Lycoming Engine Tuning Guide   May 21/20 V30 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

This is the timing offset to tell the ECU how far from TDC the magnets are. On systems with a single Hall sensor (single cable and single ECU) the Magnet Position should be set to 92. On dual ECU systems with dual sensors and cables, the green cable must go to the Primary ECU and Magnet Position will be set to 97, red cable to backup ECU with Magnet Position set to 88.

Base Maps

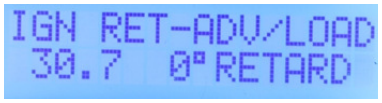
Most systems will already have a fairly close base map entered in the ECU for your combination of engine displacement and injector flow rate so the engine can start. Variations in displacement, head porting, camshaft timing, intake and exhaust systems can change airflow markedly between different Lycoming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

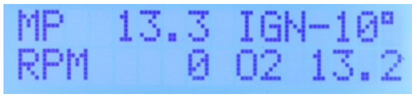
Ignition Mapping

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 Lycoming engines. You'll see example maps at the end of this manual.

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.

LOP (Lean Of Peak) Operation
This feature allows quick and efficient Lean of Peak operation with regards to both fueling and ignition timing. This feature can be configured several different ways. When enabled, 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 LOP IGNITION ADVNACE 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 LOP LEAN FUEL % window. This amount can be adjusted up to -65%. See below for more details.

LOP Control

New for V30 software, this window is to select the method of controlling the Lean Of Peak feature, either from the keypad key on the newer model SDS EFI Aero programmer unit, or using a remote mounted toggle switch wired to pin13 of the 25 pin main harness. You cannot use both methods only one of them. If you press the LOP key on your keypad and the blue LED does not light up then it is likely because this setting is PIN13. For older systems upgrading to V30 software and still using a toggle switch to activate LOP set this window to PIN 13 AUX INPUT.

<u>SDS fuel only(no ignition control)</u> systems can only use the PIN13 setting if the SDS is triggered from a hall effect sensor mounted on the crankshaft. Also a special setting in Setup Mode needs to be set for Pin13 to be used for LOP activation, email or call us for help with this special case. Commonly on SDS fuel only systems we use Pin13 for a tach signal so a crankshaft hall sensor is not required, and when pin13=tach signal it is not available for LOP use.

LOP, Max Manifold Pressure

This setting prevents the extra LOP Ignition Advance amount from being added into ignition timing above the set manifold pressure limit. You do not want extra timing at high manifold pressures, typically above 25” absolute. Too much ignition advance above 25” can hurt the engine, so this acts as a safety.

Also this blocks LOP Lean Fuel Percent from subtracting its fuel percentage from the injector pulse time above the set manifold pressure.

If you are unsure about this adjustment do not adjust it. A bit lower setting like 24 or 23 is safer. Higher than 25" is not recommended.
Older versions of software (pre V30) had this window in Setup Mode, but it has been moved into the normal windows for easier access.

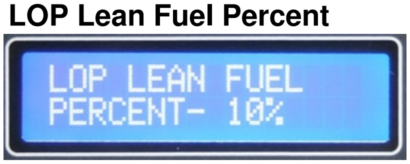
LOP Ignition Advance

This setting is the amount of ignition advance added to ignition timing when LOP is activated. Be careful as too much here could damage some engines. The extra ignition advance works well with LOP Lean fuel Percent, because more ignition advance will help the engine run smoother with a leaner mixture.
On SDS systems that control fuel only(no ignition control) this window will display NOT USED.

LOP Lean Fuel

This provides a quick way to Enable or Disable percentage leaning of fuel when the LOP is activated.

LOP Lean Fuel Percent



This setting Leans the fuel mixture when LOP is activated. The percentage amount will be subtracted from the fuel pulse width when the LOP is activated. Maximum setting is 60%.

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 LOP LEAN FUEL % 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.

