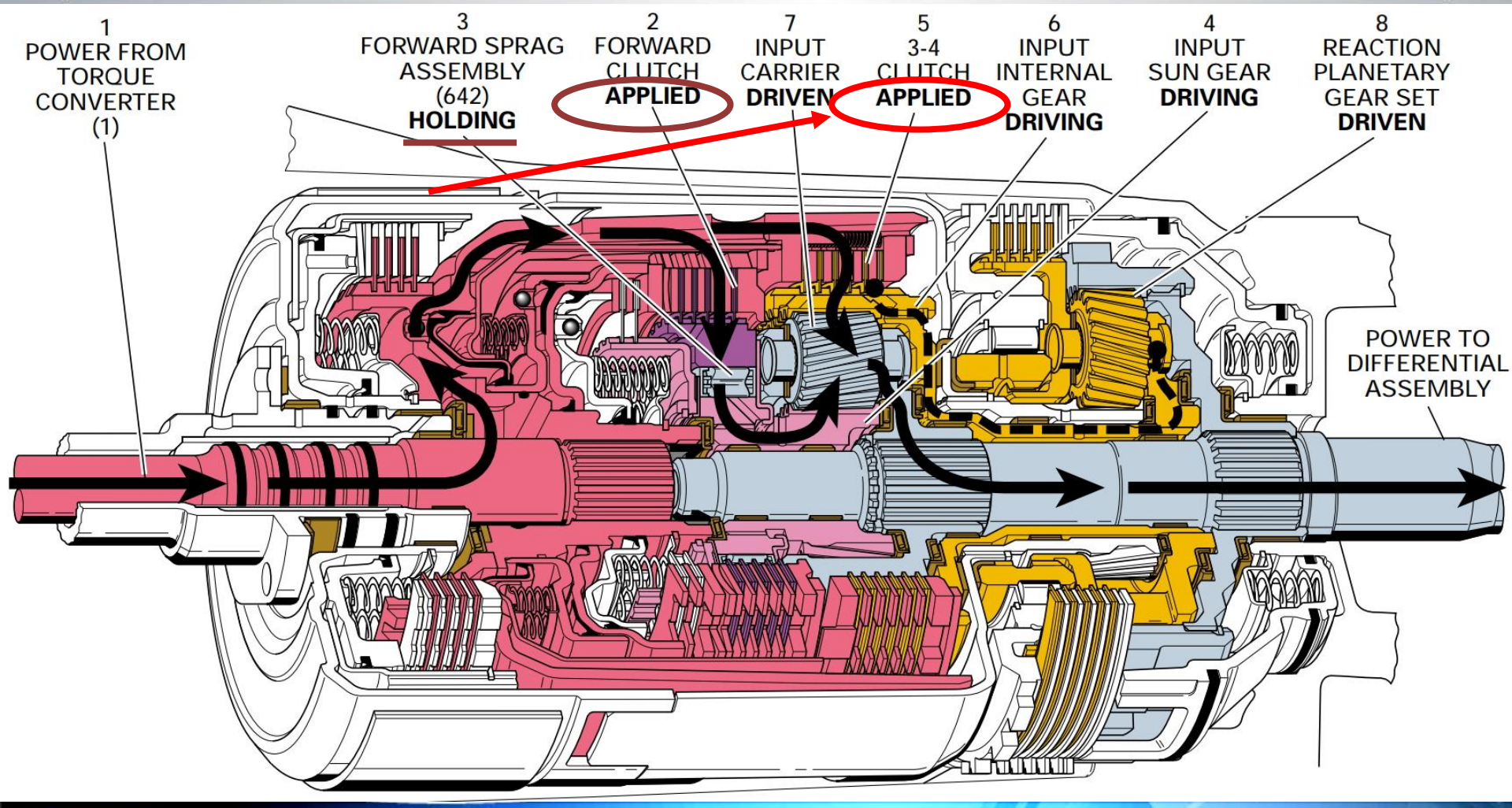
FWD – 1ST GEAR – 3.06:1



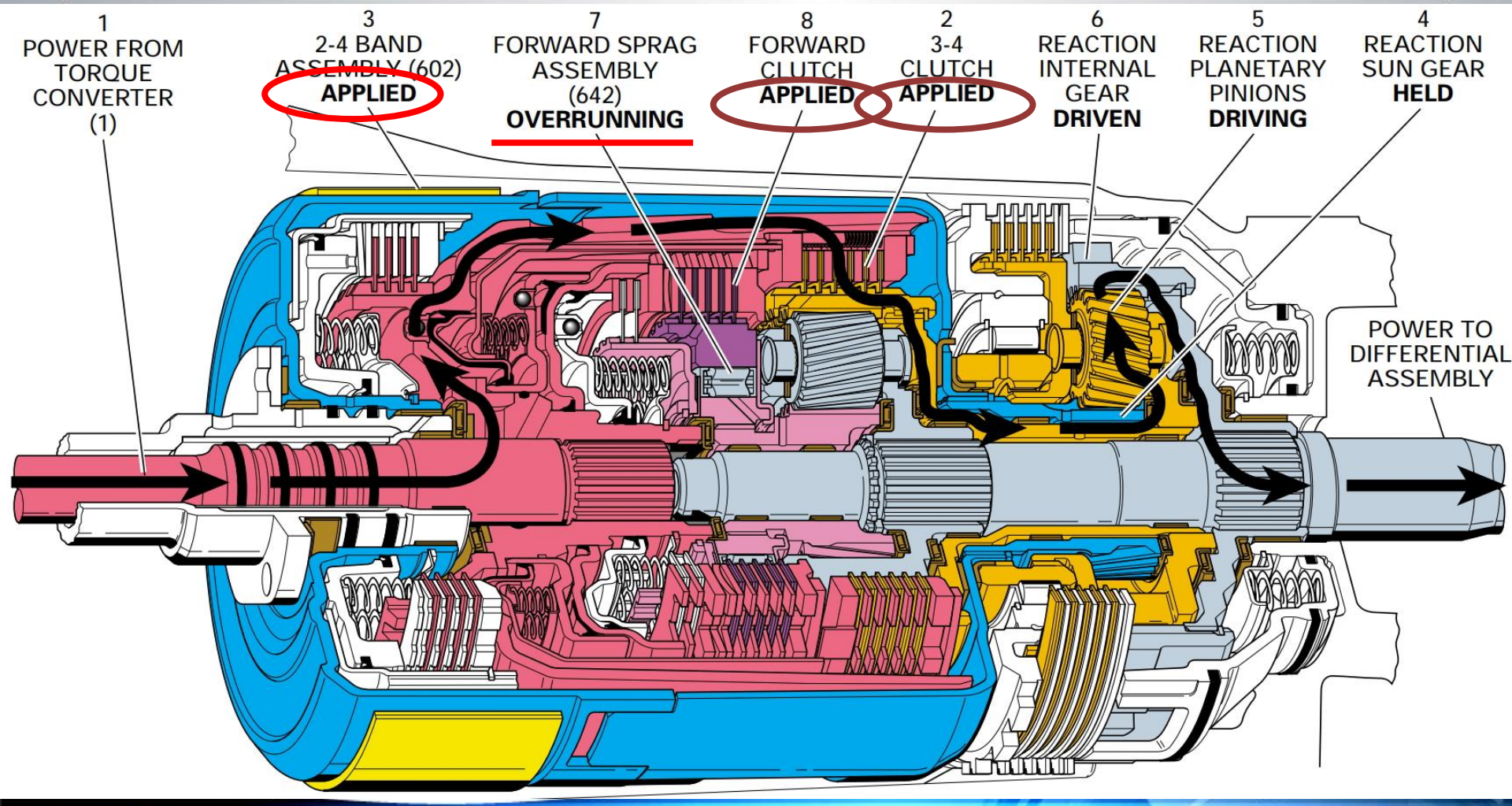
FWD – 2ND GEAR – 1.63:1



FWD – 3RD GEAR – 1.00:1

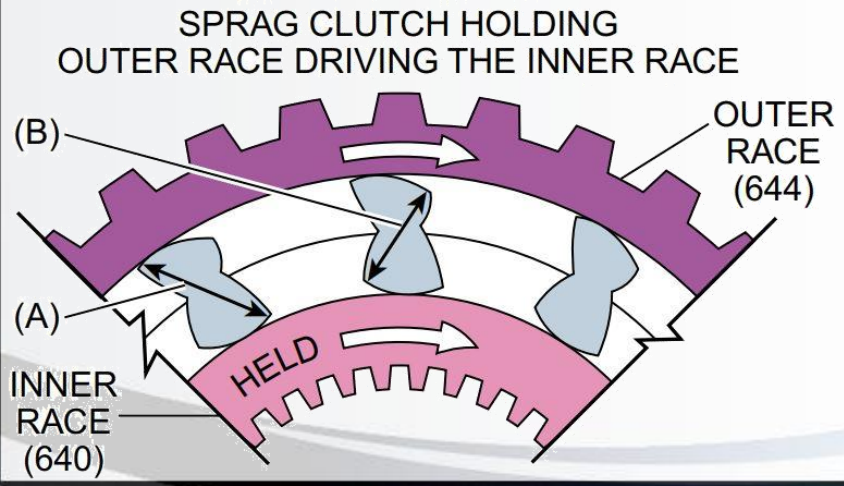


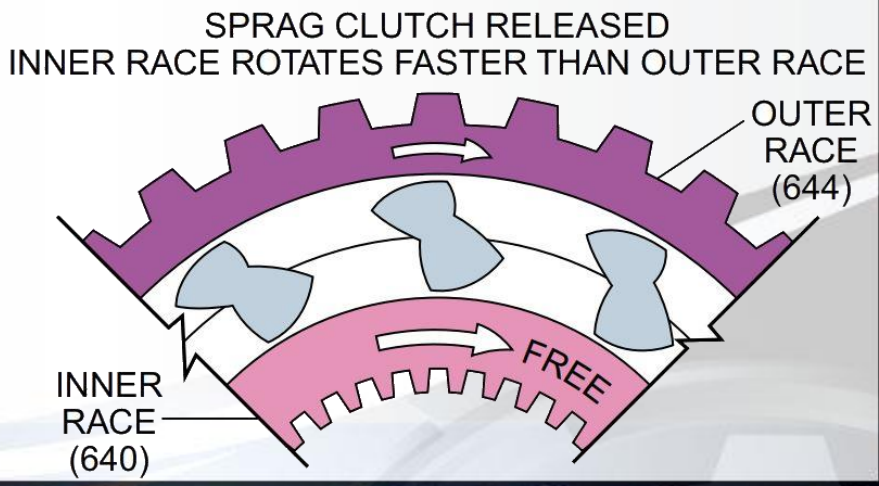
FWD – 4TH GEAR – 0.69:1



DOWNSHIFTS ARE ALL “OVERRUN”

- When downshifting and/or decelerating, the Forward Sprag Assembly will coast / freewheel / overrun until the engine RPM and the driveshaft RPM meet at the correct gear’s ratio.





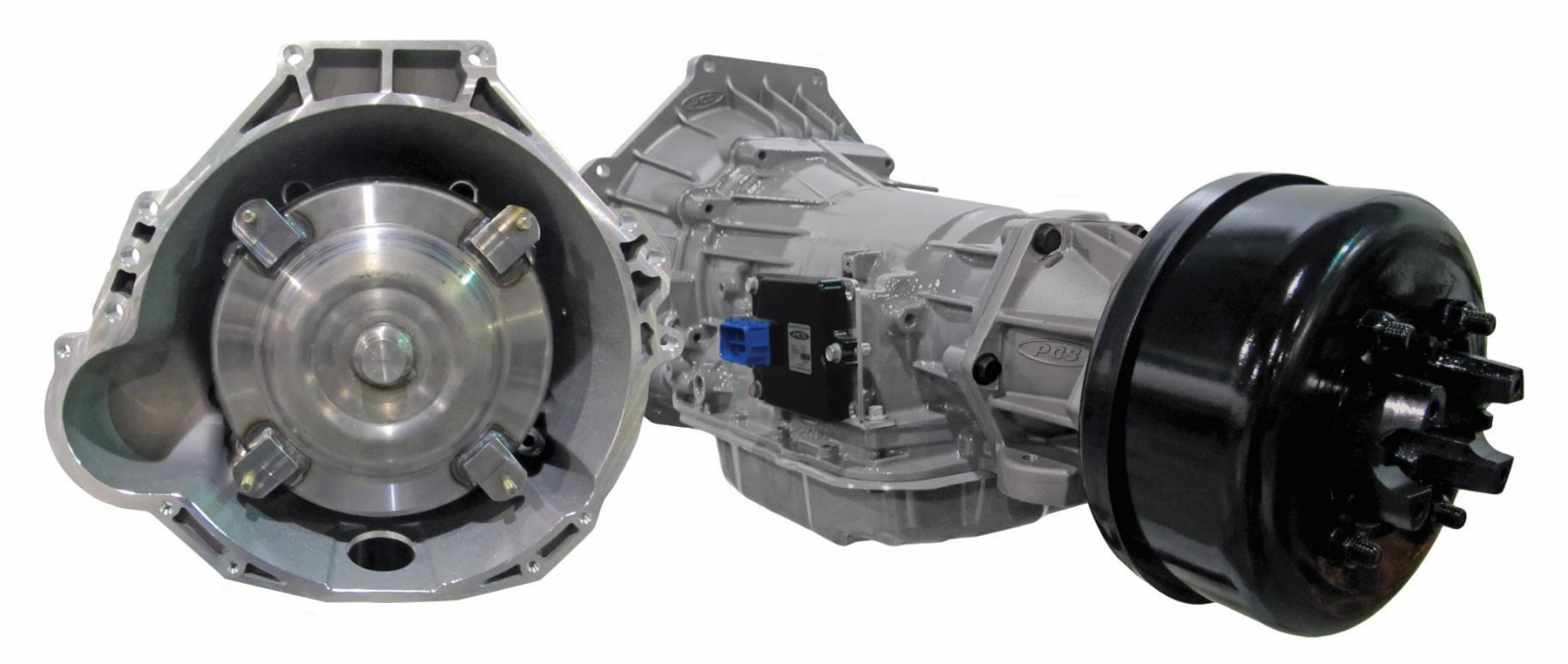
TRN4240 / TRN5240 (GEN-2)

- Very common in 2013-2018 vehicle builds
- Looks like a 4L60E. LS Bell & Slip Yoke
- 258mm Converter
- GEN-2 VB

- Also 14T2D
- and similar numbers

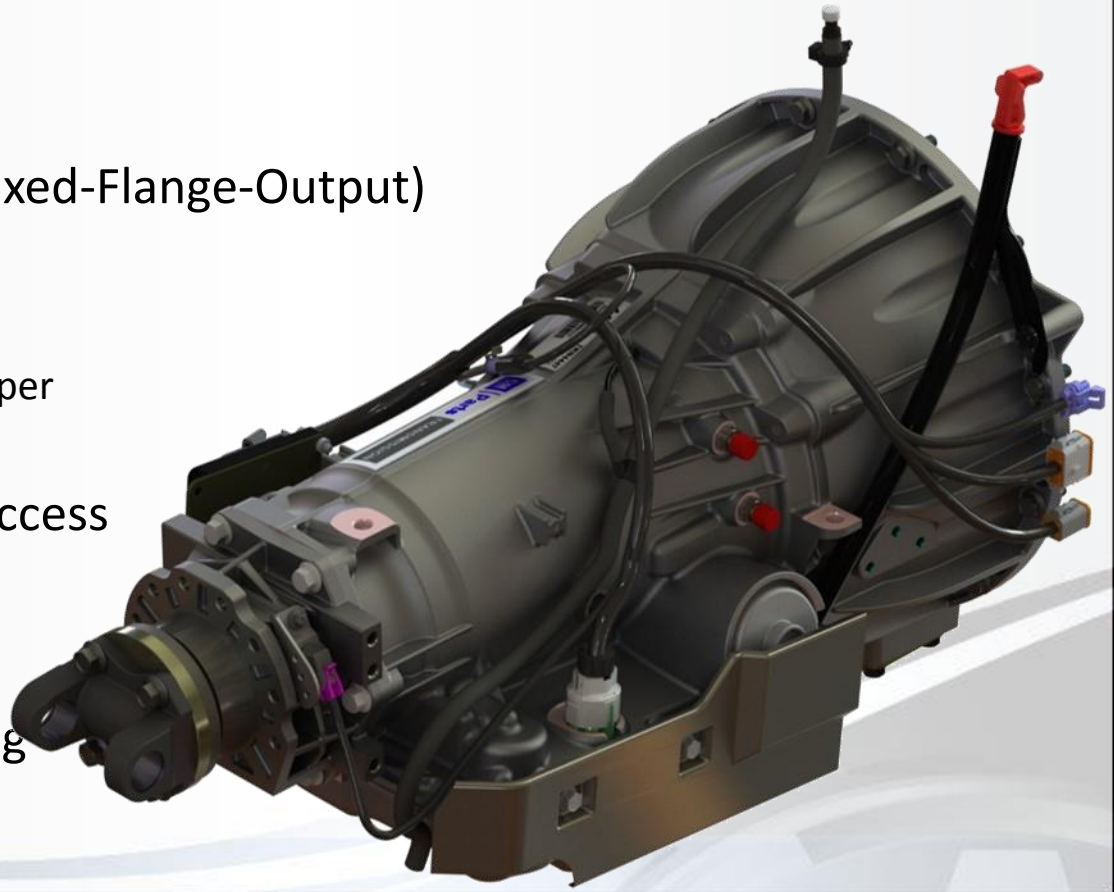
TRN4265 / 5265 “Ford C6 Replacement” (GEN-3)

- New, GM 4-speed that will bolt-in where a Ford C6 fits!



