TUNING THE F7 FUEL CURVE FOR MAXIMUM OUTPUT
Jim Czekala

Scott Norine (aka predator711 on the internet and formerly of WI, MI and now CT) has been to our dyno several times in the past, and has always used our fuel flow numbers and power peak RPM direct from the dyno and those published in DynoTech as gospel for dialing in his and his pals' performance sleds.

So when I asked him to volunteer his new '04 F7 EFI on his way home from a 1000-mile week of riding in N. WI, he was eager to oblige. Scott was anxious to see how the '03 and '04 ECU's he had with him compared on the same F7, same day. He had switched back and forth while trail riding/ lake racing and he felt that the '03 ECU was better performing for his driving style, but maybe a bit harsh as it "hit very hard" when the exhaust valves opened, and pulled a few more revs during acceleration and top end runs. The '04 box, on the other hand seemed richer, less crisp, and more gradual building HP when the valves open. Here is Scott's sled, dyno'd in cold weather with both ECU's. Note that the earlier calibration had leaner midrange fuel flow, resulting in hotter pipe center section temperature during our acceleration dyno tests.

Stock 2004 F7 EFI, stock '04 ECU

EngSpd	STPTrq	STPPwr	BSFC	Fuel B	A/F	Air 2	FUEL P	AirTmp
RPM	Clb-ft	CHp	lb/hph	lb/hr	Ratio	scfm	psig	degF
5400	64.2	66.1	0.86	56.9	12.3	153	xxxxxxxxxx	25
5500	65.1	68.2	0.82	56.3	12.6	155		24
5600	66.2	70.6	0.79	55.9	12.9	157		24
5700	68.2	74.1	0.75	55.6	13.1	160		24
5800	70.8	78.2	0.72	56.7	13.1	163		24
5900	74.2	83.3	0.73	61.2	12.6	169		24
6000	74.4	85.1	0.73	62.7	12.5	171		24
6100	76.2	88.5	0.72	64.1	12.3	173		24
6200	77.2	91.2	0.71	64.8	12.4	176		24
6300	77.5	93.2	0.71	65.8	12.4	178		24
6400	78.2	95.3	0.71	66.9	12.4	181		24
6500	79.2	98.1	0.69	68.1	12.4	184		24
6600	83.3	104.7	0.66	69.9	12.7	193		24
6700	82.6	105.4	0.67	70.6	12.7	196		24
6800	84.8	109.8	0.68	74.5	12.4	202		25
6900	85.6	112.4	0.66	74.1	12.7	206		25
7000	86.3	115.1	0.65	74.9	12.9	211		25
7100	88.6	119.7	0.64	77.5	12.8	217		25
7200	90.7	124.3	0.69	86.1	11.9	223		25
7300	92.3	128.2	0.78	100.4	10.8	237		25
7400	92.4	130.2	0.81	106.1	10.6	246		24
7500	92.8	132.6	0.81	108.6	10.6	252		23
7600	92.1	133.3	0.84	112.4	10.5	257		24
7700	88.9	130.3	0.87	114.6	10.3	259		25

7800	86.4	128.3	0.88	113.7	10.4	259	25
7900	84.1	126.3	0.91	115.3	10.4	261	25
8000	81.2	123.7	0.91	113.7	10.6	263	25
8100	79.1	122.1	0.91	110.5	11.1	266	25
8200	65.2	101.4	1.03	105.1	11.4	261	26

