Anatomy of a Shift - Part Two

Sean Boyle, Southern Illinois University

How are you all liking EXPO at San Antonio so far? (test to see you guys log in and manage the survey)

I love it! It's awesome

0

I love it! The hotter the better!

0

I love it! I'm selling my house and moving here

0

I love it! I partied with "The Weeknd" last Wednesday night!

0

How would you rate your knowledge when it comes to electrical fundamentals?

0

Pretty darn good

0

Okay, but there's always room to learn more

0

Definitely room for improvement

0

Help, I'm not strong in electrical at all!

0

How would you rate your skills when it comes to electrical diagnosis?

Strong! Electrons are my friends

0

I manage, but I do scratch my head a bit

0

Definitely room for improvement. I have a high capacity parts cannon

0

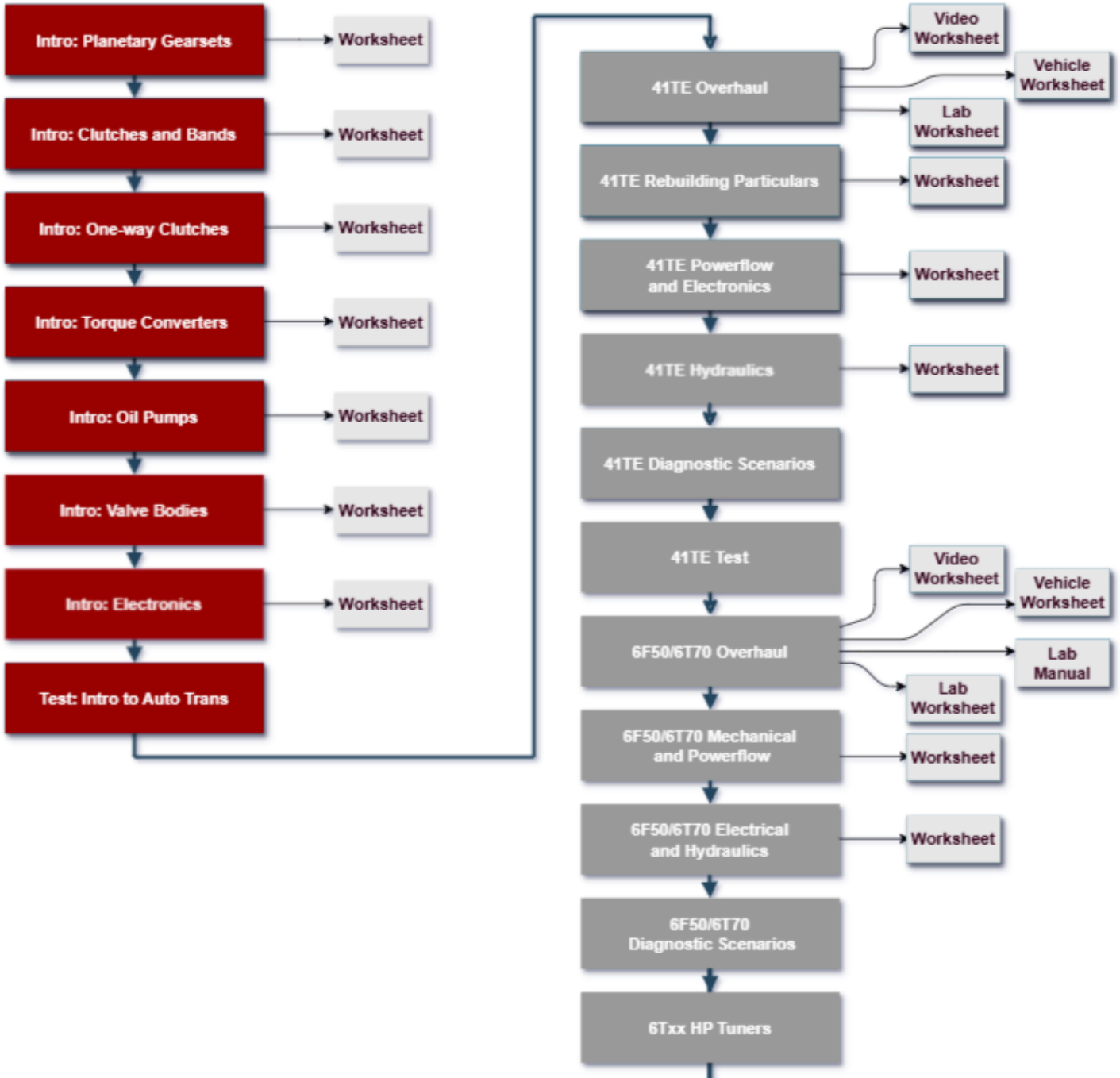
They don’t let me mess with electrical. I’m just allowed to plug in the Milwaukee batteries.

0

Southern Illinois University - SIU

- 4-year Automotive Technology Program
  - **Not engineering**
  - Service focused, but includes management training
  - Many transfer AAS students
- Opportunity for faculty to dig deeper into operation and diagnosis

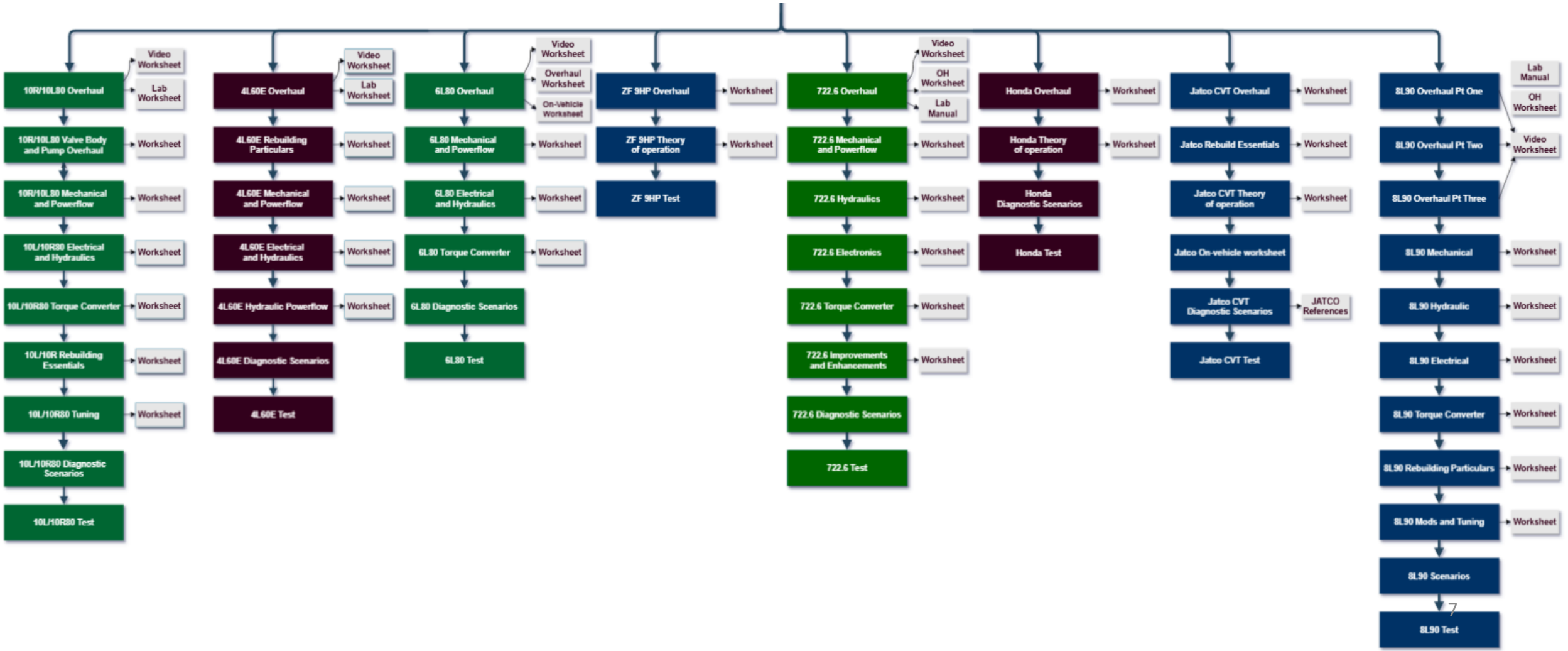
Automatic Transmission Curriculum



Color Legend

- More challenging, but more rewarding!
- Intermediate level of challenge
- Easiest to understand and digest
- Required intro curriculum

Southern Illinois University - SIU



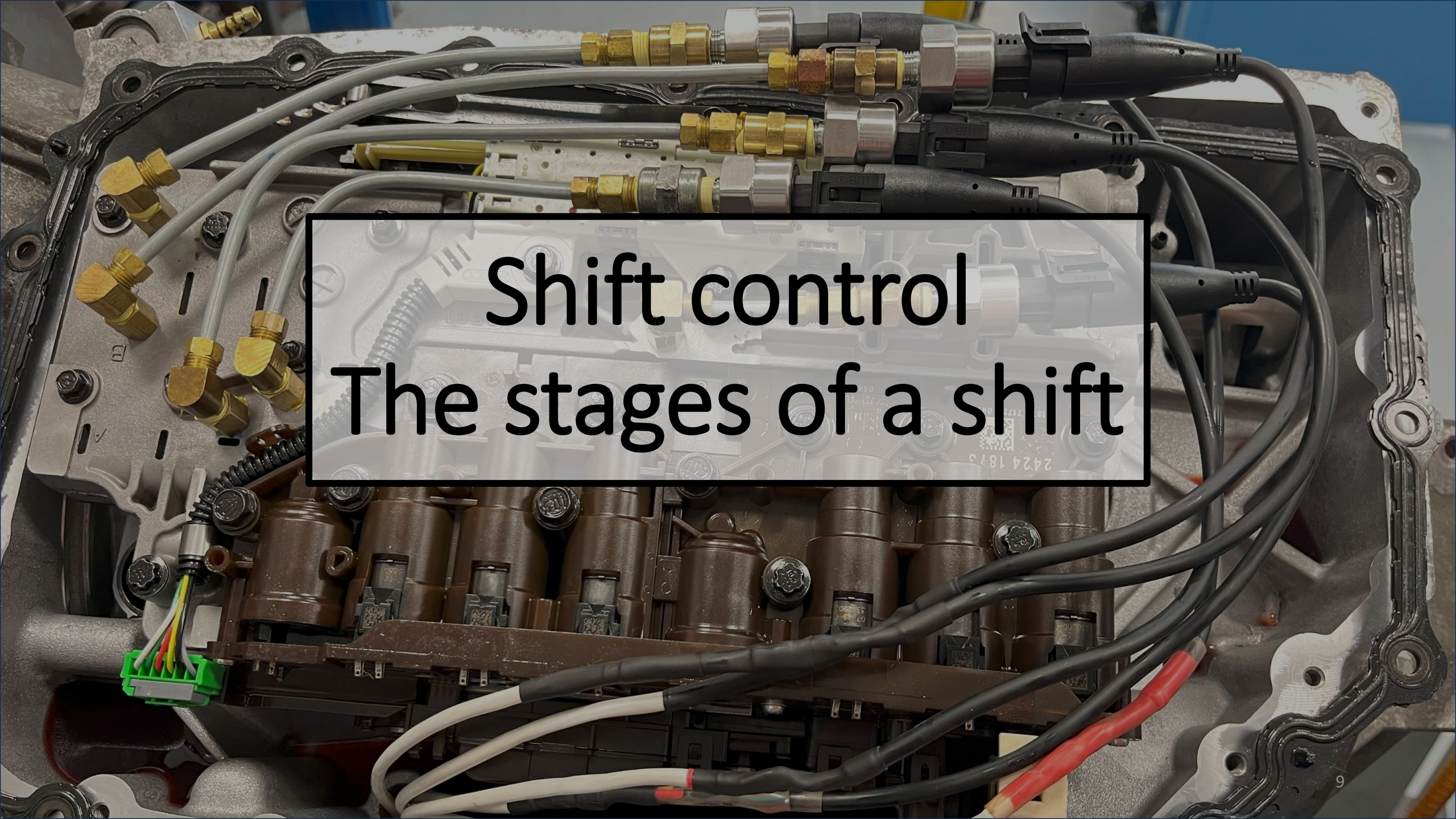
YouTube: siu automotive

overlay

Automatic Transmissions

siu automotive - 1 / 60

▶	20:19	Basic planetary gearsets	siu automotive
2	12:41	Basic auto trans clutches and bands	siu automotive
3	8:34	Basic one-way clutch operation	siu automotive
4	41:59	Basic torque converter operation	siu automotive
5	10:15	Basic auto trans oil pump operation	siu automotive
6	34:07	Basic auto trans valve bodies	siu automotive
		Basic auto trans electronics	



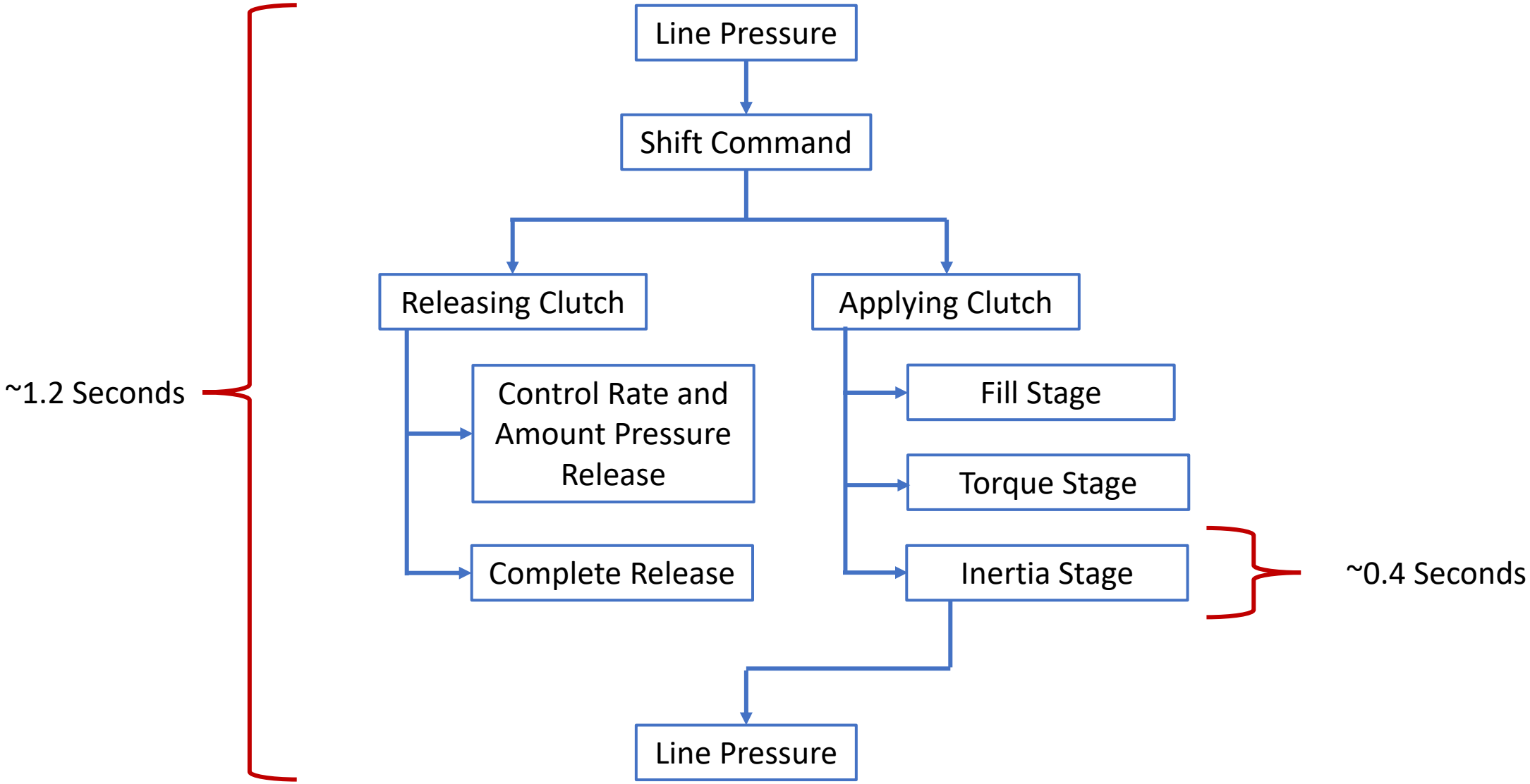
Shift control
The stages of a shift

Shift Control Evolution –Comparison – Old vs. New

- Hydraulically controlled transmissions
  - Pressure increase for holding force
  - Clutch count/surface area
  - One-way clutches (shift feel)
  - Accumulators
  - Orifices
  - Wave/dished steels
  - Piston return springs

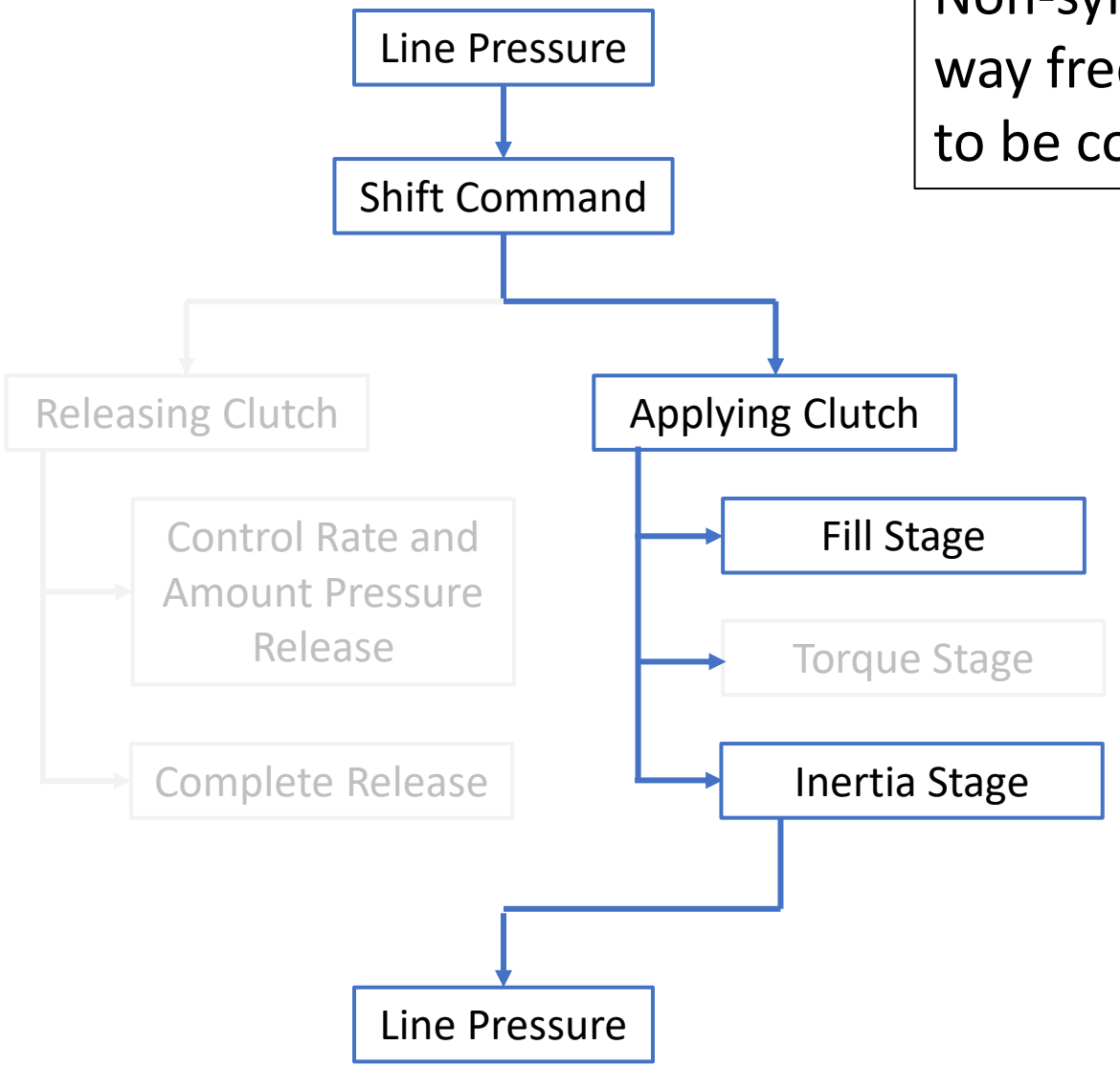
- Modern Electronically Controlled transmissions
  - Torque Management
    - Throttle and spark advance
  - Solenoid control
    - Reduced pressure during the shift
    - Specific phases of a shift
  - Wave/dished steels
  - Balance pressure
  - Piston return springs

Shift Control – The process



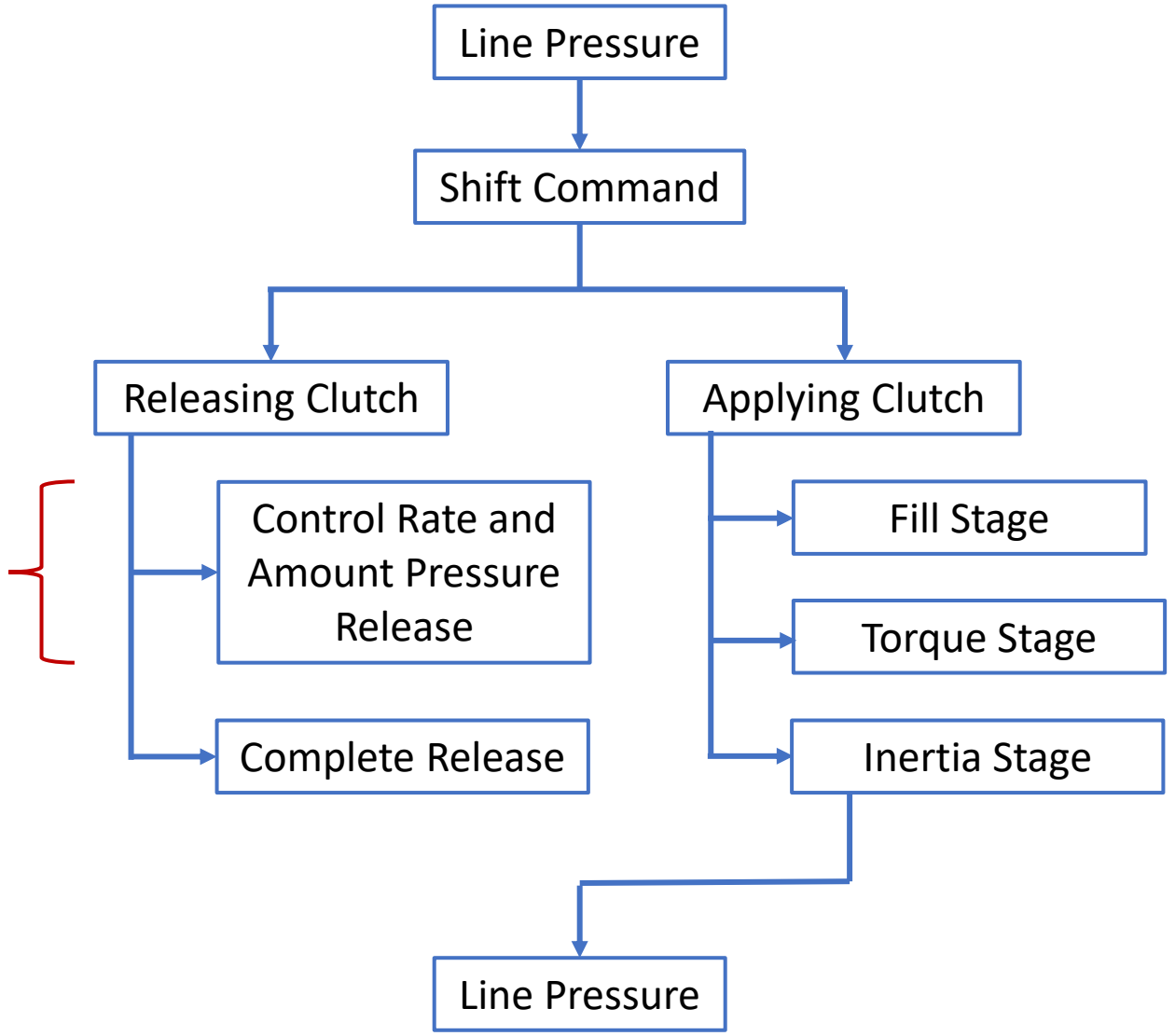
Shift Control – good ol' days – THM 400

Non-synchronous shifts (one-way freewheeling) didn't have to be concerned about timing



Mechanical calibration
- Piston return spring
- Wave/Dish plates
- Orifices
- Accumulator piston size
- Acc spring tension
- Line pressure

Shift Control - modern electronically controlled transmission

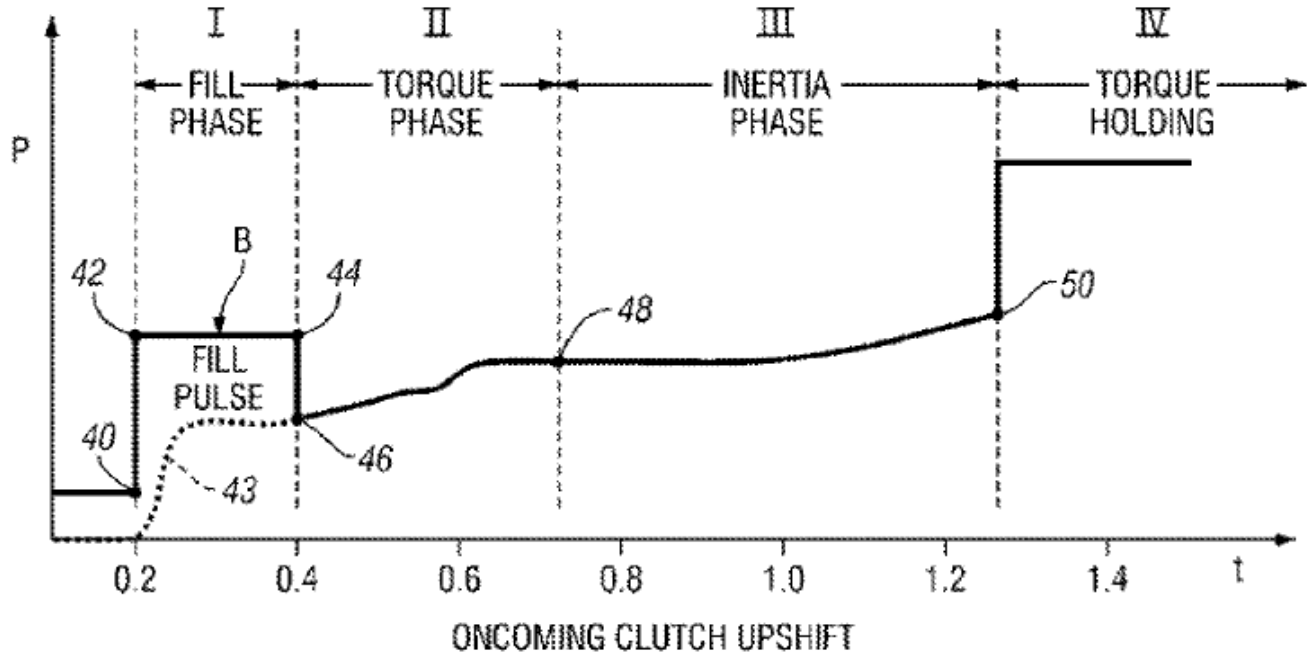


- Solenoid control

- Piston return spring
- Solenoid control
- Solenoid control
- Torque management
- Solenoid control

What controls clutch feel?

- Fill phase – fill the clutch with fluid, compress the piston return spring
- Torque phase – on-coming pressure rise and off-going drop. No ratio change at this point. *Torque hole* because of bind-up and heat.
- Inertia phase – ratio change, engine speed drops, torque management portion
- Torque holding – after ratio change, keeps the clutches from slipping



Synchronous Shift

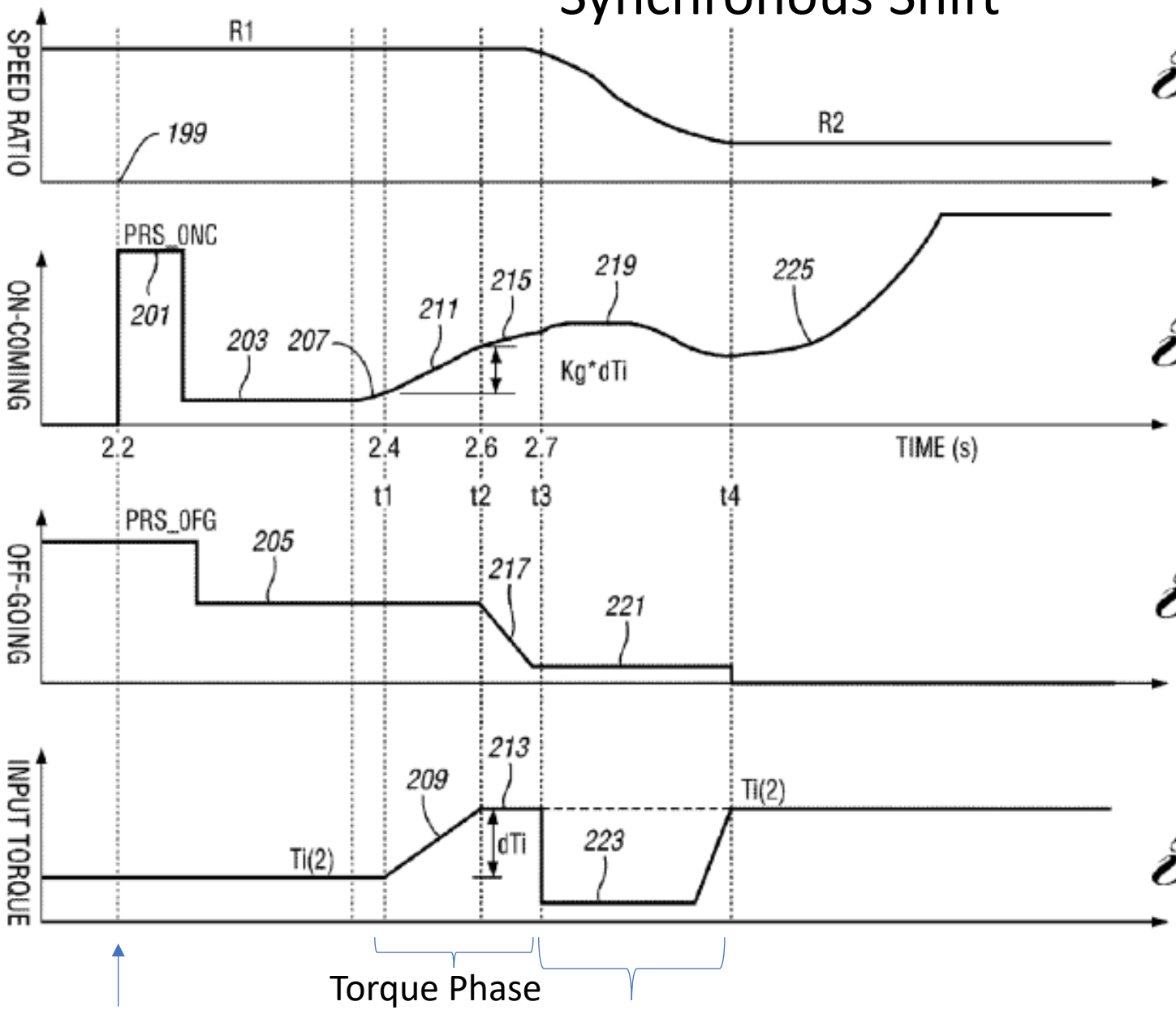


Fig. 6a

Fig. 6b

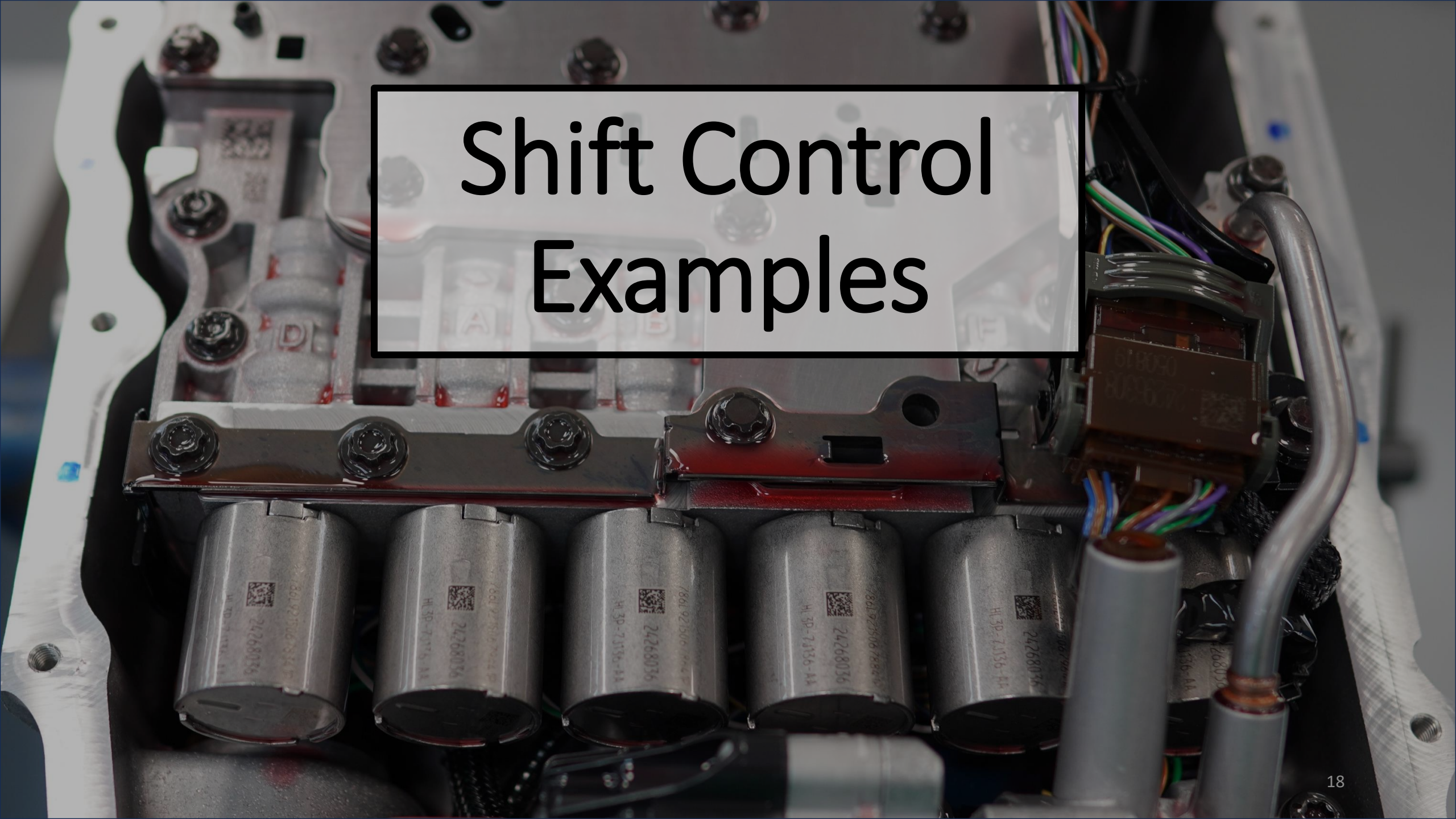
Fig. 6c

Fig. 6d

Torque Phase

Shift command

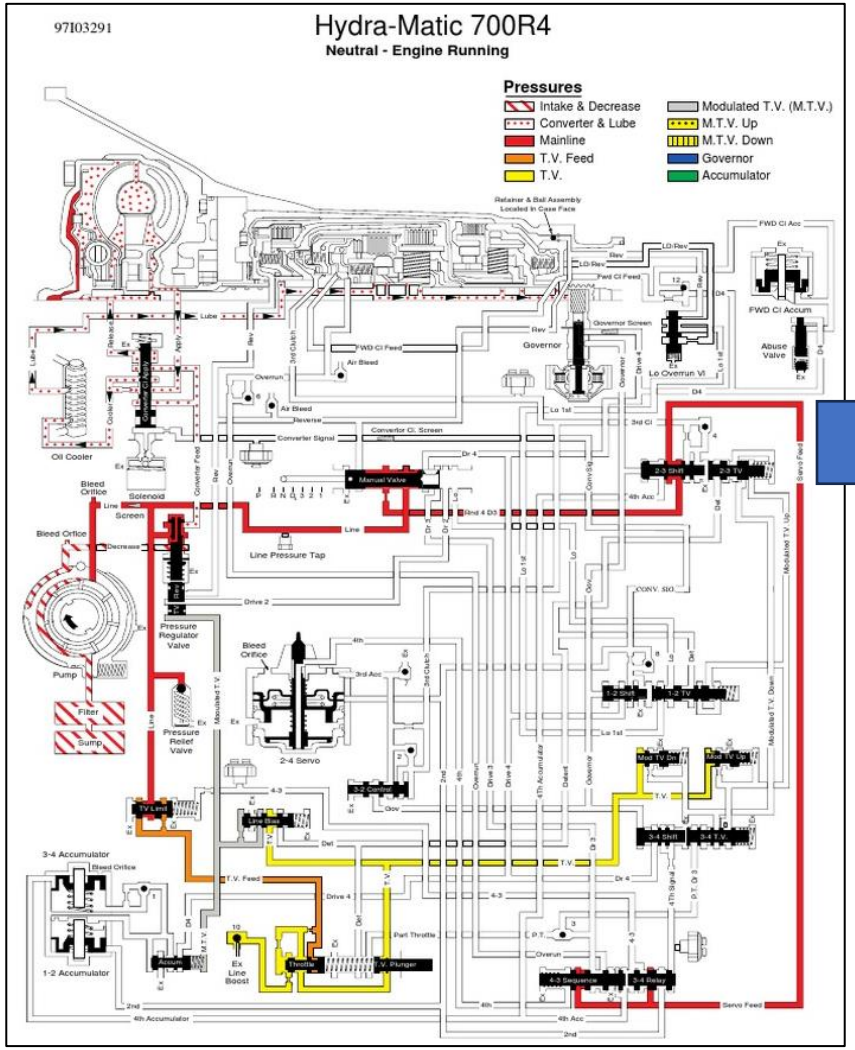
Inertia Phase (speed ratio change)



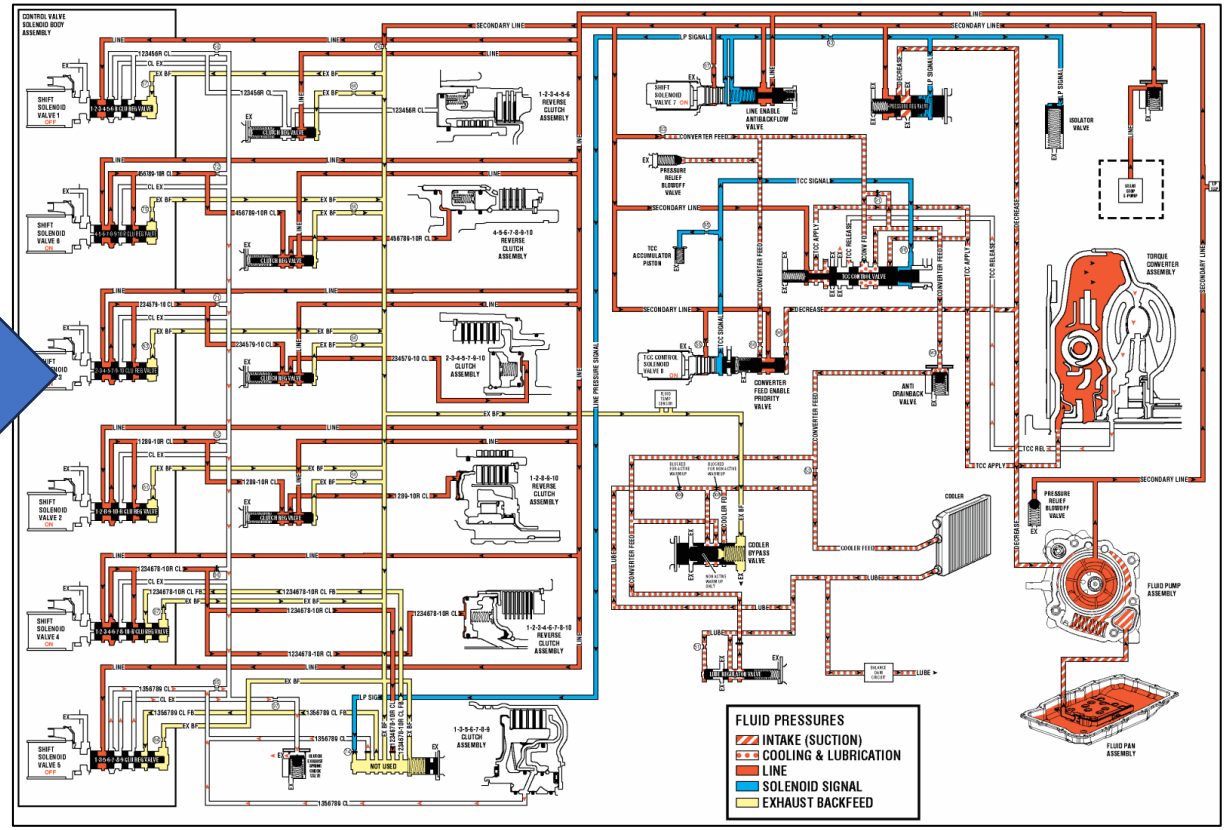
Shift Control Examples

Shift Evolution - Simpler yet more complicated

- GM 700R4
  - 23 valves, 4 accumulators, 3 upshifts

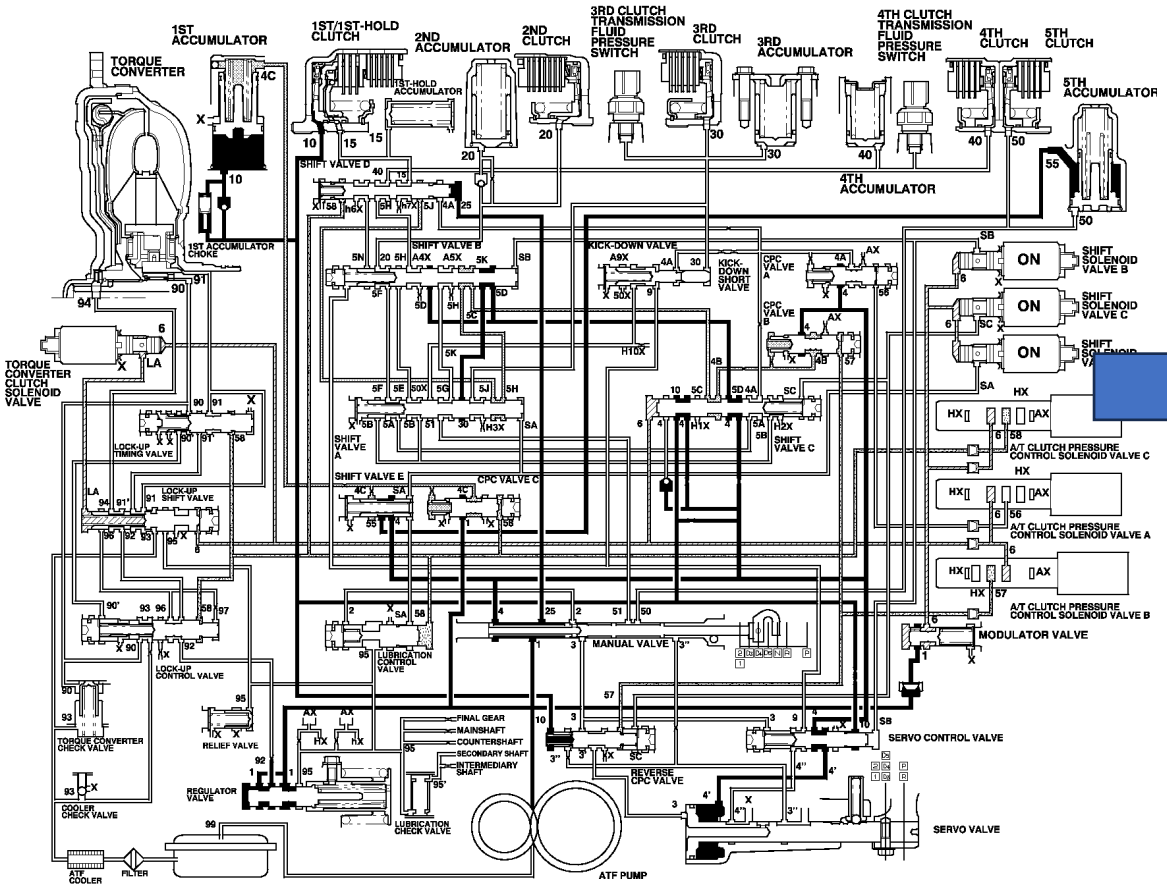


- GM 10L – Ten Speed Trans
  - 16 valves, 9 upshifts



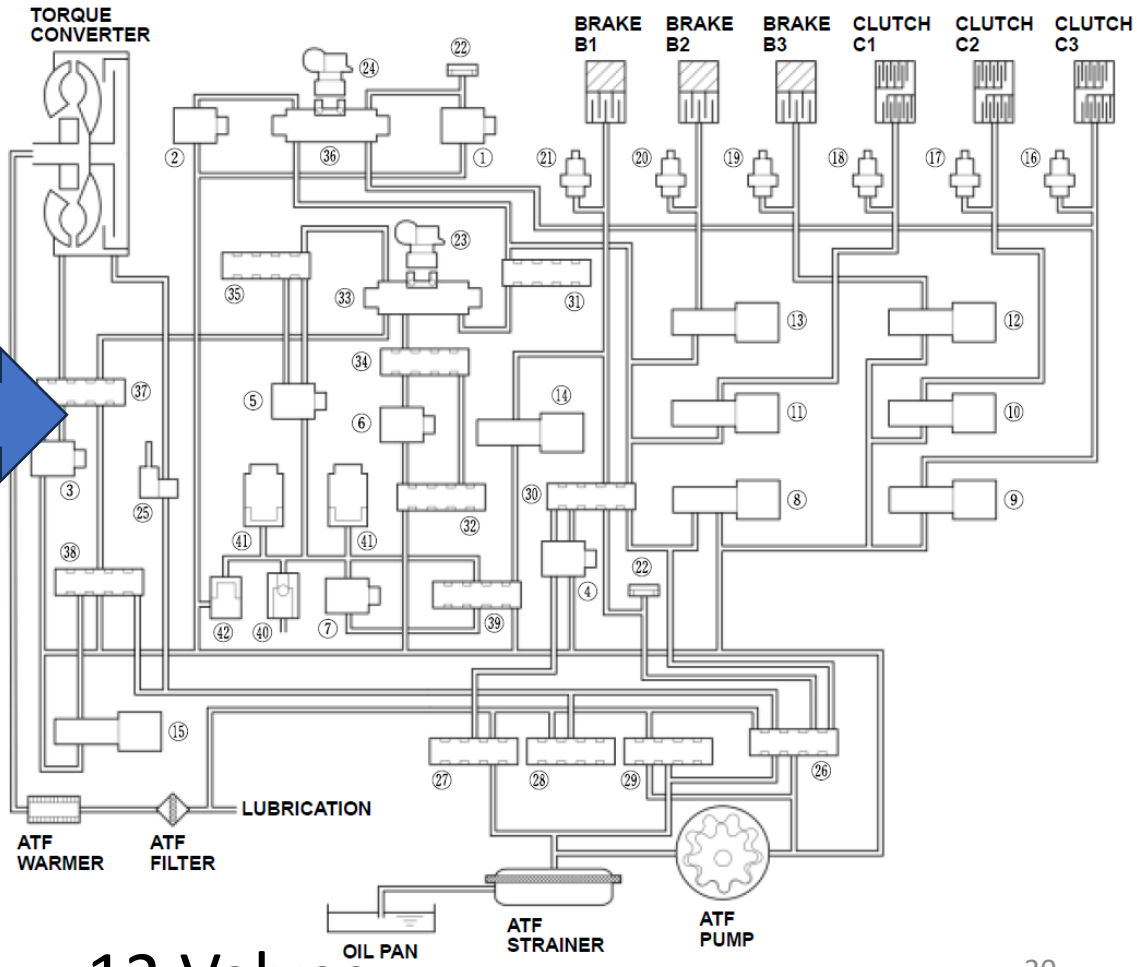
Shift Evolution - Simpler yet more complicated

- Honda 5-Speed Trans

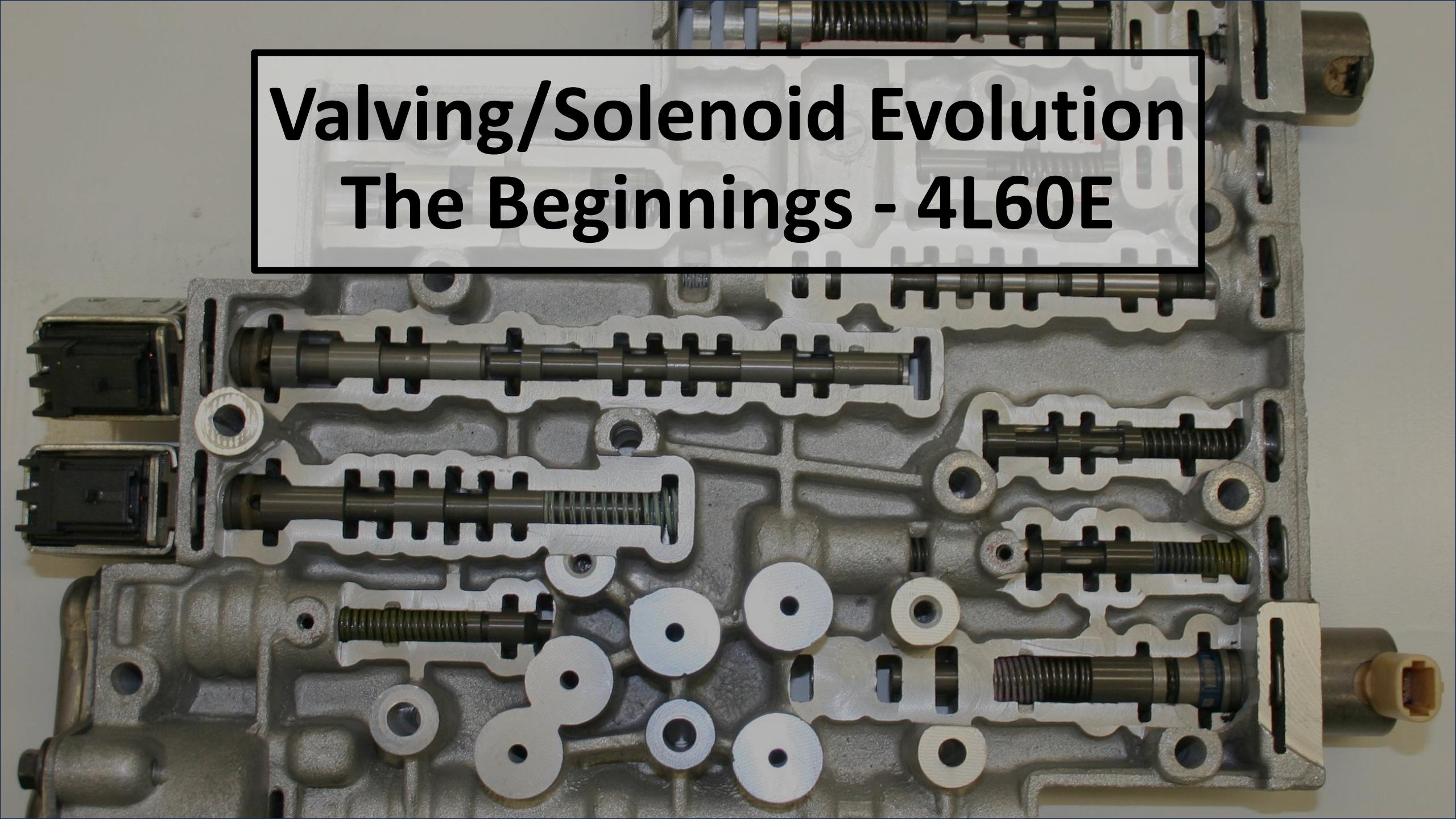


22 Valves

- Honda 10-Speed Trans

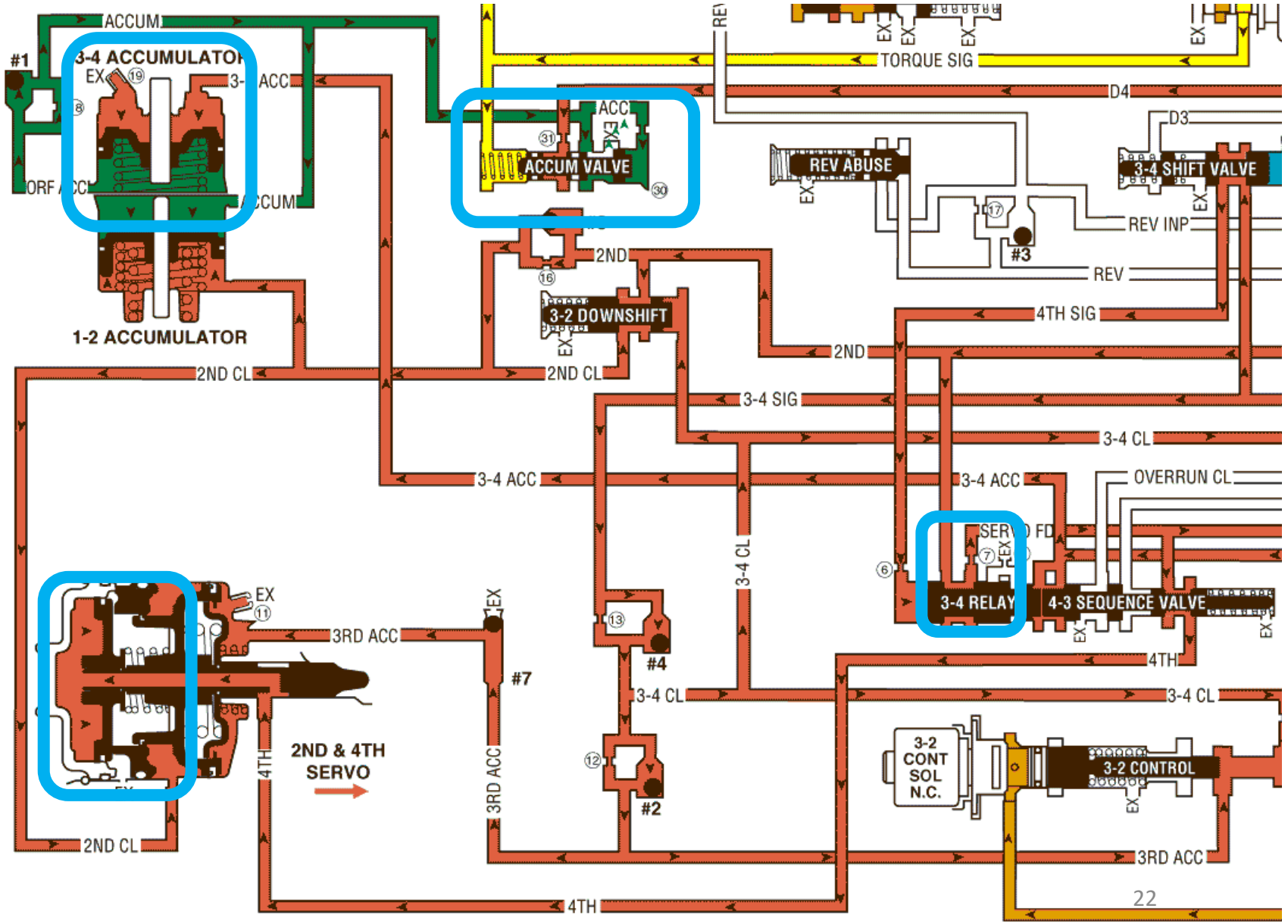


12 Valves


Valving/Solenoid Evolution
The Beginnings - 4L60E

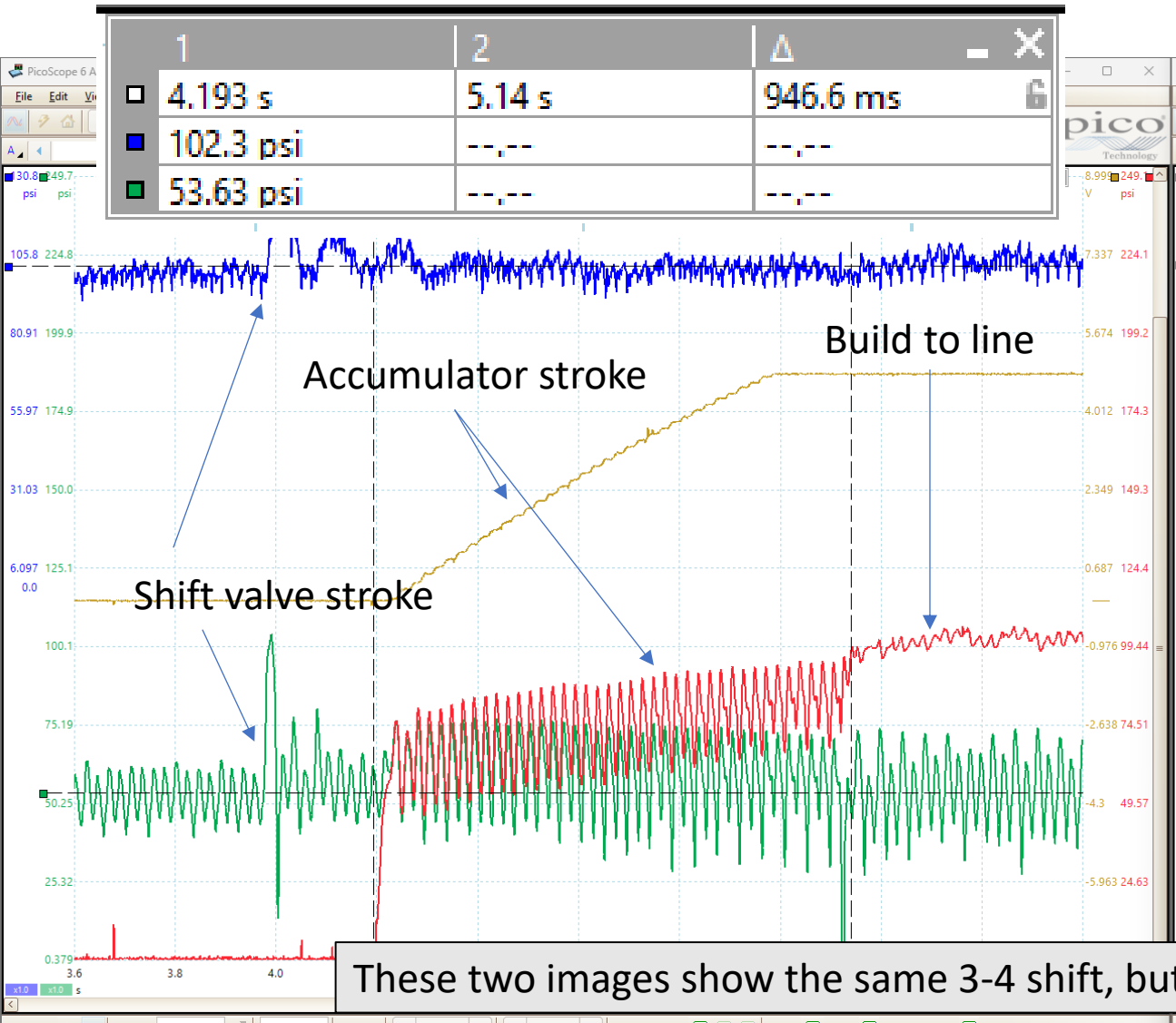
Evolution - Very Basic Electronic Control - 4L60e 3-4 shift

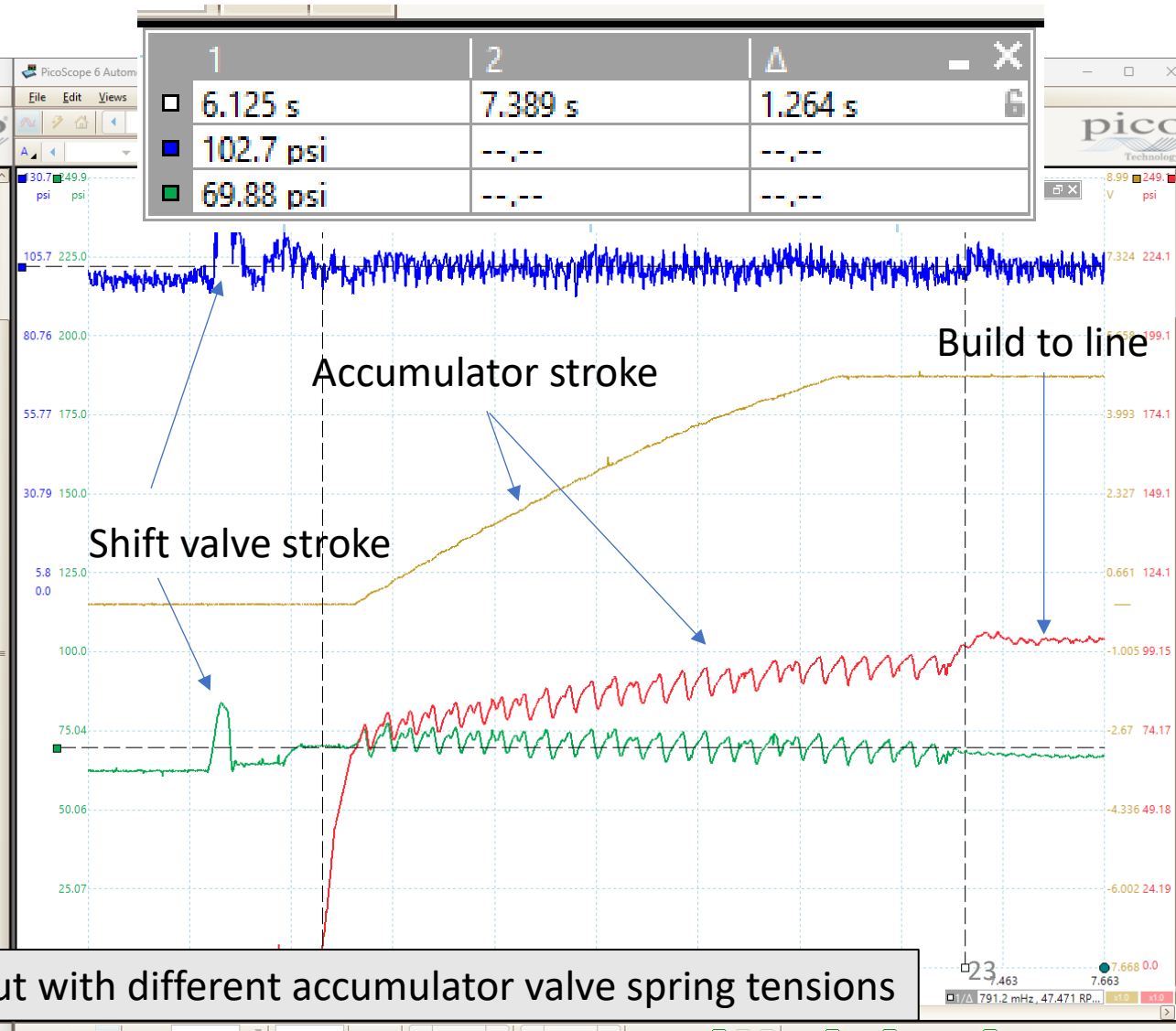
- Line pressure
- Orifice
  - Control fluid flow
- Accumulator
  - Cushion shifts
- Accumulator valve
  - Control accumulator back fill pressure
- Servo
  - Piston area
  - Return spring



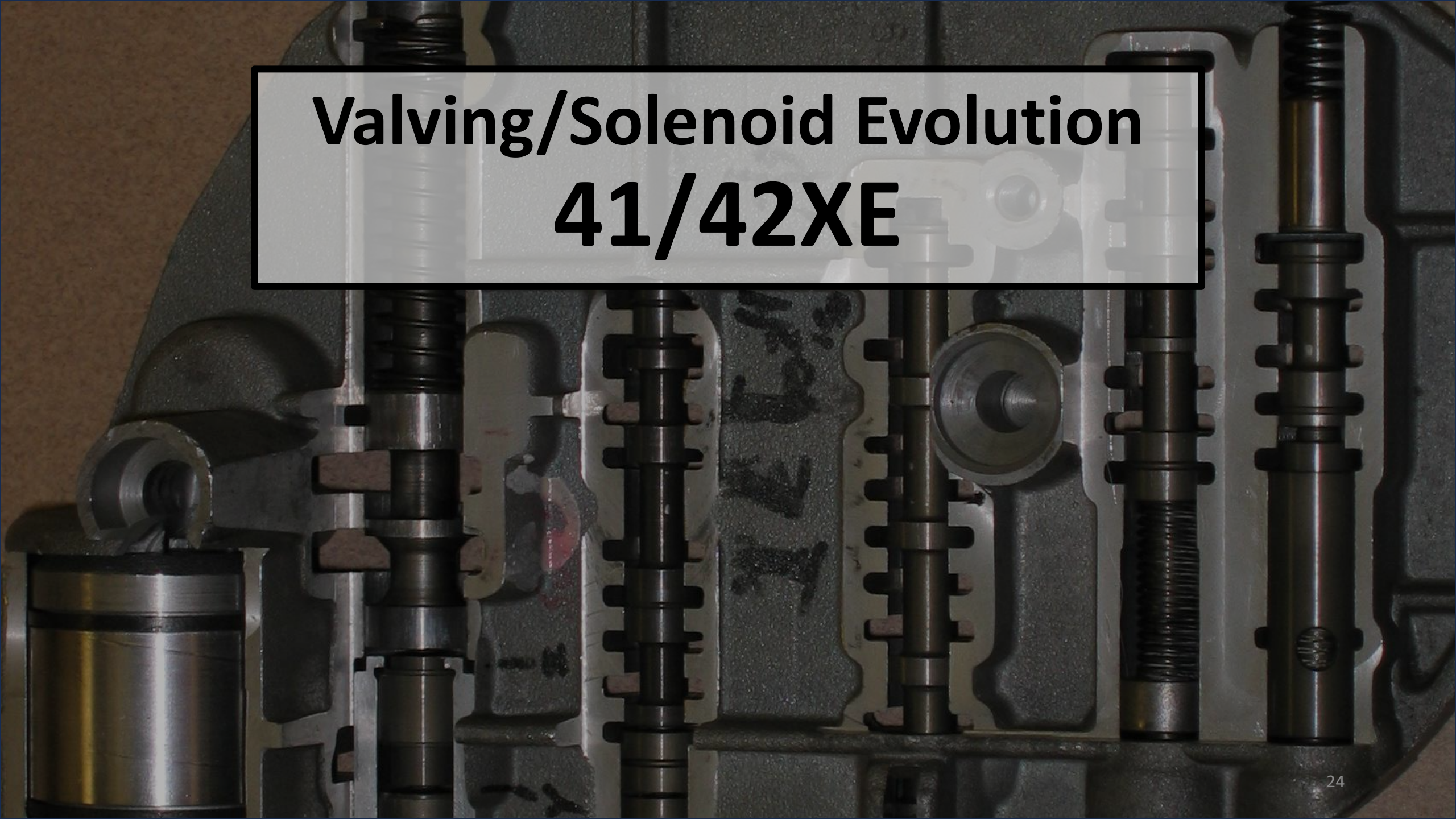
Evolution - Very Basic Electronic Control - 4L60e 3-4 shift

Shift valve directs pressure, EPC manipulates line pressure, accumulators cushion, orifices control flow





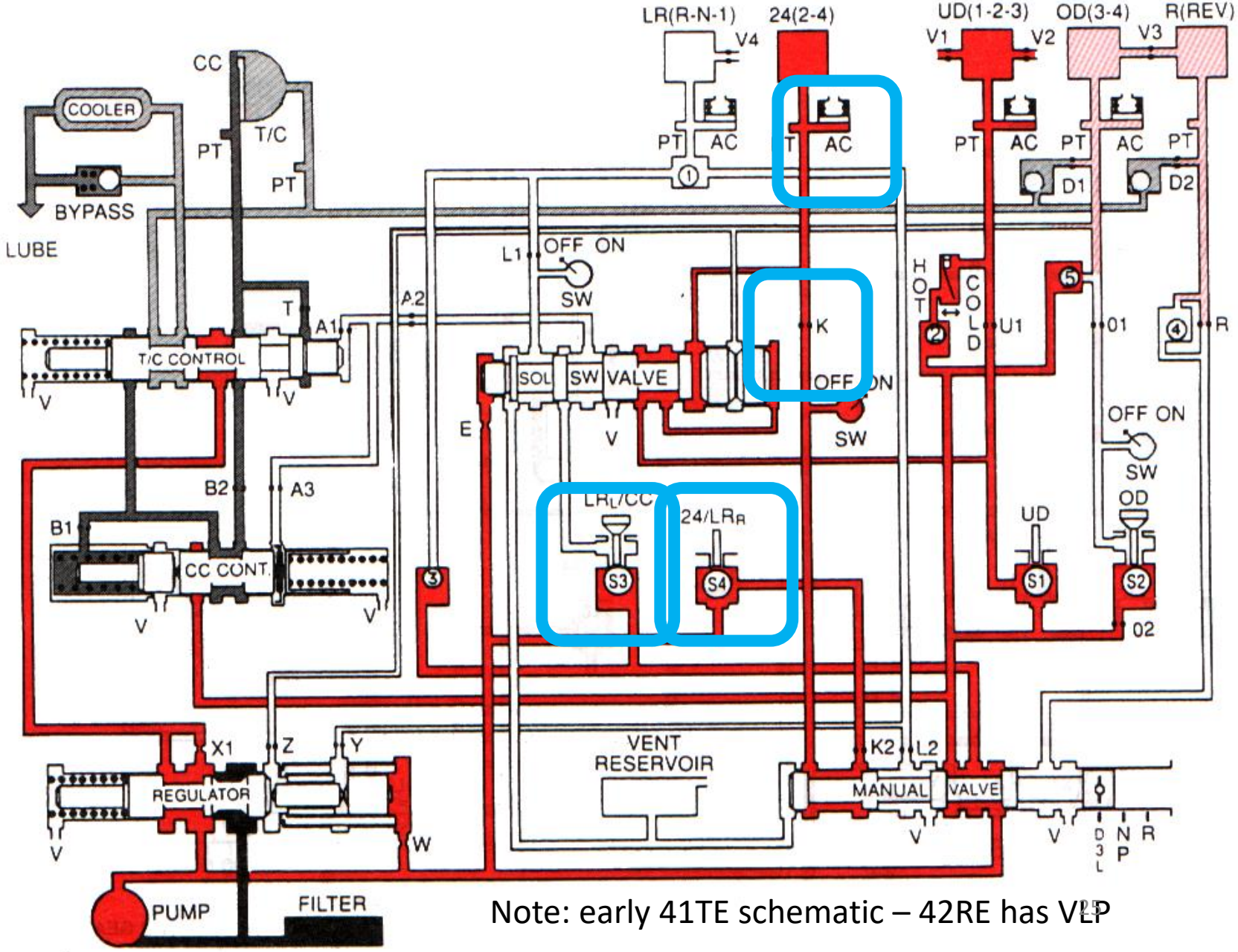
These two images show the same 3-4 shift, but with different accumulator valve spring tensions



Valving/Solenoid Evolution
41/42XE

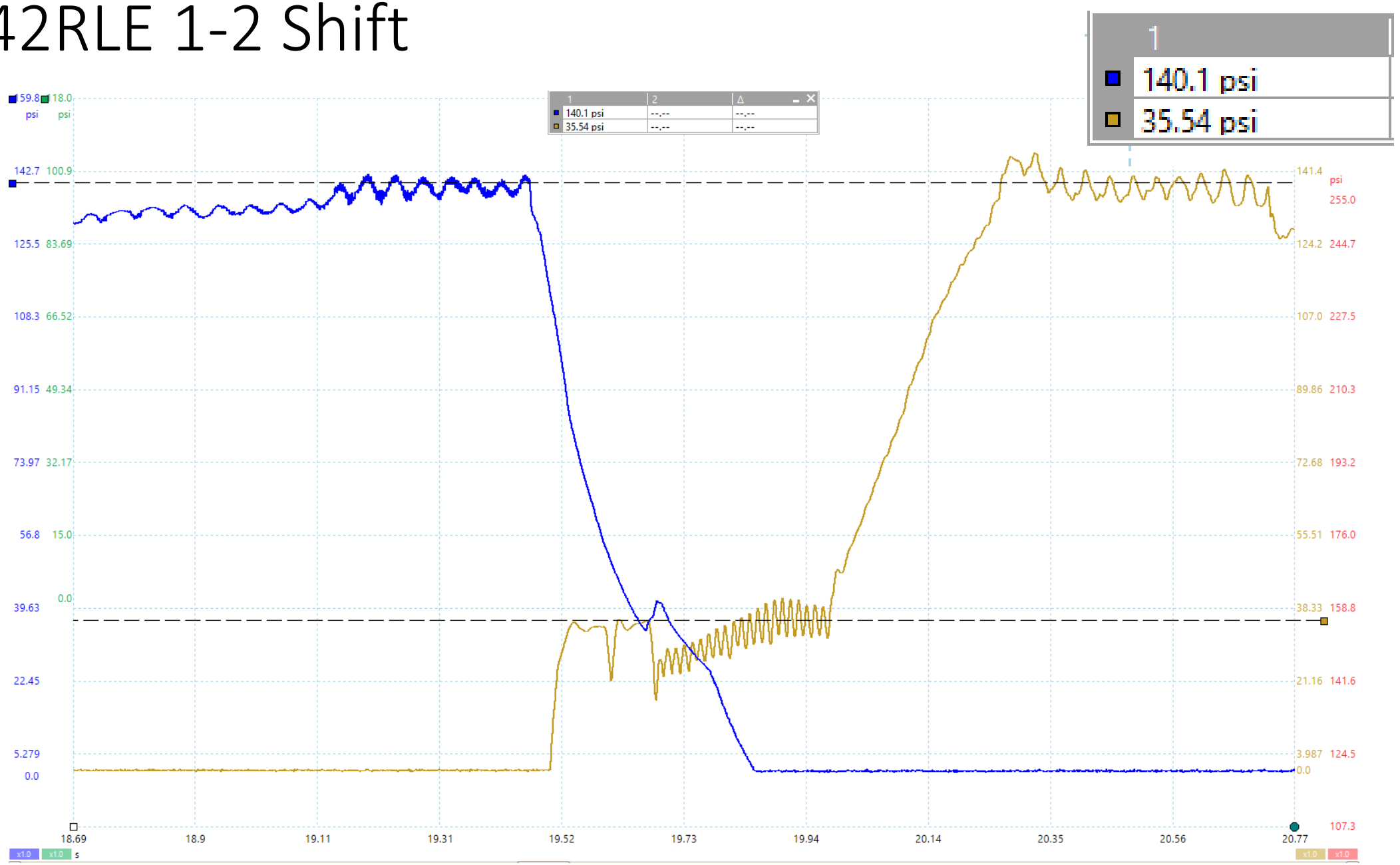
Evolution – Advanced yet simple hydraulics
42RE 1-2 Shift

- TCM – Solenoid PWM
- Accumulator
- Dish plates
- Orifice

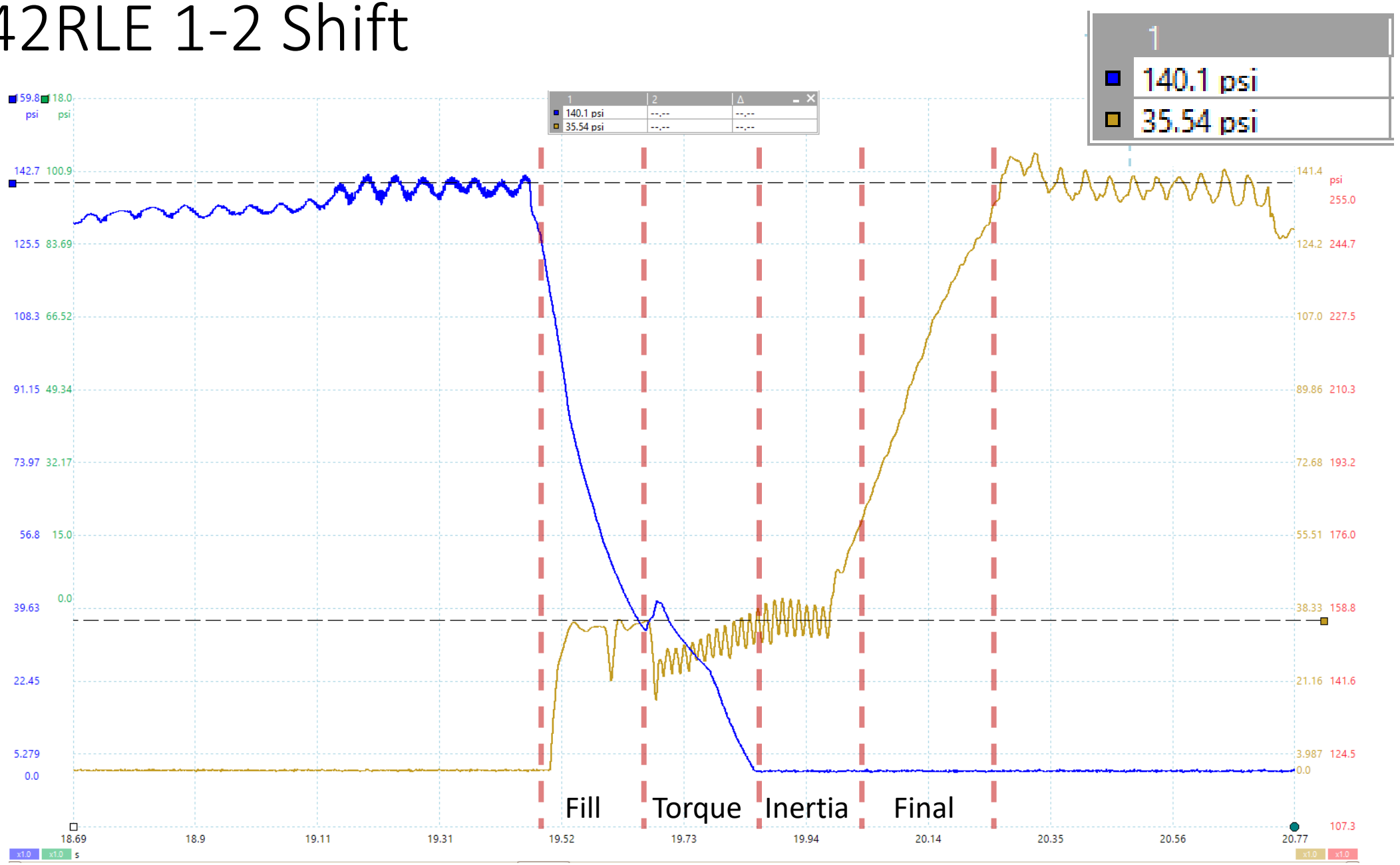


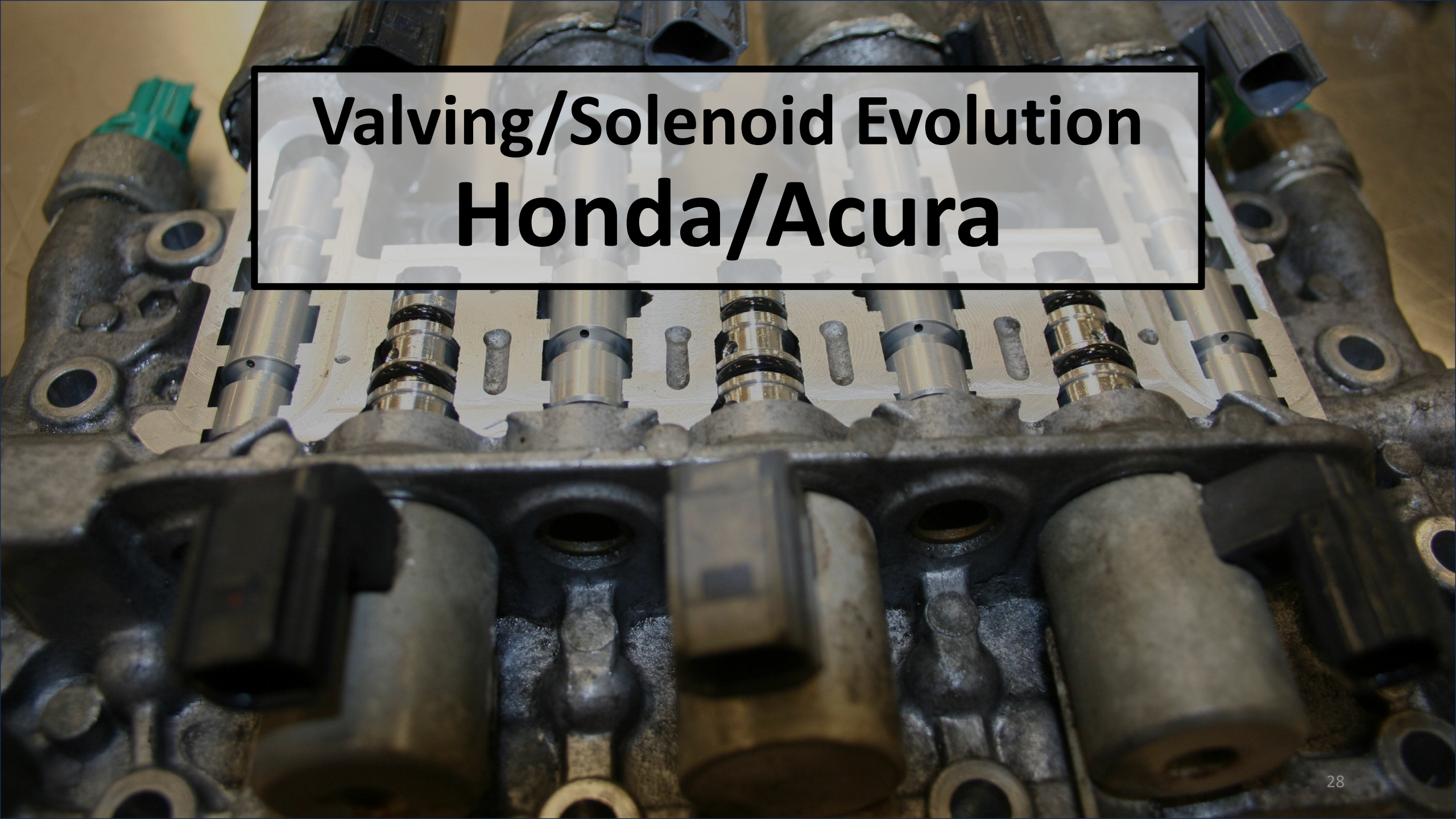
Note: early 41TE schematic – 42RE has VLP

Evolution – Advanced yet simple hydraulics
42RLE 1-2 Shift



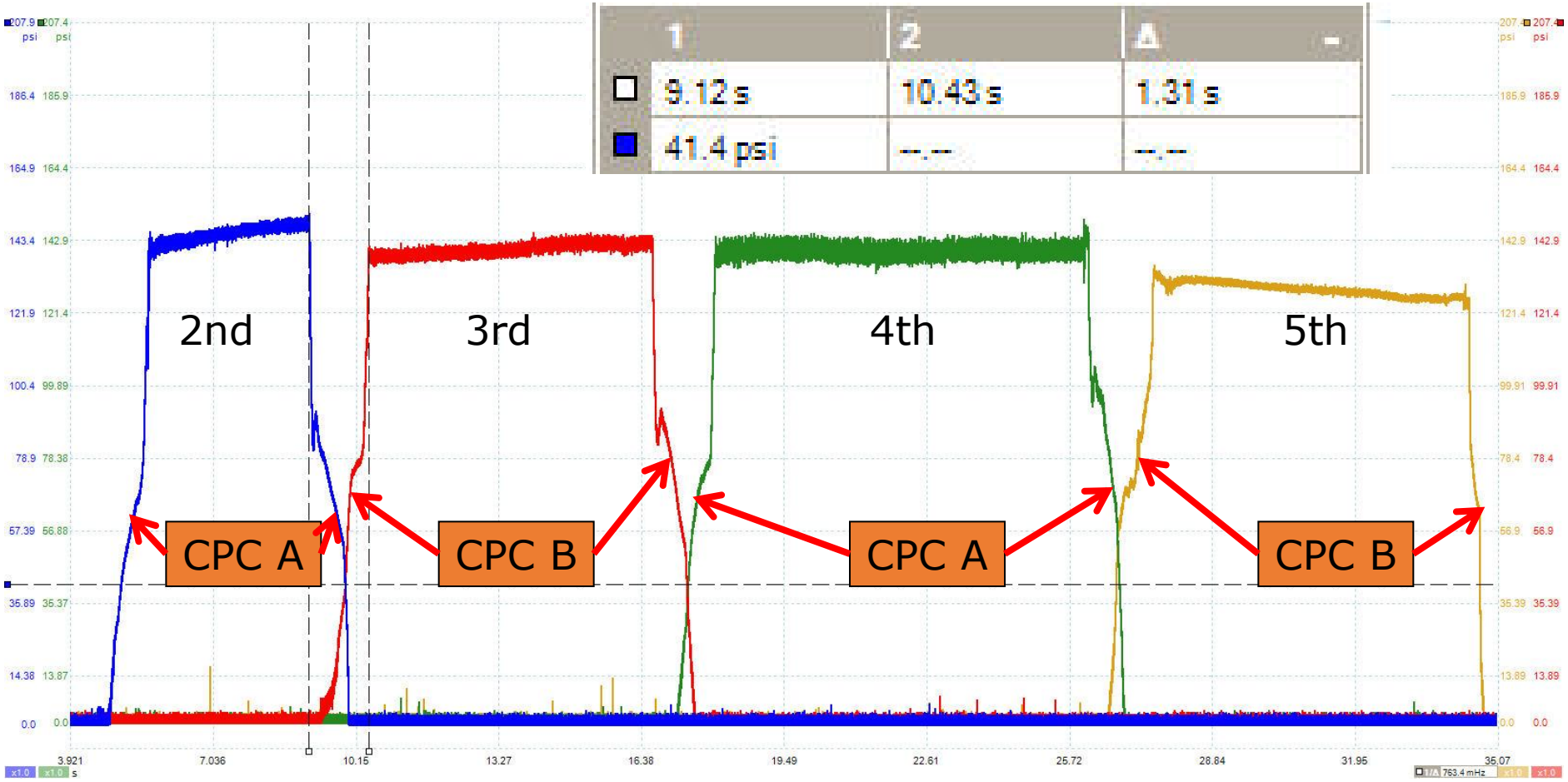
Evolution – Advanced yet simple hydraulics
42RLE 1-2 Shift



