

# EM-5 Aviation Installation and Tuning Manual for Version 31 Software. Fuel Injection Portion.

July 14/21.

## 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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**Please read the entire manual before attempting any hookup or running of the system.**

Due to the technical nature of this system, we have broken down the information into various separate manuals to make the information easier to find and update. **This manual covers the fuel injection portion of the installation.**

For tech help email Racetech/SDS at [racetech1@telus.net](mailto:racetech1@telus.net) or call 403-671-4015. When calling for help please let us know which system you have. See below for descriptions of different systems.

## System Description

SDS EM-5 is available in 2 different models for aviation applications:

EM-5-D controls fuel injectors only.

EM-5-F controls fuel and ignition timing using multiple ignition coils.

EM-5 is a microprocessor based, digital, programmable EFI system intended to control port type injectors. The EM-5 allows you to access all points in the engine operating map with the engine running and alter them according to your own specific needs utilizing a hand-held or panel mounted LCD programming box. As such, the system can be used on virtually any engine type or displacement



## New for Version 31 Software

V31 and higher software now allows RPM Fuel values to be adjusted up to a maximum of 350, prior to V31 max was 255. Also V31 can now produce an injector pulse width up to 65mS where older versions only went to 32mS. This can benefit some applications with relatively large engine cylinder displacement combined with a lower flow rate injector, which then may require an RPM Fuel value a bit higher than 255.

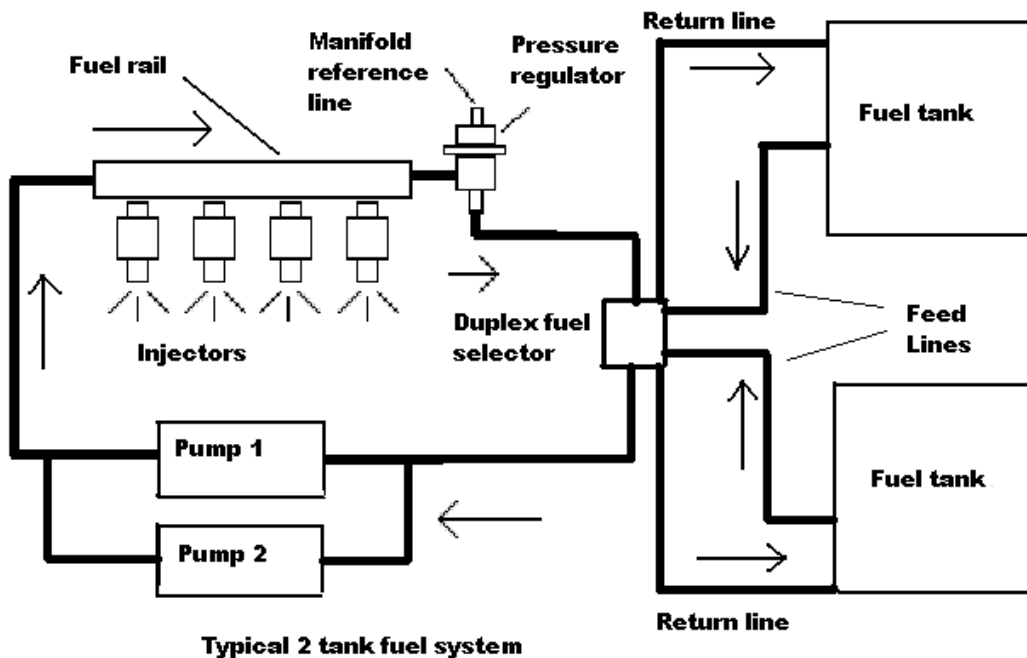
## Theory of Operation

Air temperature, CHT (or coolant temperature), manifold pressure, throttle position and rpm are all measured and taken into account by the EM-5 which determines how often and how long the injectors remain open. The EM-5 generates a precise triggering pulse, which is fed to the injectors. The manifold pressure value multiplied by the rpm value determines the primary pulse width. Barometric compensation in V29 software also corrects AFR with altitude behind the scenes, regardless of MAP.

## Fuel System

In order for any EFI system to function properly, an adequate supply of fuel at the proper pressure must be present at the injectors. Problems are invariably blamed on the electronics when in fact 99% of all running problems are due to mechanical deficiencies. Most running problems are due to poor electrical connections or insufficient fuel supply/ pressure issues. **Failure to follow proper fuel system recommendations and layout can cause a partial or complete power loss.**

**Any fuel system design must ensure that fuel feeds from the tanks to pump inlets at all times during normal flight conditions including uncoordinated flight at high bank angles.**

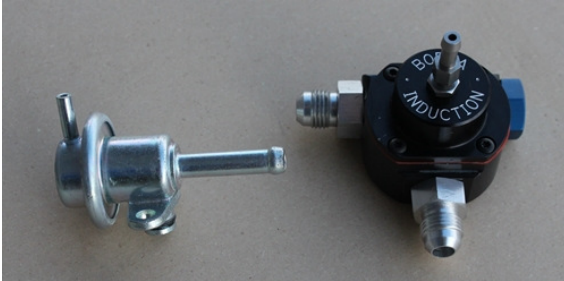


## Injectors

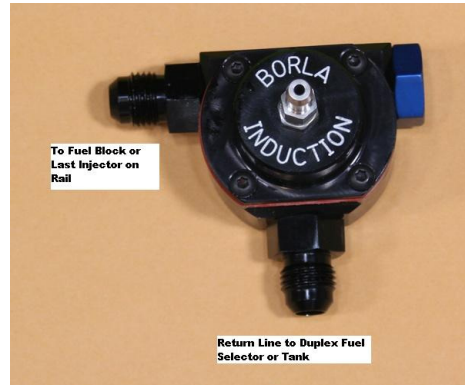
We supply properly sized and matched injectors for your application. You should consult us if you plan to use different injectors for some reason. **Improperly sized or matched injectors can create running or tuning problems and our mapping recommendations may not be valid. Undersized injectors can cause engine damage in extreme cases.**

## Fuel Pressure Regulator

We supply either an adjustable Borla regulator with AN-6 fuel fittings or a non-adjustable OEM type with O-ring sealed inlet and either barb outlet or 1/8 or 1/4 female NPT outlet fitting. We recommend the adjustable type have its **fuel pressure set to 45-50 psi** using the adjusting screw on the top of the regulator with the engine **not running**. Both regulator types have a MAP reference hose port for connection to intake manifold vacuum. **Using other unproven regulators is not recommended as failure can cause partial or complete power loss.** The adjustable regulator should be rigidly mounted to the firewall.



Non-adjustable and AN6 adjustable fuel pressure regulators



## Fuel Pumps

We recommend using only the supplied/ recommended genuine Walbro pumps to ensure maximum reliability and safety with regards to re-priming in the event of a dry tank condition and to be sure they are properly matched to the hp of your engine. **The use of other brands is not recommended as failure can cause a partial or complete power loss condition.**

We can supply either a single pump or dual pumps mounted in a module to allow easier plumbing and mounting. **Be sure to follow the safety/ assembly instructions that come with the pump modules. Improper fitting assembly can cause line or pump blockage, leading to a partial or complete power loss.** Dual pumps should have separate power feeds, breakers and ground points for maximum redundancy. Fuse each pump with a 15 amp fuse or breaker. Nominal current draw is between 4.5 to 5.5 amps each at 14V, running at 45 psi pressure, depending on pump model.



Dual fuel pump module

On low wing aircraft, we recommend the pumps be mounted as low as possible on the floor, preferably parallel to the floor. **If you must mount the pumps vertically, mount them with the outlets facing UP, never down.** Inlet lines to the pumps should be 3/8 inch or AN6 with a minimum number of fittings used. We recommend not using any 90 degree fittings if possible on the pump inlets. Pump inlets should preferably be flooded by fuel at all times.

