Lycoming Engine Tuning Guide   Sept. 4/17 V29 Software

Disclaimer

These products do not conform to any recognized set of standards or certifications for aviation applications.

This ECU is not waterproof and will not function as designed if moisture invades the enclosure or power/ ground connections are interrupted.

Failure of this unit may result in a complete loss of engine power.

Use of these products on amateur built/ experimental aircraft is at the discretion of the buyer who accepts full responsibility for any consequences resulting from its use. Since Racetech Inc. cannot control the installation, programming, application environment or use of its products, we accept no responsibility for damage, loss or personal injury resulting from the use of SDS products. By using SDS products, the user understands and accepts this.

If any user does not agree to this disclaimer, they may return the system/ parts in new condition for a full refund.

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You should first become familiar with all the different programmable parameters by reading the main SDS manual.

Improper programming of fuel and ignition parameters can cause engine damage and a complete power loss in extreme cases.

Background Technical Information

Air/ fuel Ratio

In most spark ignition, internal combustion engines, the mixture is combustible within an AFR (air/fuel ratio) range of roughly 9 to 1 to about 18 to 1. 9 being very rich, 18 being very lean. 14.7-15.2 is the stoichiometric ratio (chemically correct) for lowest emissions. Best power is obtained at around 12.5 for most naturally aspirated engines.

Detonation

The fuel/air mixture normally burns at a uniform rate within the combustion chamber however if the rate of pressure or temperature rise becomes excessive, detonation can occur. This is the spontaneous explosion of the remaining mixture sometime after the spark event occurs. The result is a rapid and excessive pressure and temperature rise within the chamber, which can often lead to broken ring lands on the piston. Some engines can withstand light or moderate detonation for many hours, some can't. Heavy detonation is like hammer blows on top of the piston and most engines won't take this for more than a few seconds at a time under heavy detonation. Having the ignition timing too far advanced for the fuel octane is the leading cause of detonation, running the AFR too lean also contributes to detonation. You are not likely to be able to hear detonation over the noise of the propeller and exhaust in an airplane so we must program the ECU so that detonation cannot occur in the first place.

Pre-ignition

This happens when there is a hot spot somewhere within the cylinder which raises the temperature of the mixture above its autoignition temperature. This happens before the spark is initiated, leading to a massive temperature and pressure rise before the piston reaches TDC. Most of the heat and excess pressure goes into the piston. Within the space of a few seconds, the piston will simply melt in the middle, the pressure caving in the crown and melting the spark plug electrode off. You cannot hear pre-ignition at all and failure is virtually instantaneous in all cases.

Now that the scary stuff has been discussed, we can get into the meat of proper ECU programming to try to prevent these things.

Magnet Position Value

First item to check is the magnet position value**. You must verify this or all your actual timing may be wrong which can lead to engine damage.** Read the appropriate section in the SDS F Supplement Manual to fully understand this. Basically, this is a one time calibration to the ECU to correct displayed ignition timing with actual ignition timing on the engine. You must connect a timing light to the #1 plug or coil wire and have a mark on the crank pulley for TDC or 10 degrees BTDC. In some cases, you can try the inductive clip on the coil trigger wire, red positive coil wire or black ground coil wire. Use a dumb timing gun without an adjustable knob on it. (important)

If you only have a TDC mark, set the rpm ignition timing in the programmer to 0 at 750, 1000 and 1100 rpm. If you have a 10 degree BTDC mark, set the rpm ignition timing to 10 at these three rpm ranges. Start the engine (mindful of the propeller!) And set the throttle to get an idle at 1000 rpm, confirm in gauge 1 mode. Scroll right until you get to the Magnet Position Parameter. The default value is 80 for magnet position. Check your timing mark with the gun. If your timing is the same as what you have set in the ECU, no adjustment to Magnet Position is required. If the timing does not agree, change the setting by using the +1 or -1 buttons to increment or decrement the 90 value until actual timing matches your programmer timing value at 1000 rpm. A change of 1 will change ignition timing 1 degree. Once Magnet Position is set, whatever you enter for rpm ignition timing will be correct as long as you don't move the Hall sensor. You may now reset your rpm timing values to whatever you desire. On dual ECU systems, each ECU will require a different Magnet Position setting, usually around 86/93. Be aware that if you have MAP advance/ retard values entered, these will change total timing. To set Magnet Position, you should have all MAP ignition values set at 0 initially.