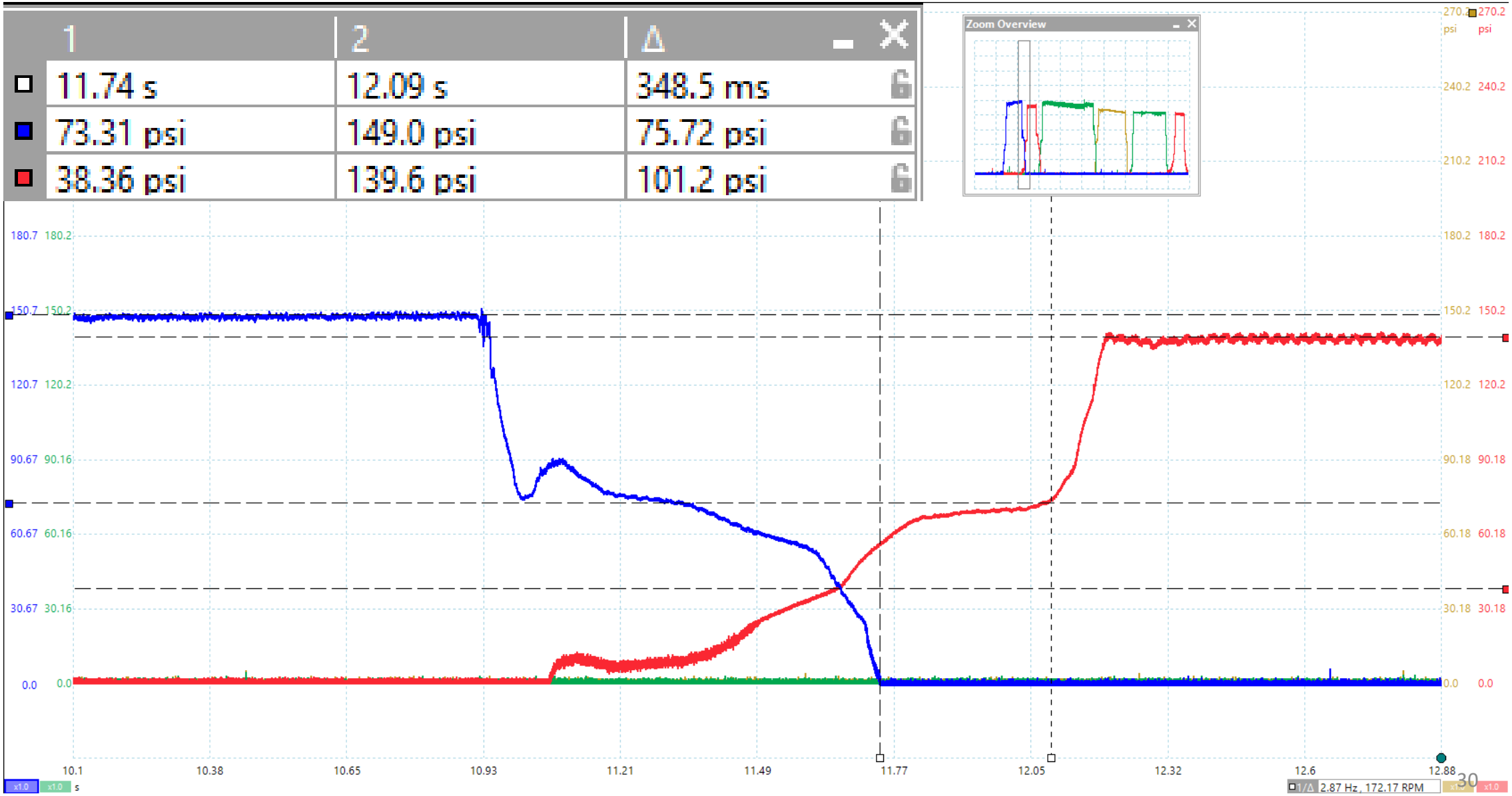


Valving/Solenoid Evolution
Honda/Acura

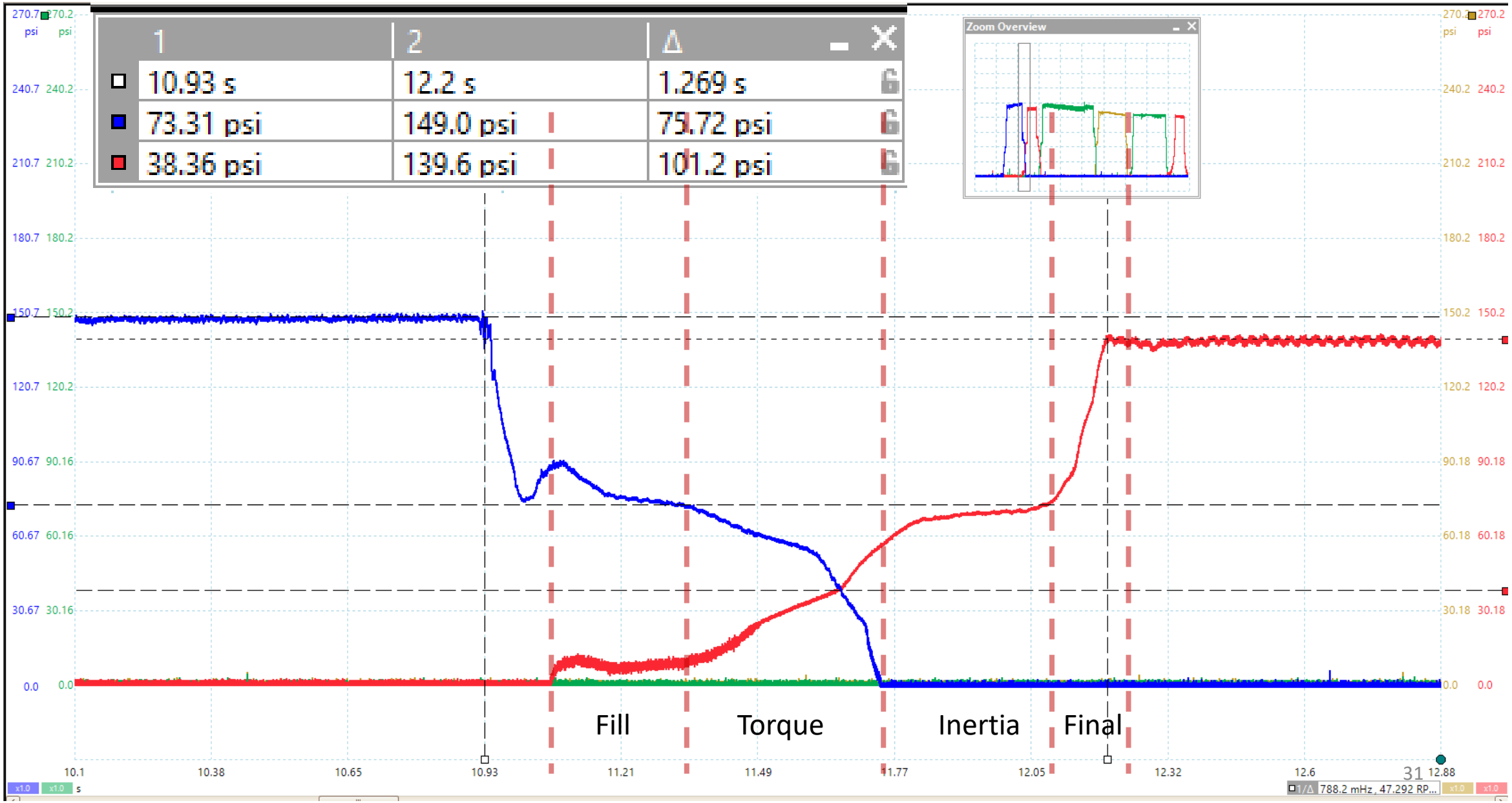
Evolution – More Advanced/Unnecessarily Complicated Honda/Acura 5-speed shifts



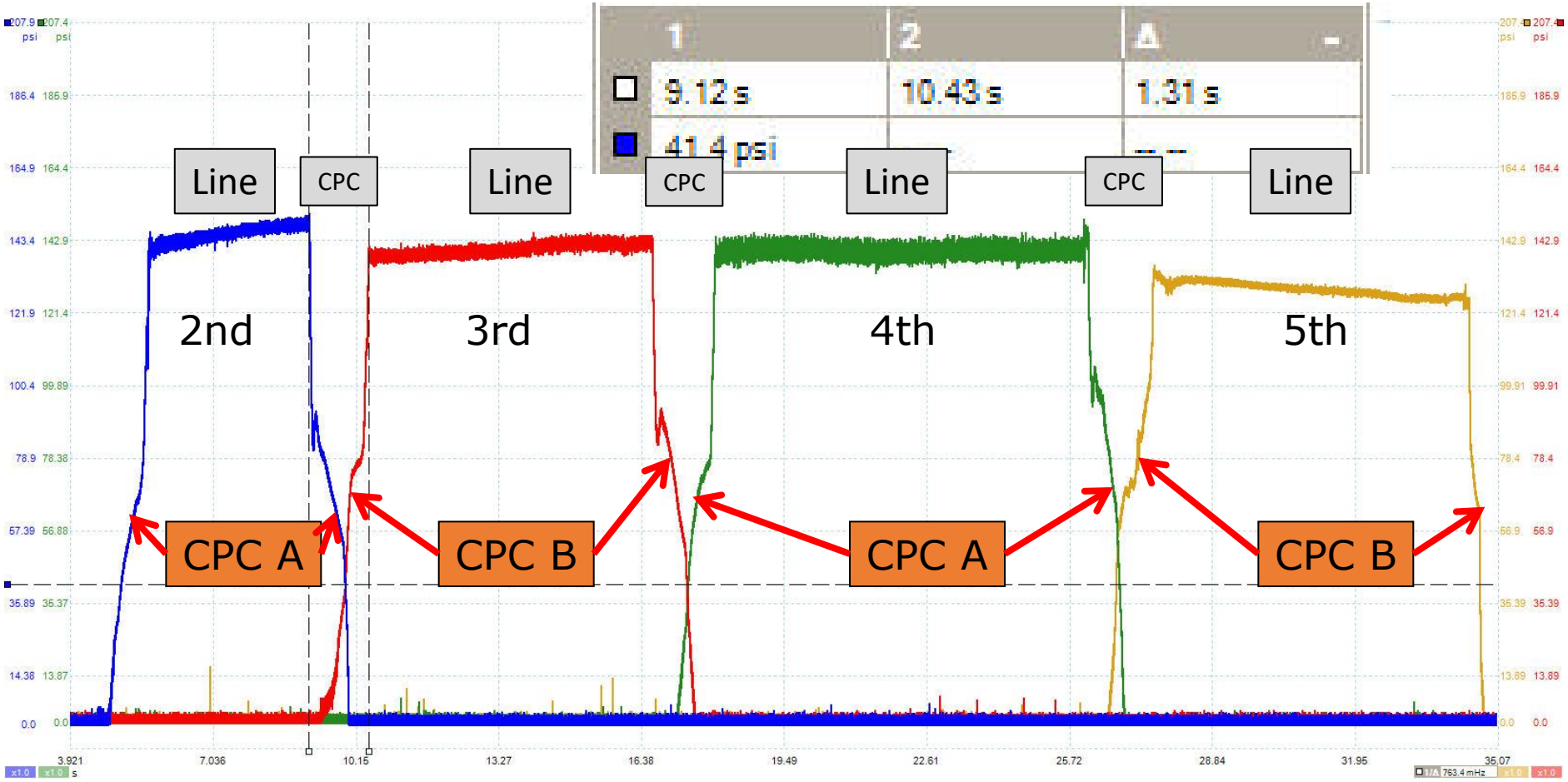
Honda/Acura 5-speed shifts



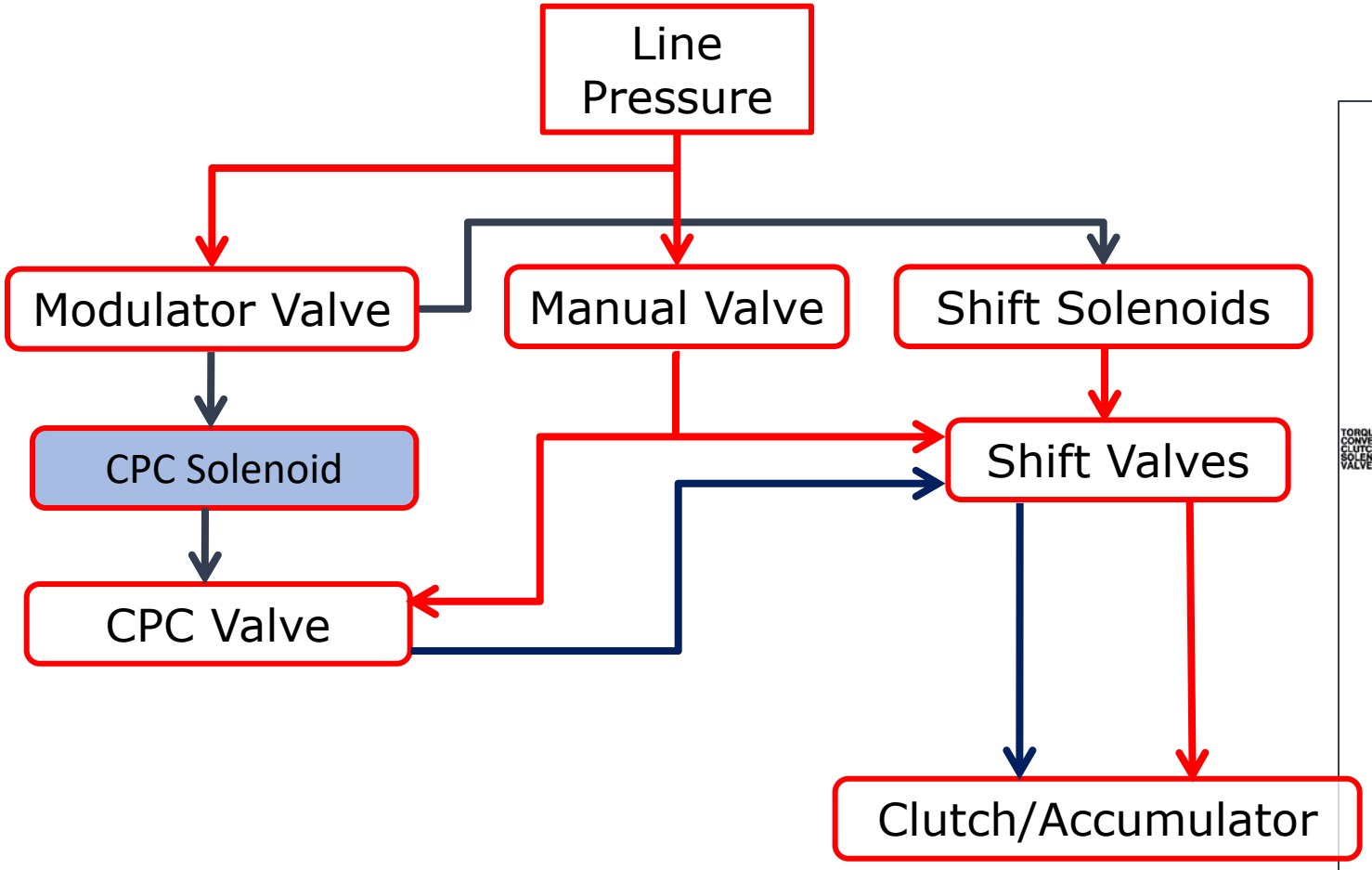
Honda/Acura 5-speed shifts



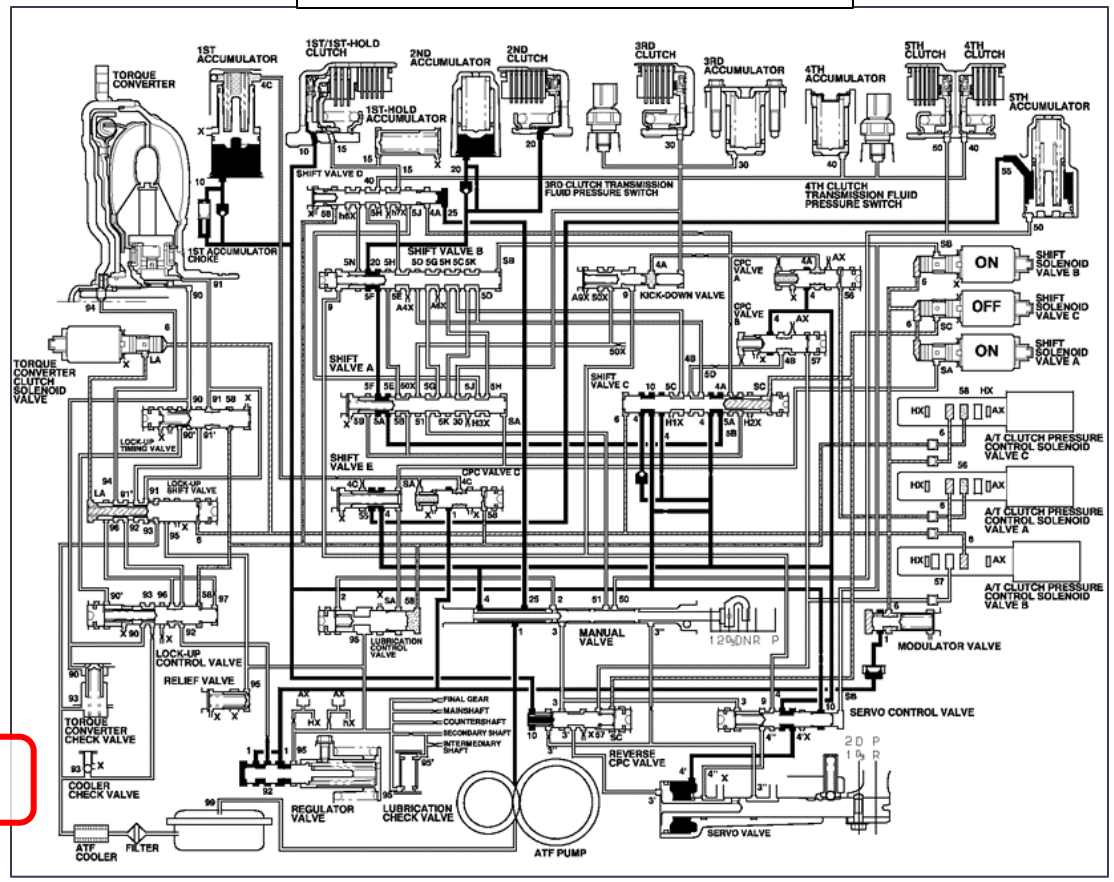
Honda/Acura 5-speed shifts



Honda Evolution: Clutch Pressure Control
1st Generation- Hydraulic Flow – Complicated

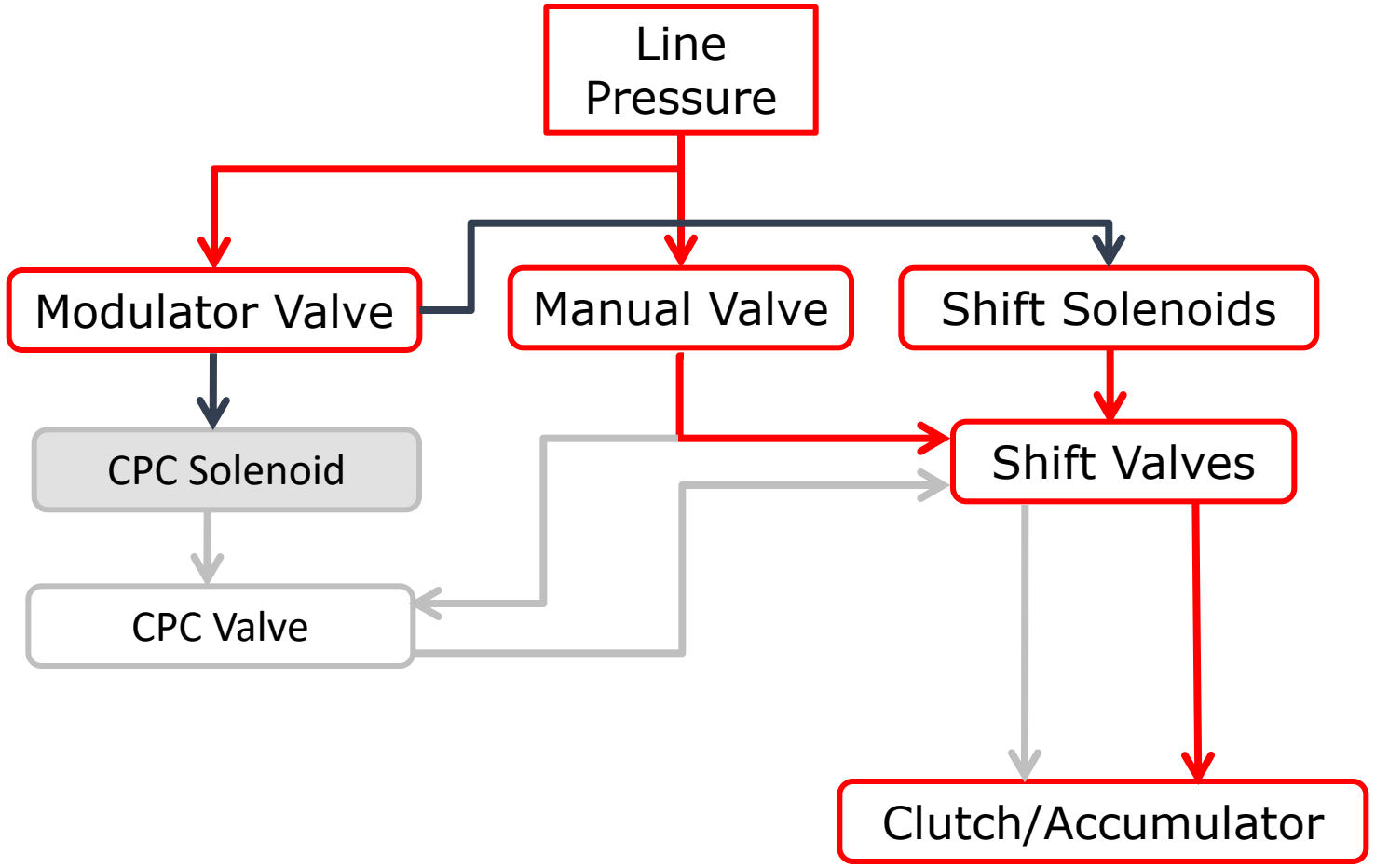


Example 2008 Honda Pilot



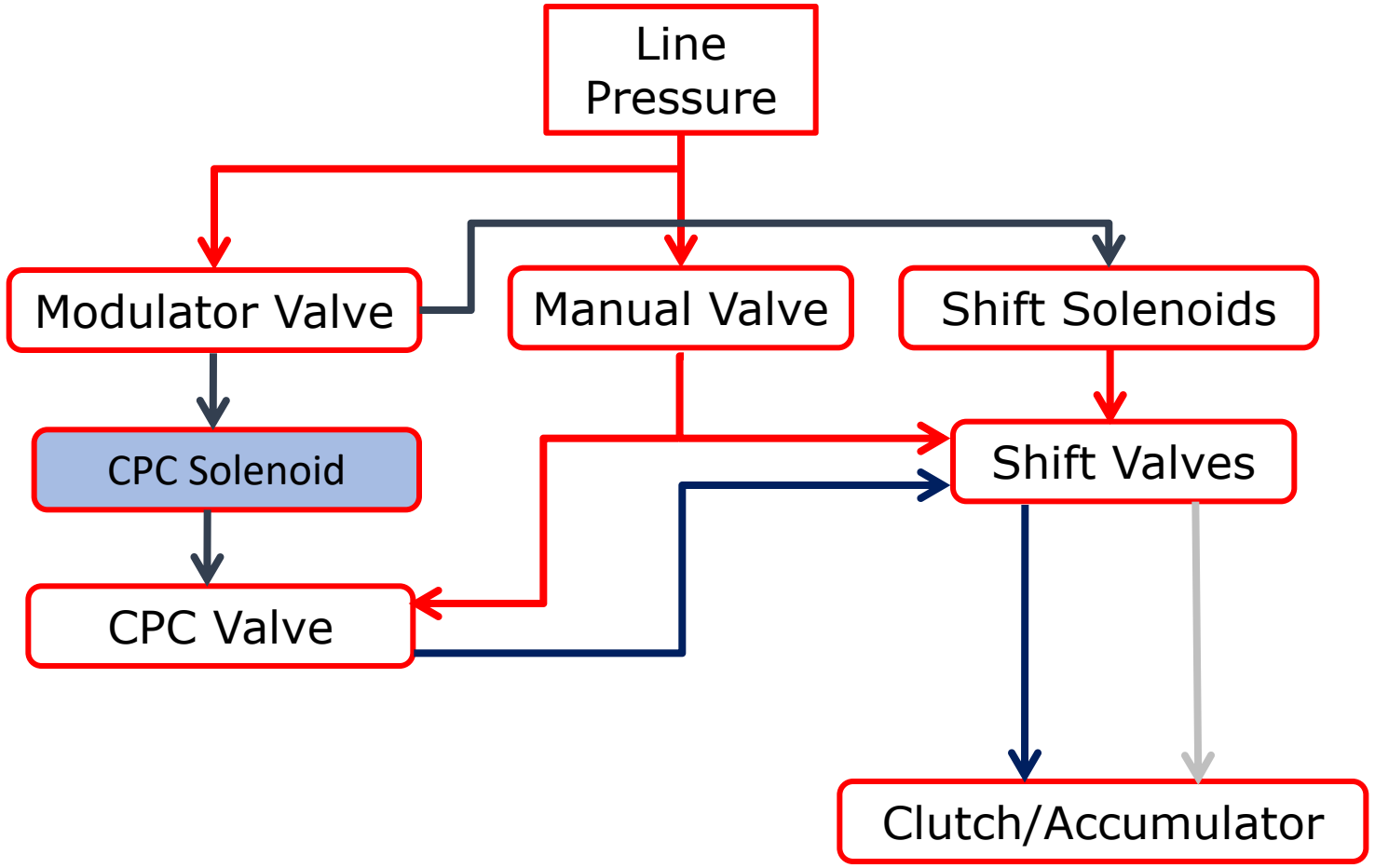
RED = Line Pressure DK Blue = Modulator Pressure

Honda Evolution: Clutch Pressure Control
1st Generation- Hydraulic Flow Chart – **In-Gear Situation**



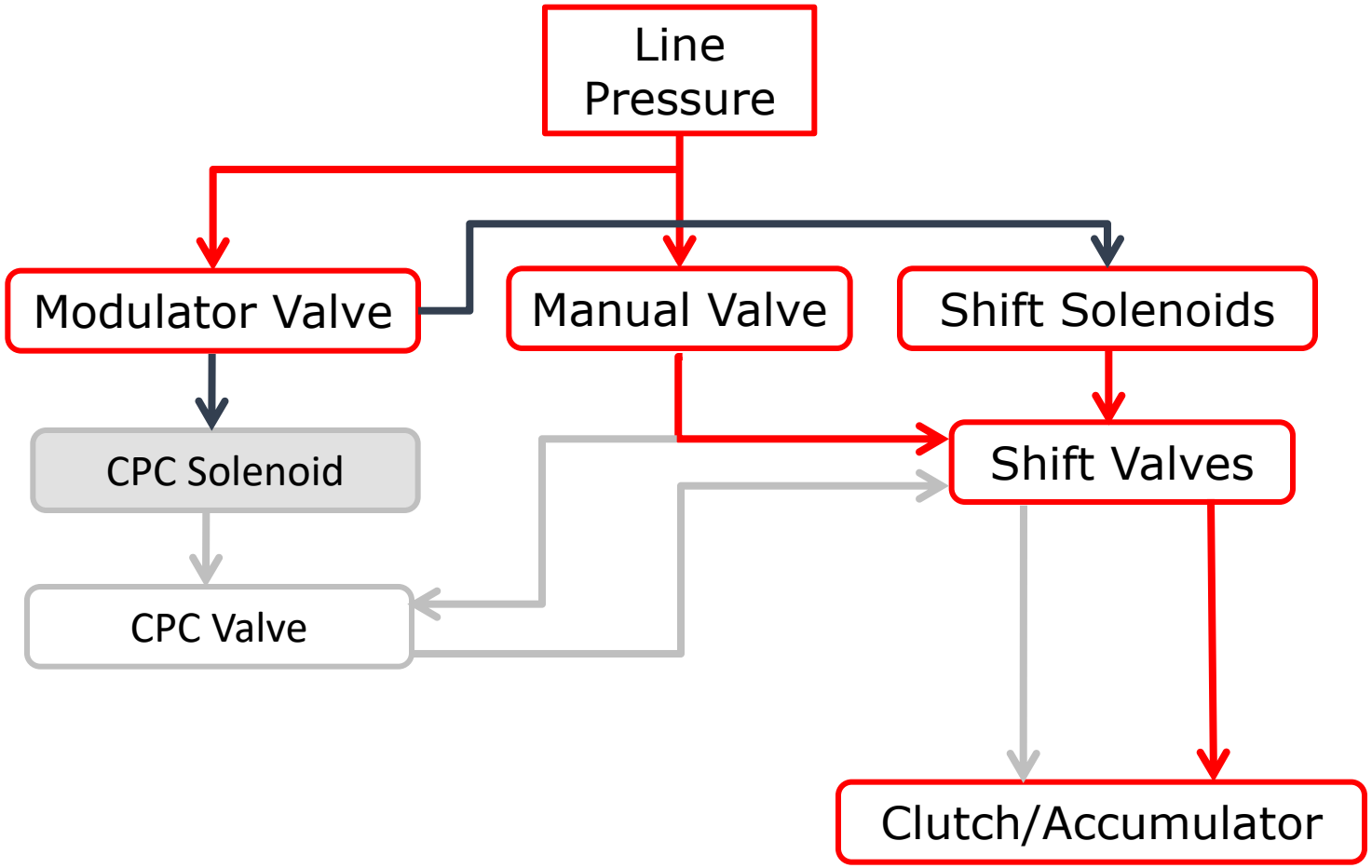
RED = Line Pressure DK Blue = Modulator Pressure

Honda Evolution: Clutch Pressure Control
1st Generation- Hydraulic Flow Chart – **During a shift**



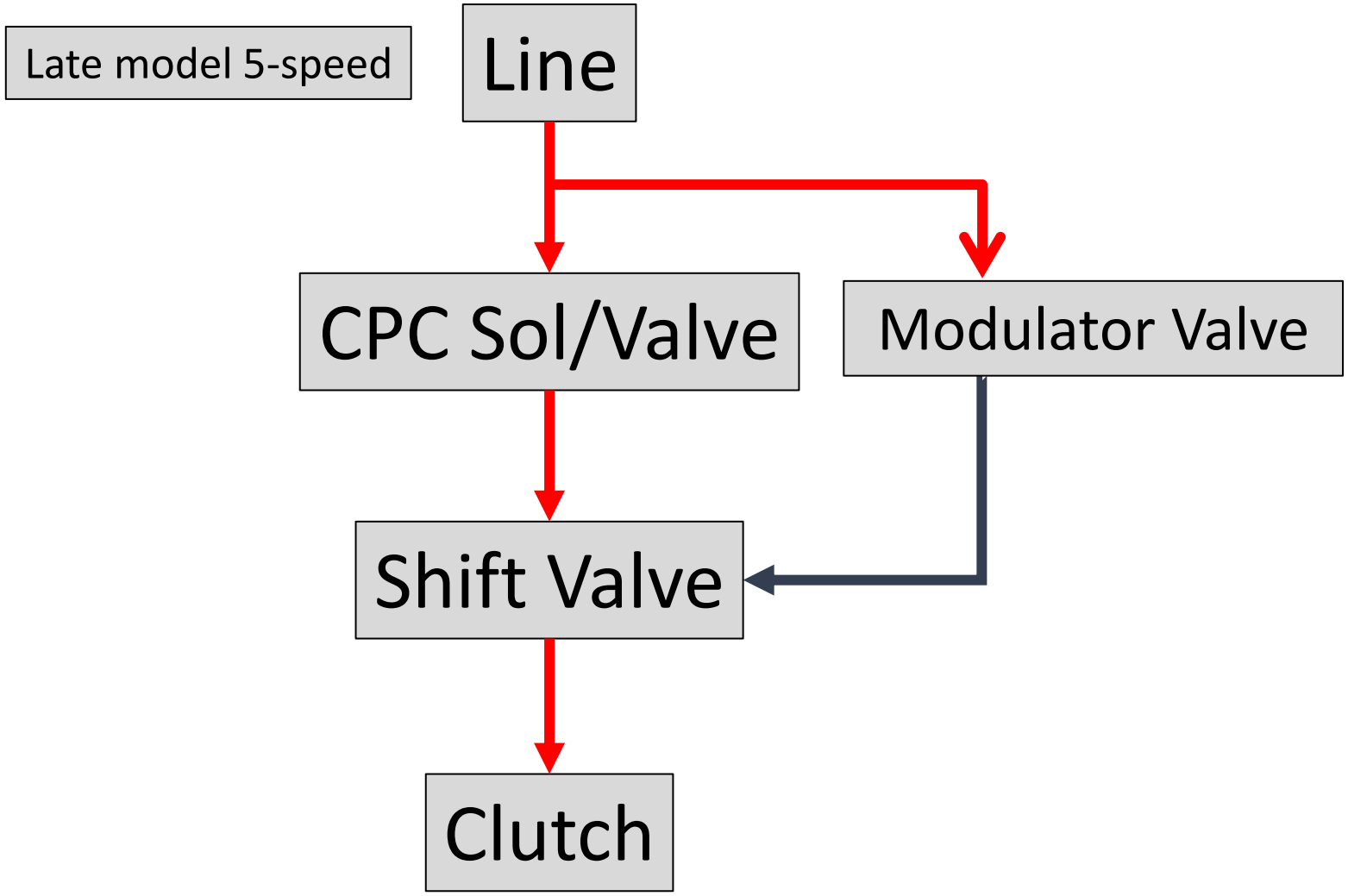
RED = Line Pressure DK Blue = Modulator Pressure

Honda Evolution: Clutch Pressure Control
1st Generation- Hydraulic Flow Chart – **After Shift**



RED = Line Pressure DK Blue = Modulator Pressure

Honda Evolution: Clutch Pressure Control
2nd Generation- Hydraulic Flow Chart – Less complicated



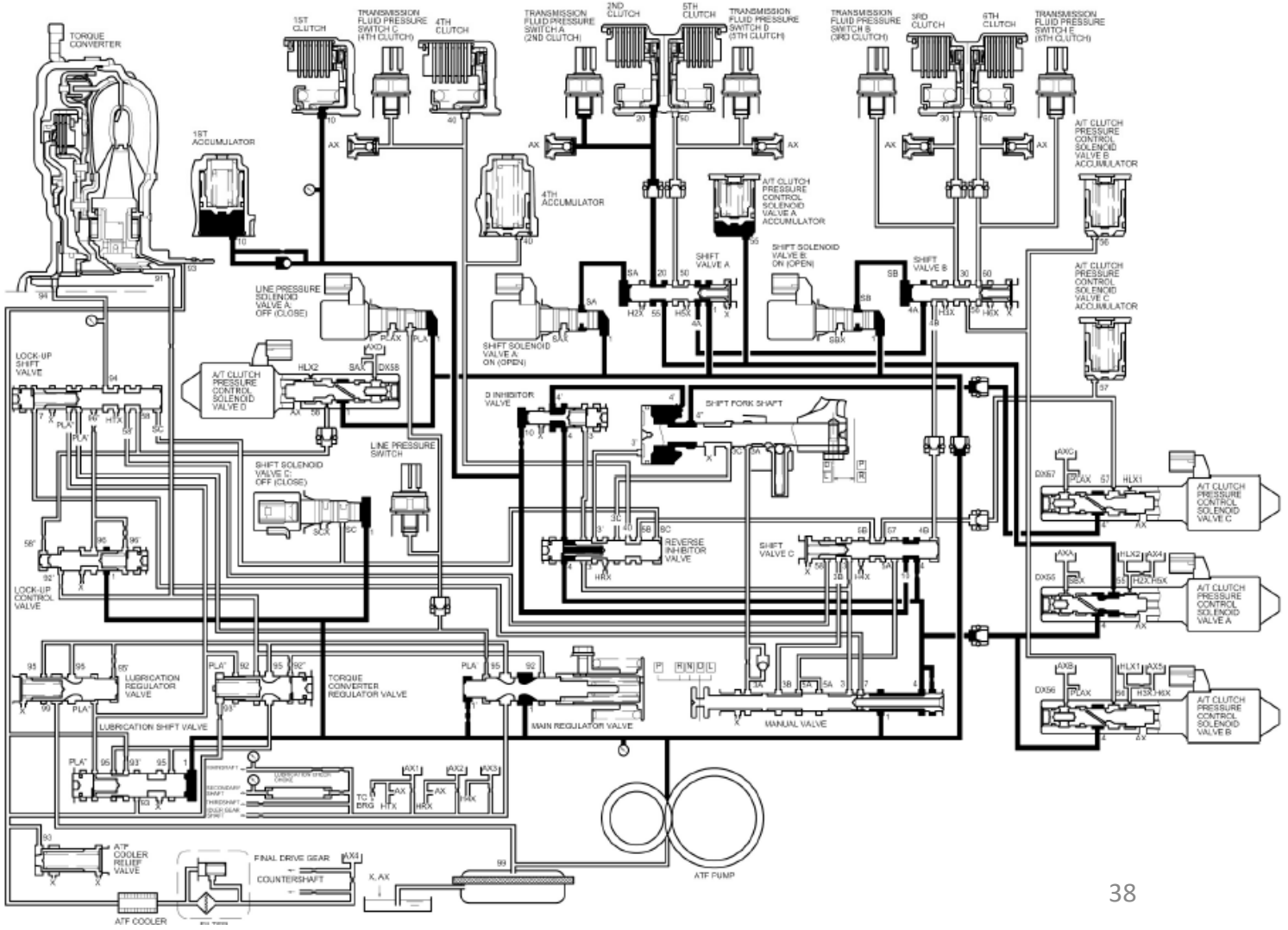
Honda Evolution: Clutch Pressure Control 3rd Generation- 6 – speed - Hydraulic Flow Chart

6-speed

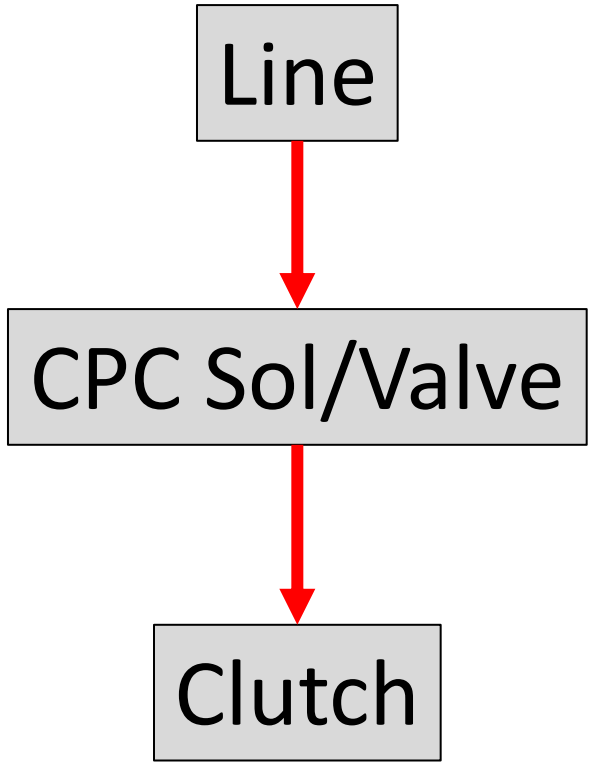
Line

CPC Sol/Valve

Clutch



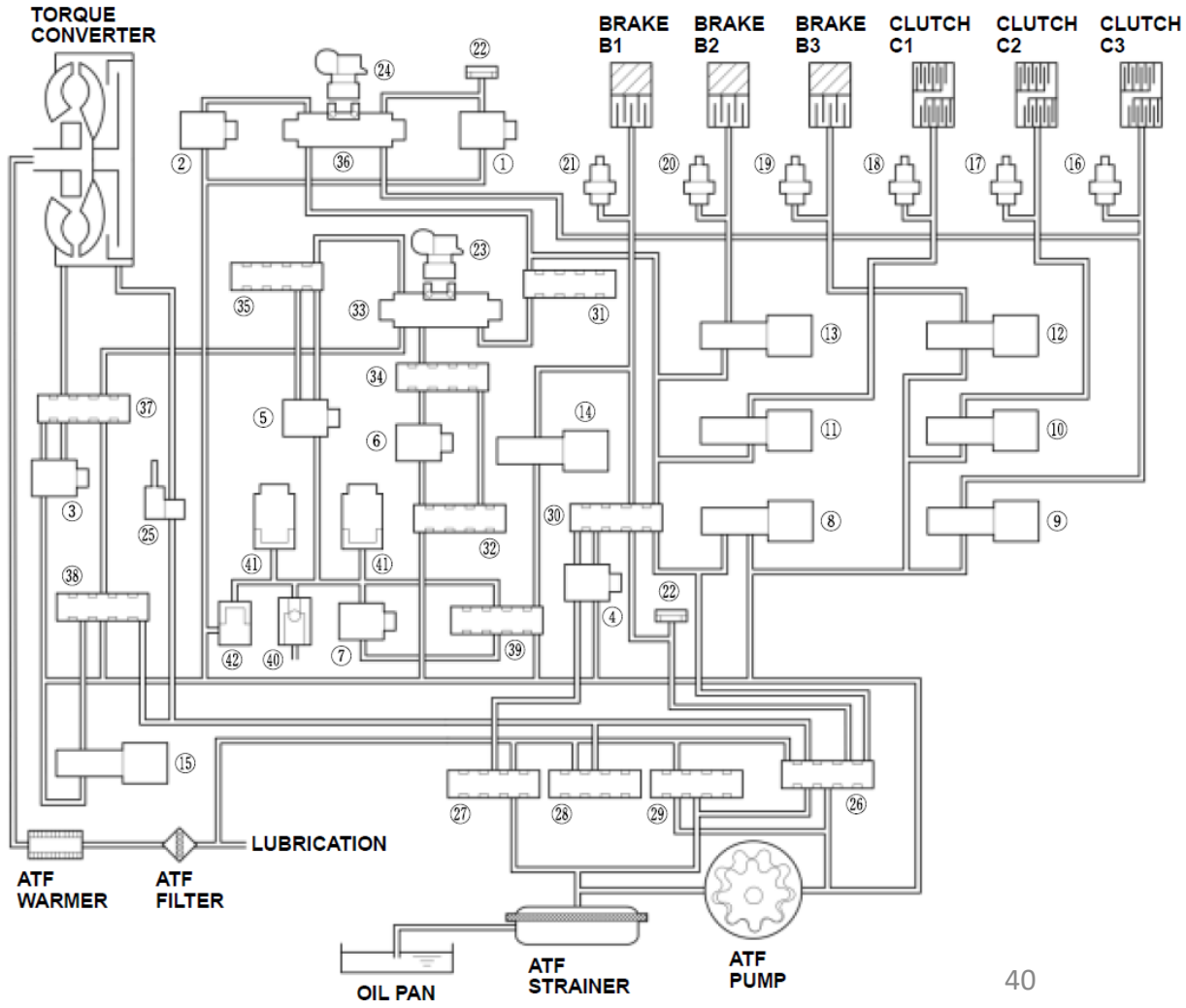
Honda Evolution: Clutch Pressure Control 3rd Generation- 6 – speed - Hydraulic Flow Chart

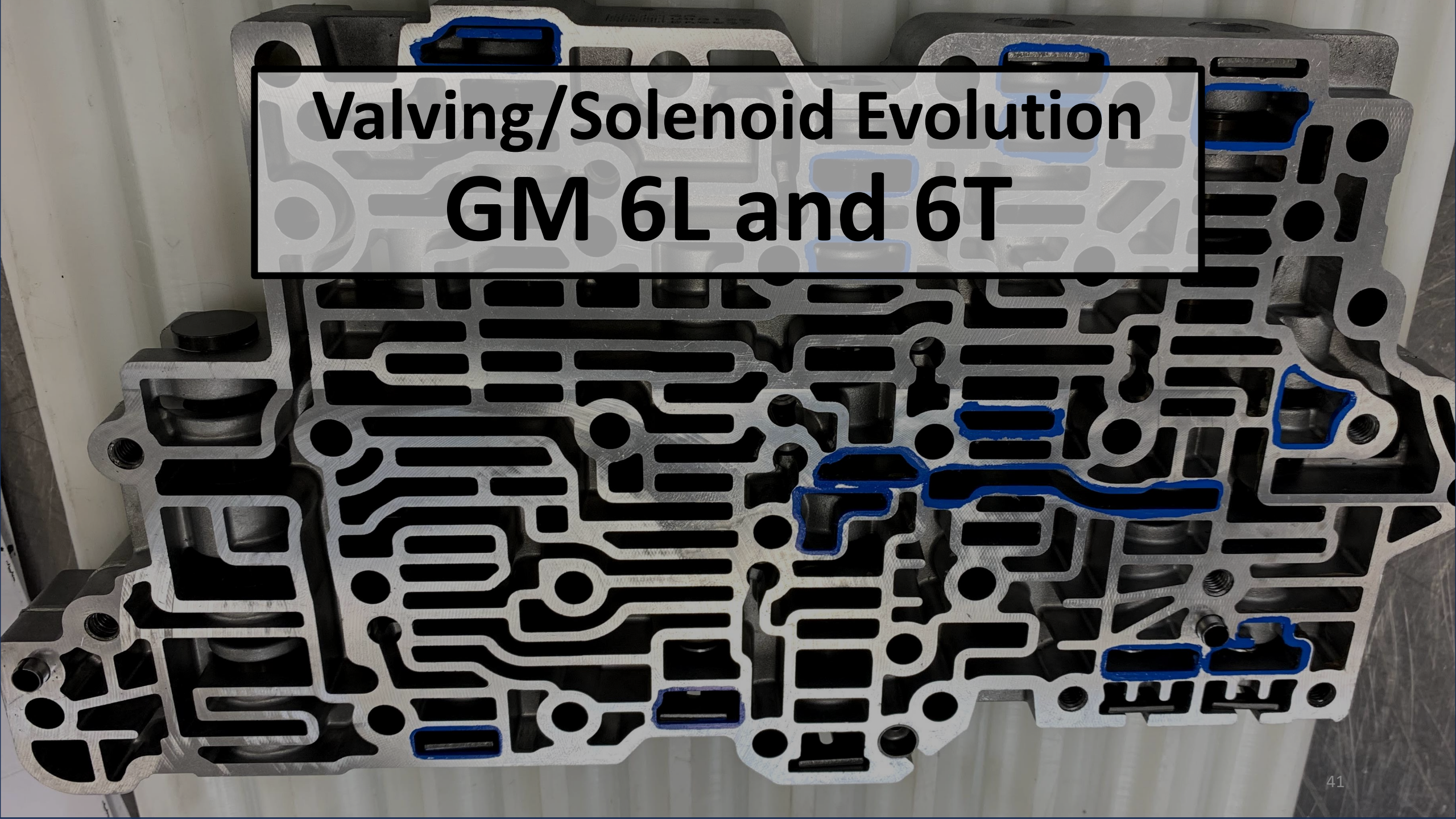


Shift Lever Position	P	R	N	D, L		D			
				1st	2nd	3rd	4th	5th	6th
Shift solenoid valve A	ON	OFF	ON	ON	ON	OFF	OFF	OFF	OFF
Shift solenoid valve B	OFF	OFF	OFF	ON	ON	ON	ON or OFF	ON or OFF	OFF
Shift solenoid valve C	ON	ON	OFF	ON or OFF	ON or OFF	ON or OFF	ON or OFF	ON or OFF	ON or OFF
Line pressure solenoid valve A	ON or OFF	ON or OFF	ON or OFF	ON or OFF	ON or OFF	ON or OFF	ON or OFF	ON or OFF	ON or OFF
A/T clutch pressure control solenoid valve A	OFF	OFF	OFF	OFF	ON	OFF	OFF	ON	OFF
A/T clutch pressure control solenoid valve B	OFF	OFF	OFF	OFF	OFF	ON	OFF	OFF	ON
A/T clutch pressure control solenoid valve C	OFF	OFF	OFF	OFF	OFF	OFF	ON	OFF	OFF
A/T clutch pressure control solenoid valve D	OFF	ON	OFF	ON or OFF	ON or OFF	ON or OFF	ON or OFF	ON or OFF	ON or OFF

Honda Evolution: Clutch Pressure Control 4th Generation – 10-speed - Hydraulic Flow Chart

- Honda's 10-speed hyd diagram leaves much to be desired
- CPC solenoids manipulate line pressure to the clutches, similar to Gen 3

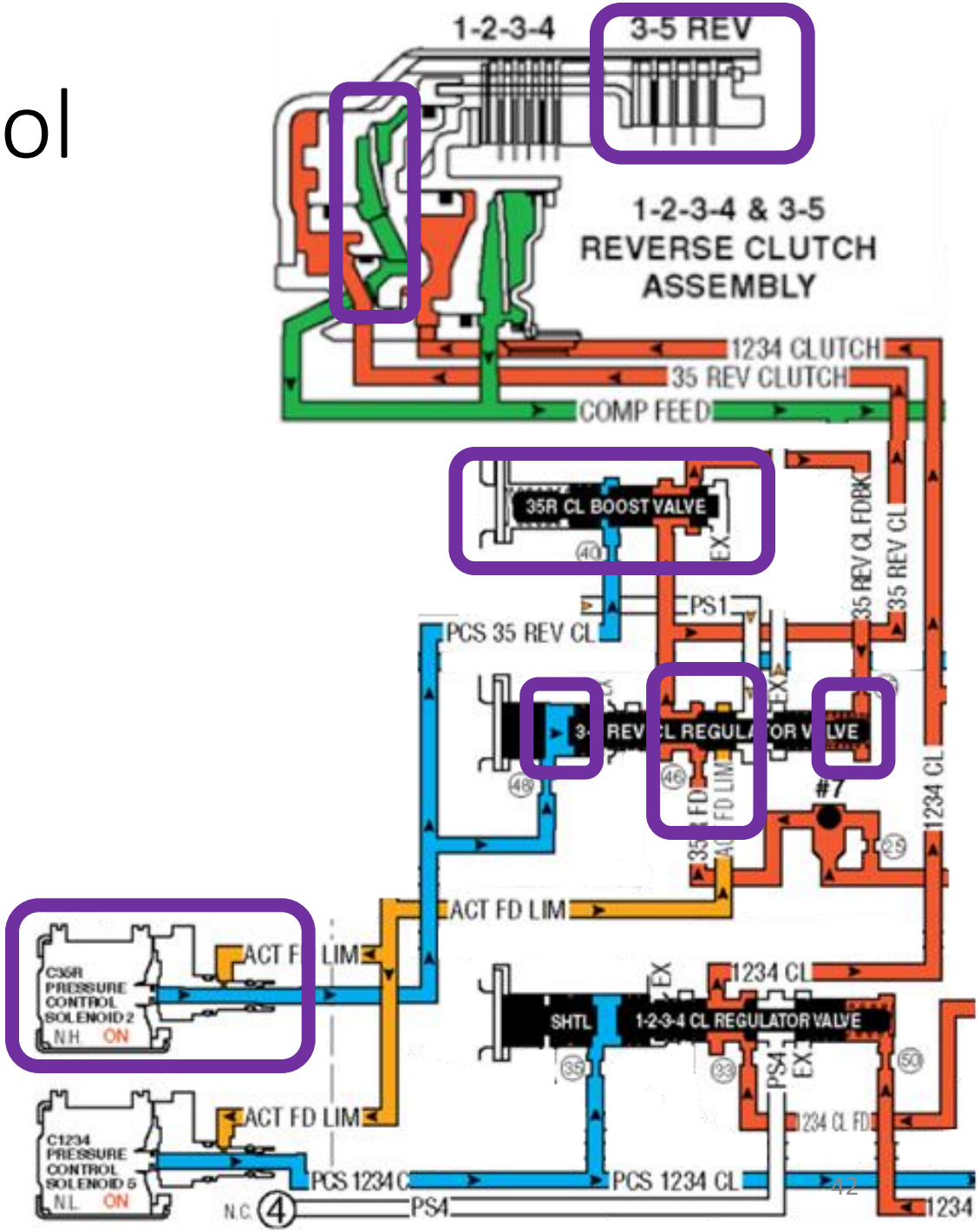




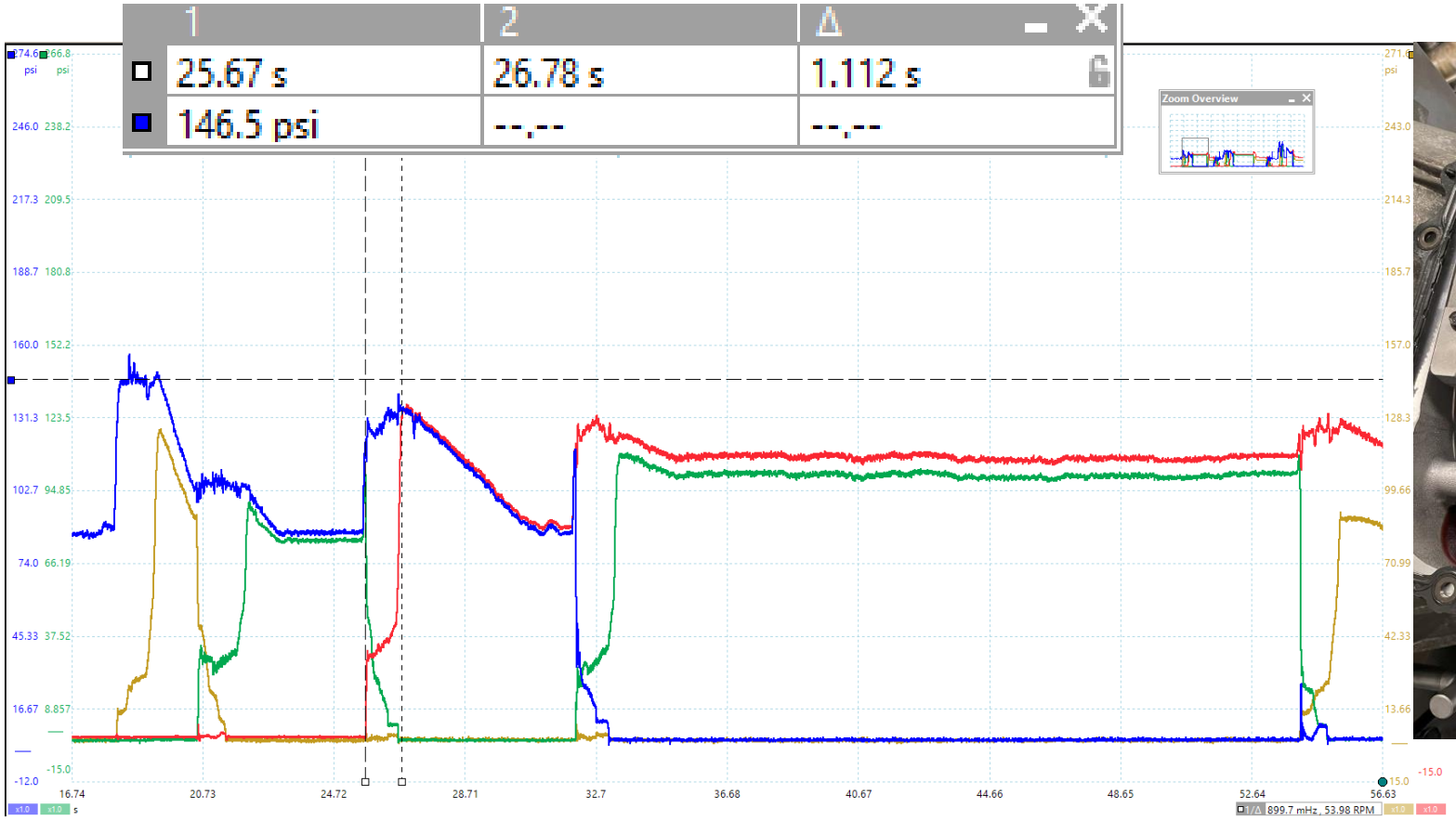
Valving/Solenoid Evolution
GM 6L and 6T

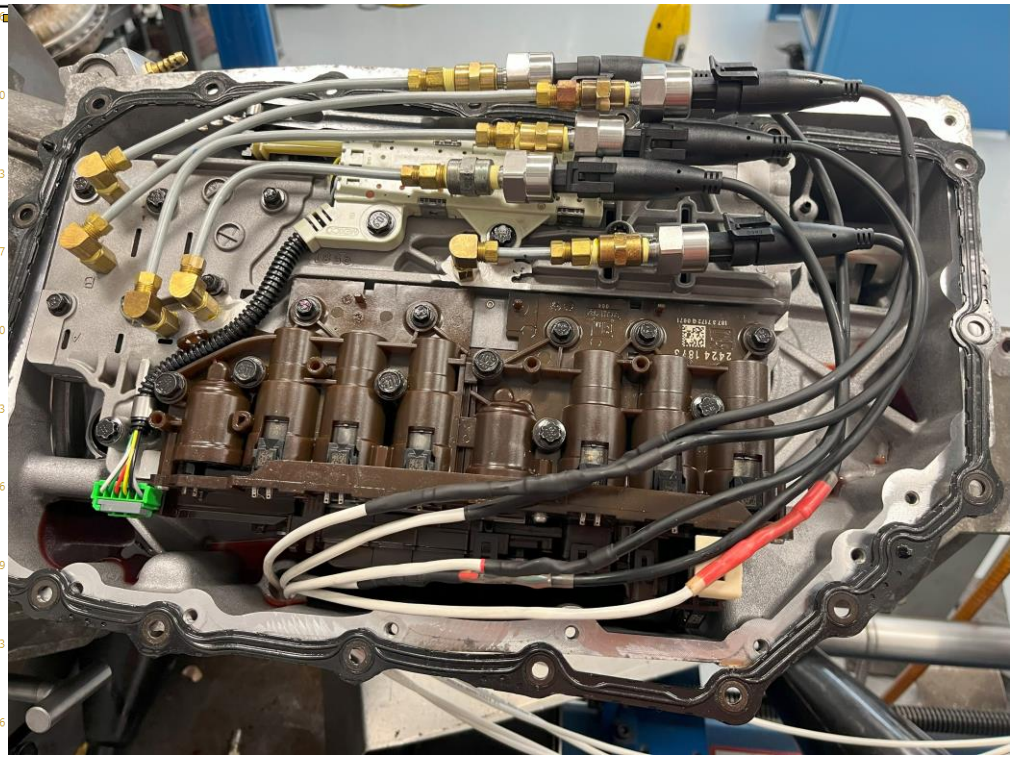
6L80 Third Gear Shift Control

- Orifice
- Solenoid
  - Clutch regulator valve
    - Boost valve
- Return spring
- Balance pressure
- Wave plate

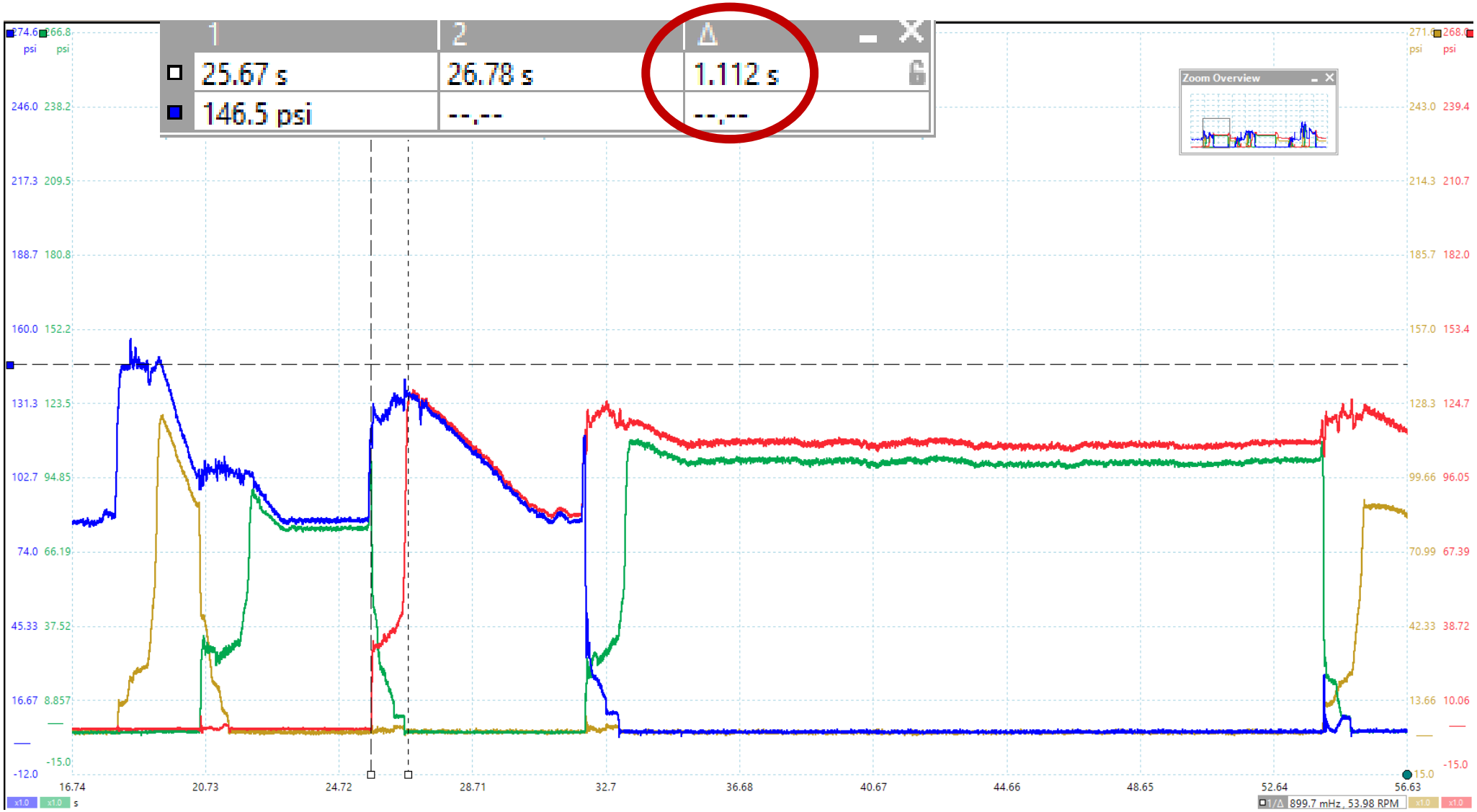


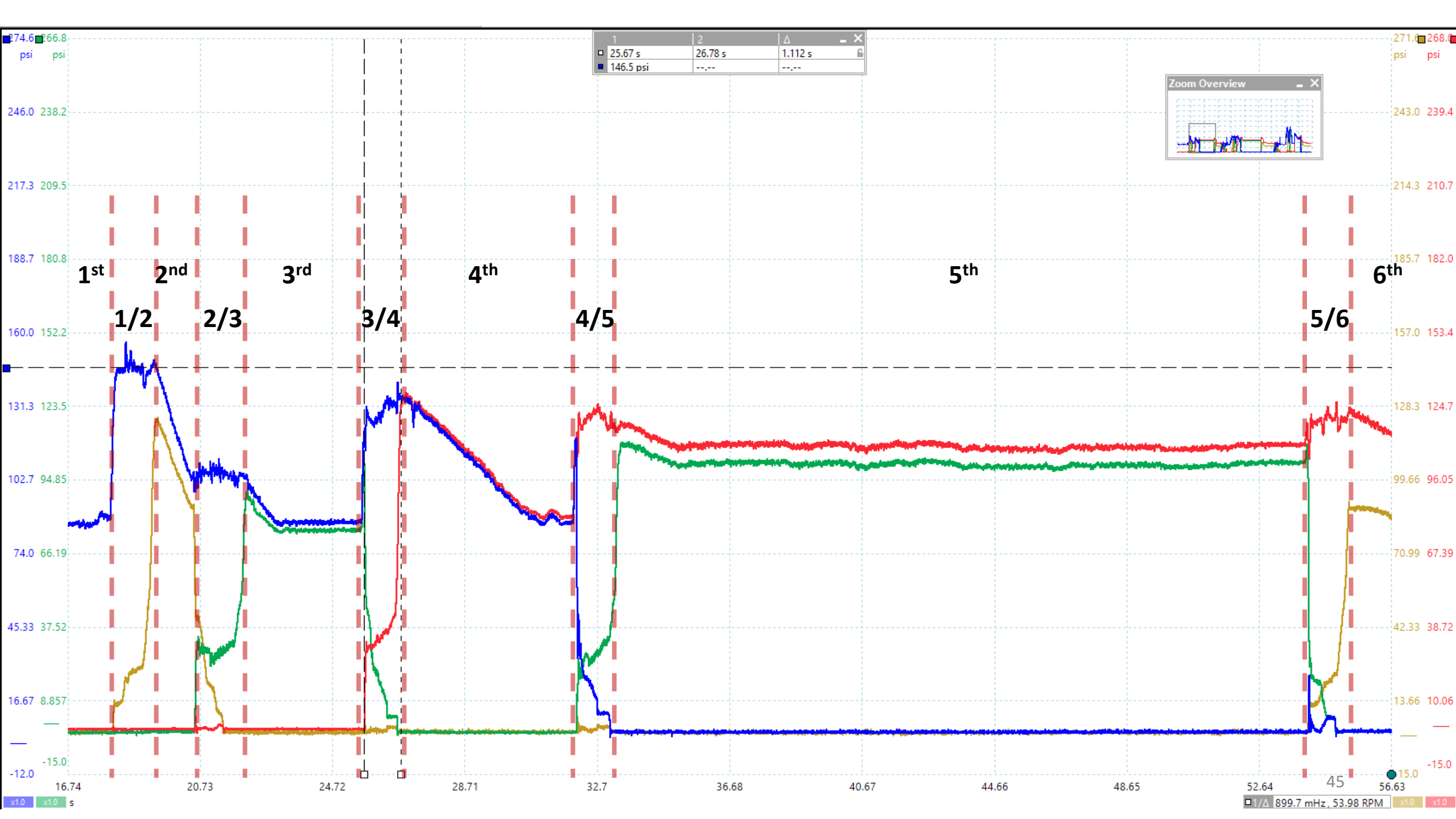
6L80 Upshift through 6th Gear



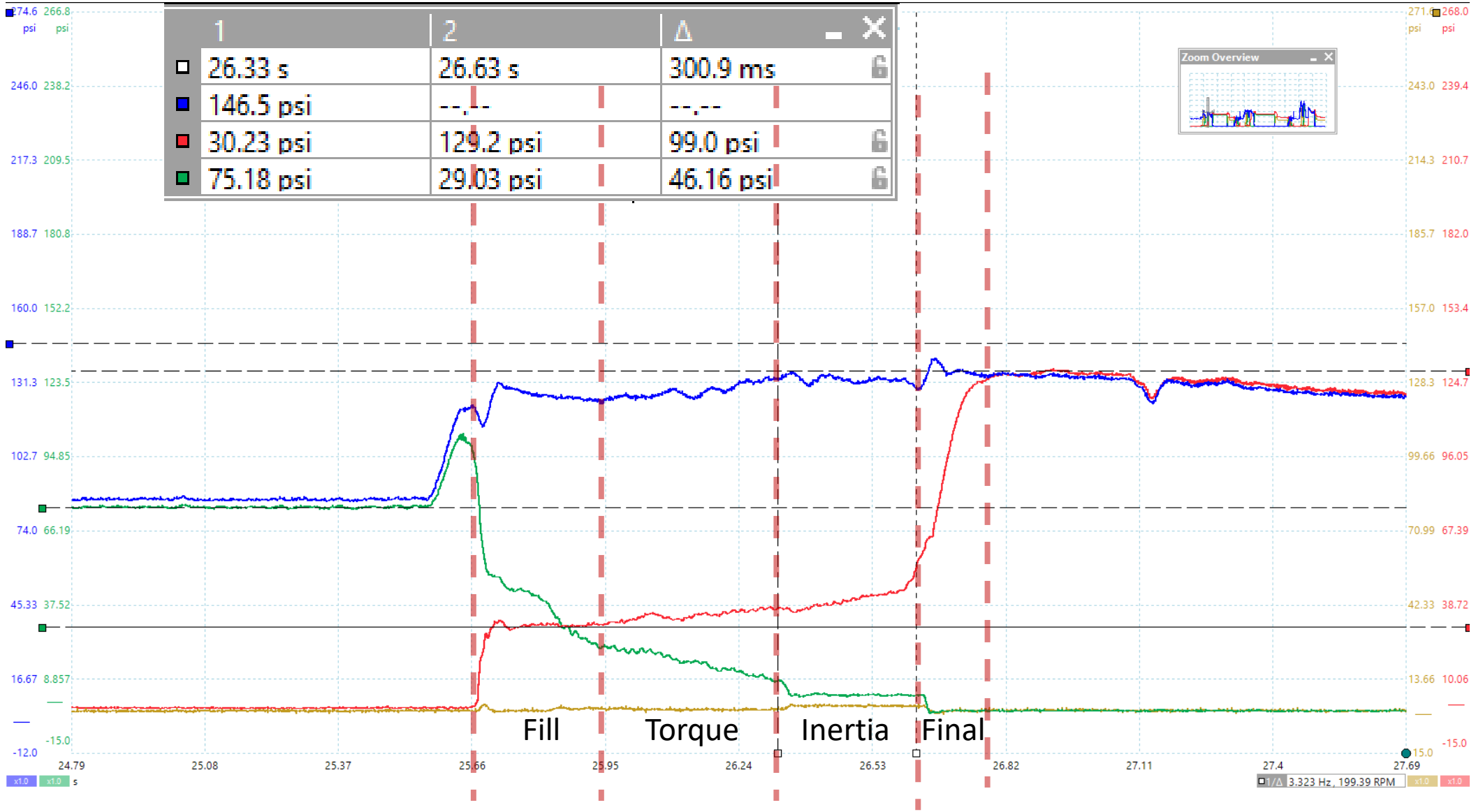


6L80 Upshift through 6th Gear

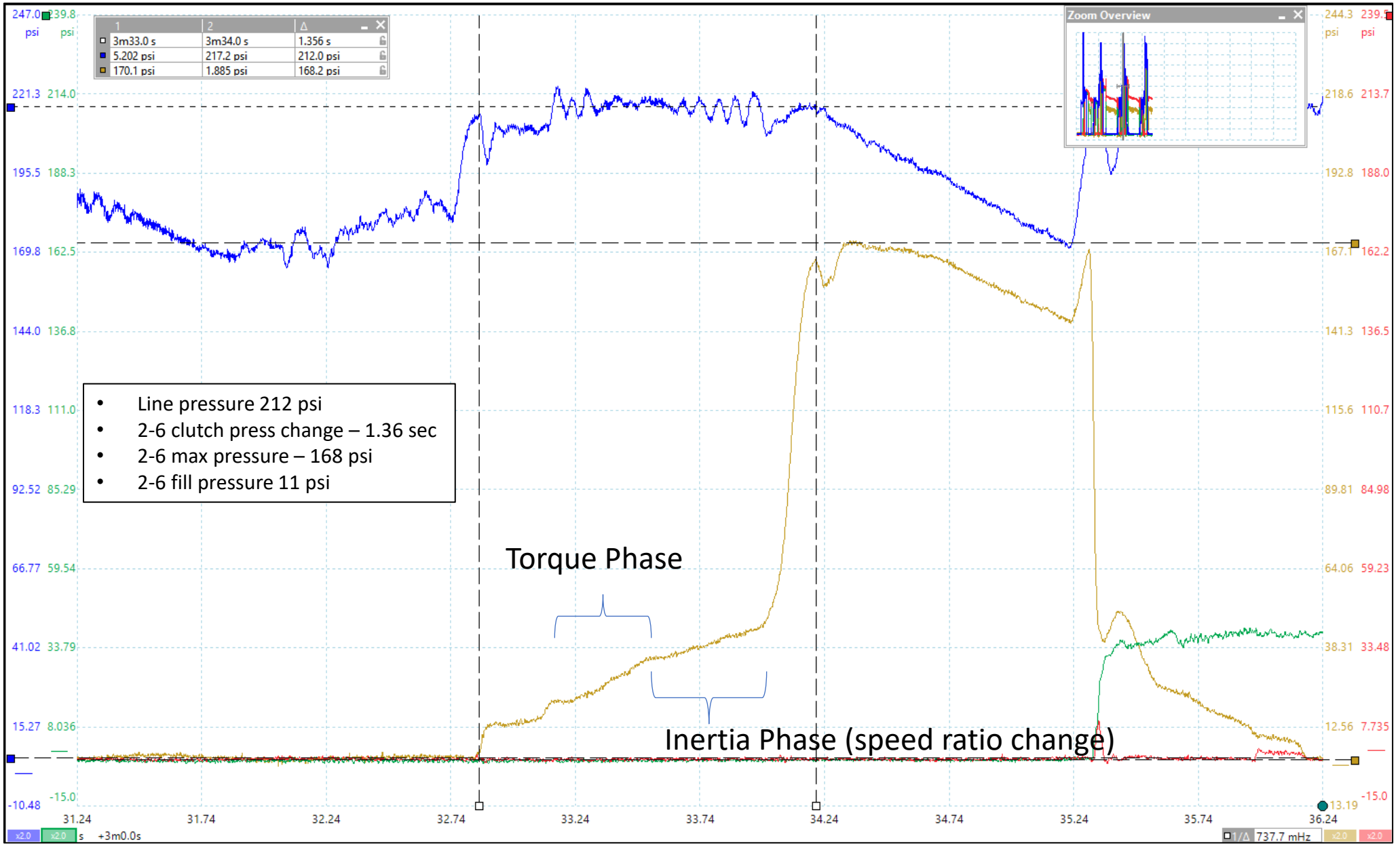



1
2
Δ
25.67 s
26.78 s
1.112 s
146.5 psi
--.--
--.--
Zoom Overview
1st
2nd
3rd
4th
5th
6th
1/2
2/3
3/4
4/5
5/6
274.6 266.8 psi psi
246.0 238.2
217.3 209.5
188.7 180.8
160.0 152.2
131.3 123.5
102.7 94.85
74.0 66.19
45.33 37.52
16.67 8.857
-12.0 -15.0
271.6 268.0 psi psi
243.0 239.4
214.3 210.7
185.7 182.0
157.0 153.4
128.3 124.7
99.66 96.05
70.99 67.39
42.33 38.72
13.66 10.06
15.0 -15.0
16.74
20.73
24.72
28.71
32.7
36.68
40.67
44.66
48.65
52.64
56.63
s
1/Δ 899.7 mHz, 53.98 RPM

6L80 3-4 Upshift

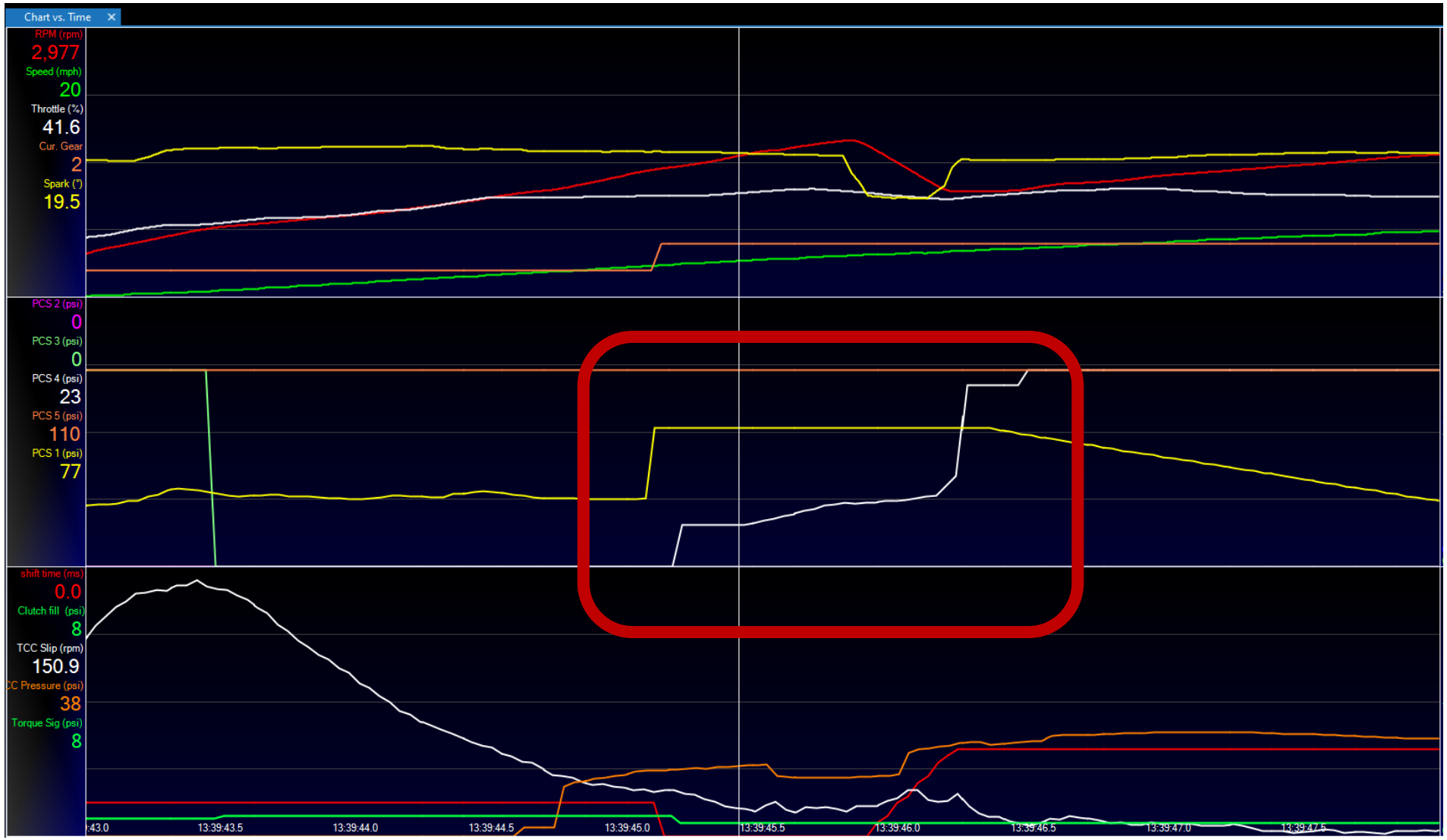


1-2 shift 40% throttle



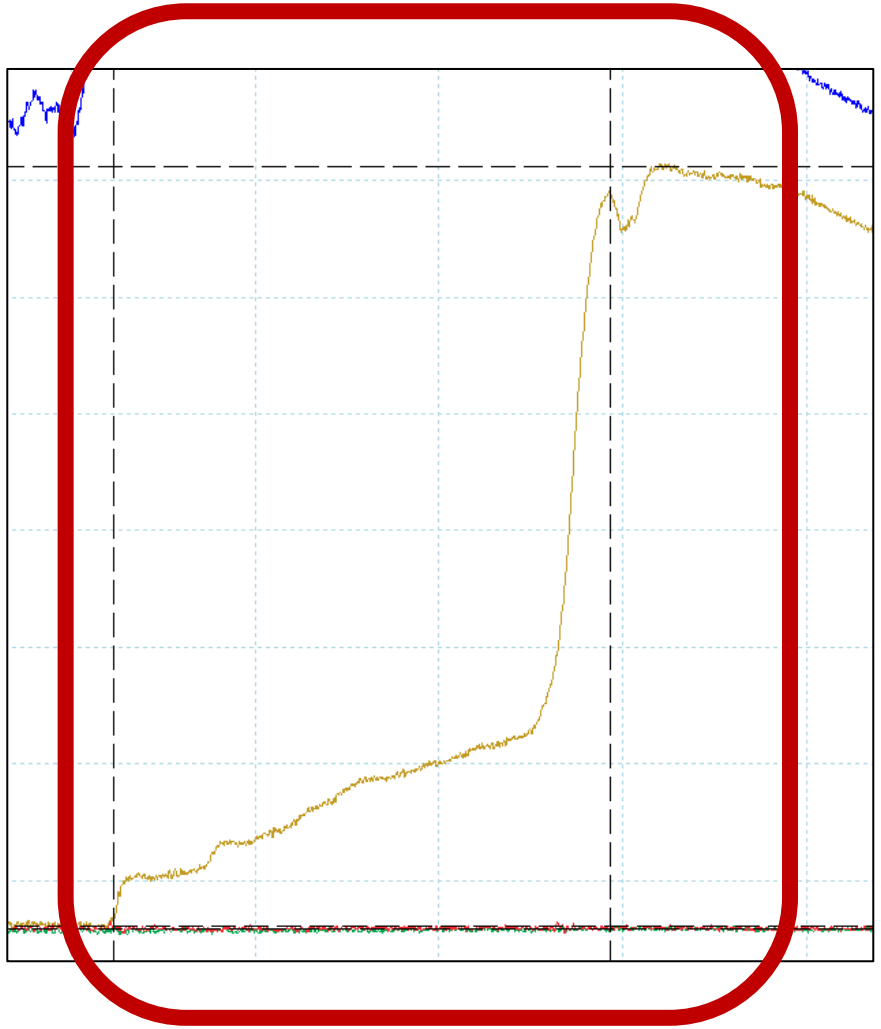
1-2 shift 40% throttle

The solenoids, as graphed on a scan tool, matches the pressure curves pretty close. It's not actual clutch pressure, but the shape of the pressure curve is spot on.