**Never place fuel pumps close to any hot engine parts unless they have proper heat shielding/cooling.**

## Fuel Lines

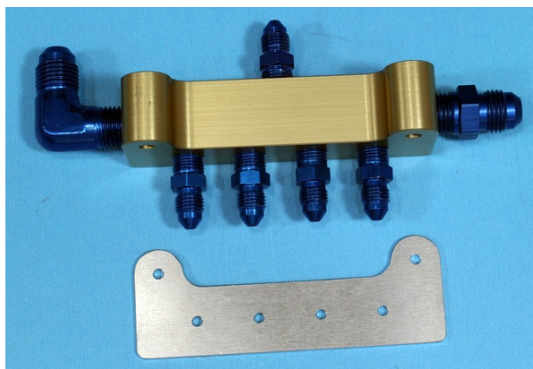
Fuel lines from the fuel tanks to fuel selector and pumps may be rigid aluminum or steel tubing or Teflon lined, stainless steel braided flexible hoses. **Flexible hoses must have a conductive inner liner designed to limit static electricity buildup when carrying gasolines.**

Fuel lines between the airframe and engine must be flexible types of at least medium pressure rating (over 100 psi burst strength). **Never use rigid line between the airframe and engine which can lead to vibration breakages and fire hazard. Never place fuel lines close to any hot engine parts unless they have proper heat shielding.**

Some installations will route fuel from the pumps to a fuel block, then use separate braided hoses to connect to each injector boss. In this case, fuel from the pump enters on end of the block and return fuel exits the regulator on the other end of the block. Other installations will use a rail or loop type system where each injector is linked in series to each other. In this case, fuel from the pump enters the first injector and Tee fittings on each injector boss routes fuel to each remaining injector in turn. The regulator is placed after the last injector in the loop and fuel is returned to the selected tank through a Duplex fuel selector.



Fuel block with non-adjustable regulator



Fuel block and template for rear baffle mounting



Top engine mount fuel block

You must use fuel return lines with SDS EFI. Fuel return lines have little or no pressure present. Return fuel should enter the tank(s) at least 4 inches from where the fuel feed exits. Installation of return lines into many tanks can be made in the access/ sender cover plate. Bulkhead fittings sealed with Earls Stat-o-Seals on both sides can make installation easier in many cases. We recommend 3/8 or AN-6 return fittings and lines.



Return line (lower) using Earls Stat-o-seals

## Fuel Selector

On any system using more than one fuel tank, we recommend using a Duplex selector which has a feed and return port for each tank. This ensures that returned fuel always goes to the selected tank which prevents pumping fuel overboard. Andair makes a wide range of Duplex type selectors.



Andair Duplex fuel selector

## Fuel Filters

All fuel tanks should have screen type finger strainers on the fuel feed lines and/or 40-50 micron filters between the tanks and the pump inlets. We supply a large 40 micron filter for the pump inlet and smaller 40 micron one for the pump discharge. **Be sure to check the filters annually. On new build aircraft, construction debris can clog filters leading to pump damage or a loss of fuel flow which can cause a partial or complete power loss.**

**On the pressure side of the pumps, always be sure that any filters used are rated to at least 100 psi. and use 3/8 lines or AN-6 fittings.**

## Gascolators

We don't recommend the use of gascolators with our EFI systems as they serve no useful purpose with a high pressure return type fuel system. If regulations require them, best to install them on the high pressure side between the pumps and injectors and use them as filters. **Be sure gascolators are rated to at least 100 psi.**

## Fuel injector Mounting

Your kit may provide either steel or aluminum base injector bosses which must be welded onto your induction tubes in most cases. The injectors should be mounted as near as possible to the intake ports, pointed towards the valve. Be sure when determining placement, that you can run fuel lines and fitting to the boss tops which won't be too close to exhaust pipes or any other obstructions. Be sure



you'll be able to get the TIG torch all the way around the boss to do a good weld. Also be sure to check that you'll have cowling clearance for the boss and fuel fittings feeding it.



Weld-in injector boss



Make oval hole in induction tube

Mark the outside of the tube where the boss will be placed. Find the center of your mark and center punch it. Drill a 1/8 inch hole through the tube. Enlarge to 7/16 with a step drill. Take a 7/16 drill bit and put it straight through the hole. Lean the drill down slowly so an oval hole is cut into the tube to match your injector boss (45 degree angle). Line up the boss carefully with your hole (a cut off 7/16 bolt through the boss base, clamped in place, can help align it while tacking). Carefully tack the bosses in place, recheck fit and clearance. Remove the bolt before final welding. Final weld in place once you are satisfied everything is right.

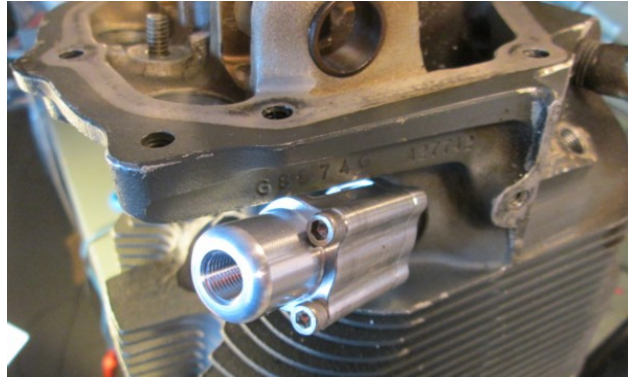


Injector boss welded in place ( Lycoming)

### **Lycoming Parallel Valve Engines**

On these, you are usually supplied with our dedicated injector mounting system which mounts the EFI injectors directly into the existing 1/8 NPT injector holes on the top of the heads. These use a special high strength stainless steel lower portion for low heat transfer and a floating 7075T6 bolting flange to hold the injector cap in place. We fit a stainless steel body injector for maximum temperature resistance.





To mount these, remove the 1/8 NPT plugs from the injector ports (heat may be required). Slide the gold flange over the lower silver adapter from below. Apply Loctite 246 to the threads on the silver part and thread by hand into the injector port. Thread in until finger tight then tighten 1 ½ more turns. You should get about 5-6 turns of thread engagement. Be careful here, stripping the threads will be a very expensive exercise! Lubricate the lower injector O-ring and slide the injector into the adapter. Rotate the injector so that the electrical plug faces towards the spark plug. Lubricate the upper O-ring and slide the gold cap over the injector. Apply Loctite 246 on the two 8/32 Stainless socket head cap screws as shown above and tighten in place.

We supply/ recommend –3 Stainless steel braided hoses to join the injector tops to the fuel blocks. The top cap is threaded 1/8 NPT female. Apply pipe sealant (not Teflon tape) sparingly to the fitting (either steel or aluminum) only, **making sure not to get sealant on the first thread**. Screw the fittings in at least a ½ turn past finger tight to get it orientated towards the fuel block fittings. **Never turn the fitting backwards once you start screwing it in**. Tighten the braided line swivel fitting in place being sure that they do not touch any other parts and are supported from vibration at least on one point. The upper gold parts should not rotate on the lower hex with hard hand pressure.

## Lycoming Angle Valve Engines

We supply a different adapter for AV engines but the threaded silver base and gold ring are installed using the same procedure as above. Test fit the hex fitting and lower gold ring dry to check for clearance to the cylinder head. In some cases, you may have to relieve a small arc in the head for clearance with a Dremel tool. See photo on page 8. **These parts cannot touch the head when tight.**

Once the base and ring are installed, lubricate the top and bottom injector O-rings and slide the injector into the lower base. We recommend you install the upper AN fittings into the gold top cap prior to installing the cap since you will not be able to tighten the fitting once the cap is installed. Use pipe sealant on the fitting threads as described above. Tighten and clock the fitting so it's perpendicular to the top cap flange holes as shown below before installing the top cap assembly to the injector.





Apply Loctite 246 to the stainless cap screws and slide them through the tubular spacers. Alternately start to tighten the cap screws with an Allen wrench but stop just before the spacers start to touch the gold parts. Rotate the lower ring and top cap to the orientation shown below so you can get the Allen wrench on the cap screw. **Just before the cap screws are snug, squeeze the two spacers together with your fingers so that they engage the lower hex.** Tighten the cap screws fully. You can rotate the injector to orientate the connector as desired. The upper gold parts should not rotate on the lower hex with hard hand pressure.