If you don't verify that the magnet position is correct, you really don't know if your actual ignition timing is correct so you could have more advanced timing than you think, which can lead to detonation.

Base Maps

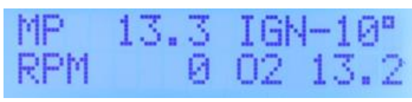
Most systems will already have a fairly close base map entered in the ECU for your combination of engine displacement and injector flow rate so the engine can start. Variations in displacement, head porting, camshaft timing, intake and exhaust systems can change airflow markedly between different Lycoming engines so you'll have to verify that timing and fueling is appropriate for your particular engine.

Ignition Mapping

On most Lycoming engines, best power is made at around 24-25 degrees BTDC at sea level, assuming no detonation is present. Typically, ignition timing starts out on most engines at about 10 degrees BTDC from 750 to 1000 rpm and we'd increase timing about a few degrees per 100 rpm step in the programmer until you reach 24-25 degrees at 2700 rpm when you are operating on 100LL. We've found that timing should be limited to no more than 24 degrees when running on 91 octane mogas so that detonation is less likely to occur and we may retard timing further at high manifold pressures to stop detonation. Timing values would be also adjusted downwards as compression ratios are taken above 8.5 to 1. Consult the example maps in the back of this manual for typical values.

On the SDS, we have two parameters affecting ignition timing- RPM IGNITION and IGN RET- ADV/ LOAD. Total timing is the composite of these two figures- RPM timing plus or minus the MAP retard or advance value. It's possible for advanced users to also use the IGN RET- ADV/ LOAD parameter to advance timing at low manifold pressures (MAP) and retard it at high MAP to possibly obtain higher cruise efficiency. On naturally aspirated engines, IGN RET- ADV/ LOAD values can all be set to 0 so they don't affect total timing and make things easier to understand. This might involve a slight tradeoff in efficiency at lower manifold pressures however. TOTAL timing is shown in gauge 4 mode.

MAP IGN RET-ADV/LOAD



Gauge 4 mode showing MAP, ign timing, rpm and AFR

Fuel Mapping

You need to have a wideband AFR monitor installed to display and verify AFRs. Most mapping can be done with the aircraft chocked, brakes on and tied to a vehicle on the ground. Take suitable precautions when ground running at high power settings and watch that oil and CHTs, don't exceed limits here. Watch the AFR (O2) reading in Gauge 4 mode, shown above..

RPM Fuel Values

This parameter compensates for volumetric efficiency changes with rpm.

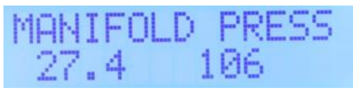
Our goal is simply to adjust the RPM FUEL parameter at each 100 rpm break point to obtain an AFR of around 12.0 to 12.5 up to 1500 rpm (idle and taxi range) and 11.5 to 12.0 above 1500 rpm. Get on the brakes and start the engine. Don't do any programming to RPM Fuel values until the engine reaches at least 150F engine/ cylinder head temperature. At each rpm, verify it's stabilized at each rpm break point in the SDS programmer (not the aircraft tach), check AFR, increment or decrement the RPM FUEL value using the +1 or -1 buttons until you get the desired AFR. Making the RPM FUEL value larger makes the AFR richer and vice versa. Note there will be some scatter in the readings so aim for a nominal reading. If you are trying to get 11.0, it's somewhat normal to see variations between about 10.8 to 11.2.

Keep increasing the throttle to increase rpm, stabilize and verify at each 100 rpm break point, check AFR, correct the RPM FUEL value to get desired AFR. Repeat. Go all the way up the rev range until you are at full throttle.