TRN4347 / 5347 “SAE4 Standard Package” (GEN-3)

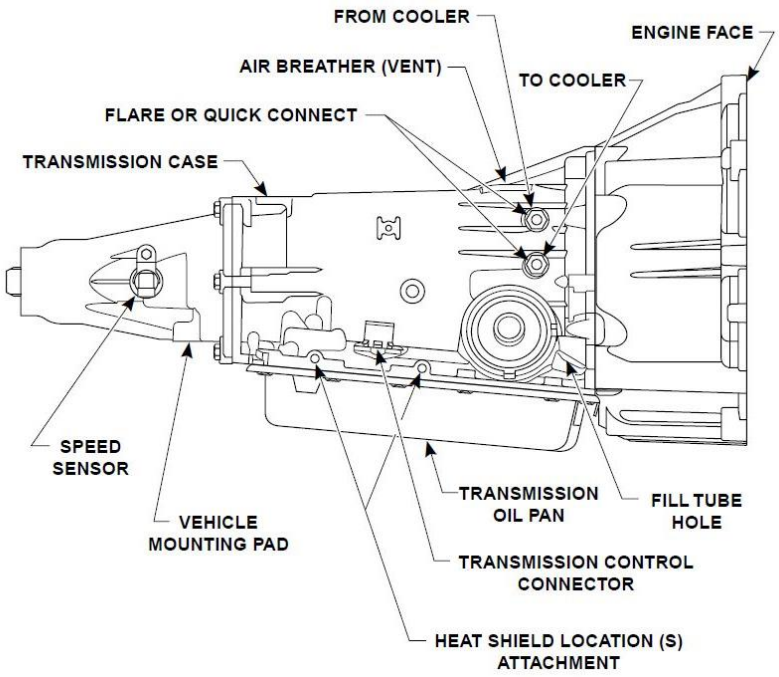
- TRN4347 Transmission
- SAE4 Bellhousing
- FFO Extension Housing (Fixed-Flange-Output)
- Disc Brake compatibility
  - Mechanical Caliper
  - Mechanical / Hydraulic Caliper
  - Electric / Hydraulic Caliper
- Better torque converter access
- Smallest overall package
- Heavy-duty output seal
- Heavy-duty output bearing

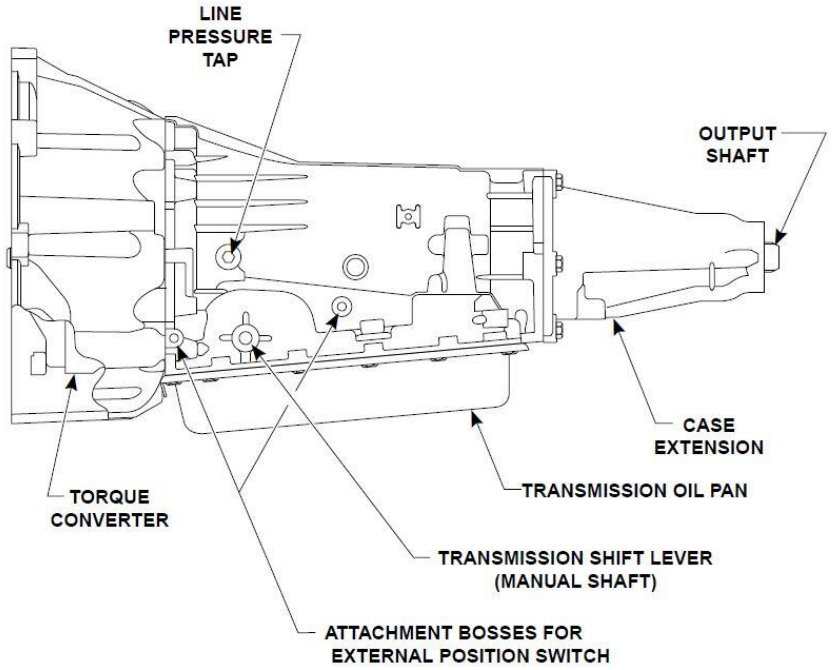


“IES” Industrial Electronic Shifter

- “Morse” shifter replacement
  - Same bolts & same mounting
- Abuse Lockout Solenoid
  - Trans vs Vehicle issue indication
- IP66 Ingress/Weather Rating
  - Vacuum tested
- LED Range Position
- LED Trans / Shifter Fault
  - Shifter faults red, trans faults yellow
- Automatic Brake-Failure detection
  - Blinks Range LED’s after 30s
- 3x 12v 10A Fuse requirement
- 10A Reverse Light Relay
- 10A Neutral Safety Relay

External Feature Locations





TCM - TRANSMISSION CONTROL MODULE

- LINE PRESSURE
- SHIFT POINTS
- TOP GEAR CONTROL (1, 2, 3, OR 4)
- FWD / REV RANGE CONTROL (IES VS IMS)
- GEN-2 vs GEN-3
- DATA I/O FOR ENGINE
- DIAGNOSTICS
- SAFETY INTERLOCKS
- **EVERYTHING ABOVE CHANGES PER VEHICLE!!!**

TCM – ENGINEERING RECAP "A"

- LINE PRESSURE
- SHIFT POINTS
- CAL-A TOP GEAR CONTROL (1, 2, 3, OR 4)
- CAL-B TOP GEAR CONTROL (Normally limits to 1st)
- TORQUE CONVERTER LOCKUP (FIRMNESS AND TIMING)
- FWD / REV RANGE CONTROL (IES VS IMS)
- GEN-2 vs GEN-3 VALVEBODY
- THROTTLE POSITION (J1939, Analog 1, or Analog 1+2)
- REDLINE-PER-GEAR (J1939: 1st-3200, 2nd-3200, 3rd-2600)
- SAFETY INTERLOCKS (Brake, Parking-Brake, Seat, BL-Boom…)
- BODY CONTROL MODULE FEATURES (Engine Shutdown, Accessory Control…)

TCM – ENGINEERING RECAP “B”

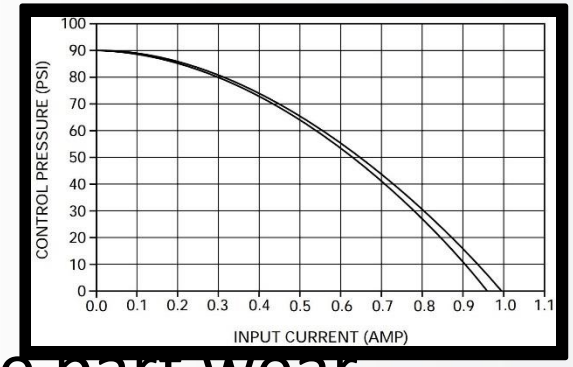
- Regarding Shift-Points, CAL-A / B Tables are where we control and Adjust:
  - TOP GEAR CONTROL (MAX SPEED)
  - OPTIMIZING LOADED TRACTOR PERFORMANCE
  - OPTIMIZING UNLOADED TRACTOR PERFORMANCE
  - ENSURING UPSHIFTS WHEN ENGINE-RPM / POWER HAS PEAKED
  - ENSURING DOWNSHIFTS WHEN LOAD / GRADE INCREASES

TCM – ENGINEERING RECAP “C”

- Doing Calibration Validation you normally tune and optimize Shift Points and Line Pressures to meet the following criteria:
  - **High-Throttle vs High-Load** (no clutch slippage) with good performance and reasonably FIRM shifts
  - **High-Throttle vs Low-Load** (no clutch slippage) with comfortable "enough" shifts
  - **Low-Throttle vs High-Load** (no clutch slippage)
  - **Low-Throttle vs Low-Load** (no clutch slippage) with reasonable "cruise around" performance and reasonably light shifts

Line Pressure – Factory Settings

- Vehicle Weight / Tow-Capacity specific!
  - Big difference between Belt Loader & Cargo… weight and differential ratio
- Based on Throttle Position

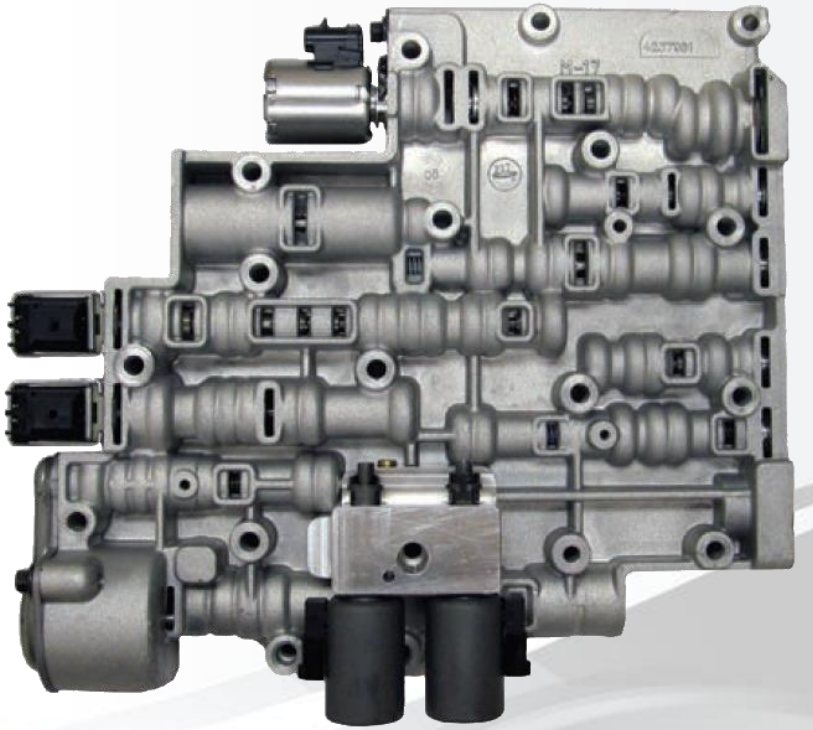


- Too Low – Clutches slip & burn
  - Shifting Into Gear vs Steady State
- Too High – **Hard** shifts & premature part wear

- Pump is capable of 300+ PSI
- Clutches normally take 54-193 PSI steady state

PCS 4LHD Valve Body Enhancements

- Abuse Protection – requirement for ground support industry
  - Reverse lockout
  - Neutral drop prevention
- Anti-Collision
- Neutral Idle
- Electronic Range
- Inching Mode

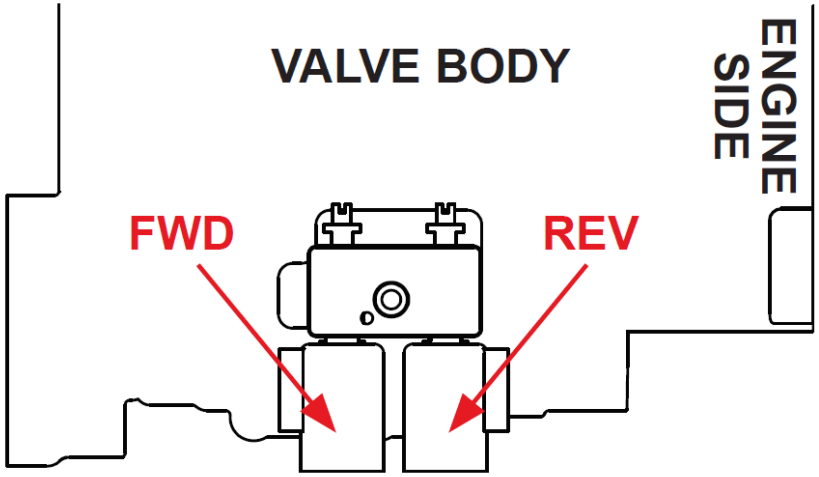


Patent 9,777,829

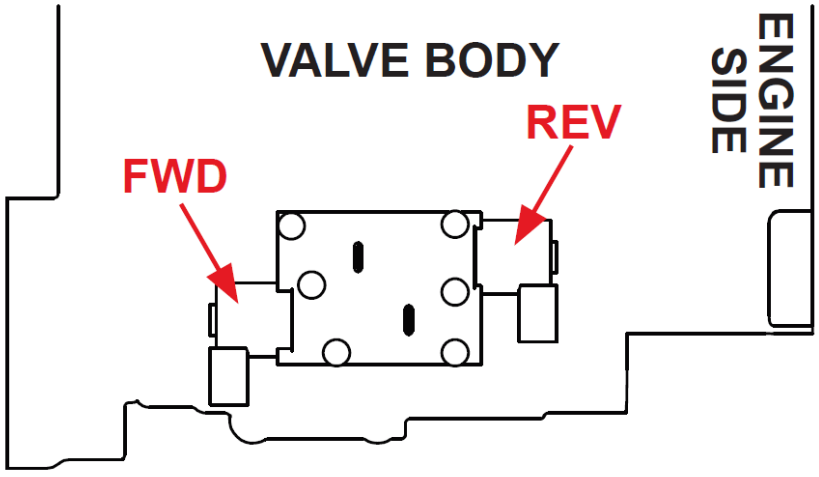
Gen 2 vs Gen 3 Valve Body

- Gen 2: Abuse Protection.
- Gen 3: Abuse Protection, inching, electronic shift, anti-collision.
- To identify:
  - Measure solenoid resistance:
    - Pin E to Pin R (Gen 2: 3-6 ohms / Gen 3: 10-15 ohms)
    - Pin E to Pin S (Gen 2: 3-6 ohms / Gen 3: 10-15 ohms)
  - Use TDD for reverse solenoid operation.
  - Remove pan and filter and compare images.

Gen 2 vs Gen 3 Valve Body



GEN 2



GEN 3

Preventative Maintenance

- Recommended service interval for industrial use is 1,000 hours or 12-months whichever comes first.
- Filter and pan gaskets should be replaced.
- Transmission fluid must be DEXRON VI.
- PCS stocks filter and pan gasket kits for PM, PCS Part Number TRN7090.

PRE-RAMP CHECK LIST	
KEY OFF PHYSICAL INSPECTION	
Fastener Torque:	Inspect all mounting bolts, torque converter bolts, flywheel bolts, and all other driveline hardware for proper torque.
Position Lever Check:	Move the shift lever through all ranges and verify that the transmission shift arm is centered in the detent for each position.
KEY ON, ENGINE OFF SOFTWARE VERIFICATION	
Connect:	Connect to the TCM with the PCS TCM Diagnostic software. To download the software, please visit: **www.GSEhelp.com**.
Position Lever Verification:	Move the shift lever through the ranges and verify the actual shift lever position matches the position shown in the software.
Throttle Position Sensor:	Verify the throttle position reading is zero when the pedal is not press and 100% when fully depressed.
STATIONARY ENGINE RUNNING CHECKS	
Fluid Level Check:	Start the engine and check the fluid level is sufficient.
Engine RPM:	Verify the engine RPM on the software matches the actual engine RPM.
DTC Check:	Verify there are no diagnostic codes set.
TEST DRIVE (Operate the vehicle until trans is at operating temp)	
Vehicle Speed:	Move the vehicle and verify that the vehicle speed operates properly.
Shifting:	Check proper transmission operation in all gears.
*Data log recommended. For help, view "**How to Datalog**."	
POST DRIVE CHECK	
DTC Verification:	Check for diagnostic codes.
Fluid Level Verification:	Verify the fluid level is correct and no fluids are leaking from the vehicle.