## ECU Mounting and Wiring Considerations

The ECU should be mounted in the passenger compartment in an area where they cannot get wet. If mounted horizontally, be sure the wiring harnesses have a drip loop to prevent water from running down them, into the ECU. **The ECU is not waterproof!** If possible, mounting the ECU with the connectors facing down gives the best protection against water ingress. **Never mount the ECU on top of the radio stack or within 3 inches of any DC motors or high pulsing current/ voltage wires or devices.** The ECU does not need any cooling or vibration isolation.

You should plan the ECU mounting to make wiring routing from it logically flow towards your firewall grommet holes. For best possible resistance to electrical noise, we prefer to have all ECU and other low level voltage/ current wires (thermocouples etc.) routed on one side of the firewall and all other airframe wires which carry higher voltages and current (alternator, starter, DC motors etc.) routed on the opposite side of the firewall and engine compartment. **Never tie wrap high voltage/current wires such as the starter, spark plug wires, alternator, strobes, radio transmitter, transponder, DC motors etc. to any of the ECU wiring.** A minimum 3 inch separation is preferred.

### EM-5 ECU connectors

Injector drive Main harness Hall Programmer



The dual board ECU enclosure stacks 2 boards in a single box. The upper board, closest to the lid, is the Primary or "A" computer. The lower, closest to the mounting flange is the Backup or "B" computer. The optional PC data logging function can only be connected to the "A" computer. On 4 cylinder models using the dual board ecu, there is no TPS, air temperature sensor, CHT sensor or mixture knob connected to the backup computer since these are non-critical to running the engine. 6 Cyl dual board models use two air temp and two CHT sensors, but share the TPS signal.

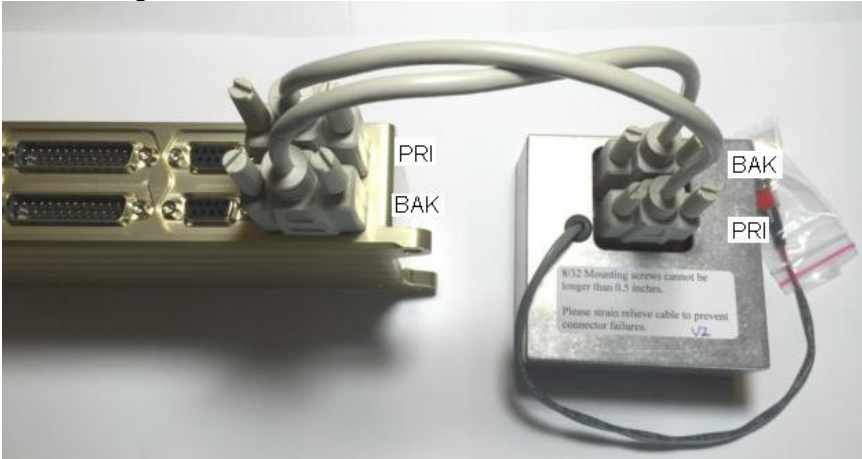


Dual board ECU

Dual board ECUs generally are used on engines with 2 spark plugs per cylinder. One ECU board drives the upper plugs and the other board drives the lower plugs at all times. A relay switch box is used to switch injector outputs between the 2 boards. The upper board is the Primary ECU, lower is the Backup.

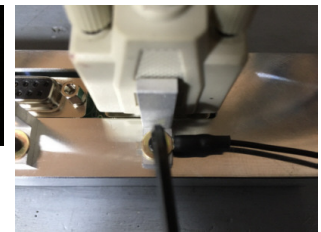
The dual board ECU also uses a special programmer with dual serial ports in the back, one connecting to each ECU with a toggle switch to select each ECU. Upper ECU board plugs into lower programmer connector.

### 3-1/8" Programmer unit cable connections:



Dual board ECU with dual board programmer box and toggle switch. See end programming section for details.

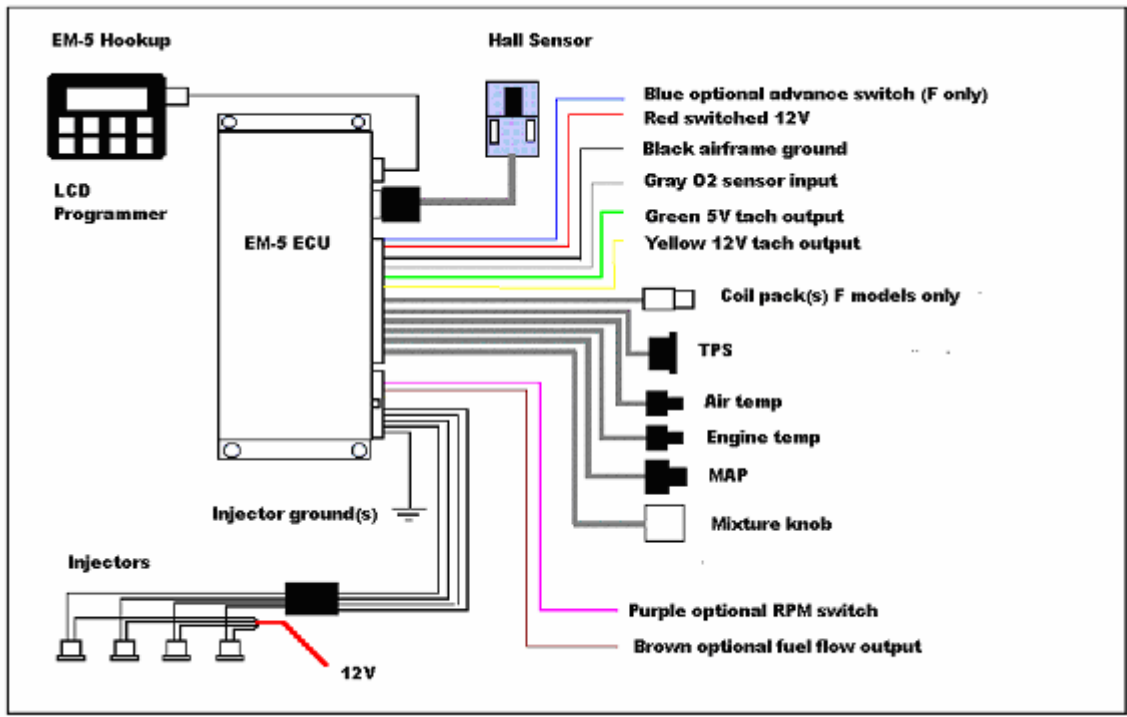
New for 2020, SDS EFI AERO programmer the Primary ecu cable goes to the right side connector as viewed from the rear. Backup ecu goes to the left connector. The 2ft black wires goes to chassis ground for static protection. L-brackets are to support the cable weight. Be sure they contact the cable connector and adjust as needed. The L brackets have slotted holes.



### Main Harness

Shown here has a 25 pin connector and connects the ECU to all the sensors. Right photo shows color coded main harnesses for dual ECU systems. Green for Primary, red for Backup.





## Main harness 25 Pin D Sub

Black 20 gauge (computer ground). Ground to aircraft structure or ground strip close to the EM-5.  
**Important! Makes sure this connection is good.**

Red 20 gauge ECU power. Switched 12V. Fused with 2 to 5 Amp fuse.  
**Important! Makes sure this connection is good.**

Plug in the mixture knob, white 3 pin plug.

Green 20 gauge, pin 12: This supplies a 5V tach signal output to your tach or EIS.

Yellow 20 gauge, pin 22: This supplies a 12V tach signal output to your tach or EIS.

Gray 20 gauge and O2 sensor or Wideband meter hookup, pin 24

On the SDS main harness there is a single gray 20 gauge wire which you can connect to a wideband O2 sensor controller. Connection is required when you want to display the AFR (air/fuel ratio) in the SDS programmer or use Closed loop and Lean Warning functions in the SDS computer. The SDS can run without an O2 sensor if this is desired but a wideband should be used to accurately tune the system. Recommended Wideband O2 air/fuel sensor & controller is the AEM #30-0310.