Be aware that injector size directly affects the RPM Fuel value. Smaller injectors require larger RPM Fuel values and vice versa. We supply 46 lb. Injectors (yellow) for most parallel valve engines and 60 lb. Injectors (blue) for most angle valve engines. You'll see example maps at the rear of this manual for both types.

Once the engine is warmed up, AFRs are a composite of RPM FUEL values X MAP FUEL values with small corrections for intake air temperature. Since MAP values are usually a linear progression, we usually don't have to touch those values on naturally aspirated engines and most programming is done only on the RPM FUEL values. You should check your MAP values however and they should look something like the figures below in the example maps at the end of this manual.

MAP Values



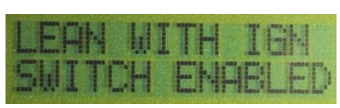
The 110s at low MAP are the defaults to keep the engine running in the event of a MAP sensor failure so don't change these. The values are around 32 in the idle range (around 10 inches).

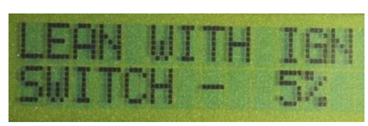
Do all programming with the mixture knob at 0% correction (straight up). This can be verified in Gauge 2 mode. Set the propeller to full fine pitch. Use the < or > button to scroll to the correct screen. Pressing the gauge button will take you to Gauge 1, press it again and it will take you back to whatever screen you were at previously.

Once you are done the basic programming outlined here, you are ready to test fly. When in flight, keep checking the AFRs, if they are off quite a bit, you can temporarily fix with the mixture knob. You can note the trends and knob percentage required to correct the AFRs at certain rpms. You can correct these on the ground later. For example, if the AFR in flight is 12.0 at 2500 rpm and you want 11.0, take 12/11= 1.09. Multiply your RPM fuel at 2500 rpm by 1.09 and re-enter. If the value was 200 originally, change it to 218. This normally should not be required after ground running but the proof is in the pudding while flying.

Pin 13 Input LOP Operation

This feature allows quick and efficient Lean of Peak operation with regards to both fueling and ignition timing. This input can be configured several different ways. When 12V is applied to the blue pin 13 input wire, it will activate certain code depending on what you select in the windows shown below. Default is to advance timing only (set this amount in IGN ADV window) and is used to recover the most energy possible from the fuel when running LOP (Fuel DISABLED). You may also select ENABLED, which will simultaneously lean the mixture the amount you program in the LEAN WITH IGN SWITCH window. This amount can be adjusted up to -65%.





If we run best power mixture at 12 to 1 AFR for climb and wish to run LOP in cruise, we'd set MAP and rpm with the throttle and prop control. From previous flights, we've determined from the engine monitor EGT/ AFR meter and mixture knob that we like to run at about 16.5 AFR LOP. This required going 37% lean with the mixture knob. We can now program –37% into the LEAN WITH IGN SWITCH window. Now we can quickly go LOP just by throwing the toggle switch without touching the mixture knob. This feature should only be used once you're familiar with your engine and typically cruise at or near the same MAP/ RPM power settings.