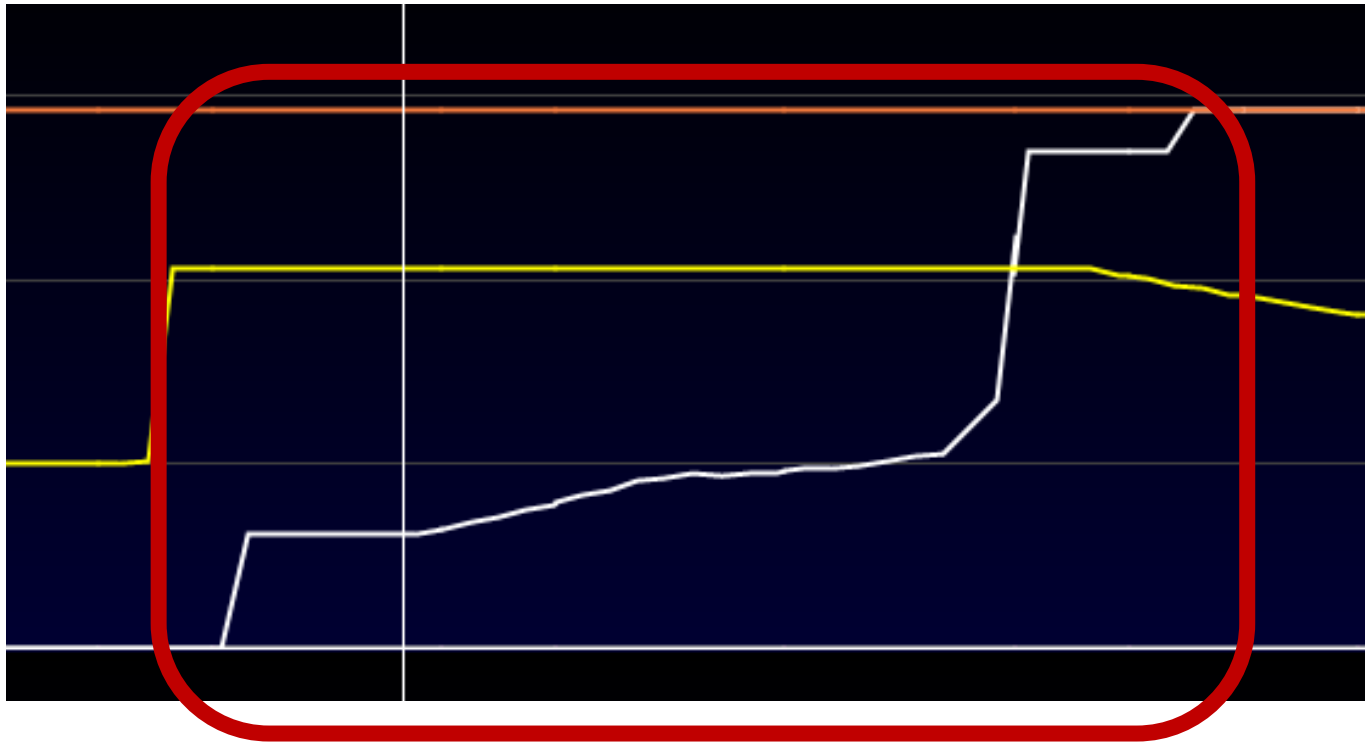


1-2 shift 40% throttle

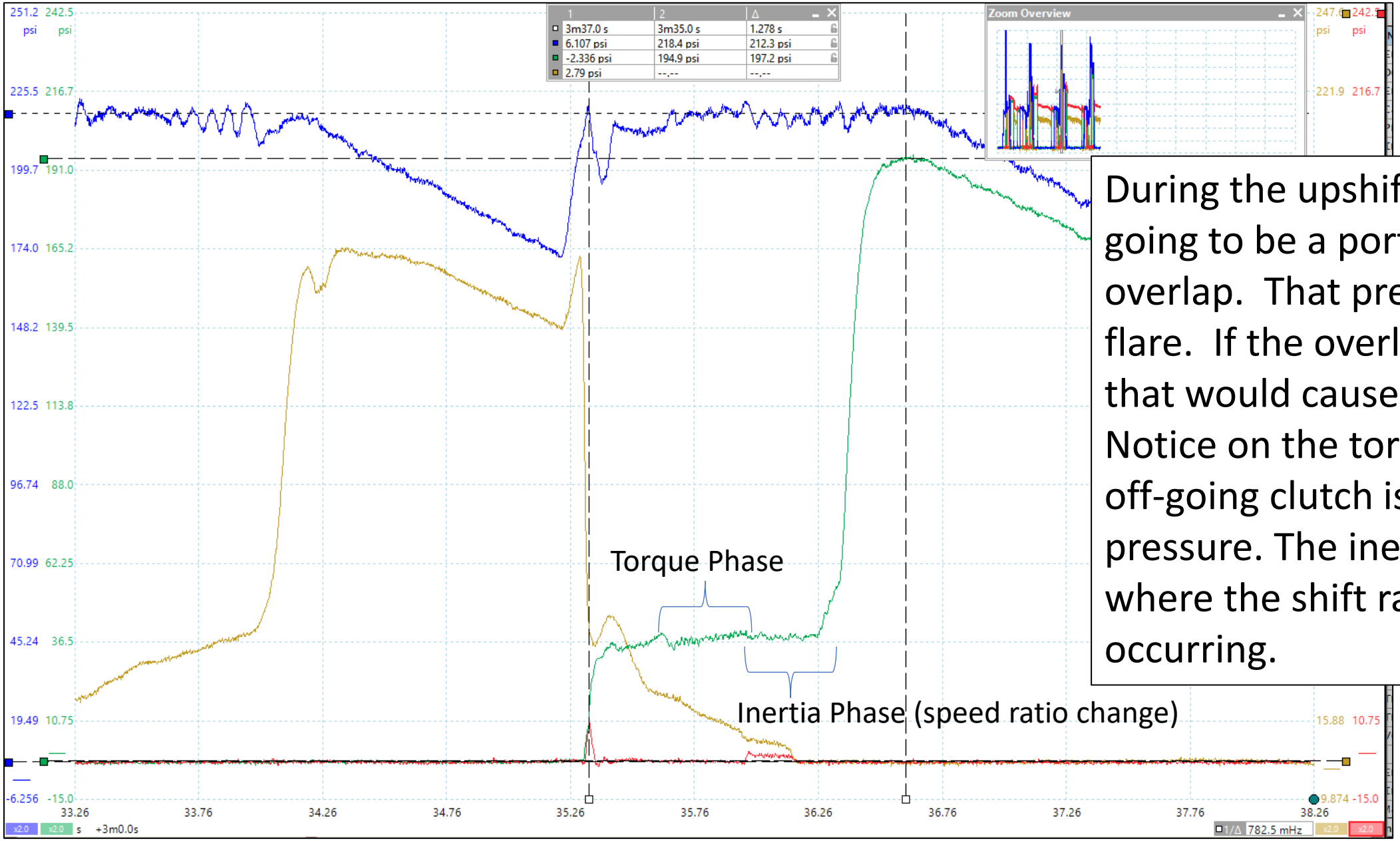
Actual Pressure



Solenoid command amperage

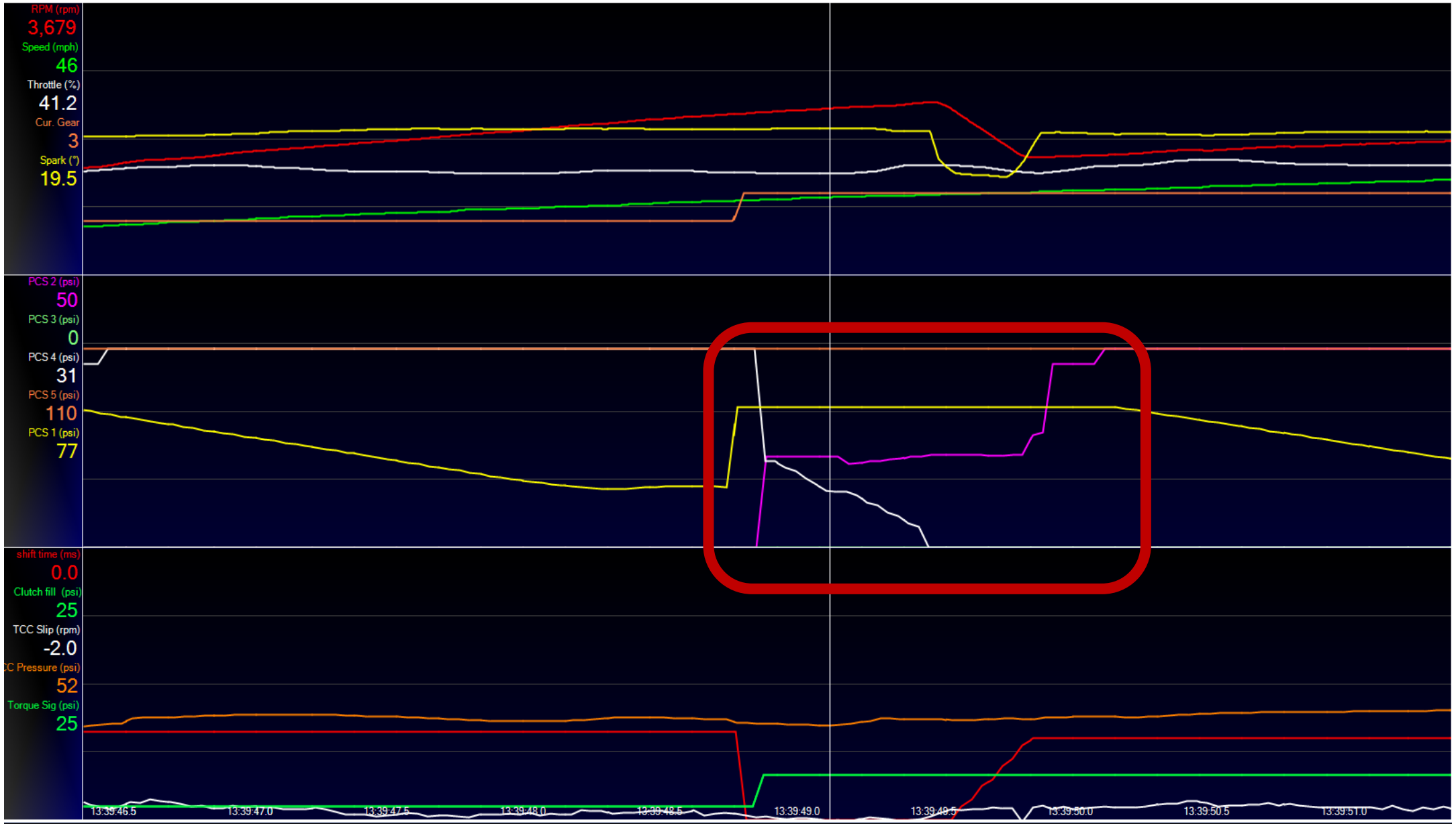


2-3 shift 40% throttle

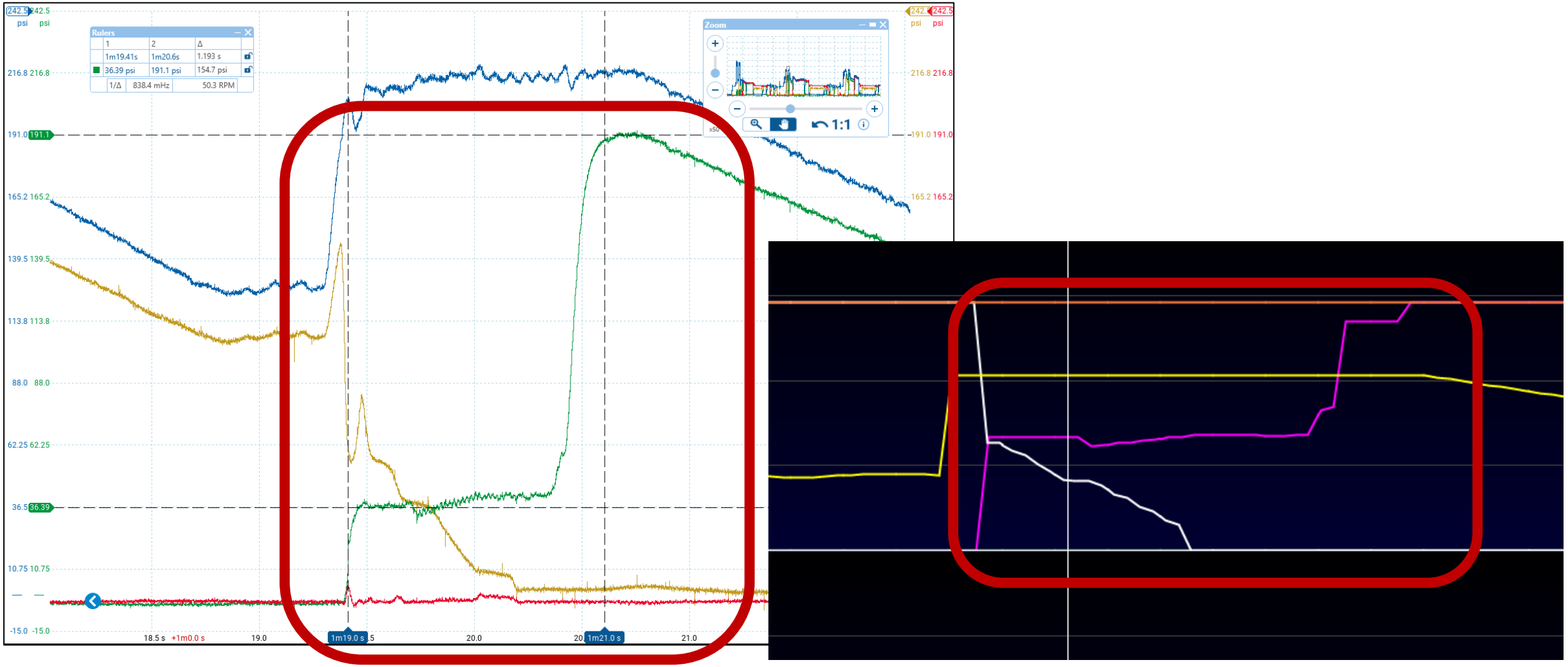


During the upshift, there's going to be a portion of overlap. That prevents a shift flare. If the overlap is too long, that would cause a shift bind. Notice on the torque phase, the off-going clutch is dropping pressure. The inertia phase is where the shift ratio change is occurring.

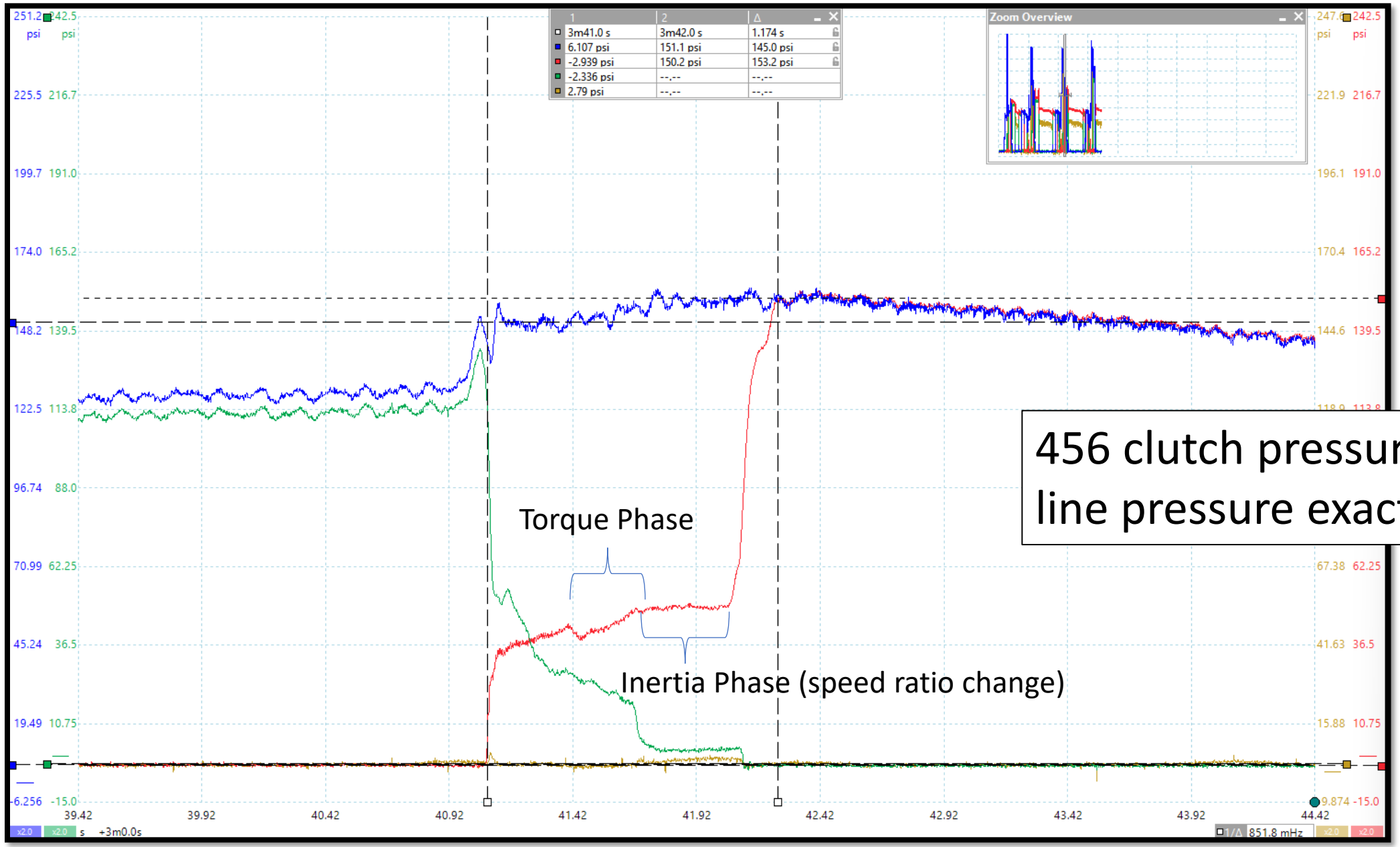
2-3 shift 40% throttle



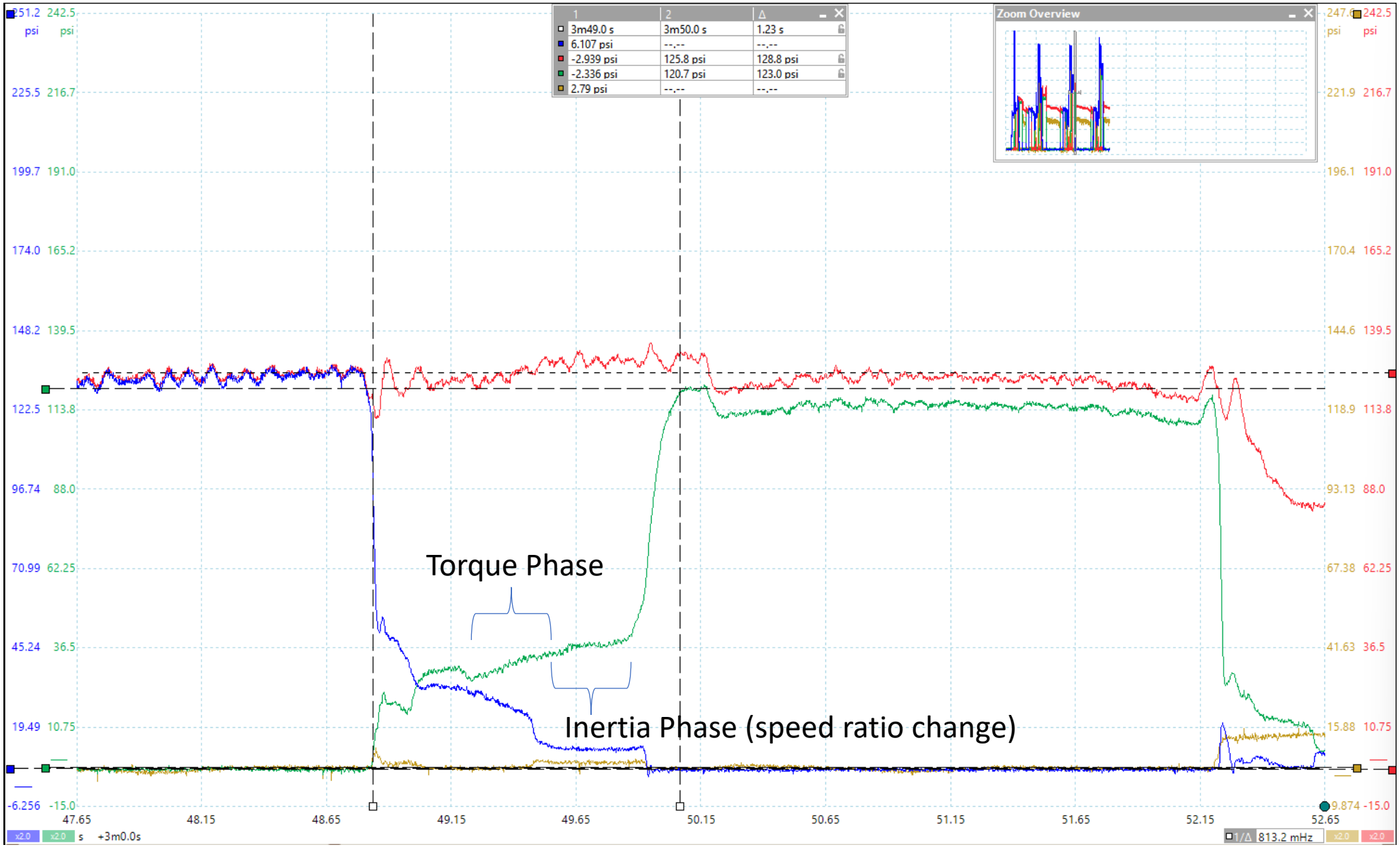
2-3 shift 40% throttle



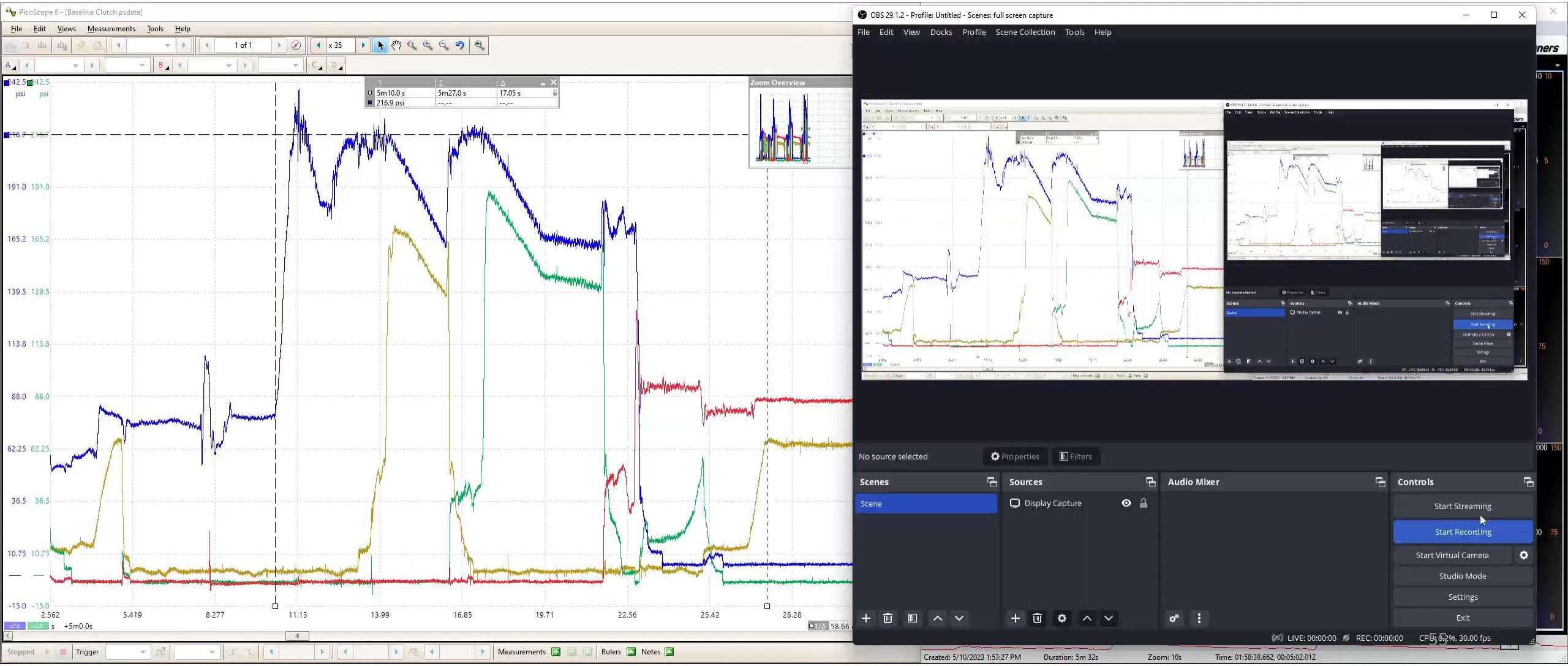
3-4 shift 40% throttle



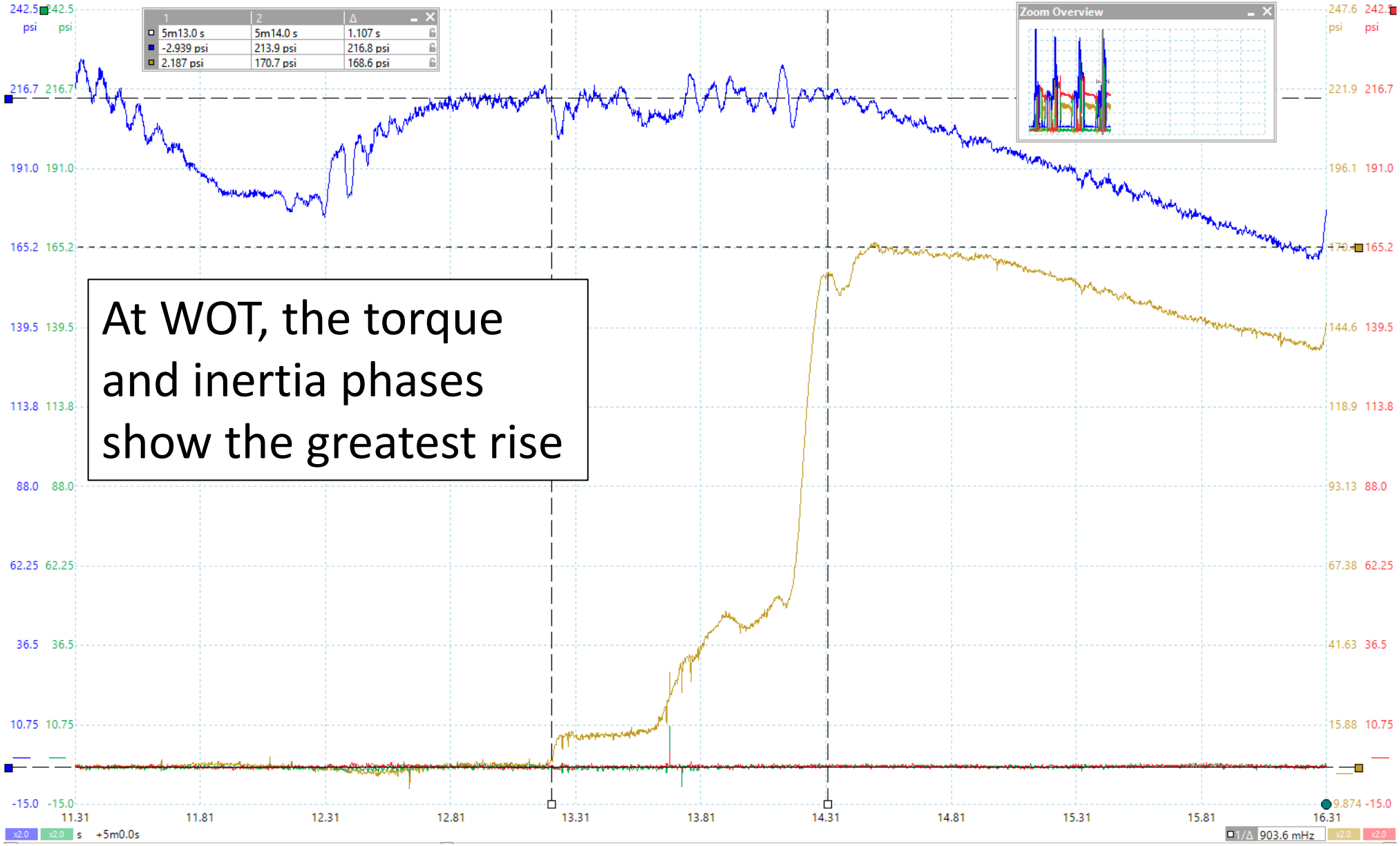
4-5 shift 40% throttle



6L80 Recording at WOT

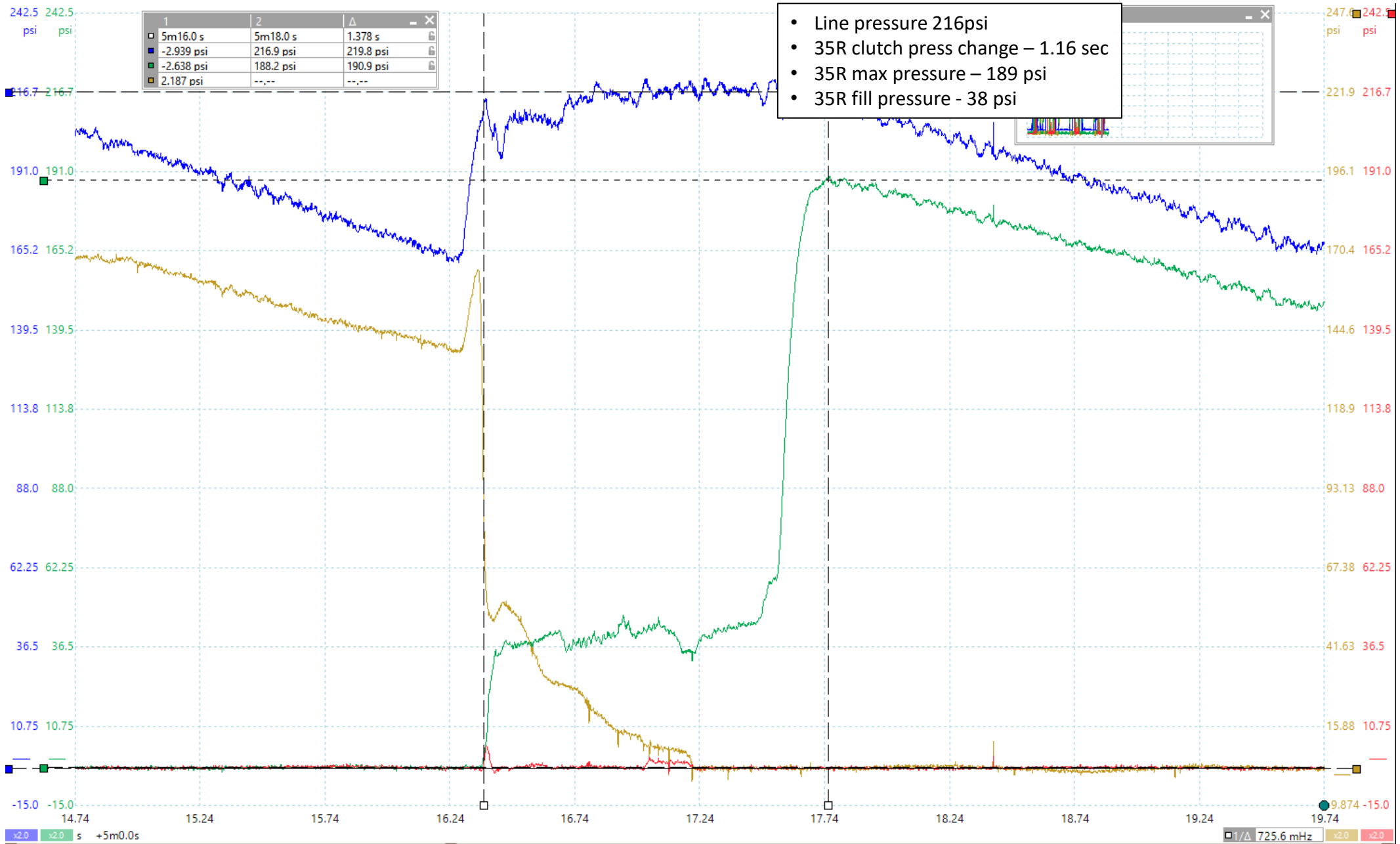


1-2 WOT



At WOT, the torque and inertia phases show the greatest rise

2-3 shift WOT



- Line pressure 216psi
- 35R clutch press change – 1.16 sec
- 35R max pressure – 189 psi
- 35R fill pressure - 38 psi

Torque Management

- Much lower engine torque during shift
  - Timing Reduction
  - Throttle Reduction
- Only during Inertia Phase

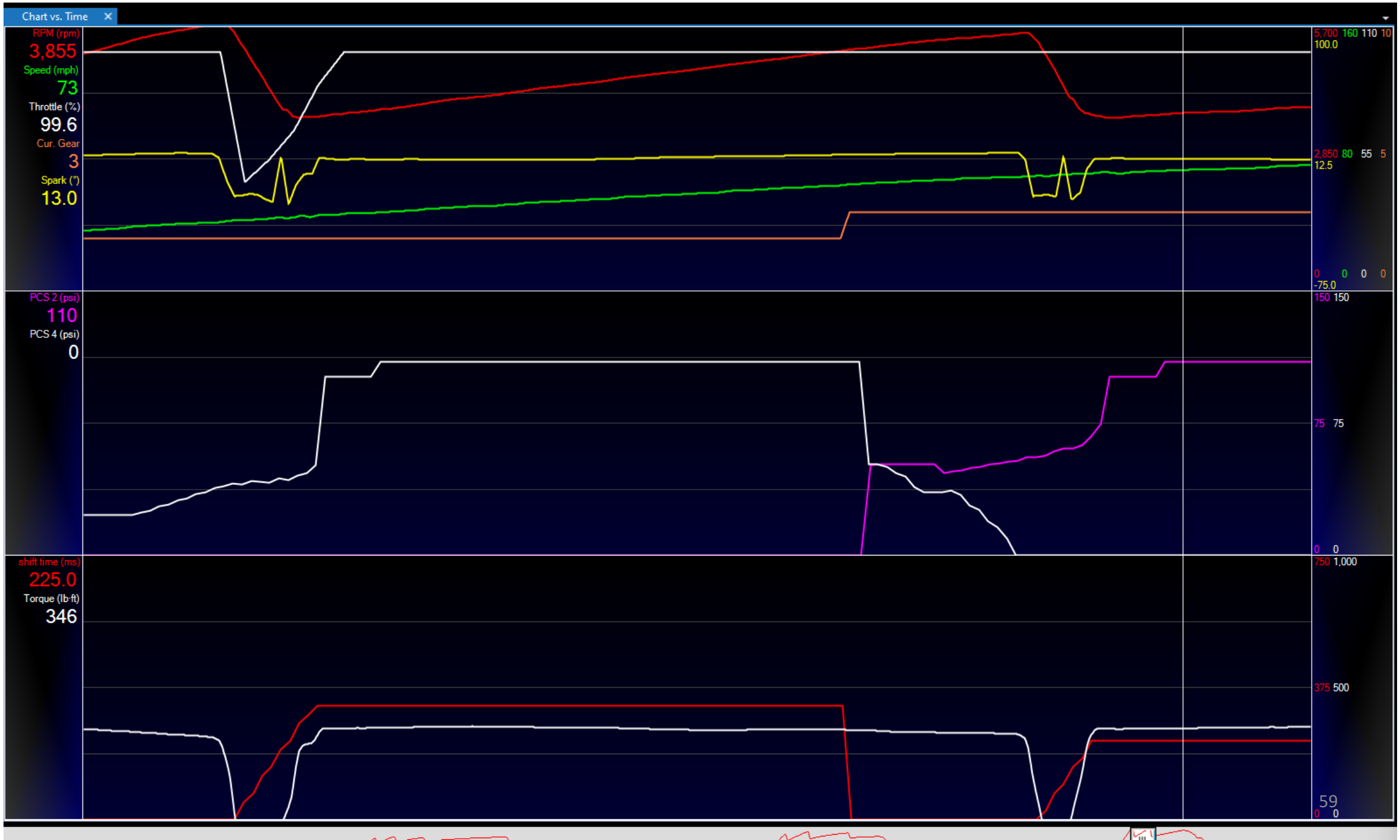


Chart vs. Time
RPM (rpm)
3,855
Speed (mph)
73
Throttle (%)
99.6
Cur. Gear
3
Spark (°)
13.0
5,700 160 110 10
100.0
2,850 80 55 5
12.5
0 0 0 0
-75.0
PCS 2 (psi)
110
PCS 4 (psi)
0
150 150
75 75
0 0
shift time (ms)
225.0
Torque (lb·ft)
346
750 1,000
375 500
59
0 0

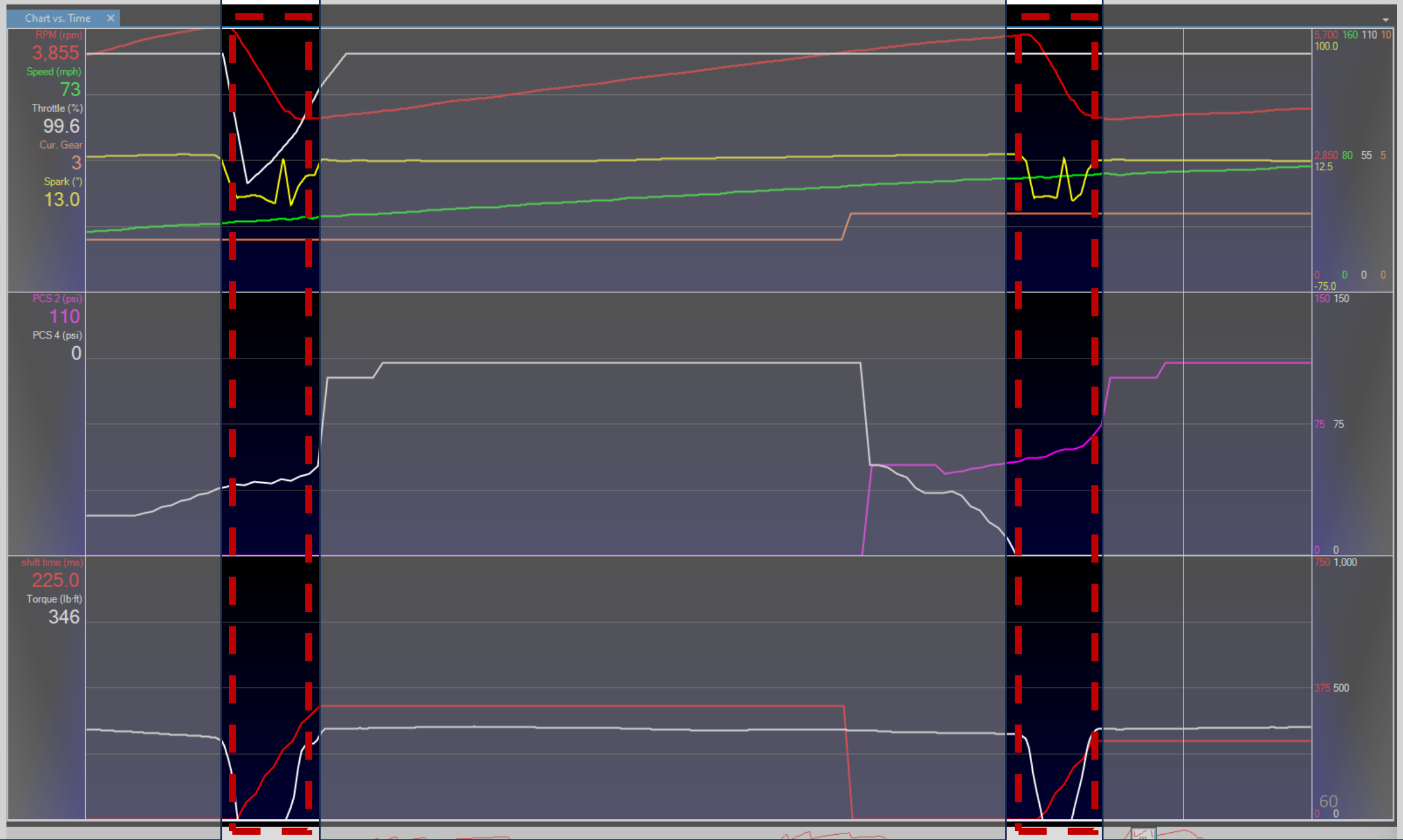


Chart vs. Time
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13.0
5,700 160 110 10
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2,850 80 55 5
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0 0 0 0
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PCS 2 (psi)
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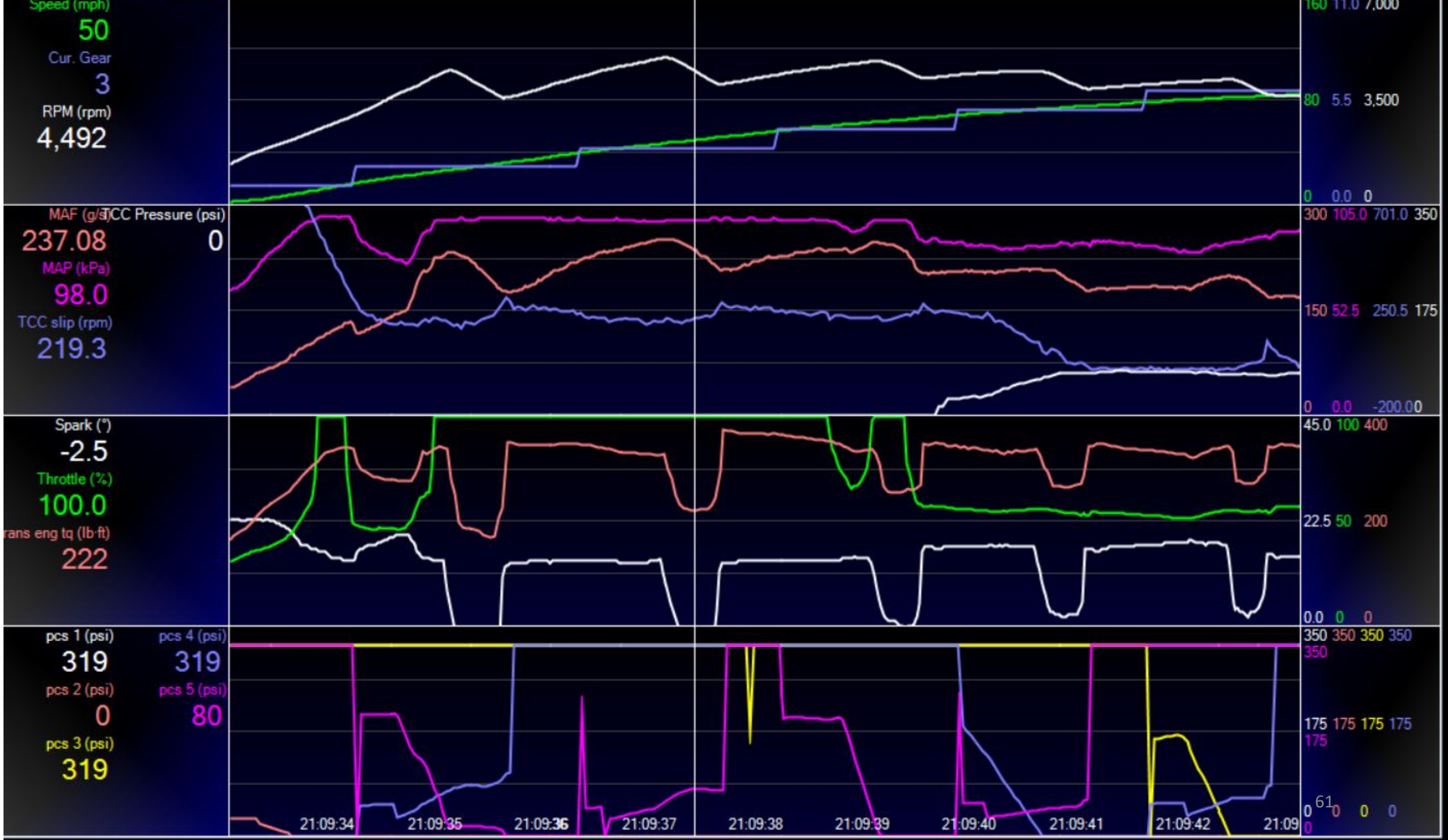
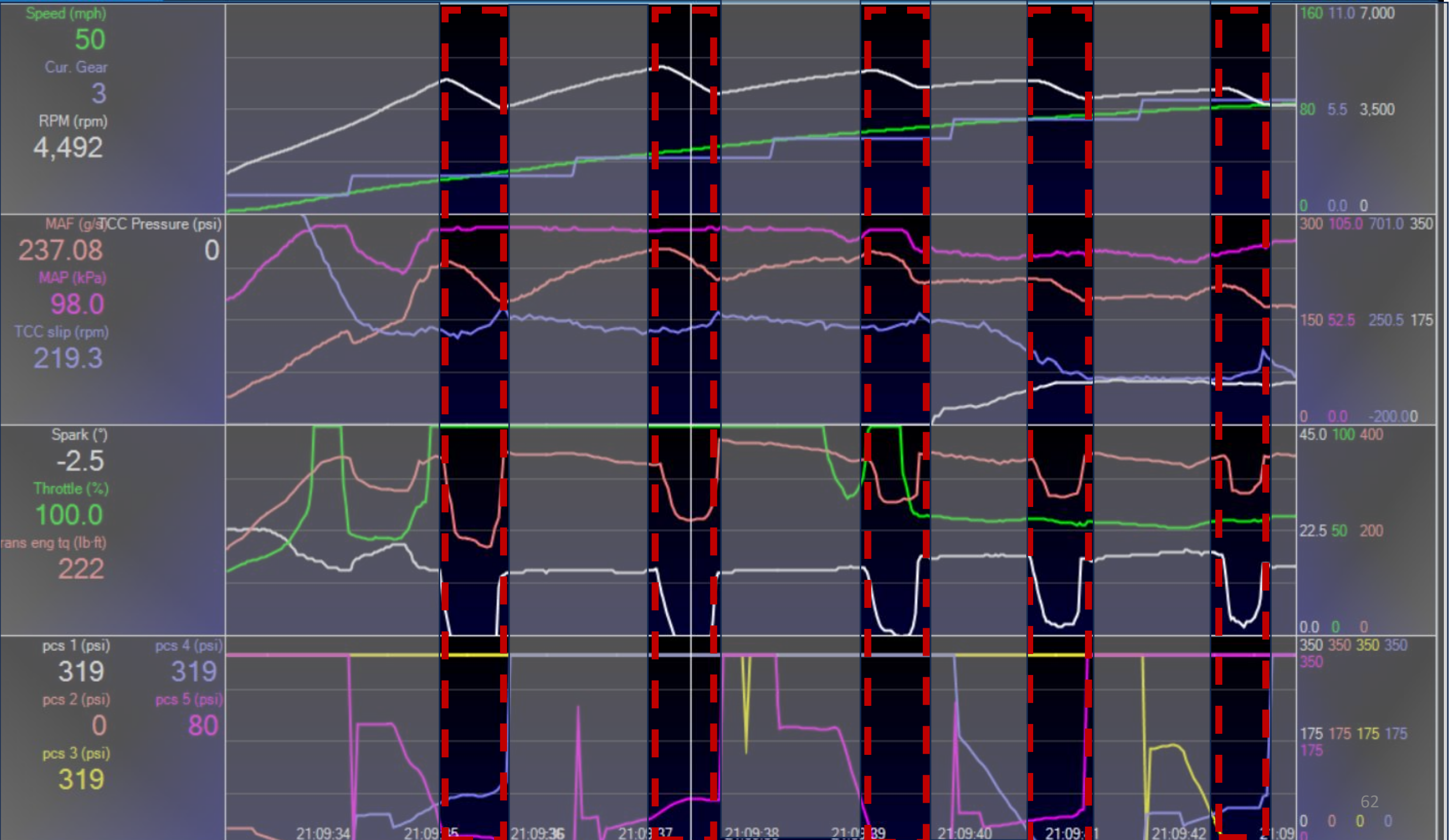
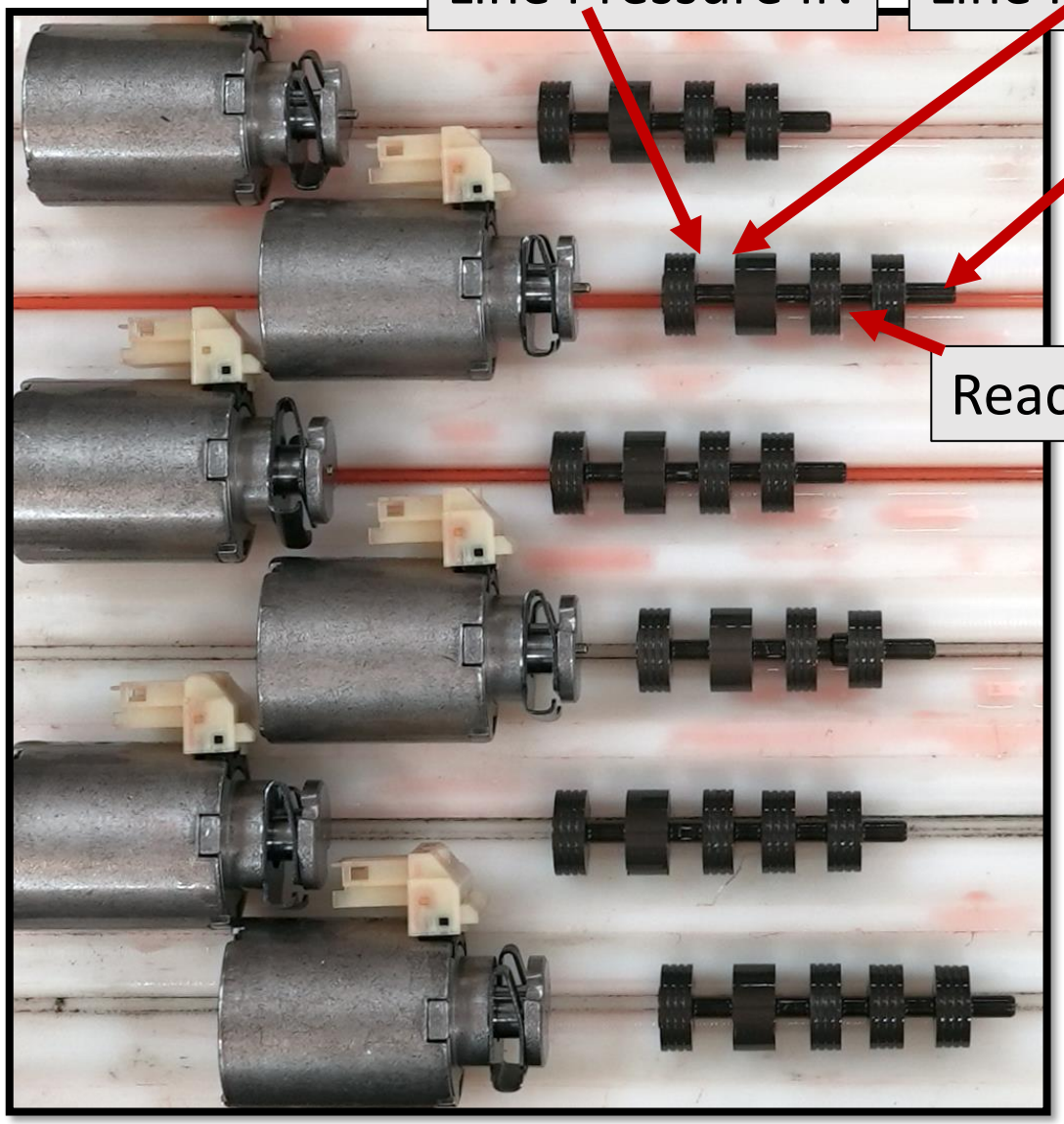
PCS 4 (psi)
0
150 150
75 75
0 0
shift time (ms)
225.0
Torque (lb·ft)
346
750 1,000
375 500
60
0 0


Speed (mph)
50
Cur. Gear
3
RPM (rpm)
4,492
160 11.0 7,000
80 5.5 3,500
0 0.0 0
MAF (g/s)
237.08
TCC Pressure (psi)
0
MAP (kPa)
98.0
TCC slip (rpm)
219.3
300 105.0 701.0 350
150 52.5 250.5 175
0 0.0 -200.0
Spark (°)
-2.5
Throttle (%)
100.0
rans eng tq (lb·ft)
222
45.0 100 400
22.5 50 200
0.0 0 0
pcs 1 (psi)
319
pcs 4 (psi)
319
pcs 2 (psi)
0
pcs 5 (psi)
80
pcs 3 (psi)
319
350 350 350 350
350
175 175 175 175
175
0 0 0 0
0
21:09:34
21:09:35
21:09:36
21:09:37
21:09:38
21:09:39
21:09:40
21:09:41
21:09:42
21:09

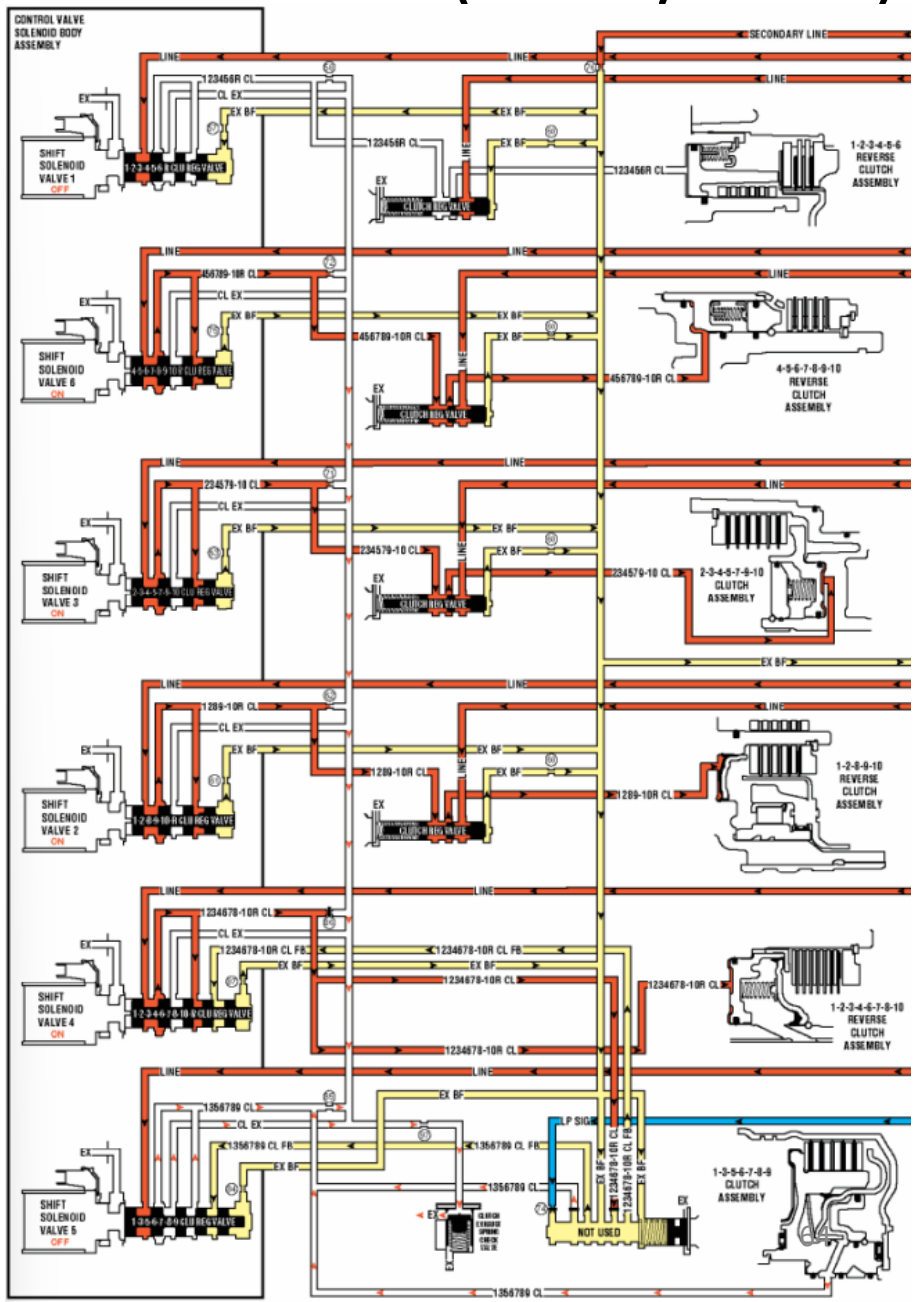

Speed (mph)
50
Cur. Gear
3
RPM (rpm)
4,492
160 11.0 7,000
80 5.5 3,500
0 0.0 0
MAF (g/s)
237.08
TCC Pressure (psi)
0
MAP (kPa)
98.0
TCC slip (rpm)
219.3
300 105.0 701.0 350
150 52.5 250.5 175
0 0.0 -200.00
Spark (°)
-2.5
Throttle (%)
100.0
rans eng tq (lb·ft)
222
45.0 100 400
22.5 50 200
0.0 0 0
pcs 1 (psi)
319
pcs 4 (psi)
319
pcs 2 (psi)
0
pcs 5 (psi)
80
pcs 3 (psi)
319
350 350 350 350
350
175 175 175 175
175
62
0 0 0 0
21:09:34
21:09:36
21:09:38
21:09:40
21:09:42

Valving/Solenoid Evolution
GM 10L

Electronic Operation – Linear Solenoids (10R/10L)

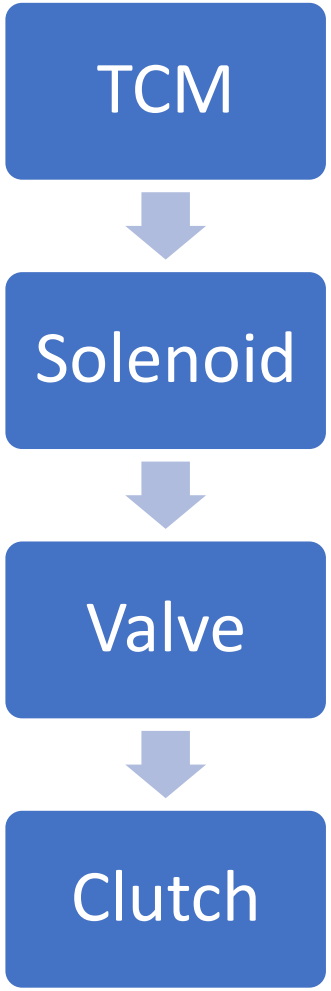


TCM → Solenoid → Valve → Clutch



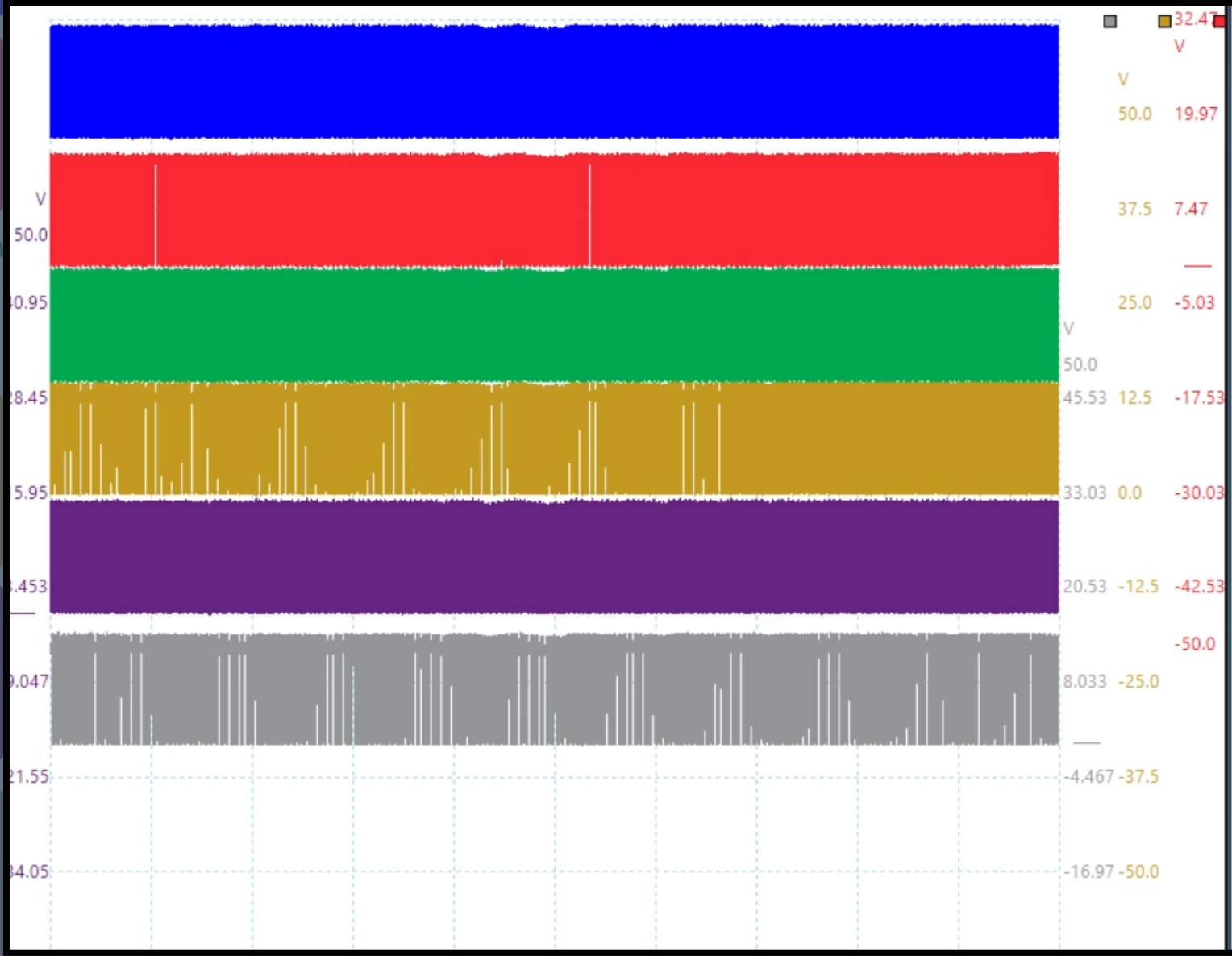
Electronic Operation – Linear Solenoids (10R)

Linear Solenoids use a mechanical pintle to push on the hydraulic valve. Nothing new, Toyota and Honda has been doing this for a while. The 10R/L doesn't use springs to return the valve/pintle. Backfill pressure is used to return



10L/10R TCM Control - PWM

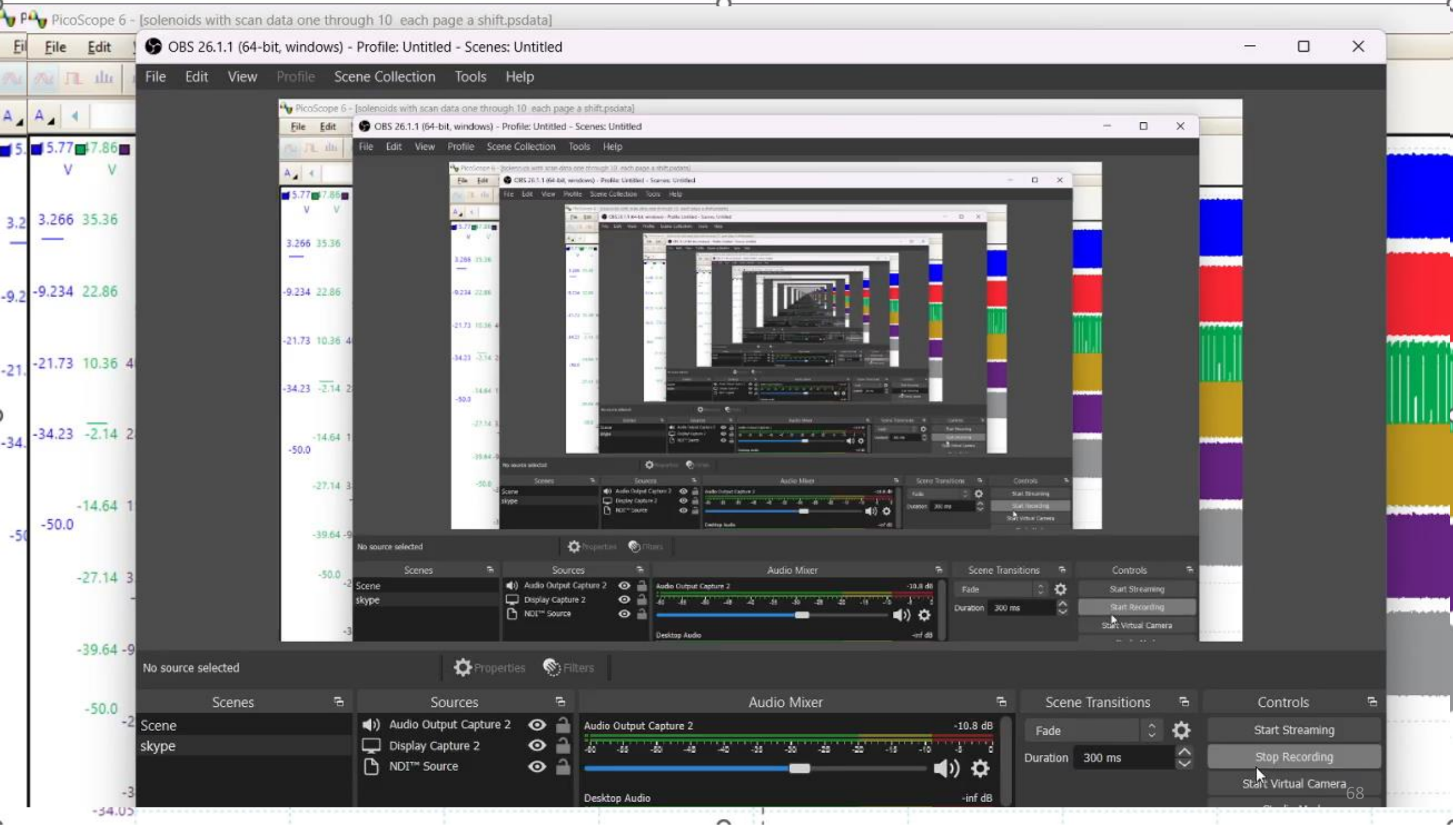
10L/10R Outputs – Solenoid Control



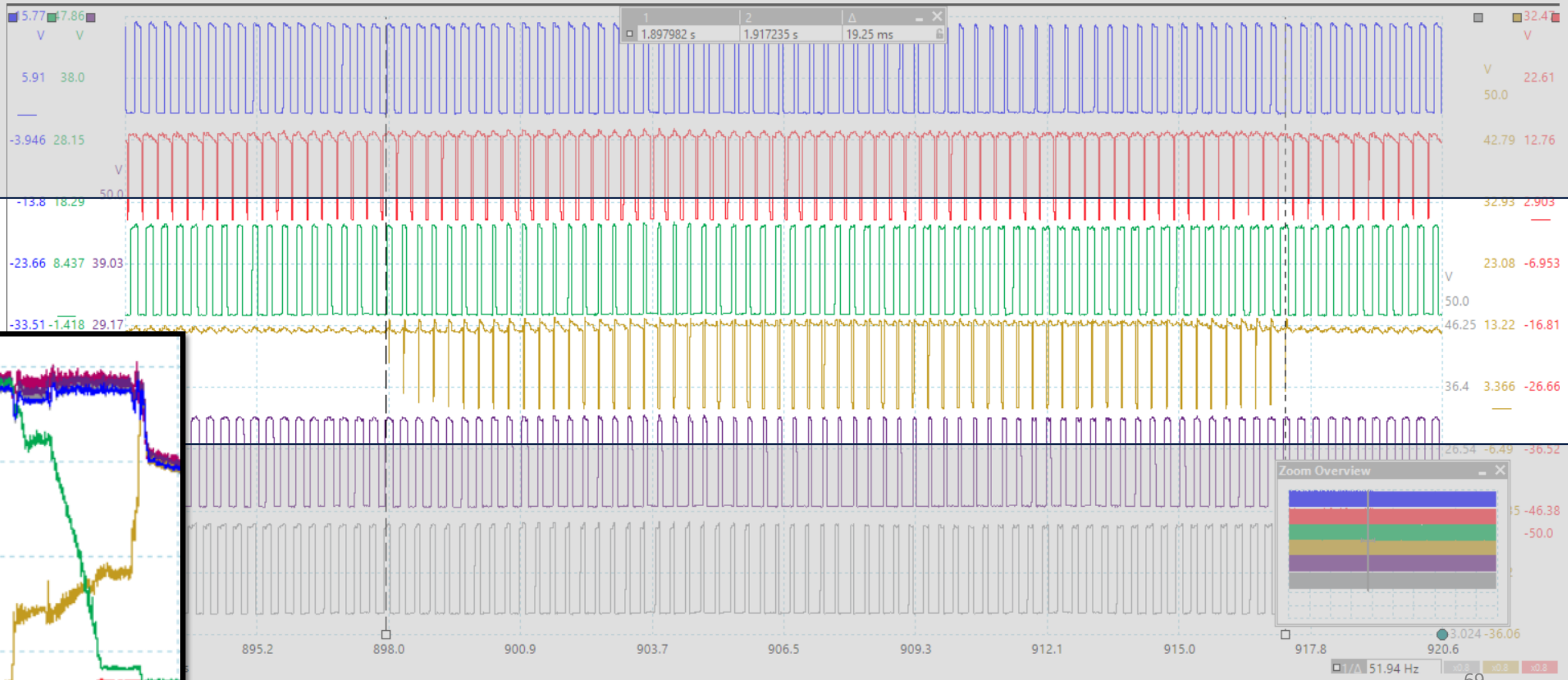
Shift Data

Parameter Name	Value	Unit	
Gear Command	1		Tra
Transmission Control Solenoid Valve ...	2200.25	kPa	Tra
Transmission Control Solenoid Valve ...	2200.25	kPa	Tra
Transmission Control Solenoid Valve ...	2146.31	kPa	Tra
Transmission Control Solenoid Valve ...	0.00	kPa	Tra
Transmission Control Solenoid Valve ...	2200.75	kPa	Tra
Transmission Control Solenoid Valve ...	0.00	kPa	Tra
Line Pressure Command	632.8	kPa	Tra
TCC Pressure Control Solenoid Valve ...	0.00	kPa	Tra

Parameter Name	Value
Last Shift Time	0.00
TCC Slip Speed	36
TCC Desired Slip Speed	10

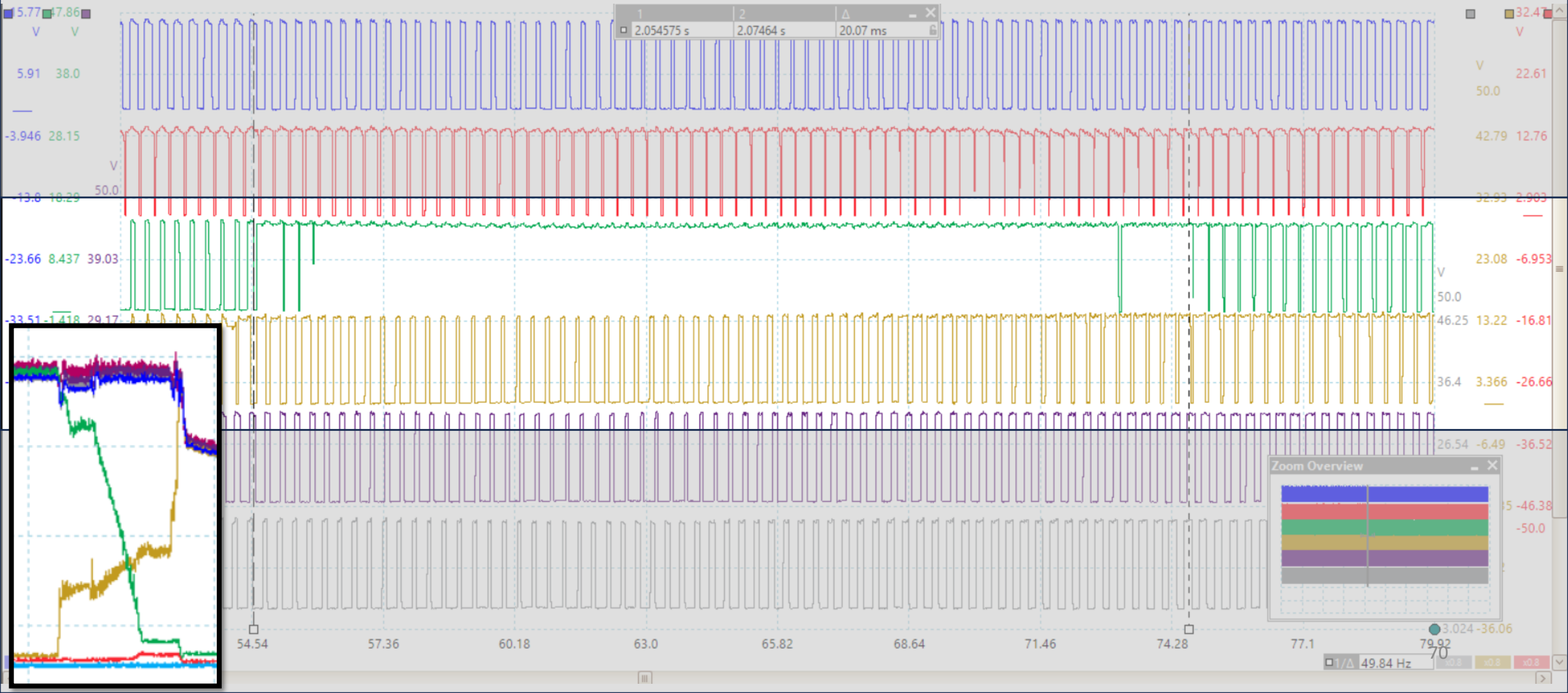

PicoScope 6 - [solenoids with scan data one through 10 each page a shift.psdata]
File Edit
OBS 26.1.1 (64-bit, windows) - Profile: Untitled - Scenes: Untitled
File Edit View Profile Scene Collection Tools Help
No source selected
Properties
Filters
Scenes
Scene
skype
Sources
Audio Output Capture 2
Display Capture 2
NDI™ Source
Audio Mixer
Audio Output Capture 2
-10.8 dB
Desktop Audio
-inf dB
Scene Transitions
Fade
Duration
300 ms
Controls
Start Streaming
Stop Recording
Start Virtual Camera

10L Solenoid Control – Electrical 5-6 shift C ON, D OFF



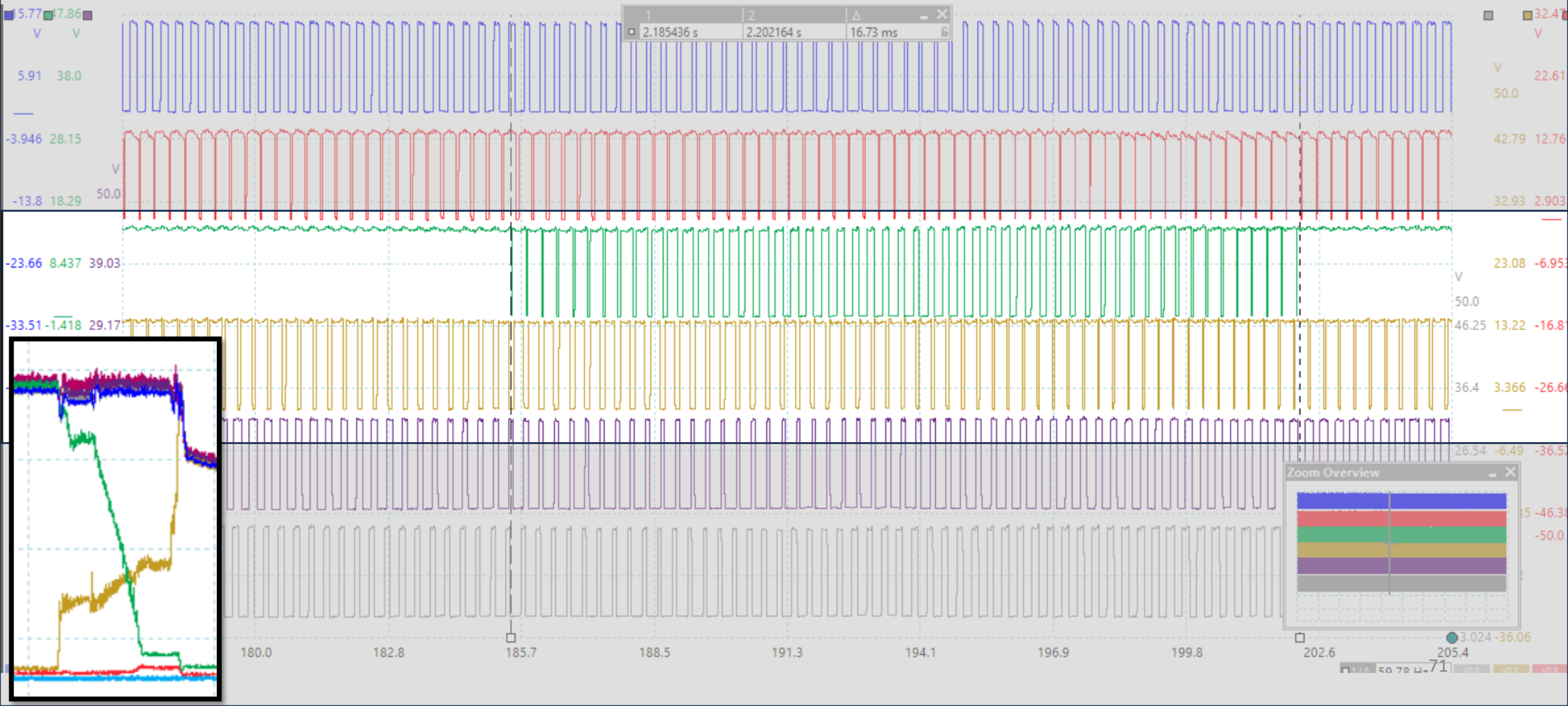
10L Solenoid Control – Electrical 5-6 shift

C modulates OFF, D modulates ON (fill phase)



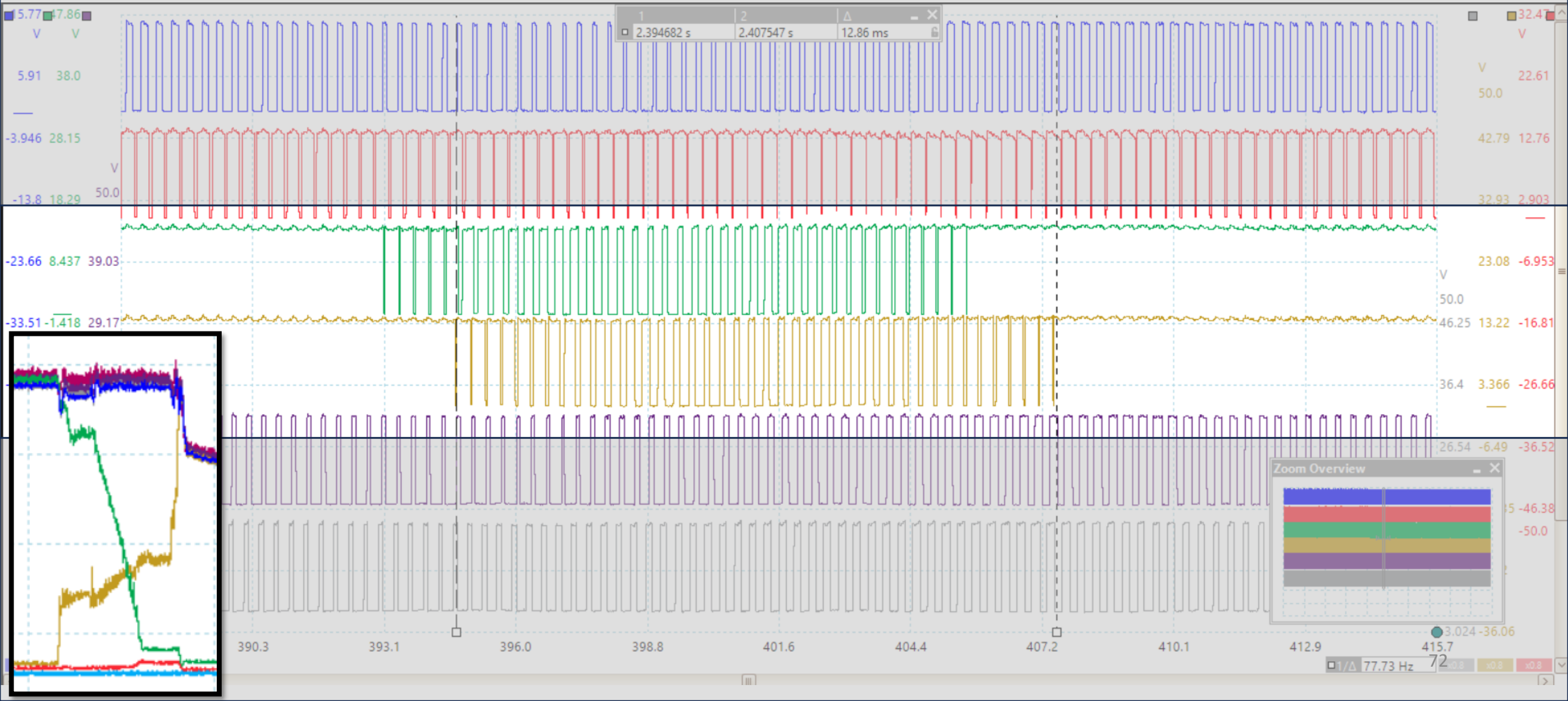
10L Solenoid Control – Electrical 5-6 shift

C modulates OFF (torq phase), D modulates ON (torq phase)



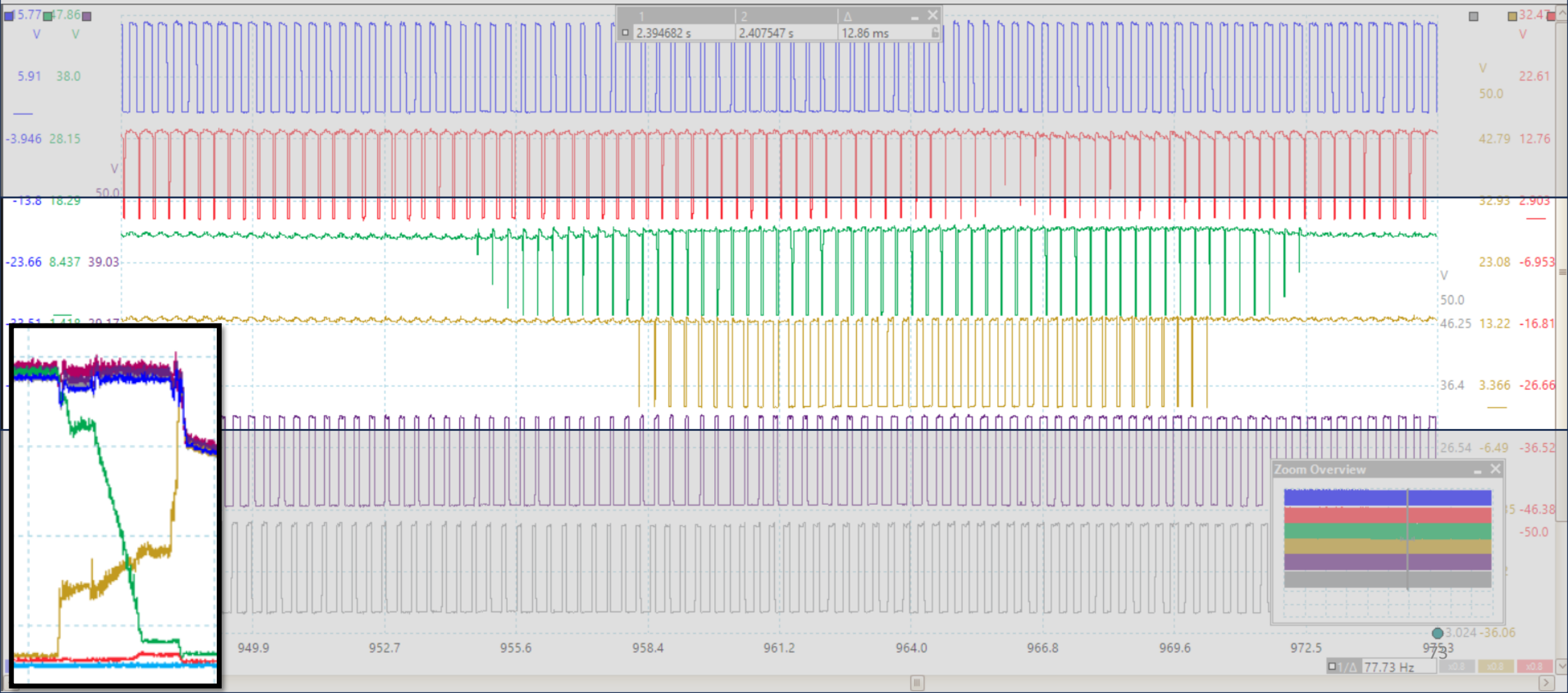
10L Solenoid Control – Electrical 5-6 shift

C modulates OFF (torq phase), D modulates ON (torq phase)

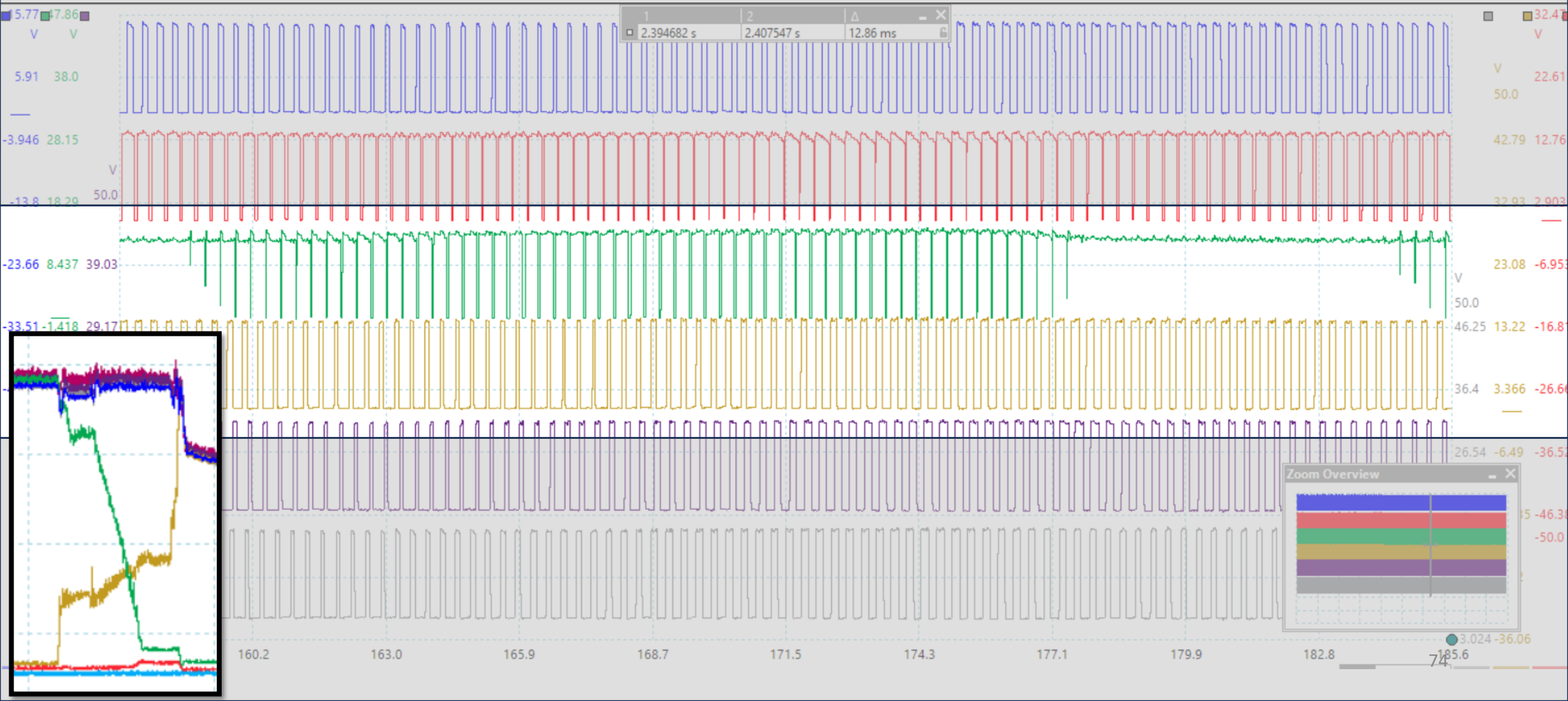


10L Solenoid Control – Electrical 5-6 shift

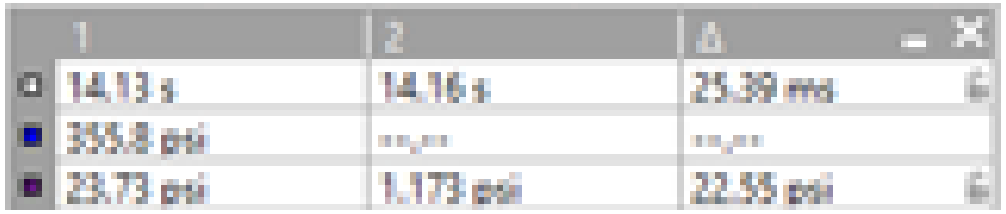
C is OFF, D modulates ON (Inertia phase)