AEM hookup to SDS is as follows:

AEM Red to switched 12V through 5A breaker or fuse.

AEM Black to ground buss or chassis ground.

AEM White to SDS main harness gray wire.

AEM Brown connect to same place as SDS ECU pin 18 ground wire.

Mounting the AEM O2 sensor, mount sensor minimum 12 inches from the exhaust port, and minimum 12 inches from exhaust tip. Sensor may overheat too close to port, and may pickup air when too close to exhaust tip.

**TPS** (throttle position sensor signal) On dual ECU 4cyl systems you will only connect the TPS to the Primary ECU while the backup ECU will not need any connection to the TPS. On Dual 6 cylinder systems, the **orange** wire from the backup ECU harness will connect to the white TPS wire on the primary ECU.

Purple and brown wires are for future use and not connected at this time.

## Hall sensor 9 pin D Sub

Plugs into the middle DB-9 port on the ECU. On Dual ECU systems, the primary harness and Hall sensor cable is color coded green and the backup ones are color coded red.

DB-9 Pin#, function, Tefzel cable color:

5, +5V, orange stripe

4, Trigger, solid white

3, Ground, blue stripe

8, Sync signal, green stripe.



## Single board ECU Injector Drive Harness and wiring from 16 Pin White Molex to Injectors

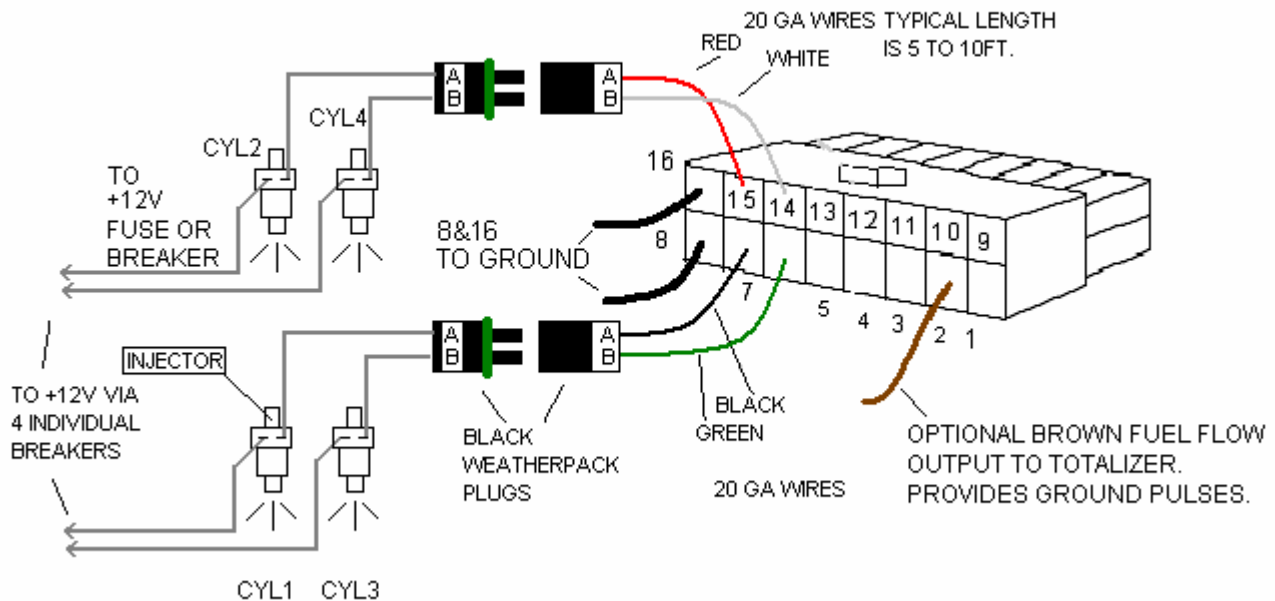
This connects the ECU injector outputs to the injector harness and also contains the injector ground wires and the option control wires. The two short black wires from pin 8 & 16 should go to **separate airframe grounds and have no other wires grounded to the same point**. On Dual ECU systems the Drive harness will connect via injector relay box(es). Details below.

### Injector Harness

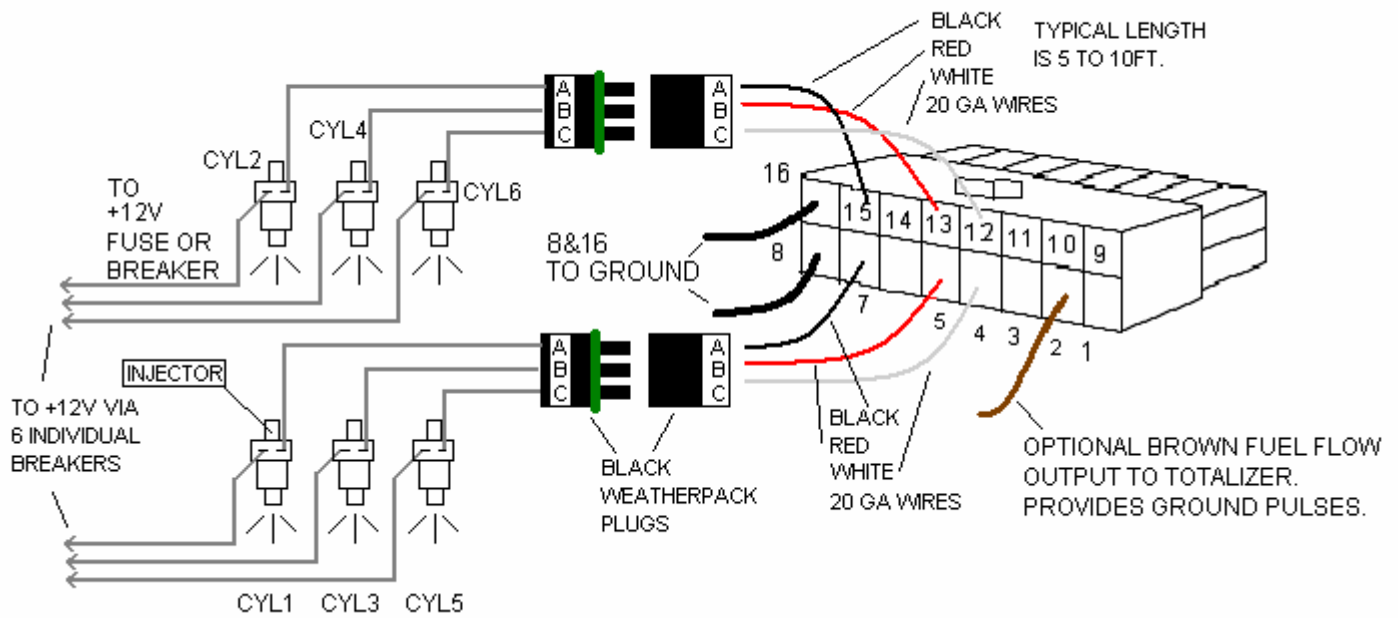
This plugs into the drive harness on one end and the injectors on the other end. One side of each injector will go to the appropriate drive harness wire from the 16 pin white ECU, or in the case of dual ECUs, from the injector relay boxes. The other injector wire will go to switched 12V. Fuse each of these power wires with a 5 amp fuse/ breaker. This gives some redundancy for a breaker or shorted injector failure. Be sure to connect the proper wire colors from the drive harness plug to the correct injector number when using the fuel trim option. See the layout schematic at the end of the manuals. For 6 cylinder dual ecu's see the supplement manual.