Pre-Ramp Check

- Commissioning new equipment.
- Preventative Maintenance (all maintenance if possible).
- Transmission replacement.

BREAK..

.

Break?

Electronic Transmission Diagnosis

- Generally, if a C6 transmission didn't shift – it needed to be replaced.
- With electronic transmissions, there are numerous causes for a transmission not to shift – outside the transmission – such as an engine sensor.
- GSE Engines are nowhere near the torque/power output of the 4L60E's capacity.
- Isolating the problem requires you to answer the simple question – "***inside or outside***?"

Field Service Five Step Approach

1. Check fluid level & condition
2. Check for codes
3. Check the basics – power and shift linkage
4. Check the signals
5. Directly control the transmission

Field Service Five Step Approach

1. **Check fluid level & condition**
2. Check for codes
3. Check the basics – power and shift linkage
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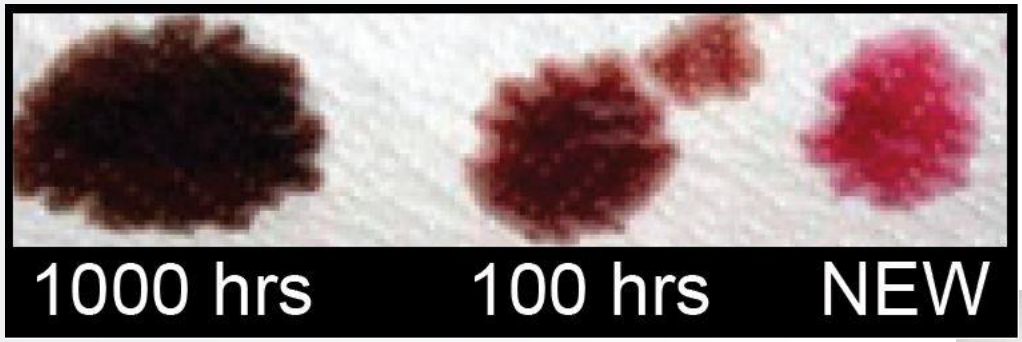
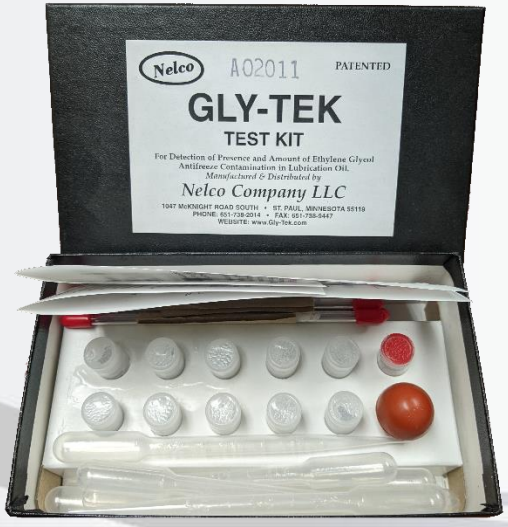
5. Directly control the transmission

Transmission Fluid

- Transmission fluid must be DEXRON VI (6).
- Fluid should be red in color .
  - A brown color is also normal.
- Burnt smelling fluid (Dark Color) most likely indicates internal abnormal transmission operation.
- Fluid that has a cloudy or milky appearance is possibly contaminated with water from engine coolant or an external source.
  - Transmission vent
  - Radiator
  - Fluid Storage Container

Transmission Fluid

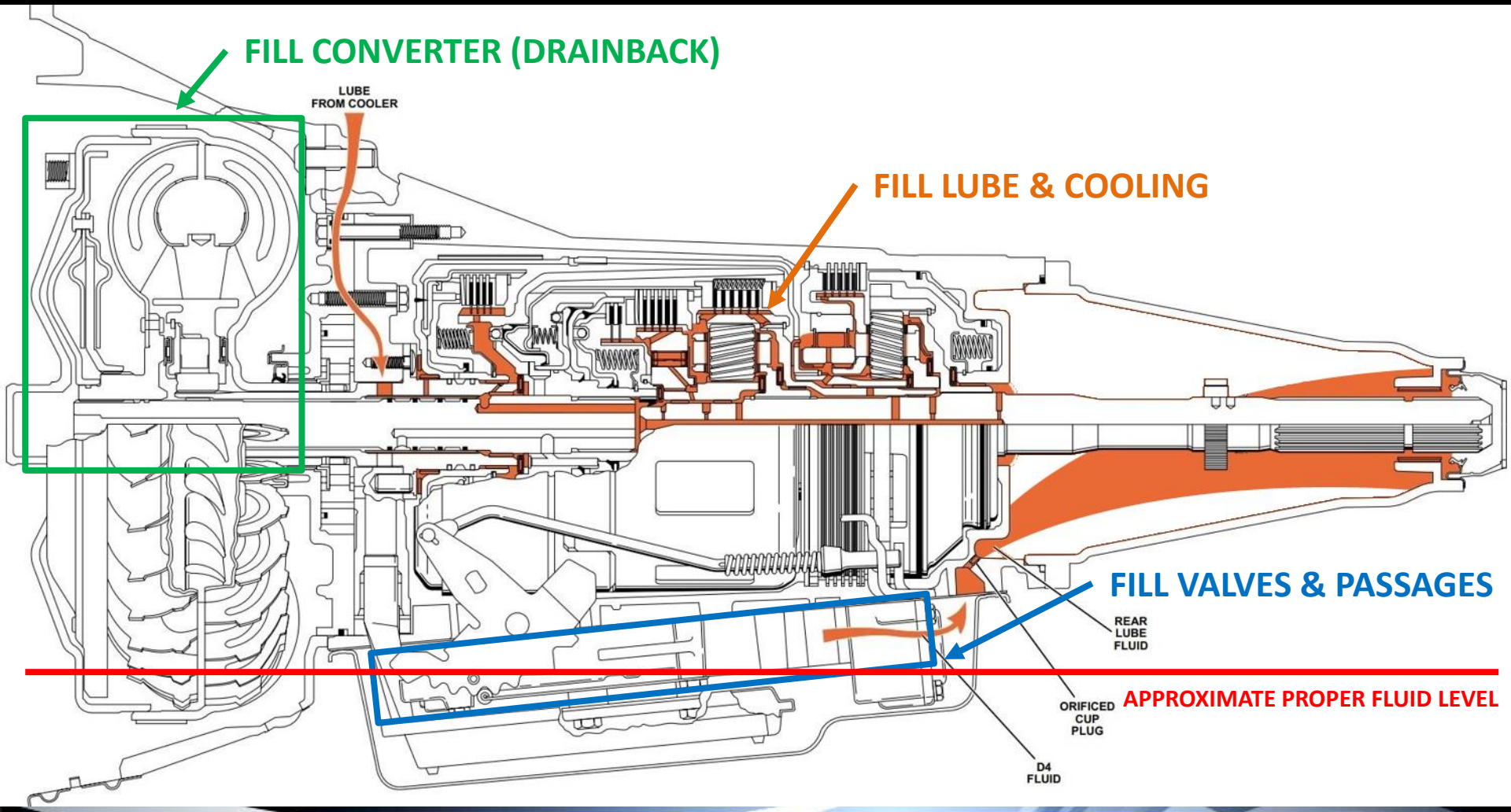


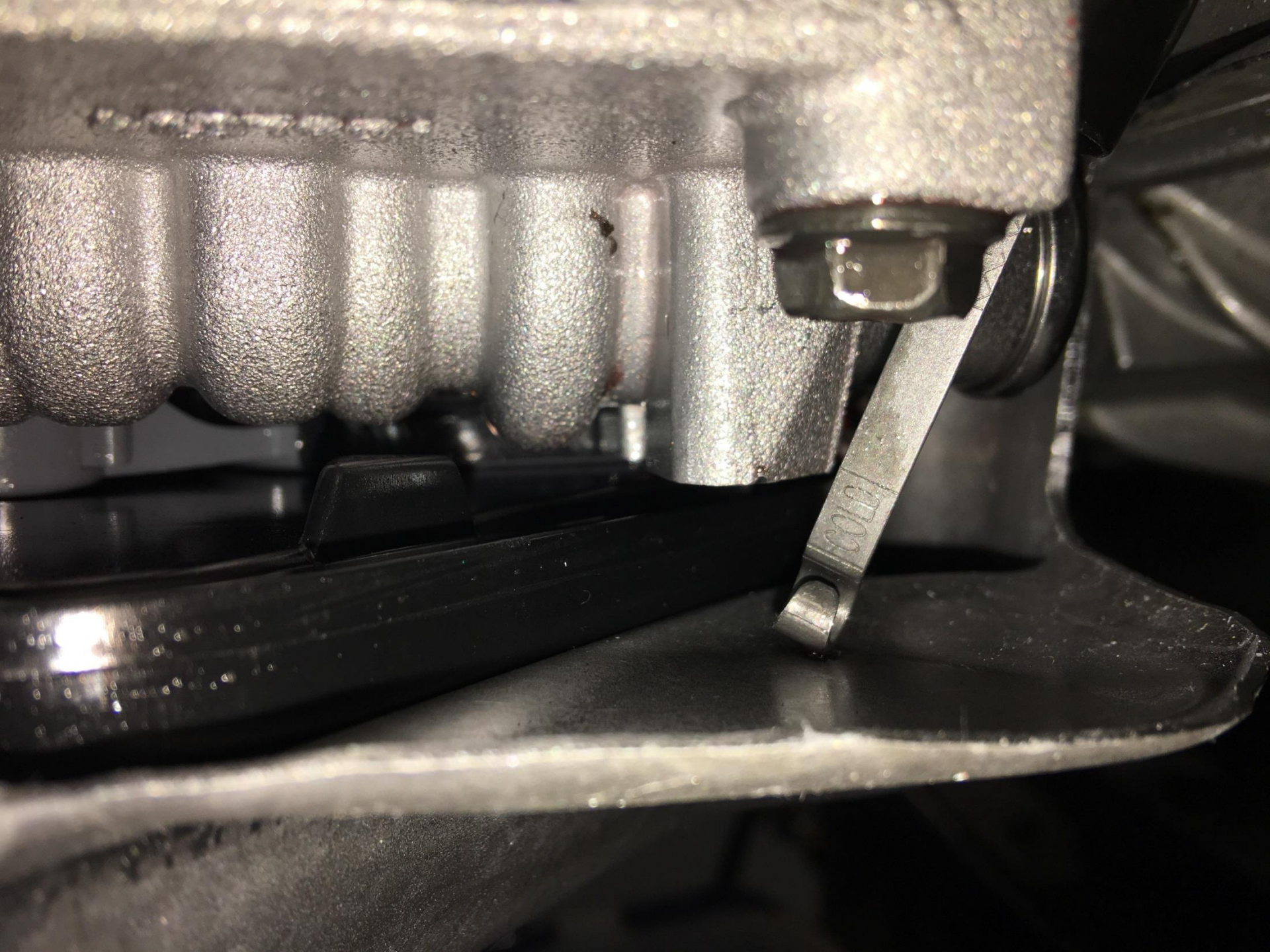


Transmission Fluid

- Proper level check procedure must be performed:
  - Engine at idle.
  - Move lever to ranges N-F & N-R for 3-5 sec each
  - “Proper” level is very transmission temperature dependent.

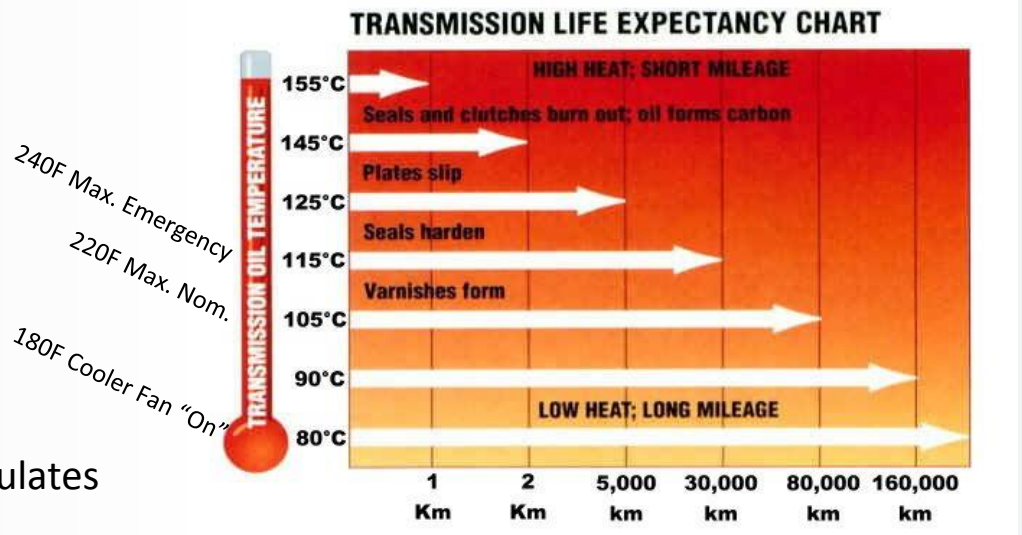
Transmission Fluid





Purpose of Transmission Fluid

- Hydraulic Actuation
  - Moving Pistons and valves
- Lubrication
  - Metal-on-metal, clutches, seals
- Detergent
  - Preventing Oxidation
  - Absorbing and removing particulates
- Cooling
  - Pulling heat; planets, clutches, and converter
- Friction Modifier
  - Aiding proper clutch and band engagement
    - (loss or too little causes harsh shifts / shudder)



Development of Transmission Fluid

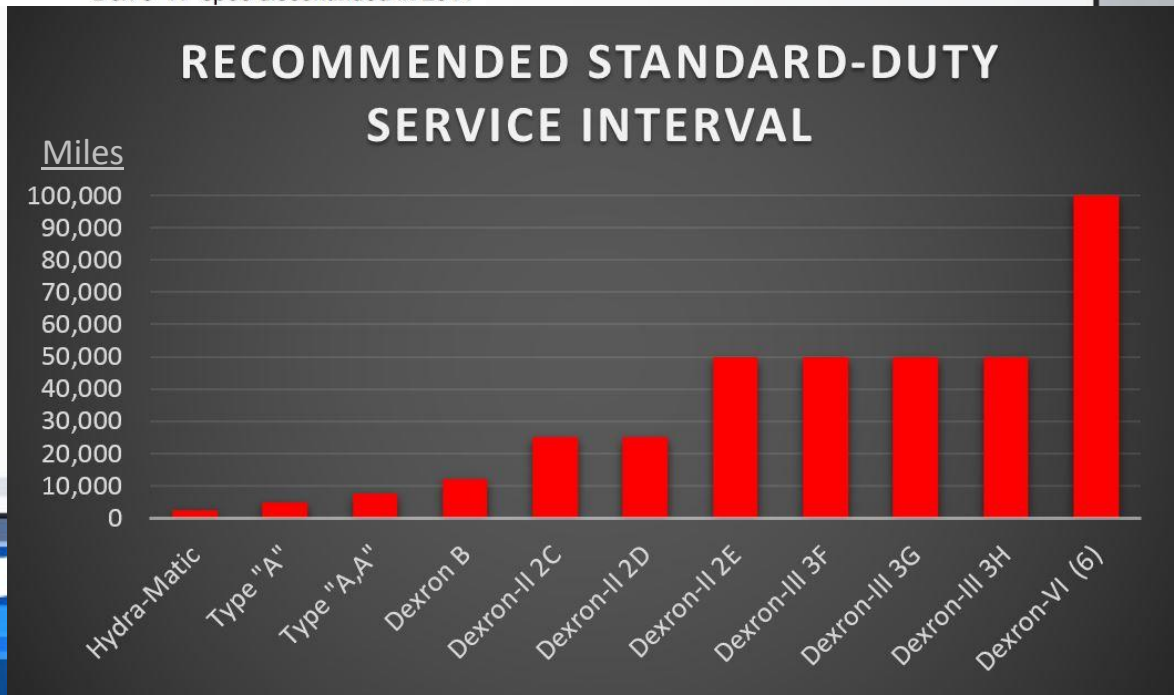
YEAR	NAME	REV	MILES	TYPE	NOTES
1940	Hydra-Matic	0	2,500	1	Renamed "Fluid" vs motor oil
1949	Type "A"	A	5,000	1	Standardized, longer service interval
1957	Type "A" suf "A"	AA	7,500	1	Improved for multi-contverter elements
1967	Dexron B	B	12,000	1+	Hydro-treating oil introduced
1973	Dexron-II (2)	C	25,000	1+	Whale oil lubricant removed
1975	Dexron-II (2)	D	25,000	1+	4-Speeds & Converter Lock
1990	Dexron-II (2)	E	50,000	2	Full synthetic introduced
1993	Dexron-III (3)	F	50,000	2	Cold temp improvements
1998	Dexron-III (3)	G	50,000	2+	TCC shudder improvement
2003	Dexron-III (3)*	H	50,000	2+	Further shudder improvement
2006	**Dexron-VI (6)**	**J**	**100,000**	**4**	**GM & Ford standardized formula**

*Dex-3 "H" spec discontinued in 2011

Fascinating history:

Info on this page is very watered down!