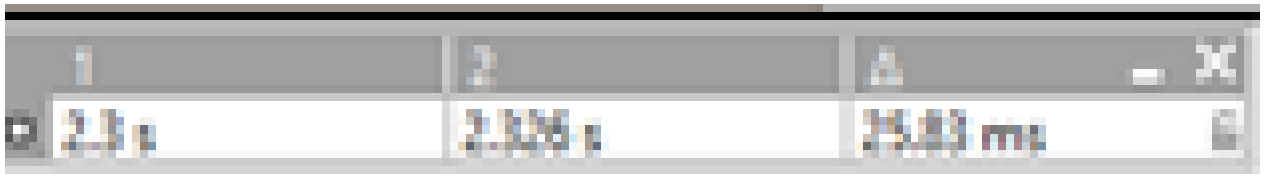


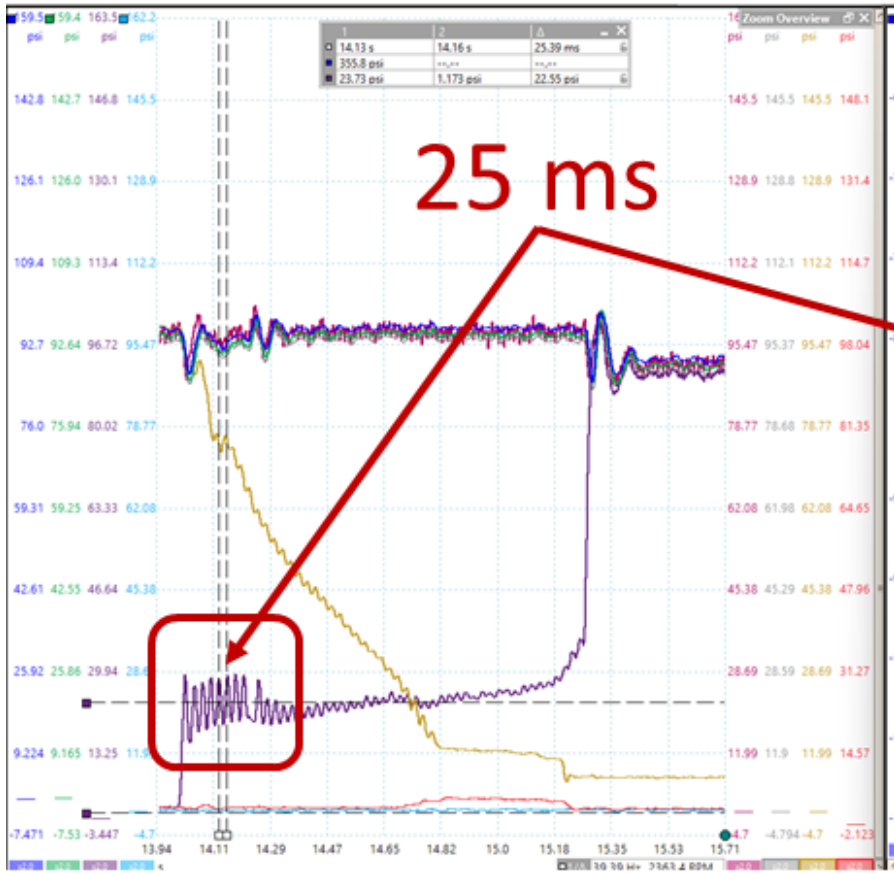
10L Solenoid Control – Electrical 5-6 shift final

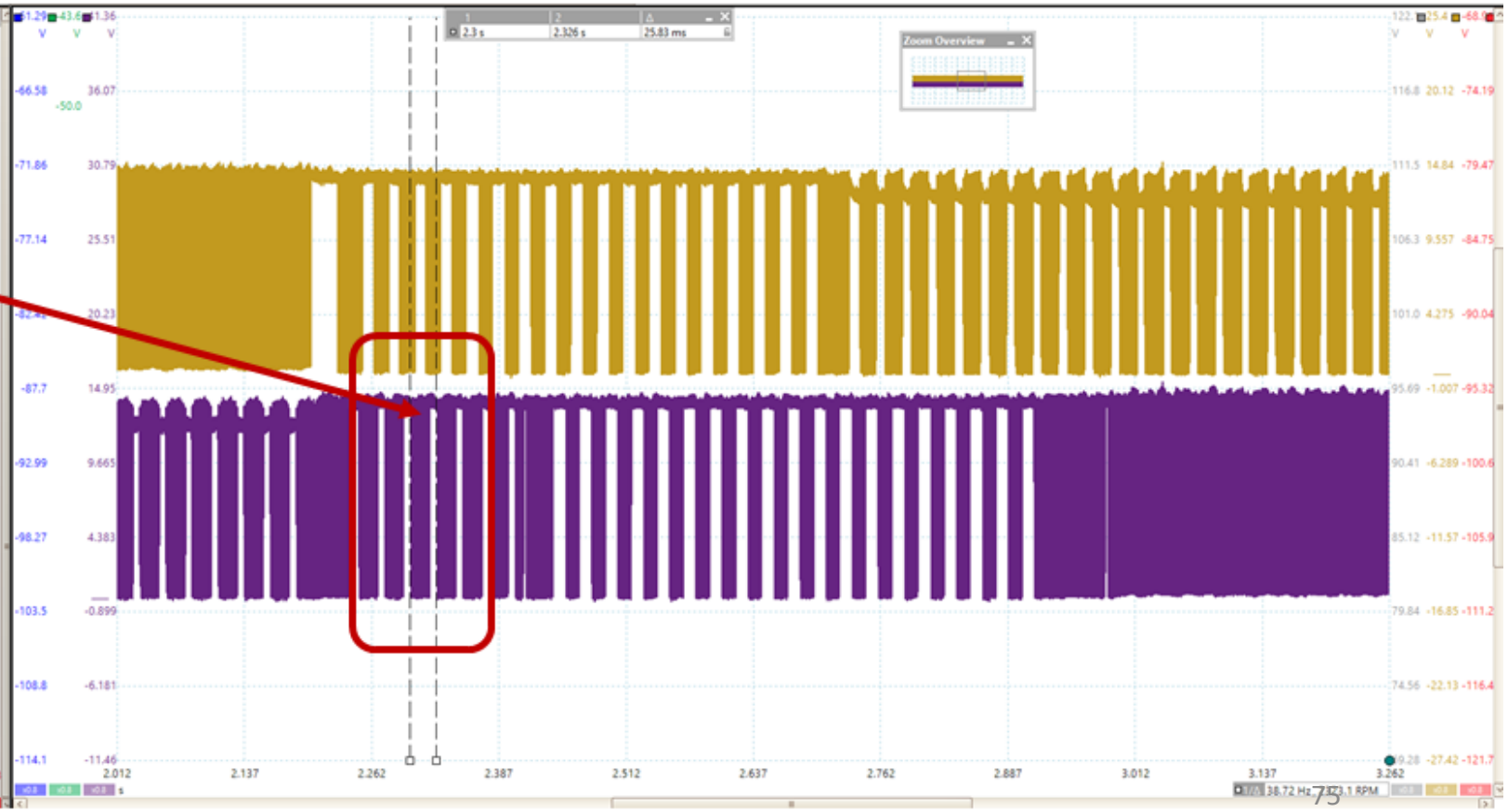


Solenoid Reaction Sensitivity



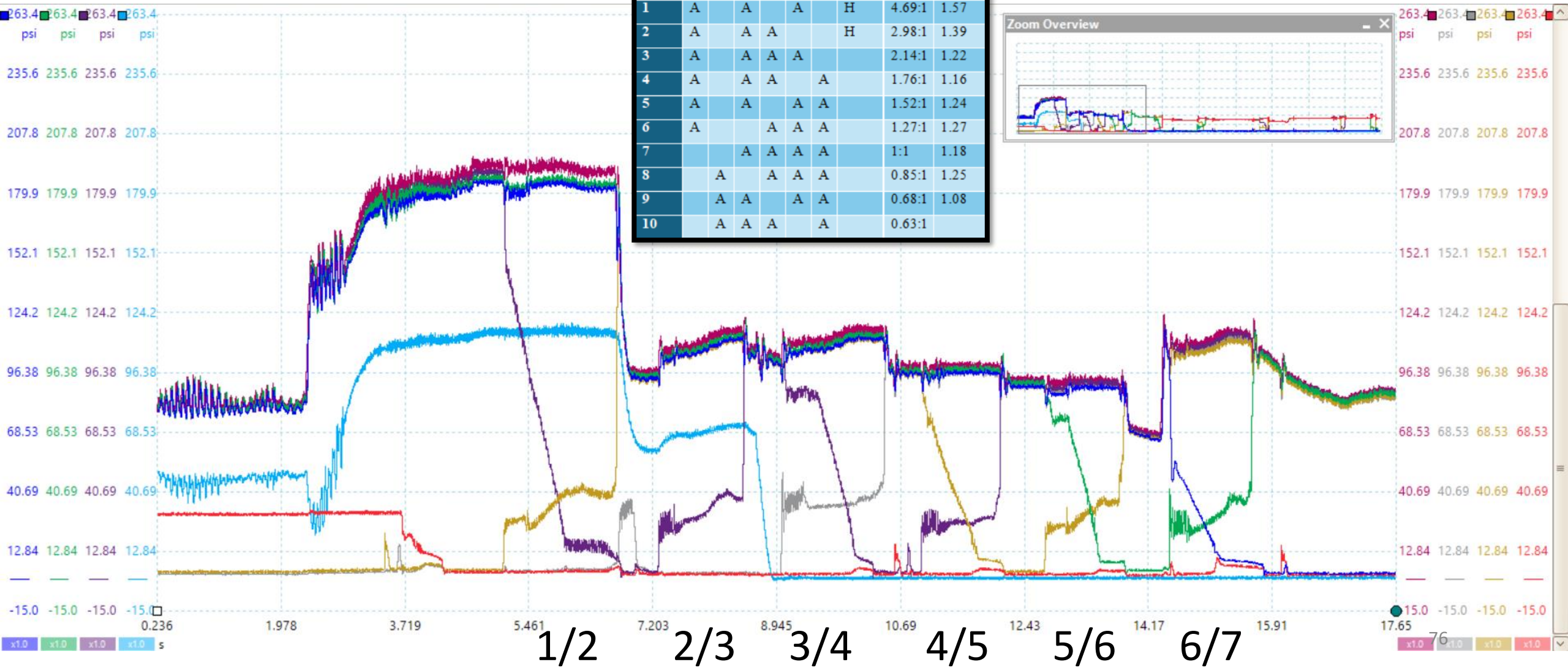




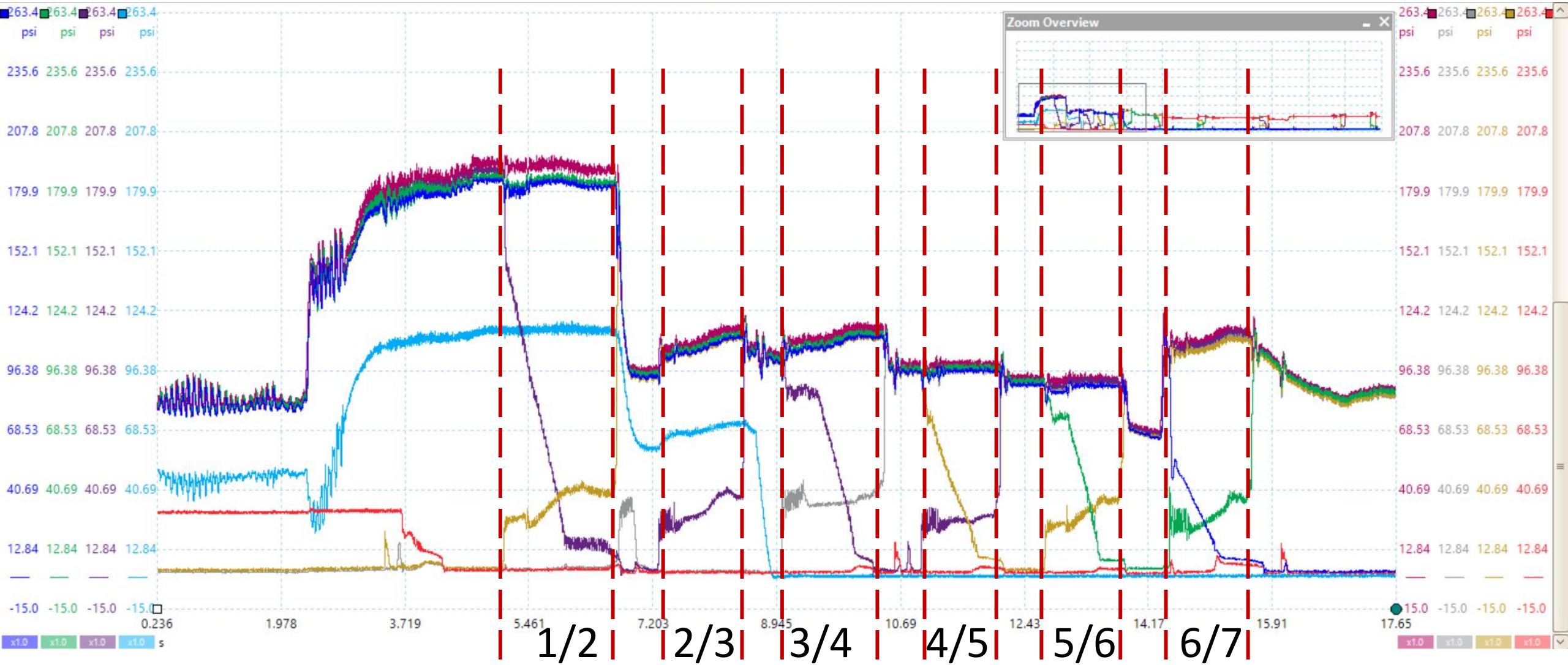


Evolution – 10L80

Clutches/Solenoids									
Gear	A	B	C	D	E	F	One-way	Ratio	Spread
P	*	A		*		*			
R	A	A		A		A		4.86:1	
N	*	A				A			
1	A		A		A		H	4.69:1	1.57
2	A		A	A			H	2.98:1	1.39
3	A		A	A	A			2.14:1	1.22
4	A		A	A		A		1.76:1	1.16
5	A		A		A	A		1.52:1	1.24
6	A			A	A	A		1.27:1	1.27
7			A	A	A	A		1:1	1.18
8		A		A	A	A		0.85:1	1.25
9		A	A		A	A		0.68:1	1.08
10		A	A	A		A		0.63:1	

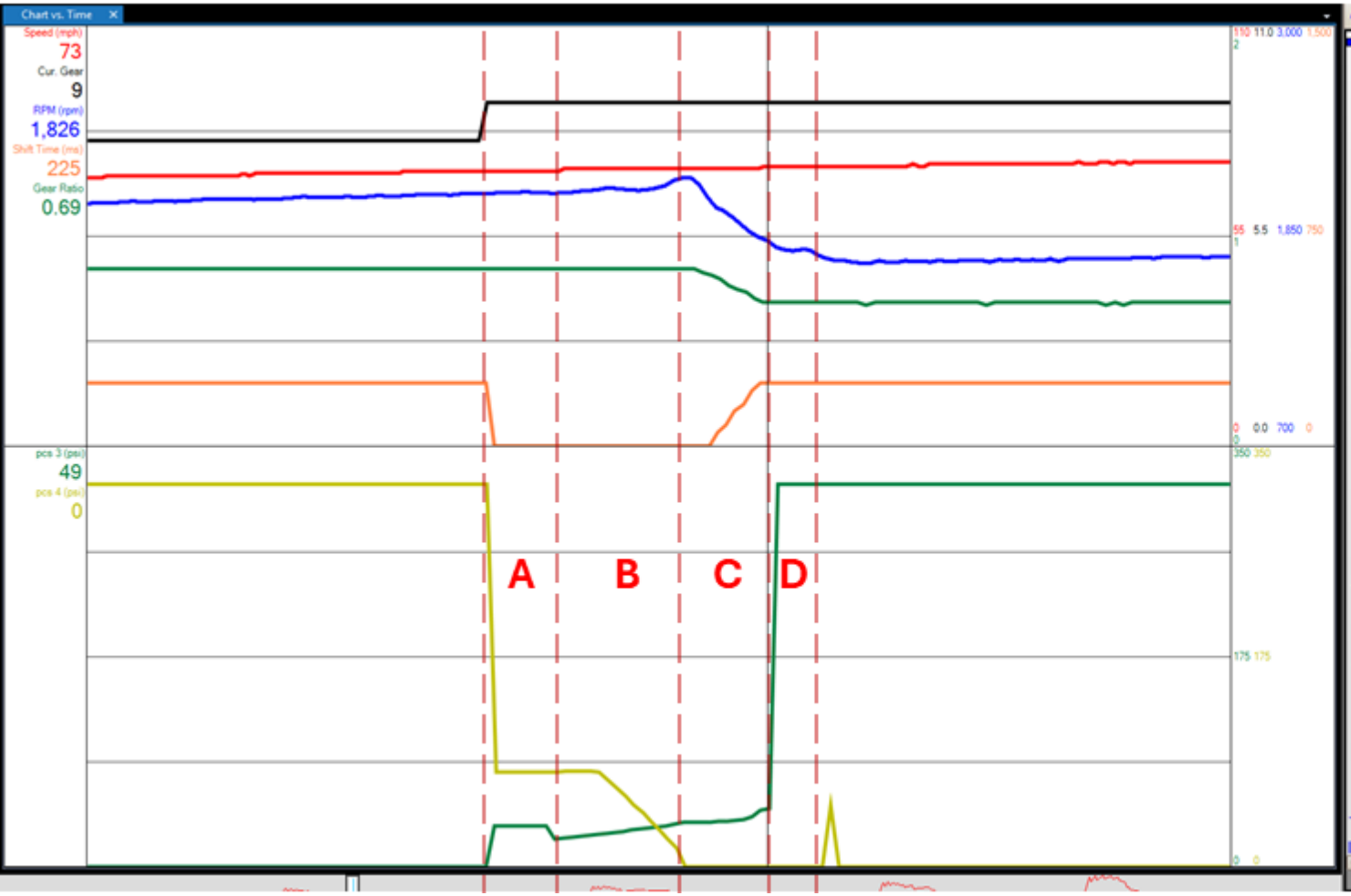


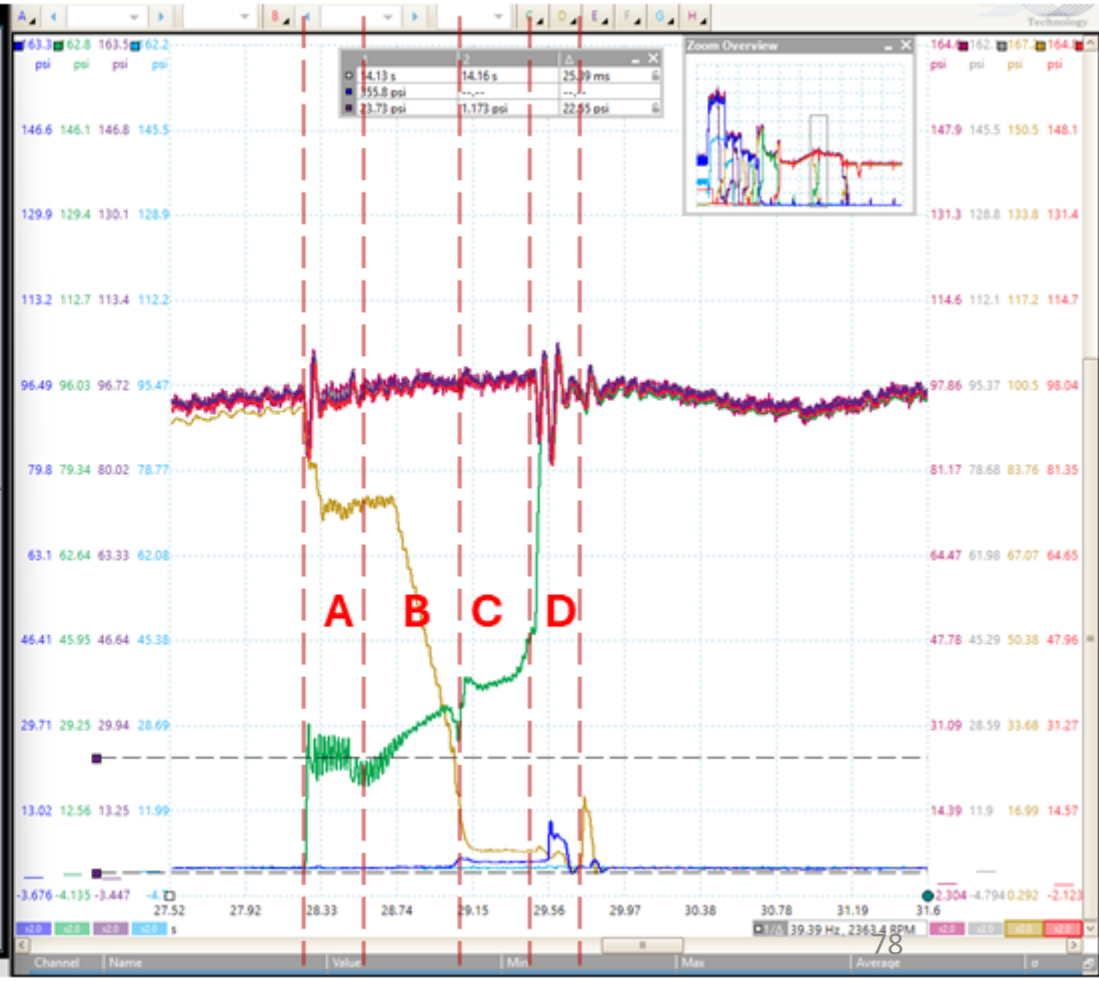
Evolution – 10L80



Look how much of this 10 second acceleration is just shifting!

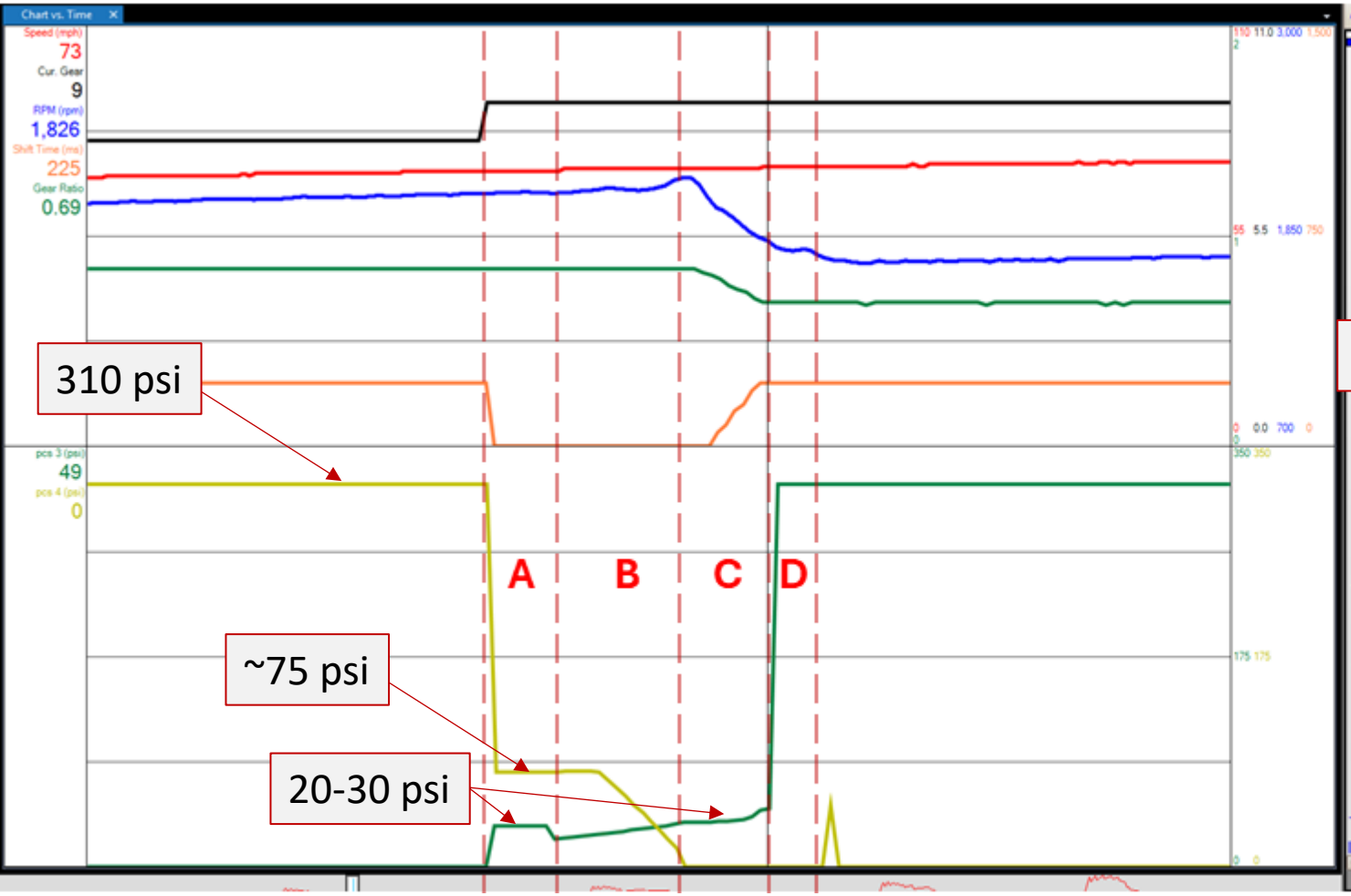
Evolution – 10L80 shift phases solenoid command vs actual pressure

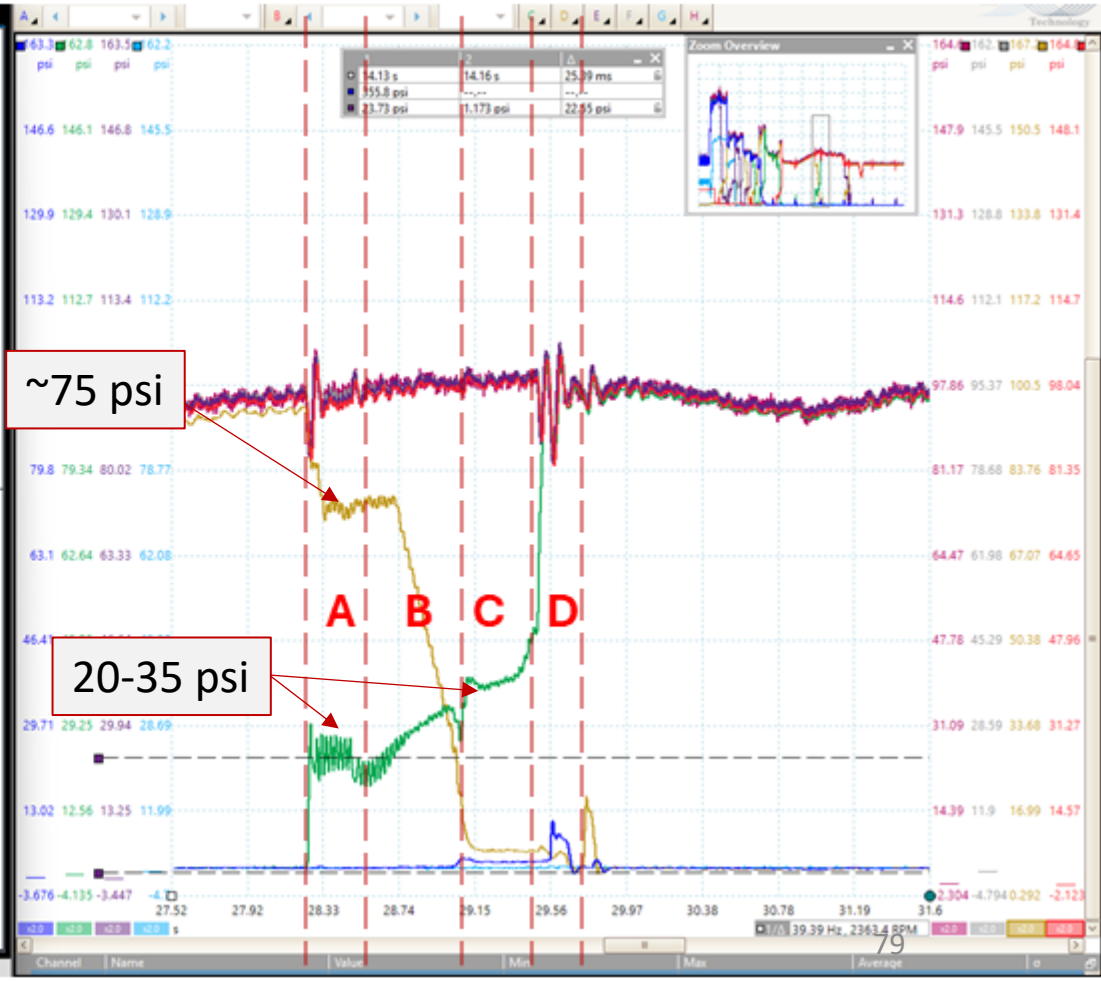




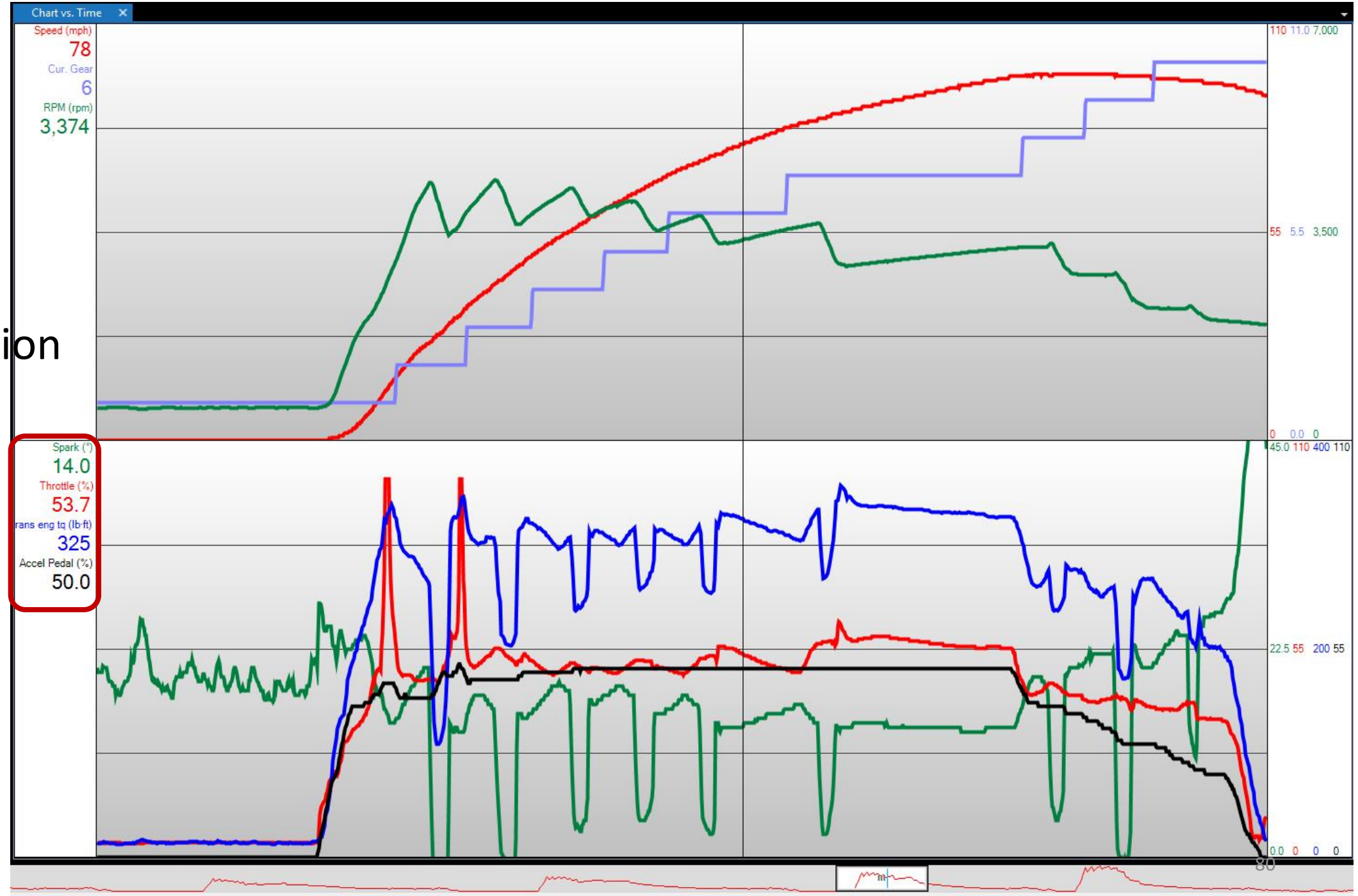
Evolution – 10L80 shift phases solenoid command vs actual pressure

Although the “max” pressure shown at 310psi is never achieved, the fill/torque/inertia pressure shown on scan data is pretty close to actual pressure at the clutch





- Torque Reduction
- TP manipulation



Knowing how precise the electronic control is…….

Keep in mind clutch clearance, leaks, pressures, bore wear

Clutch Clearance

- Essential
  - 6L80 Example
    - ~0.025” window
  - Five snap rings available
    - ~0.010 difference

3–5 Reverse Clutch

Clutch Pack Travel Specification – 1.21–1.79 mm (0.048–0.070 in)		
Retaining Ring Thickness		O.D. Color
Metric	English	
Note: After measuring clutch pack travel, determine if the measurement is within the specification. If the measurement is not within the specification, measure the thickness of the existing retaining ring, and then choose a thicker or thinner retaining ring that will bring the measurement within specification.		
1.61–1.71 mm	0.063–0.067 in	Gray
1.88–1.98 mm	0.074–0.078 in	Light Green
2.15–2.25 mm	0.085–0.089 in	Yellow
2.42–2.52 mm	0.095–0.099 in	None
2.69–2.79 mm	0.106–0.110 in	Purple

1–2–3–4 Clutch

Clutch Pack Travel Specification – 1.53–1.99 mm (0.060–0.078 in)		
Retaining Ring Thickness		O.D. Color
Metric	English	
Note: After measuring clutch pack travel, determine if the measurement is within the specification. If the measurement is not within the specification, measure the thickness of the existing retaining ring, and then choose a thicker or thinner retaining ring that will bring the measurement within specification.		
2.42–2.52 mm	0.095–0.099 in	None
2.69–2.79 mm	0.106–0.110 in	Purple
2.96–3.06 mm	0.117–0.120 in	Light Blue
3.23–3.33 mm	0.127–0.131 in	Orange
3.50–3.60 mm	0.138–0.142 in	White

Clutch Clearance – 10R example

Clutch	Specifications	
A clutch	0.029–0.048 in (.73–1.23 mm)	**5 plates, ~0.008” variation**
B clutch	0.052–0.069 in (1.31–1.74 mm)	**6 snap rings, 0.012” variation**
C clutch	0.062–0.074 in (1.57–1.87 mm)	**5 snap rings, 0.008” variation**
D clutch	0.069–0.081 in (1.75–2.05 mm)	**6 snap rings, 0.008” variation**
E clutch	0.044–0.068 in (1.12–1.72 mm)	**6 plates, ~0.004” - 0.008” variation**
F clutch	0.048–0.060 in (1.22–1.52 mm)	**6 snap rings, 0.008” variation**

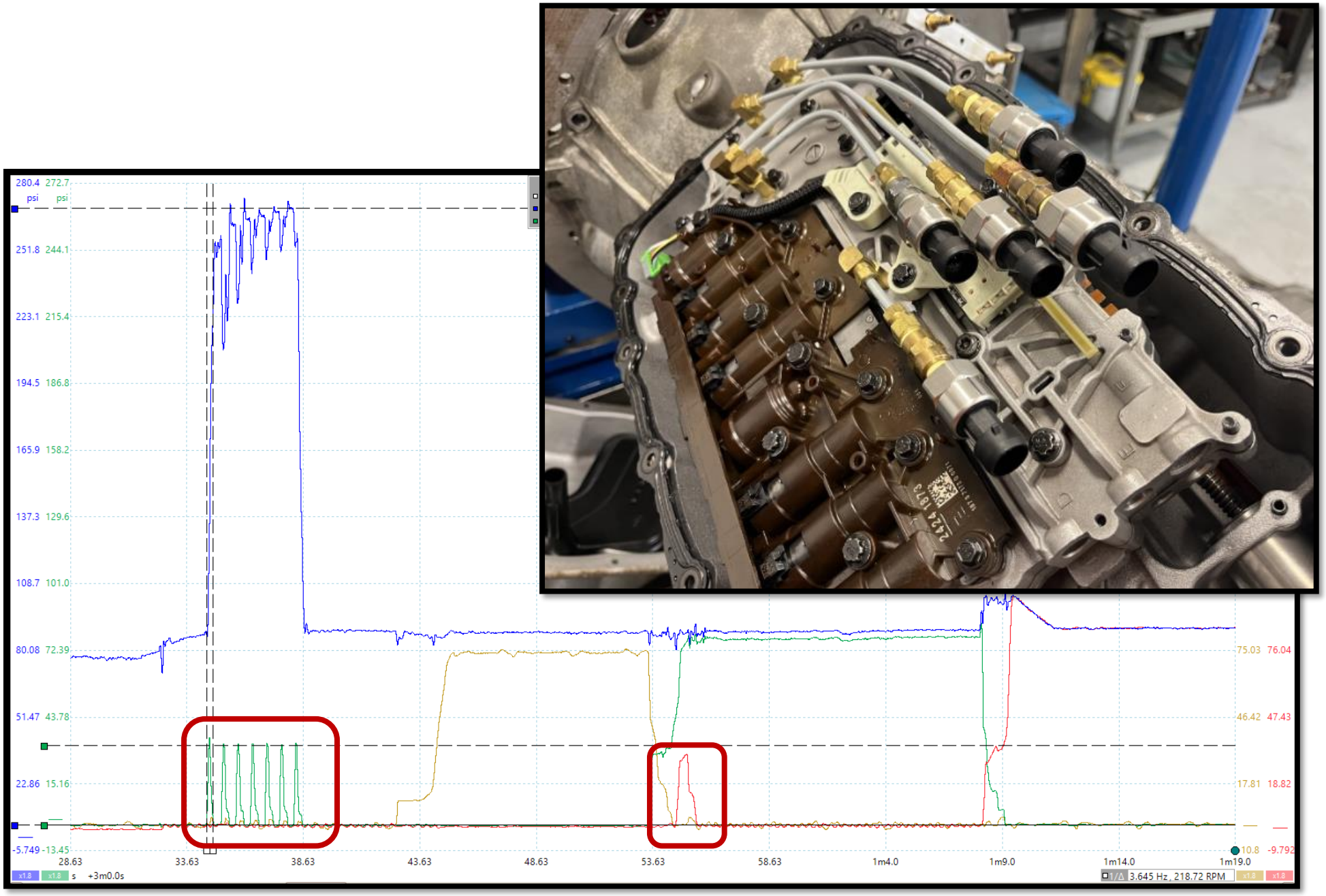
- 0.012” – 0.024” window of clutch clearance between all clutches

Air Purge

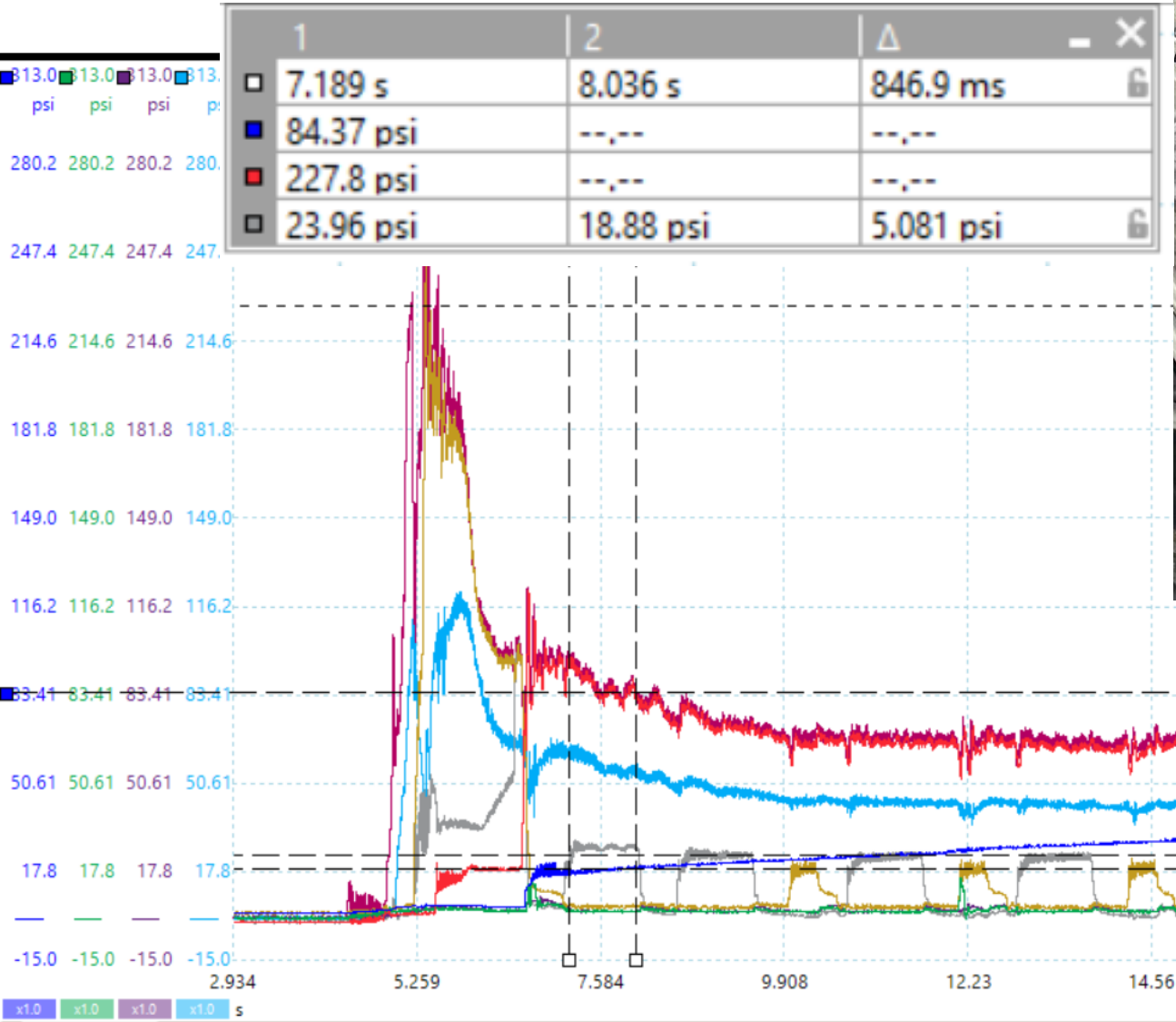
Example – 6L80

Line pressure 265psi, 3/5/R pressure pulses to about 35 psi for ¼ second intervals

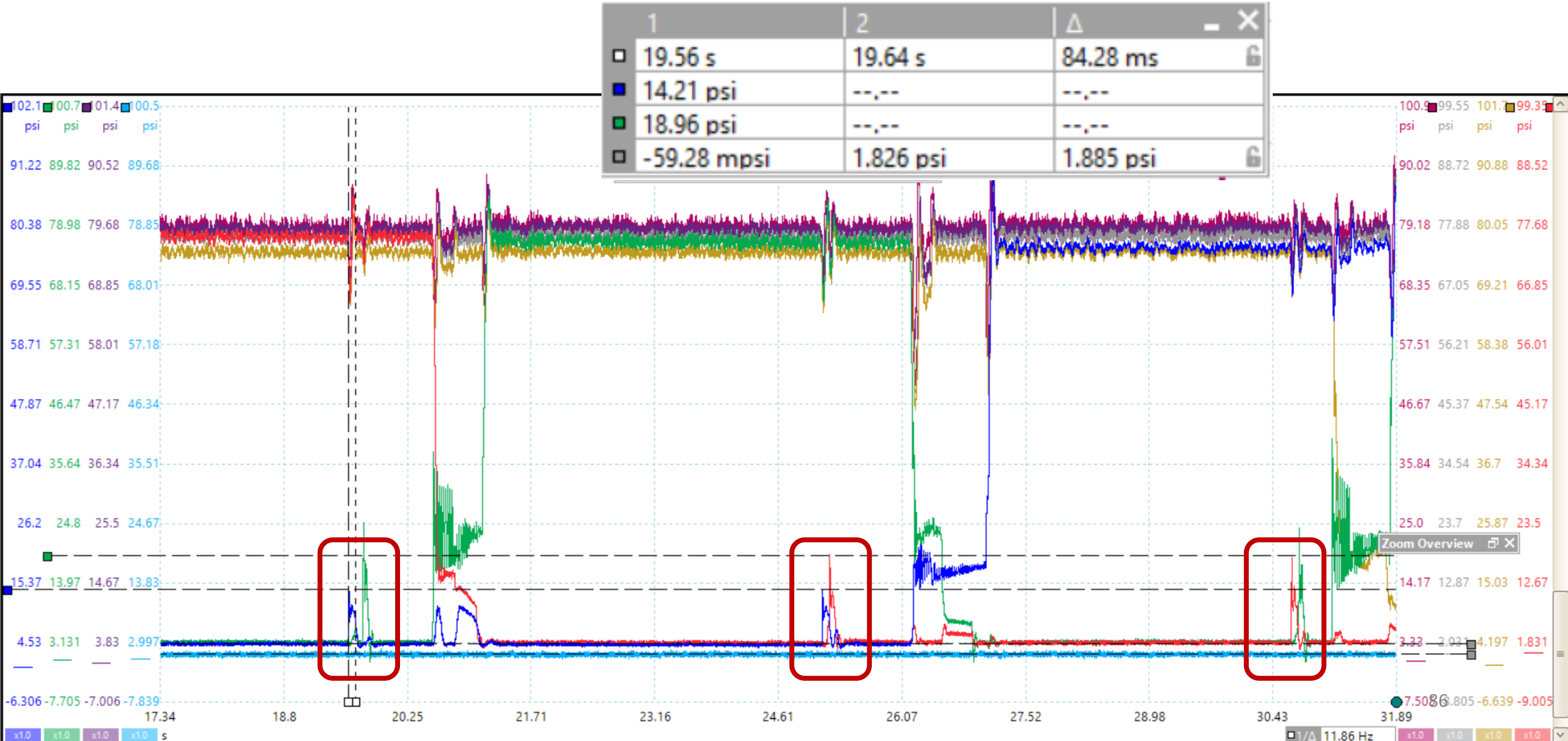
Single 456 pulse to about 31 psi

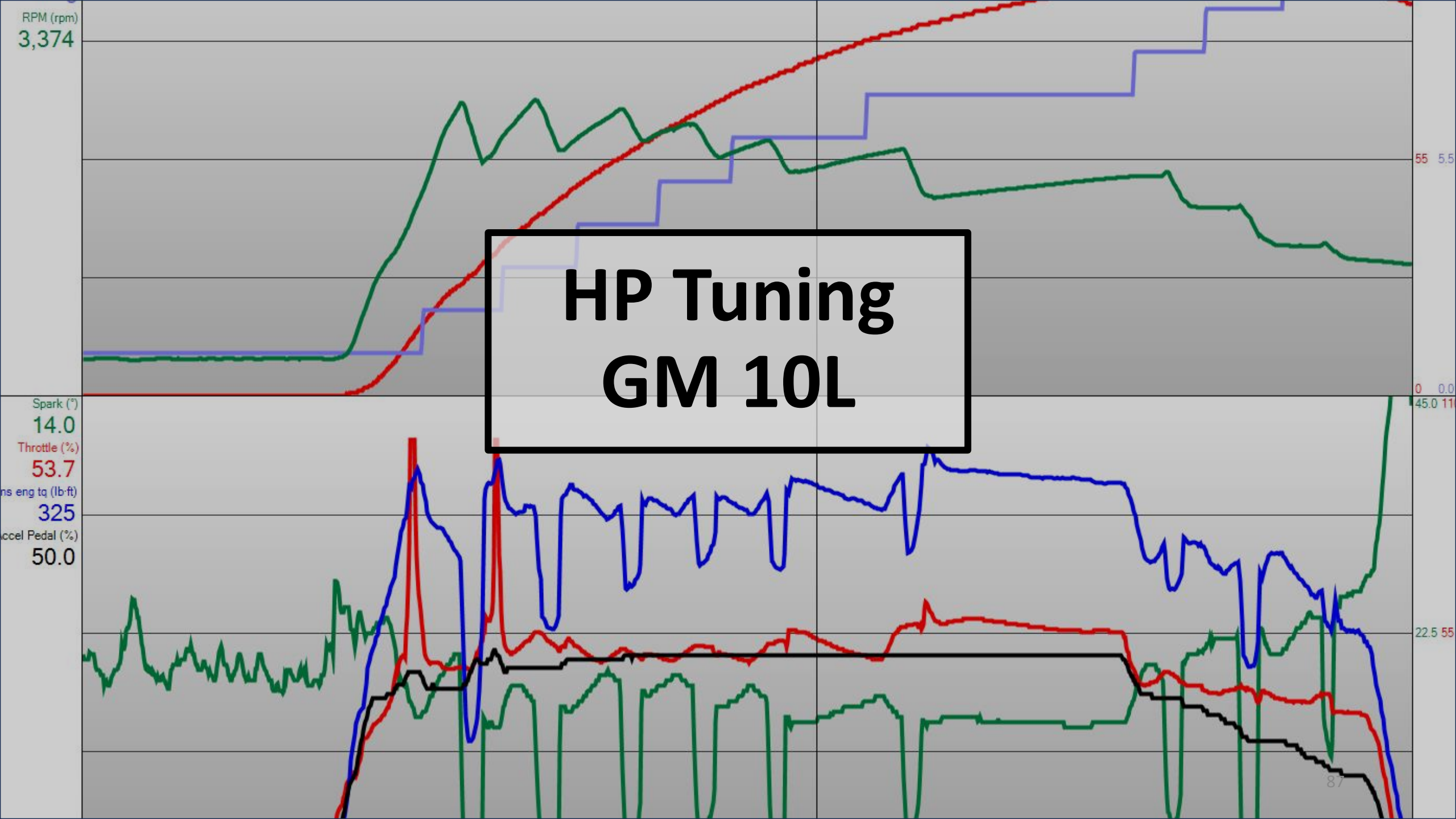


Air Purge Example – 10L80



Air Purge Example – 10L80




RPM (rpm)
3,374
55 5.5
0 0.0
Spark (°)
14.0
Throttle (%)
53.7
ns eng tq (lb·ft)
325
ccel Pedal (%)
50.0
45.0 11
22.5 55
HP Tuning
GM 10L

Who's using HP Tuners with transmissions?

I am, I use the editor and scanner

0

I am, but I only use the scanner

0

I am, but I only use the editor

0

No HP tuners for me .... yet

0

No HP tuners for me ..... ever!

0

If I did an evening HPTuners live session online, would you participate?

Monday evening 0

Tuesday evening 0

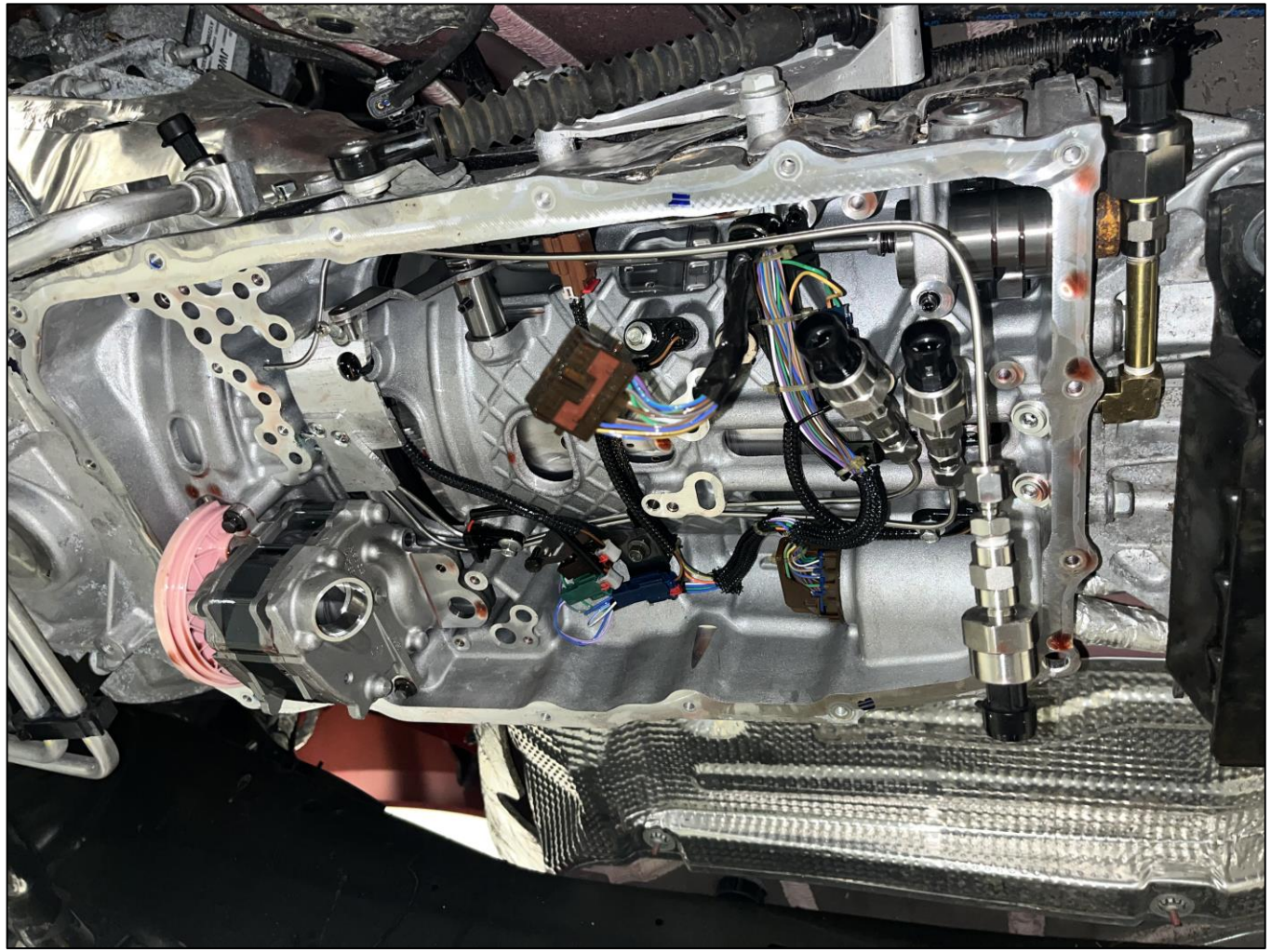
Wednesday evening 0

Thursday evening 0

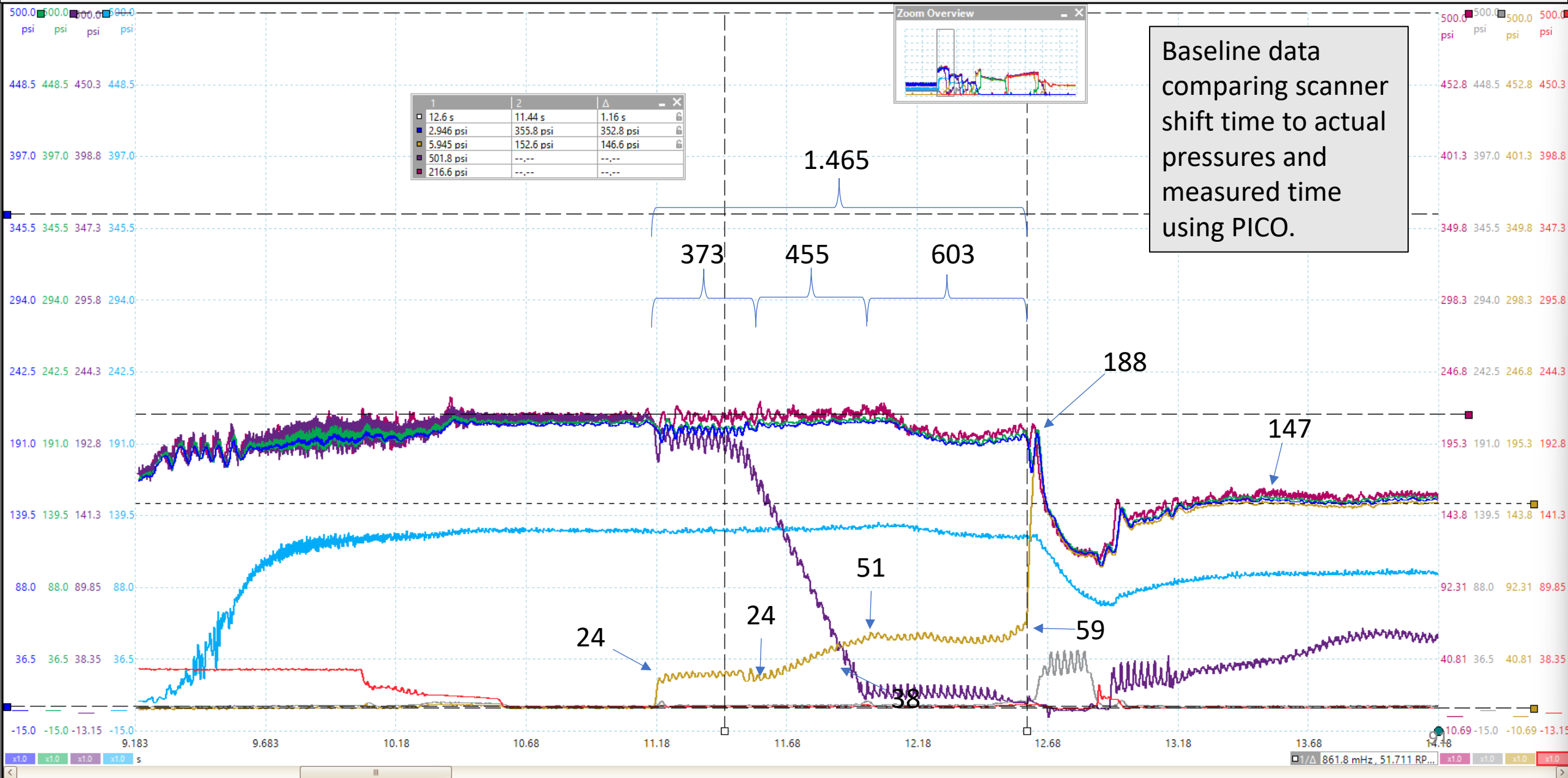
Are you kidding me? Beer-thirty, I'm off the clock and my brain turns off! 0

10L80 Tuning

- 2022 Silverado with clutches tapped for pressure
- What changed?
  - Shift Inertia
  - Shift time
  - Desired output torque factor
  - Torque management
- What didn’t change?
  - Baseline pressure
  - Max pressure
  - Max clutch
  - Pressure offset

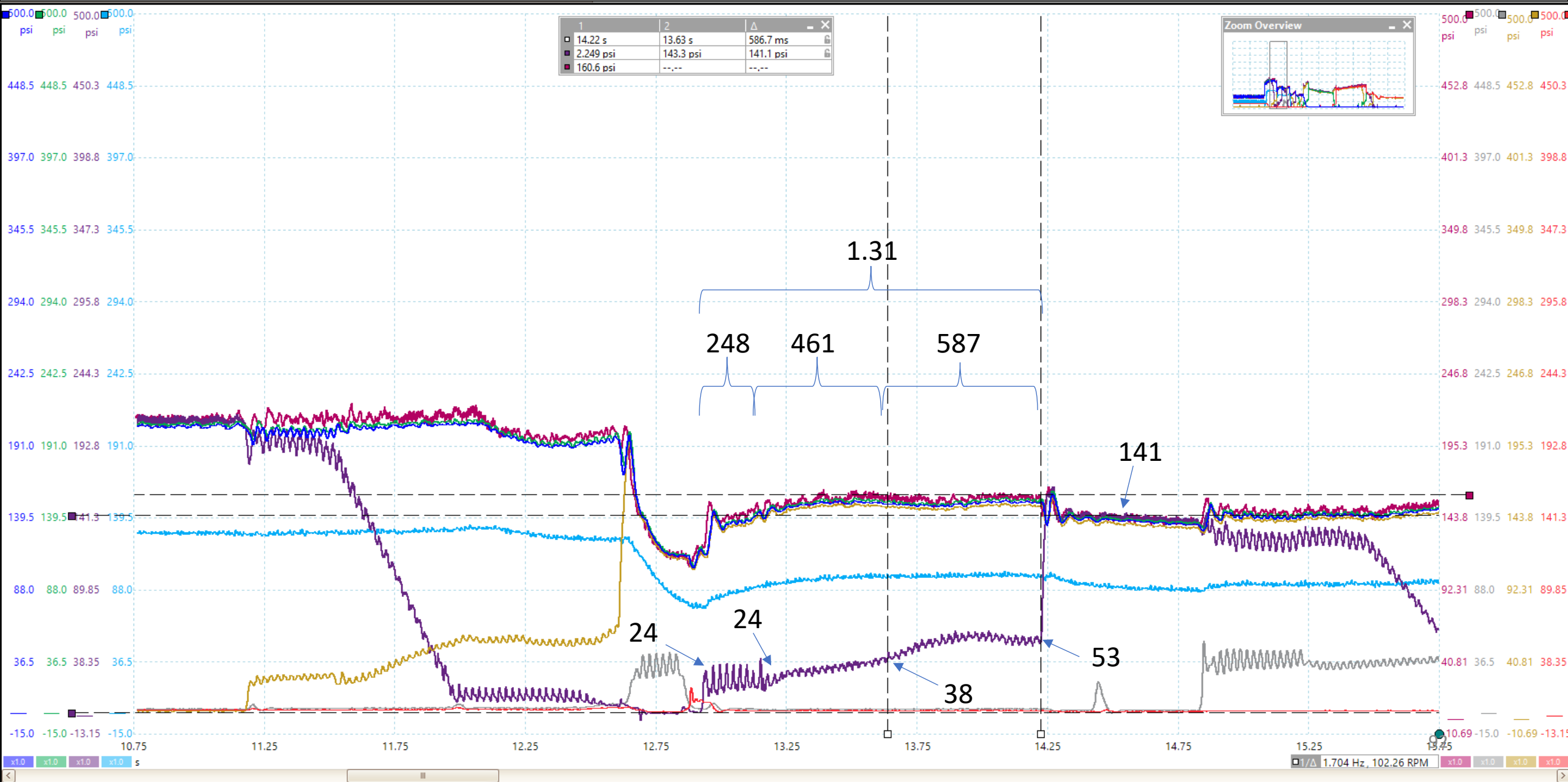


10L Baseline 40% Throttle 1-2 shift – ST 450ms



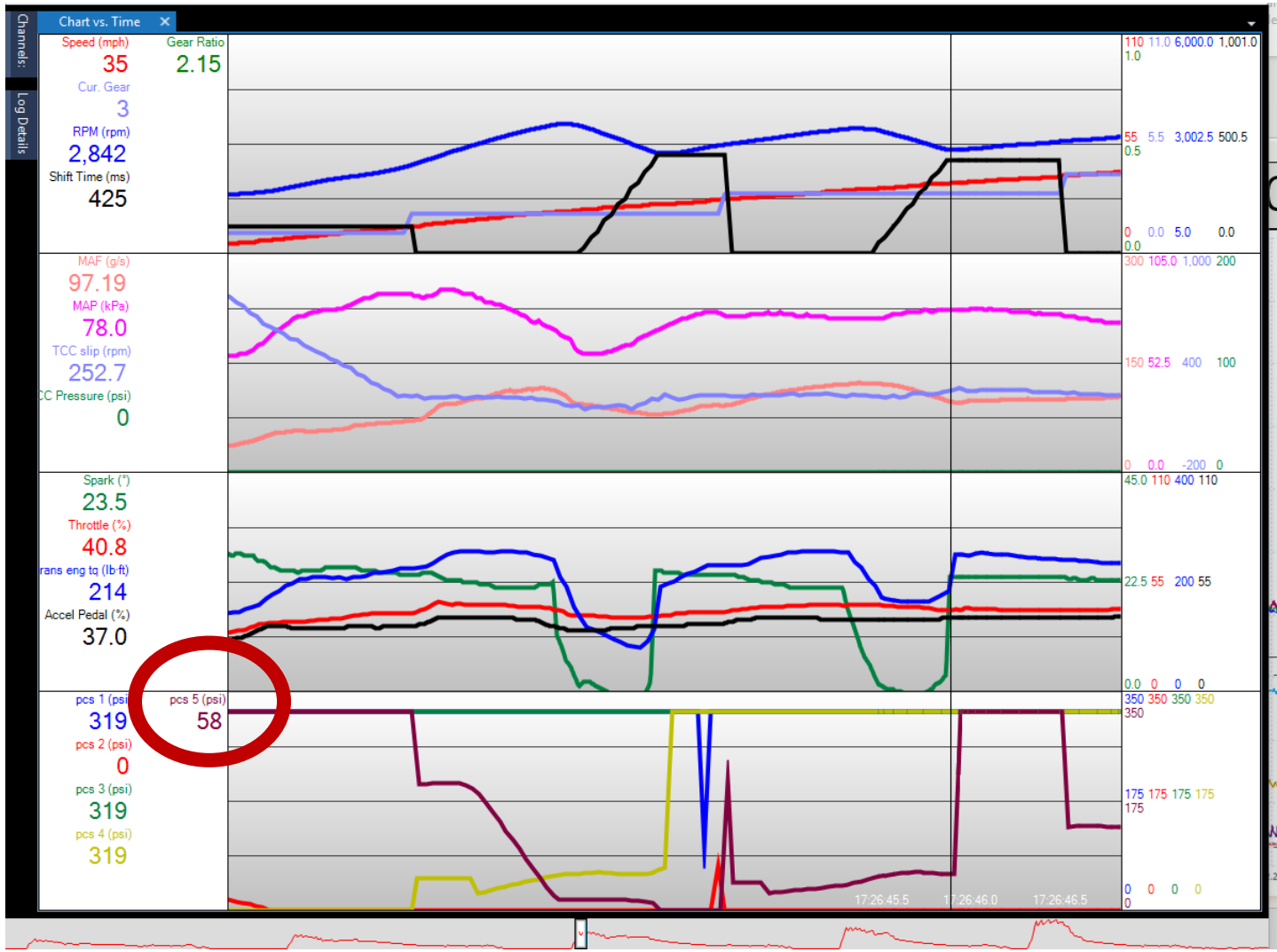
Baseline data comparing scanner shift time to actual pressures and measured time using PICO.

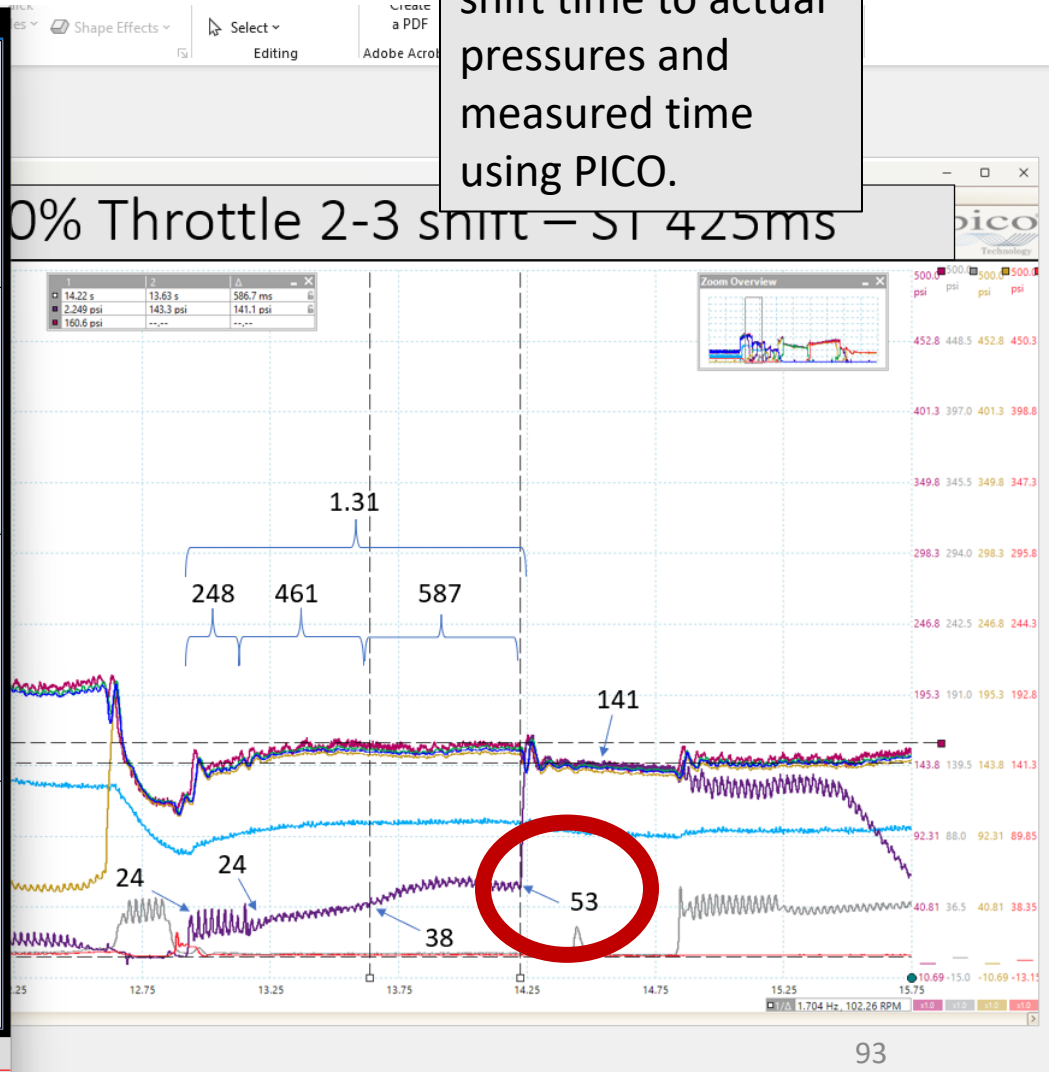
10L Baseline 40% Throttle 2-3 shift – ST 425ms



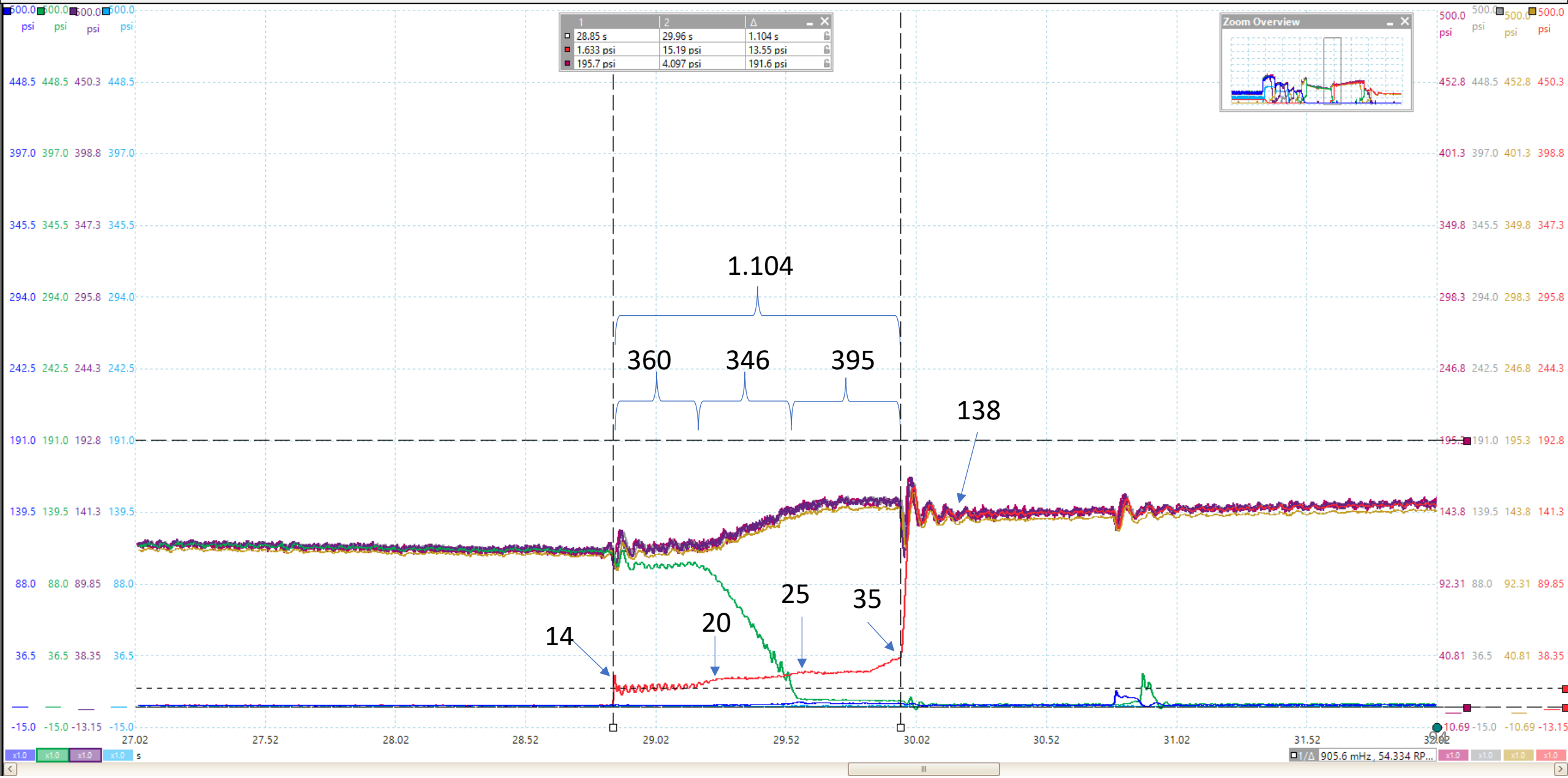
10L Baseline 40% Throttle 2-3 shift – ST 450ms

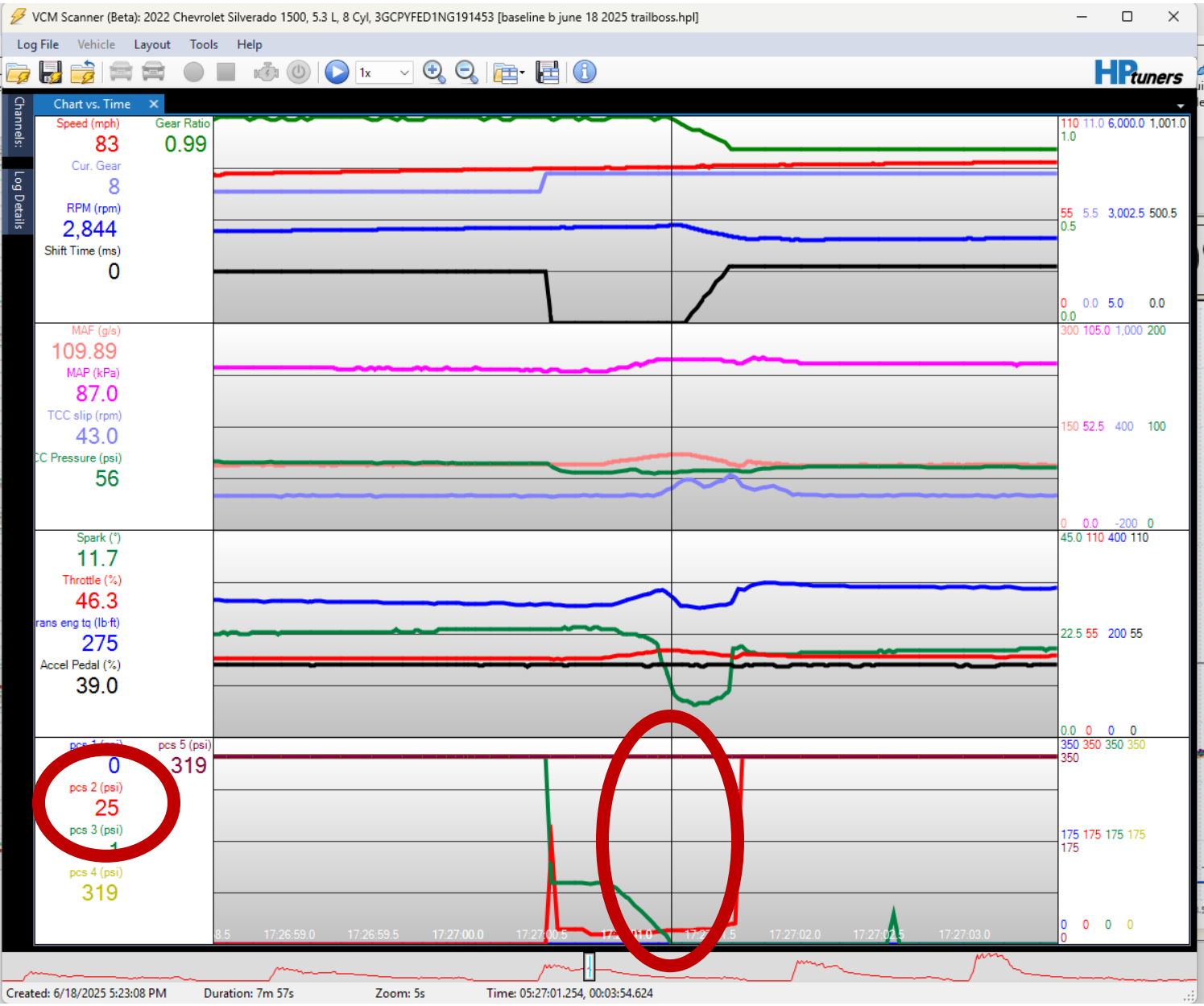
Baseline data comparing scanner shift time to actual pressures and measured time using PICO.