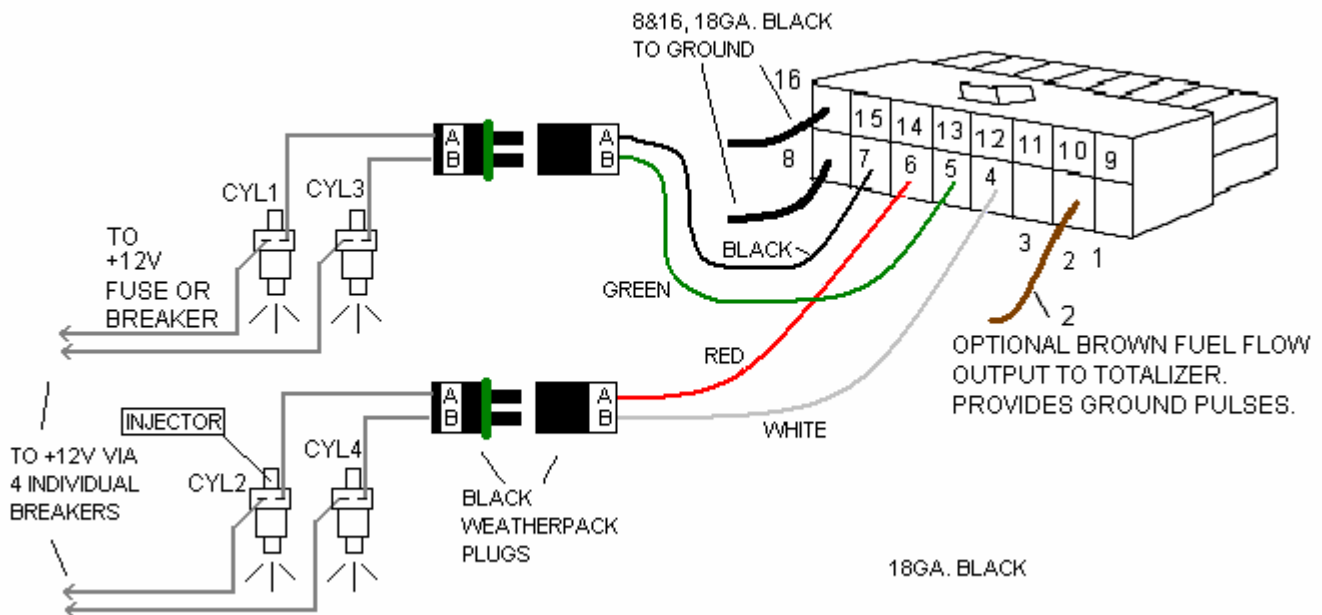
### 4 CYL FUEL INJECTOR WIRING SCHEMATIC (SINGLE BOARD ECU ONLY)



### 6 CYL FUEL INJECTOR WIRING SCHEMATIC (SINGLE BOARD ECU ONLY)



### 4 CYL FUEL INJECTOR WIRING SCHEMATIC (SINGLE BOARD ECU WITH TRIM)



Dual ECU systems use relay boxes between the 16 pin Molex connectors and the connections to the injector harness.

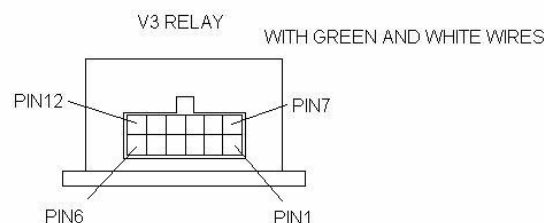
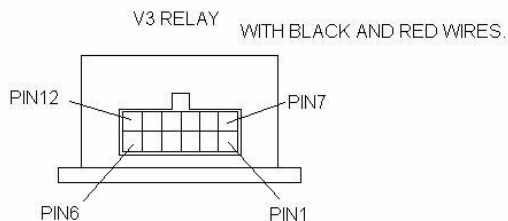
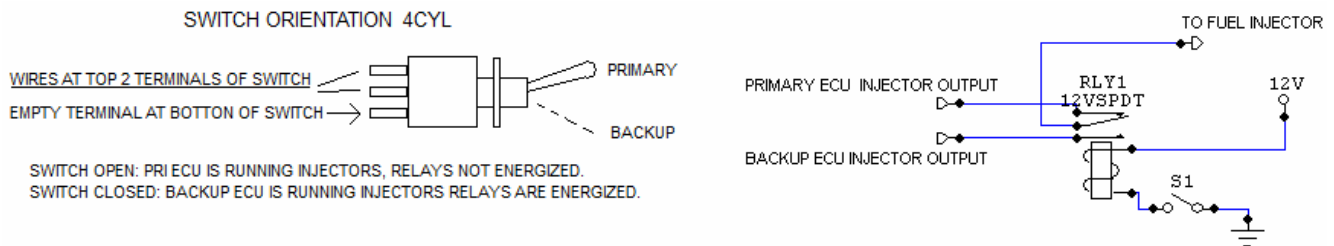
Relay box photo, 4 cylinder shown.



For 6 cylinder dual systems please see the 6 cylinder dual supplement manual for details.

4cyl dual systems without individual cylinder trim: **One** injector relay box is used to switch fuel injector circuits between Primary and Backup ECU.

4cyl dual systems with optional individual cylinder trim: **Two** injector relay boxes are used to switch fuel injector circuits between Primary and Backup ECU. Each relay box switches 2 injector outputs. By default relays are sending out the injector output from the Primary ECU. When the relay toggle switch is turned on, the relay coils are energized and then the relays are sending out the output from the Backup ecu. Below shows the schematic for one injector circuit for better understanding.



PIN1 BACKUP RED  
PIN2 RED TO INJECTOR #2CYL  
PIN3 NOT USED  
PIN4 BLACK PRIMARY ECU  
PIN5 GRAY TO SWITCH  
PIN6 GROUND FOR RELAY BLACK 18 GAUGE  
PIN7 BLACK BACKUP ECU  
PIN8 BLACK TO INJECTOR #1 CYL  
PIN9 NOT USED  
PIN10 RED PRIMARY ECU  
PIN11 GROUND FOR SWITCH.  
PIN12 +12VOLT SUPPLY FOR RELAY COIL

PIN1 BACKUP WHITE  
PIN2 WHITE TO INJECTOR #4CYL  
PIN3 NOT USED.  
PIN4 GREEN PRIMARY ECU  
PIN5 GRAY TO SWITCH  
PIN6 GROUND FOR RELAY BLACK 18 GAUGE  
PIN7 BACKUP GREEN  
PIN8 GREEN TO INJECTOR #3 CYL  
PIN9 NOT USED  
PIN10 WHITE PRIMARY ECU  
PIN11 GROUND FOR SWITCH  
PIN12 +12V SUPPLY FOR RELAY COIL

ON DUAL ECU'S, WE USE TWO RELAY BOXES. ONLY 1 SWITCH GROUND WIRE IS NEEDED. BOTH RELAYS NEED A GRAY WIRE GOING TO THE SWITCH.

CURRENT DRAW FOR EACH RELAY BOXES IS APPROX 0.42 AMPS BUT ONLY IF SWITCH TO BACKUP ECU. WHEN ON PRIMARY THE RELAYS DO NOT DRAW ANY CURRENT VIA THE 12V SUPPLY. A SINGLE FUSE OF 3 TO 5 AMPS IS SUFFICIENT FOR BOTH RELAY BOXES.

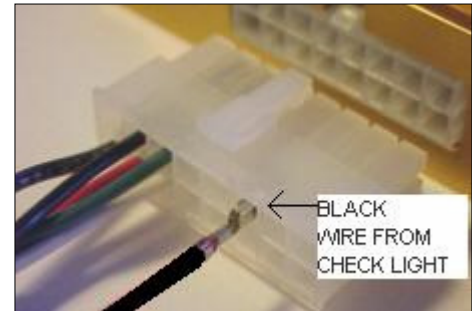
BOTH RELAY BOXES ARE IDENTICAL INSIDE.

The EM-5 can control a check engine light, L.E.D. or lamp to warn in the event of certain sensor problems or failures.

This will not be supplied with systems in 2020 which have the newer programmer units with a built in fault LED.