There are tons of online resources for the curious!



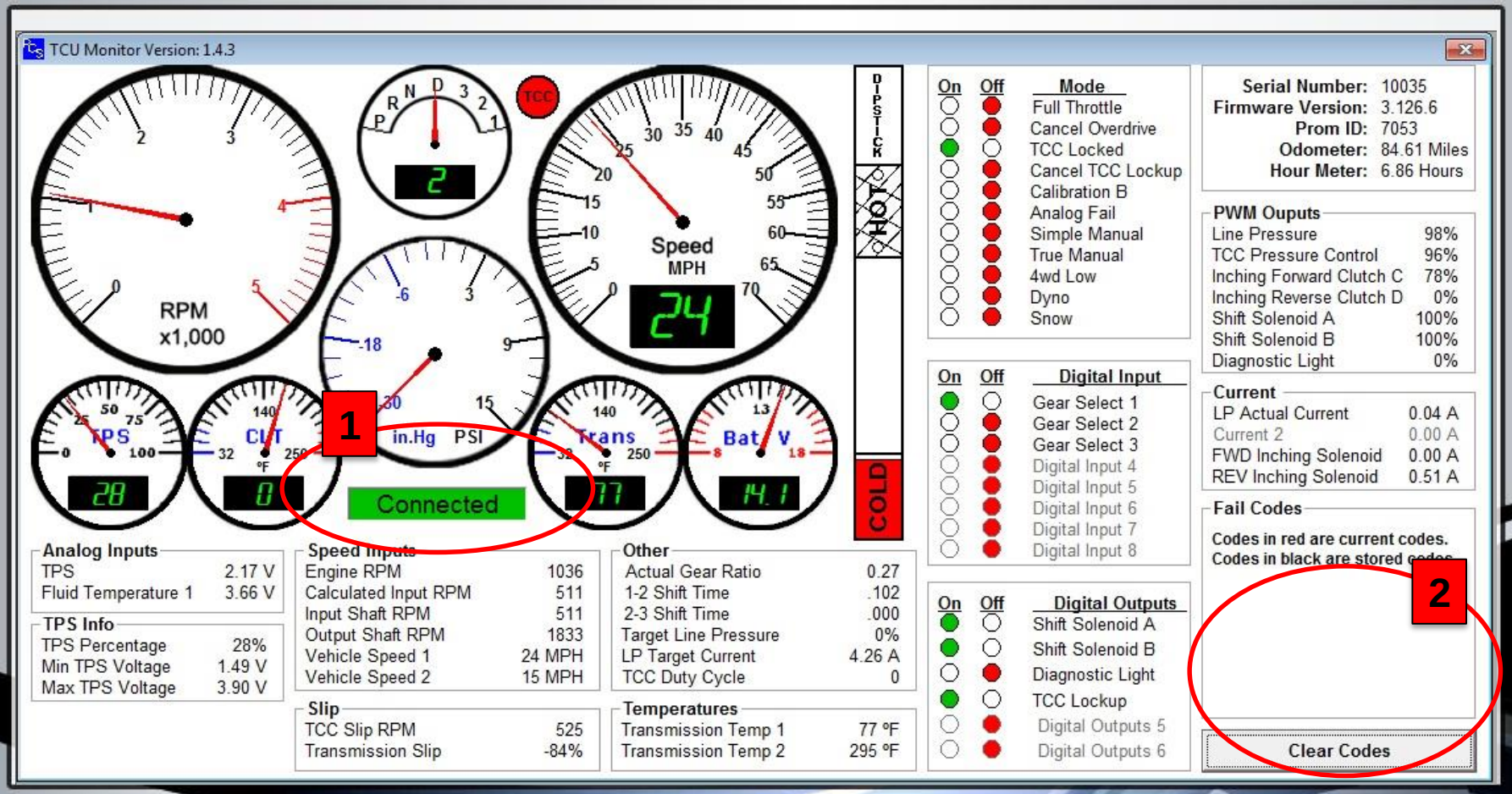
Field Service Five Step Approach

1. Check fluid level & condition
2. **Check for codes**
3. Check the basics – power and shift linkage
4. Check the signals
5. Directly control the transmission

Check for Codes

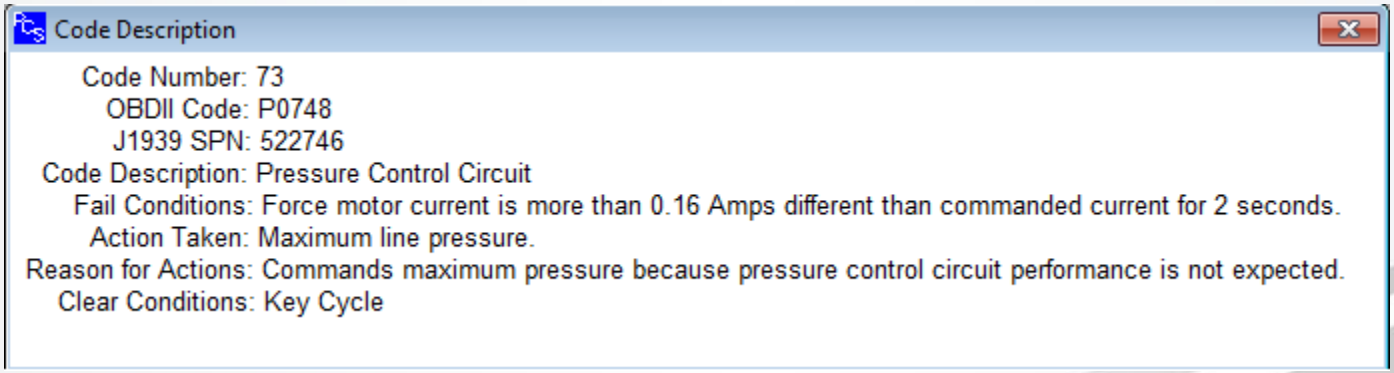
- Codes can be read by:
  - PCS Software interface on laptop.
  - “Check Trans” indicator on dash.
  - Diagnostic screen.

Check for Codes – PCS Software



Check for Codes - Software

- Clicking on the code number will open a code description window with full description, action taken, and clear conditions.



CODES ARE INDICATORS, NOT ROOT-CAUSES!

Check for Codes - Light

- Labels vary for the “Check Trans” light.
  - “Trans Overtemp” is common.
- If DTC is active and engine is running, light will be solid on.
- If DTC is active or stored and engine is not running, but ignition is on, the DTC’s will flash.
  - Slow is the first digit, fast is the second digit.
  - See Quick Reference Page 5 and 6 for trouble code list.
- Disconnecting the battery will clear DTC’s.

Field Service Five Step Approach

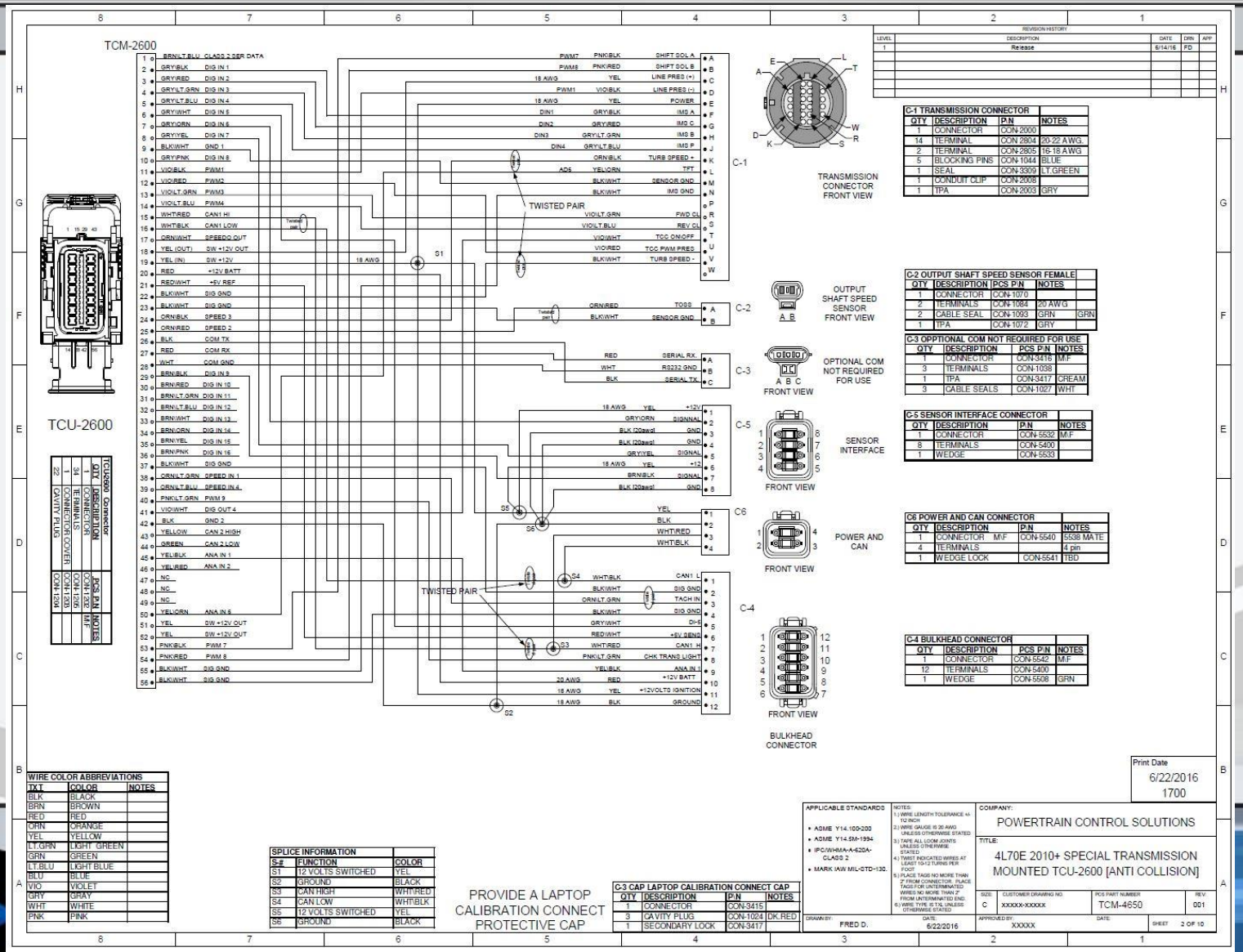
1. Check fluid level & condition
2. Check for codes
3. Check the basics – power and shift linkage
4. **Check the signals**
5. Directly control the transmission

Check the Input Signals

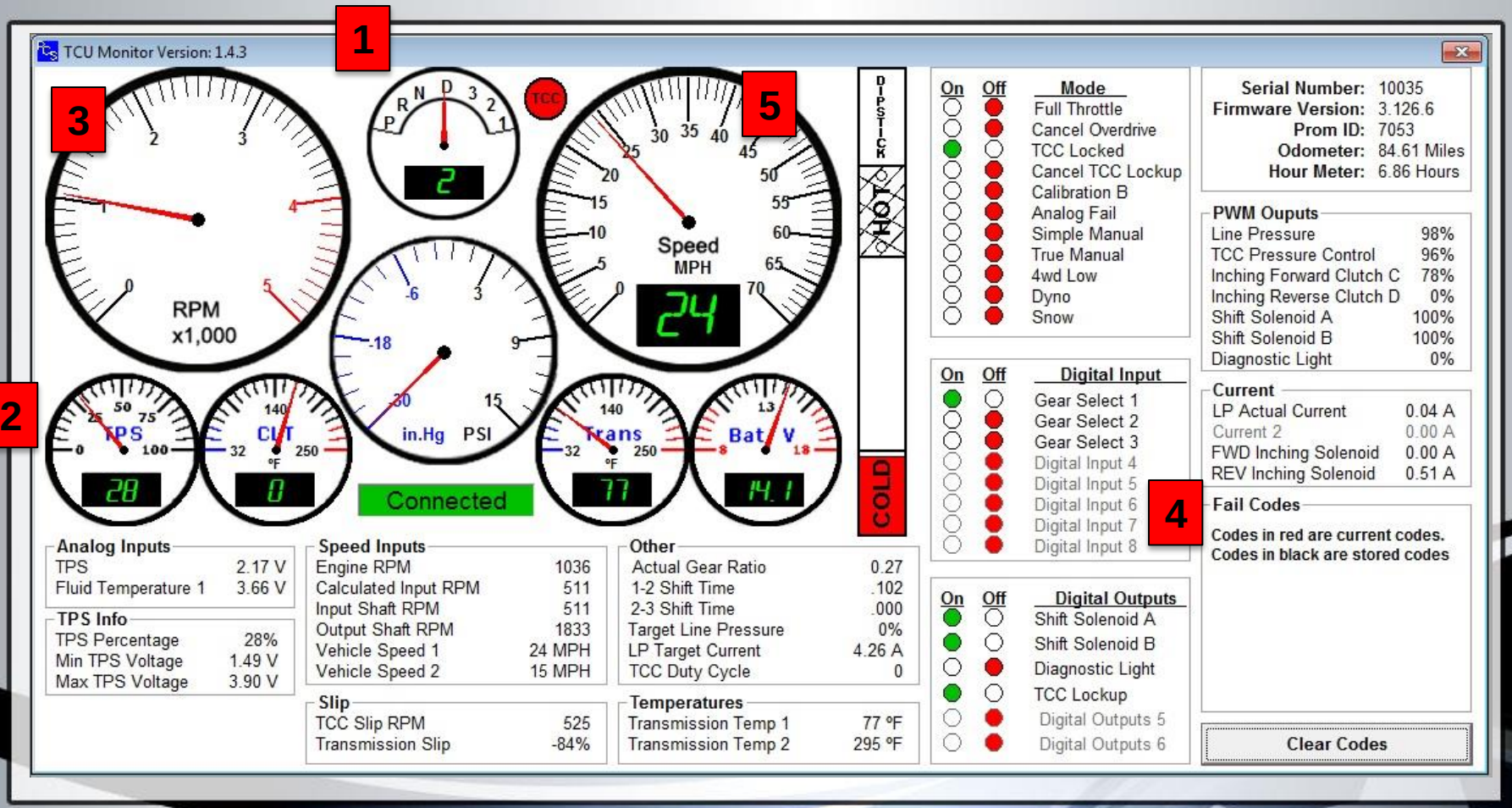
REQUIRED INPUT SIGNALS TO THE TCM

- **INSIDE** the transmission:
  - Transmission Mode Switch (IMS)
  - Transmission Temperature
  - Output Shaft Speed (OSS)
  - Input Shaft Speed (ISS)
- **OUTSIDE** the transmission:
  - +12V Constant and Switched Ignition (To TCM and Transmission)
  - Ground (To TCM and Transmission)
  - Throttle Position (CAN or hardwired)
  - Engine RPM (CAN or hardwired)
  - Neutral Input (Discrete input)

Download the Harness Drawing

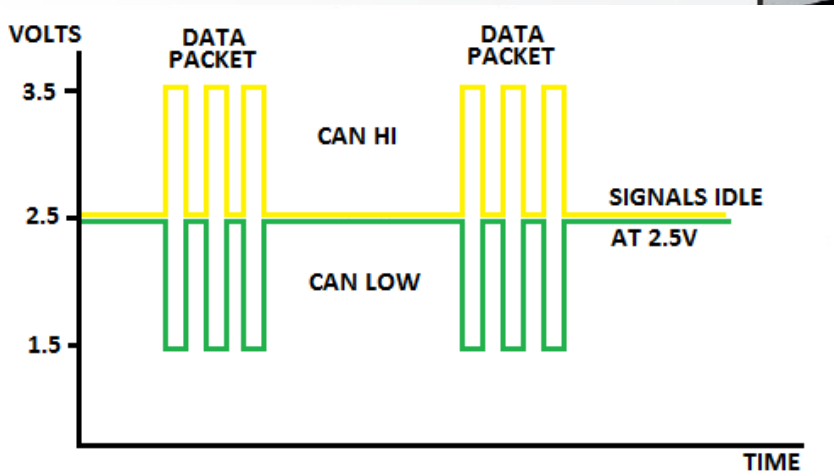


Check the Signals - Software



Side note on CAN

- CAN – Controller Area Network
- Most industrial CAN applications use J1939.
- High speed, two wire communication protocol.
- Twisted wire, 120-ohm terminating resistors.
- CAN H (pin 7 of bulkhead), CAN L (pin 1).
- Tools available for monitoring CAN, scopes & PeakCAN.