2004 F7 EFI, '03 ECU

EngSpd	STPTrq	STPPwr	BSFC	Fuel B	A/F	Air 2	AirTmp
RPM	Clb-ft	CHp	lb/hph	lb/hr	Ratio	scfm	degF
5500	66.2	69.4	0.79	55.1	12.8	154	28
5600	67.2	71.7	0.76	54.8	13.1	155	28
5700	68.5	74.4	0.76	56.3	12.8	158	28
5800	70.8	78.2	0.73	57.5	12.8	161	28
5900	72.3	81.2	0.71	58.1	13.2	165	28
6000	73.1	83.4	0.71	58.8	13.1	167	27
6100	75.3	87.5	0.71	61.1	12.7	170	28
6200	76.9	90.8	0.71	64.4	12.3	174	29
6300	77.2	92.6	0.72	65.2	12.2	174	29
6400	77.6	94.6	0.71	66.1	12.3	178	29
6500	79.7	98.6	0.68	66.8	12.4	180	29
6600	83.1	104.3	0.66	69.2	12.5	188	28
6700	83.2	105.9	0.65	69.3	12.7	193	27
6800	83.7	108.4	0.64	69.2	13.1	197	27
6900	85.7	112.6	0.62	69.8	13.4	204	28
7000	85.9	114.5	0.61	69.9	13.6	207	28
7100	87.2	117.9	0.61	70.6	13.8	213	28
7200	87.4	119.8	0.59	71.1	13.8	214	28
7300	91.8	127.6	0.75	95.7	11.1	232	28
7400	93.1	131.1	0.81	105.1	10.6	242	28
7500	93.6	133.6	0.81	106.9	10.7	249	28
7600	90.8	131.4	0.85	112.1	10.4	256	28
7700	88.5	129.7	0.89	115.1	10.2	257	28
7800	85.7	127.3	0.92	115.3	10.3	258	28
7900	81.1	121.8	0.95	116.4	10.3	261	27
8000	77.5	118.1	0.97	114.5	10.5	263	27

We've had lots of experience mechanically altering fuel flow on turbocharged EFI Harley V-twins to provide added fuel flow necessary to support double the stock HP. 4-strokes are easy to calibrate for high performance—usually if you err on the lean side, pipes get red, and the engines may annoy you with deto-induced rattling until fuel flow is corrected. No harm, no foul. But, 2-strokes are much less forgiving for fuel management goofs, and can seize almost instantly if silent detonation results from even momentary lapses in tuning on the lean side. Messing with fuel flow on a 2-stroke really needs full instrumentation to be done safely. Torque, fuel flow, A/F ratio, coolant temp and BSFC should be monitored constantly as the desired tuning is achieved. It takes several people in the dyno room to do it correctly; each is assigned the task of monitoring specific

gauges as testing proceeds. Even though dyno digital gauges are programmed to blink red when desired limits are exceeded, there is just too much going on for one person to manage correctly.

I've followed most of the currently available F7 EFI fuel management mods, and do-it-yourself seat of the pants field-tweaking is difficult and hazardous, and many who are trying this will tell me, privately, of frustration that I understand first hand. My first experience calibrating an EFI 2-stroke was with Ron Chastine at Injection Research Services. I watched with wet armpits as my engine howled for hours on their dyno, as Ron and his crew used over 50 gallons of 100LL av gas, creating a spark/ fuel map for my Yamaha engine that ultimately would need further adjustment in the field. You can bet that the Cat engineers used 1000('s?) gallons of fuel creating the maps for the F7 Firecats. Starting with a blank chip in an ECU is a daunting prospect for anyone, so it seems like a wise idea to stay with the factory calibration, and make only those adjustments necessary to suit your situation.

In Scott's case, he desired less top end fuel and maybe just a bit less in the midrange with his '04 ECU. His first 1000 miles was all with 87 octane, and he would gladly spend a little extra for premium if we could get him down to .70 lb/hphr. .70 has, in the past been fine for his various performance sleds.

We decided to mechanically alter the fuel curve to try to combine the stock '03 ECU's excellent drivability with leaned out top end fuel flow to see how things would be at .70 lb/hphr or thereabouts. Scott knew that Bill DiFranco has run all winter on pump gas with his "1000 ft" ECU, so was willing to try that if we could just get rid of some top end fuel flow. Our experience with fuel pressure regulators on Harleys and other EFI things would pay off here. The idea would be to drop fuel pressure at high revs and leave it alone in the midrange. Our dyno measures and records fuel pressure in *1/10th psi increments* which is absolutely necessary to do this with any sort of accuracy. This sort of tuning can be likened to drive clutch adjustments, with different spring pressures and rates, fancy helix' and weights measured in 10ths of a gram. Good clutch tuners can create whatever RPM rise is necessary to match the gradually climbing HP peak RPM as pipe heat climbs. But we also know that the clutch setup that works flawlessly on one machine may be only a decent starting point on another identical sled. We plan to try the same fuel calibration on Bill DiFranco's F7 who, though pleased with the top end power of his 1000' ECU, is not happy with fuel mileage or trail manners (remember Bill's is a factory race box). But will Bill's stock fuel pump deliver identical stock pressure as Scott's? If he has one less PSI to begin with, will Scott's fuel system mods give Bill one psi less at peak (that could be very bad)? The following series of dyno tests is a compilation of the results of 25 or more dyno runs on Scott's F7 w/ '04 ECU, making the most minute fuel pressure adjustments on each dyno run to home in on the desired results. Note also that fuel flow is slightly diminished in midrange full throttle (we'll try part throttle testing with Bill's sled). Note fuel delivery and A/F ratio changes, and shifting of HP curve to higher revs, and improvement in overrev HP. *Caution- do not try this at home without a fully instrumented dyno!*