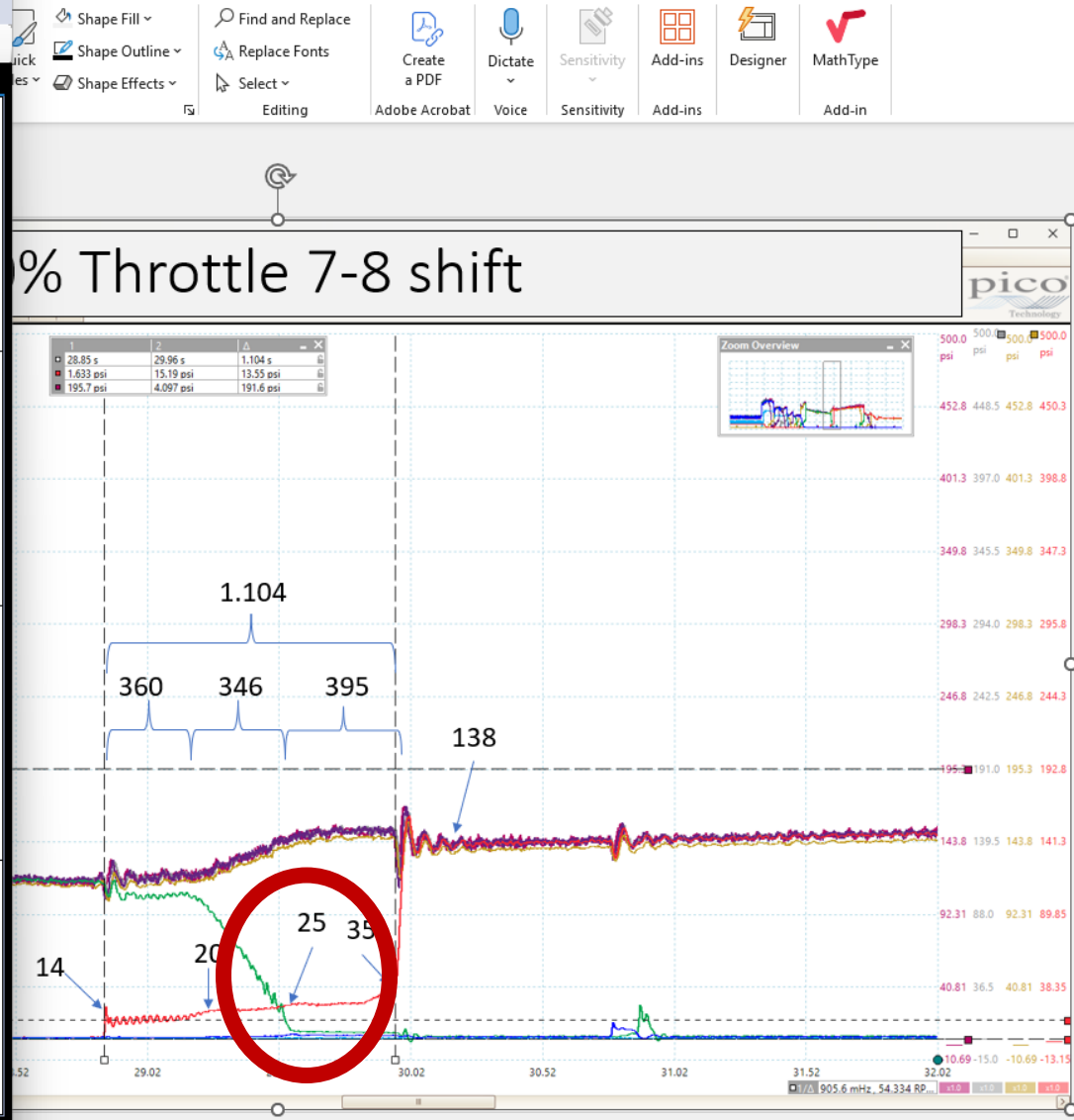




10L Baseline 40% Throttle 7-8 shift – ST 275ms




VCM Scanner (Beta): 2022 Chevrolet Silverado 1500, 5.3 L, 8 Cyl, 3GCPYFED1NG191453 [baseline b june 18 2025 trailboss.hpl]
Log File
Vehicle
Layout
Tools
Help
HPtuners
Chart vs. Time
Channels:
Log Details
Speed (mph)
83
Gear Ratio
0.99
Cur. Gear
8
RPM (rpm)
2,844
Shift Time (ms)
0
MAF (g/s)
109.89
MAP (kPa)
87.0
TCC slip (rpm)
43.0
CC Pressure (psi)
56
Spark (°)
11.7
Throttle (%)
46.3
rans eng tq (lb·ft)
275
Accel Pedal (%)
39.0
pcs 5 (psi)
319
0
pcs 2 (psi)
25
pcs 3 (psi)
pcs 4 (psi)
319
Created: 6/18/2025 5:23:08 PM
Duration: 7m 57s
Zoom: 5s
Time: 05:27:01.254, 00:03:54.624


Shape Fill
Shape Outline
Shape Effects
Find and Replace
Replace Fonts
Select
Editing
Create a PDF
Adobe Acrobat
Dictate
Voice
Sensitivity
Add-ins
Designer
MathType
Add-in
% Throttle 7-8 shift
pico
1.104
360
346
395
138
14
20
25
35

VCM Scanner (Beta): 2022 Chevrolet Silverado 1500, 5.3 L, 8 Cyl, 3GCPYFED1NG191453 [baseline b june 18 2025 trailboss.hpl]

Log File Vehicle Layout Tools Help

Chart vs. Time

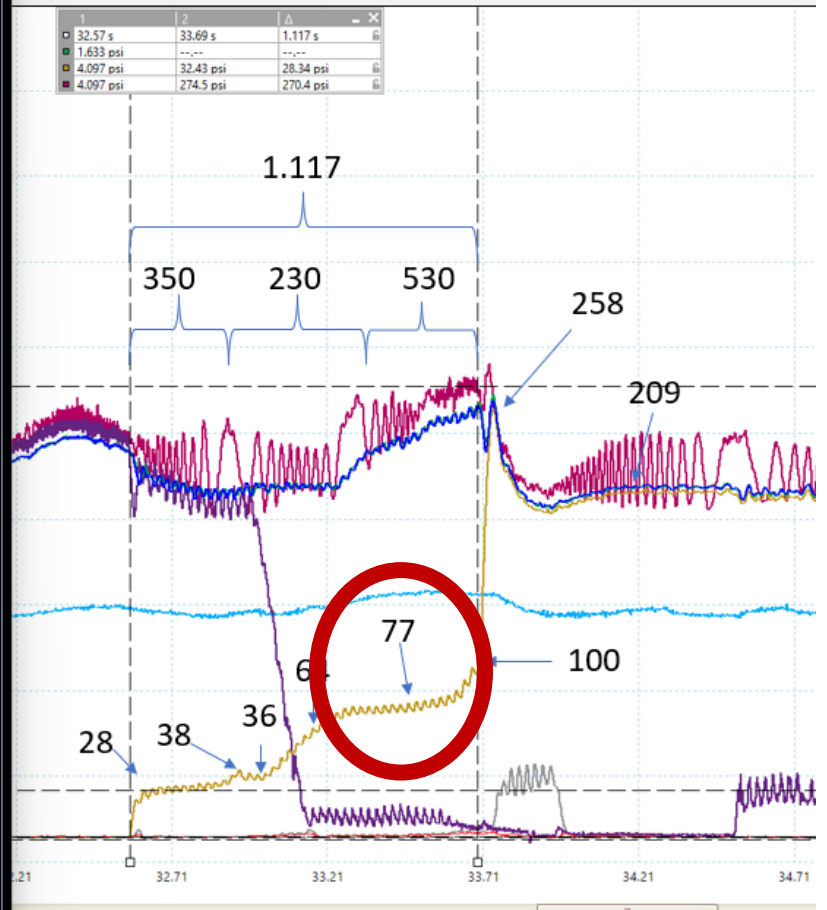
Speed (mph) 36 | Gear Ratio 3.86
Cur. Gear 2
RPM (rpm) 4,929
Shift Time (ms) 140
MAF (g/s) 253.55
MAP (kPa) 96.0
TCC slip (rpm) 186.3
TC Pressure (psi) 0
Spark (°) -7.0
Throttle (%) 100.0
trans eng tq (lb·ft) 158
Accel Pedal (%) 99.0
pcs 1 (psi) 319 | pcs 5 (psi) 16
pcs 2 (psi) 0
pcs 3 (psi) 319
pcs 4 (psi) 88

17:29:34.5 17:29:35.0 17:29:35.5 17:29:36.0 17:29:37.5 17:29:38.0 17:29:38.5

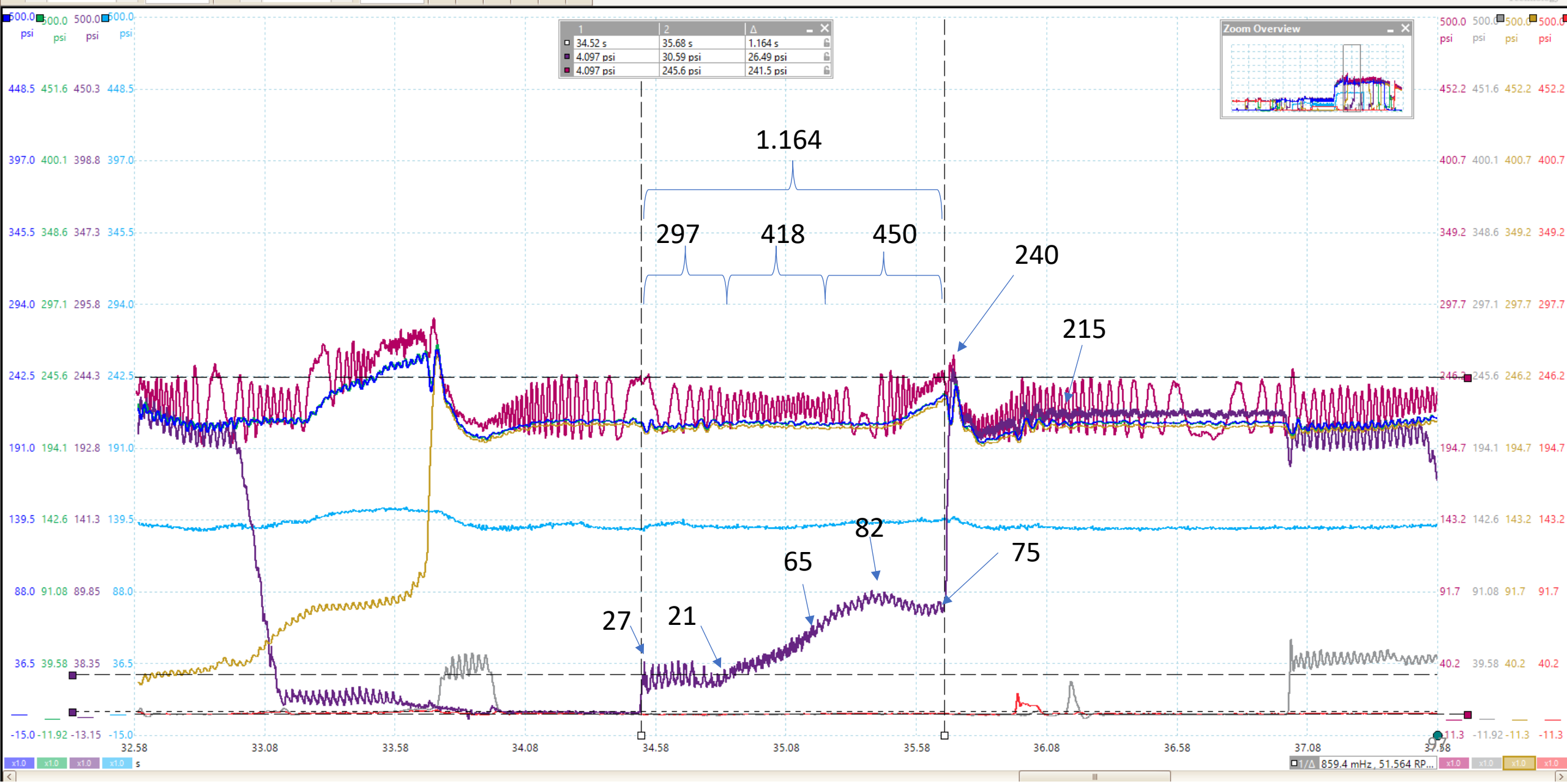
Created: 6/18/2025 5:23:08 PM Duration: 7m 57s Zoom: 5s Time: 05:29:36.592, 00:06:29.9

Shape Fill Shape Outline Shape Effects Find and Replace Replace Fonts Select Editing Create a PDF Adobe Acrobat Dictate Voice Sensitivity Sensitivity Add-in

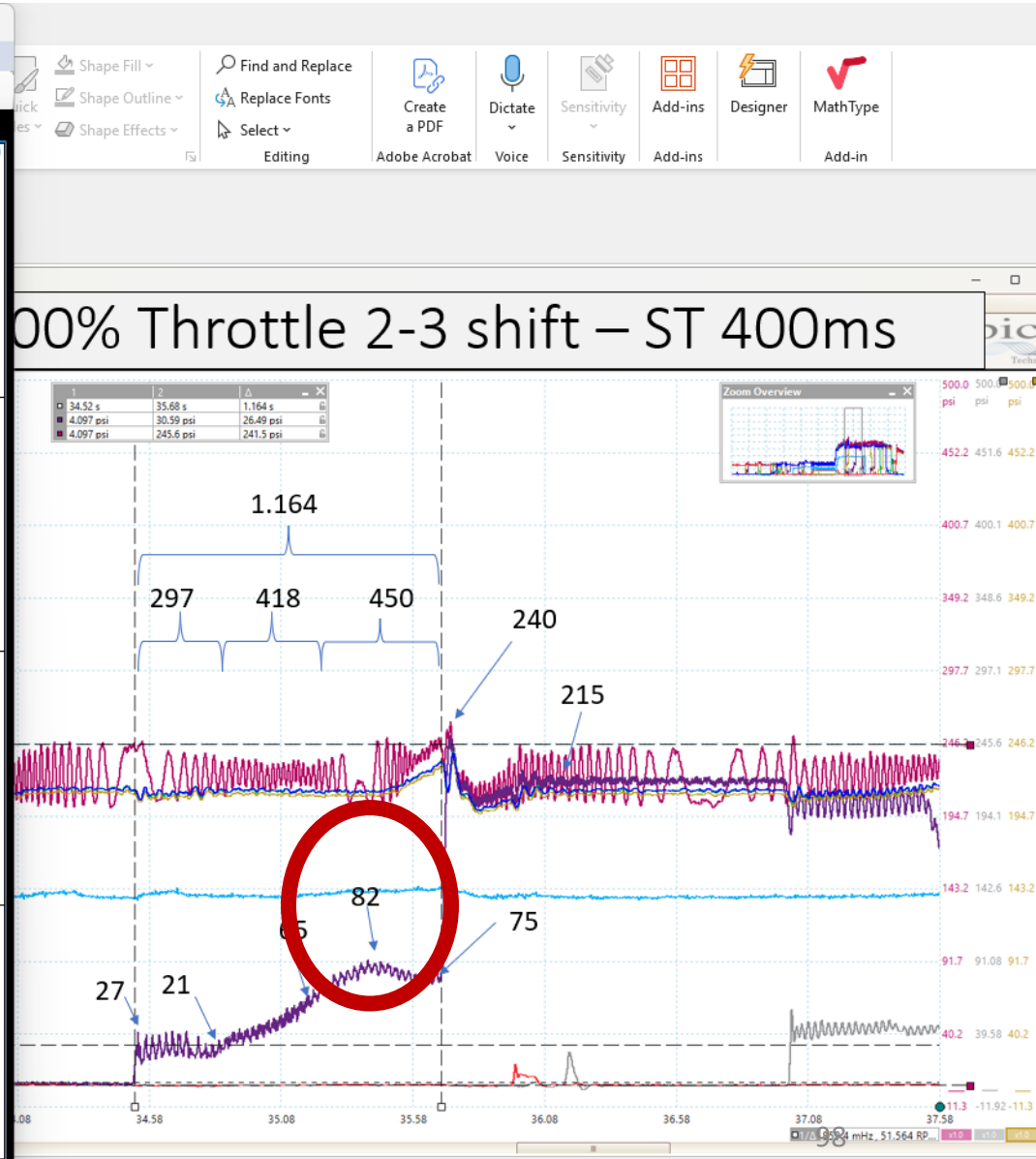
0% Throttle 1-2 shift – ST



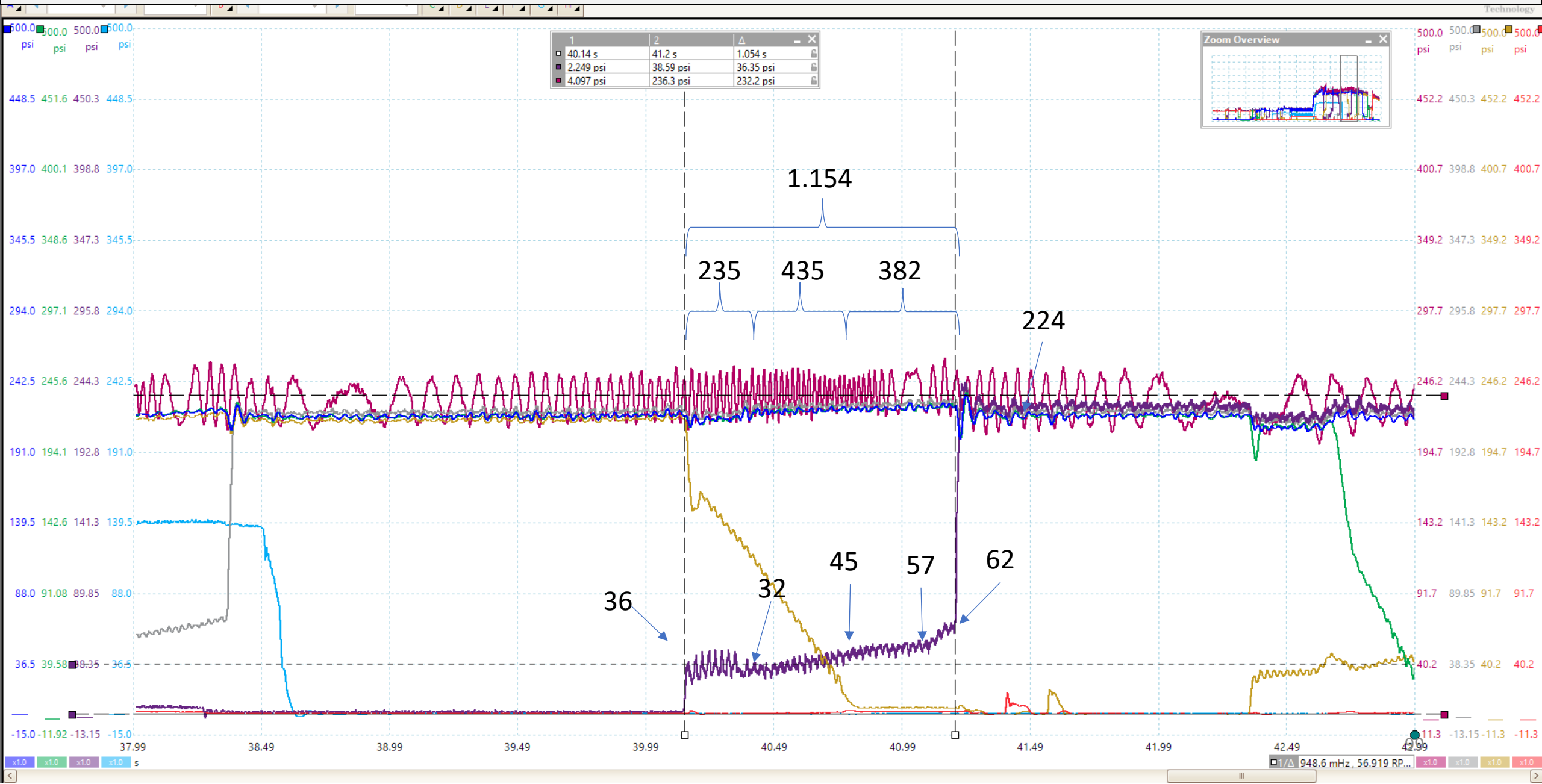
10L Baseline 100% Throttle 2-3 shift – ST 400ms



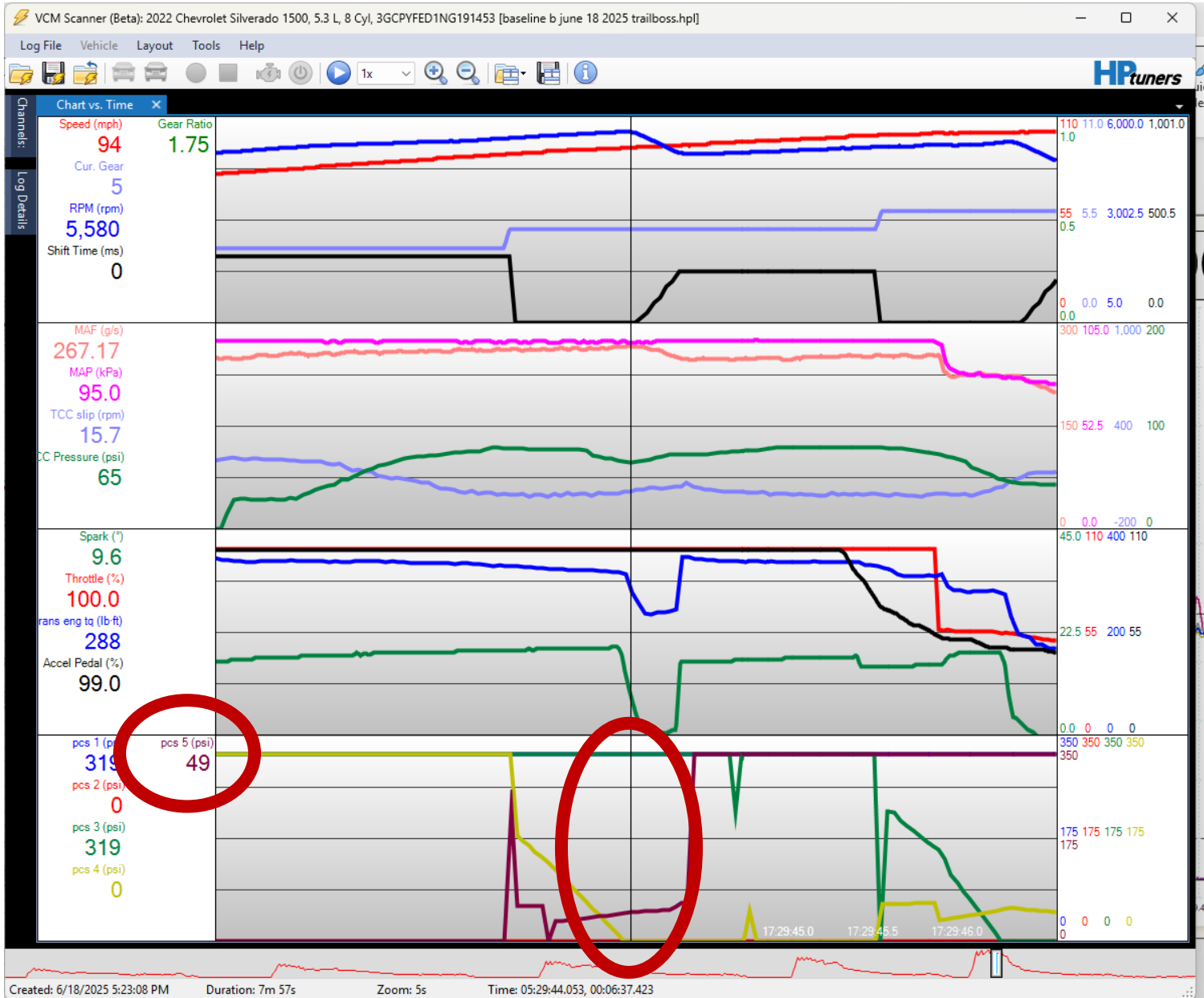
10L Baseline 100% Throttle 2-3 shift – ST 400ms

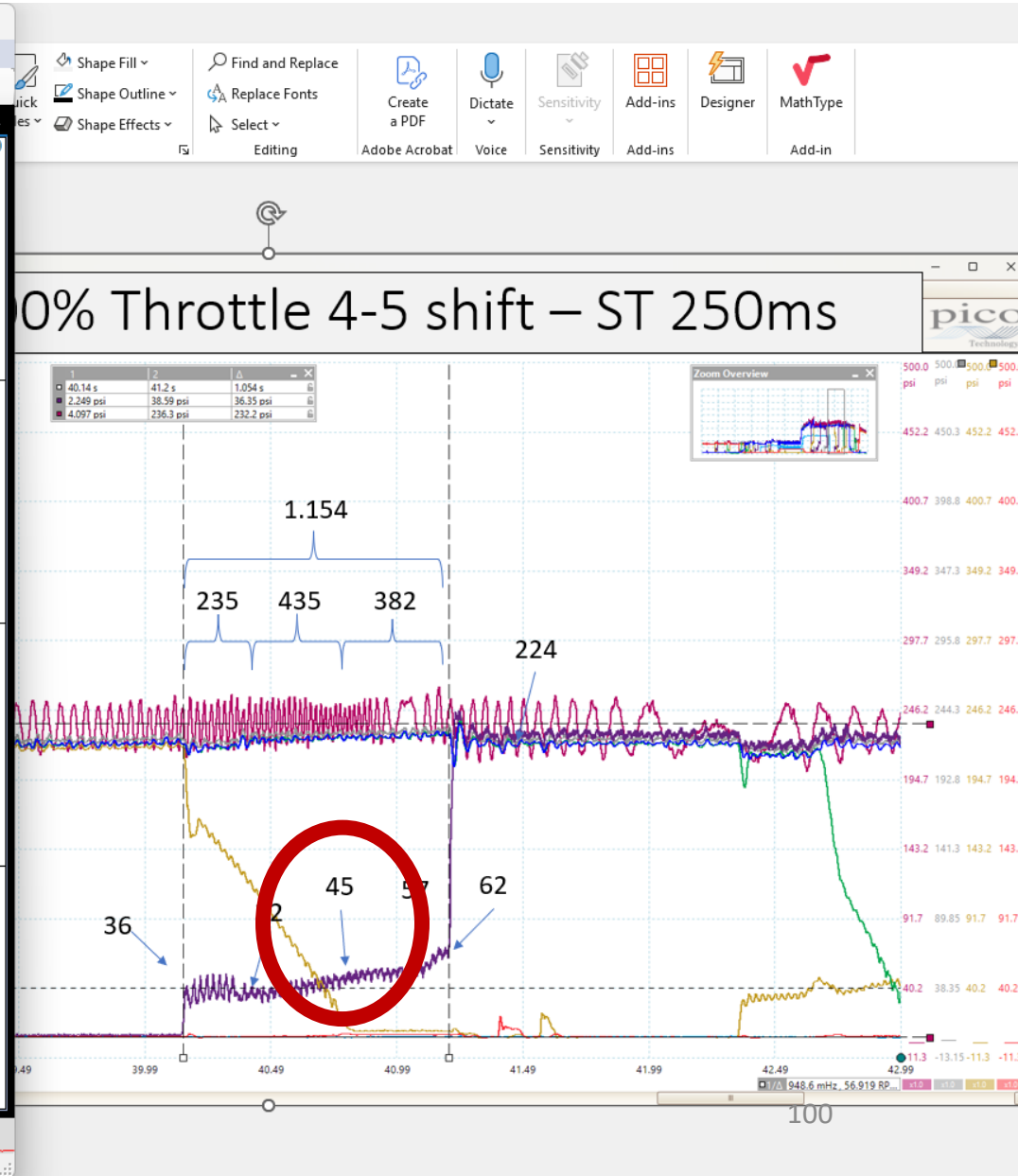


10L Baseline 100% Throttle 4-5 shift – ST 250ms

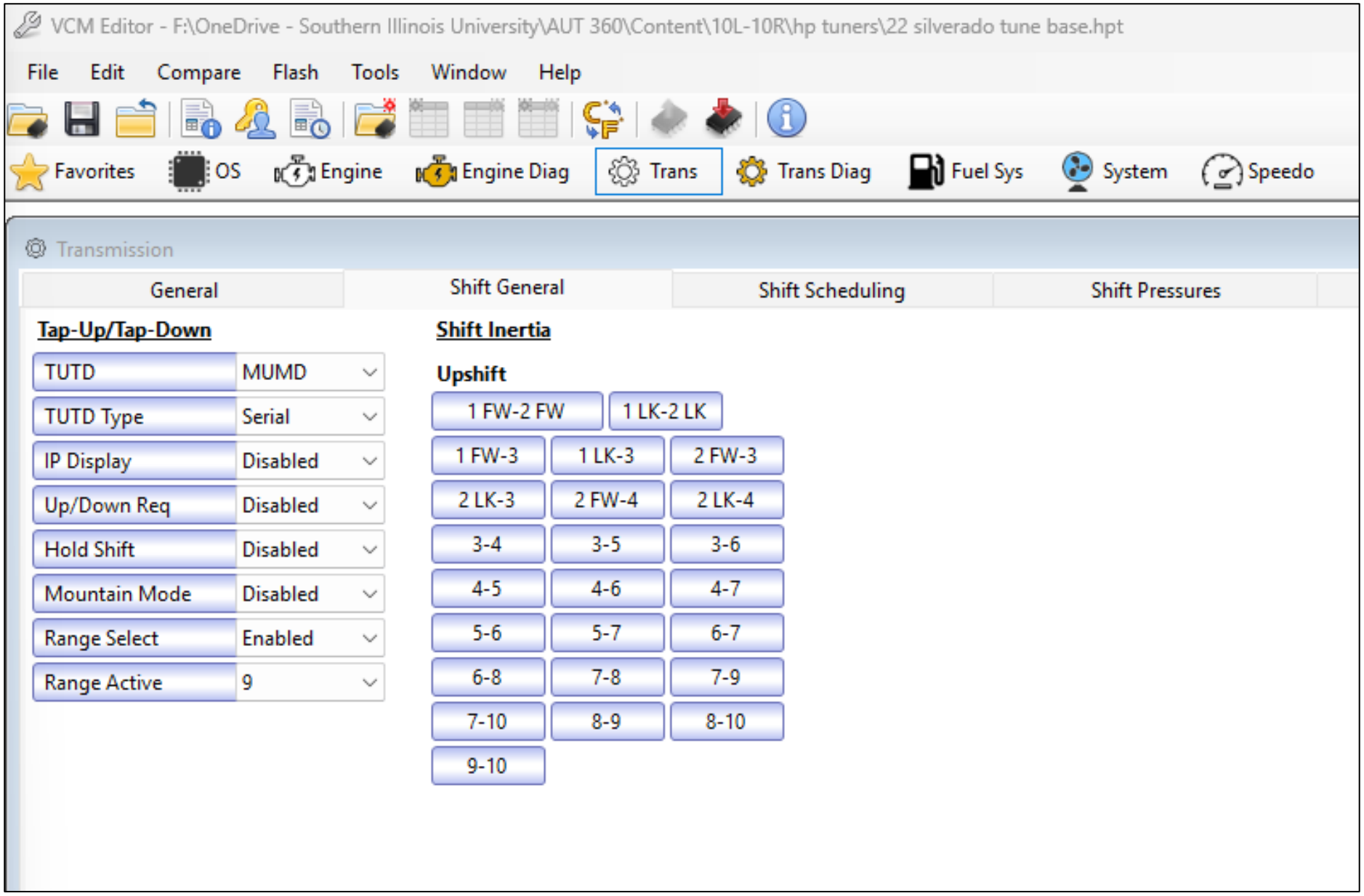


10L Baseline 100% Throttle 4-5 shift – ST 250ms

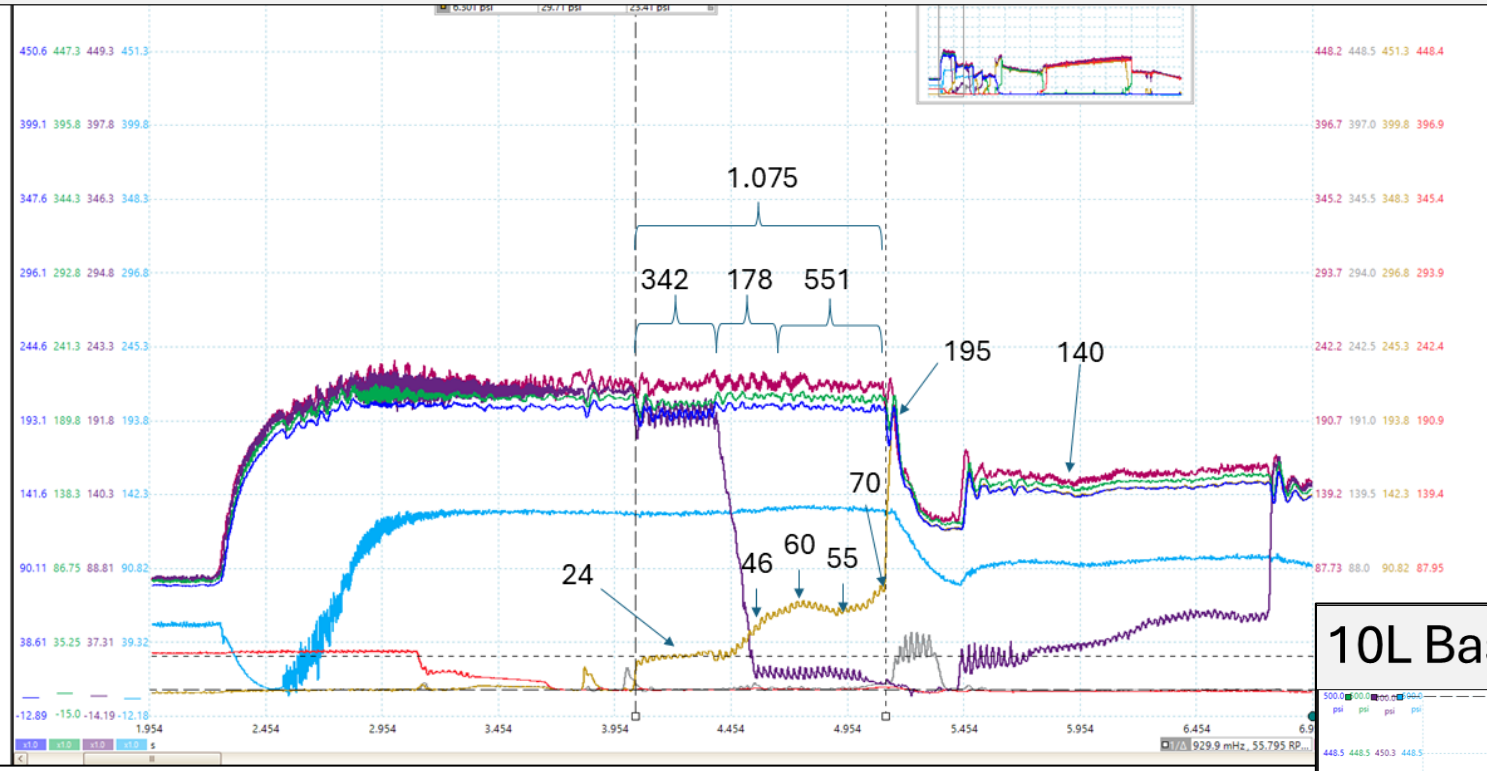


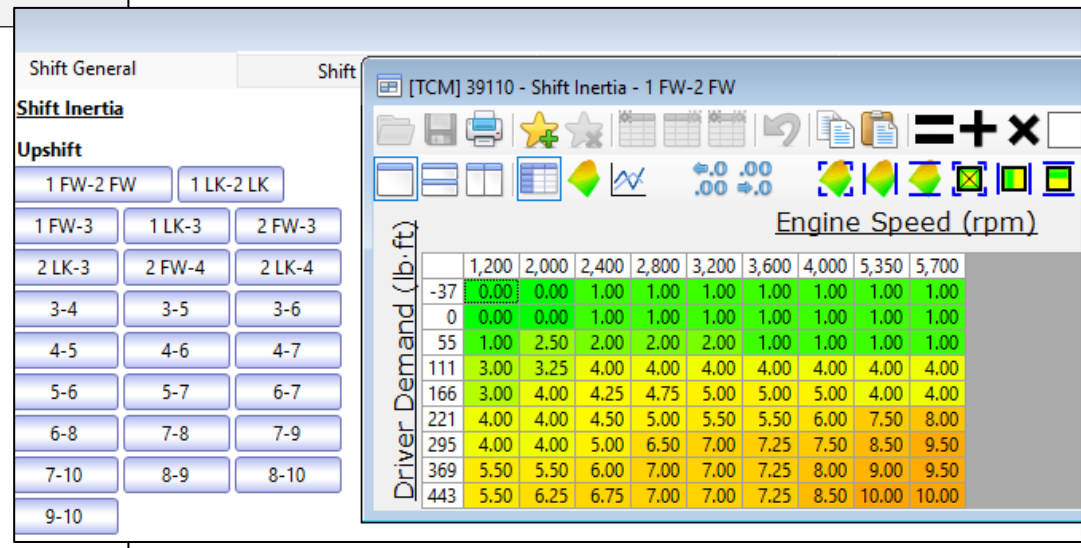


10L HP Tuner - Shift Inertia Tables



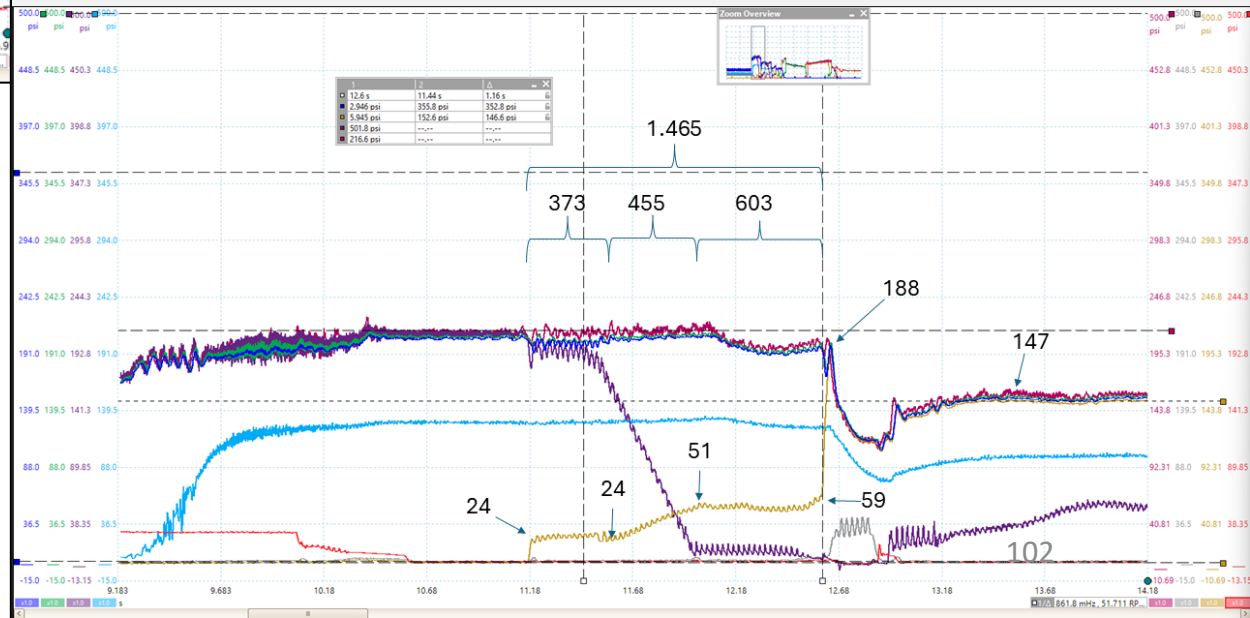
Shift Inertia Increased 30%, 40% Throttle 1-2 shift – ST 375 ms





	1,200	2,000	2,400	2,800	3,200	3,600	4,000	5,350	5,700
-37	0.00	0.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
0	0.00	0.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
55	1.00	2.50	2.00	2.00	2.00	1.00	1.00	1.00	1.00
111	3.00	3.25	4.00	4.00	4.00	4.00	4.00	4.00	4.00
166	3.00	4.00	4.25	4.75	5.00	5.00	5.00	4.00	4.00
221	4.00	4.00	4.50	5.00	5.50	5.50	6.00	7.50	8.00
295	4.00	4.00	5.00	6.50	7.00	7.25	7.50	8.50	9.50
369	5.50	5.50	6.00	7.00	7.00	7.25	8.00	9.00	9.50
443	5.50	6.25	6.75	7.00	7.00	7.25	8.50	10.00	10.00

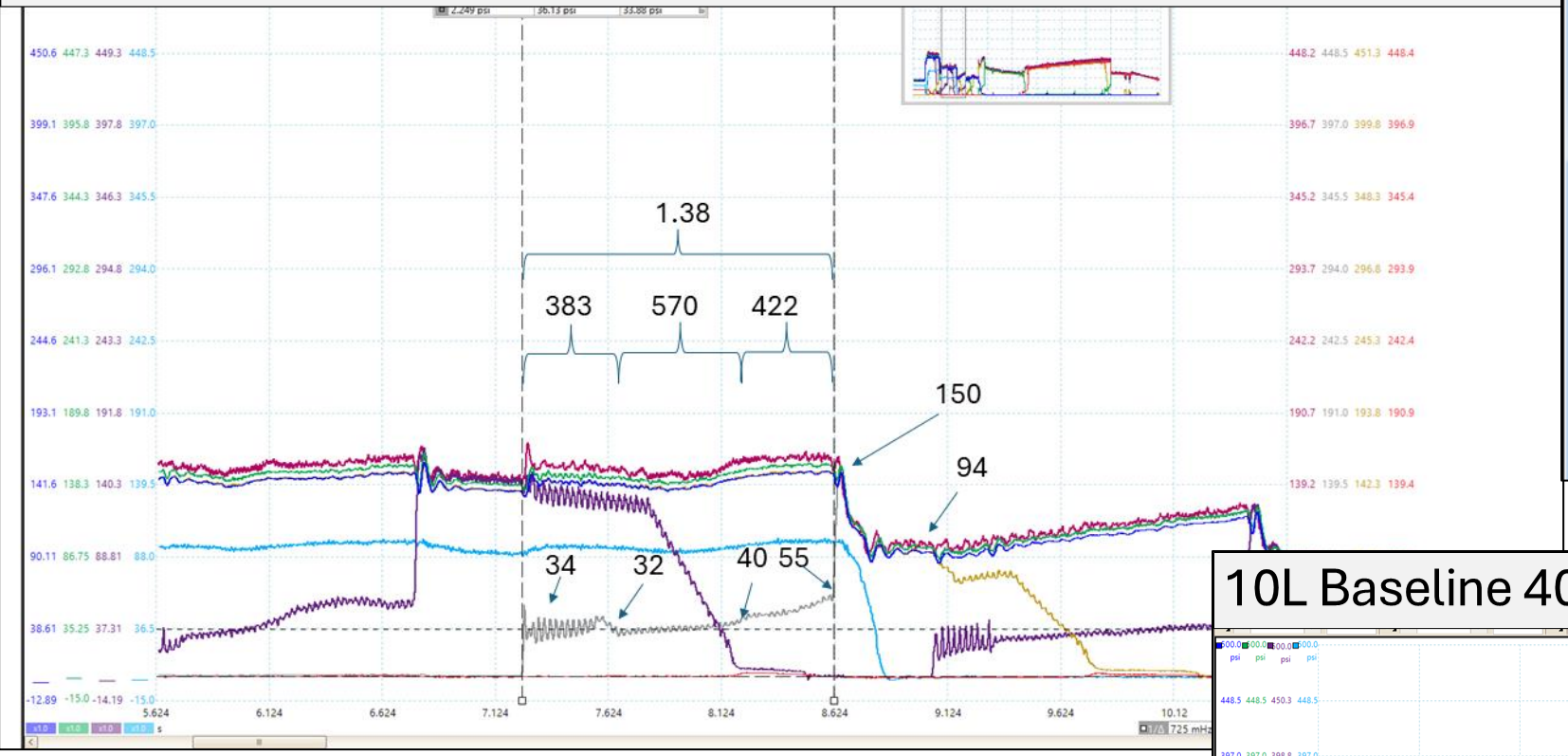
10L Baseline 40% Throttle 1-2 shift – ST 450ms



Shift inertia:

- Affected medium throttle shifts more than WOT
- Scanner reported shift times didn't change much (except 1-2)
- Quicker overall shift time
- Mostly the Torque Phase
- Shifting pressure remained the same or slightly higher

Shift Inertia Increased 30%, 40% Throttle 3-4 shift – ST 275 ms



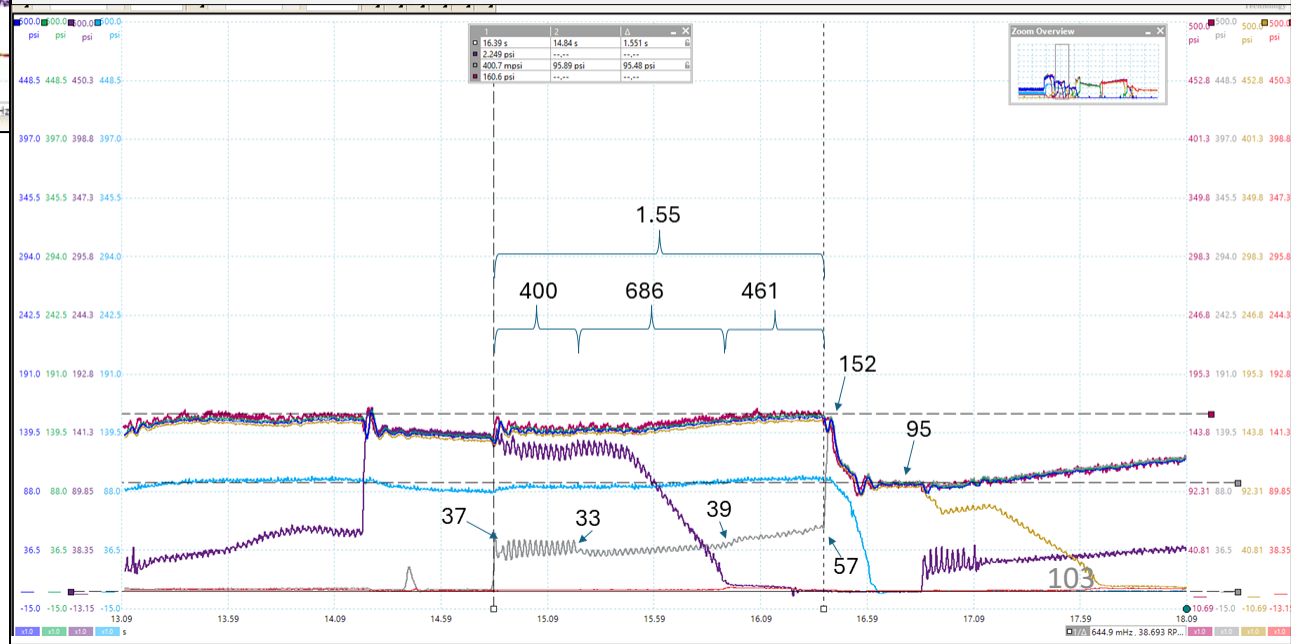
[TCM] 39350 - Shift Inertia - 3-4

Engine Speed (rpm)

Driver Demand (lb·ft)

	1,200	2,000	2,400	2,800	3,200	3,600	4,000	5,350	5,700
-37	2.00	2.00	2.00	2.00	2.00	2.50	3.25	4.00	4.00
0	2.00	2.00	2.00	2.50	2.50	3.00	3.75	4.50	4.50
55	2.00	2.00	2.50	3.00	3.50	4.25	4.75	5.50	5.50
111	2.50	3.00	3.75	4.00	4.00	4.75	5.50	6.00	6.00
166	2.75	3.00	4.00	4.25	4.50	5.00	6.00	6.50	7.00
221	3.25	4.00	4.50	4.75	5.00	5.50	6.25	7.00	8.00
295	4.00	4.50	5.00	5.50	6.00	6.50	7.00	8.25	9.50
369	4.50	5.00	5.50	6.00	6.50	7.00	8.00	9.00	9.50
443	5.00	5.75	6.25	6.75	7.50	7.50	8.00	9.00	9.50

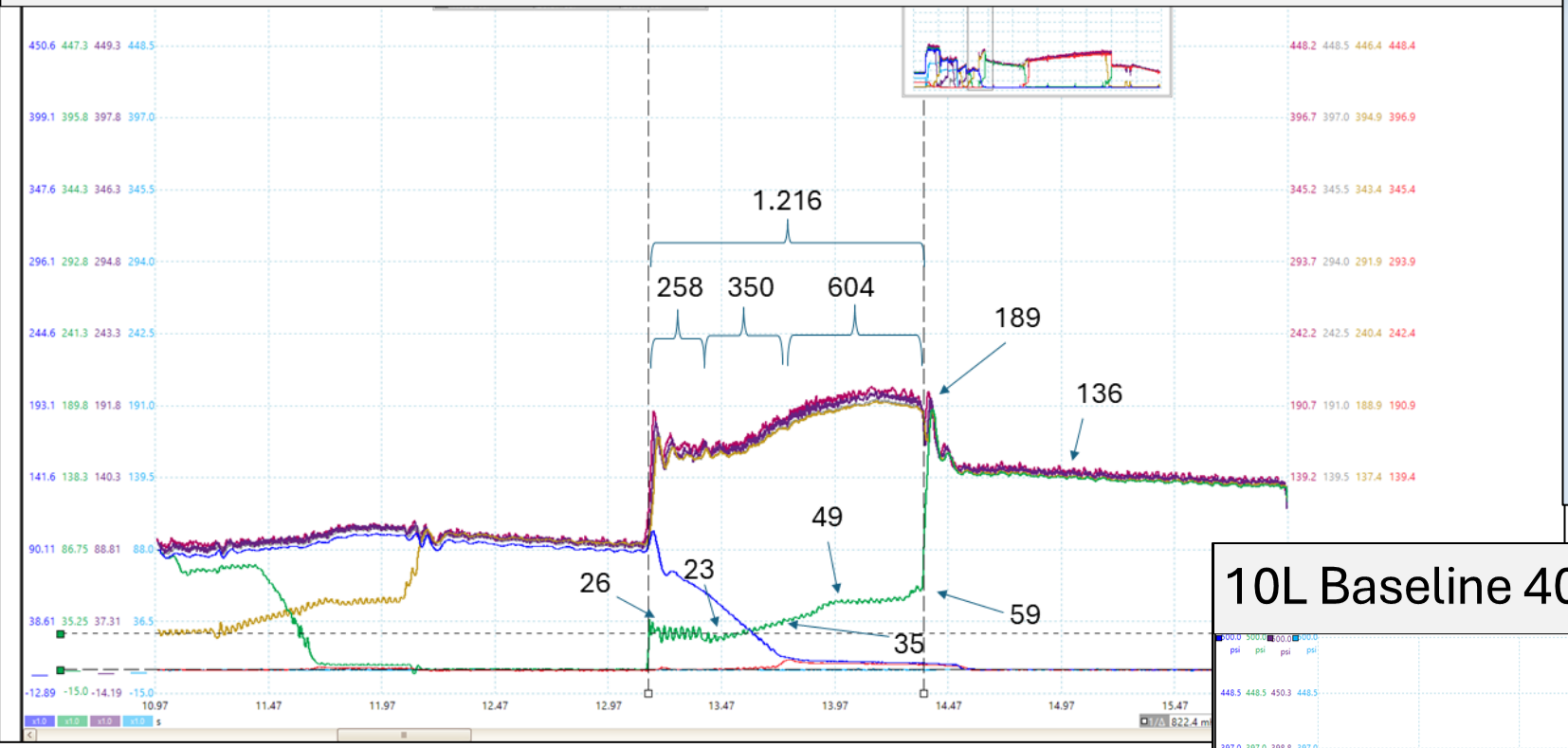
10L Baseline 40% Throttle 3-4 shift – ST 275ms



Shift inertia:

- Affected medium throttle shifts more than WOT
- Scanner reported shift times didn't change much
- Quicker overall shift time
- Mostly the Torque Phase
- Shifting pressure remained the same or slightly higher

Shift Inertia Increased 30%, 40% Throttle 6-7 shift – ST 275 ms



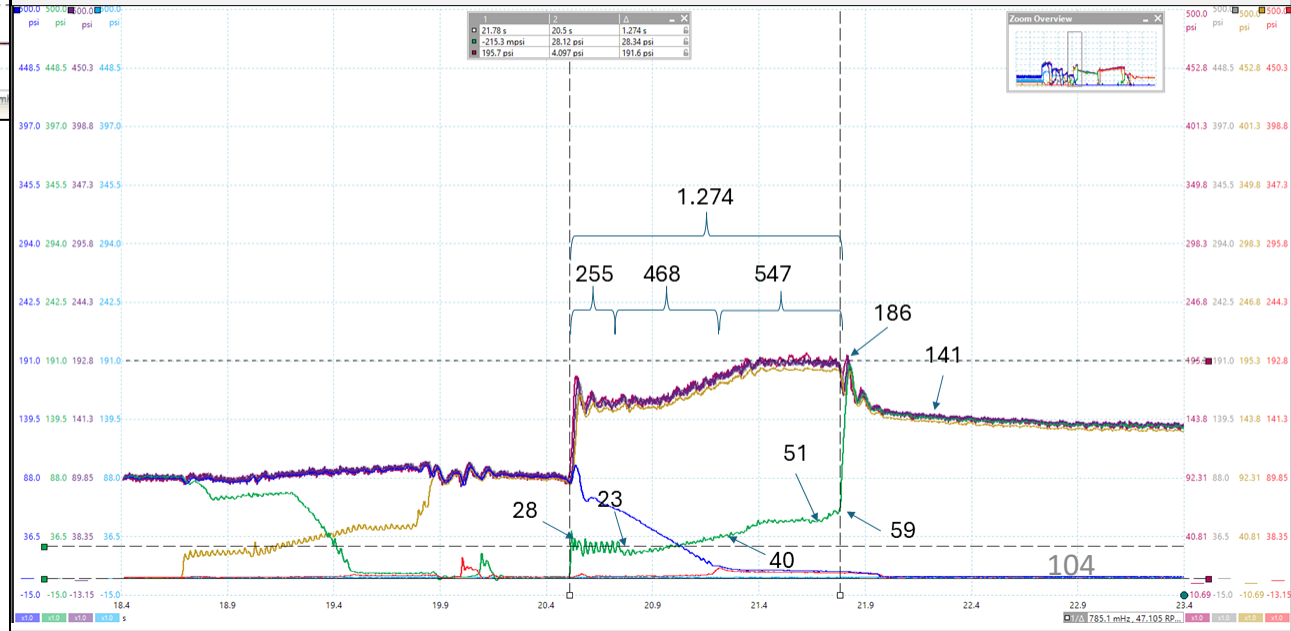
[TCM] 39353 - Shift Inertia - 6-7

Engine Speed (rpm)

Driver Demand (lb·ft)

	1,200	2,000	2,400	2,800	3,200	3,600	4,000	5,350	5,700
-37	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
0	2.00	2.25	2.50	2.50	2.50	2.50	2.50	2.50	2.50
55	2.00	3.00	3.25	3.50	3.50	3.50	4.00	4.50	5.00
111	2.50	3.25	3.75	4.00	4.25	4.75	5.25	6.00	6.50
166	2.75	3.50	4.00	4.50	4.75	5.50	6.00	6.50	7.00
221	3.50	4.00	4.50	5.00	5.50	5.50	5.50	7.00	9.00
295	4.75	5.00	5.50	6.00	6.25	6.25	6.25	7.50	9.00
369	5.00	5.50	6.00	6.50	7.00	7.00	7.00	9.00	9.00
443	5.50	6.25	6.50	7.00	7.50	7.50	7.50	9.00	9.00

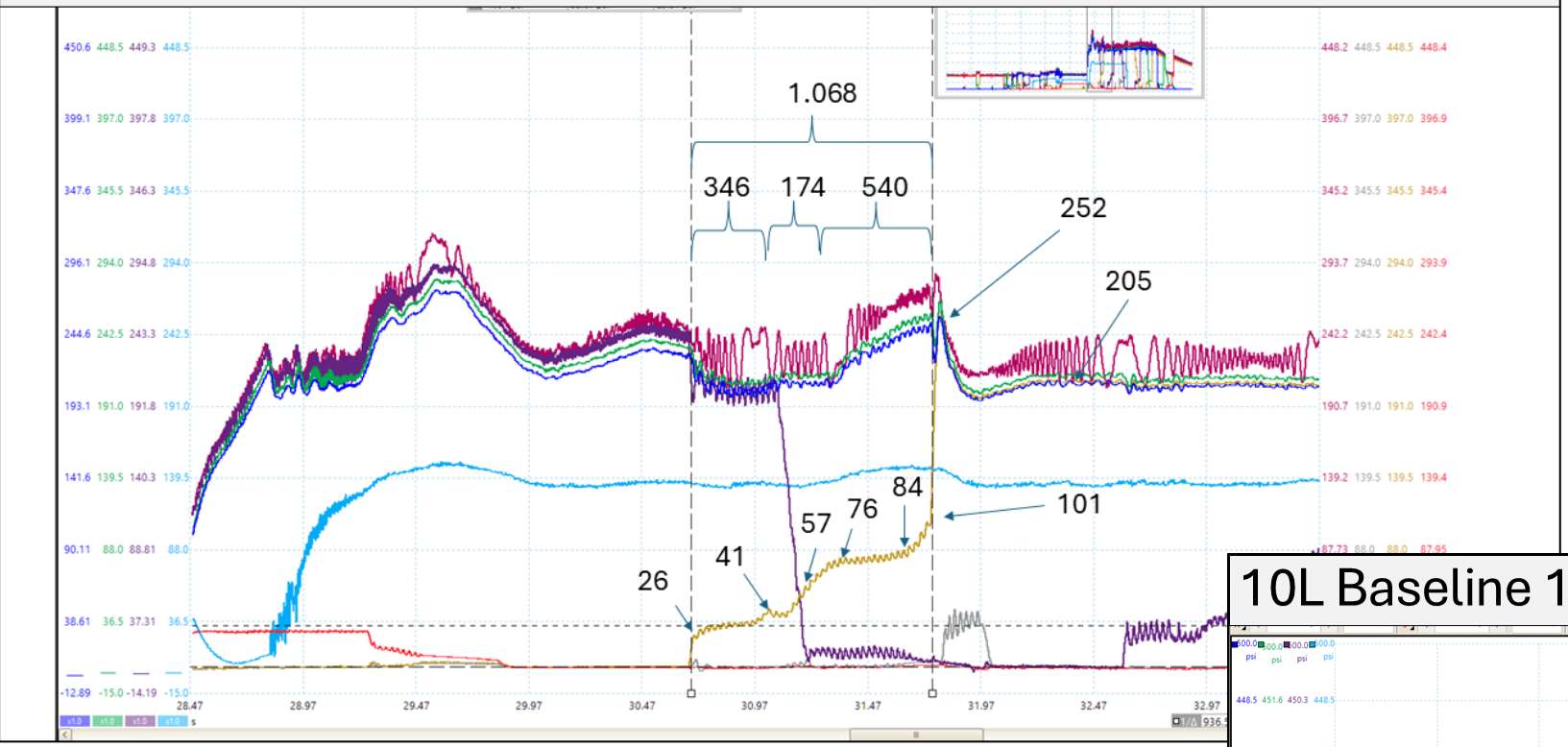
10L Baseline 40% Throttle 6-7 shift – ST 250ms

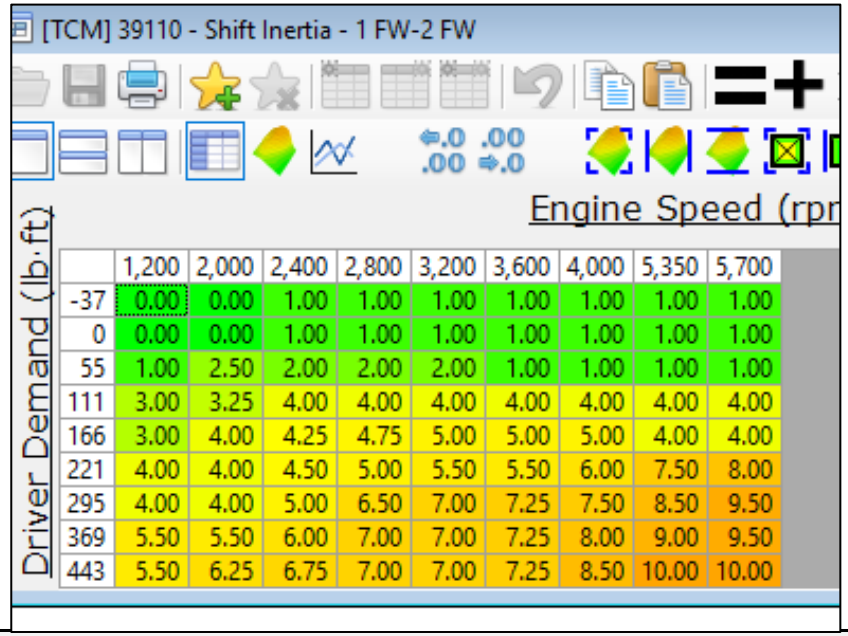


Shift inertia:

- Affected medium throttle shifts more than WOT
- Scanner reported shift times didn't change much
- Quicker overall shift time
- Mostly the Torque Phase
- Shifting pressure remained the same or slightly higher

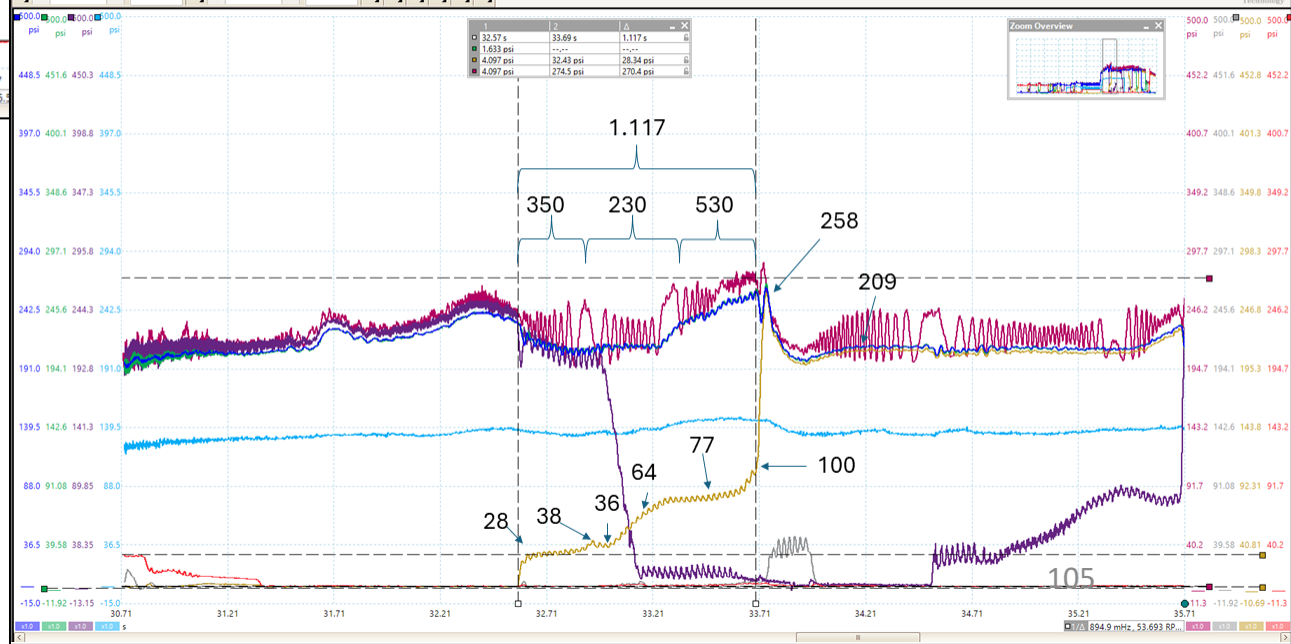
Shift Inertia Increased 30%, 100% Throttle 1-2 shift – ST 375 ms





	1,200	2,000	2,400	2,800	3,200	3,600	4,000	5,350	5,700
-37	0.00	0.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
0	0.00	0.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
55	1.00	2.50	2.00	2.00	2.00	1.00	1.00	1.00	1.00
111	3.00	3.25	4.00	4.00	4.00	4.00	4.00	4.00	4.00
166	3.00	4.00	4.25	4.75	5.00	5.00	5.00	4.00	4.00
221	4.00	4.00	4.50	5.00	5.50	5.50	6.00	7.50	8.00
295	4.00	4.00	5.00	6.50	7.00	7.25	7.50	8.50	9.50
369	5.50	5.50	6.00	7.00	7.00	7.25	8.00	9.00	9.50
443	5.50	6.25	6.75	7.00	7.00	7.25	8.50	10.00	10.00

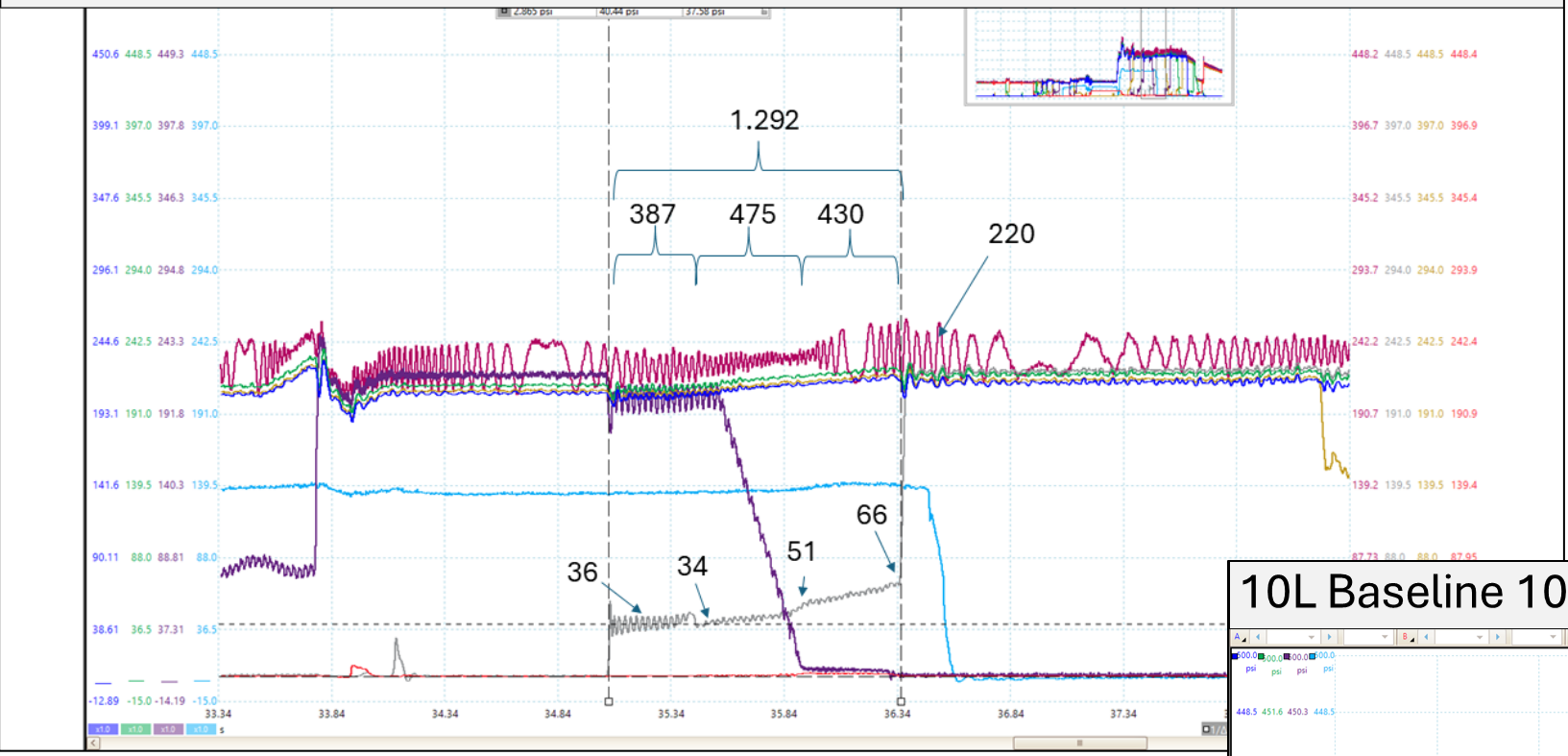
10L Baseline 100% Throttle 1-2 shift – ST 375ms



Shift inertia:

- Affected medium throttle shifts more than WOT
- Scanner reported shift times didn't change much
- Quicker overall shift time
- Mostly the Torque Phase
- Shifting pressure remained the same or slightly higher

Shift Inertia Increased 30%, 100% Throttle 3-4 shift – ST 300 ms



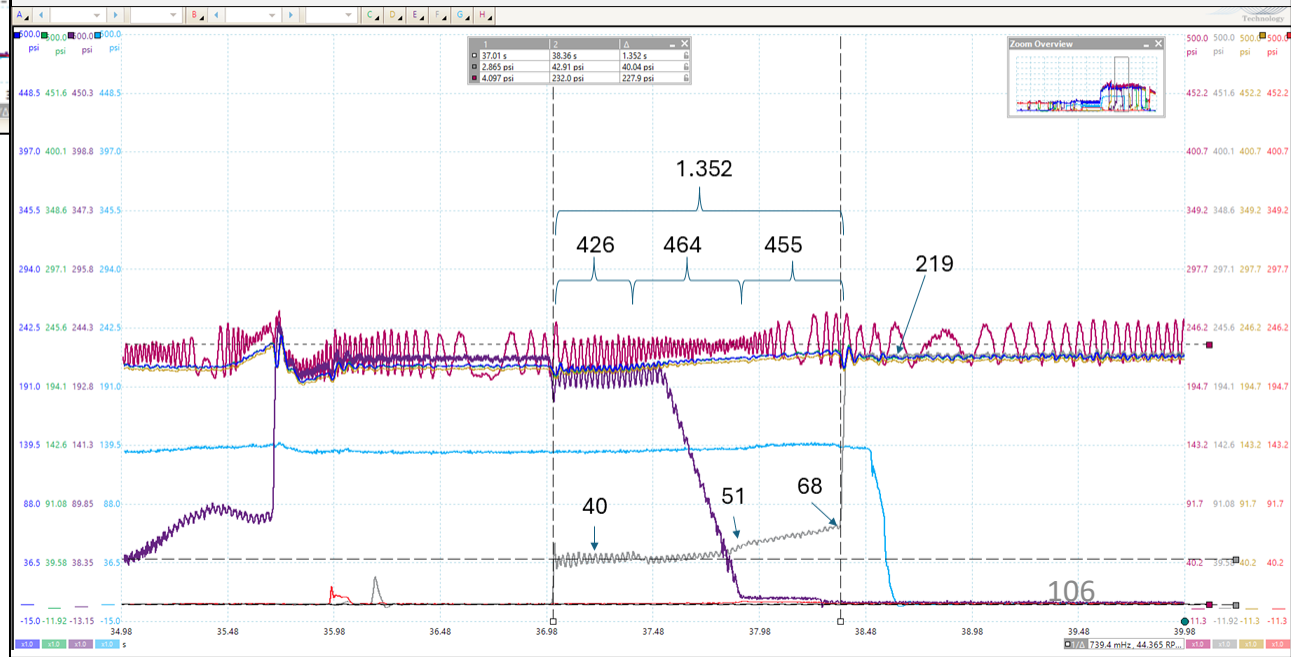
[TCM] 39350 - Shift Inertia - 3-4

Engine Speed (rpm)

Driver Demand (lb·ft)

	1,200	2,000	2,400	2,800	3,200	3,600	4,000	5,350	5,700
-37	2.00	2.00	2.00	2.00	2.00	2.50	3.25	4.00	4.00
0	2.00	2.00	2.00	2.50	2.50	3.00	3.75	4.50	4.50
55	2.00	2.00	2.50	3.00	3.50	4.25	4.75	5.50	5.50
111	2.50	3.00	3.75	4.00	4.00	4.75	5.50	6.00	6.00
166	2.75	3.00	4.00	4.25	4.50	5.00	6.00	6.50	7.00
221	3.25	4.00	4.50	4.75	5.00	5.50	6.25	7.00	8.00
295	4.00	4.50	5.00	5.50	6.00	6.50	7.00	8.25	9.50
369	4.50	5.00	5.50	6.00	6.50	7.00	8.00	9.00	9.50
443	5.00	5.75	6.25	6.75	7.50	7.50	8.00	9.00	9.50

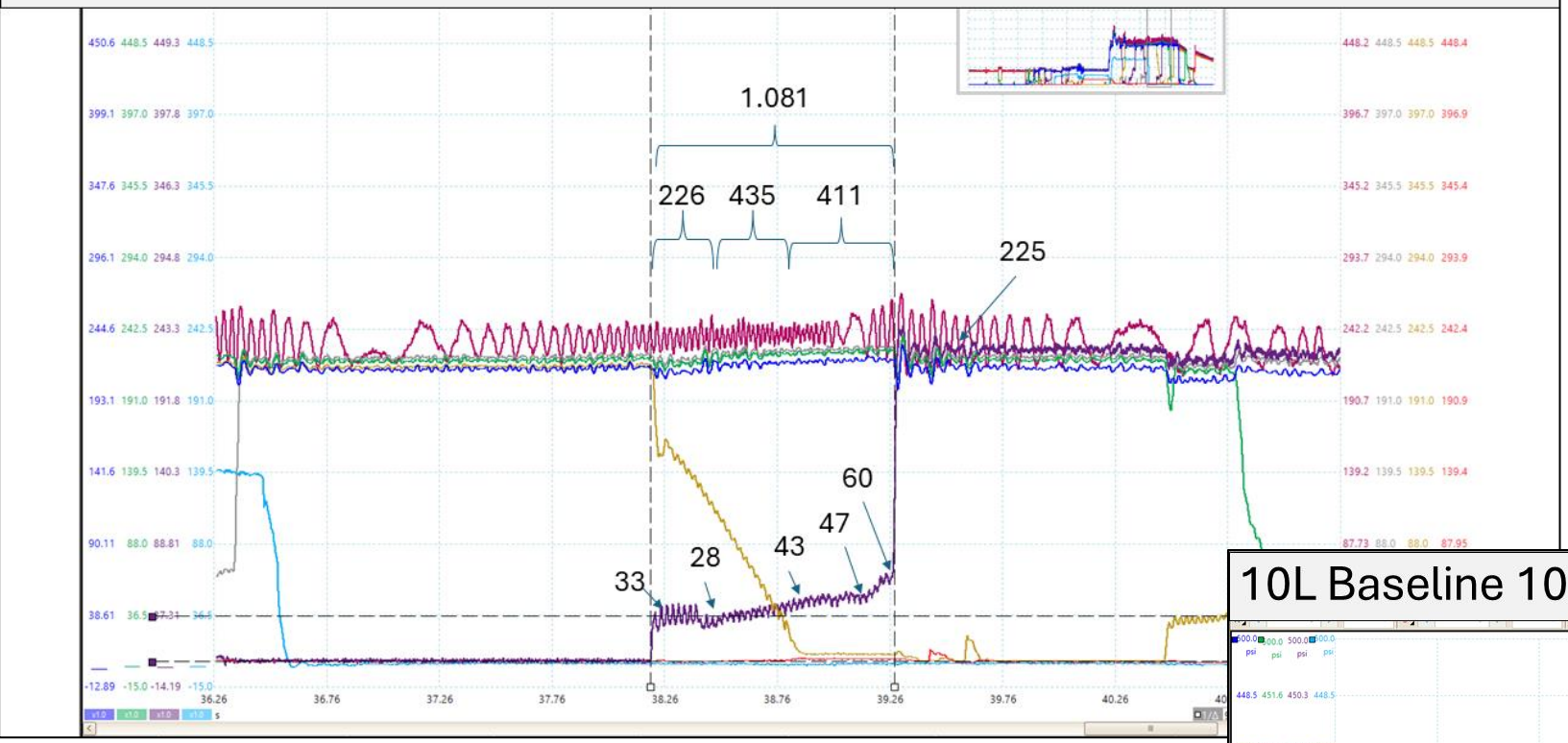
10L Baseline 100% Throttle 3-4 shift – ST 325ms



Shift inertia:

- Affected medium throttle shifts more than WOT
- Scanner reported shift times didn't change much
- Quicker overall shift time
- Mostly the Torque Phase
- Shifting pressure remained the same or slightly higher

Shift Inertia Increased 30%, 100% Throttle 4-5 shift – ST 250 ms

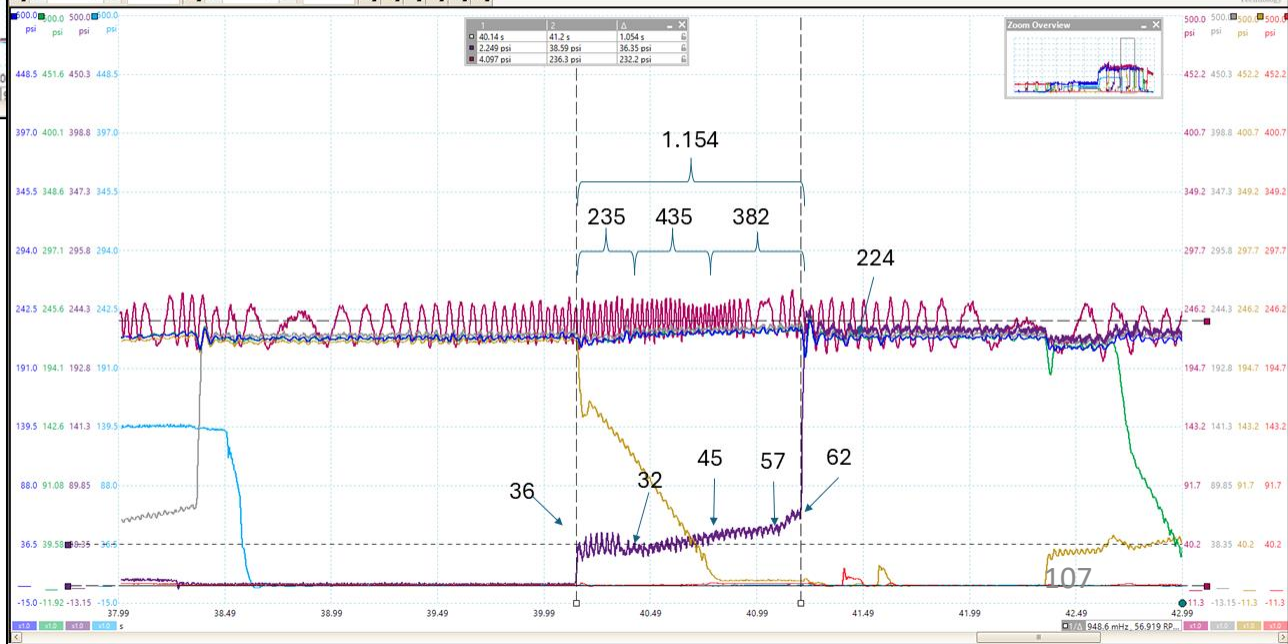


[TCM] 39351 - Shift Inertia - 4-5

Engine Speed (rpm)

Driver Demand (lb.ft)	1,200	2,000	2,400	2,800	3,200	3,600	4,000	5,350	5,700
-37	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
0	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
55	2.00	2.50	2.00	2.00	2.00	2.00	2.00	2.00	2.00
111	2.50	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00
166	2.75	3.50	4.00	4.50	4.50	4.50	4.50	4.50	4.50
221	3.25	3.75	4.25	4.75	5.50	5.50	5.50	5.50	6.00
295	4.00	4.25	4.75	5.50	6.25	6.25	6.25	8.00	9.25
369	4.50	5.00	5.50	6.25	7.00	7.00	7.00	8.50	9.50
443	5.00	5.75	6.25	7.00	7.50	7.50	7.50	9.00	9.50

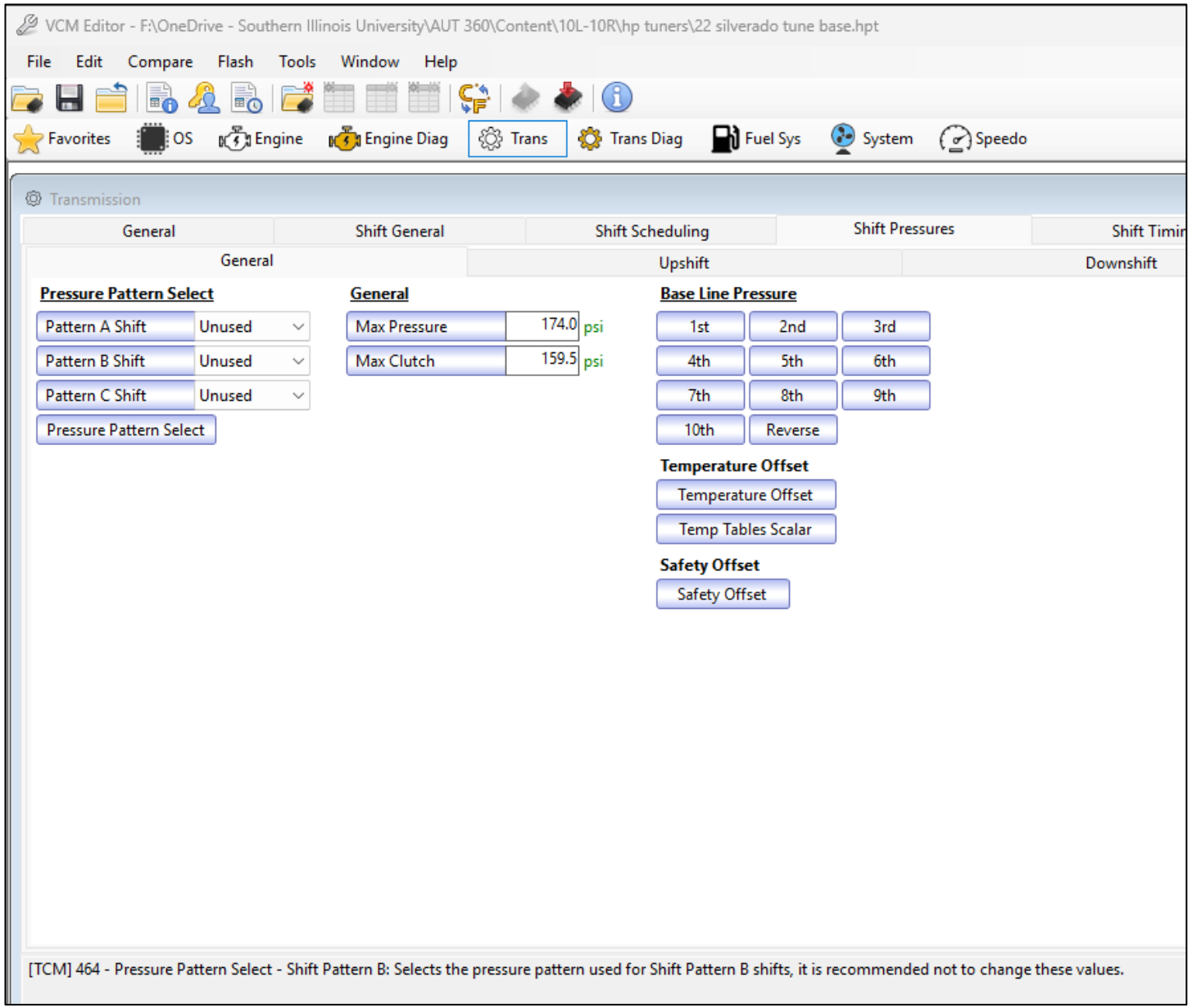
10L Baseline 100% Throttle 4-5 shift – ST 250ms



Shift inertia:

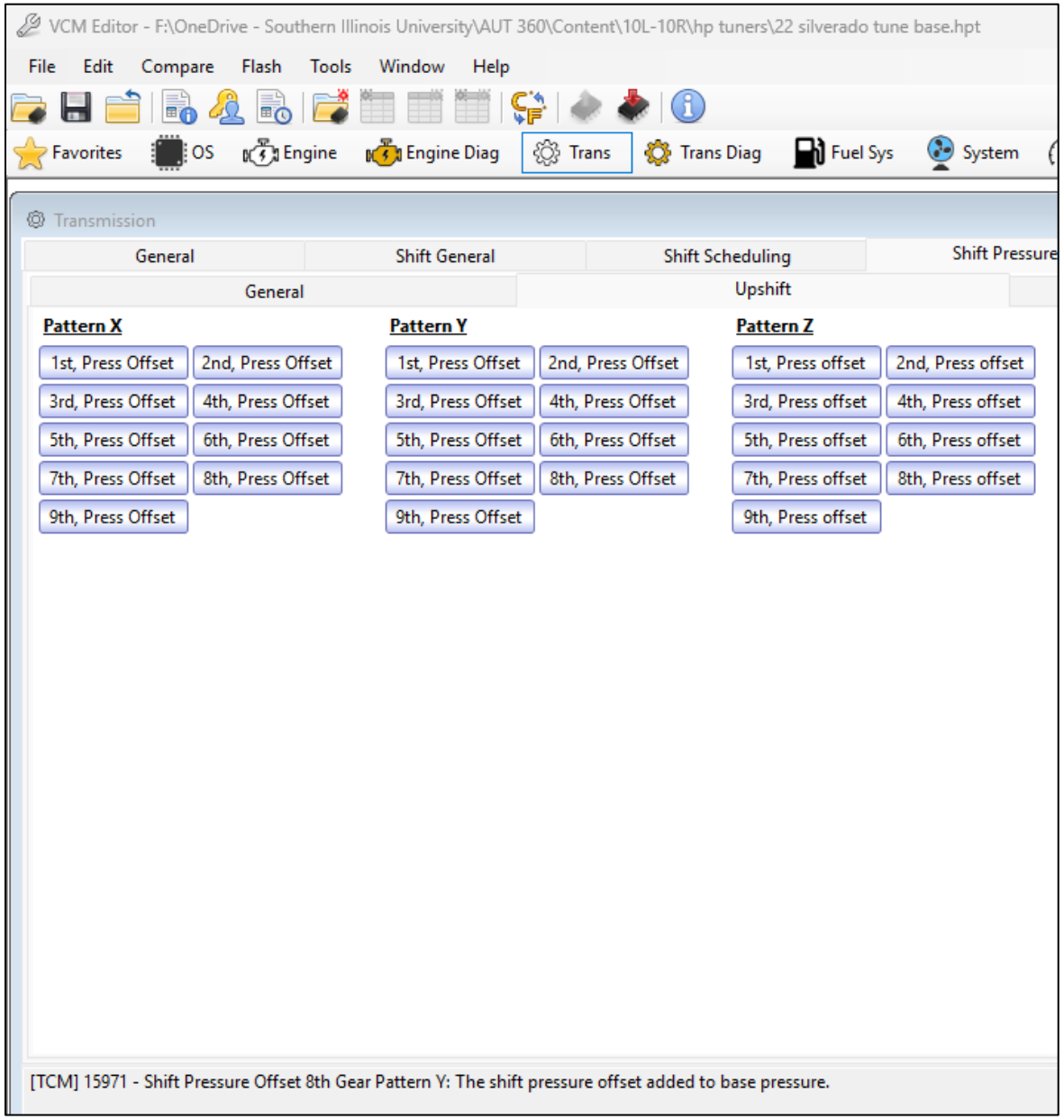
- Affected medium throttle shifts more than WOT
- Scanner reported shift times didn't change much
- Quicker overall shift time
- Mostly the Torque Phase
- Shifting pressure remained the same or slightly higher

10L HP Tuner – Base Line Pressure



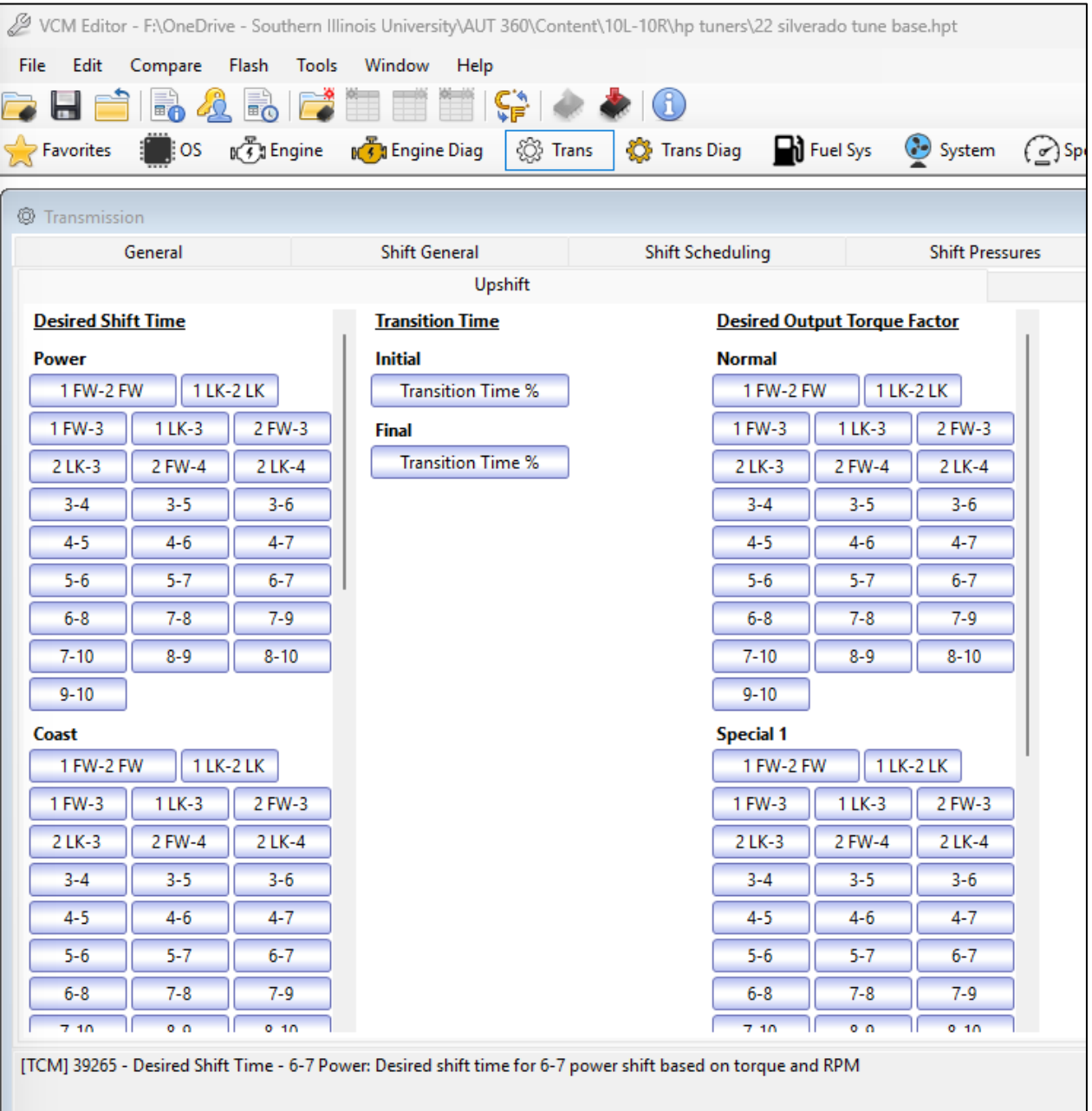
No noticeable change in shift feel, and know significant change in pressure and timing