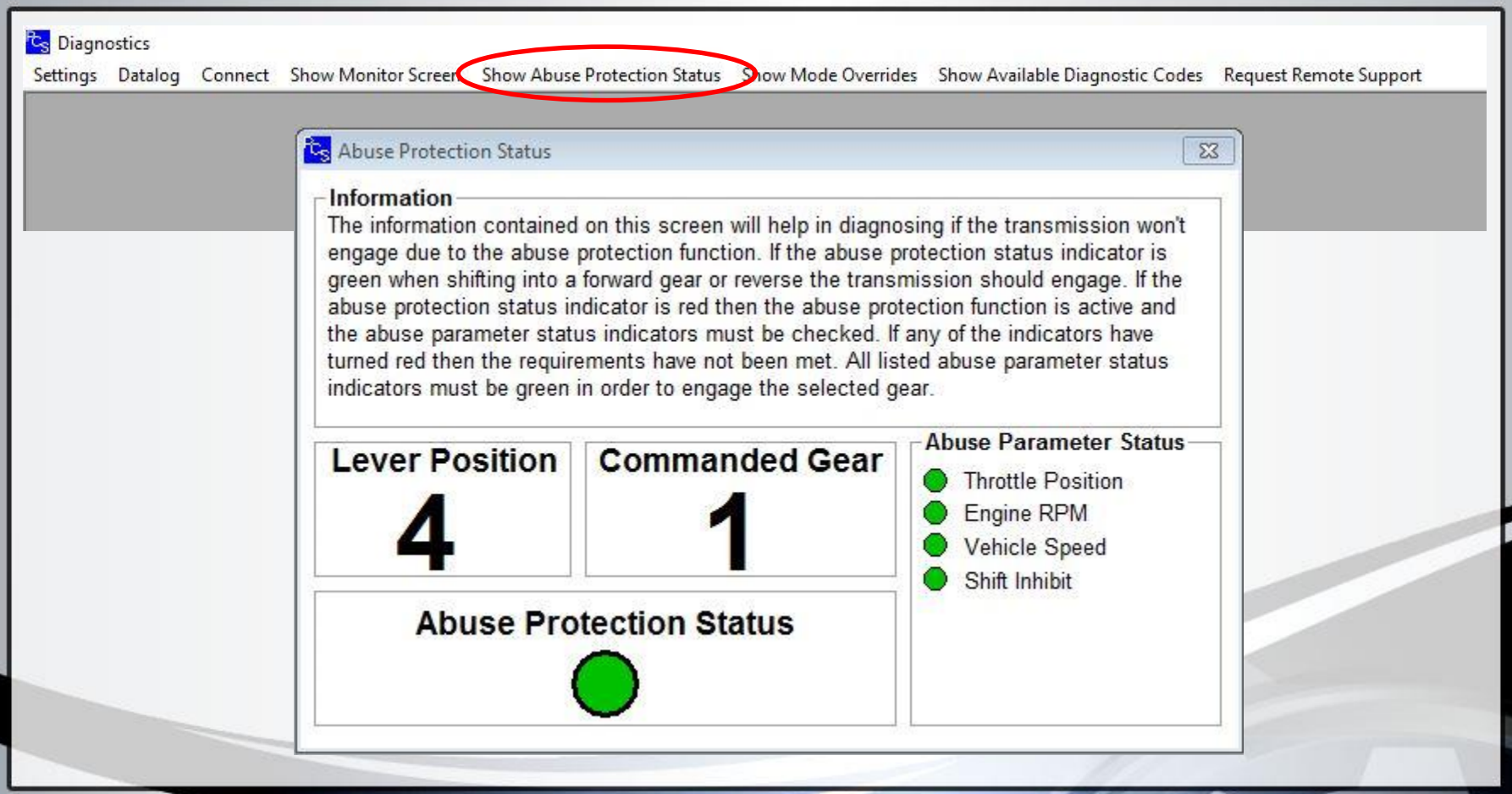


CAN VOLTAGE LEVELS

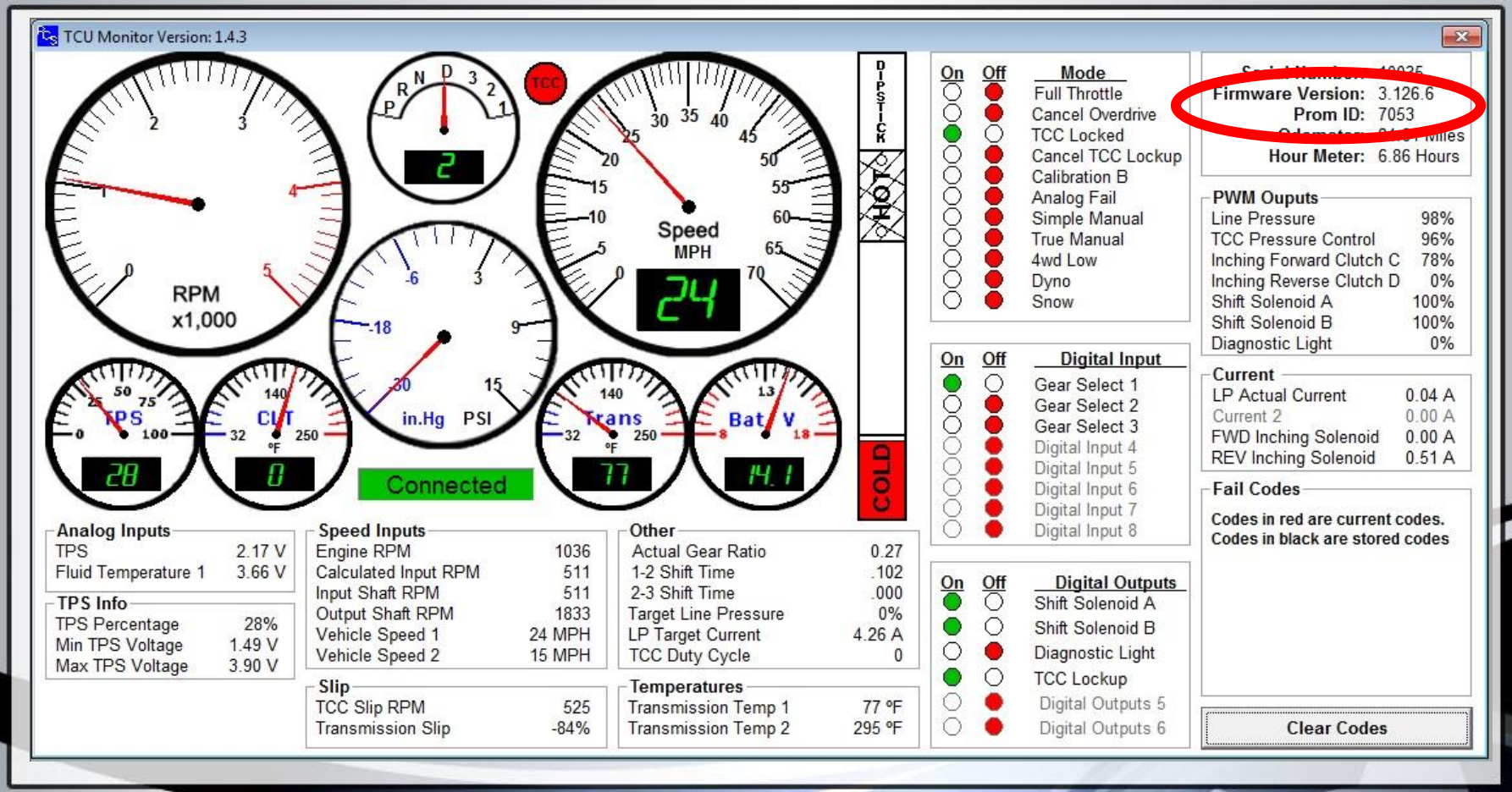
Abuse Protection Limits

- All 4LHD/4LHDX transmissions contain the PCS abuse protection valve body.
- To engage forward or reverse from neutral:
  - TPS less than 15%.
  - RPM less than 1500.
  - Not moving in the opposite direction.
  - Optional (but common) brake must be pressed, parking brake released, and more.

Abuse Protection



Verify TCM & Calibration is Original



DO NOT SWAP OR REPROGRAM TCM'S

- Step-1, confirm if TCM is OEM original.
- Step-2, if damaged I/O is suspected; confirm.
  - Optional, swap TCM with exact vehicle replica to confirm. Prom-ID, Firmware, Vehicle Harness, Trans Harness, engine, manufacturing month must all match!!!
- Step-3, purchase/warranty exact replacement.

DO NOT SWAP OR REPROGRAM MVP'S

- Critical for proper TPS functionality on many Kubota / Deutz builds.
- EPS / Vehicle OEM's change these per vehicle, for options and bug resolutions.
- Functional and Display-Only variants.

EPS Kubota / Deutz Dash Interface

CONTACT ENGINE POWER SOURCE "EPS" OR DEUTZ IF THIS IS IN QUESTION!!!

Verify TCM & Calibration is Original

- TCM Model (TCM2600 vs TCM2800)
- TCM Firmware (3.xxx.6 vs 3.xxx.8)
- TCM Prom-ID / SOF / Calibration / Program

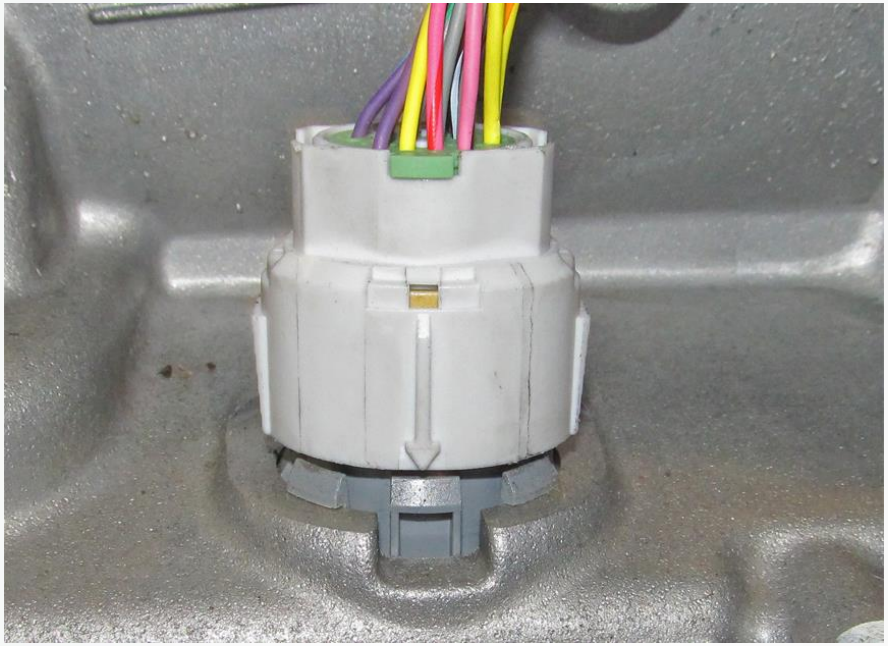
4L60E / 4LHD STRATEGIES ARE NOT ADAPTIVE LIKE SIX-SPEEDS!!!
THE CONTROLLERS MUST NOT BE UPDATED UNLESS PCS / OEM APPROVES!!!

Field Service Five Step Approach

1. Check fluid level & condition
2. Check for codes
3. **Check the basics – power and shift linkage**
4. Check the signals
5. Directly control the transmission

Transmission Connector

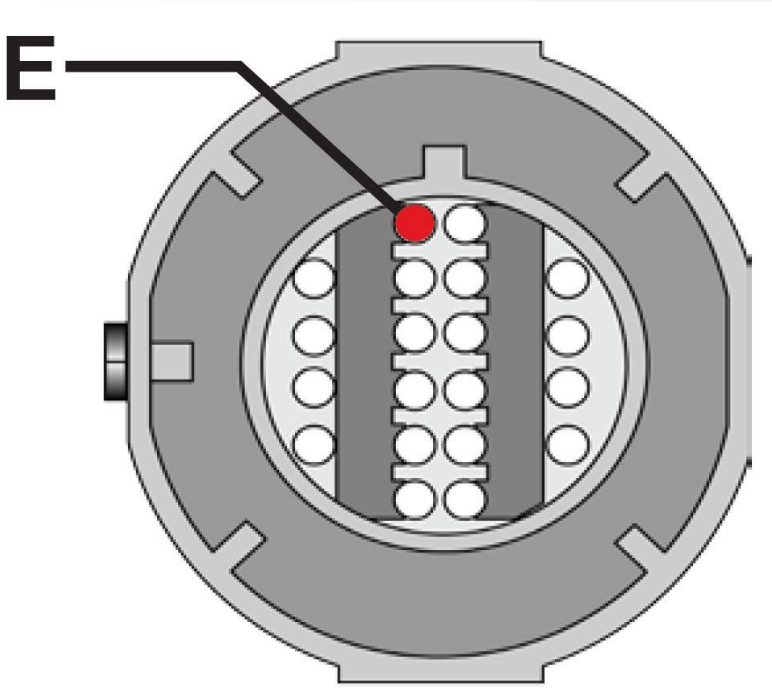
Click-Pull
Test Method!