TESTS of 2004 F7 EFI with reduced top end fuel flow

2004 F7 EFI, '04 ECU, reduced top end fuel flow

EngSpd RPM	STPTrq Clb-ft	STPPwr CHp	BSFC lb/hph	Fuel B lb/hr	A/F Ratio	Air 2 scfm		AirTmp degF
6000	78.9	90.1	0.73	65.6	12.3	176		35
6100	78.8	91.6	0.71	64.3	12.5	176		36
6200	79.6	93.9	0.71	66.2	12.3	177		35
6300	80.7	96.8	0.71	67.5	12.2	180		36
6400	81.4	99.2	0.69	68.3	12.2	182		35
6500	82.1	101.5	0.68	68.4	12.3	184		35
6600	84.1	105.6	0.66	69.1	12.5	189		35
6700	86.1	109.8	0.66	71.8	12.5	197		35
6800	86.6	112.1	0.64	71.2	12.9	202		35
6900	88.2	115.9	0.63	72.8	12.9	206		35
7000	89.1	118.8	0.63	74.3	13.2	214		34
7100	89.3	120.7	0.63	76.4	13.1	218		34
7200	90.8	124.5	0.65	80.8	12.6	222		35
7300	93.8	130.4	0.73	94.2	11.6	240		35
7400	94.7	133.5	0.74	97.6	11.5	246		36
7500	94.3	134.7	0.76	101.4	11.2	249		36
7600	94.6	136.9	0.78	106.7	10.9	256		35
7700	92.1	135.1	0.81	108.2	10.9	258		35
7800	89.2	132.5	0.84	110.3	10.8	260		35
7900	85.9	129.2	0.87	111.9	10.7	261		36
8000	82.2	125.2	0.88	109.2	11.1	264		35
8100	74.6	115.1	0.93	107.1	11.4	265		35

Stock 2004 F7, '04 ECU, reduce top end fuel flow

EngSpd RPM	STPTrq Clb-ft	STPPwr CHp	BSFC lb/hph	Fuel B lb/hr	A/F Ratio	Air 2 scfm		AirTmp degF
6000	78.1	89.2	0.71	63.9	12.6	176		29
6100	78.3	91.1	0.71	64.5	12.5	176		29
6200	79.3	93.7	0.69	64.9	12.6	179		29
6300	80.1	96.1	0.68	65.7	12.7	182		29
6400	80.3	97.9	0.69	67.7	12.5	184		29
6500	81.8	101.3	0.67	67.9	12.6	186		29
6600	83.4	104.8	0.64	67.7	12.9	191		29
6700	85.2	108.7	0.64	69.7	13.1	200		29
6800	86.3	111.8	0.63	70.2	13.3	205		29
6900	87.6	115.1	0.62	71.5	13.3	207		29
7000	89.4	119.2	0.62	73.6	13.3	214		29
7100	88.8	120.1	0.63	75.3	13.3	219		29
7200	89.4	122.6	0.62	76.2	13.3	221		29
7300	93.4	129.8	0.65	84.1	12.8	235		28
7400	95.1	133.8	0.72	96.6	11.7	248		28

7500	96.1	137.1	0.74	101.5	11.4	252	28
7600	95.1	137.4	0.77	105.7	11.2	258	28
7700	92.7	135.9	0.79	107.2	11.2	262	28
7800	90.8	134.8	0.81	108.5	11.2	266	28
7900	88.3	132.8	0.82	109.7	11.2	268	28
8000	83.8	127.7	0.84	108.3	11.4	270	28