10L HP Tuner – Pressure Offset



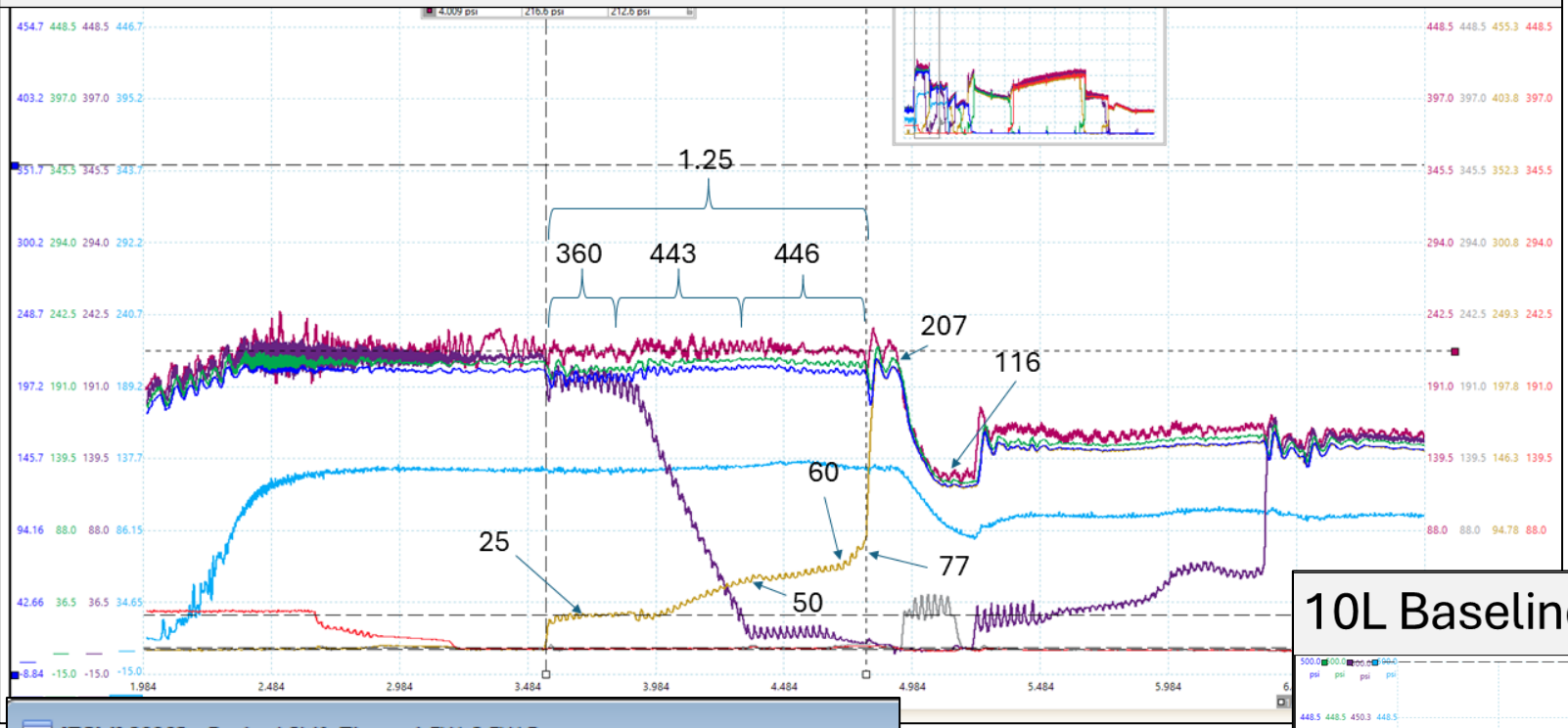
No noticeable change in shift feel, and know significant change in pressure and timing

10L HP Tuner – Desired Shift Time



Reduced the inertia stage, which makes sense since that's where the engine RPM drop exists

10L Desired Shift Time Reduced 30%, 40% Throttle 1-2 shift – ST 300ms



Desired shift time:

- Reduced the inertia phase of the shift
- Pressures remain the same

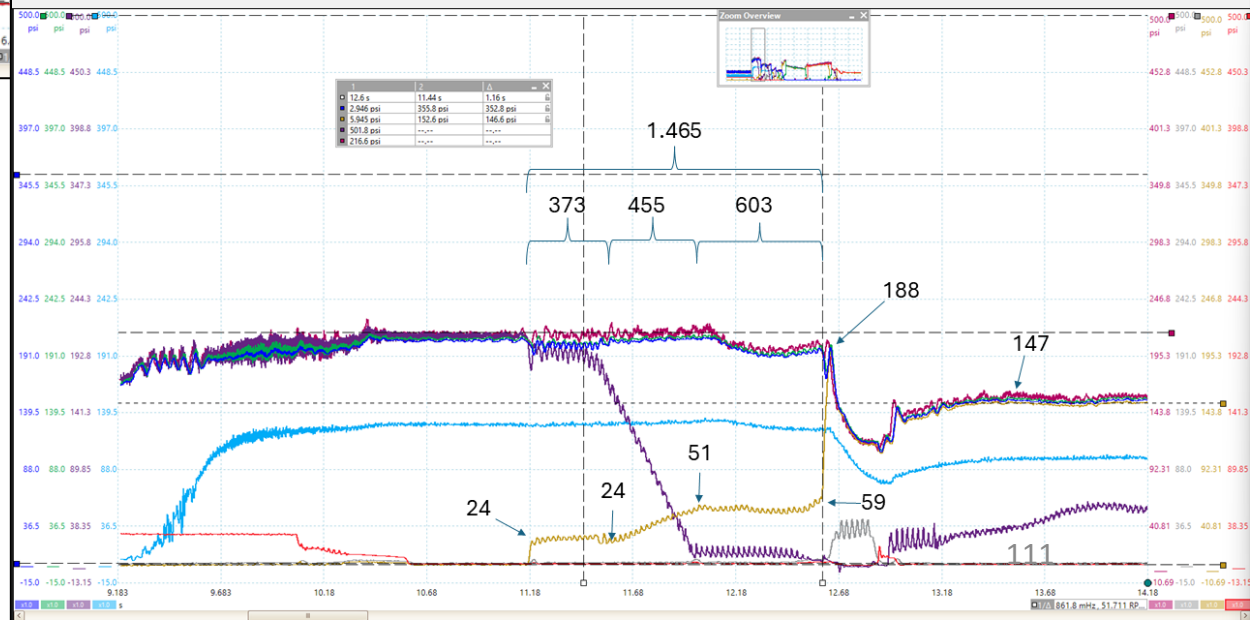
[TCM] 39065 - Desired Shift Time - 1 FW-2 FW Power

Engine Speed (rpm)

Driver Demand (lb·ft)

	1,200	2,000	2,400	2,800	3,200	3,600	4,000	5,350	5,700
-37	0.175	0.300	0.362	0.425	0.476	0.525	0.575	0.700	0.800
0	0.800	0.900	1.000	1.398	1.499	1.599	1.698	1.799	1.799
55	0.650	0.851	1.000	1.399	1.399	1.449	1.499	1.500	1.500
111	0.499	0.700	0.750	0.899	0.999	1.000	1.100	1.250	1.250
166	0.300	0.500	0.500	0.550	0.649	0.649	0.650	0.700	0.700
221	0.300	0.350	0.399	0.424	0.425	0.450	0.450	0.551	0.551
295	0.300	0.300	0.350	0.400	0.415	0.430	0.440	0.525	0.530
369	0.300	0.300	0.350	0.400	0.410	0.415	0.438	0.476	0.500
443	0.300	0.300	0.350	0.350	0.400	0.400	0.425	0.461	0.475

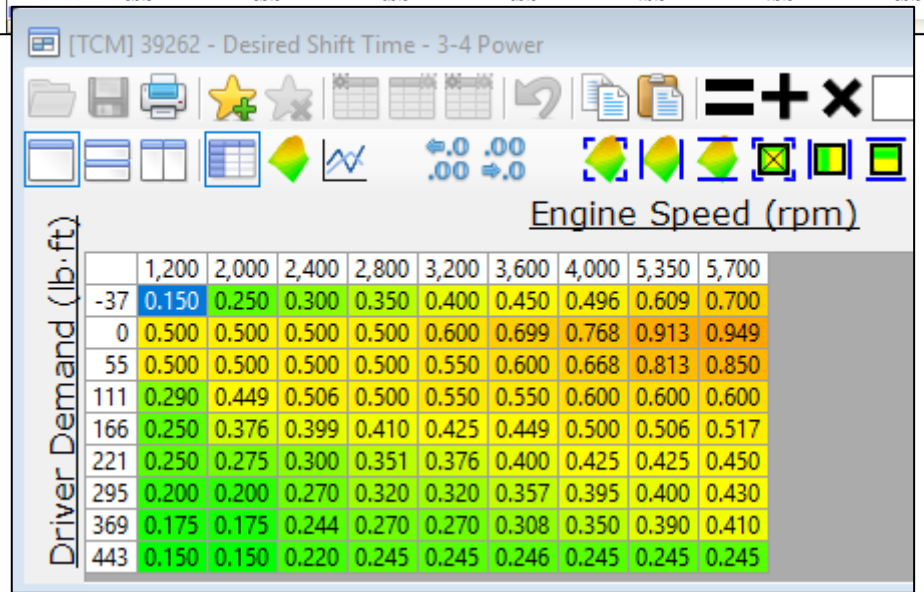
10L Baseline 40% Throttle 1-2 shift – ST 450ms



10L Desired Shift Time Reduced 30%, 40% Throttle 3-4 shift – ST 200ms

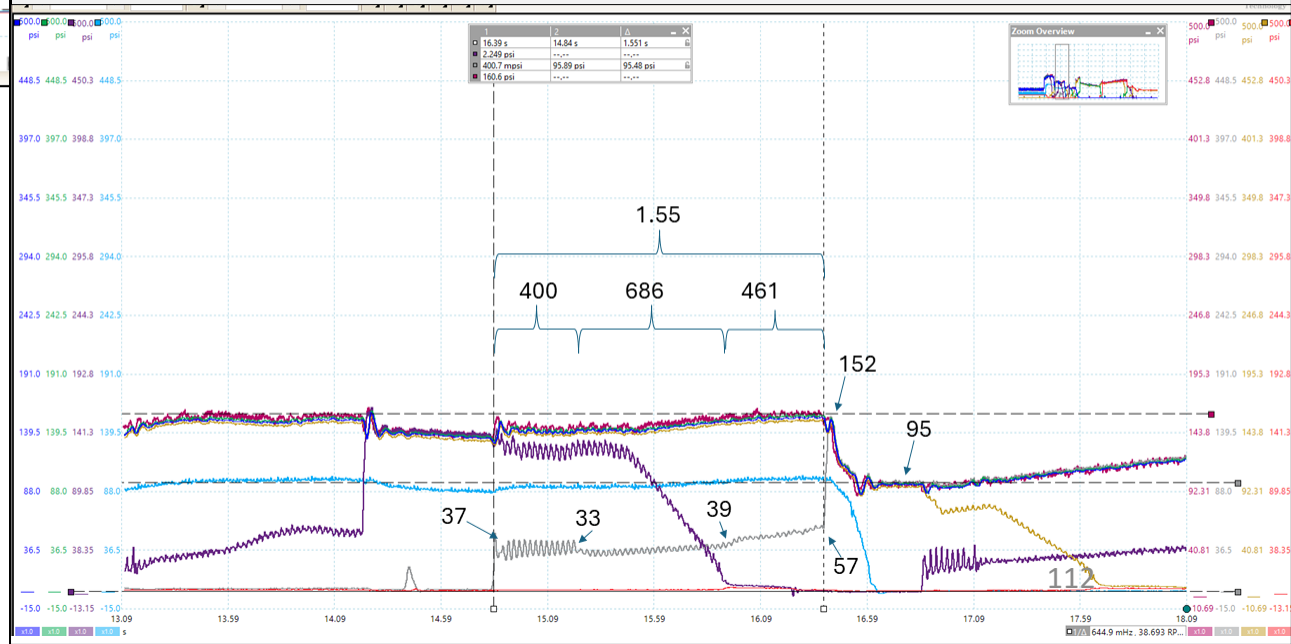
Desired shift time:

- Reduced the inertia phase of the shift
- Pressures remain the same

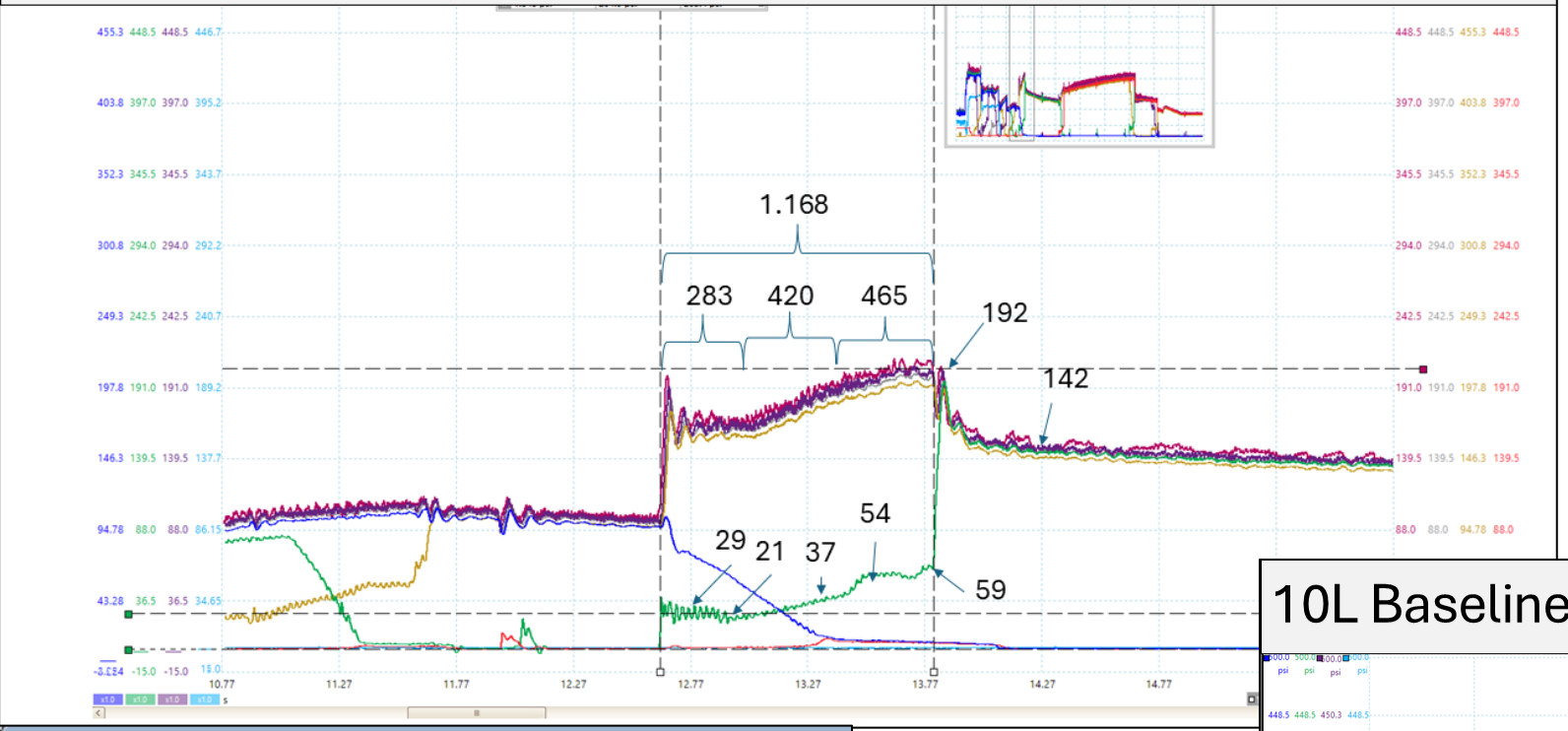


	1,200	2,000	2,400	2,800	3,200	3,600	4,000	5,350	5,700
-37	0.150	0.250	0.300	0.350	0.400	0.450	0.496	0.609	0.700
0	0.500	0.500	0.500	0.500	0.600	0.699	0.768	0.913	0.949
55	0.500	0.500	0.500	0.500	0.550	0.600	0.668	0.813	0.850
111	0.290	0.449	0.506	0.500	0.550	0.550	0.600	0.600	0.600
166	0.250	0.376	0.399	0.410	0.425	0.449	0.500	0.506	0.517
221	0.250	0.275	0.300	0.351	0.376	0.400	0.425	0.425	0.450
295	0.200	0.200	0.270	0.320	0.320	0.357	0.395	0.400	0.430
369	0.175	0.175	0.244	0.270	0.270	0.308	0.350	0.390	0.410
443	0.150	0.150	0.220	0.245	0.245	0.246	0.245	0.245	0.245

10L Baseline 40% Throttle 3-4 shift – ST 275ms



10L Desired Shift Time Reduced 30%, 40% Throttle 6-7 shift – ST 175 ms



Desired shift time:

- Reduced the inertia phase of the shift
- Pressures remain the same

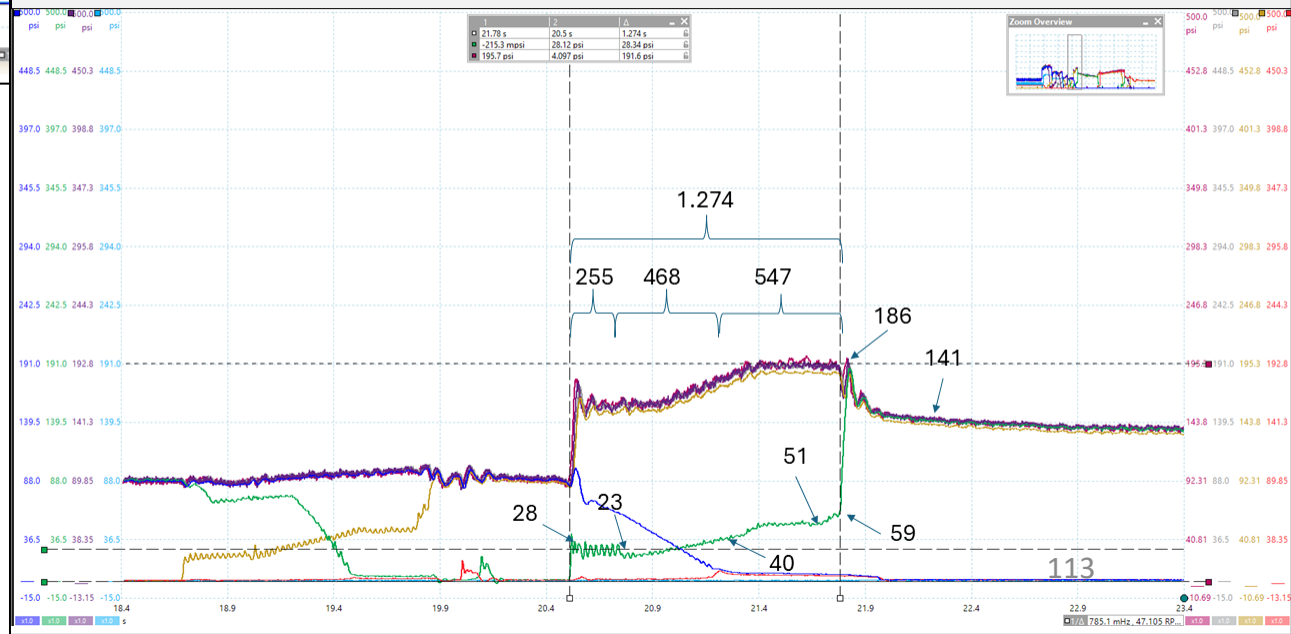
[TCM] 39265 - Desired Shift Time - 6-7 Power

Engine Speed (rpm)

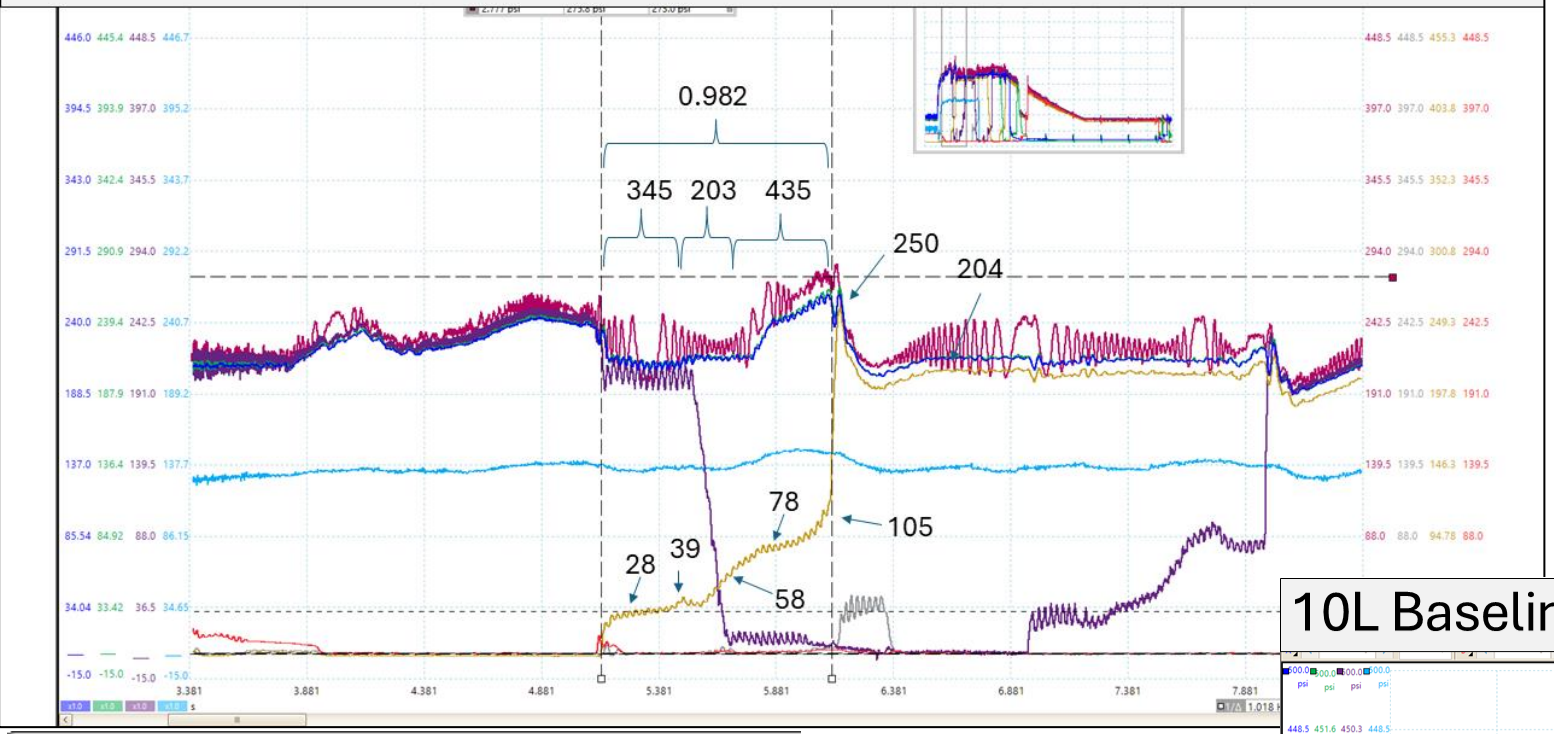
Driver Demand (lb·ft)

	1,200	2,000	2,400	2,800	3,200	3,600	4,000	5,350	5,700
-37	0.250	0.399	0.450	0.500	0.550	0.600	0.636	0.677	0.800
0	0.450	0.550	0.675	0.675	0.699	0.749	0.800	0.800	0.800
55	0.450	0.550	0.675	0.675	0.699	0.749	0.800	0.800	0.800
111	0.300	0.399	0.450	0.550	0.600	0.649	0.649	0.649	0.649
166	0.250	0.300	0.324	0.399	0.501	0.600	0.600	0.600	0.600
221	0.250	0.250	0.301	0.375	0.453	0.550	0.574	0.574	0.574
295	0.225	0.225	0.250	0.300	0.373	0.400	0.500	0.549	0.549
369	0.225	0.225	0.225	0.250	0.273	0.299	0.324	0.374	0.374
443	0.225	0.225	0.225	0.250	0.273	0.299	0.324	0.374	0.374

10L Baseline 40% Throttle 6-7 shift – ST 250ms



10L Desired Shift Time Reduced 30%, 100% Throttle 1-2 shift – ST 275 ms



Desired shift time:

- Reduced the inertia phase of the shift
- Pressures remain the same

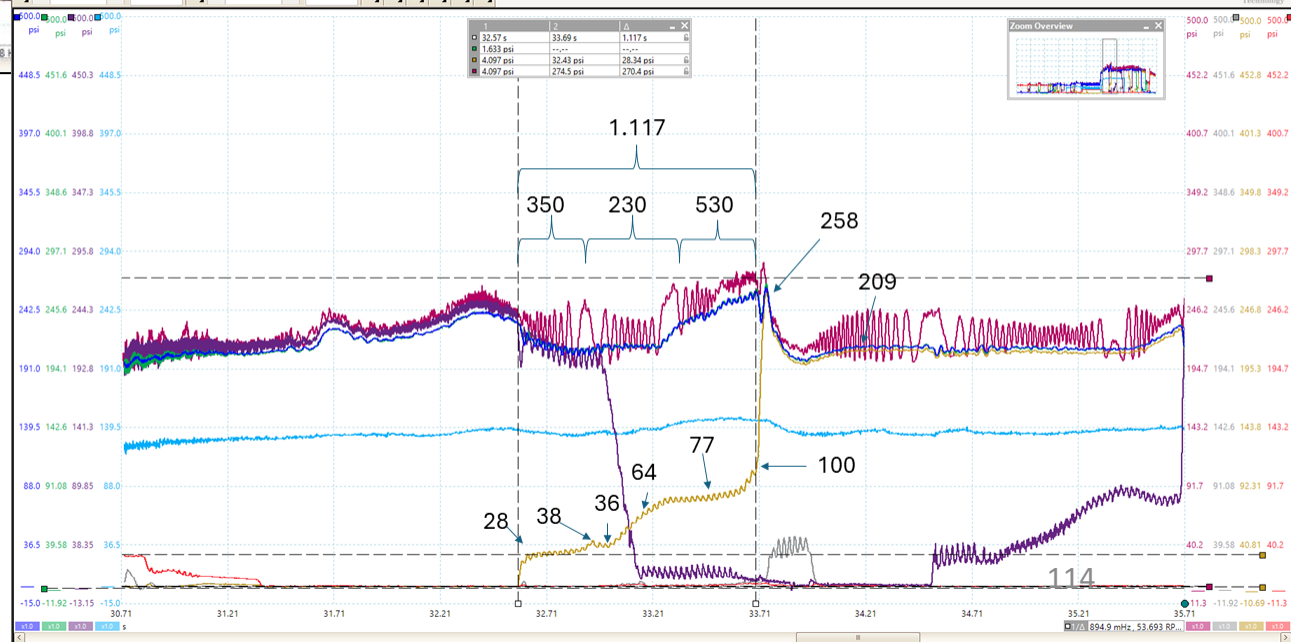
[TCM] 39065 - Desired Shift Time - 1 FW-2 FW Power

Engine Speed (rpm)

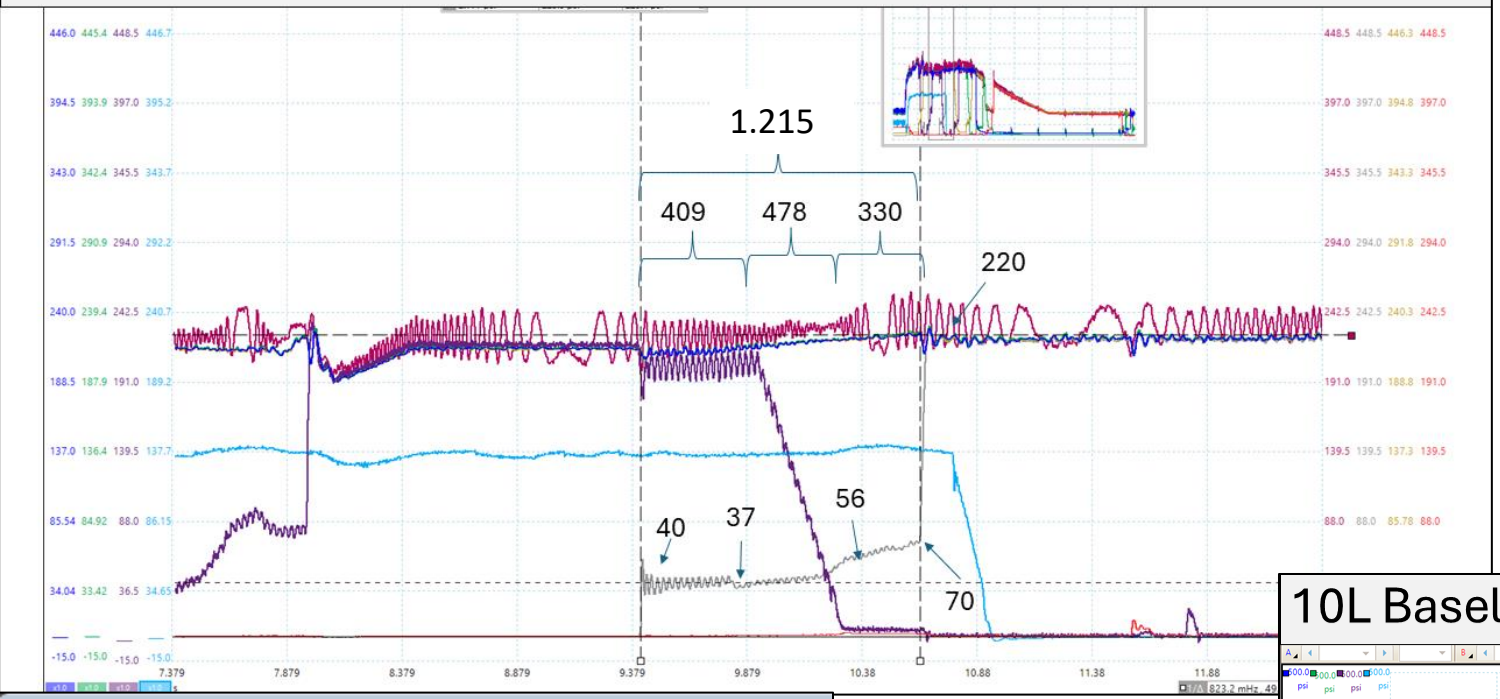
Driver Demand (lb·ft)

	1,200	2,000	2,400	2,800	3,200	3,600	4,000	5,350	5,700
-37	0.175	0.300	0.362	0.425	0.476	0.525	0.575	0.700	0.800
0	0.800	0.900	1.000	1.398	1.499	1.599	1.698	1.799	1.799
55	0.650	0.851	1.000	1.399	1.399	1.449	1.499	1.500	1.500
111	0.499	0.700	0.750	0.899	0.999	1.000	1.100	1.250	1.250
166	0.300	0.500	0.500	0.550	0.649	0.649	0.650	0.700	0.700
221	0.300	0.350	0.399	0.424	0.425	0.450	0.450	0.551	0.551
295	0.300	0.300	0.350	0.400	0.415	0.430	0.440	0.525	0.530
369	0.300	0.300	0.350	0.400	0.410	0.415	0.438	0.476	0.500
443	0.300	0.300	0.350	0.350	0.400	0.400	0.425	0.461	0.475

10L Baseline 100% Throttle 1-2 shift – ST 375ms



10L Desired Shift Time Reduced 30%, 100% Throttle 3-4 shift – ST 225 ms



Desired shift time:

- Reduced the inertia phase of the shift
- Pressures remain the same

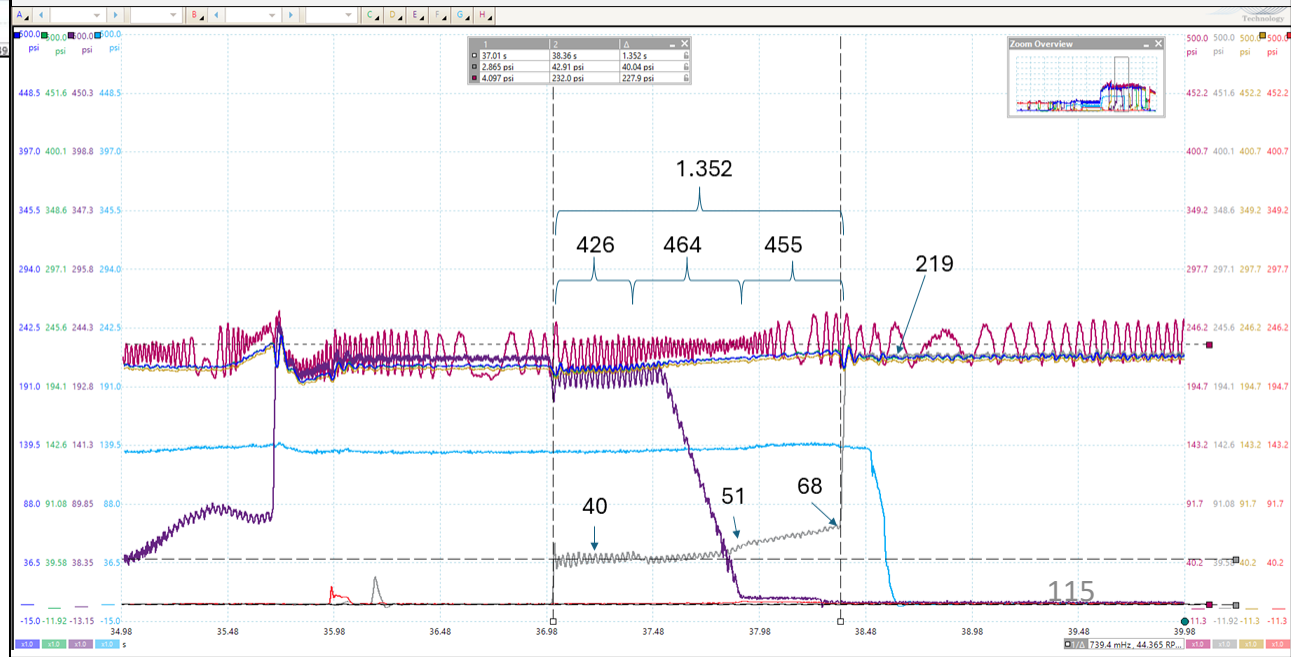
[TCM] 39262 - Desired Shift Time - 3-4 Power

Engine Speed (rpm

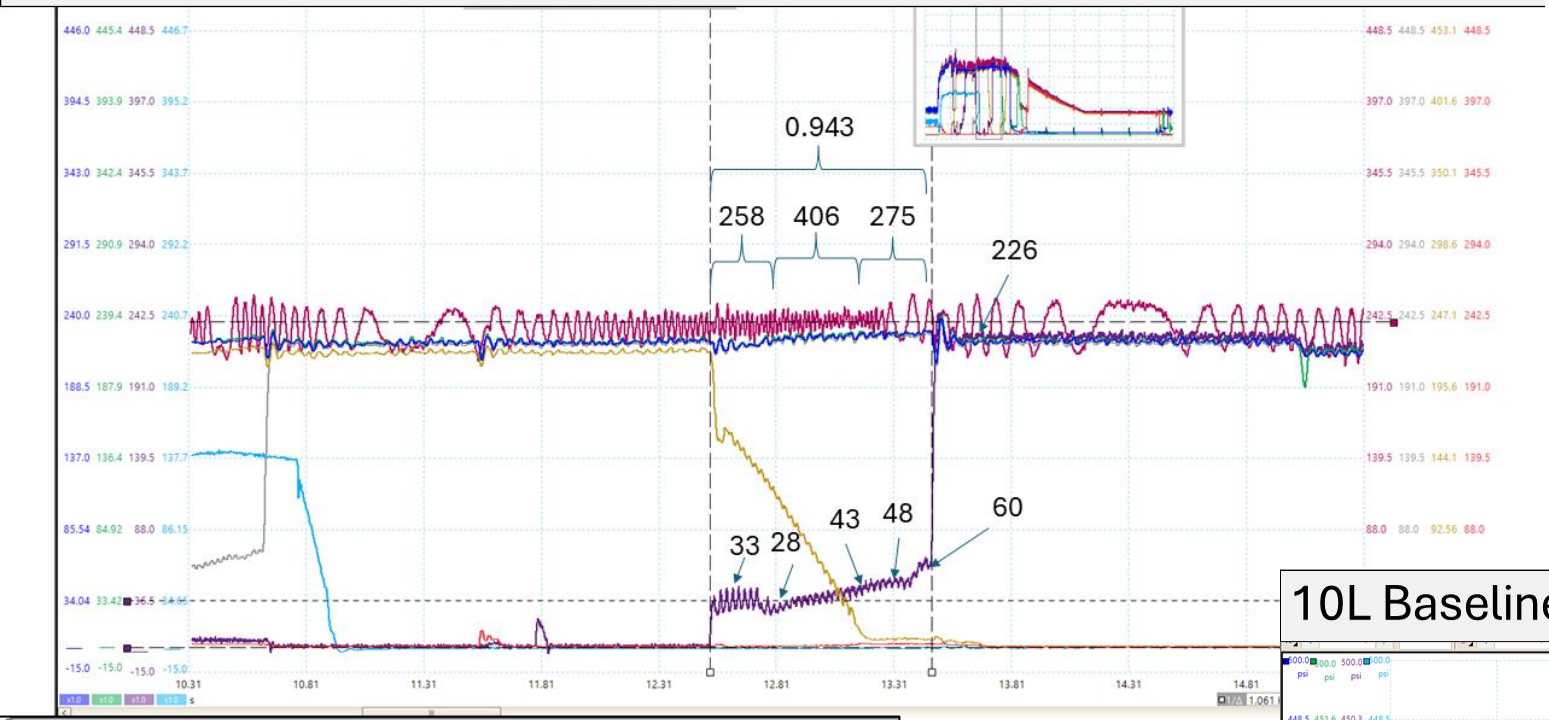
Driver Demand (lb·ft)

	1,200	2,000	2,400	2,800	3,200	3,600	4,000	5,350	5,700
-37	0.150	0.250	0.300	0.350	0.400	0.450	0.496	0.609	0.700
0	0.500	0.500	0.500	0.500	0.600	0.699	0.768	0.913	0.949
55	0.500	0.500	0.500	0.500	0.550	0.600	0.668	0.813	0.850
111	0.290	0.449	0.506	0.500	0.550	0.550	0.600	0.600	0.600
166	0.250	0.376	0.399	0.410	0.425	0.449	0.500	0.506	0.517
221	0.250	0.275	0.300	0.351	0.376	0.400	0.425	0.425	0.450
295	0.200	0.200	0.270	0.320	0.320	0.357	0.395	0.400	0.430
369	0.175	0.175	0.244	0.270	0.270	0.308	0.350	0.390	0.410
443	0.150	0.150	0.220	0.245	0.245	0.246	0.245	0.245	0.245

10L Baseline 100% Throttle 3-4 shift – ST 325ms



10L Desired Shift Time Reduced 30%, 100% Throttle 4-5 shift – ST 150 ms



[TCM] 39263 - Desired Shift Time - 4-5 Power

Engine Speed (rpm)

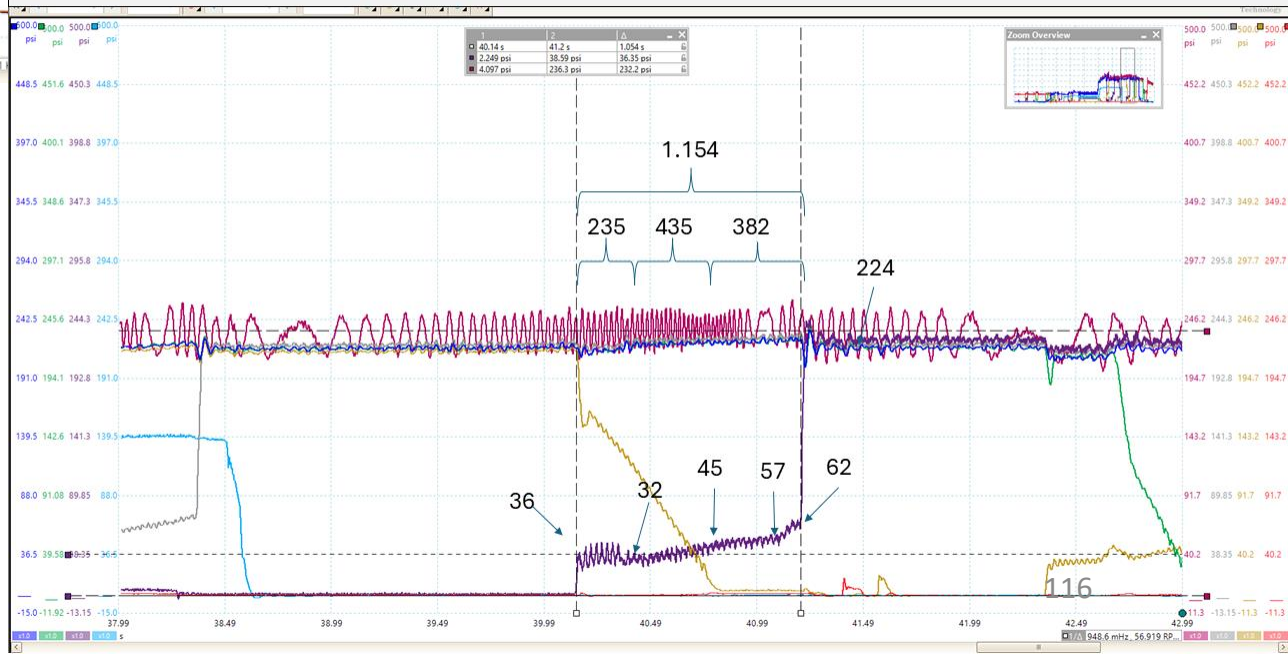
Driver Demand (lb·ft)

	1,200	2,000	2,400	2,800	3,200	3,600	4,000	5,350	5,700
-37	0.149	0.149	0.175	0.250	0.275	0.350	0.377	0.444	0.499
0	0.389	0.399	0.399	0.425	0.475	0.549	0.698	0.748	0.748
55	0.350	0.350	0.399	0.425	0.475	0.549	0.648	0.648	0.648
111	0.280	0.350	0.375	0.425	0.449	0.549	0.599	0.599	0.599
166	0.225	0.300	0.325	0.375	0.450	0.499	0.551	0.551	0.551
221	0.195	0.267	0.306	0.356	0.400	0.450	0.499	0.499	0.499
295	0.188	0.241	0.278	0.304	0.315	0.352	0.375	0.399	0.399
369	0.183	0.246	0.277	0.290	0.301	0.301	0.327	0.302	0.250
443	0.176	0.227	0.251	0.276	0.276	0.276	0.276	0.251	0.250

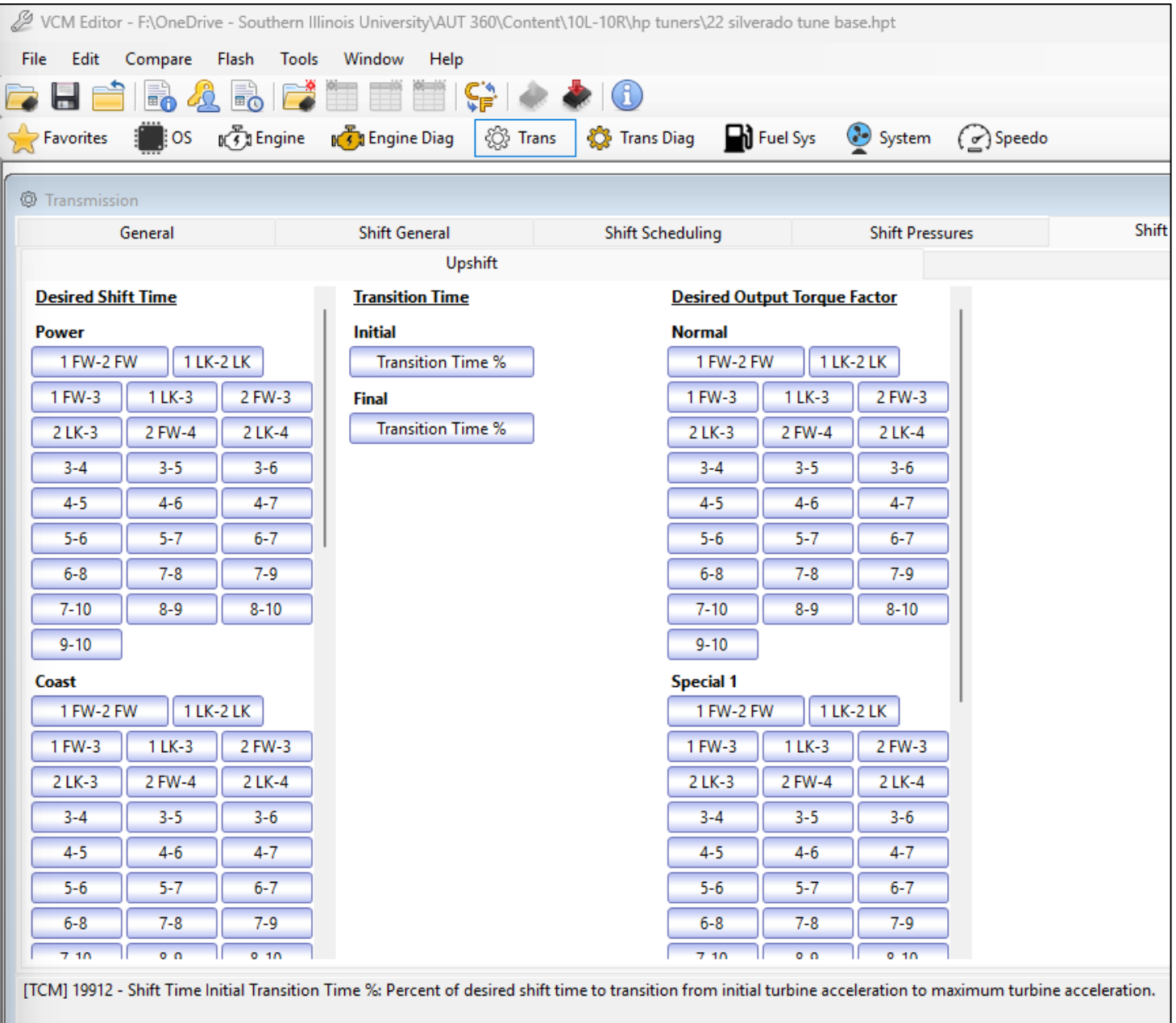
Desired shift time:

- Reduced the inertia phase of the shift
- Pressures remain the same

10L Baseline 100% Throttle 4-5 shift – ST 250ms

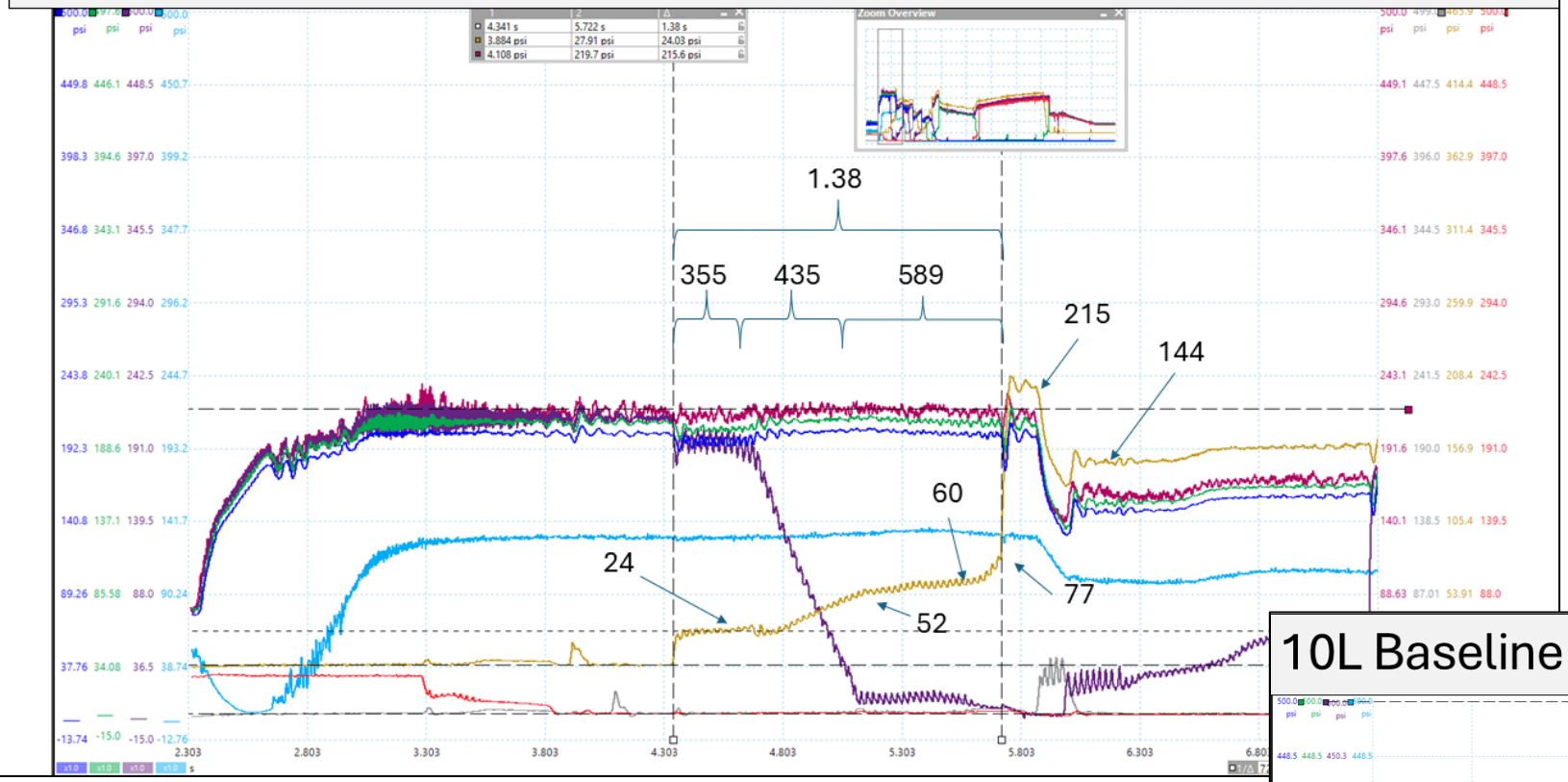


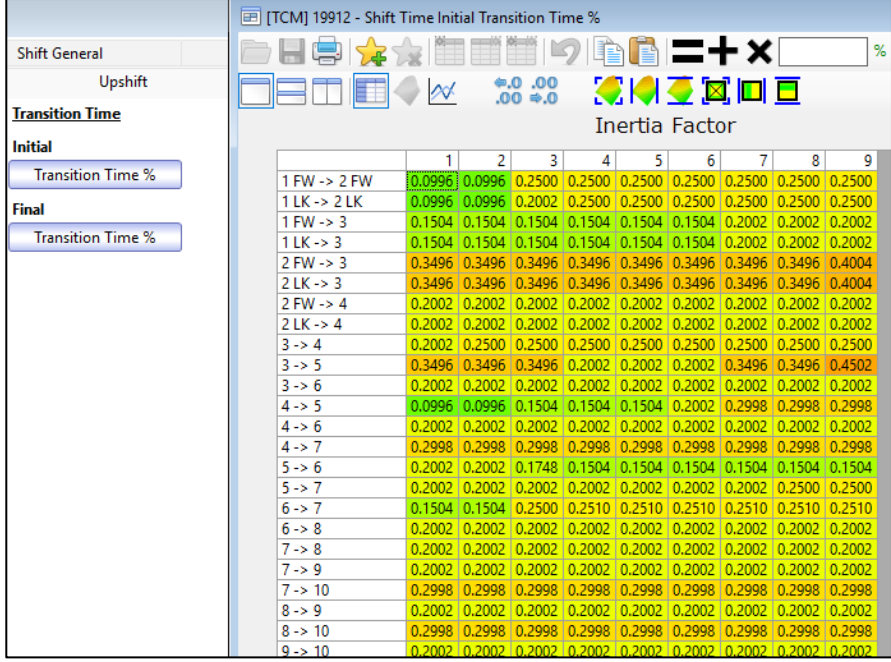
10L HP Tuner – Transition Time



No noticeable change in shift feel, and know significant change in pressure and timing

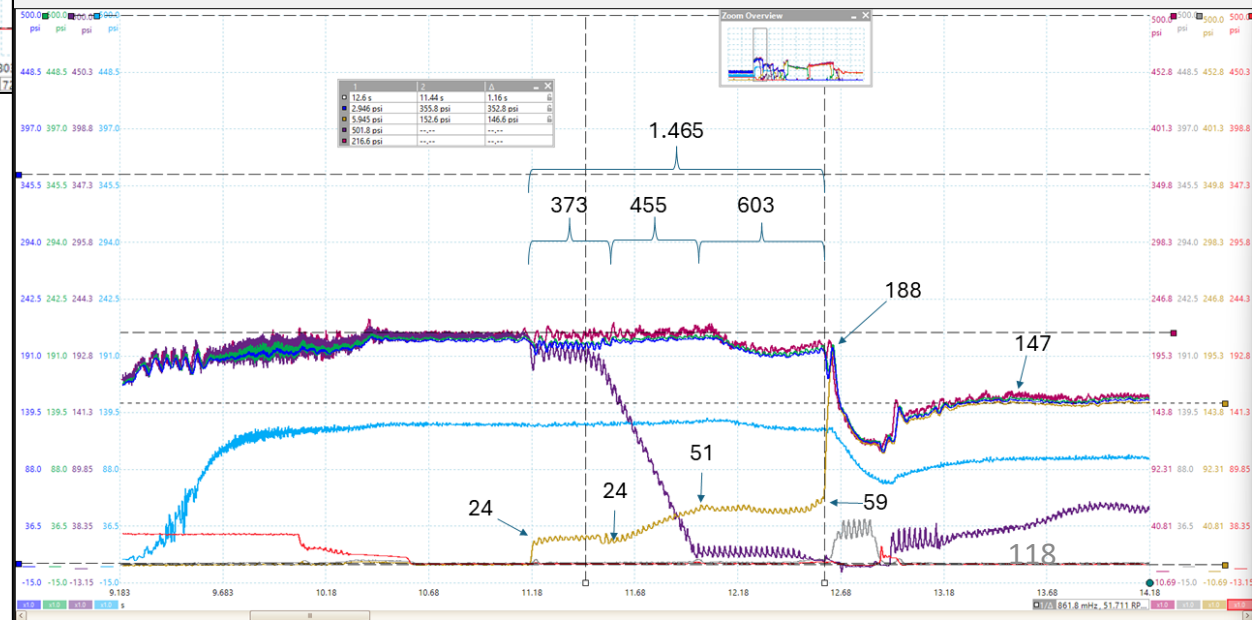
10L initial trans time red 30%, 40% Throttle 1-2 shift – ST 450ms





	1	2	3	4	5	6	7	8	9
1 FW -> 2 FW	0.0996	0.0996	0.2500	0.2500	0.2500	0.2500	0.2500	0.2500	0.2500
1 LK -> 2 LK	0.0996	0.0996	0.2002	0.2500	0.2500	0.2500	0.2500	0.2500	0.2500
1 FW -> 3	0.1504	0.1504	0.1504	0.1504	0.1504	0.1504	0.2002	0.2002	0.2002
1 LK -> 3	0.1504	0.1504	0.1504	0.1504	0.1504	0.1504	0.2002	0.2002	0.2002
2 FW -> 3	0.3496	0.3496	0.3496	0.3496	0.3496	0.3496	0.3496	0.3496	0.4004
2 LK -> 3	0.3496	0.3496	0.3496	0.3496	0.3496	0.3496	0.3496	0.3496	0.4004
2 FW -> 4	0.2002	0.2002	0.2002	0.2002	0.2002	0.2002	0.2002	0.2002	0.2002
2 LK -> 4	0.2002	0.2002	0.2002	0.2002	0.2002	0.2002	0.2002	0.2002	0.2002
3 -> 4	0.2002	0.2500	0.2500	0.2500	0.2500	0.2500	0.2500	0.2500	0.2500
3 -> 5	0.3496	0.3496	0.3496	0.2002	0.2002	0.2002	0.3496	0.3496	0.4502
3 -> 6	0.2002	0.2002	0.2002	0.2002	0.2002	0.2002	0.2002	0.2002	0.2002
4 -> 5	0.0996	0.0996	0.1504	0.1504	0.1504	0.2002	0.2998	0.2998	0.2998
4 -> 6	0.2002	0.2002	0.2002	0.2002	0.2002	0.2002	0.2002	0.2002	0.2002
4 -> 7	0.2998	0.2998	0.2998	0.2998	0.2998	0.2998	0.2998	0.2998	0.2998
5 -> 6	0.2002	0.2002	0.1748	0.1504	0.1504	0.1504	0.1504	0.1504	0.1504
5 -> 7	0.2002	0.2002	0.2002	0.2002	0.2002	0.2002	0.2002	0.2500	0.2500
6 -> 7	0.1504	0.1504	0.2500	0.2510	0.2510	0.2510	0.2510	0.2510	0.2510
6 -> 8	0.2002	0.2002	0.2002	0.2002	0.2002	0.2002	0.2002	0.2002	0.2002
7 -> 8	0.2002	0.2002	0.2002	0.2002	0.2002	0.2002	0.2002	0.2002	0.2002
7 -> 9	0.2002	0.2002	0.2002	0.2002	0.2002	0.2002	0.2002	0.2002	0.2002
7 -> 10	0.2998	0.2998	0.2998	0.2998	0.2998	0.2998	0.2998	0.2998	0.2998
8 -> 9	0.2002	0.2002	0.2002	0.2002	0.2002	0.2002	0.2002	0.2002	0.2002
8 -> 10	0.2998	0.2998	0.2998	0.2998	0.2998	0.2998	0.2998	0.2998	0.2998
9 -> 10	0.2002	0.2002	0.2002	0.2002	0.2002	0.2002	0.2002	0.2002	0.2002

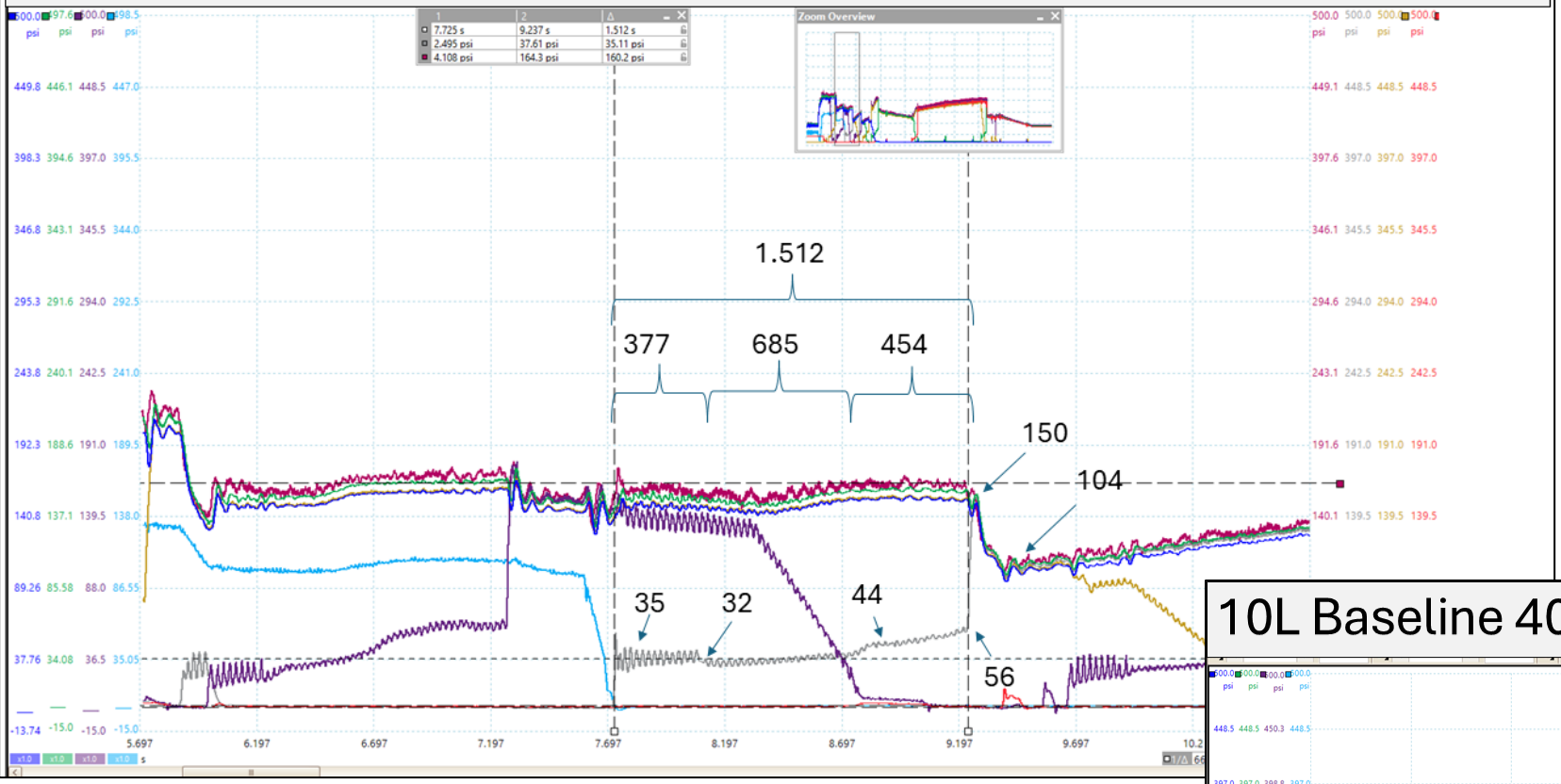
10L Baseline 40% Throttle 1-2 shift – ST 450ms



Initial trans time:

- Although this example seemed like the shift time was faster, it was only during this 1-2 shift
  - Slightly higher throttle might be at play (line pressure is higher)
- Inconsistent changes but pressures and shift times mostly remain the same

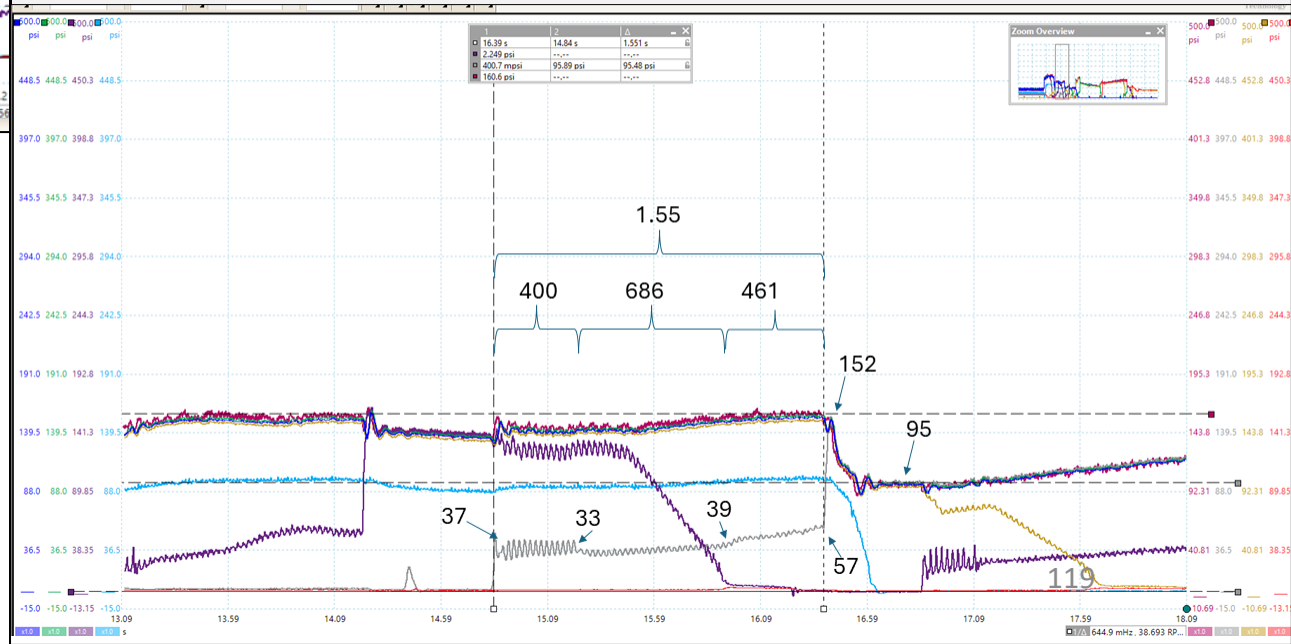
10L initial trans time red 30% - 40% Throttle 3-4 shift – ST 300ms



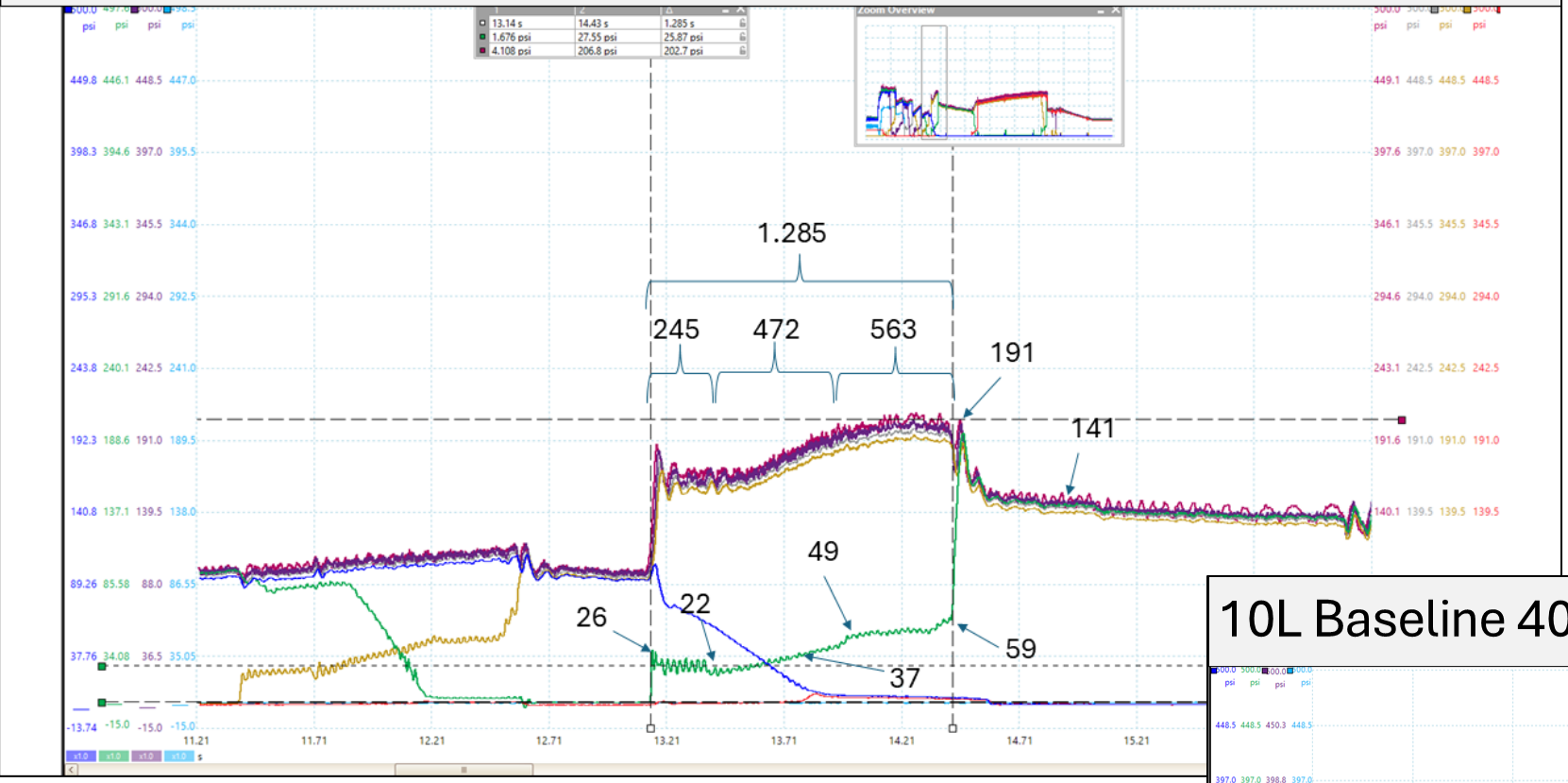
Initial trans time:

- Inconsistent changes but pressures and shift times mostly remain the same

10L Baseline 40% Throttle 3-4 shift – ST 275ms



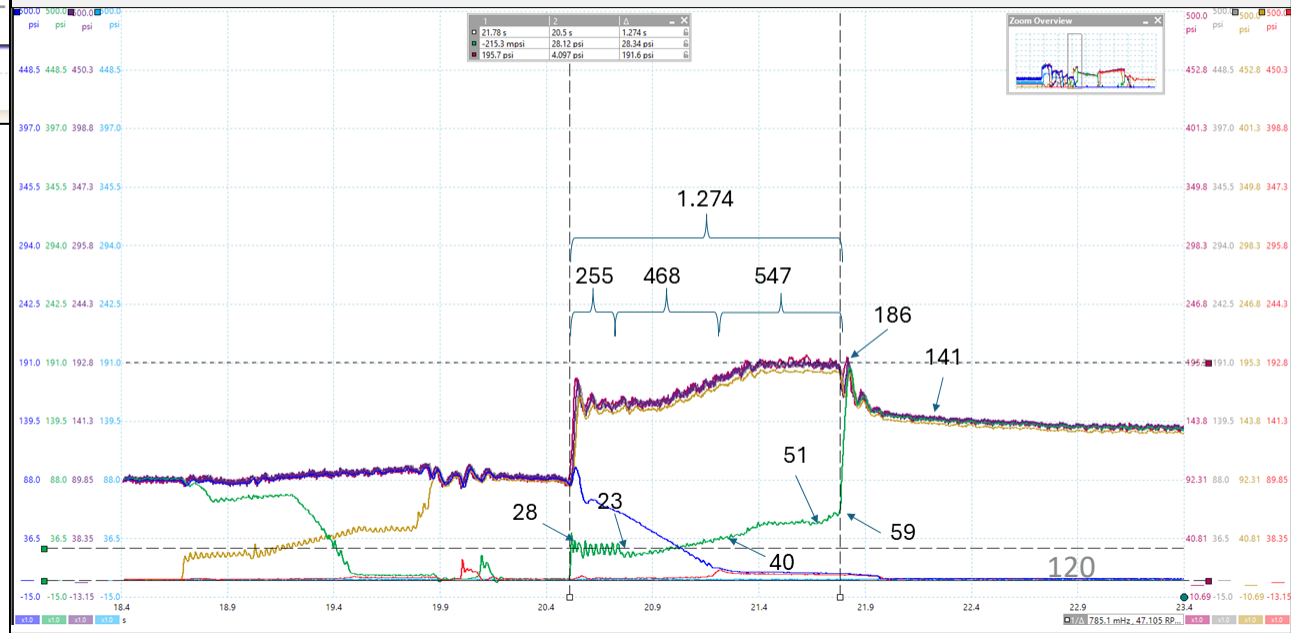
Initial trans red 30%, 40% Throttle 6-7 shift – ST 275ms



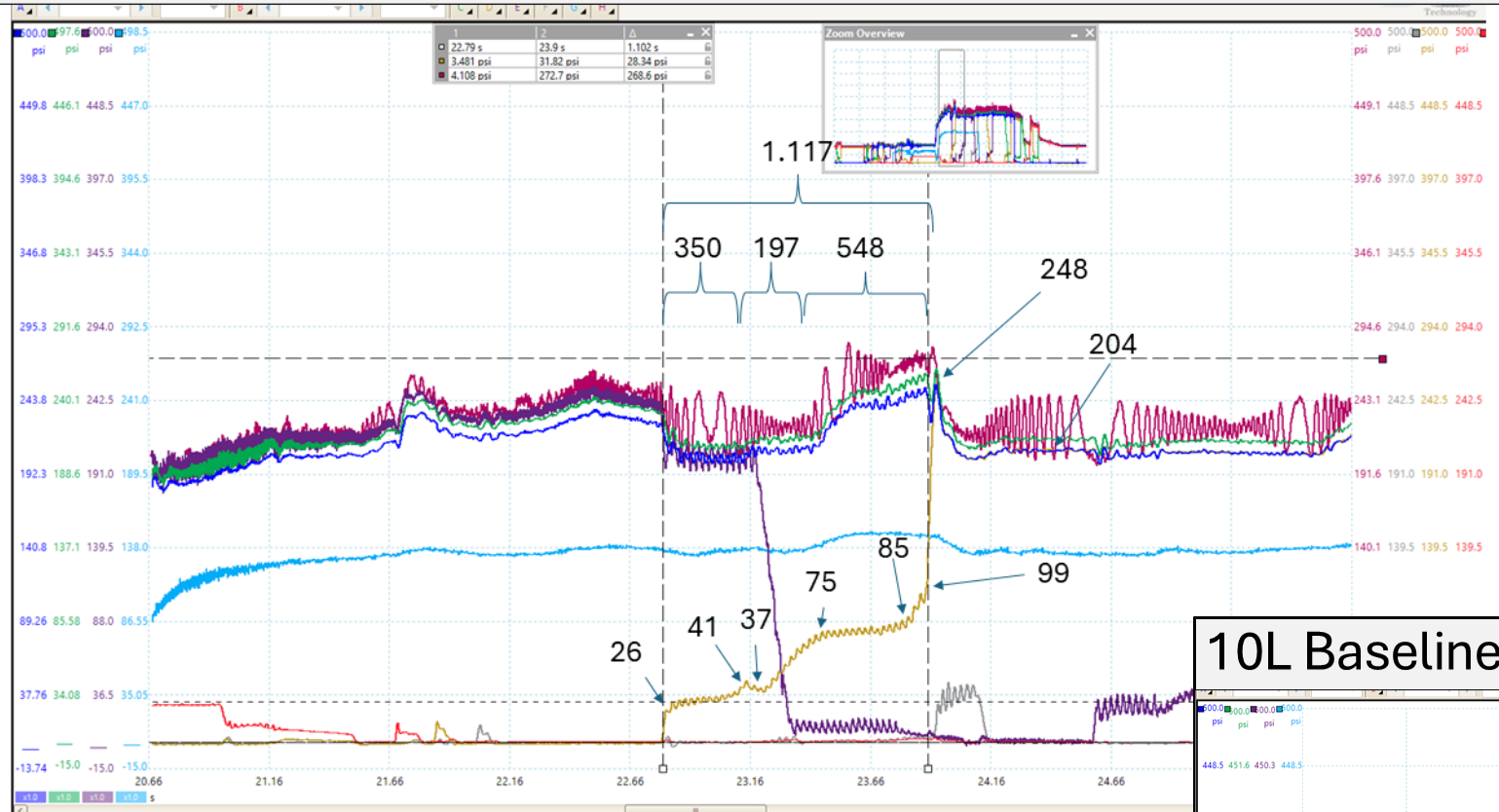
Initial trans time:

- Inconsistent changes but pressures and shift times mostly remain the same

10L Baseline 40% Throttle 6-7 shift – ST 250ms



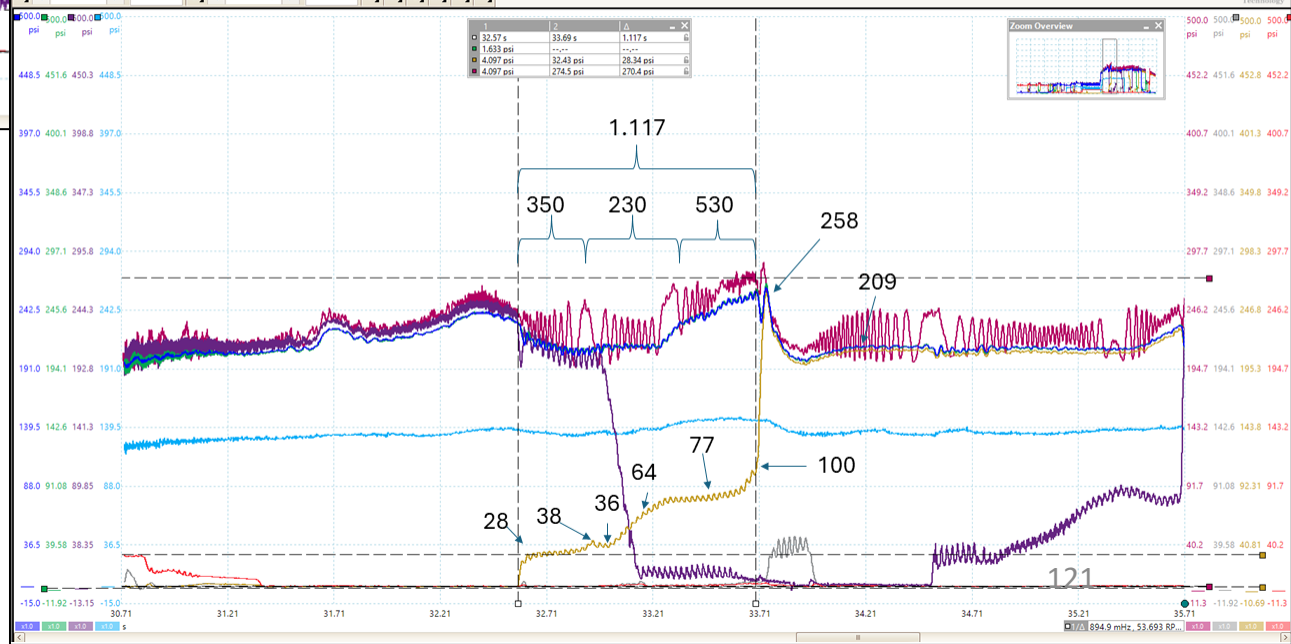
Initial Tran Red 30%, 100% Throttle 1-2 shift – ST 400 ms



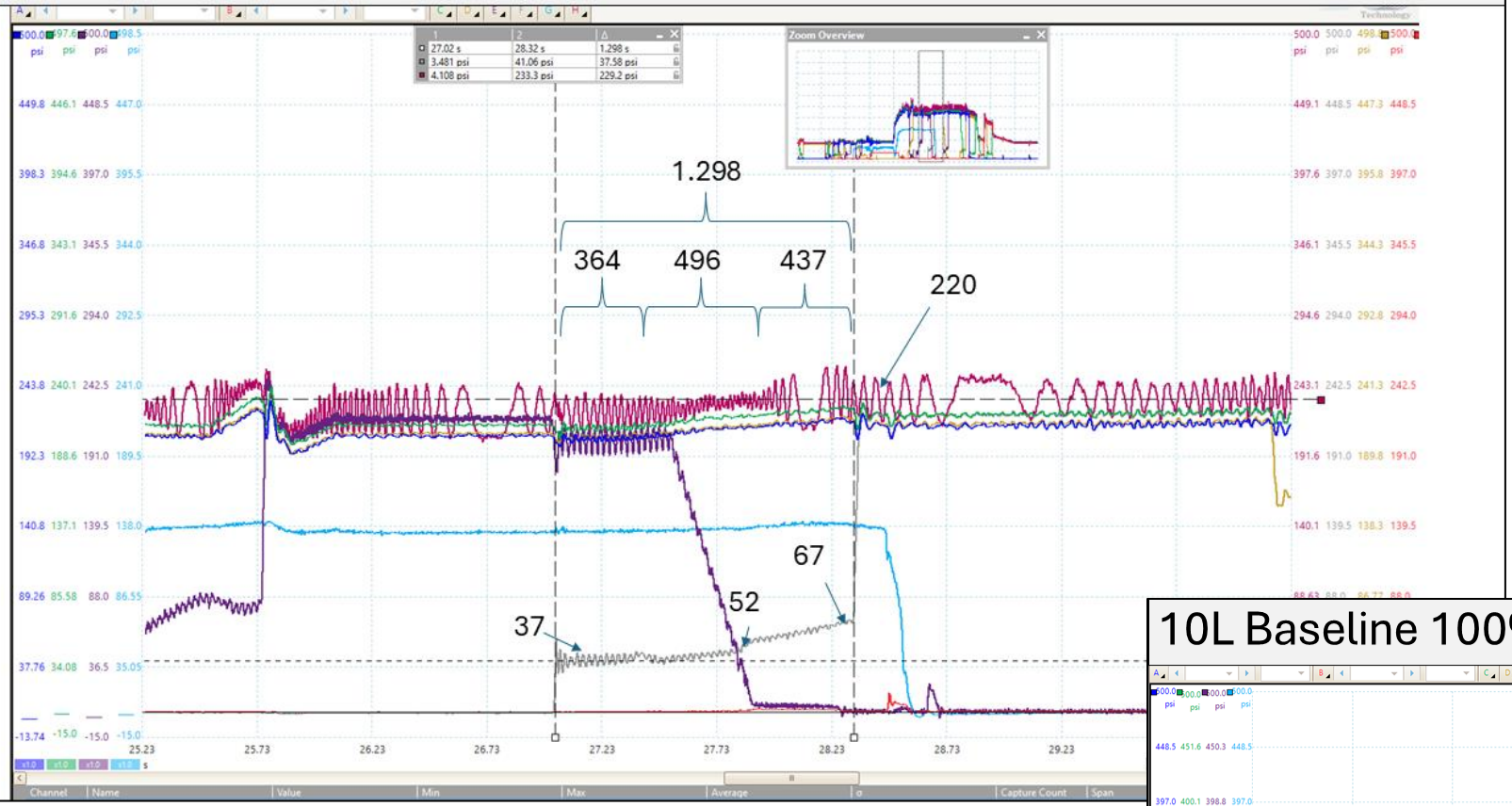
Initial trans time:

- Inconsistent changes but pressures and shift times mostly remain the same

10L Baseline 100% Throttle 1-2 shift – ST 375ms



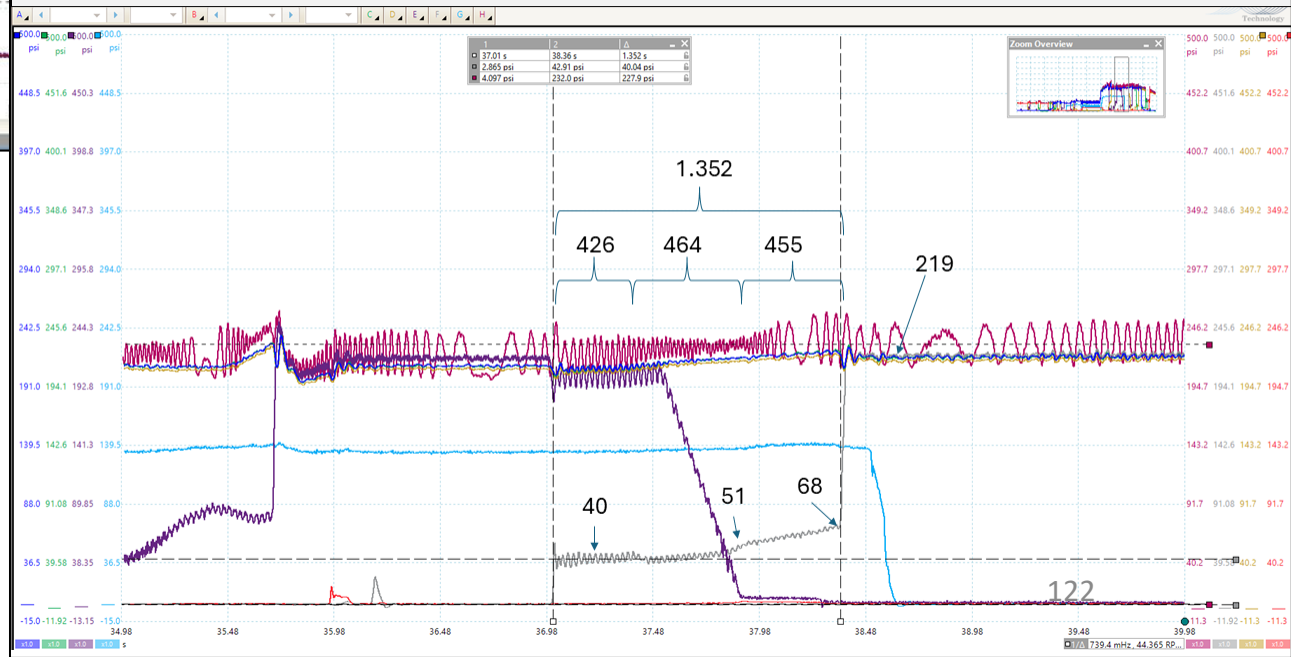
Initial Tran Red 30%, 100% Throttle 3-4 shift – ST 325ms



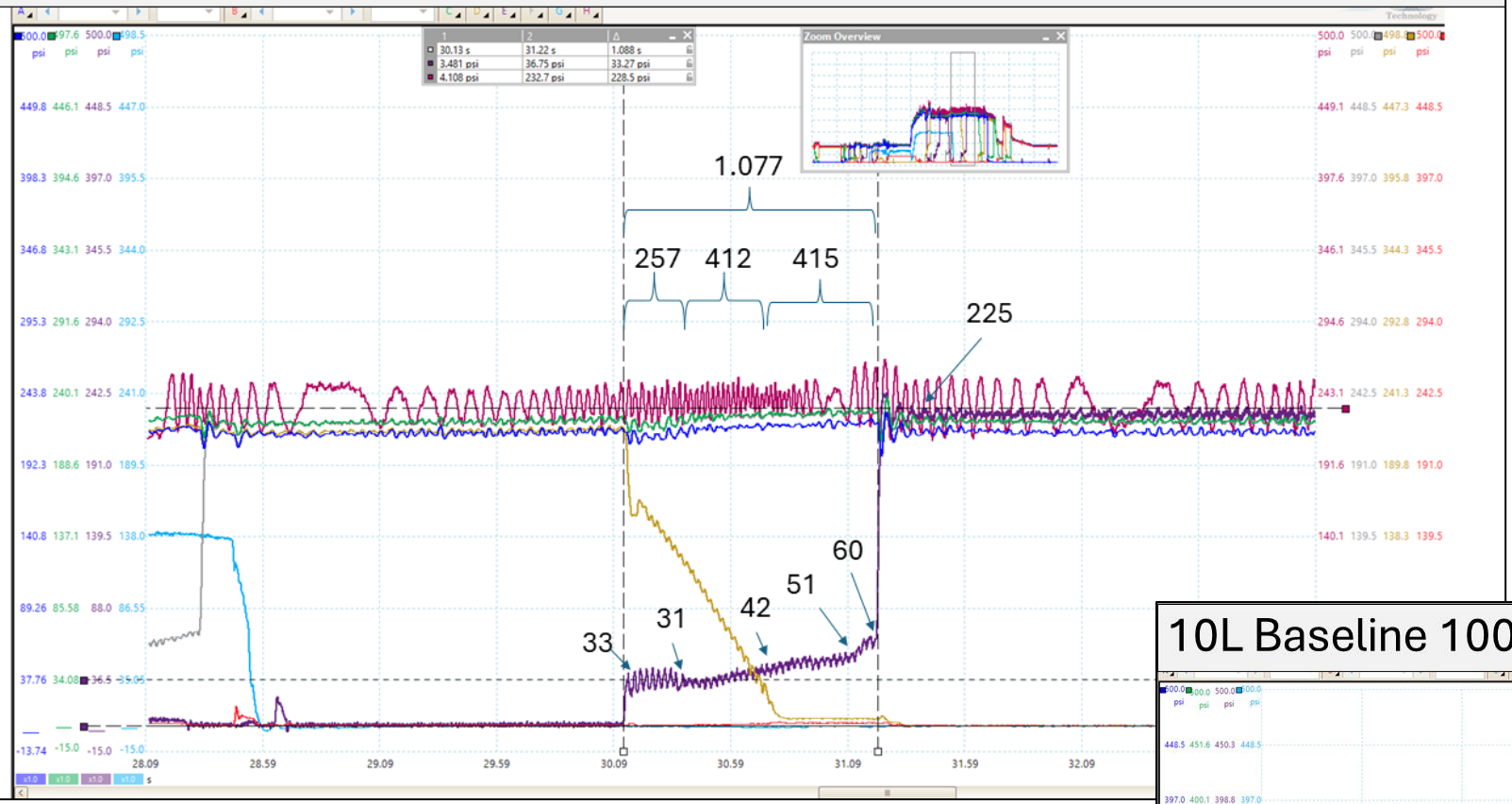
Initial trans time:

- Inconsistent changes but pressures and shift times mostly remain the same

10L Baseline 100% Throttle 3-4 shift – ST 325ms



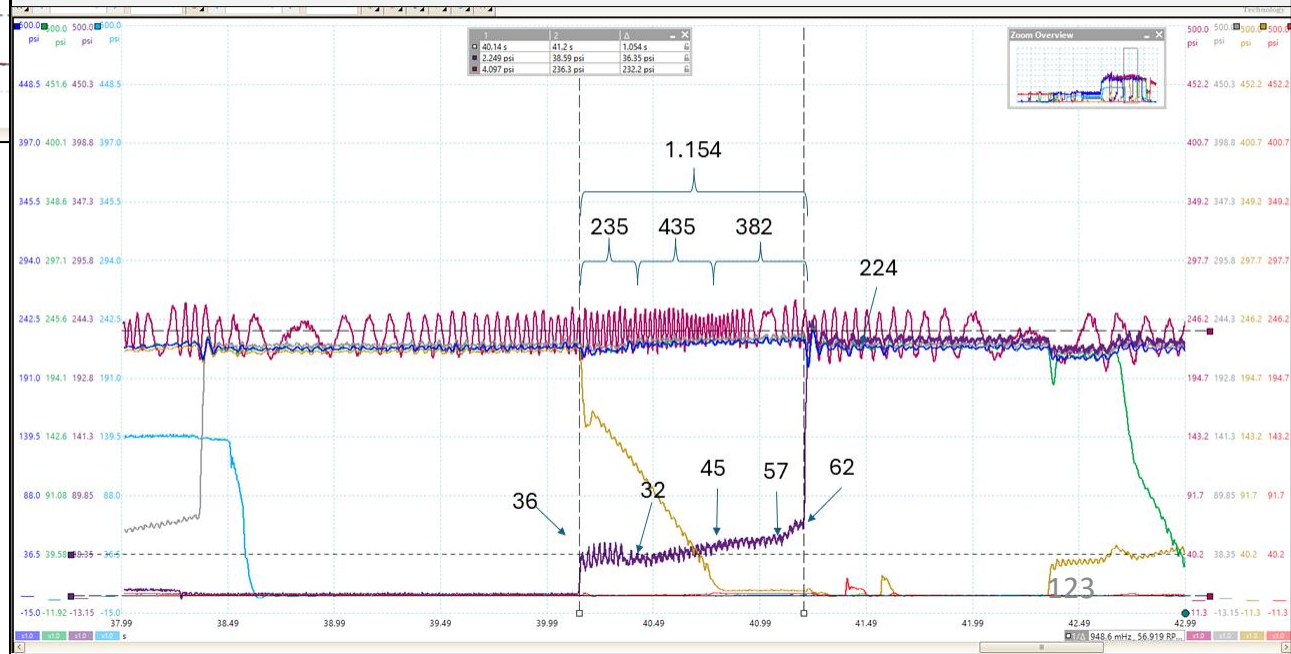
Initial Tran Red 30%, 100% Throttle 4-5 shift – ST 250 ms



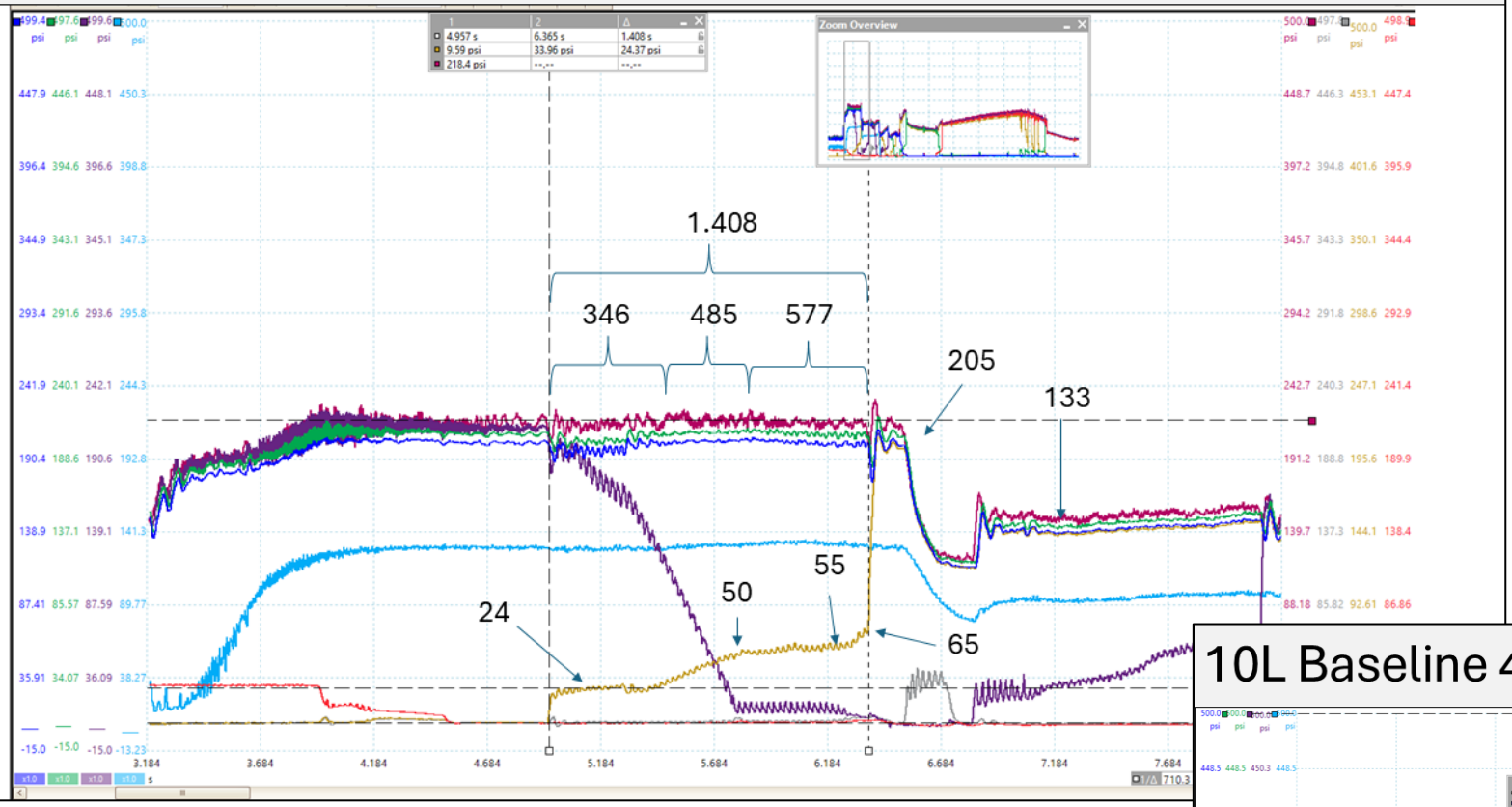
Initial trans time:

- Inconsistent changes but pressures and shift times mostly remain the same

10L Baseline 100% Throttle 4-5 shift – ST 250ms



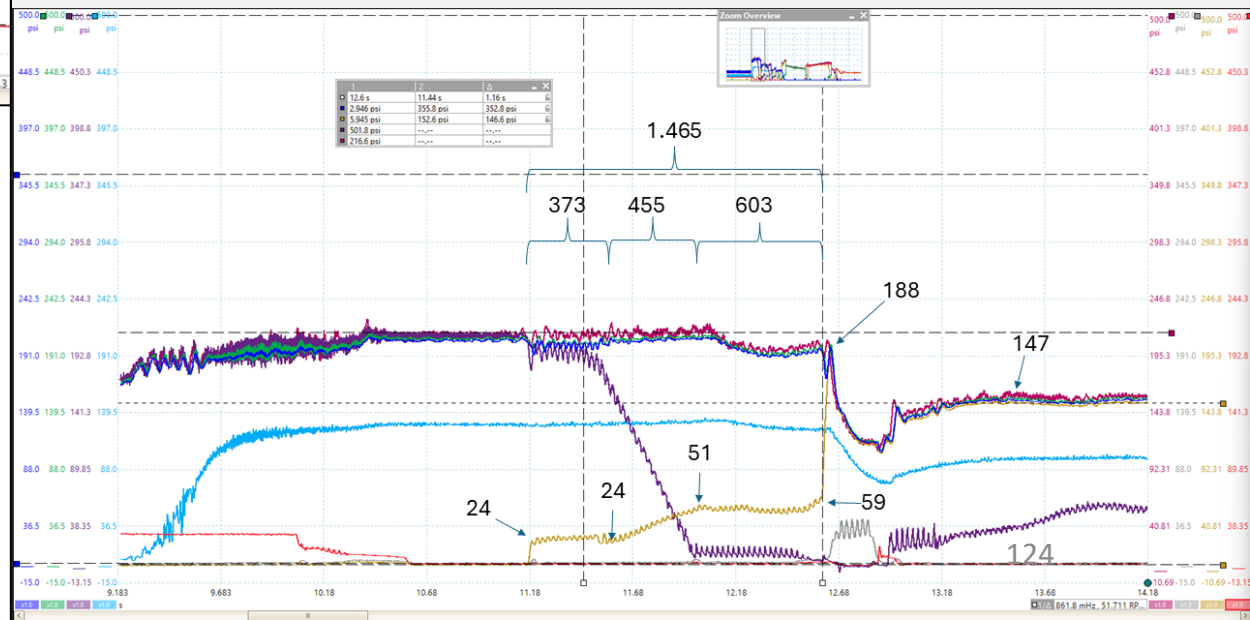
Final trans time red 30%, 40% Throttle 1-2 shift – ST 400 ms

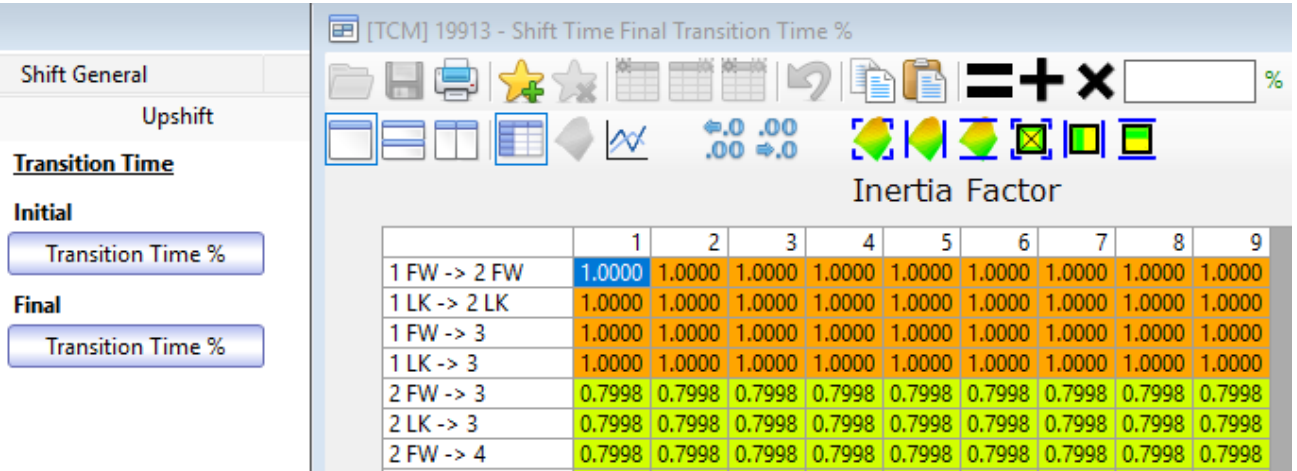


Final trans time:

- Inconsistent changes but pressures and shift times mostly remain the same

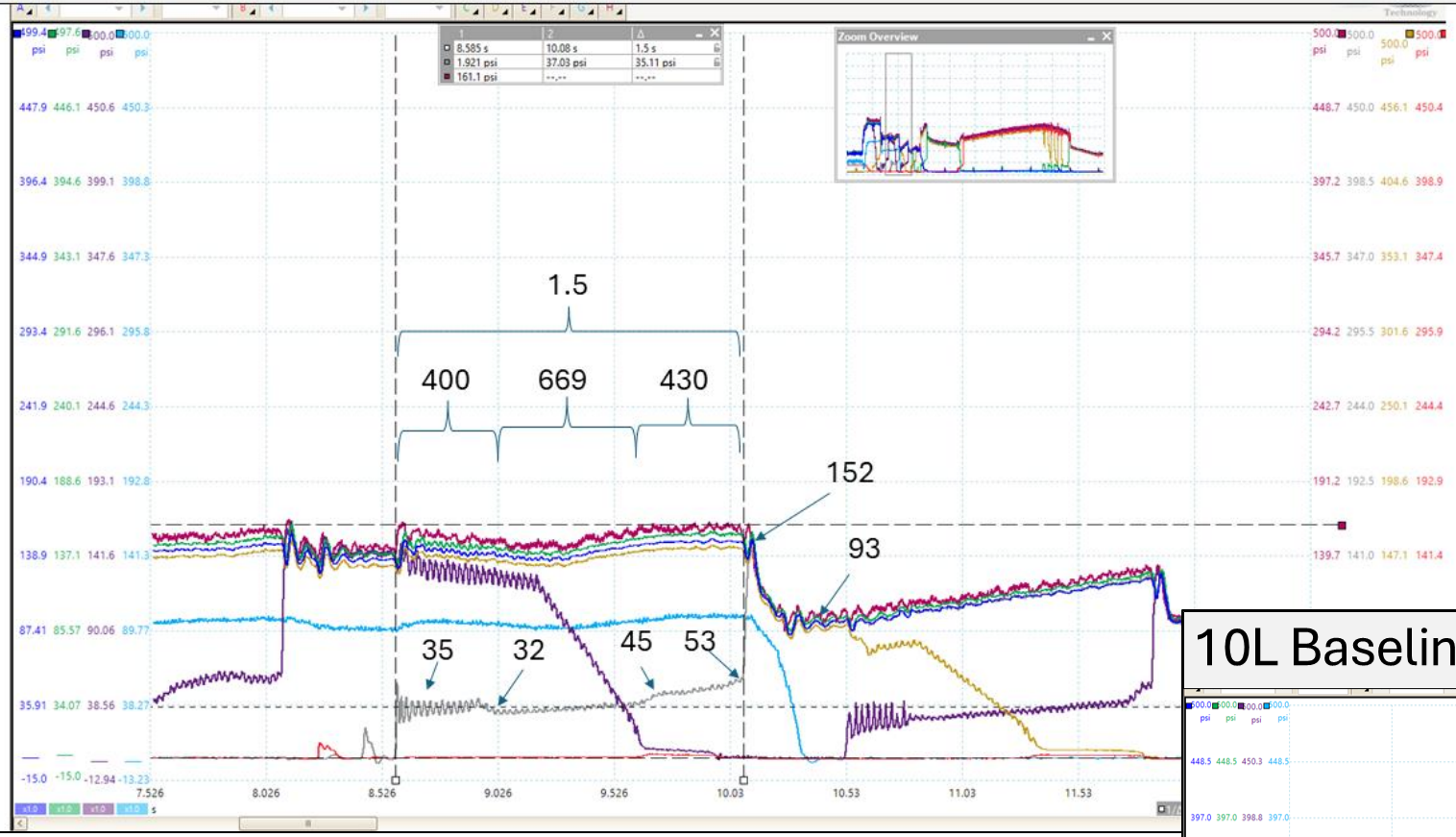
10L Baseline 40% Throttle 1-2 shift – ST 450ms





	1	2	3	4	5	6	7	8	9
1 FW -> 2 FW	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
1 LK -> 2 LK	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
1 FW -> 3	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
1 LK -> 3	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
2 FW -> 3	0.7998	0.7998	0.7998	0.7998	0.7998	0.7998	0.7998	0.7998	0.7998
2 LK -> 3	0.7998	0.7998	0.7998	0.7998	0.7998	0.7998	0.7998	0.7998	0.7998
2 FW -> 4	0.7998	0.7998	0.7998	0.7998	0.7998	0.7998	0.7998	0.7998	0.7998

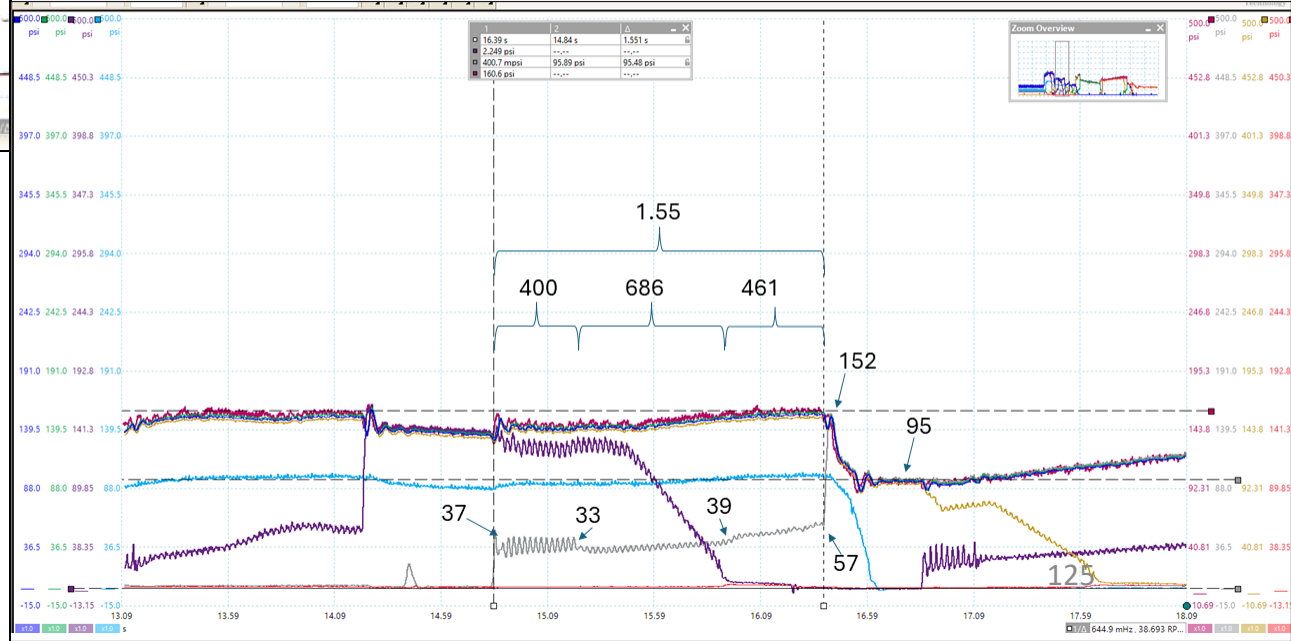
Final trans time red 30% - 40% Throttle 3-4 shift – ST 275 ms



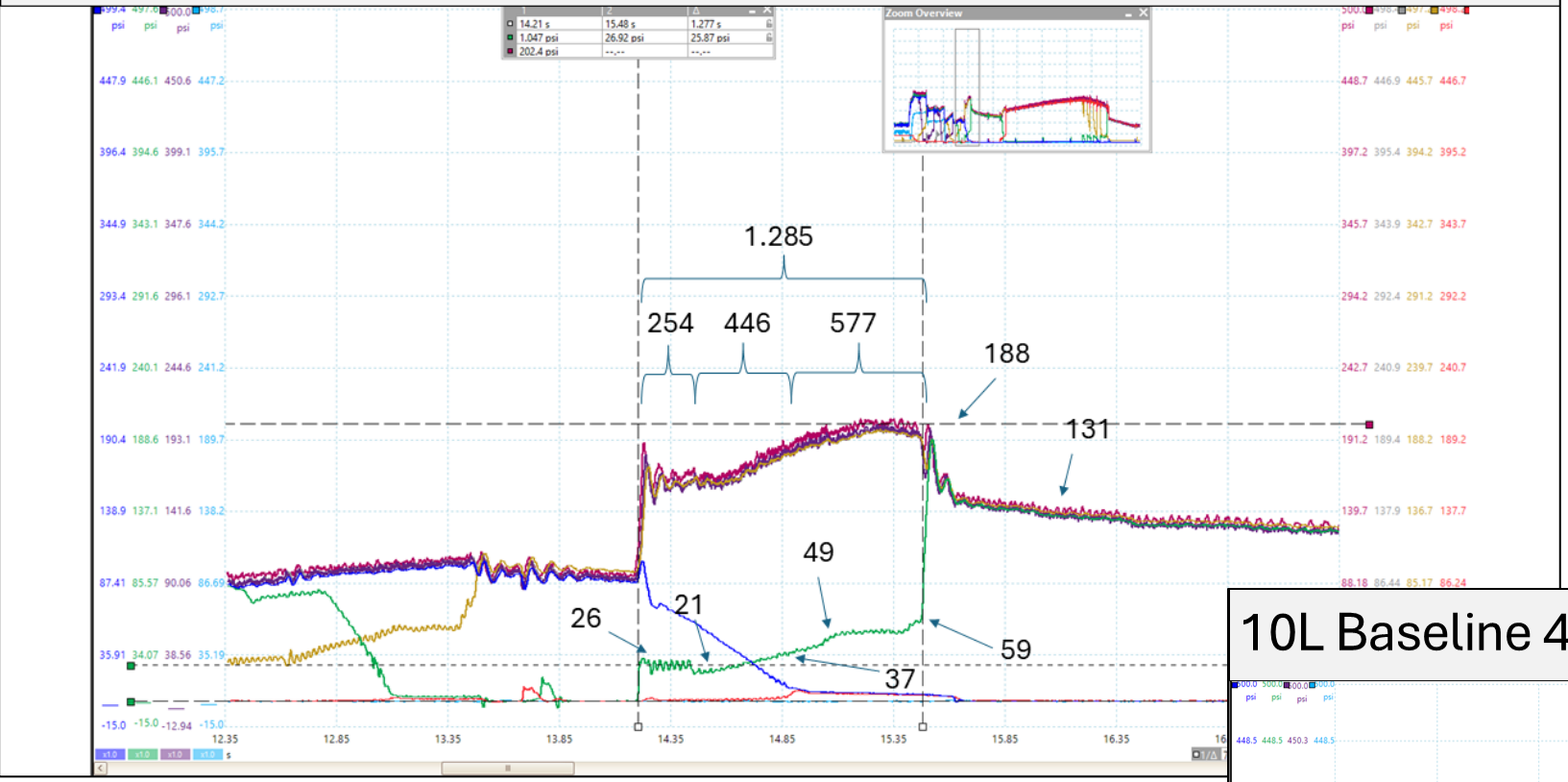
Final trans time:

- Inconsistent changes but pressures and shift times mostly remain the same

10L Baseline 40% Throttle 3-4 shift – ST 275ms



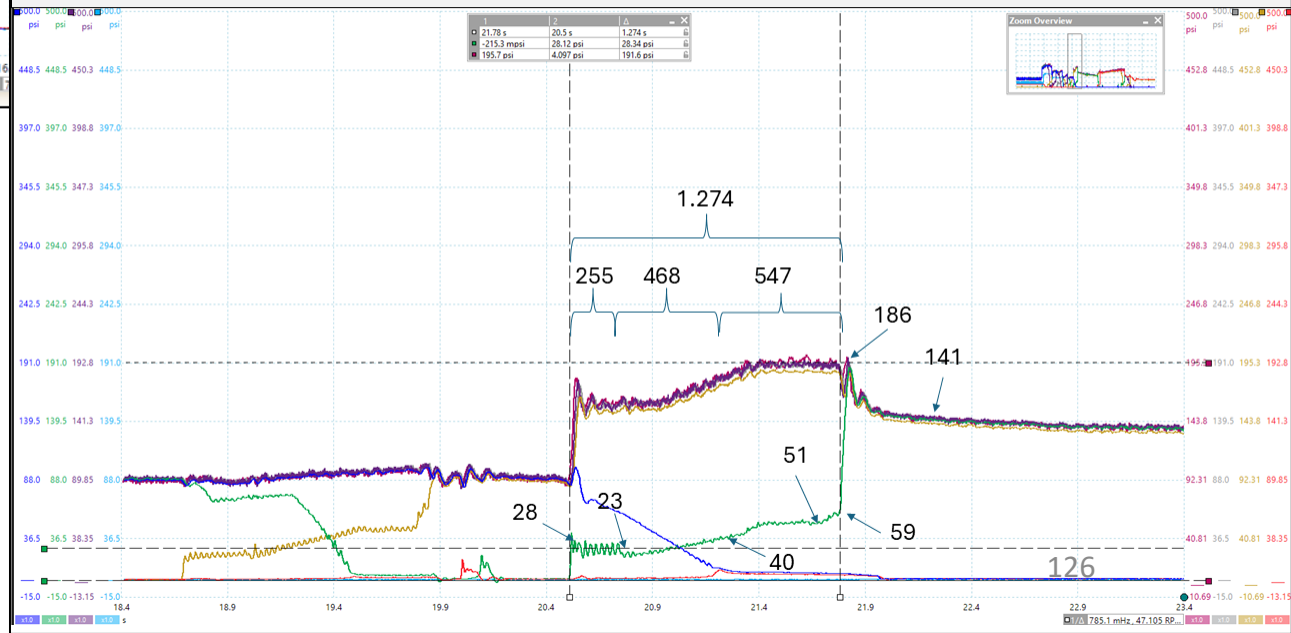
Final trans red 30%, 40% Throttle 6-7 shift – ST 250 ms



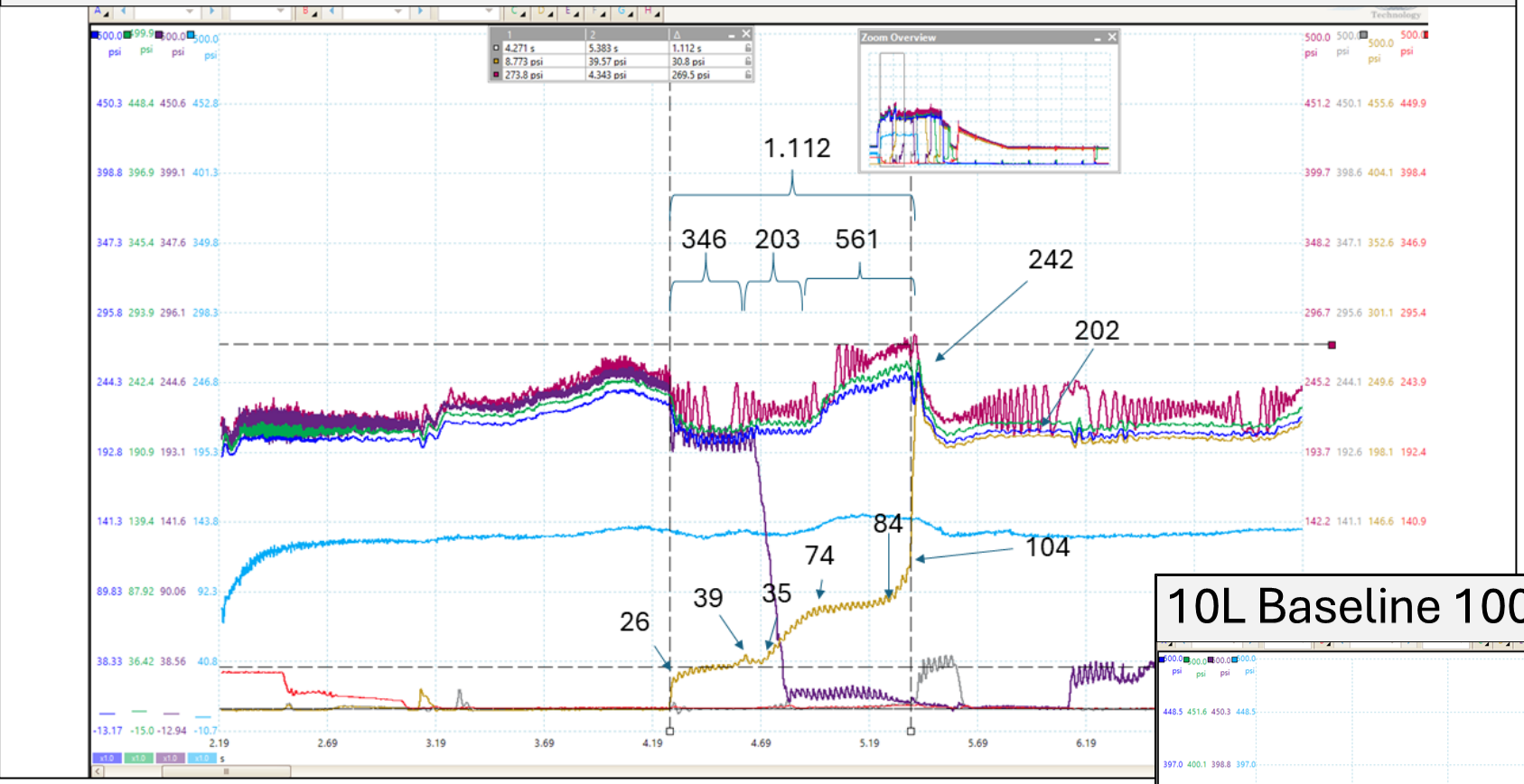
Final trans time:

- Inconsistent changes but pressures and shift times mostly remain the same

10L Baseline 40% Throttle 6-7 shift – ST 250ms



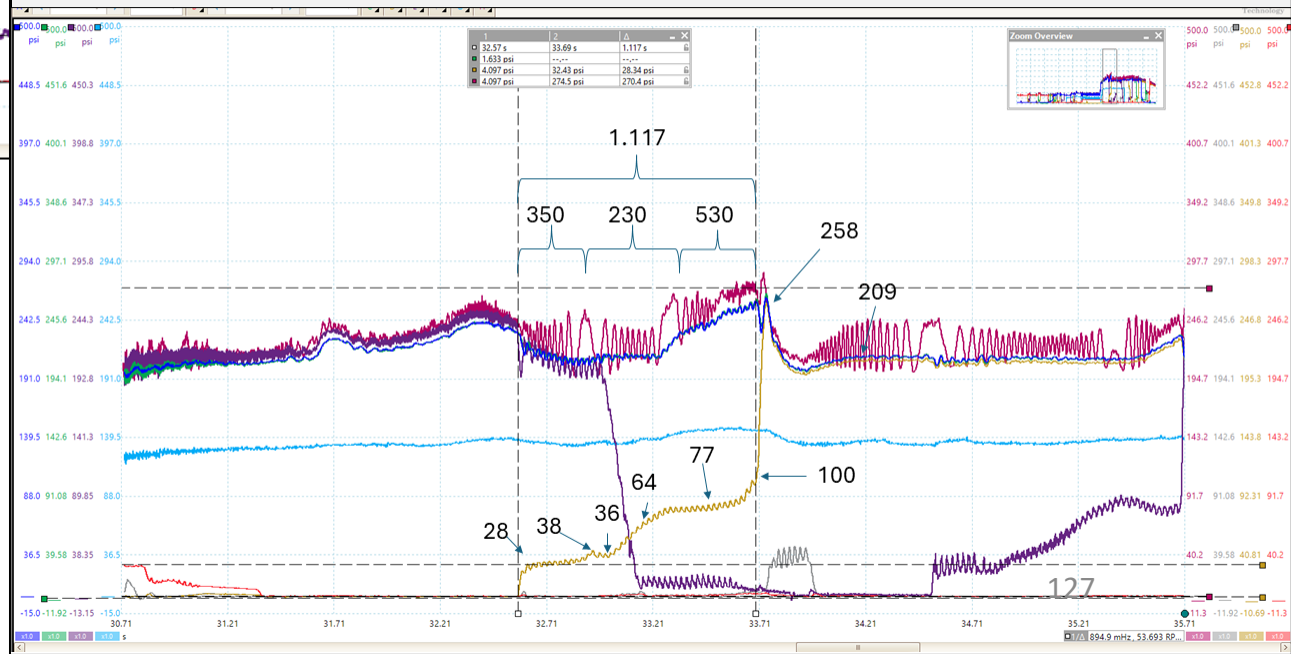
Final Tran Red 30%, 100% Throttle 1-2 shift – ST 400 ms



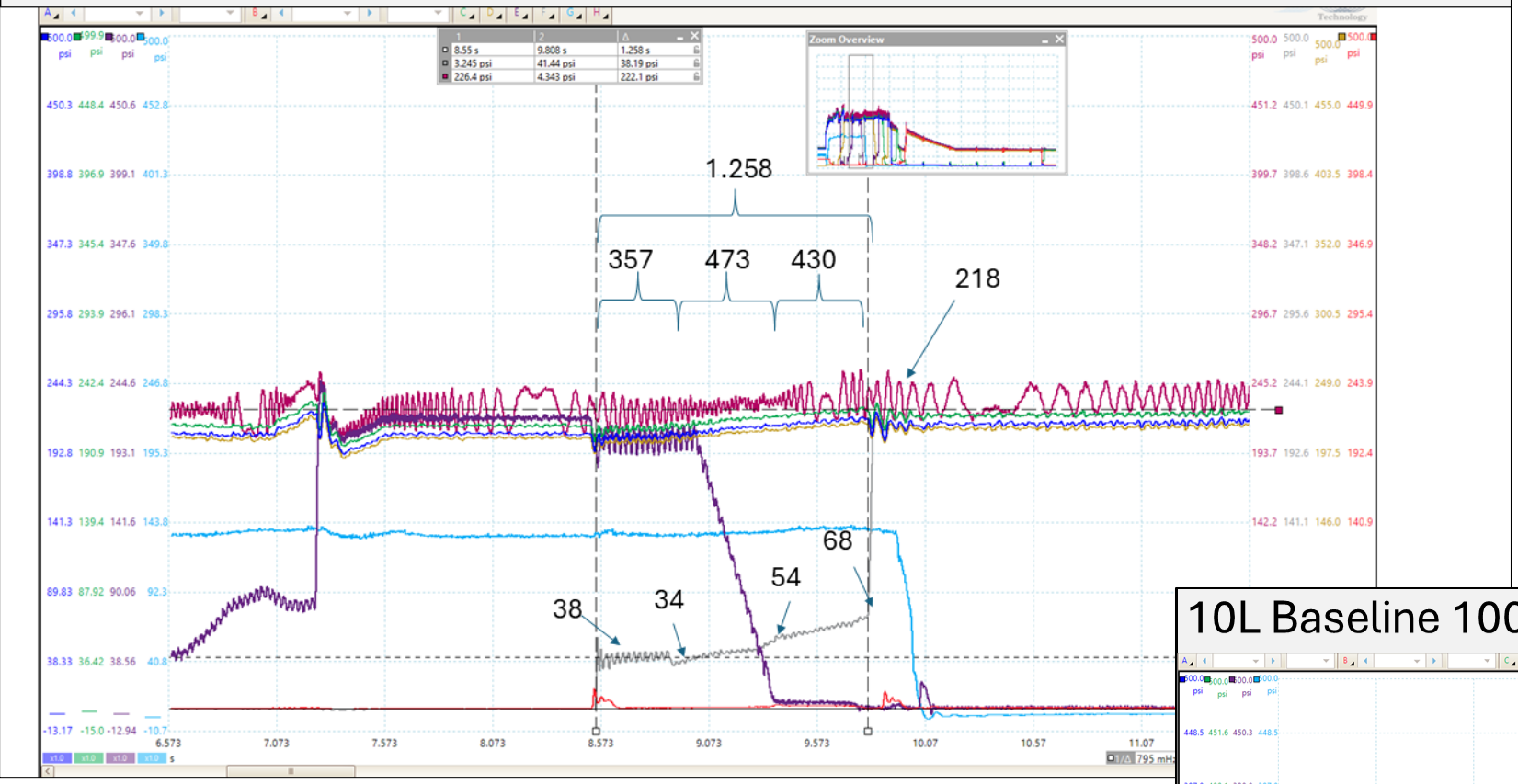
Final trans time:

- Inconsistent changes but pressures and shift times mostly remain the same

10L Baseline 100% Throttle 1-2 shift – ST 375ms



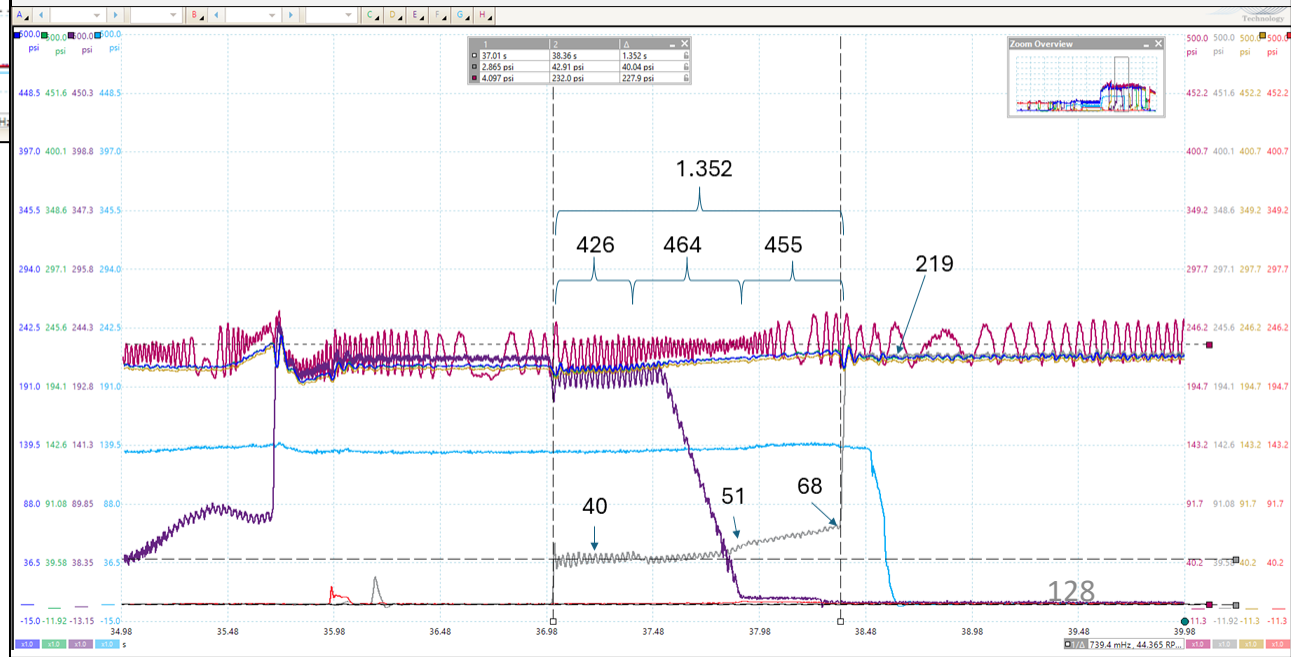
Final Tran Red 30%, 100% Throttle 3-4 shift – ST 300 ms



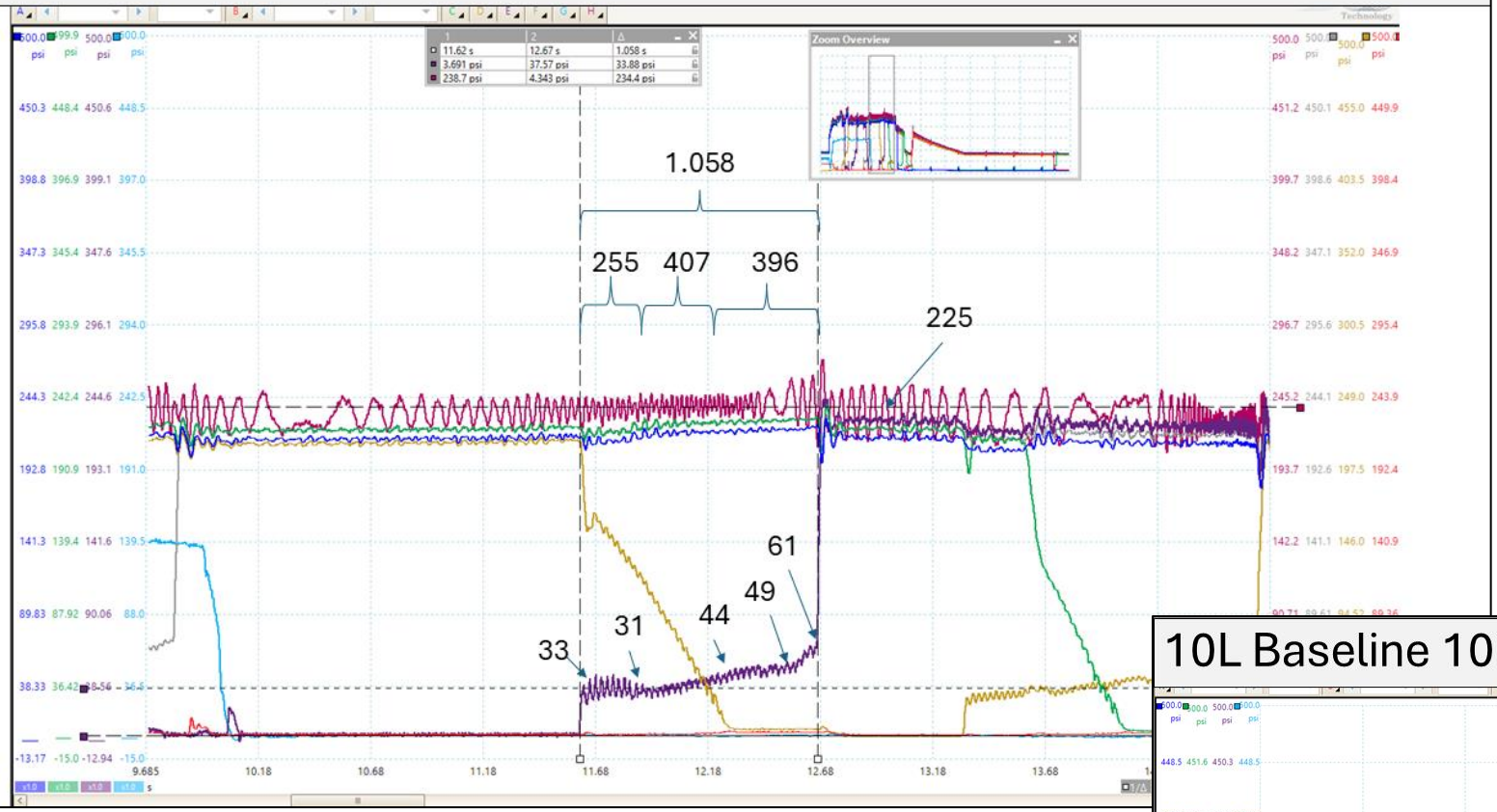
Final trans time:

- Inconsistent changes but pressures and shift times mostly remain the same

10L Baseline 100% Throttle 3-4 shift – ST 325ms



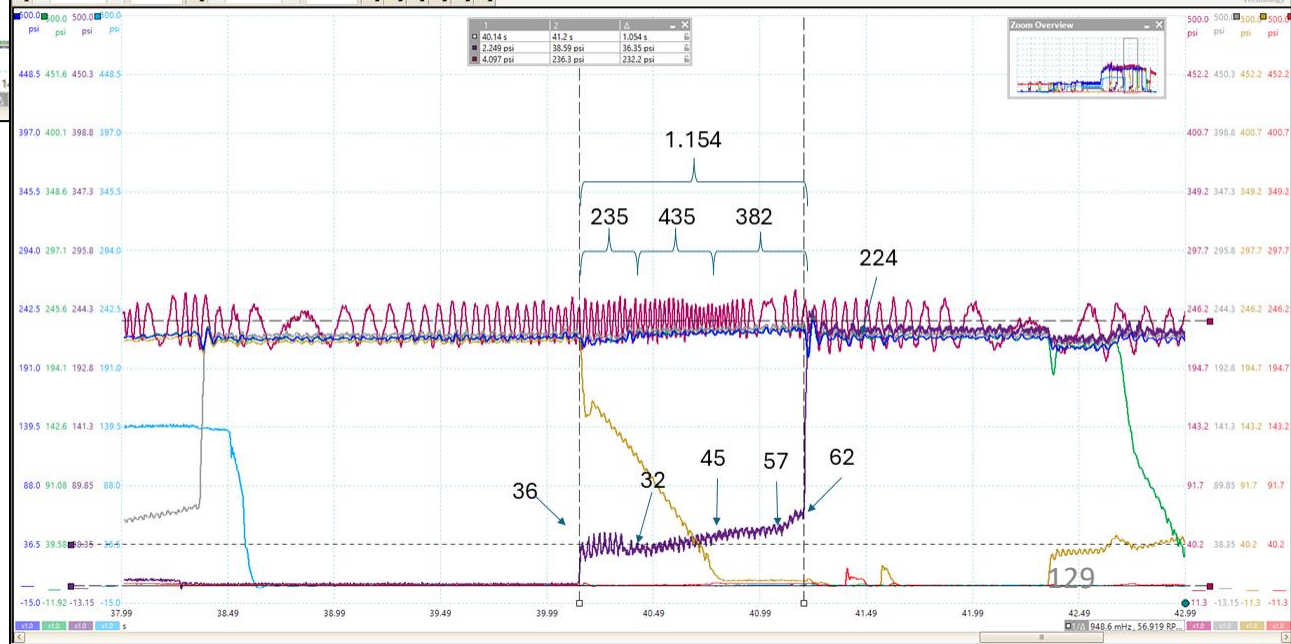
Final Tran Red 30%, 100% Throttle 4-5 shift – ST 225 ms



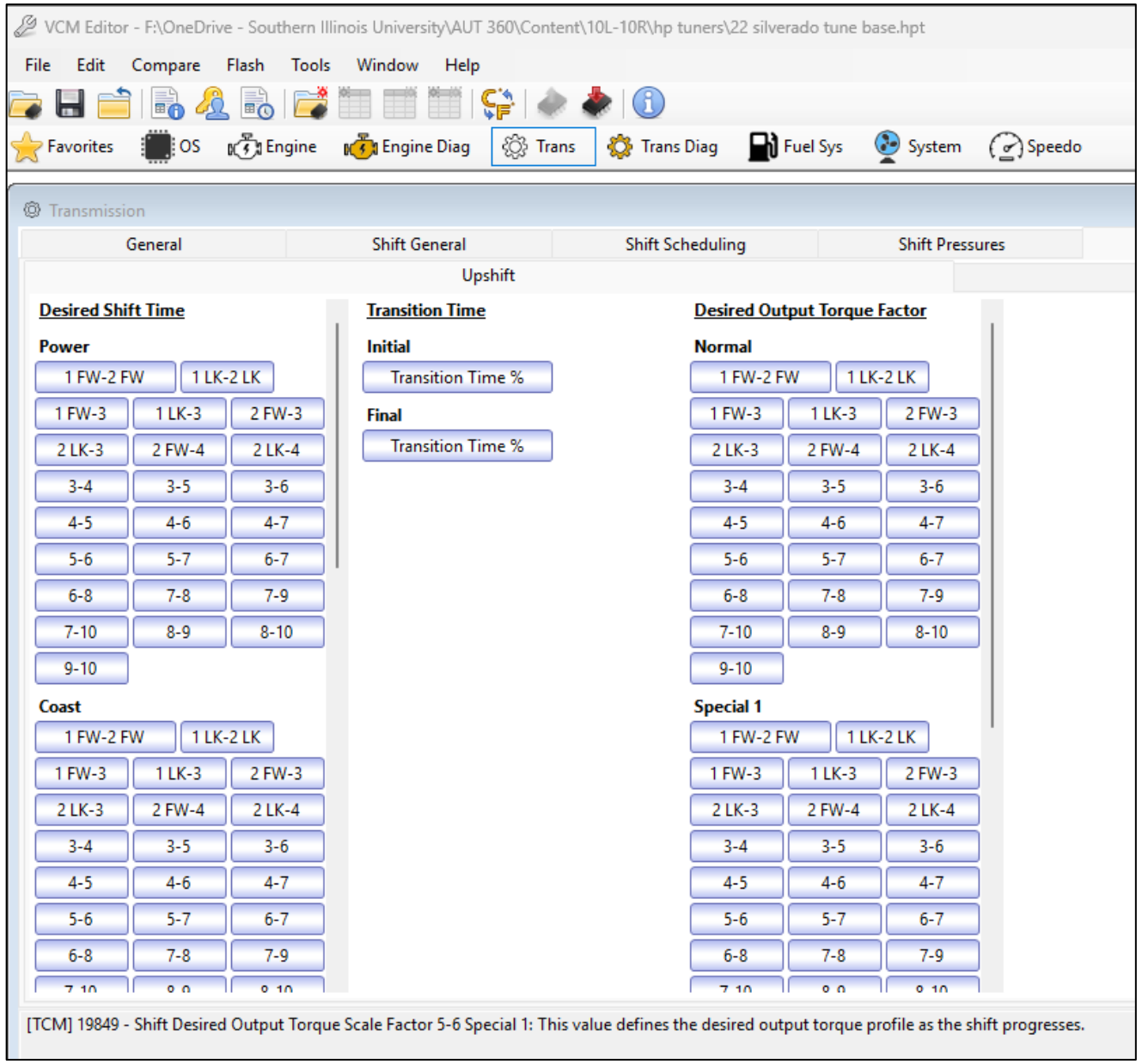
Final trans time:

- Inconsistent changes but pressures and shift times mostly remain the same

10L Baseline 100% Throttle 4-5 shift – ST 250ms

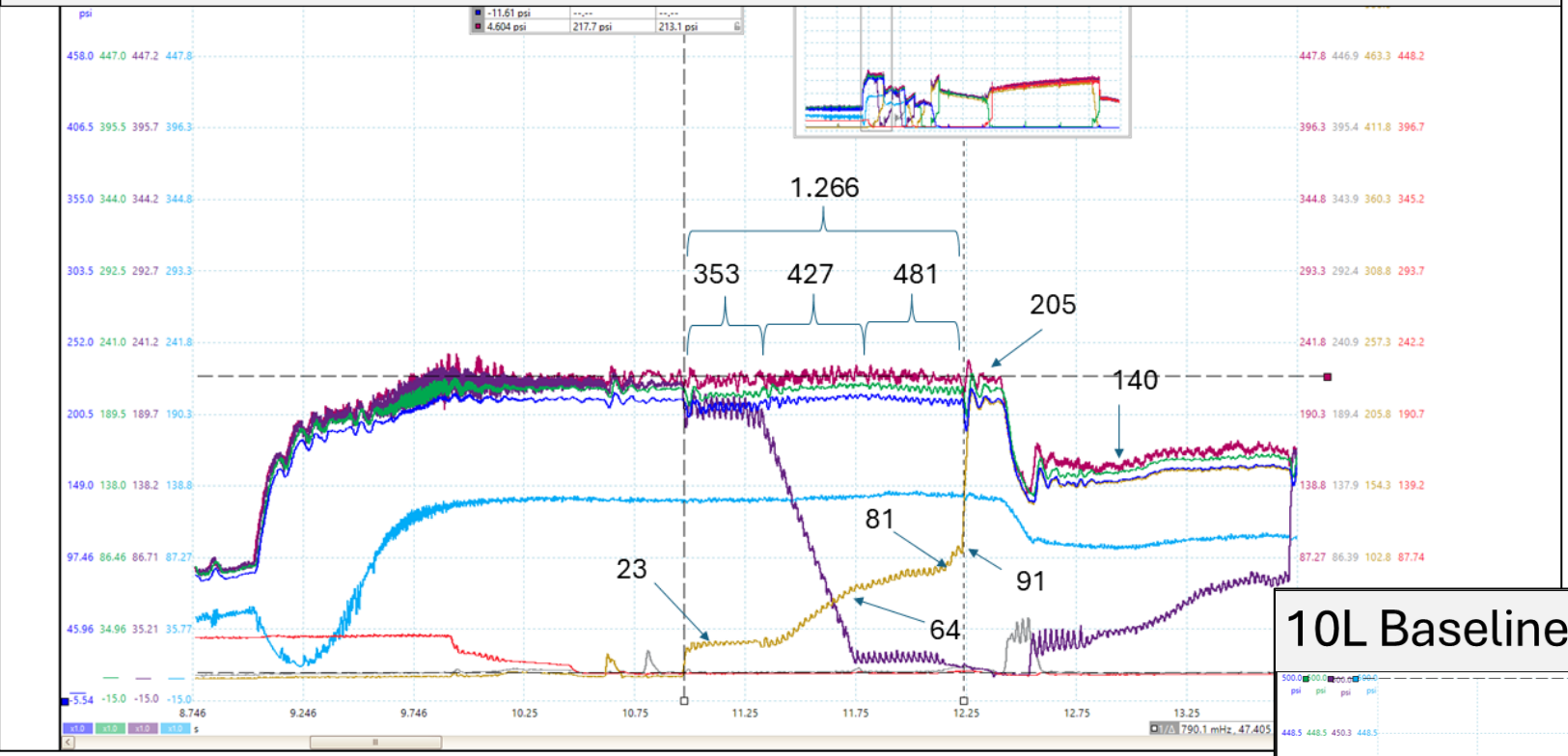


10L HP Tuner – Desired Output Torque Factor



- Slight effect on shift time
- Sometimes Torque Phase/Sometimes Inertia Phase
- Shift times didn't really change much

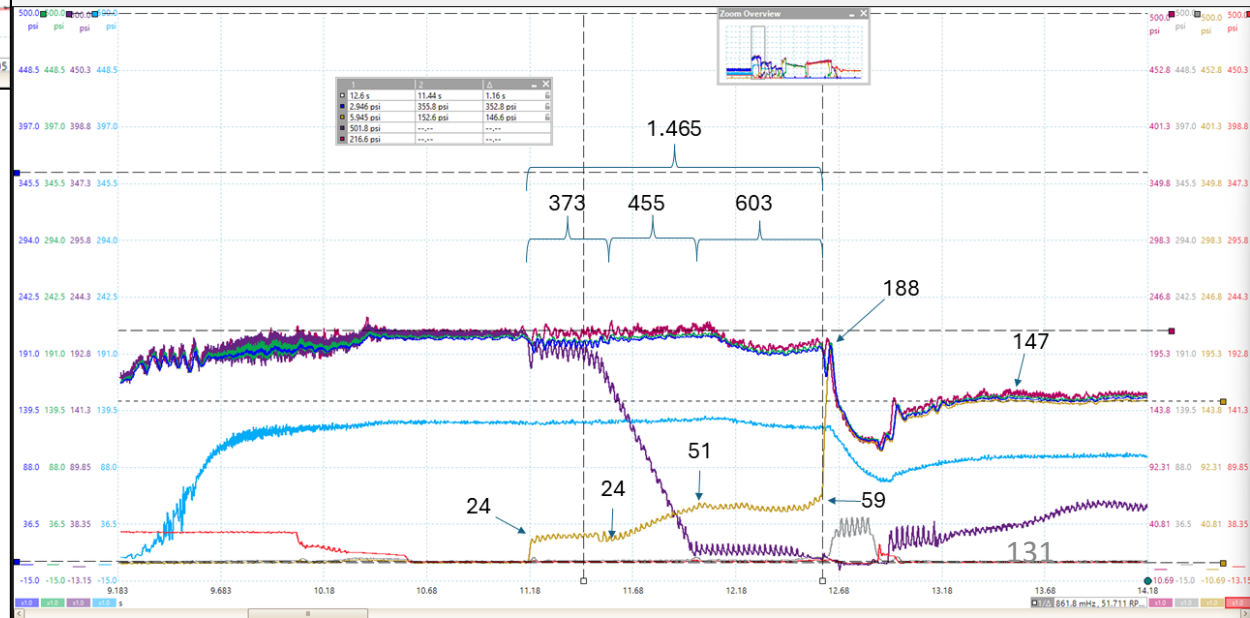
Output Torque Factor Increased 30%, 40% Throttle 1-2 shift – ST 350 ms



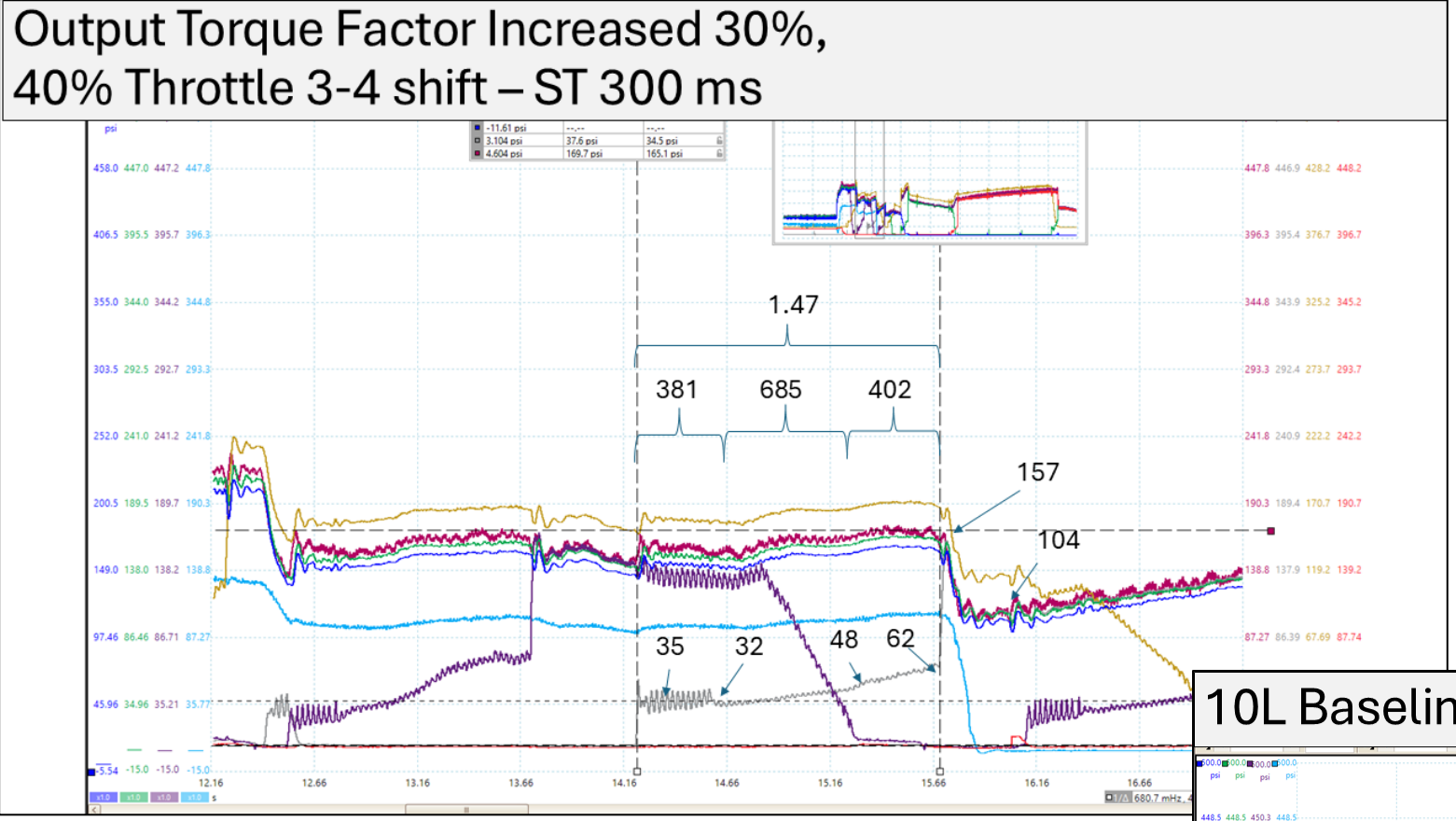
Output torque factor:

- Didn't always increase the shift speed as measured by the scanner.
- Increased the shifting pressures slightly
- For some gears, the total shift time was slightly quicker

10L Baseline 40% Throttle 1-2 shift – ST 450ms



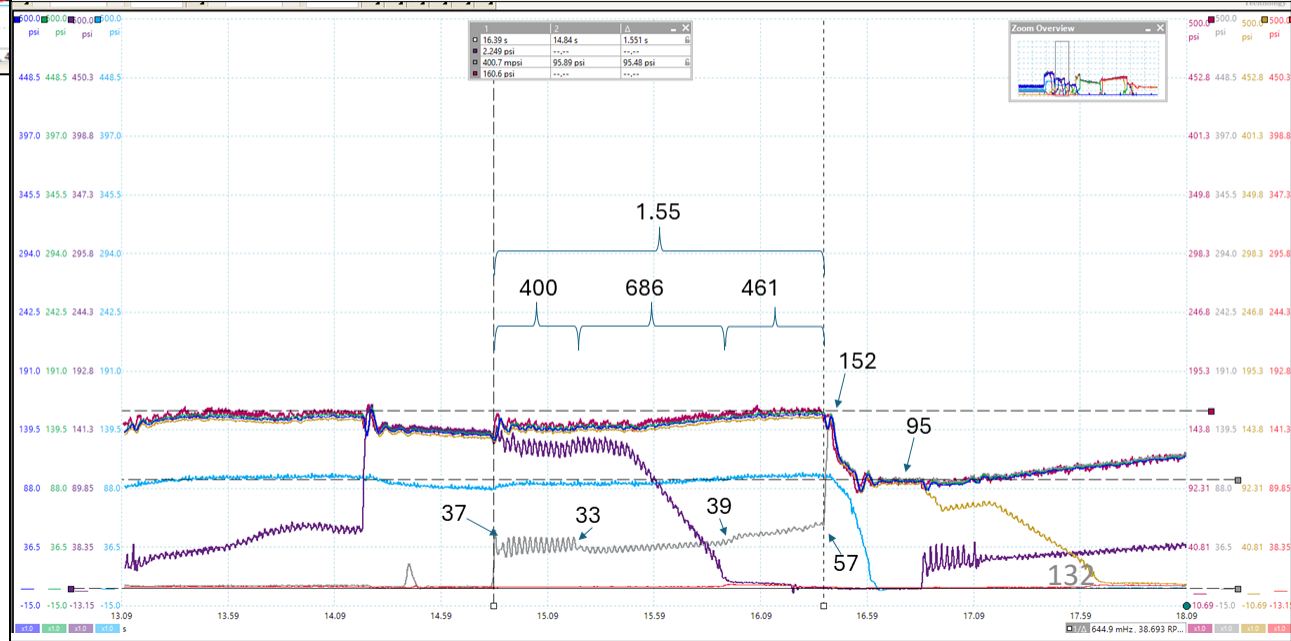
Output Torque Factor Increased 30%, 40% Throttle 3-4 shift – ST 300 ms



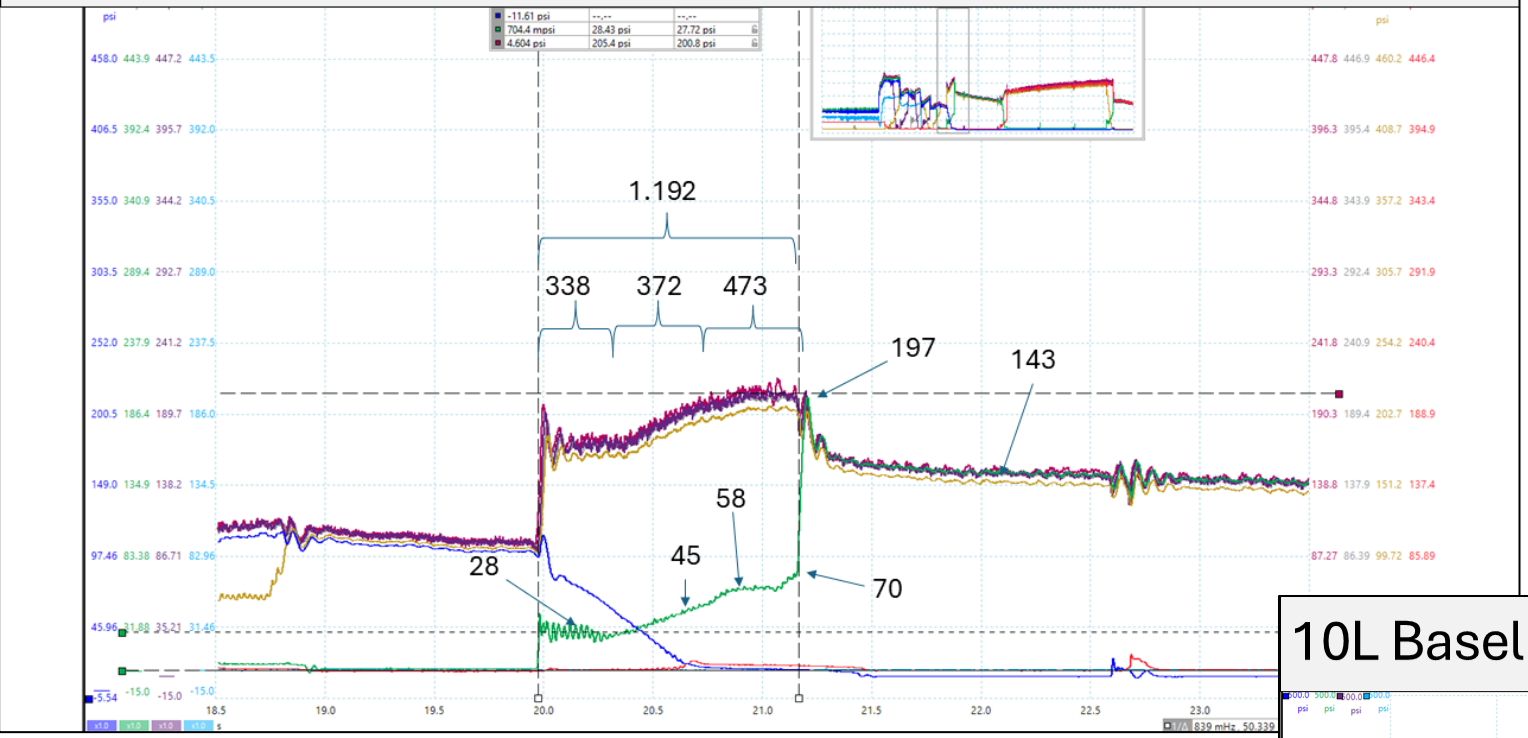
Output torque factor:

- Didn't always increase the shift speed as measured by the scanner.
- Increased the shifting pressures slightly
- For some gears, the total shift time was slightly quicker

10L Baseline 40% Throttle 3-4 shift – ST 275ms



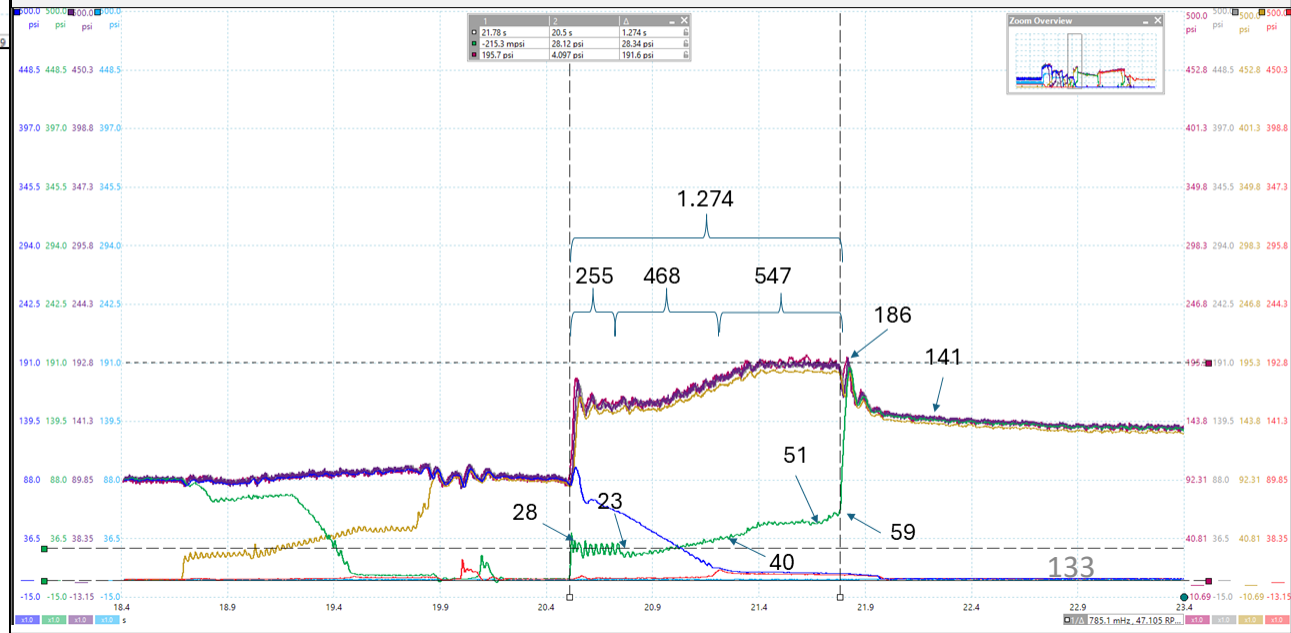
Output Torque Factor Increased 30%, 40% Throttle 6-7 shift – ST 275 ms



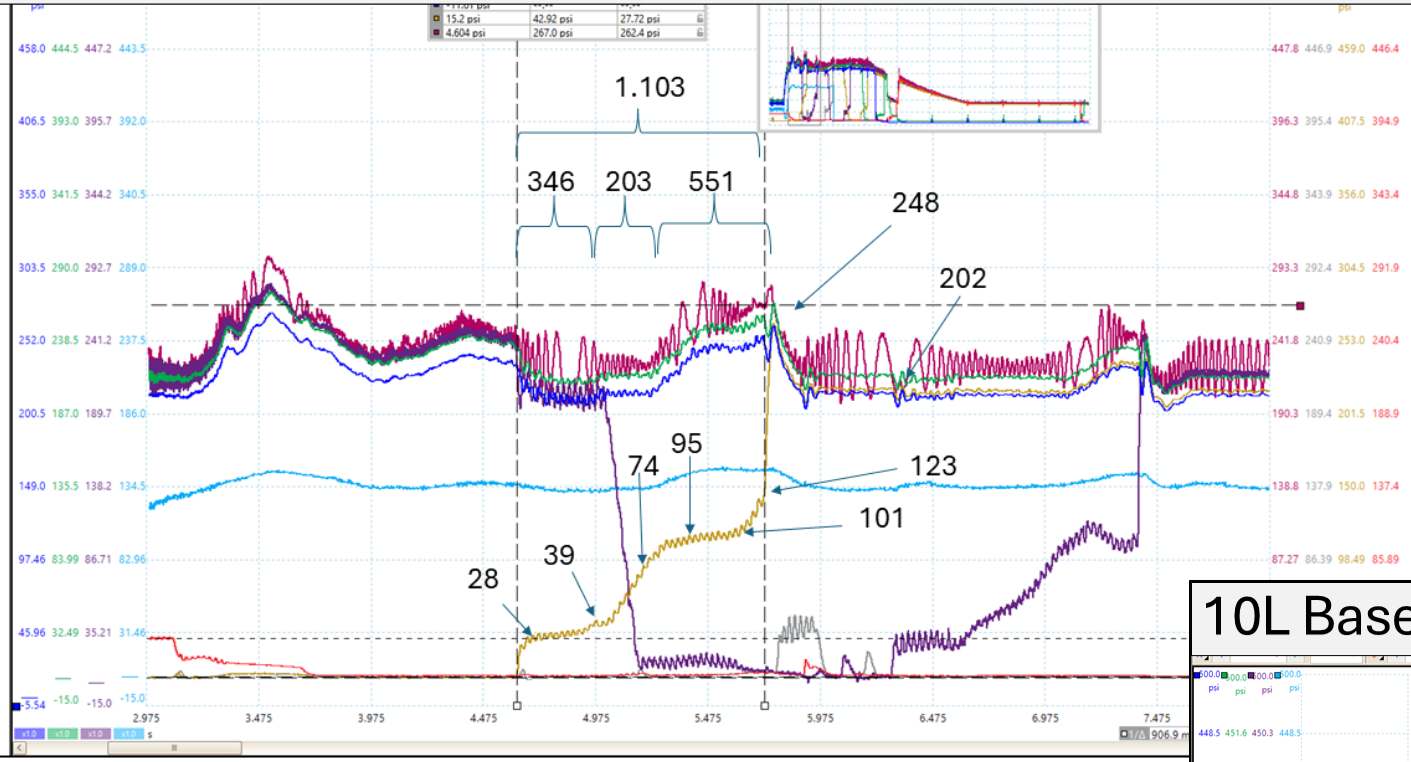
Output torque factor:

- Didn't always increase the shift speed as measured by the scanner.
- Increased the shifting pressures slightly
- For some gears, the total shift time was slightly quicker

10L Baseline 40% Throttle 6-7 shift – ST 250ms



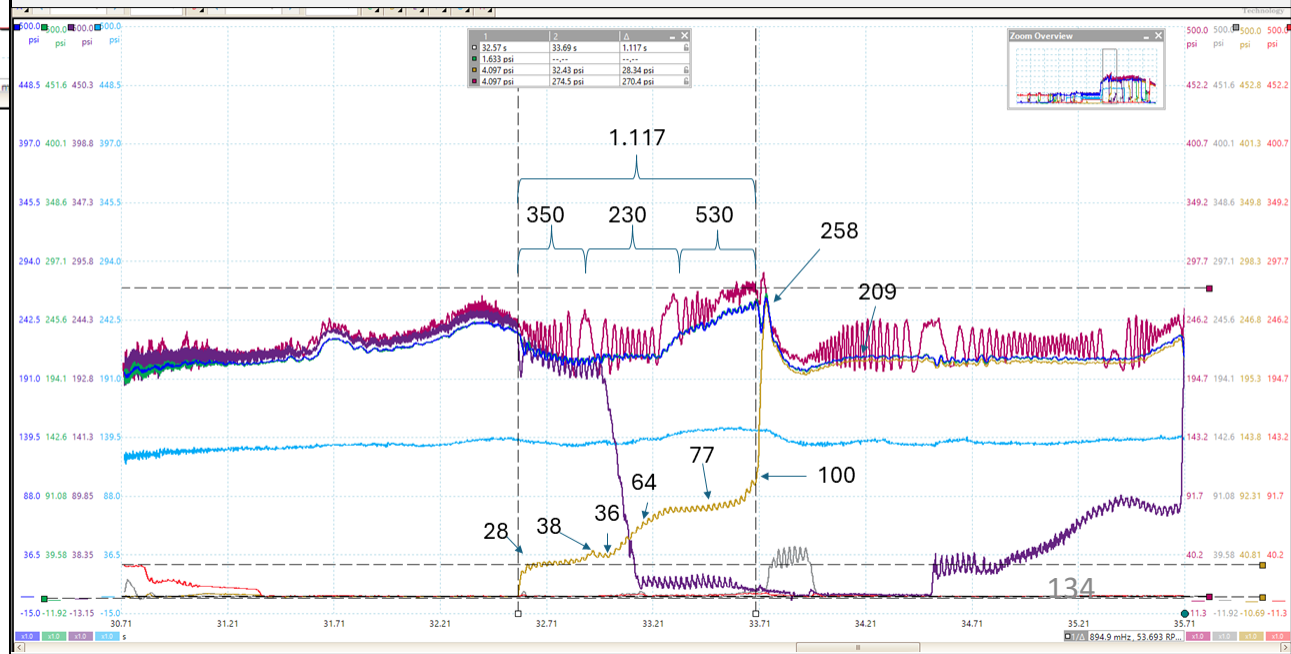
Output Torque Factor Increased 30%, 100% Throttle 1-2 shift – ST 400 ms



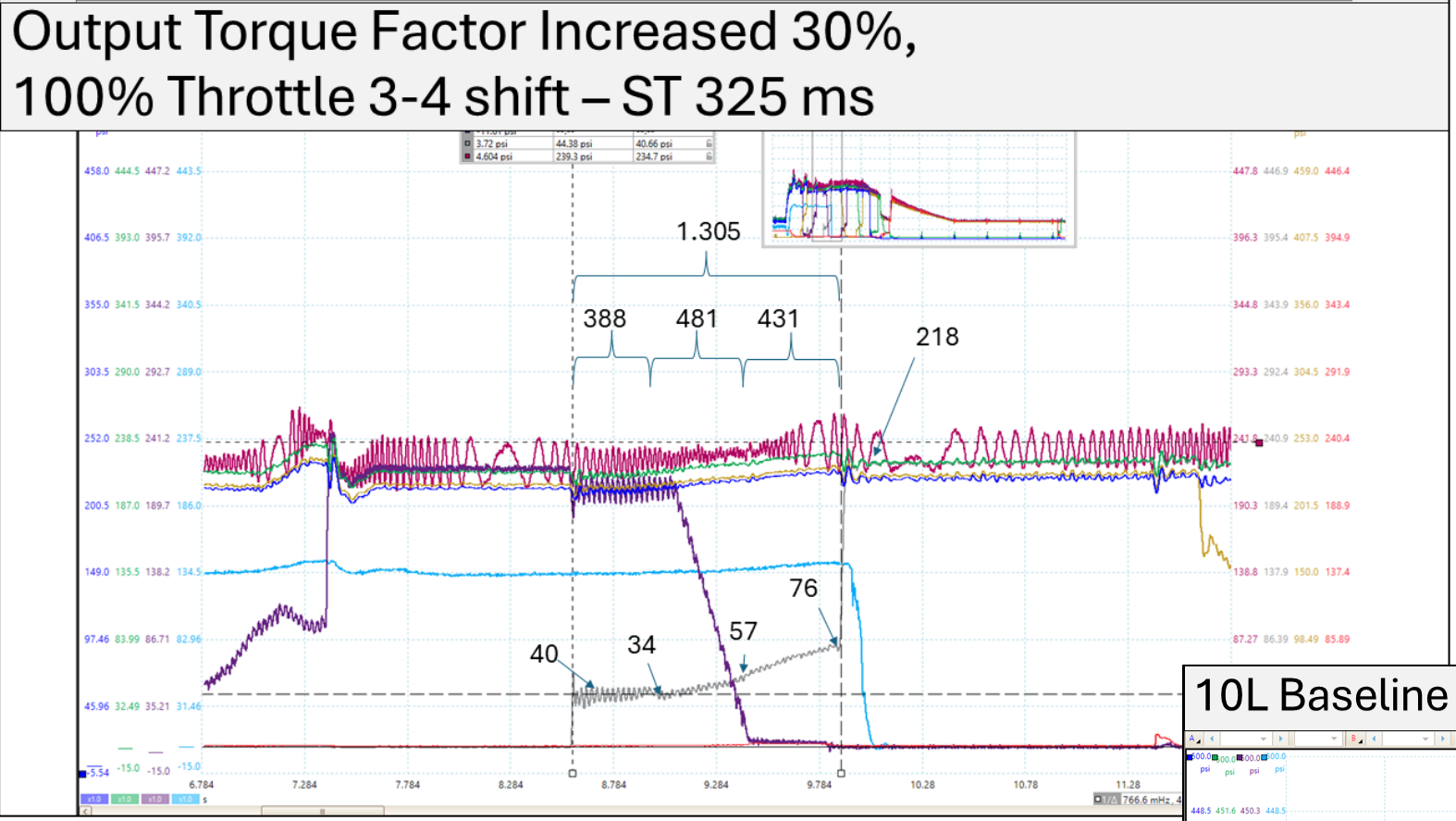
Output torque factor:

- Didn't always increase the shift speed as measured by the scanner.
- Increased the shifting pressures slightly
- For some gears, the total shift time was slightly quicker

10L Baseline 100% Throttle 1-2 shift – ST 375ms



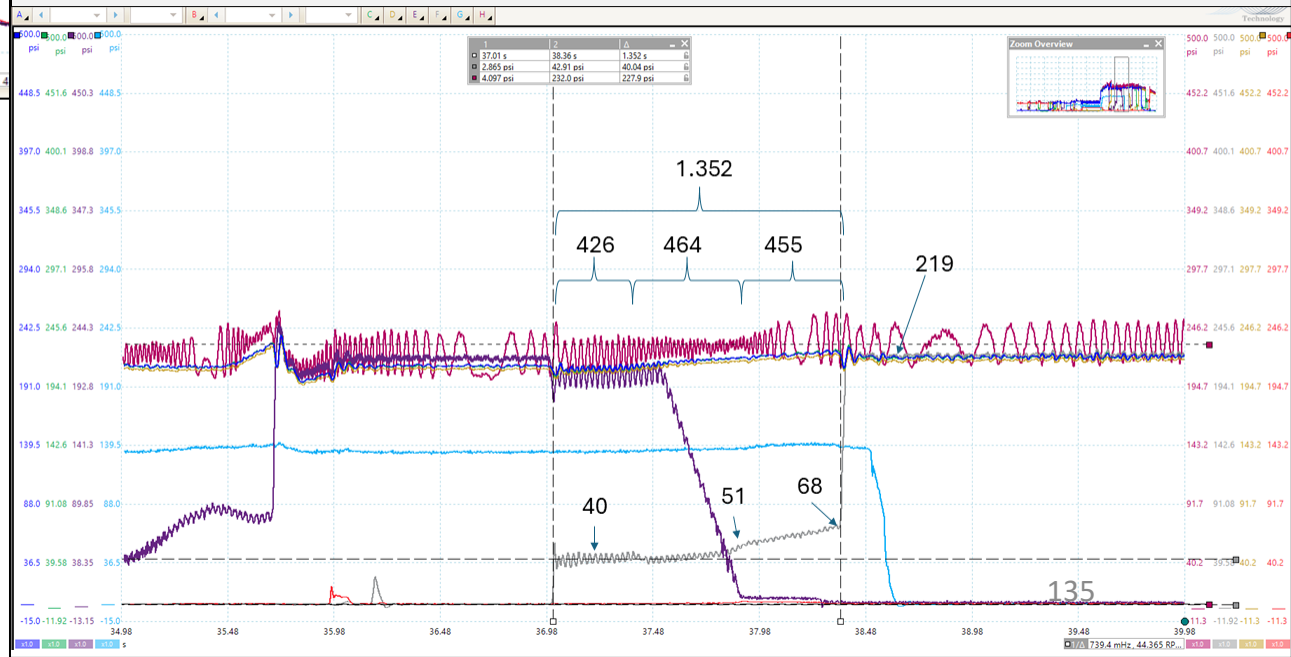
Output Torque Factor Increased 30%, 100% Throttle 3-4 shift – ST 325 ms



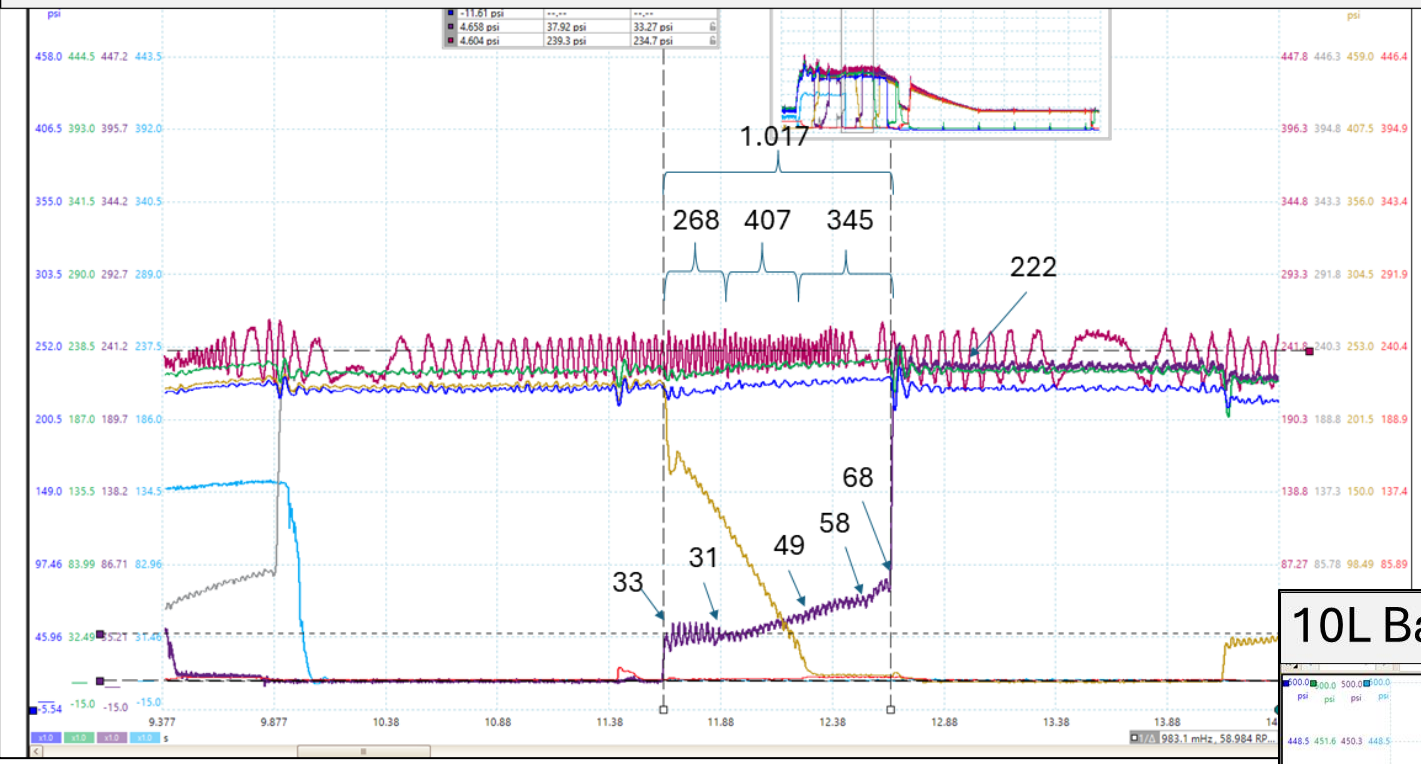
Output torque factor:

- Didn't always increase the shift speed as measured by the scanner.
- Increased the shifting pressures slightly
- For some gears, the total shift time was slightly quicker

10L Baseline 100% Throttle 3-4 shift – ST 325ms



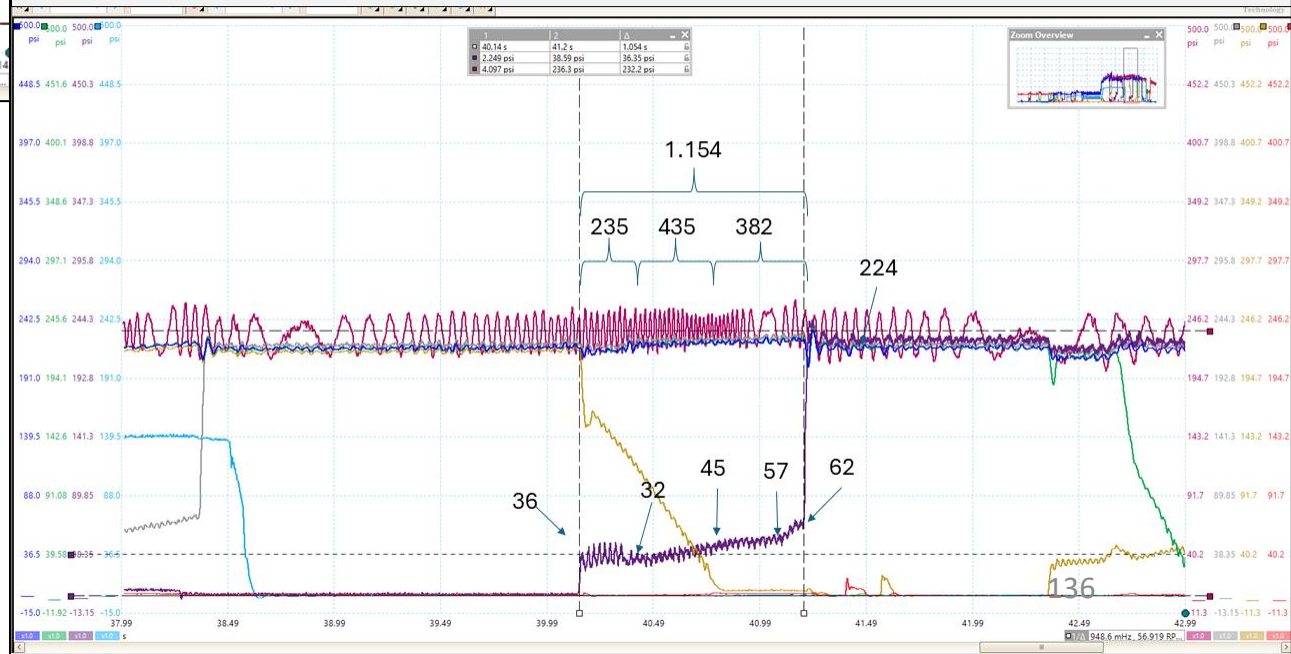
Output Torque Factor Increased 30%, 100% Throttle 4-5 shift – ST 250 ms



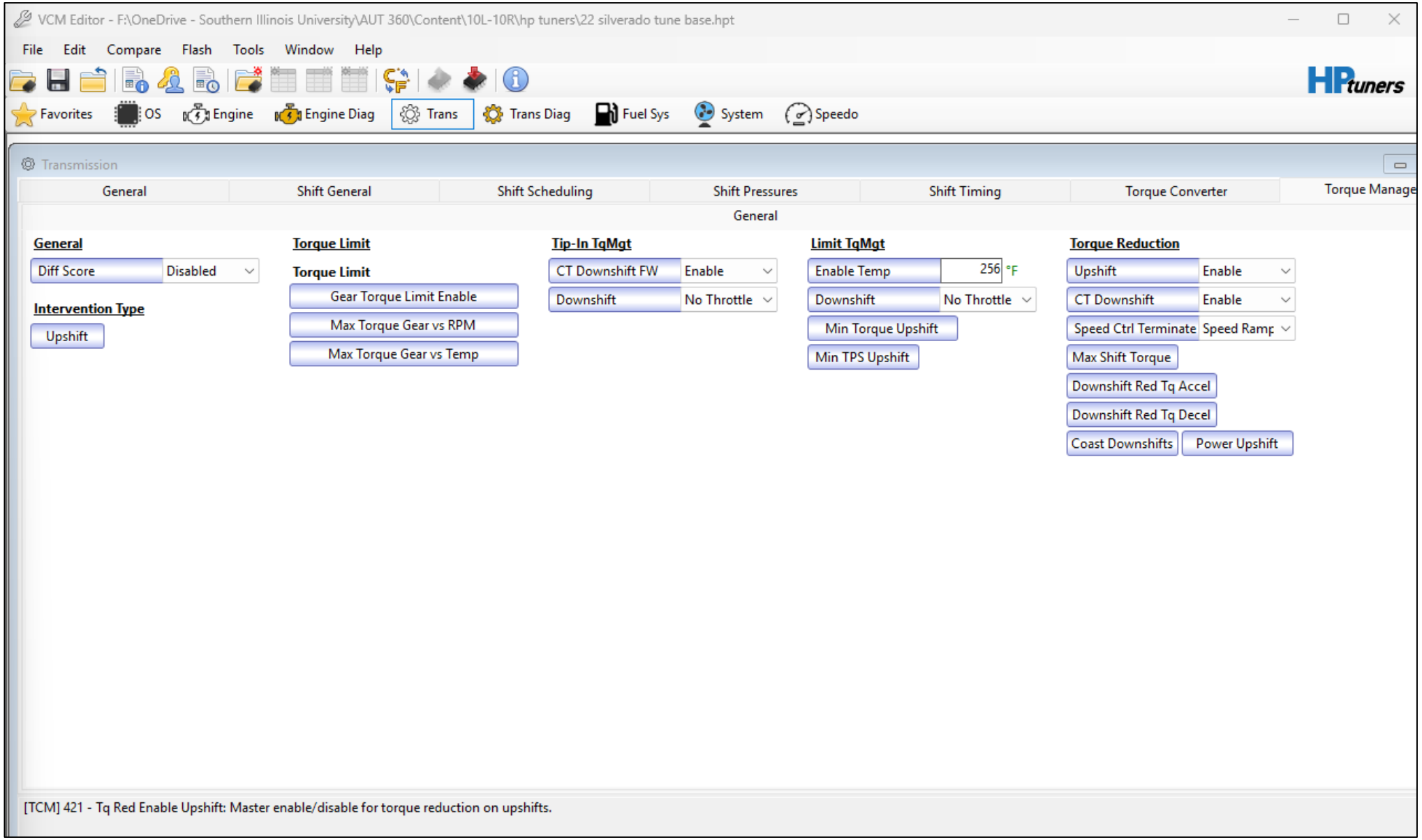
Output torque factor:

- Didn't always increase the shift speed as measured by the scanner.
- Increased the shifting pressures slightly
- For some gears, the total shift time was slightly quicker

10L Baseline 100% Throttle 4-5 shift – ST 250ms

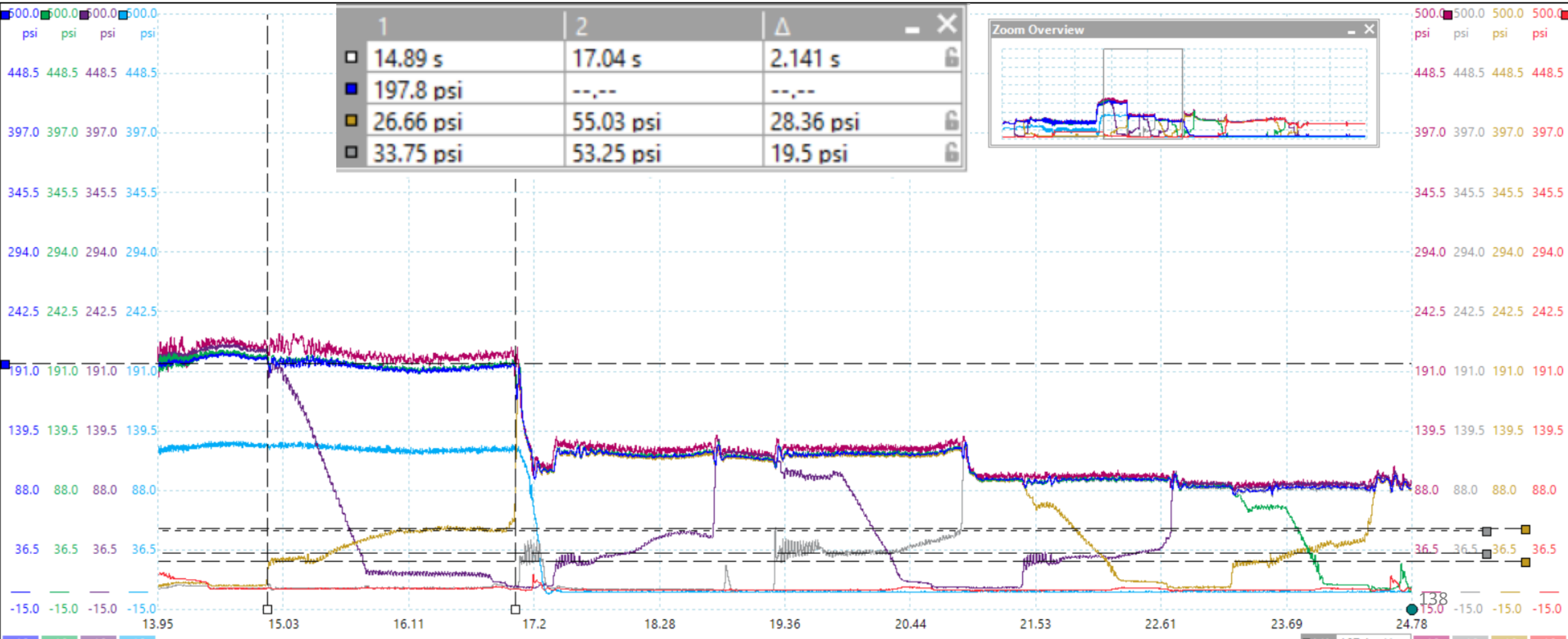


10L HP Tuner – Torque Management



Tuning – what changes?
Disable torque management

Note: this was at 40% throttle because the trans was slipping



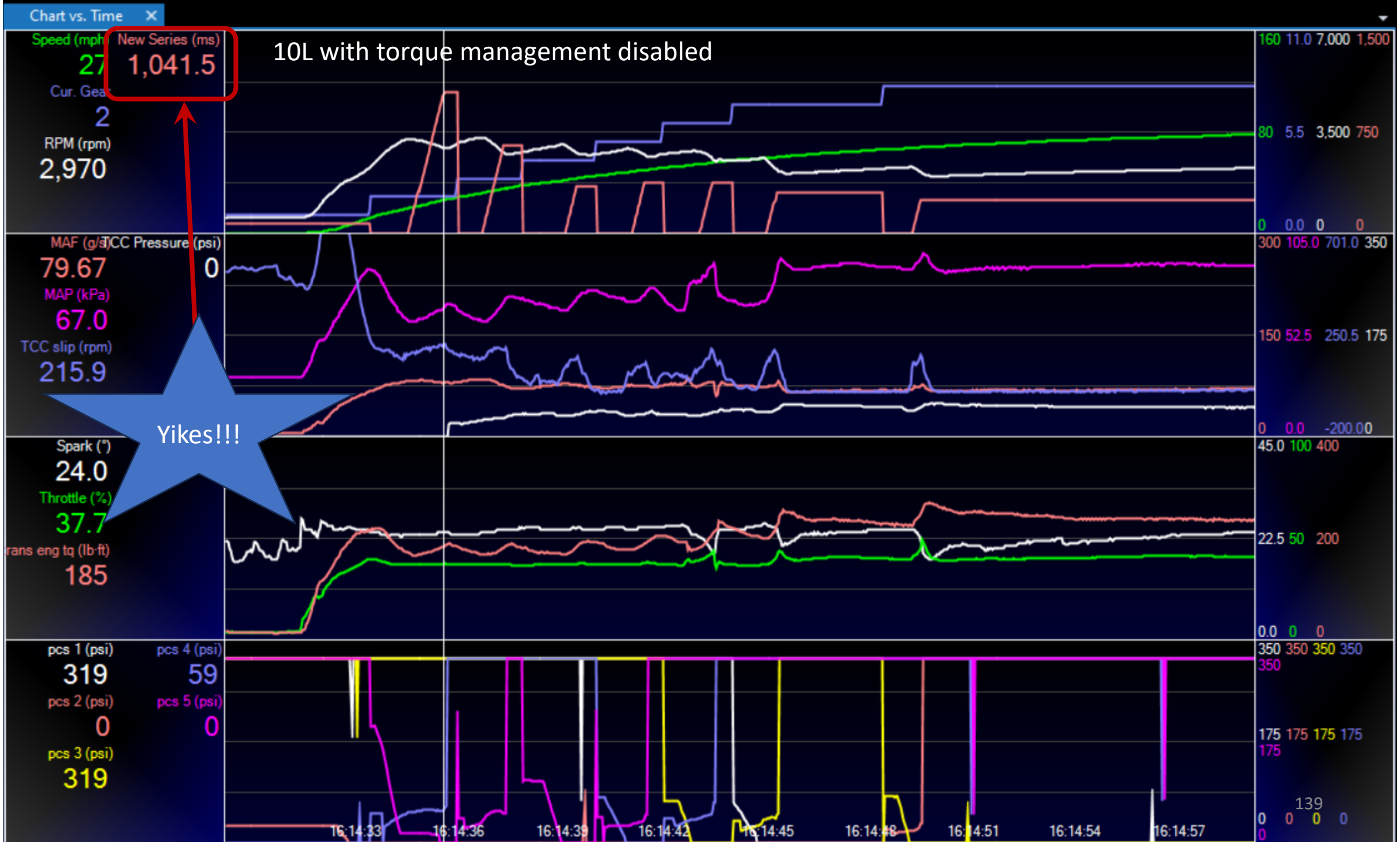
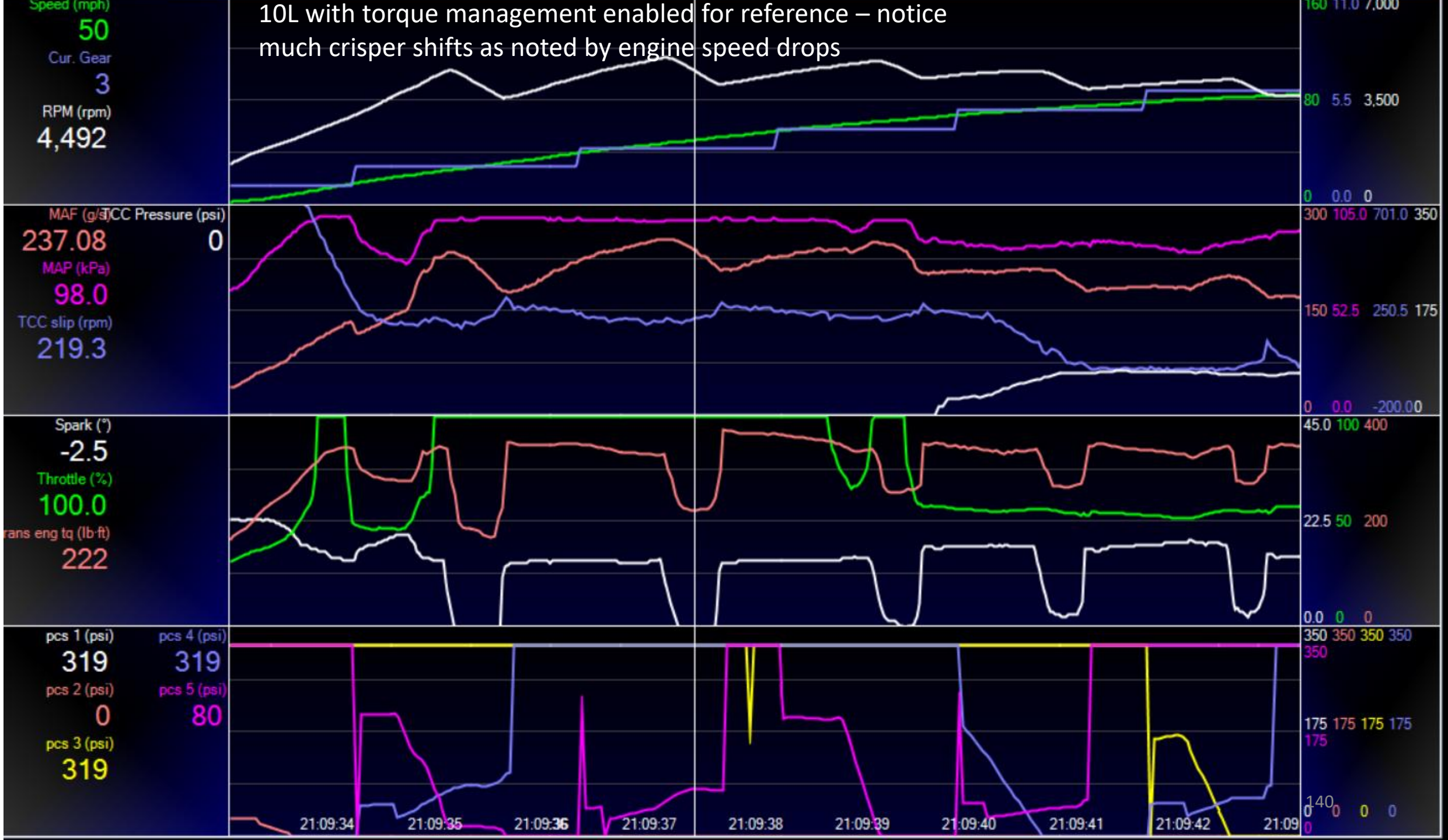


Chart vs. Time
Speed (mph)
27
New Series (ms)
1,041.5
10L with torque management disabled
Cur. Gear
2
RPM (rpm)
2,970
160 11.0 7,000 1,500
80 5.5 3,500 750
0 0.0 0 0
MAF (g/s)
79.67
TCC Pressure (psi)
0
MAP (kPa)
67.0
TCC slip (rpm)
215.9
300 105.0 701.0 350
150 52.5 250.5 175
0 0.0 -200.00
Yikes!!!
Spark (°)
24.0
Throttle (%)
37.7
Trans eng tq (lb·ft)
185
45.0 100 400
22.5 50 200
0.0 0 0
pcs 1 (psi)
319
pcs 4 (psi)
59
pcs 2 (psi)
0
pcs 5 (psi)
0
pcs 3 (psi)
319
350 350 350 350
350
175 175 175 175
175
0 0 0 0
0
16:14:33
16:14:36
16:14:39
16:14:42
16:14:45
16:14:48
16:14:51
16:14:54
16:14:57


10L with torque management enabled for reference – notice much crisper shifts as noted by engine speed drops
Speed (mph)
50
Cur. Gear
3
RPM (rpm)
4,492
MAF (g/s)
237.08
TCC Pressure (psi)
0
MAP (kPa)
98.0
TCC slip (rpm)
219.3
Spark (°)
-2.5
Throttle (%)
100.0
rans eng tq (lb·ft)
222
pcs 1 (psi)
319
pcs 4 (psi)
319
pcs 2 (psi)
0
pcs 5 (psi)
80
pcs 3 (psi)
319
21:09:34
21:09:35
21:09:36
21:09:37
21:09:38
21:09:39
21:09:40
21:09:41
21:09:42
21:09

Conclusion

- Impressive how the electronics have such an influence over the shift quality and durability of a modern transmission.
  - ECM inputs to provide information to a transmission control module
  - TCM uses that information to control clutch pressures, timing, and line pressure
  - Offgoing clutch is controlled precisely through PWM solenoid control pressure to a clutch regulator valve, which controls pressure to the clutches
  - Oncoming clutch is controlled precisely through a TCM controlling a solenoid, which controls pressure to a clutch regulator valve, which controls the pressure in the clutches
  - These all have to work consistently through various temperatures and adapt for wear over time
  - Output shaft RPM raises line pressure for some gears – Follows MAF?
  - Shift hunting in higher gears – maybe drivability symptoms?

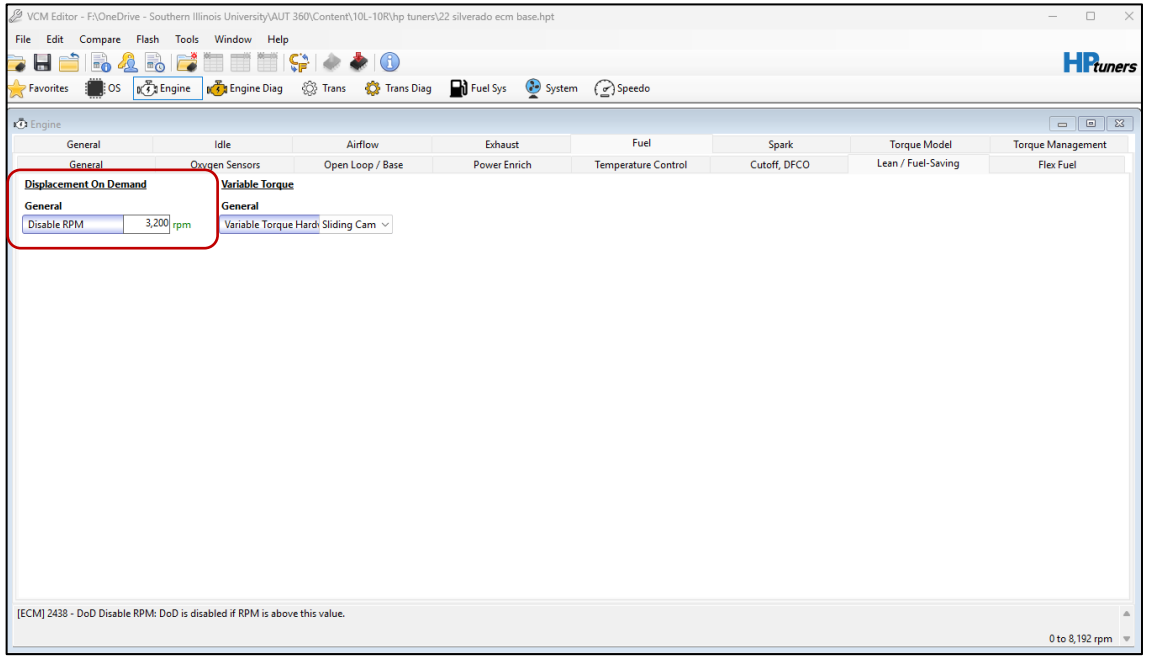

HP Tuning
GM 6L
RPM
x1000
BRAKE
Transmission Fluid
226°F
16599mi
PRNDM
MPH
ABS

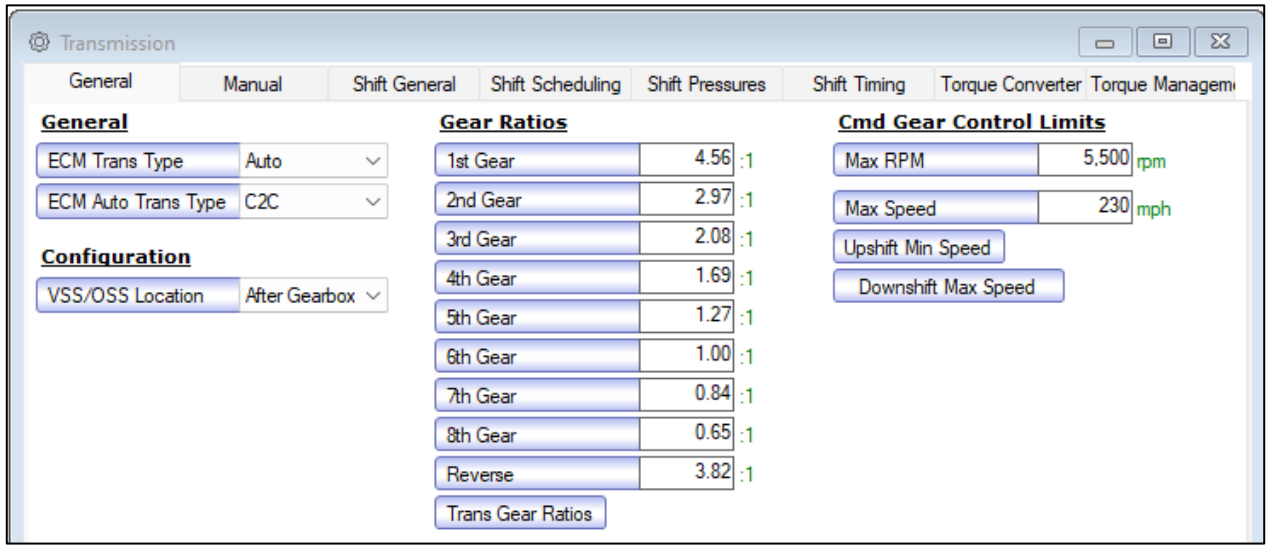
Transmission Tuning

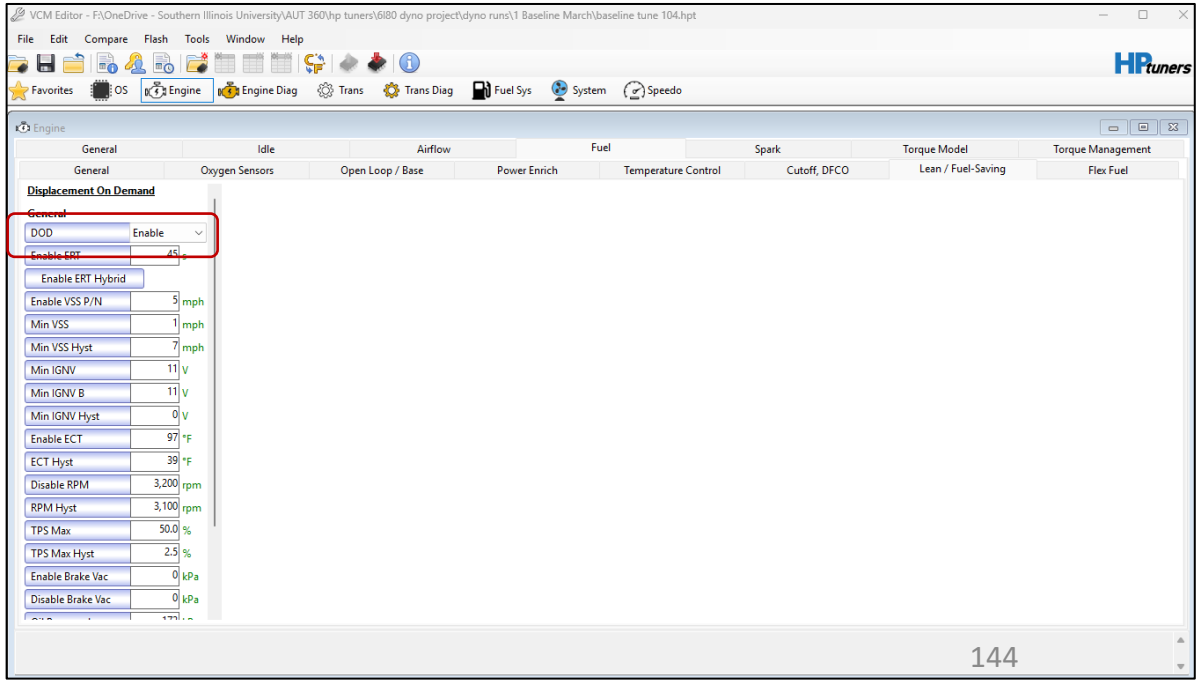
- Best practices
  - Match transmission performance to engine performance
  - Durability vs. Performance
  - Know what changes what?
  - Know what normal is before changing anything
  - Understand what scan data is showing you
    - Command vs. Actual
- Worst Practices
  - Not having a plan!
  - Assume tables change operation without verifying
  - Remove torque management without proper mechanical modifications
  - Assume that scan data values are actual values (clutch pressures)

HP tuners – 6L

- Many techs modify the TCC application and disable Active and Dynamic Fuel Management (displacement on demand)
- The following slides cover modifications that can be performed using tuning software such as HPTuners
- Experiment at your own risk

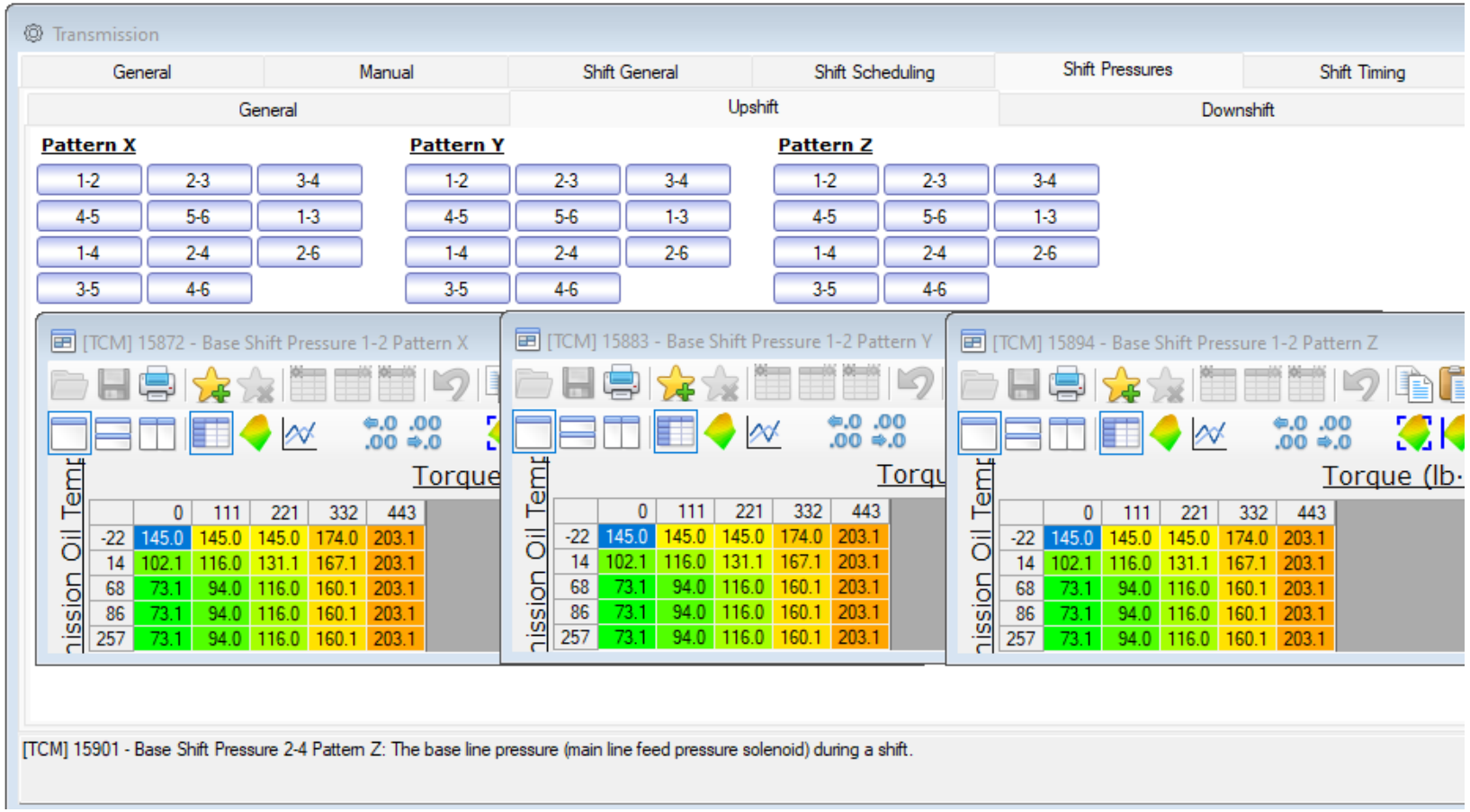




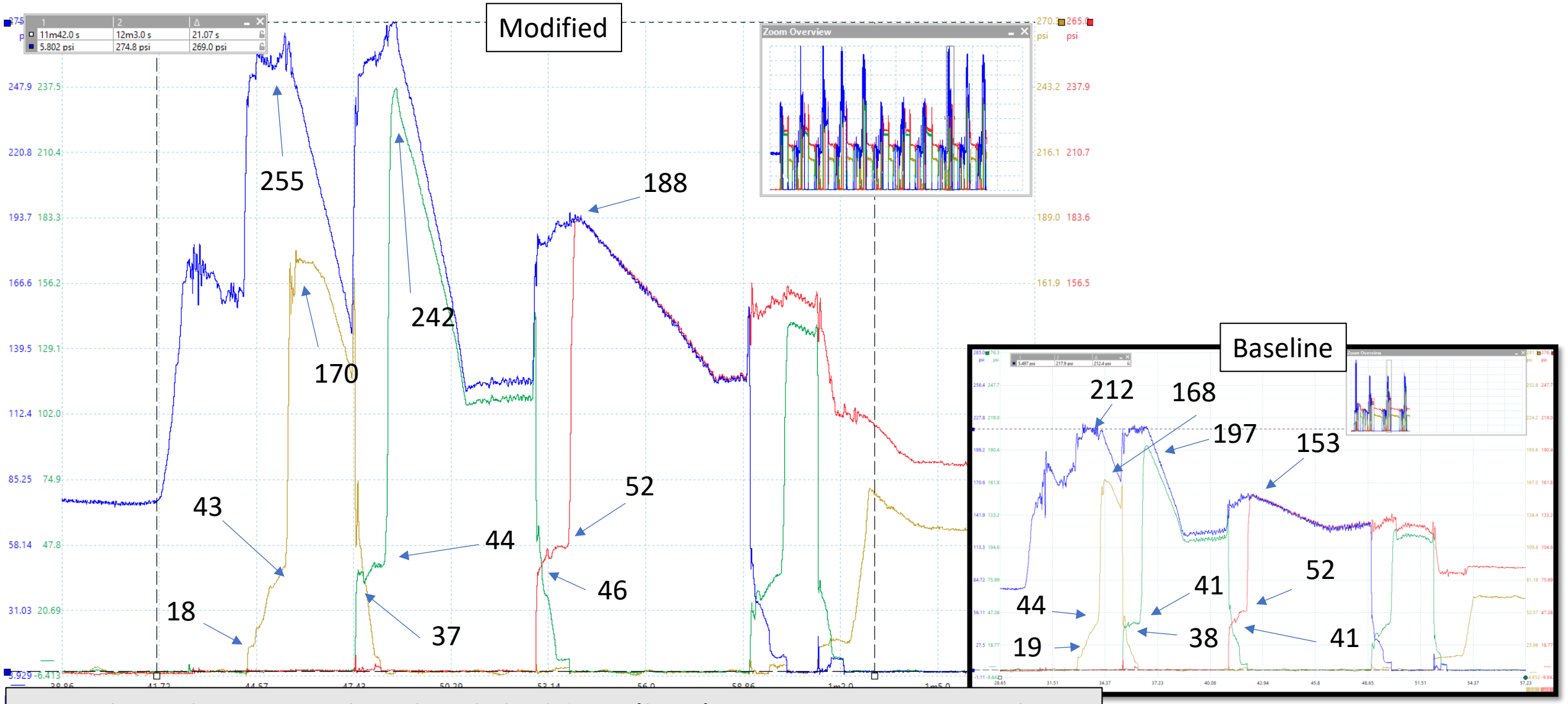


HP tuners

- Modifications that make a **significant** change
  - Shift Pressure XYZ
  - Torque Adder
  - Transition Time
  - TCC Ramp, Gain, Offset IF modifications were made

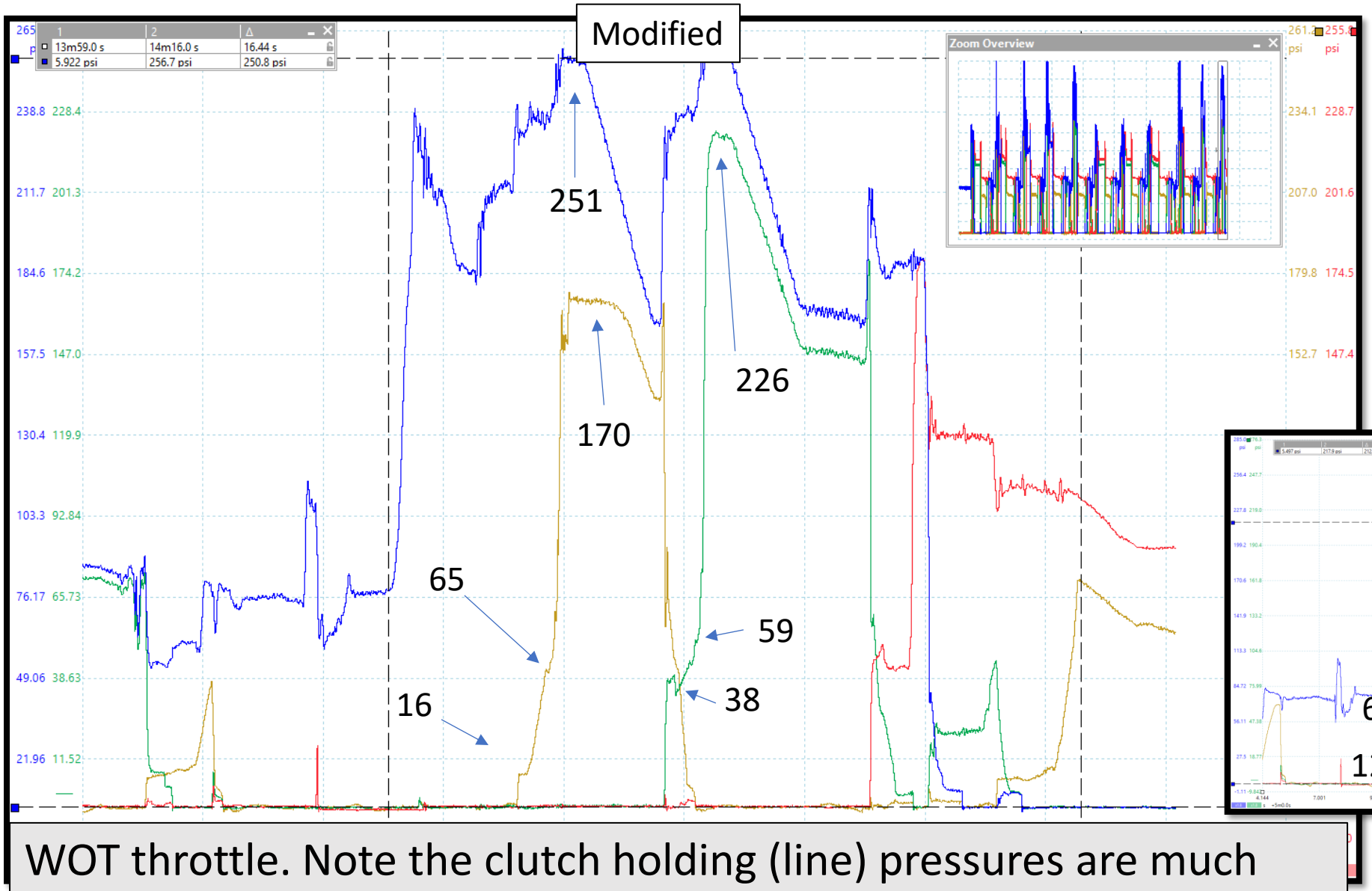


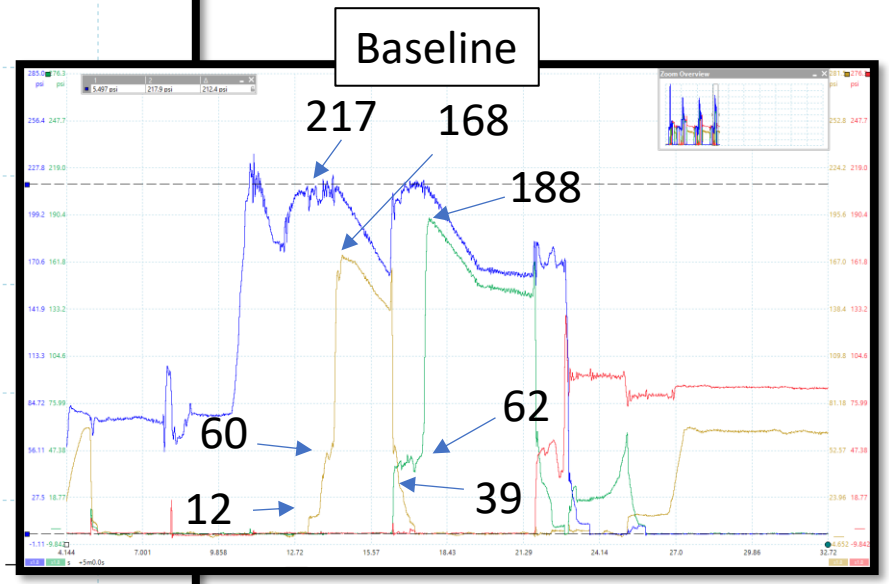
HP tuners: Increase shift pressure X,Y,Z 30%



40% throttle. Note the clutch <u>holding</u> (line) pressures are much higher, but the fill, torque, and inertia pressures don't alter much

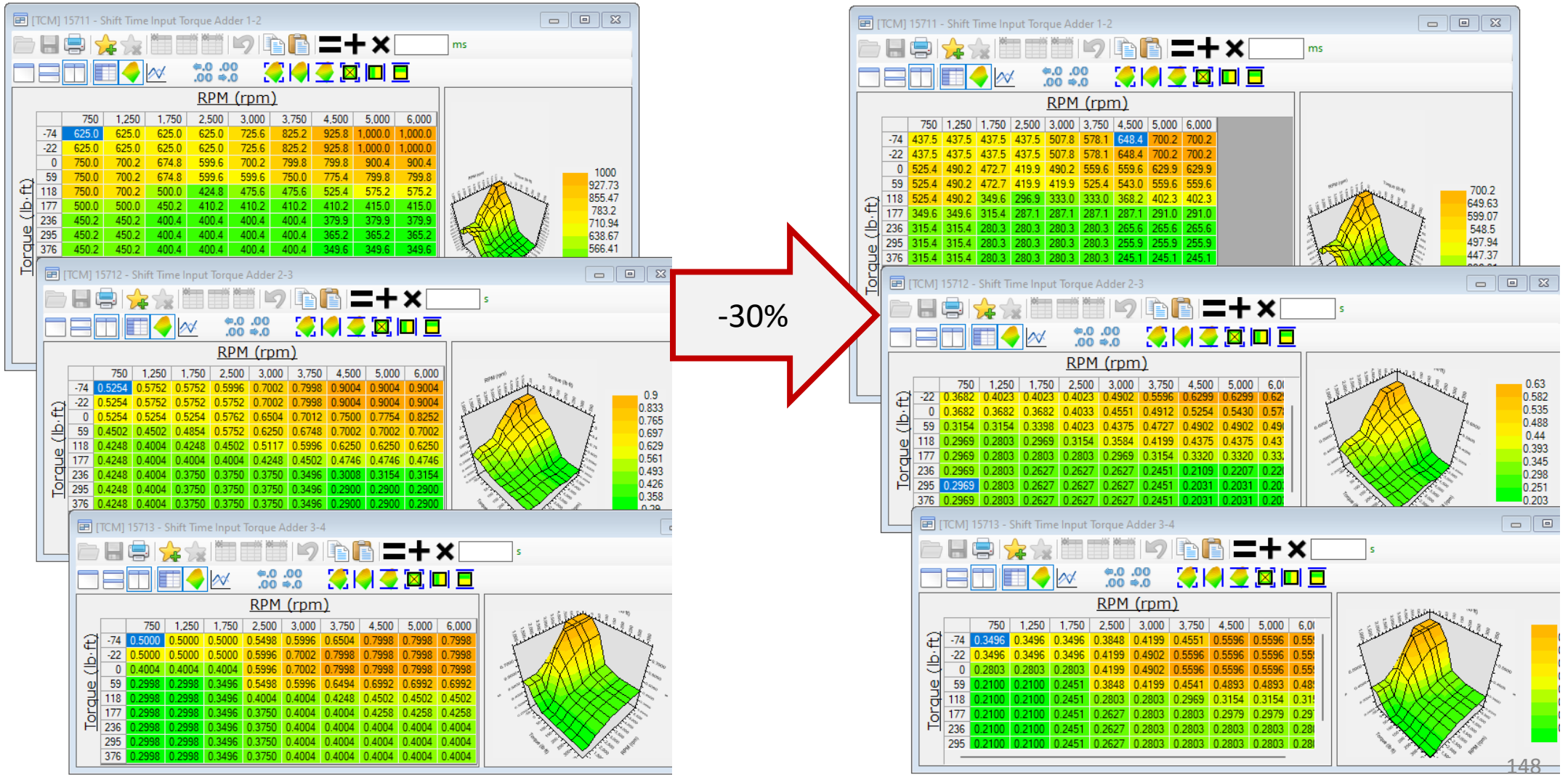
HP tuners: Increase shift pressure X,Y,Z 30%



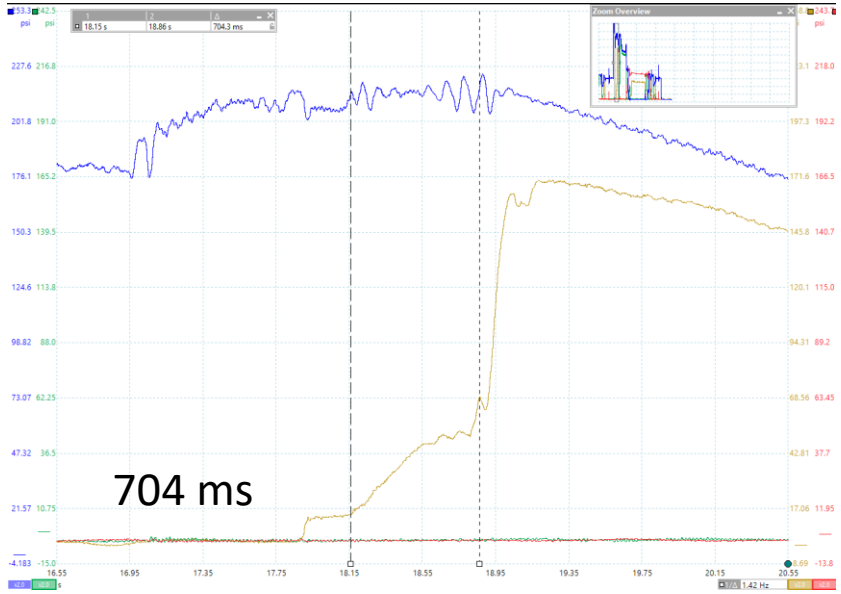


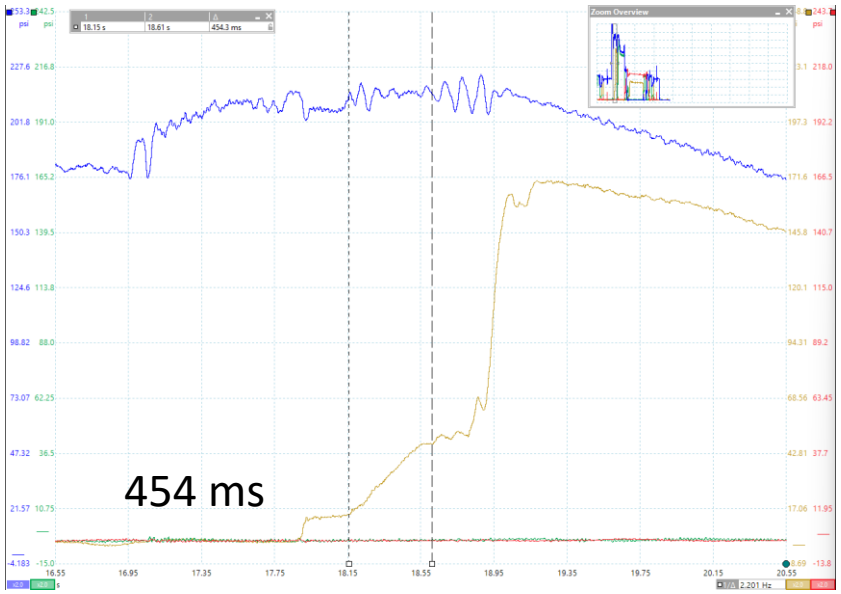
WOT throttle. Note the clutch holding (line) pressures are much higher, but the fill, torque, and inertia pressures don't alter much

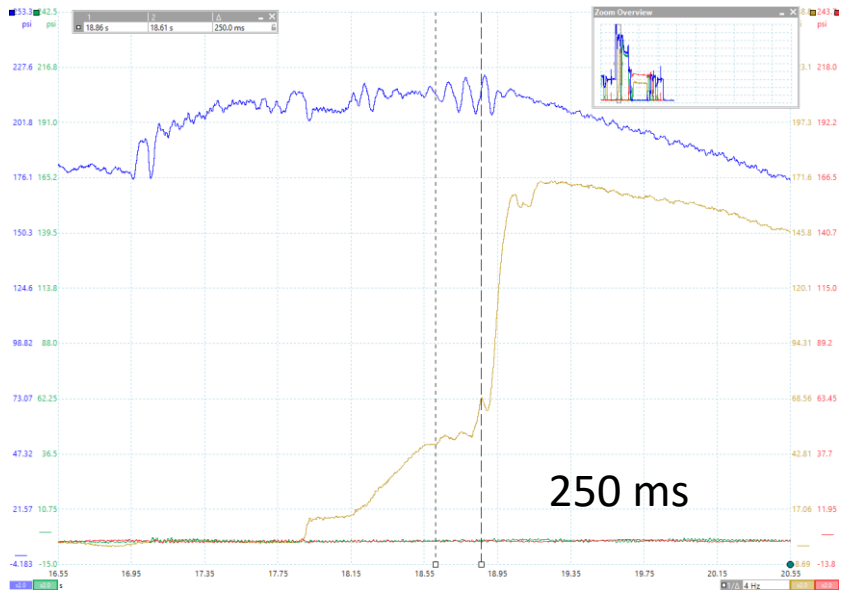
HP tuners – Torque Adder

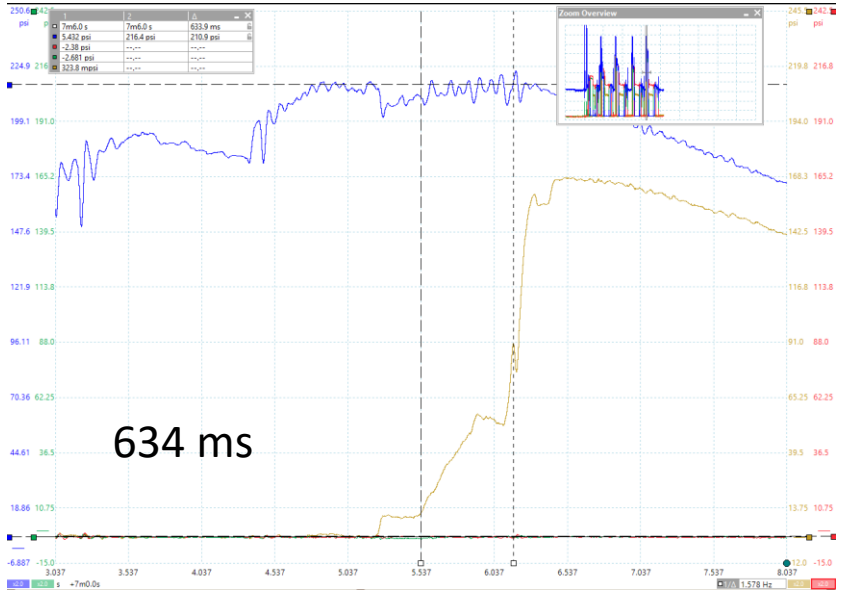


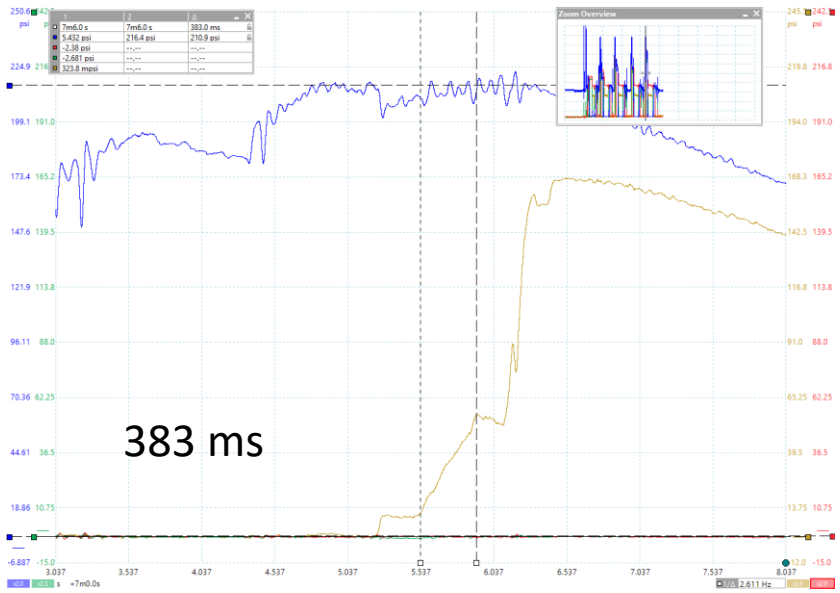
Decrease torque adder 30% - Baseline 1-2 vs Mod 1-2 shift

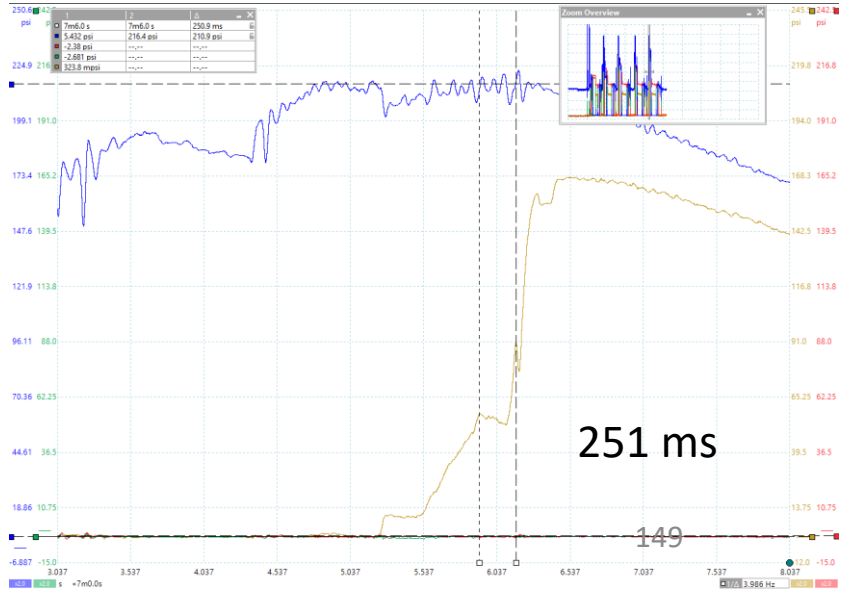




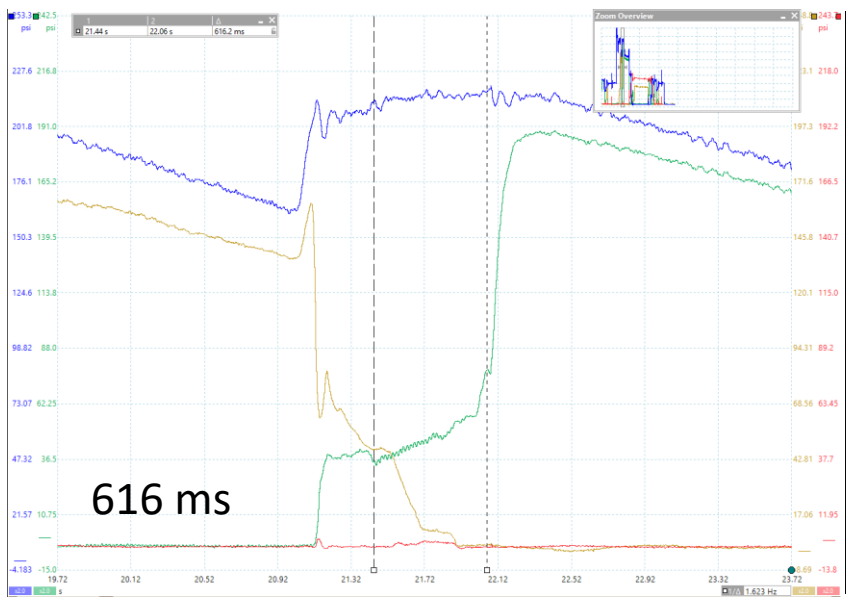


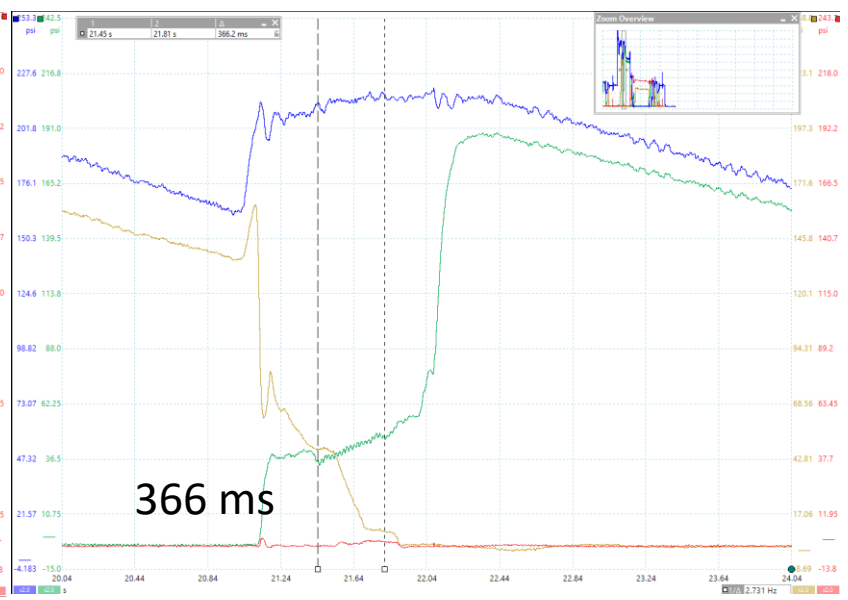


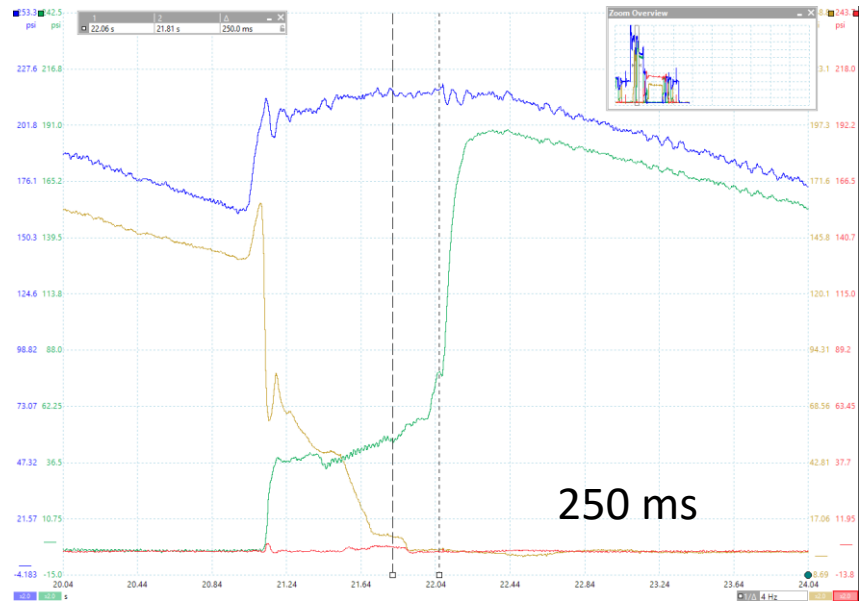


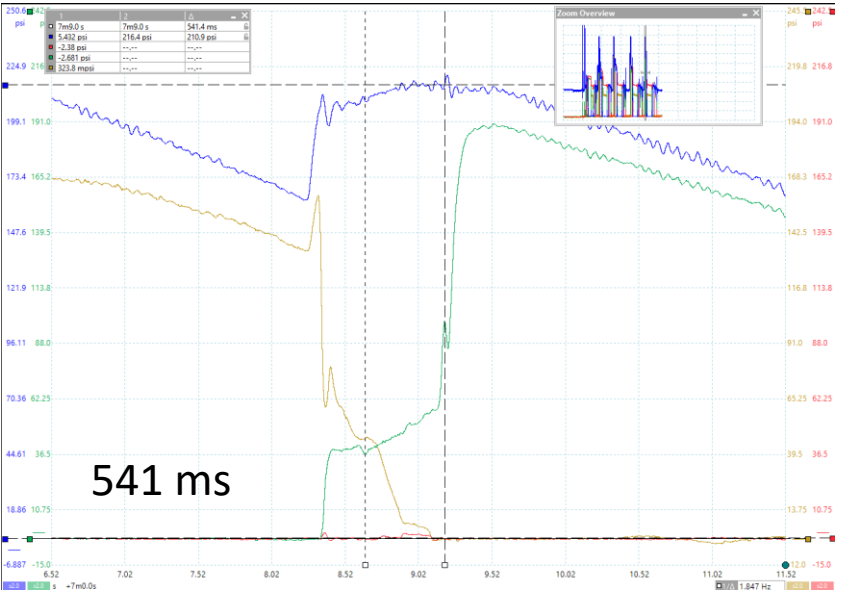


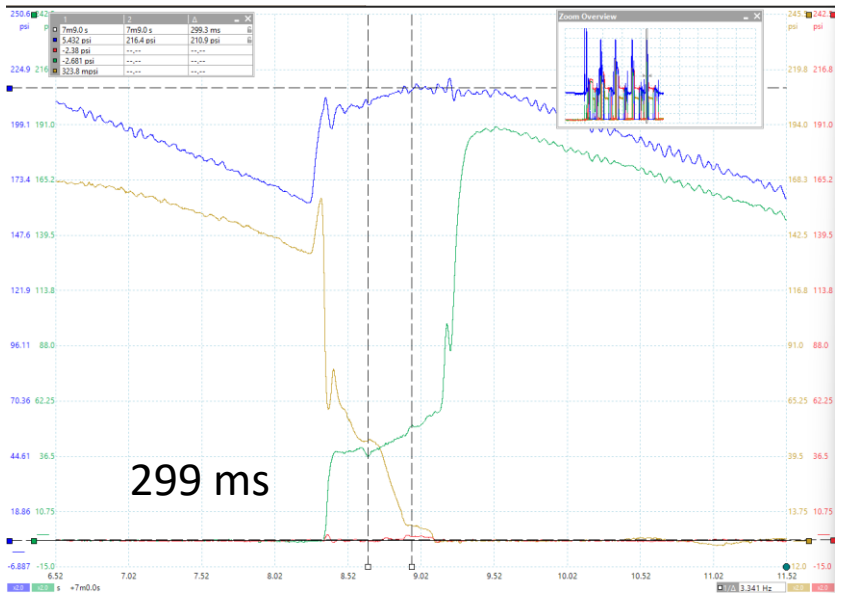
Decrease torque adder 30% at WOT throttle Baseline 2-3 vs Mod 2-3 shift

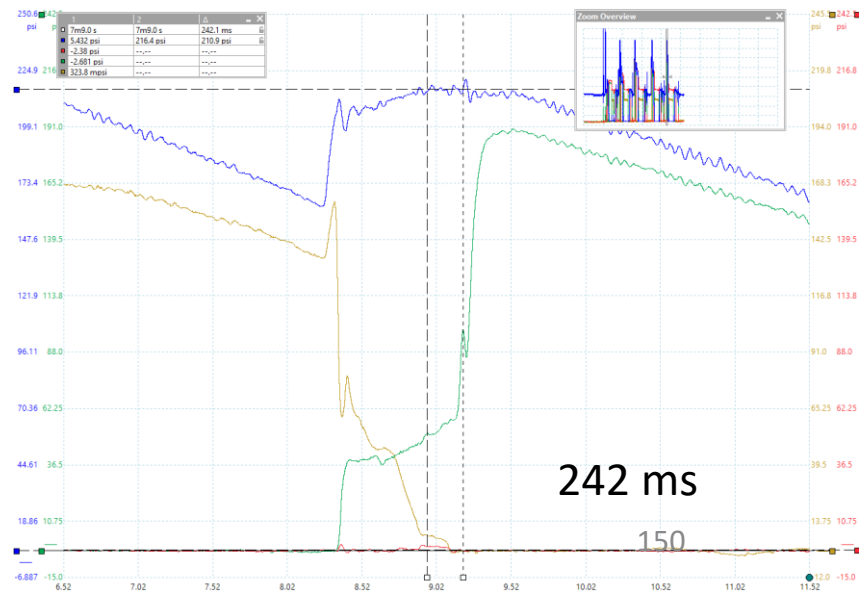






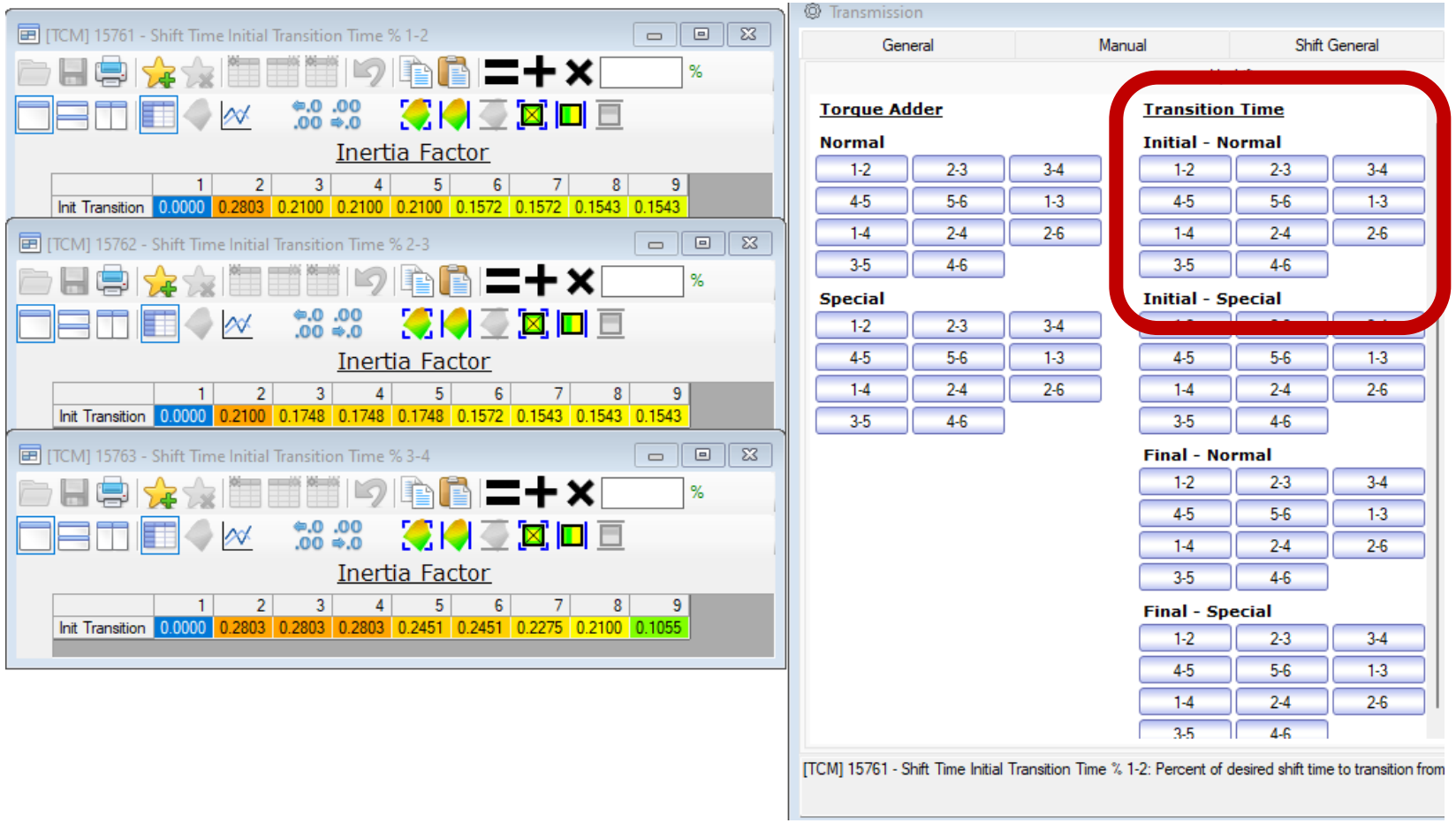






Decrease transition time 30%

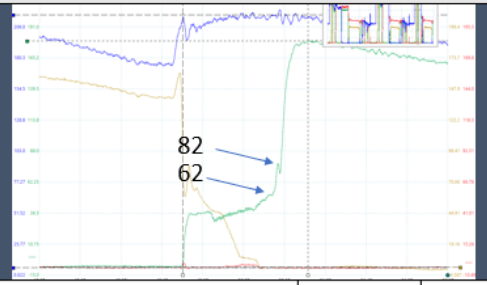
- What is “Transition Time?”
  - Decreasing this value changes the “inertia” time
  - This also changes the total solenoid time
  - Shift pressures mostly remain the same

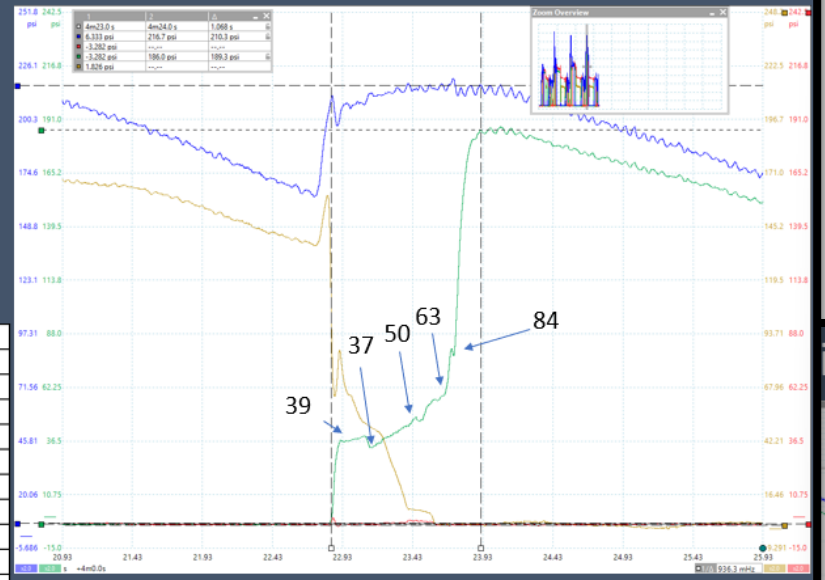


Decrease transition time 30%

Decrease upshift transition time 30% at WOT- Last 2-3 shift

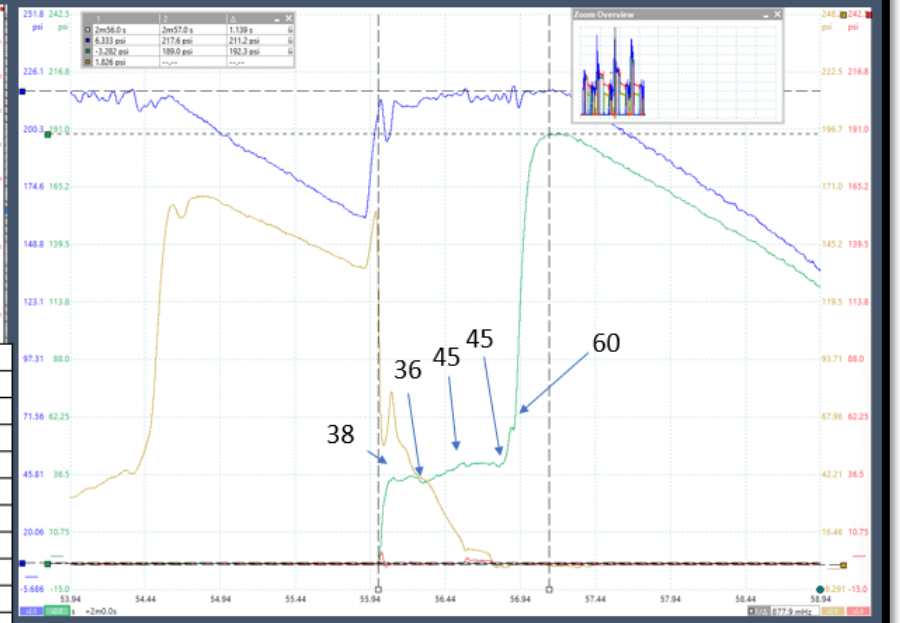
ALT BASELINE DUE TO THROTTLE MANAGEMENT





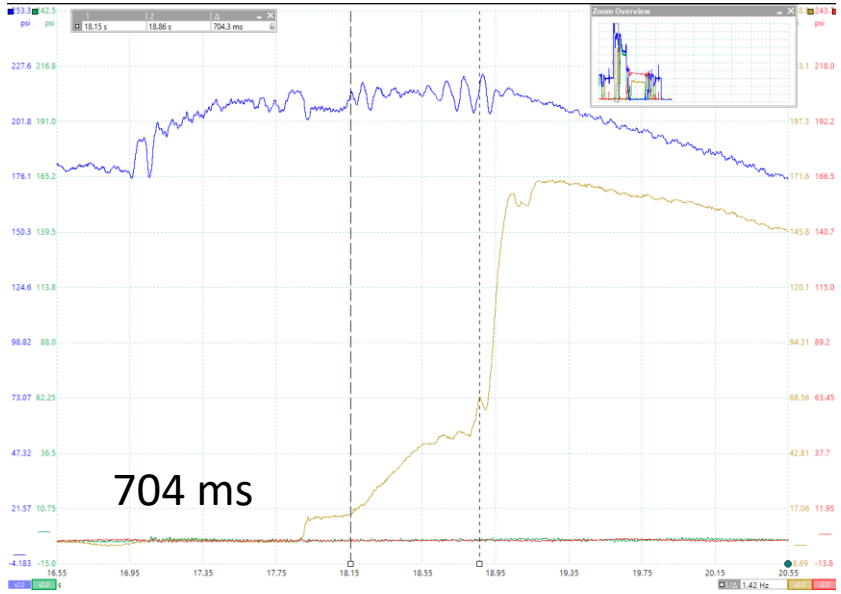
2-3 shift - Transition Time Mod	ALT Baseline	Modified
Line pressure	210 psi	210 psi
35R clutch press change	1.23 sec	1.07 sec
35R max pressure	188 psi	189 psi
Fill		
• 35R pressure change time	313 ms	282 ms
• 35R fill pressure	44 - 45 psi	39-42 psi
• 35R fill pressure change	1 psi	3 psi
Torque and Inertia phase		
• 35R pressure change time	618 ms	349/183 ms
• 35R inertia pressure	39 – 62 psi	37-50-63 psi
• 35R inertia pressure change	23 psi	26 psi
Final phase		
• 35R pressure change time	285 ms	256 ms
• 35R final pressure	78 – 188 psi	63 – 189 psi
• 35R final pressure change	110 psi	126 psi

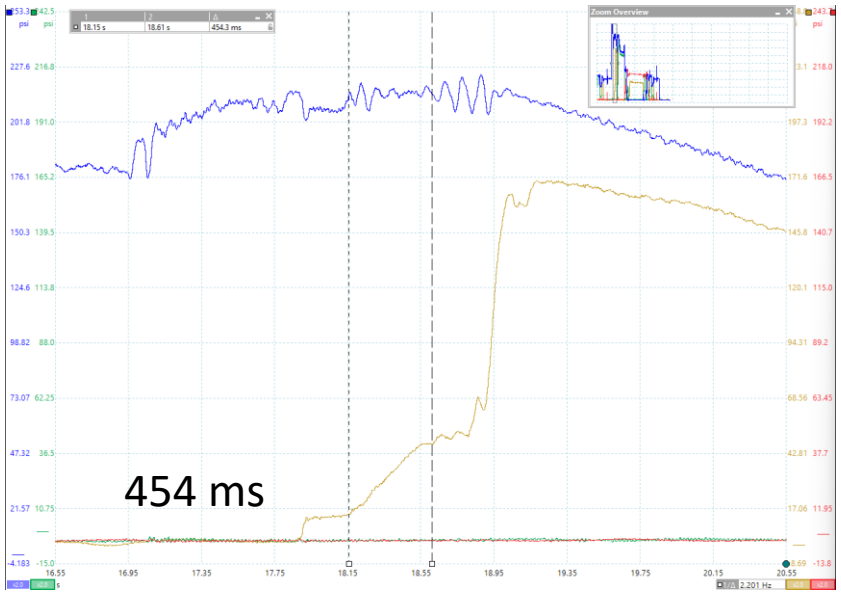
ion time 30% at 40% -last 2-3 shift

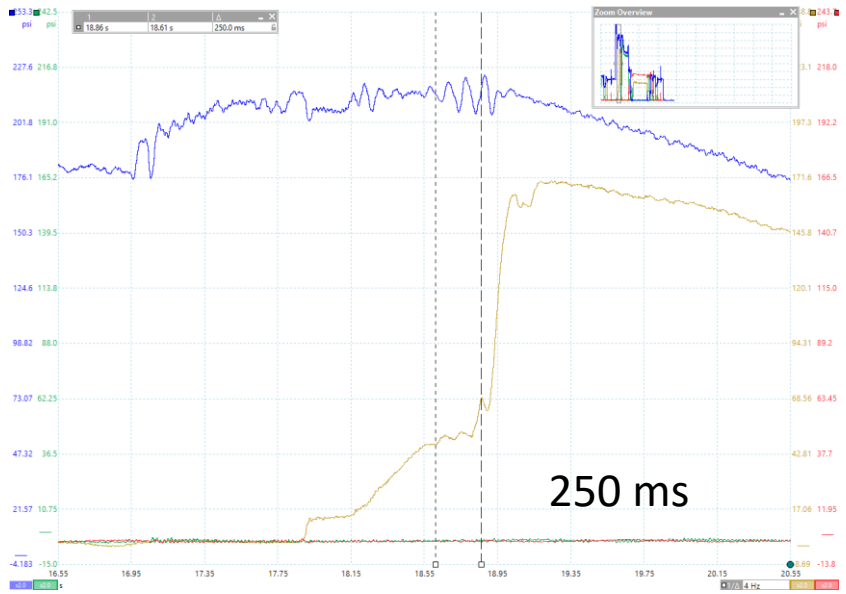


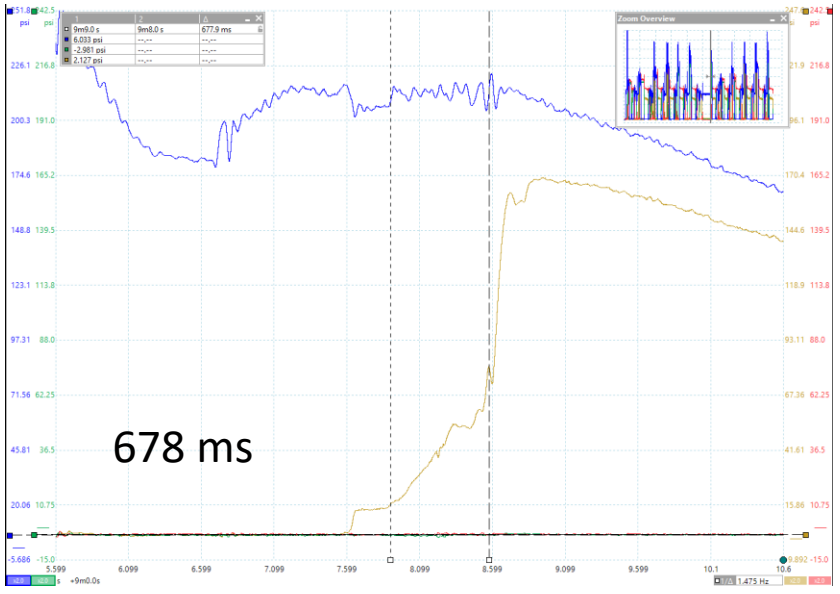
2-3 shift - Transition Time Mod	Baseline	Modified
Line pressure	212 psi	211 psi
35R clutch press change	1.28 sec	1.14 sec
35R max pressure	197 psi	192 psi
Fill		
• 35R pressure change time	334 ms	305 ms
• 35R fill pressure	37 - 41 psi	38 psi
• 35R fill pressure change	4 psi	0 psi
Torque and Inertia phase		
• 35R pressure change time	598 ms	285/250 ms
• 35R inertia pressure	38 – 41 psi	36-45-45 psi
• 35R inertia pressure change	3 psi	9 psi
Final phase		
• 35R pressure change time	306 ms	312 ms
• 35R final pressure	41 – 197 psi	45 – 192 psi
• 35R final pressure change	156 psi	147 psi

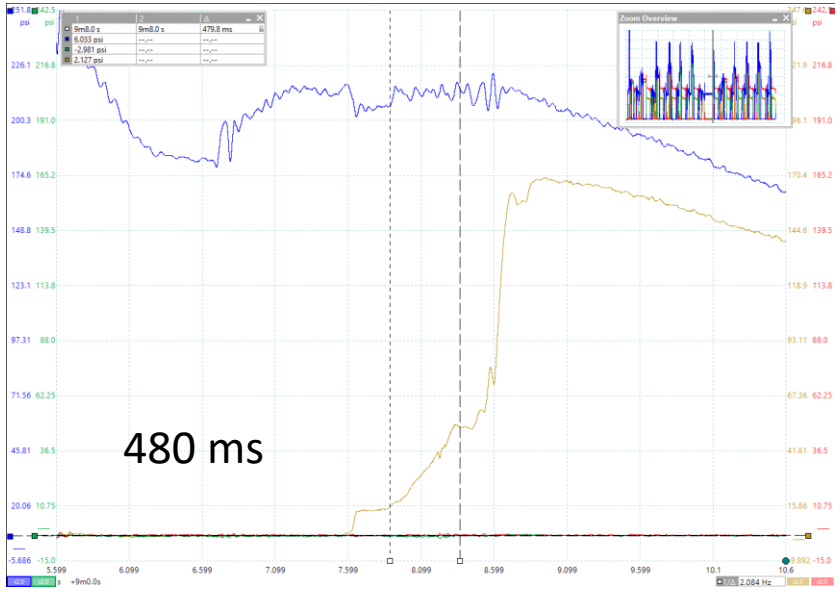
Decrease transition time 30% WOT throttle Baseline 1-2 vs Mod 1-2 shift

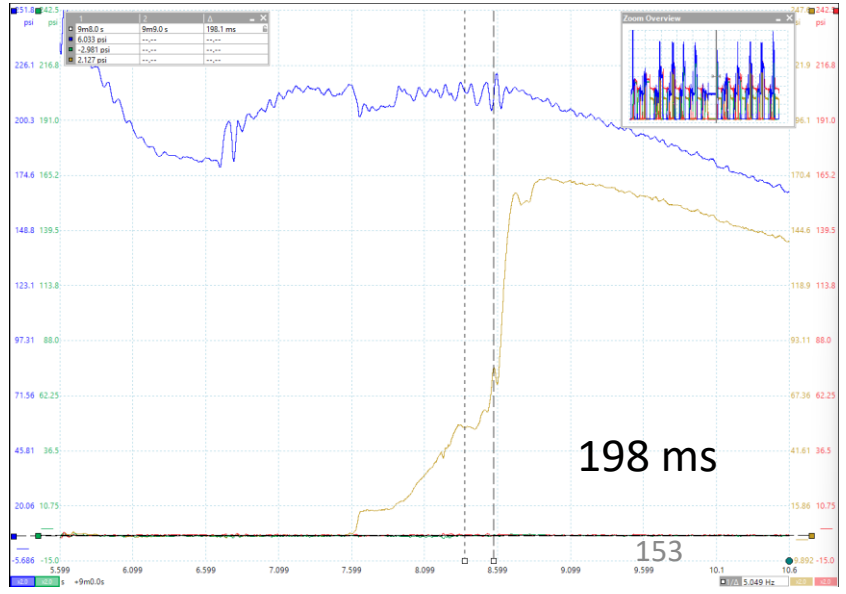












Decrease transition time 30% WOT throttle Baseline 2-3 vs Mod 2-3 shift