Arrow Out (CODES: 59, 73, 83, 94)

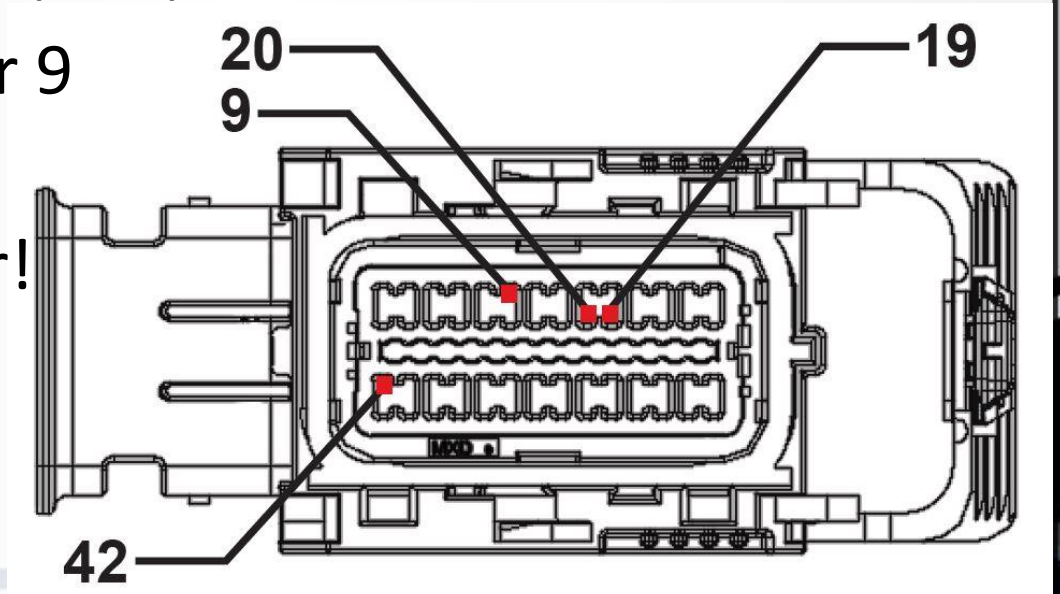
Check the Basics - Power

- Transmission Power
  - Switched power (10A), Pin E
  - Ground to case
  - Use a multimeter!



Check the Basics - Power

- TCM Power
  - Battery Power (~~3A or~~ 10A), Pin 20
  - Switched Ignition (10A), Pin 19
  - Ground, Pin 42 or 9
  - Use a multimeter!



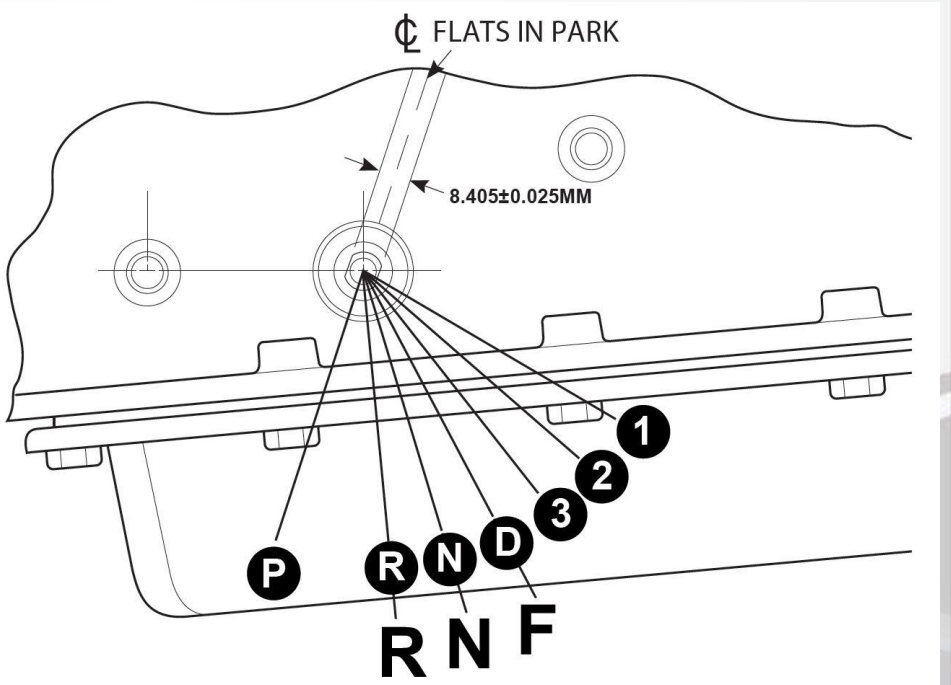
Check the Basics - Power

- No Power Operation “Limp-Mode”:
  - Gen 2:
    - One forward gear (3rd)
    - Reverse
    - Min pressure
    - Transmission will slip under load
      - ***Damage will occur if put under load***
  - Gen 3:
    - No forward
    - No reverse

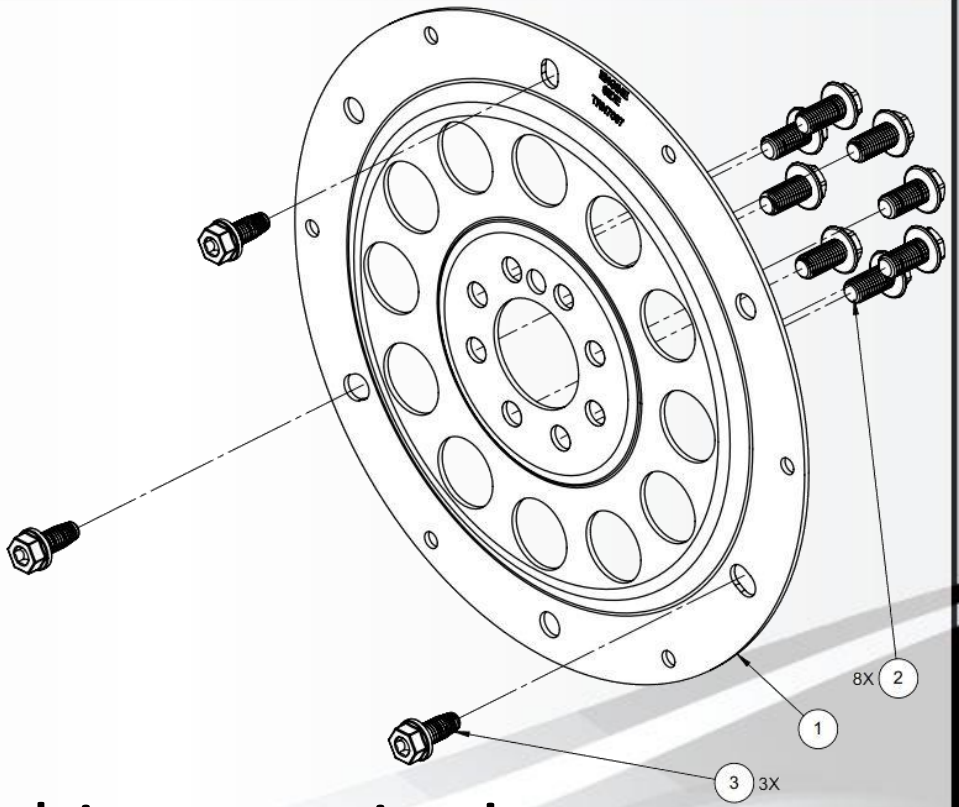
Cold McDonalds story!

Check the Basics - Linkage

- Linkage (if applicable)
  - Shifter physically moves the transmission shift lever
  - Cable connection to transmission lever
    - Connected
    - Adjusted properly



Check the Basics - Driveline



- Flexplate & Bolts
- Driveshaft & Bolts
- Broken Diff / Axle
- Threadlocker on anything rotating!

BREAK..

Break?

Field Service Five Step Approach

1. Check fluid level & condition
2. Check for codes
3. Check the basics – power and shift linkage
4. Check the signals
5. **Directly control the transmission**

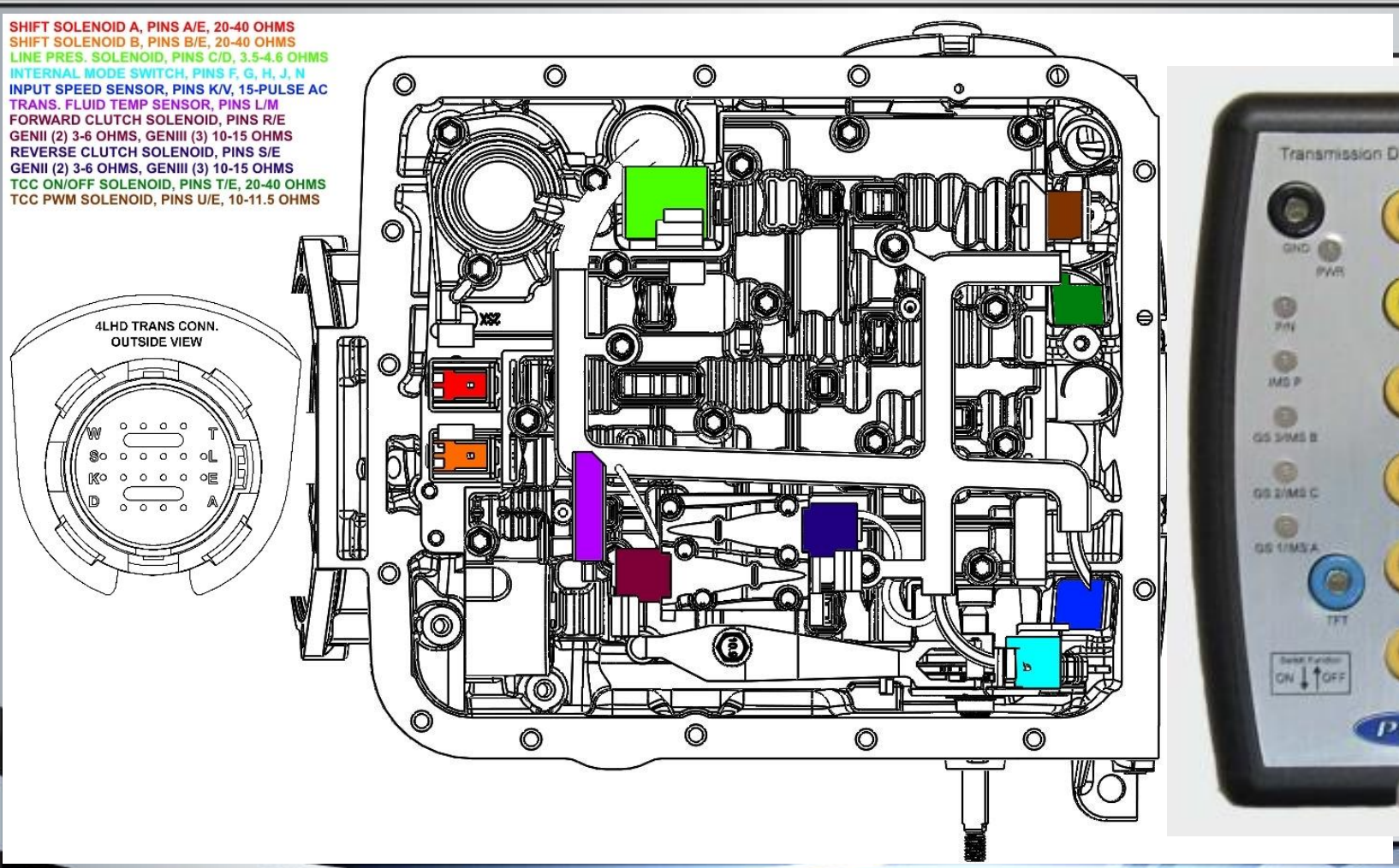
Transmission Diagnostic Device

- **SAFETY IS CRITICAL!**
  - Read the disclaimer at the top of page-4!
  - All of the **safety features** have been **bypassed**!
- Do the test on the ground, not jack-stands!
  - Feel the vehicle reaction
- 2-Man operation!
  - Driver & TDD operator
  - Help each other work through the problem

Transmission Diagnostic Device

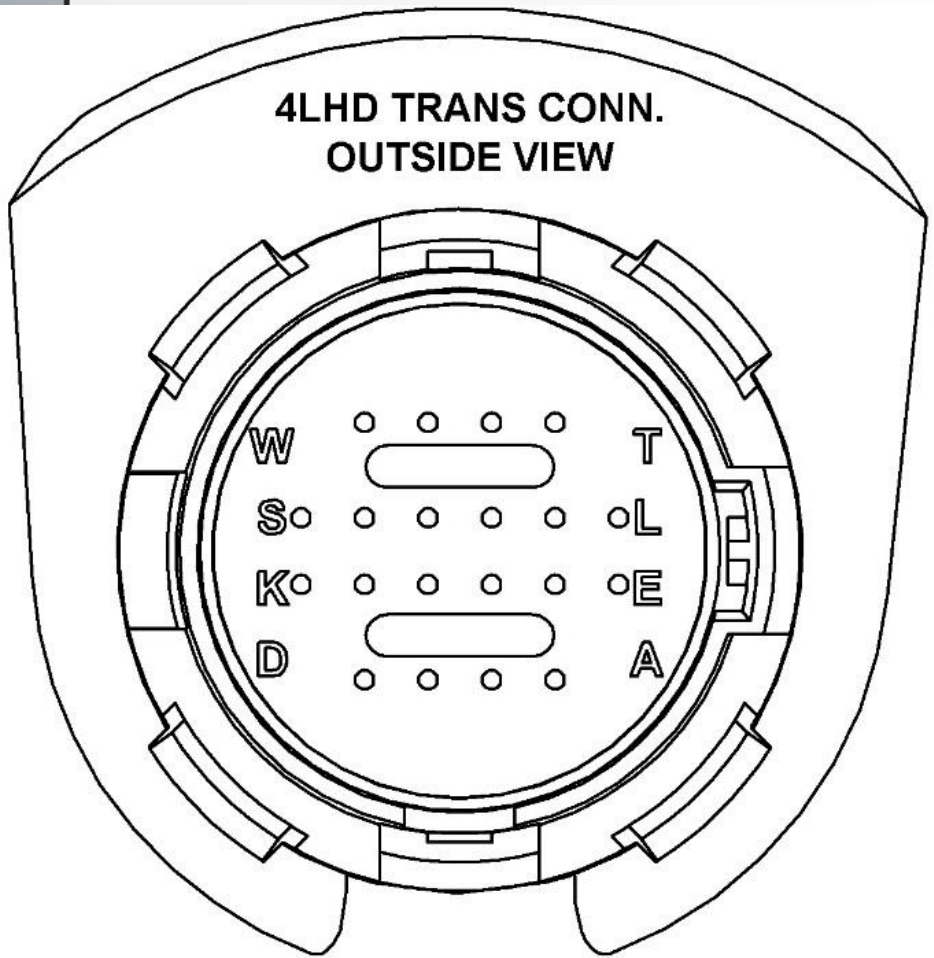
1. Connect diagnostic device to harness
2. Connect diagnostic device to transmission
3. Connect diagnostic device to power

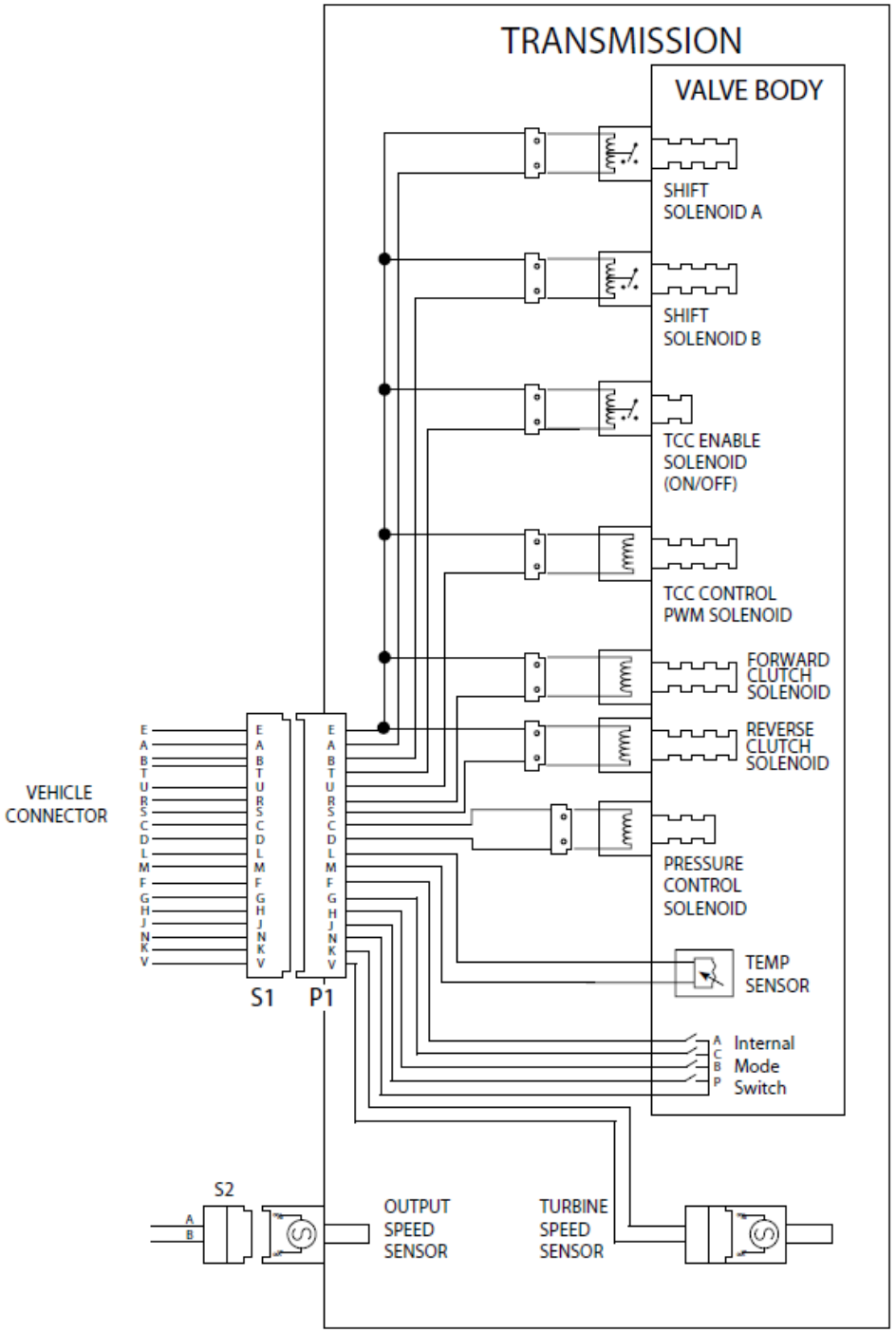
Transmission Diagnostic Device



Application Guide:

Page 18





Transmission Diagnostic Device

Internal solenoid check

- Reverse Clutch (Abuse, GEN2 vs GEN3)
- Forward Clutch (Abuse solenoid)
- Line Pressure (min/max pressure)
- Torque Convertor (lock/unlock)
- Shift Solenoid A & B (to verify all gears, 1-3 works)

Further Options, Pump or TCM

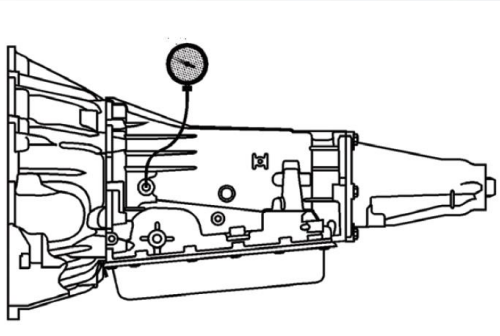
- If the problem has not been identified with the Diagnostic Device:
  - Disconnect the Diagnostic Device.
  - Reconnect the harness to the transmission.
  - Connect to the TCM with the Diagnostic Software.
  - Clear the codes (set from using the Diagnostic Device).

Line Pressure Check

- Line pressure tap (1/8” NPT)

1. Remove pressure plug.
2. Install appropriately rated pressure gauge for transmission line pressure measurement. Pressures could exceed 300 PSI.
3. Command current using PCS software.
4. Start the engine.
5. Perform test in Neutral at 1200 RPM between 100 – 200 deg F.

WARNING: Only perform this test in Neutral with the brakes applied and engine speeds below 1500 RPM. Failure to do so may result in extremely high pressures (in excess of 300 PSI) that could damage the transmission or the gauge and result in serious injury.



	AMP	PSI
4LHD	0	170-193
	0.5	135-166
	1	54-80
4LHDX	0	198-227
	0.5	154-193
	1	53-85

Beyond the 5-Step Procedure

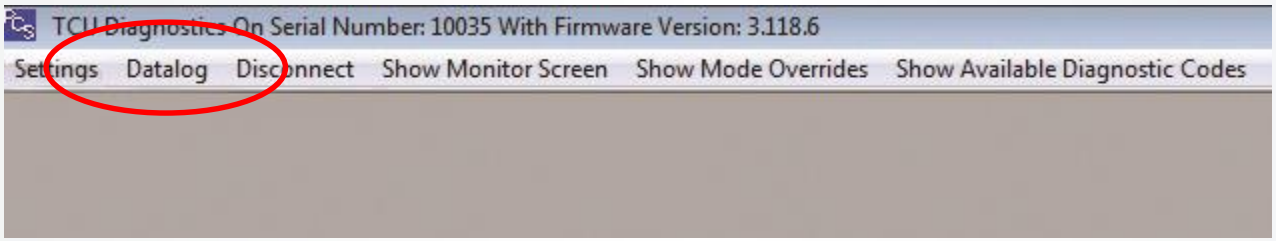
- If the problem was still not diagnosed using the 5-step procedure, there are a few more options.
- Record a data log of the issue and send to PCS for analysis.
- Contact PCS for remote assistance.

REPLACING A TRANSMISSION WITHOUT DETERMINING THE ROOT CAUSE MAY NOT SOLVE THE ISSUE AND COULD DAMAGE ANOTHER TRANSMISSION.

What to Log / Save?

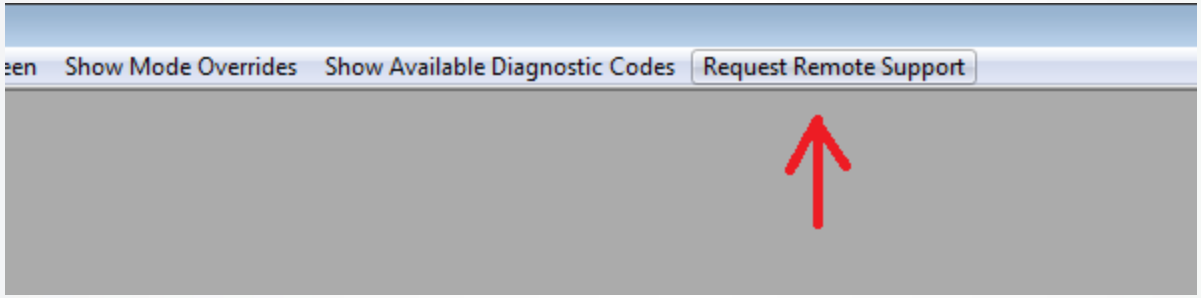
- Key the vehicle on.
- Start / Save Datalog.
- Start the engine.
- Either drive up through the gears and down to a stop, end datalog. Should be ~30-60 sec.
- Or drive the vehicle in the manner that an issue is occurring. End datalog after issue so the “time of issue” is known.

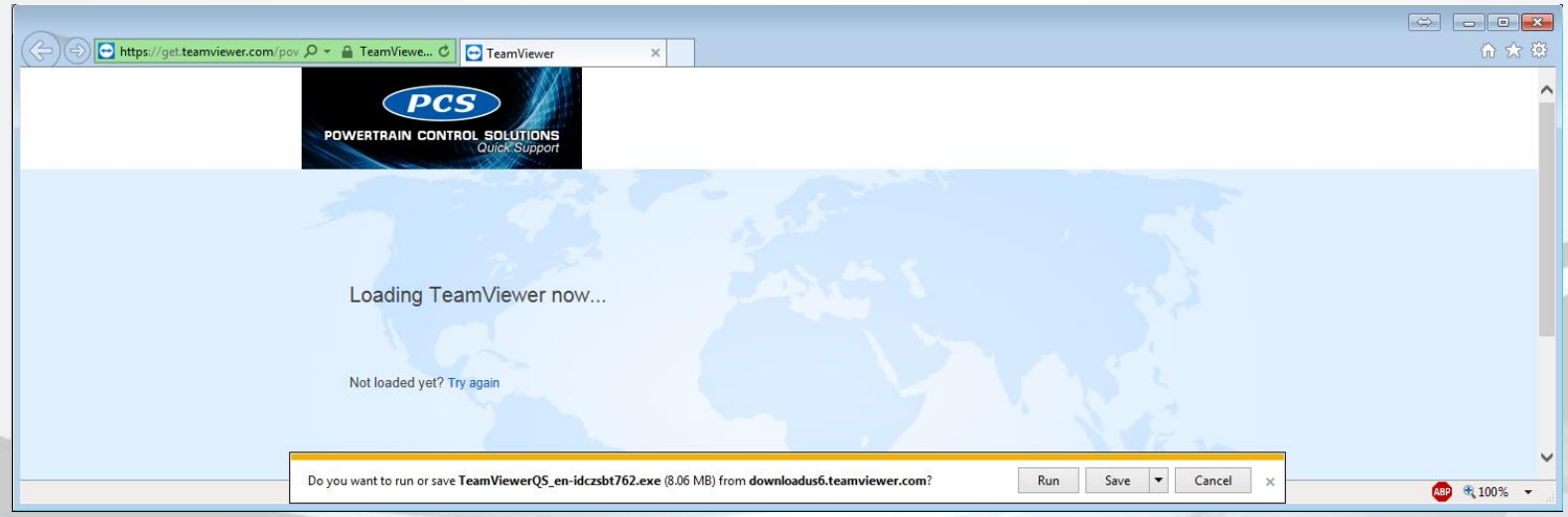
Data Log – See Additional Guide!



- Note the file location to find the file later for review and email.
- Default path is Documents folder.

PCS Remote Assistance

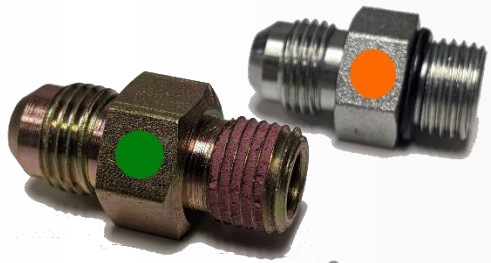




Field Replacement Considerations
Cooler and Cooler Line Contamination

If a replacement transmission is installed:

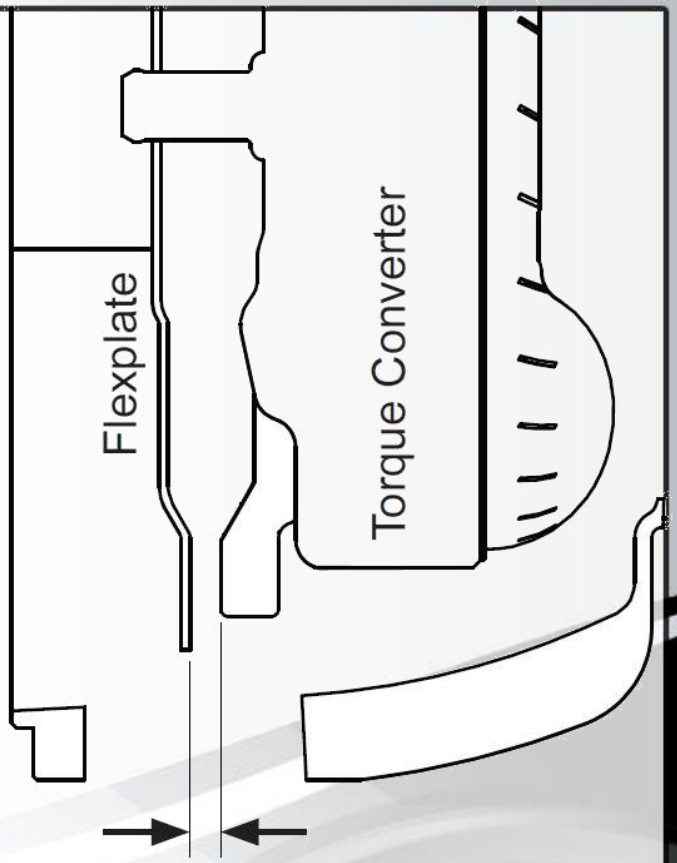
- Cooler and cooler lines must be flushed free and clear of debris – “my new replacement transmission failed too”.
- Cooler / Line replacement recommended if affordable.
- If not JIC-6 fittings, double check if they are ¼-NPS or ORB-6!



Field Replacement Considerations
Torque Converter Pullout

1. Align and install the bellhousing/transmission to the engine. Before tightening the bellhousing fasteners, check to be sure converter **rotates freely**.
2. Torque bellhousing fasteners to spec. Push the torque converter back into the transmission as far as possible.
3. Measure the gap between the flexplate mounting surface and the torque converter mounting pads.

DRILL BITS ARE EASY GAP TOOLS!!

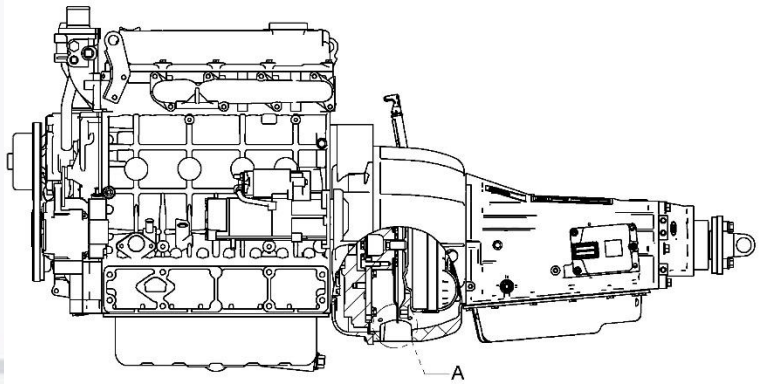


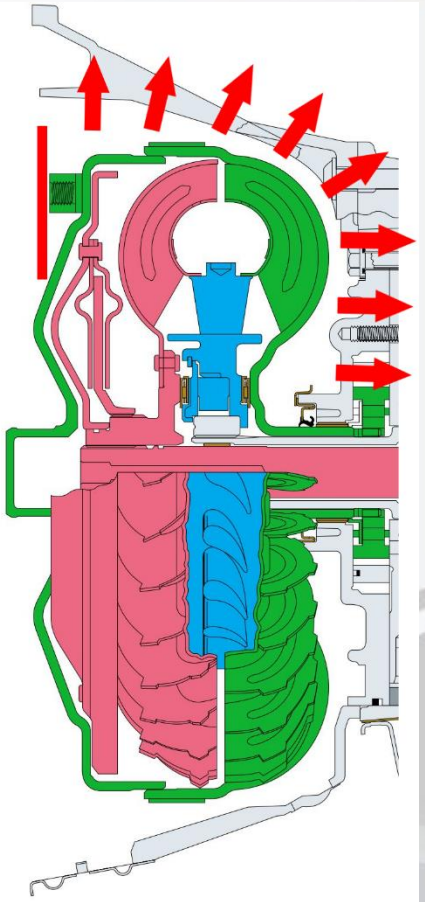
Gap distance must be between .060" (1.5mm) and .187" (4.7mm). Do not proceed and contact PCS if gap is out of range.