2004 F7 EFI, '04 ECU, reduced top end fuel flow

EngSpd RPM	STPTrq Clb-ft	STPPwr CHp	BSFC lb/hph	Fuel B lb/hr	A/F Ratio	Air 2 scfm	AirTmp degF
6000	77.7	88.7	0.76	68.2	12.1	179	25
6100	78.1	90.5	0.74	67.3	12.2	179	25
6200	79.2	93.5	0.71	67.1	12.4	182	25
6300	79.9	95.9	0.69	66.8	12.7	185	25
6400	80.4	98.1	0.68	67.5	12.7	187	25
6500	81.7	101.1	0.68	69.4	12.6	191	25
6600	84.1	105.6	0.66	69.7	12.9	196	25
6700	84.6	107.9	0.65	70.7	13.1	200	25
6800	87.7	113.5	0.63	71.7	13.4	210	26
6900	87.9	115.4	0.62	72.5	13.4	213	26
7000	88.8	118.3	0.61	73.1	13.6	217	26
7100	89.6	121.1	0.62	75.6	13.5	222	26
7200	89.3	122.4	0.62	76.1	13.5	225	26
7300	90.3	125.4	0.61	77.6	13.5	228	26
7400	96.2	135.6	0.66	89.5	12.8	251	26
7500	95.5	136.4	0.71	96.1	12.2	255	26
7600	95.7	138.5	0.71	99.3	12.1	260	26
7700	94.4	138.4	0.74	102.7	11.8	264	26
7800	93.1	138.2	0.76	106.4	11.5	268	25
7900	89.9	135.2	0.78	105.5	11.7	270	26
8000	87.1	132.5	0.78	104.5	11.9	272	26
8100	81.6	125.9	0.81	102.7	12.1	272	26

2004 F7 EFI, '04 ECU, repeat prior test w/ cooler tuned pipe center section

EngSpd RPM	STPTrq Clb-ft	STPPwr CHp	BSFC lb/hph	Fuel B lb/hr	A/F Ratio	Air 2 scfm	AirTmp degF
5700	75.1	81.3	0.77	62.9	12.6	173	30
5800	75.3	83.1	0.76	63.6	12.4	173	30
5900	76.6	86.1	0.74	64.1	12.5	175	30
6000	77.7	88.8	0.73	65.3	12.4	177	30
6100	78.2	90.9	0.73	66.1	12.3	178	30
6200	79.2	93.5	0.71	66.5	12.4	180	30
6300	80.8	97.1	0.71	67.9	12.4	184	30
6400	81.8	99.7	0.69	68.6	12.4	186	29
6500	82.7	102.4	0.68	69.5	12.4	188	30
6600	84.7	106.5	0.66	70.2	12.6	194	30

6700	86.3	110.1	0.65	71.7	12.8	201	30
6800	87.8	113.7	0.63	71.5	13.3	208	30
6900	88.2	115.9	0.62	71.8	13.5	211	30
7000	89.6	119.4	0.62	74.1	13.3	215	30
7100	90.1	121.7	0.63	76.4	13.3	221	30
7200	89.6	122.8	0.62	76.6	13.4	224	30
7300	95.1	132.1	0.64	84.2	13.1	238	30
7400	95.6	134.7	0.67	89.8	12.7	248	30
7500	96.7	138.1	0.69	95.9	12.2	255	31
7600	95.9	138.8	0.73	101.8	11.6	259	31
7700	94.1	138.1	0.75	104.2	11.5	262	31
7800	91.5	135.9	0.77	104.2	11.6	264	31
7900	87.2	131.2	0.81	106.5	11.5	266	31
8000	83.5	127.2	0.81	103.5	11.9	268	31

Since Scott was using 87 octane fuel, we opted to stop adjusting top end fuel at 138 HP *Remember that these dyno runs were 10-12 seconds in duration with very controlled coolant temperature*. Scott was suffering a bit from dyno sickness, knowing that 140 HP was perhaps one tweak away. But we decided to quit there, fairly confident that we could match the power of Bill's race ECU by matching the race ECU's A/F ratio and its required octane. Until we try this mechanical recalibration on several other local F7's, we won't address methods or actual pressures. This would certainly mean instant misery for everyone involved if the setup used on Scott's sled was not identical to everyone else's using similar modifications. We'll set up Bill and a few others nearby to see what transpires, and report as soon as we have results.