### Using the SDS supplied lamp

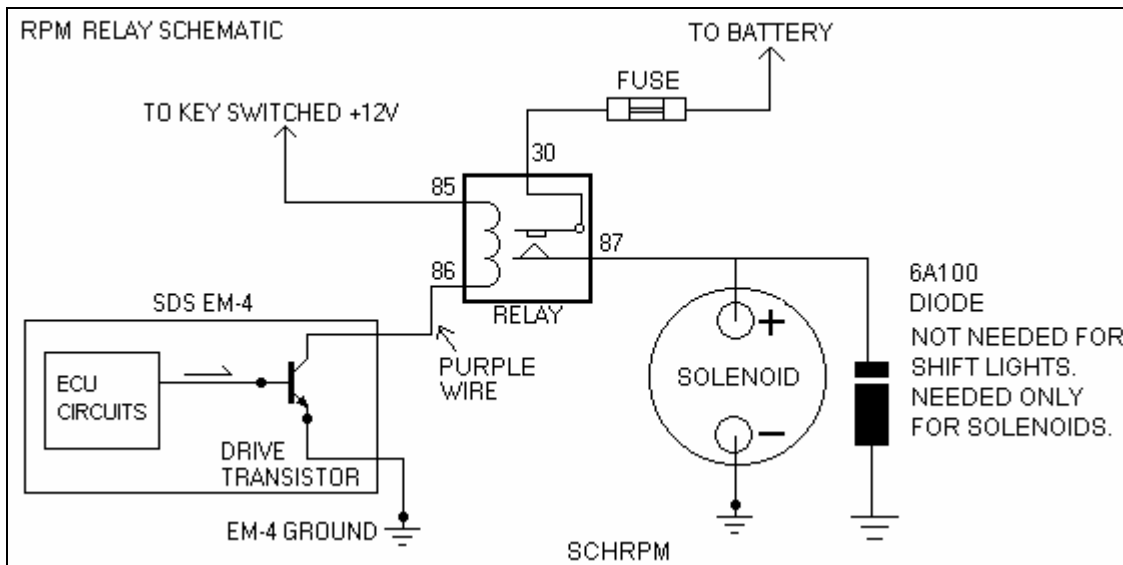
Mount the lamp for best visibility for the pilot. Drill a 1/4" hole for the lamp. Feed the wire through the hole from the front side of the panel. You will need to connect the lamp's red wire to a fused 12 volt circuit. The black wire from the check light needs to be inserted in the drive harness white plug pin 11, see photo. 3<sup>RD</sup> position from the right on the top row. A 2 amp fuse for this circuit is recommended.



Brown 20 gauge, pin 2 white Molex: This supplies fuel flow data output (optionally enabled)

Purple 20 gauge, pin 3 white Molex: Optional rpm switch, commonly used on VVT (Honda VTEC) systems.

Ground switched. Hookup schematic below:



Orange 20 gauge, pin 1 White Molex: Optional fuel pump relay trigger wire. Ground switched. We generally don't recommend using this function on aviation systems. **Each fuel pump should have a separate switch, power wire, fuse/ breaker and ground wire (not grounded to the same terminal).**

Blue 20 gauge, pin 13 Main 25 pin D Sub: Ignition advance switch on F systems only. Feed 12 volts to this wire via a panel mounted toggle switch to activate extra ignition advance over the programmed values. Mainly used for LOP operation and as an octane selector when switching between 100LL and Mogas. See the F manual for more information

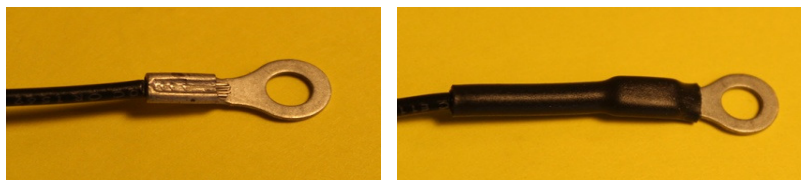
For "F" systems (coil pack) there will be a white 2 or 3 conductor cable marked "CP". This cable will be connected to the coil pack's input cable.



**Wiring connections are critical to proper ECU function. Make every connection with the thought that your life depends on each one. It does! Don't let wires dangle loose which can lead to eventual breakage. Support them every few inches for least mechanical loading on them.**

**Keep wires away from high heat sources and protect them from any possible chafing.**

**We like to see every individual wire, especially ground and power wires, be properly soldered or crimped (use the proper crimping tool!) AND a length of heat shrink tubing applied over connector and about 1 inch down the wire after for strain relief and backup wire retention. See following photos:**



### **Component Current Draw and Fuse/ Breaker Recommendations**

Item	Current Draw Range (Amps)	Recommended Breaker Size
ECU (each)	.03-.13	2
Fuel Pump (each)	4-6	15
Injectors (each )	2-4	5
Coil Pack 4 cyl. (each)	1-4	10
Coil Pack 6 cyl. (each)	2-6	10
Check Engine Light	.1-1	2
Advance Switch Power	.1	2
RPM Switch Relay Power	.3	2
Fuel Pump Relay Power	.3	2

Please note that on some devices such as coil packs and injectors, the current draw varies with rpm.

### **Backup Electrical Power Considerations**

Electrical power is necessary to keep the ECU, fuel pump, coils and injectors running so it's important to think about having a backup power source available. In the case of Lycoming engines, a small backup alternator like the B&C SD8, SD20 or BC410-H SD can be fitted to a vacuum pump pad. On other engines, a small second alternator could be fitted.

If you don't have a second alternator, you should have a small backup battery. Sizing would depend on your typical/ maximum distance between airports. Current draw of the pump, ECU, injectors and coils would be around 12 to 14 amps. A 12 amp/hour battery should give you a solid 30-40 minutes of flight time, just running the engine electrics. An 18 amp/hour one, around 1 hour. We want to be able to sustain at least 10 volts to the electrics.

We've found the most reliable, simple and light way to get backup battery power to the engine electrics is a single 12 to 14 gauge wire running from the backup battery, through a 30 amp ATO fuse, to a heavy duty switch, to an emergency buss where all the engine electrics can receive power. Simply charge the backup battery every 30 days and load test annually.

If you have the recommended check engine light fitted, it will warn you any time the battery voltage falls below 12.5V. You can monitor battery voltage in Gauge 3 mode.

## Programmer Cable(s)

These connect the ECU(s) to the programmer. If you have a single ECU, you should have a programmer with a single serial port on the rear. If you have dual ECU boards, you should have a programmer with two serial ports on the back. Each ECU has a cable to plug into the programmer. Pay attention to the labeling to be sure primary ECU is plugged into primary programmer port and backup to backup.



## Programmer Mounting, 3-1/8" Style Programmer unit

Most aviation installations use the SDS aviation, panel mount programmer which mounts in a standard 3 1/8 instrument cutout. Where there is insufficient panel space, the hand held model may be used and stored elsewhere. Some people will mount it off-panel with two-sided Velcro tape. You must have the programmer hooked up in order to program the system and access features like fuel trim in flight. The programmer does not need to be hooked up once programming is complete however without it, you have no window into the system and no diagnostics. Both programmers have internal backlighting of the LCD. Programmer serial cables are available in 1, 3 and 6 foot lengths. There is no option with the hand held programmer to access 2 ECUs.

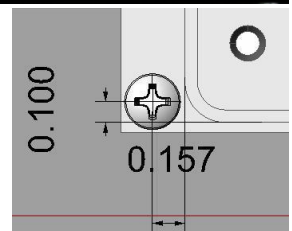


If you have dual ECU boards, you should have a dual access programmer which has a second DB9 port in the rear. One serial cable will connect to each of these ports and each ECU port. The dual access programmer also has a mini toggle switch which is panel mounted. This allows you to toggle between ECUs with the single programmer. **For maximum flight safety, we recommend all aviation applications have a programmer connected in the cockpit.**

The new for 2020 SDS EFI AERO programmer unit has two new keys, PROG AB and LOP eliminate two toggle switches used with the 3-1/8" programmer and works with single or dual ecu's. Designed to mount mid-panel where radio and intercom are mounted.