Default fuel and spark values for a IO360 Lycoming with 46lb injectors.								ENGINE		ENGINE	
ABS IN HG								1/8NPT	1/8NPT	TEMP	START
MAN PRES	VAL	RPM FUEL	VAL	RET/MANPR	VAL	RPM IGN	VAL	F	C	VALUE	VALUE
3.72	100	500	165	3.72	0	500	10	302	150	0	9
4.16	100	750	165	4.16	0	750	15	275	135	0	7
4.59	35	1000	165	4.59	0	1000	20	239	115	0	5
5.03	36	1100	165	5.03	0	1100	25	221	105	0	0
5.46	37	1200	165	5.46	0	1200	25	203	95	0	0
5.9	38	1300	165	5.9	0	1300	25	189	87	0	0
6.33	39	1400	165	6.33	0	1400	25	176	80	0	0
6.77	40	1500	165	6.77	0	1500	25	167	75	2	0
7.2	41	1600	165	7.2	0	1600	25	158	70	5	0
7.64	42	1700	165	7.64	0	1700	25	149	65	9	5
8.08	43	1800	165	8.08	0	1800	25	142	61	13	8
8.51	44	1900	165	8.51	0	1900	25	136	58	17	12
8.95	46	2000	165	8.95	0	2000	25	129	54	22	15
9.38	47	2100	165	9.38	0	2100	25	122	50	27	18
9.82	48	2200	165	9.82	0	2200	25	115	46	32	20
10.3	48	2300	165	10.3	0	2300	25	109	43	37	22
10.7	49	2400	165	10.7	0	2400	25	104	40	42	25
11.1	50	2500	165	11.1	0	2500	25	95	35	45	29
11.6	50	2600	200	11.6	0	2600	25	90	32	48	30
12	52	2700	200	12	0	2700	25	86	30	52	33
12.4	54	2800	200	12.4	0	2800	25	79	26	57	36
12.9	56	2900	200	12.9	0	2900	25	72	22	61	39
13.3	58	3000	200	13.3	0	3000	25	66	19	66	55
13.7	60	3100	200	13.7	0	3100	25	59	15	70	64
14.2	62	3200	200	14.2	0	3200	25	52	11	74	70
14.6	64	3300	200	14.6	0	3300	25	43	6	78	85
15	66	3400	200	15	0	3400	25	36	2	84	100
15.5	68	3500	200	15.5	0	3500	25	25	-4	90	130
15.9	70	3600	200	15.9	0	3600	25	14	-10	96	140
16.3	72	3700	200	16.3	0	3700	25	-4	-20	102	170
16.8	74	3800	200	16.8	0	3800	25	-26	-32	108	190
17.2	76	3900	200	17.2	0	3900	25	-58	-50	0	0
17.7	78	4000	200	17.7	0	4000	25				
18.1	80	4100	200	18.1	0	4100	25				
18.5	82	4200	200	18.5	0	4200	25				
19	84	4300	200	19	0	4300	25				
19.4	86	4400	200	19.4	0	4400	25				
19.8	88	4500	200	19.8	0	4500	25				
20.3	90			20.3	0						
20.7	92			20.7	0	ACCPUMPLORPM		40			
21.1	94			21.1	0	ACCPUMPHIRPM		20			
21.6	96			21.6	0	ACCPUMPSENSE		5			
22	98			22	0	START CYCLES		32			
22.4	100			22.4	0	MAGNET POSITION		PRI=88, BAK=97, SINGLE=92			
22.9	102			22.9	0	KNOCK RETARD		0			
23.3	104			23.3	0	KNOCK SENSE		1			
23.7	106			23.7	0	KNOCK MAX RPM		500			
24.2	108			24.2	0	CL MAP HI			NA		
24.6	110			24.6	0	CL MAP LO			NA		
25.1	112			25.1	0	CL RPM HI			NA		
25.5	114			25.5	0	CL RPM LO			NA		
25.9	116			25.9	0	CLOSED LOOP		OFF			
26.4	118			26.4	0	FUELCUT/MANPRESS		No Limit			
26.8	120			26.8	0	FUELCUT/RPM		2900			
27.2	122			27.2	0	FUELCUT BELOW TP		NO Cut			
27.7	124			27.7	0	FAST IDLE SWITCH		NA			
28.1	126			28.1	0	IDLE TP LOCATION		No use			
28.5	128			28.5	0	IDLE FUEL AMOUNT		No use			
29	130			29	0						
29.4	132			29.4	0						
29.8	134			29.8	0						
30.3	136			30.3	0						
30.7	138			30.7	0						
31.1	140			31.1	0						