Lycoming 360 standard values 60lb. Injectors										ENGINE	
ABS IN HG								**BOSCH**		**TEMP**	**START**
MAN PRES	VAL	RPM FUEL	VAL	RET/MANPR	VAL	RPM IGN	VAL	**F**	**C**	**VALUE**	**VALUE**
1.12	130	500	128	1.12	0	500	5	265	129	0	5
1.59	130	750	129	1.59	0	750	15	250	121	0	5
2.06	130	1000	138	2.06	0	1000	20	225	107	0	5
2.53	18	1100	138	2.53	0	1100	20	206	97	0	0
3.00	18	1200	141	3.00	0	1200	20	198	92	0	0
3.47	18	1300	141	3.47	0	1300	20	185	85	0	0
3.94	19	1400	141	3.94	0	1400	22	175	79	0	0
4.41	20	1500	141	4.41	0	1500	24	163	73	0	0
4.88	22	1600	141	4.88	0	1600	24	150	66	0	1
5.35	24	1700	140	5.35	0	1700	25	140	60	0	3
5.82	26	1800	140	5.82	0	1800	25	130	54	0	5
6.29	28	1900	140	6.29	0	1900	26	120	49	3	8
6.76	30	2000	140	6.76	0	2000	26	110	43	9	9
7.23	32	2100	140	7.23	0	2100	27	100	38	18	10
7.70	34	2200	139	7.70	0	2200	27	95	35	30	11
8.17	36	2300	138	8.17	0	2300	28	87	31	47	12
8.64	38	2400	137	8.64	0	2400	29	82	28	61	14
9.11	39	2500	137	9.11	0	2500	29	75	24	66	16
9.58	40	2600	137	9.58	0	2600	29	66	19	70	18
10.0	41	2700	137	10.0	0	2700	29	60	16	74	20
10.5	42	2800	137	10.5	0	2800	29	54	12	78	25
10.9	43	2900		10.9	0	2900		47	8	84	30
11.5	46	3000		11.5	0	3000		40	4	90	40
11.9	48	3100		11.9	0	3100		34	1	96	50
12.4	50	3200		12.4	0	3200		26	-3	102	60
12.8	53	3300		12.8	0	3300		20	-7	108	70
13.3	55	3400		13.3	0	3400		12	-11	115	80
13.8	58	3500		13.8	0	3500		2	-17	123	90
14.3	60	3600		14.3	0	3600		-5	-21	130	100
14.8	63	3700		14.8	0	3700		-20	-29	140	110
15.2	65	3800		15.2	0	3800		-40	-40	150	120
15.7	67	3900		15.7	0	3900		-55	-48	0	130
16.2	70	4000		16.2	0	4000					
16.6	72	4100		16.6	0	4100					
17.1	75	4200		17.1	0	4200					
17.6	77	4300		17.6	0	4300					
18.0	79	4400		18.0	0	4400					
18.5	82	4500		18.5	0	4500					
19.0	84			19.0	0						
19.4	87			19.4	0	ACCPUMPLORPM		35	Lycoming 360 base map 60		
19.9	89			19.9	0	ACCPUMPHIRPM		15			
20.4	91			20.4	0	ACCPUMPSENSE		6			
20.9	94			20.9	0	START CYCLES		25			
21.3	96			21.3	0	MAGNET POSITION		80			
21.8	98			21.8	0	KNOCK RETARD		0			
22.3	101			22.3	0	KNOCK SENSE		1			
22.7	103			22.7	0	CL MAP HI		NA			
23.2	105			23.2	0	CL MAP LO		NA			
23.7	108			23.7	0	CL RPM HI		NA			
24.1	110			24.1	0	CL RPM LO		NA			
24.6	113			24.6	0	CLOSED LOOP		OFF			
25.1	115			25.1	0	FUELCUT/MANPRE:		No Limit			
25.6	118			25.6	1R	FUELCUT/RPM		3000			
26.0	120			26.0	1R	FUELCUT BELOW T		NO Cut			
26.5	123			26.5	1R	FAST IDLE SWITCH		NA			
27.0	125			27.0	2R	IDLE TP LOCATION		NA			
27.4	128			27.4	2R	IDLE FUEL AMOUNT		NA			
27.9	130			27.9	2R	O2 TYPE					
28.4	133			28.4	3R						
28.8	135			28.8	3R						
29.3	138			29.3	3R						
29.8	140			29.8	4R						
30.3	142			30.3	4R						
30.7	144			30.7	4R						