Cutout opening is 5.636" wide by 1.366" high, with .195" corner radii. Cutout dimension are zero gap so expand opening by desired amount. Mount holes need to fit #6 screws. Mounting hole spacing is 5.95" x 1.166". Use #6-32 x 3/8" long screws to mount. Mounting hole dimensions from cutout opening are .157" to sides of cutout and .100" up from bottom of cutout and .100" down from top of cutout.

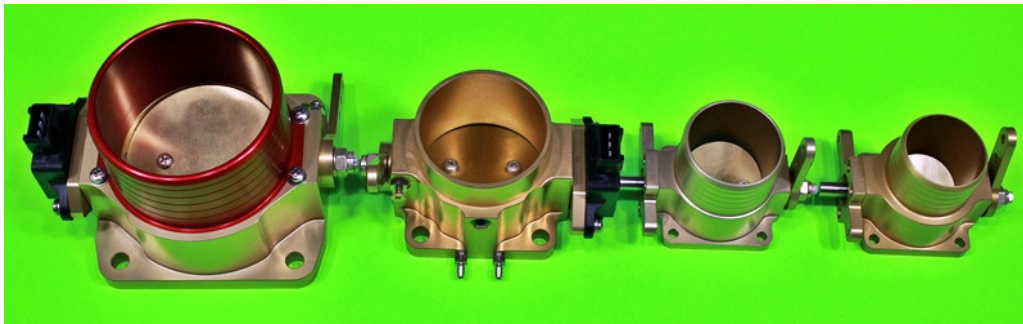


## Mixture knob Mounting

The mixture knob allows quick leaning and richening of the mixture without any reprogramming. It is used to lean the engine in cruise if you run LOP. Think of it as a conventional mixture control. **We recommend that it's always permanently installed as it gives the user important override control in the event of some sensor and fuel system malfunctions.** Try to mount it in such a way and location where it cannot be inadvertently be bumped. The tang should engage a 1/8 inch hole vertically above the main 3/8 inch diameter mounting hole in the panel. This indexes it properly for full range control (+/- 50%).



## Throttle Body Mounting



80, 60, 45 and 40mm throttle bodies

### Lycoming Vertical Induction Engines

We supply a 60mm throttle body for these engines to fit in place of the carb or RSA-5 Bendix servo on O-320- O-540 engines. The TPS and throttle arm are already mounted. Use an ACS 2.5 inch aluminum flange and supplied 2.5 inch silicone hose coupler.

O-235 and O-290 engines use the 45mm throttle body.

### Lycoming Horizontal Induction Engines

We supply either the 60mm throttle body if you have a sump designed for a carb or an RSA-5 servo, 80mm TB if your sump was designed for an RSA-10 servo. Again, the TPS and throttle arms are already mounted for you. The 60 and 80mm TBs have an O-ring seal on their bases so no gasket is required. The 60mm TB snout has a 2.5 inch snout and the 80mm TB has a 3.5 inch ID snout.

### Continental O-200 Engines

These use the wide flange 45mm throttle body

### Other engines

Engines below 120hp may use our 45mm TB in conjunction with a CNC'd adapter (Jabiru 2200/3300 engines) or bolted directly to a new fabricated or modified stock manifold. All TBs have O-ring sealed bases and provision for a TPS. Throttle arms are available for vertical, forward or aft facing applications. 10-32 Allen bolts are used to hold the TB to the manifold.

### Throttle Position Sensor

If you ordered the TPS option, it will already be installed on your throttle body. Some engines run well without a TPS. The TPS offers quicker throttle response on most engines from low rpms. Wire color connections are as follows: Pin 1 orange, Pin 2 blue, Pin 3 white.

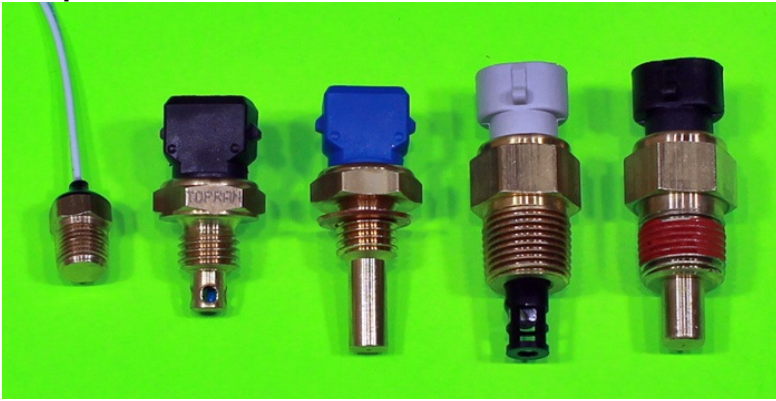
### MAP Sensor

The MAP sensor may be mounted forward or aft of the firewall. **It should be mounted with the vacuum port facing down to prevent moisture from collecting inside. Never mount it with the port up.** Join the sensor port to intake manifold port with 5/32 vacuum hose. You may tee the MAP sensor hose with MP gauges and fuel pressure regulator if desired.





## Temperature Sensors



1/8 NPT, Bosch M 12 X 1.5mm and GM 3/8 NPT temp sensors

Air cooled engines usually use the Racetech sensor provided. This has 1/8 NPT threads and is screwed into a primer or injector port as shown below. Other air cooled engines may also use oil temperature. If this was your choice, you'd have a GM 3/8NPT, Dale 1/8 NPT or Bosch 12 X 1.5mm sensor. Tap your sump accordingly.

Racetech 1/8 NPT CHT sensor mounted in primer port hole. (Lycoming). This sensor is used for cold start and warmup enrichment only and will read much colder than dedicated CHT sensors embedded in the center of the head. 6 cylinder dual systems use 2 CHT sensors.



**When routing the Engine Temp sensor cable to the sensor keep the cable away from spark plug wires by at least 1 inch, and never zip tie this cable to the spark plug wires. There is danger the plug wire could arc to the temp cable damaging this input in the CPU**

## Air Temperature Sensor

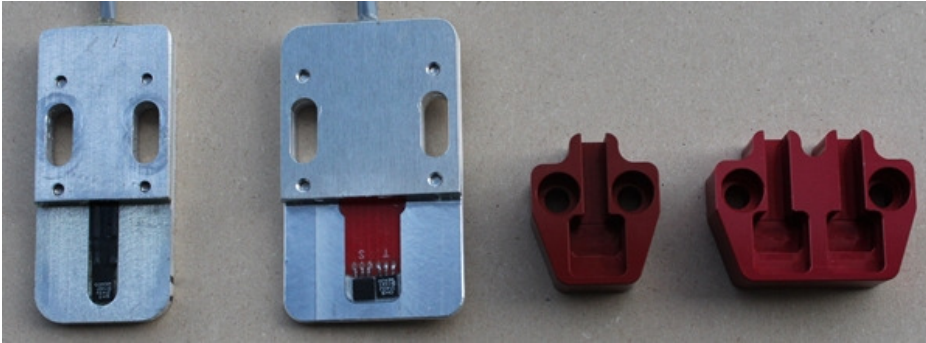
On Lycoming installations, we supply 1/8 NPT sensors. The air temp sensor needs to see induction airflow. There are provisions on some throttle bodies to mount these as below. 6 Cylinder dual systems use 2 air temp sensors. Other engines may use 3/8 NPT or Metric 12 X 1.5mm sensors. Tap accordingly. **When routing the Air Temp sensor cable to the sensor, keep the cable away from spark plug wires by at least 1 inch, and never zip tie this cable to the spark plug wires.**





### Crank Sensor (Hall Effect) and Mounts

Systems controlling fuel only (many Rotax and Jabiru engines) use an adjustable, single element Hall Effect sensor and 2 or 3 magnets mounted to the crankshaft to send rpm information to the ECU. Magnets should pass over the center of the small black squares at the end of the sensors. On Dual ECU systems, the crank sensor cables are color coded green for primary and red for backup. Checked that these are installed correctly.