Field Replacement Considerations
Torque Converter Pullout

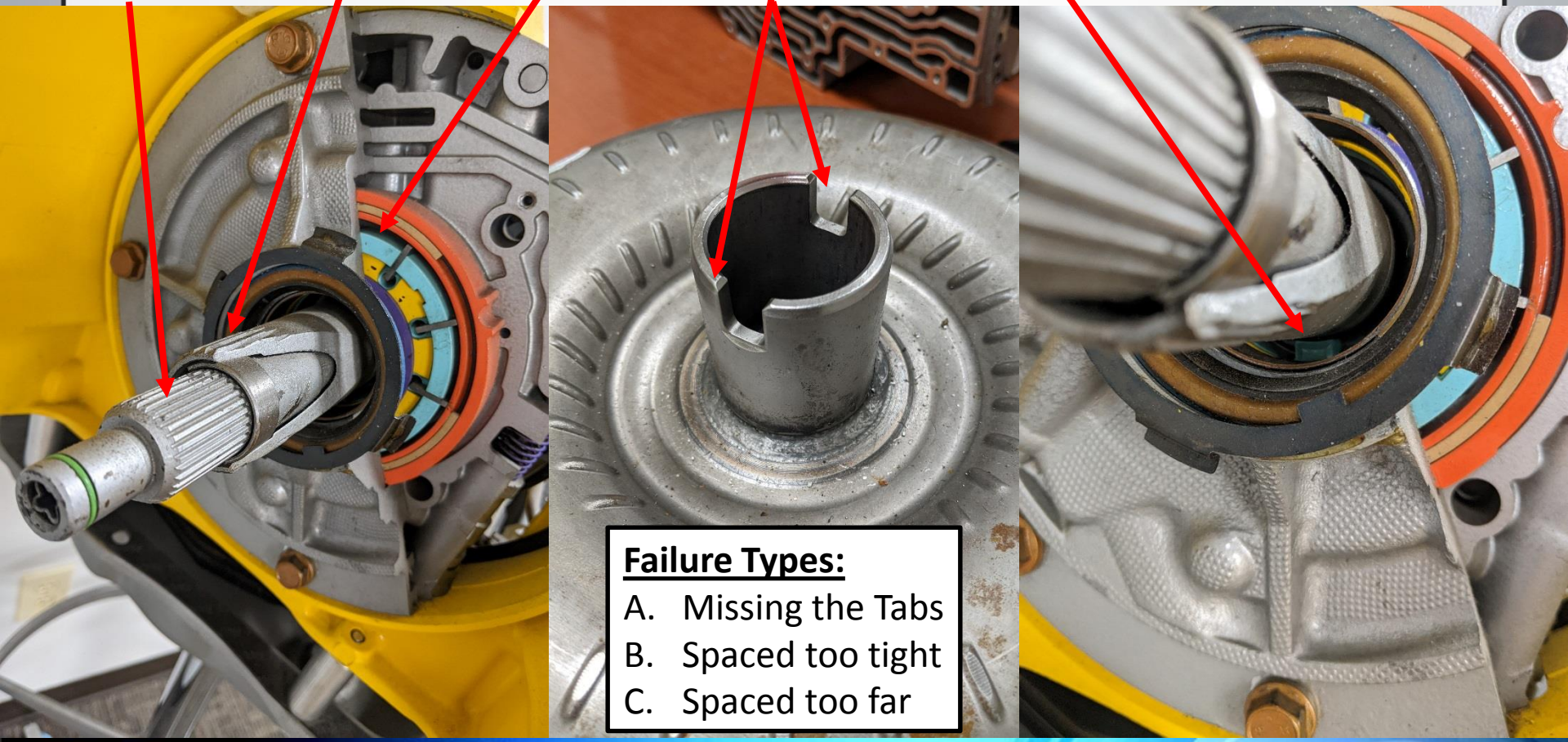
- Converter Clutch Application
- Thermal Expansion
- Engine Build Tolerances

- Converter Type
  - 300mm vs 258mm
- Crankshaft
- Flywheel
- Flywheel-Housing
- Flywheel Adapter
- Engine Spacer
- Flexplate
- Bellhousing





Field Replacement Considerations
Transmission Pump Components



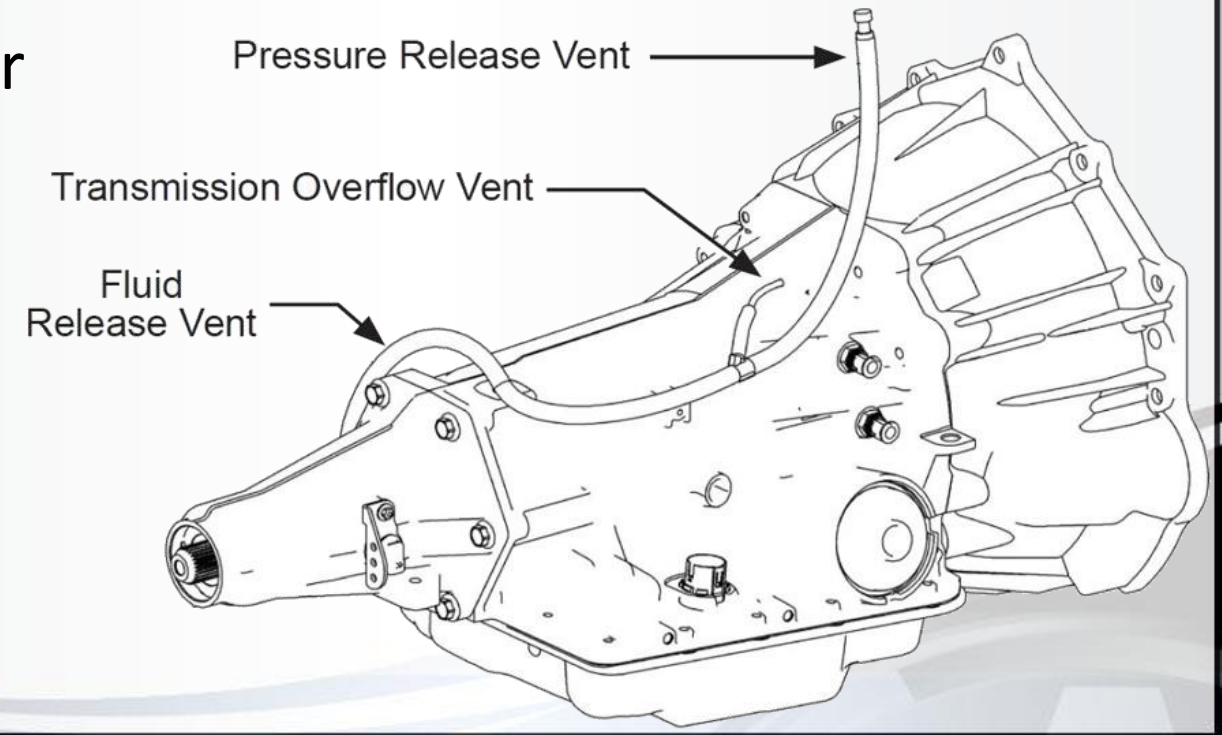
Failure Types:

A. Missing the Tabs
B. Spaced too tight
C. Spaced too far


Pump
Damage

Field Replacement Considerations
Proper Vent Hose Installation

1. Vertical Rattle-cap
2. Flamethrower
3. Puddles
4. Low-points
5. Zip-ties



Field Experiences

With 16,000+ in the field, issues are **statistically low**, but these are some descriptions we have heard from customers:

- “Transmission moves, but won’t pull”
- “Transmission will not shift out of 1st”
- “Transmission doesn’t move forward or reverse”
- “Transmission doesn’t move in reverse”
- “Transmission loses forward when hot”

“Transmission moves, but won’t pull”

1. Check fluid level & condition.
   - **Level is critical here**, fluid may be burnt as a result of this failure – if the unit is operated it will burn up the transmission.
2. Check for codes.
   - Verify communication with the TCM.
3. Check the basics – power and shift linkage.
   - Over 90% of these failures are **no power – blown fuse**, no fuse, etc.
   - If a power reset solves the problem, then a power mod is required - older firmware.
4. Check the signals.
   - Observe **TPS** and RPM.
5. Directly control the transmission.
   - If there is a solenoid issue, it will be discovered here.

“Will not shift out of 1st”

1. Check fluid level & condition.
   - Probably fine
2. Check for codes.
   - **Could be SSA or SSB Solenoids or a failed band / clutch.**
3. Check the basics – power and shift linkage.
4. Check the signals.
   - **Observe OSS / VSS. Very likely the Output Speed Sensor or wiring.**
5. Directly control the transmission
   - If there is a solenoid issue, it will be discovered here.

“Transmission doesn’t move forward or reverse”

1. Check fluid level & condition.
   - **Level is critical here,** without enough fluid there will not be line pressure to operate the transmission.
2. Check for codes.
   - Verify communication with the TCM and check codes.
3. Check the basics – power and shift linkage.
   - **Gen 3 no power condition** is no forward and no reverse.
   - Shift linkage disconnected?
4. Check the signals.
   - Observe TPS, RPM – Incorrect high TPS or RPM is most likely the cause – the transmission is in **abuse protection.**
5. Directly control the transmission.
   - There is not one electrical failure (solenoid) that can prevent forward or reverse, but you may have a mechanical failure, i.e broken pump or shaft.
   - **Perform line pressure check.**

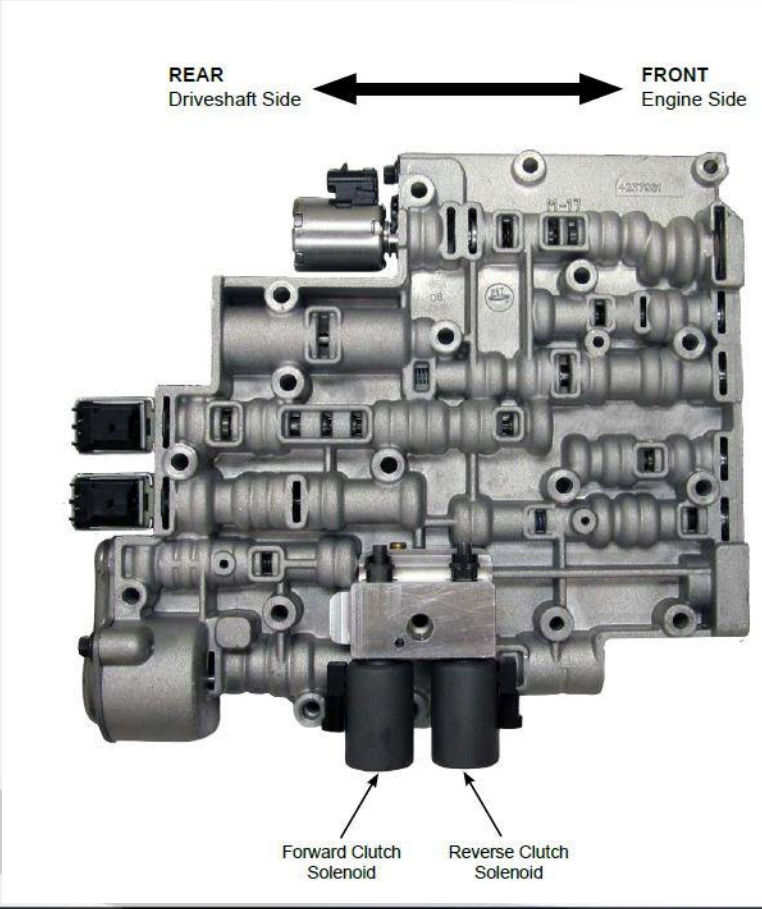
“Transmission doesn’t move in reverse”

1. Check fluid level & condition.
   - Check fluid condition. Level is probably OK since forward is working but burnt fluid could indicate burnt reverse clutch.
2. Check for codes.
   - Verify communication with the TCM and check codes.
3. Check the basics – power and shift linkage.
   - Does **shift linkage** place the shifter into reverse detent?
4. Check the signals.
   - Verify TCM is reporting reverse when the shift lever is moved. This is probably not abuse protection because forward engages.
5. Directly control the transmission.
   - There is one solenoid that controls reverse so it is likely the cause.

*-Model years **2015-2016 had a GEN-2 REV-solenoid** that could have a manufacturing issue, causing it to stick (no reverse) in the first 100 hours. **Replacing the solenoid** solves this issue.*

*-Model years **2019-2020 had a GEN-3 REV-solenoid** that locks up under extreme pressure, such as high line pressure in reverse. A **calibration update fixes this**, contact PCS for help.*

GEN-2 Forward and Reverse Solenoids



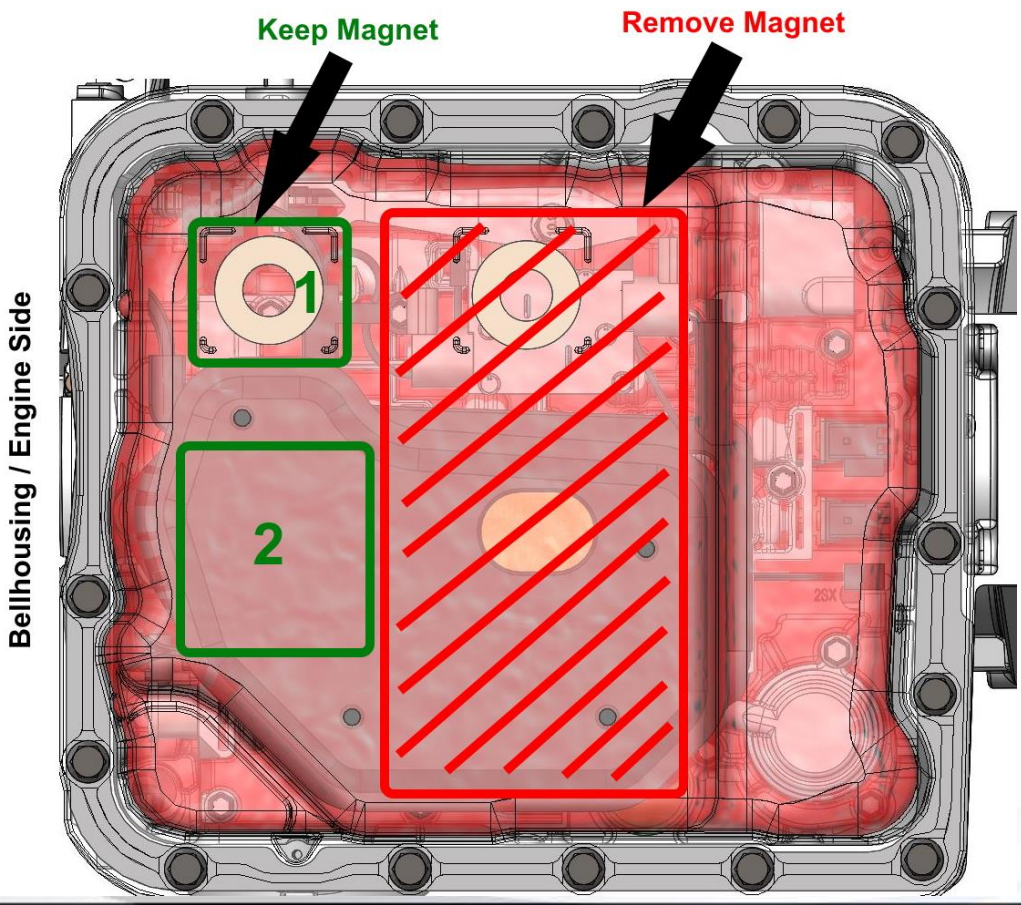
- Reverse solenoid should be marked “reverse” as shown above.
- There is no adjustment of the solenoid in the field.

“Transmission Loses Forward at Temp”

1. Check fluid level & condition.
   - Check fluid condition. Level is probably OK since forward is working but burnt fluid could indicate burnt forward clutch.
2. Check for codes.
   - Verify communication with the TCM and check codes.
3. Check the basics – power and shift linkage.
   - Does **shift linkage** place the shifter directly in the forward detent?
4. Check the signals.
   - Verify TCM is reporting forward when the shift lever is moved. This is probably not abuse protection because forward engages.
5. Directly control the transmission.
   - There is one solenoid that controls forward so it is possibly the cause.

2019+ GEN-3 4LHD Transmissions with this very specific symptom has a significant 90%+ performance improvement when the rear pan magnet is removed, new aux-block installed, and software-patch verified by PCS Technical Support! Send the datalog to our gsetechs support email for verification!

Magnet, GEN-3 Block, and TCM Update



- Remove the magnet from the pan as shown on the left.
- Replace the entire aux block. New ones are tested and wear free.
- Detailed step-by-step instructions on gsehelp.com for this procedure

Tools Every Shop Should Have

- Cable and Software (preprogrammed laptop available)
- Transmission Diagnostic Device
- Volt/Ohm Meter
- Pressure Gauge, 1/8-NPT, 400 PSI
- Fluid Evacuator

Want to learn more?

- GM 4L60E Technicians Guide
- ATSG 4L60E Repair and Overhaul Manual
- Precision Transmission (YouTube)
  - Tear downs and root cause analysis
- Weber Auto (YouTube)
  - History of Transmission Fluid
  - Description of Transmission Operation
- SIU Automotive (Youtube)
  - Description of Transmission Operation

The Keys to Troubleshooting

- Have the right tools!
- Follow the 5-step process!
- Add a transmission check to every maintenance event!
- Transmission “inside or outside” diagnosis should be a 15 minute task!

Any Questions?

(Next let’s look at a data-log!)