		Lycoming 360 base map 46 lb. injectors								ENGINE	
ABS IN HG								**BOSCH**		**TEMP**	**START**
MAN PRES	VAL	RPM FUEL	VAL	RET/MANPR	VAL	RPM IGN	VAL	**F**	**C**	**VALUE**	**VALUE**
1.12	130	500	186	1.12	0	500	5	265	129	0	5
1.59	130	750	188	1.59	0	750	15	250	121	0	5
2.06	130	1000	200	2.06	0	1000	20	225	107	0	5
2.53	18	1100	202	2.53	0	1100	20	206	97	0	0
3.00	18	1200	206	3.00	0	1200	20	198	92	0	0
3.47	18	1300	206	3.47	0	1300	20	185	85	0	0
3.94	19	1400	206	3.94	0	1400	22	175	79	0	0
4.41	20	1500	206	4.41	0	1500	24	163	73	0	0
4.88	22	1600	206	4.88	0	1600	24	150	66	0	1
5.35	24	1700	204	5.35	0	1700	25	140	60	0	3
5.82	26	1800	204	5.82	0	1800	25	130	54	0	5
6.29	28	1900	204	6.29	0	1900	26	120	49	3	8
6.76	30	2000	204	6.76	0	2000	26	110	43	9	10
7.23	32	2100	204	7.23	0	2100	27	100	38	18	13
7.70	34	2200	202	7.70	0	2200	27	95	35	30	16
8.17	36	2300	202	8.17	0	2300	28	87	31	47	20
8.64	38	2400	201	8.64	0	2400	29	82	28	61	25
9.11	39	2500	200	9.11	0	2500	29	75	24	66	29
9.58	40	2600	200	9.58	0	2600	29	66	19	70	36
10.0	41	2700	200	10.0	0	2700	29	60	16	74	40
10.5	42	2800	200	10.5	0	2800	29	54	12	78	45
10.9	43	2900		10.9	0	2900		47	8	84	50
11.5	46	3000		11.5	0	3000		40	4	90	60
11.9	48	3100		11.9	0	3100		34	1	96	70
12.4	50	3200		12.4	0	3200		26	-3	102	80
12.8	53	3300		12.8	0	3300		20	-7	108	90
13.3	55	3400		13.3	0	3400		12	-11	115	100
13.8	58	3500		13.8	0	3500		2	-17	123	110
14.3	60	3600		14.3	0	3600		-5	-21	130	120
14.8	63	3700		14.8	0	3700		-20	-29	140	130
15.2	65	3800		15.2	0	3800		-40	-40	150	140
15.7	67	3900		15.7	0	3900		-55	-48	0	150
16.2	70	4000		16.2	0	4000					
16.6	72	4100		16.6	0	4100					
17.1	75	4200		17.1	0	4200					
17.6	77	4300		17.6	0	4300					
18.0	79	4400		18.0	0	4400					
18.5	82	4500		18.5	0	4500					
19.0	84			19.0	0						
19.4	87			19.4	0	ACCPUMPLORPM		40			
19.9	89			19.9	0	ACCPUMPHIRPM		20			
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20.9	94			20.9	0	START CYCLES		25			
21.3	96			21.3	0	MAGNET POSITION		80			
21.8	98			21.8	0	KNOCK RETARD		0			
22.3	101			22.3	0	KNOCK SENSE		1			
22.7	103			22.7	0	CL MAP HI		NA			
23.2	105			23.2	0	CL MAP LO		NA			
23.7	108			23.7	0	CL RPM HI		NA			
24.1	110			24.1	0	CL RPM LO		NA			
24.6	113			24.6	0	CLOSED LOOP		OFF			
25.1	115			25.1	0	FUELCUT/MANPRE:		No Limit			
25.6	118			25.6	1R	FUELCUT/RPM		3000			
26.0	120			26.0	1R	FUELCUT BELOW T		NO Cut			
26.5	123			26.5	1R	FAST IDLE SWITCH		NA			
27.0	125			27.0	2R	IDLE TP LOCATION		NA			
27.4	128			27.4	2R	IDLE FUEL AMOUNT		NA			
27.9	130			27.9	2R	O2 TYPE					
28.4	133			28.4	3R						
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30.7	144			30.7	4R						