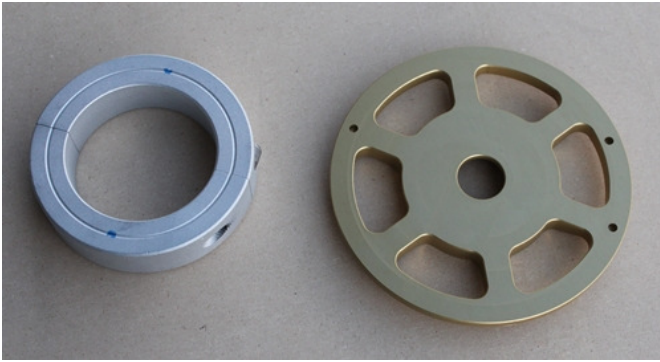
D type (fuel only), F type adjustable blade, Lycoming F type single and dual Hall sensors

**Rotax 912 engines** use a machined magnet disc, which bolts to the rear of the crankshaft (slides over dynamo stub) and a machined Hall sensor mount which bolts to the upper left side of the engine. Magnets are already installed for you. Follow factory recommended torquing procedures for the rear crankshaft nut.



Hall sensor mounts. Left to right: Lycoming 3.25 spacing., Lycoming 3.50 spacing., Rotax and Jabiru

**Jabiru 2200 and 3300 engines** use a split magnet collar, which bolts over the crankshaft as shown below. The supplied Hall sensor mount bolts to the right front of the crankshaft seal plate as shown below.



### **Jabiru and Rotax magnet discs**

Set magnet air gap from the sensor to .050 - .080 inches by shimming the sensor or moving the collar as the case may be.

Indexing of the magnet discs is not important on fuel-only systems. The ECU just needs a frequency. 4 cylinder engines will use 2 magnets 180 degrees apart, 6 cylinder engines have 3 magnets 120 degrees apart. These are called the trigger magnets.

If your engine has fuel and spark control, your magnet disc will have an extra magnet mounted, inverted polarity from the rest. This is the synch magnet and identifies #1 cylinder to the ECU for spark control purposes. You'll also have a twin element Hall sensor instead of the single element one.

If you have spark control, you need to index the magnet disc so that, with the crank at TDC#1, the #1 trigger magnet (one of the equally spaced ones with the synch magnet closest to it) is 80 degrees past the black squares on the Hall sensor, in the direction of crank rotation. See the diagrams in the F Supplemental Manual.

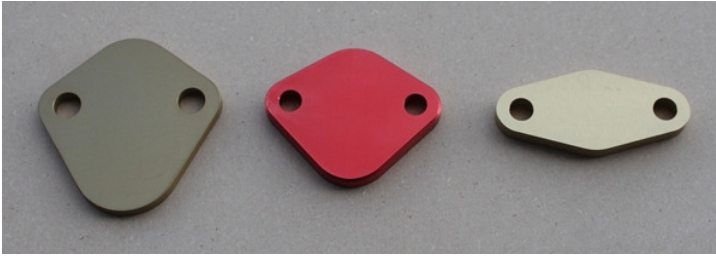
**Lycoming engines** usually have fuel and spark control so magnet indexing is critical. The Hall sensor is non-adjustable and bolts to a dedicated CNC'd mount on the right front side of the crankcase, using the front-most case through bolts. Undo the nuts and be sure the bolts go through the case with the heads on the left side and threads protruding on the right side. On 540 engines, the upper fastener is a stud instead of a bolt as on the 4 cylinder engines. Be sure to have one standard washer against the case on the right side in both cases. Screw the long hex nuts provided in place of the standard Lycoming nuts. Torque to 300 inch lbs. or as recommended for your model of engine.

Single ECU systems use a twin element sensor (red color) with a single cable. Twin ECU systems use a quad element Hall sensor with 2 cables. Install the AN-6 bolts provided with one standard washer under the head, through the gold bracket, into the hex nuts and tighten finger tight for now. Extra thick and thin washers provided are to establish prop air gap from the magnets to sensor face and from the edge of the sensor to the flywheel ID. See photos in the Ignition Supplement for more detail. Be sure the Hall sensor bolts don't hit the case bolts. If they do, place another washer under the head of the Hall sensor bolts. Torque AN6 bolts to 215 in/lb. The 10-32 Allen bolts in the mount to sensors are torque to 25 in/ lb. with blue Locktite on the threads, 30 in/lb. dry.

**The magnets on Lycoming installations are mounted into the flywheel using the drilling/tapping kit provided for your engine type. You must have the 8 7/16 ID flywheel. See the separate detailed instructions included for your engine type.**

### **Fuel Pump Cover**

We supply a fuel pump plate to cover the hole where the old mechanical fuel pump was mounted. Seal this with RTV before bolting in place. If you have the engine apart, you can leave the fuel pump drive rod out (Lycoming), as it's not required with the electric EFI fuel pumps.



Lycoming, Jabiru and Rotax fuel pump covers

## END OF FUEL INSTALLATION PART

\*\*\*\*\*

### General system information

#### EM-5 Reset

Any time that the power is shut off or interrupted to the EM-5, or if interference prevents the software from executing properly, the EM-5 will automatically perform a reset. This takes about 0.5 seconds and the engine will falter during that period. When this happens, the SDS EFI startup screen will appear in the LCD window. Reset can also be caused by the switching of high current devices such as electric pumps, motors or solenoids. These devices cause high voltage spikes that are difficult to filter. Filtering can sometimes be successful if a rectifier diode is placed across the offending solenoid, motor etc. The striped end (cathode) of the diode should connect to the (+) terminal and the other side of the diode to the (-) terminal. **Never attempt to fly the aircraft if your ECU is resetting on the ground! This indicates there is a serious issue. Find it and fix it before flying!**

#### Shutting off Power and Memory

Programmed values are stored in the EM-5 microprocessor in EEPROM memory, which holds the values in memory when power is turned off, needing no battery power. As soon as you change a value with the programmer, it is permanently changed and stored in EEPROM memory. Disconnecting the aircraft battery will have no effect on the SDS system.

#### Disconnecting the LCD Programmer

Set the VALUES LOCK to the ON position before disconnecting the programmer. No data will be lost. Data is stored in the EM-5.

#### Injector Drivers

Injector drive transistors may be triggered in ones, pairs, threes or fours depending on application. Four cylinder aircraft ECUs fire the injectors in ones as of Jan. 31/16 to allow for individual cylinder fuel trimming.

#### Air Temperature (AT)

The air temperature correction map is pre-programmed when delivered, and is not normally user accessible. It provides an absolute density correction relating to cues from the air temperature sensor. AT is displayed in GAUGE mode.

#### Mixture Knob (KNOB)

The mixture knob controls the overall mixture across all ranges. In effect, it adds or subtracts a

percentage to the injector pulse width. From the straight up or 12 o'clock position, the mixture can be leaned roughly 50% by turning the knob fully counter clockwise or 50% richer by turning it fully clockwise.


The knob is very useful in determining a rich or lean condition and is used in cruise flight for leaning the mixture in LOP operations and we recommend it be mounted in all aviation installations. **The knob allows quick changes of mixture without re-programming in the event of some sensor or fuel system malfunctions so should always be installed in aircraft.** Be sure to complete all programming with the knob in the 12 o'clock position so the ECU defaults to best power mixture with the knob at 0% correction. Precise return of the knob to an exact position can be noted in gauge 2 mode under KNOB. A +%, 0, or -% indicates rich, neutral or lean position.



## LCD Programmer

The programmer allows you to access all points within each parameter and change values to program the system. When powered up, SDS EFI should appear in the LCD window along with the system type, software version and burn#. From here, parameters may be called up by pressing the right or left parameter select buttons (< or >). As each parameter is gone through, the next parameter will appear in the window.

Boot up screen:



SDS EFI EM-5  
4U30.0 #7572

Parameters will appear in the programmer window in the following order from left to right:

GAUGE 1

GAUGE 2

GAUGE 3

GAUGE 4

MAGNET SEEN/NOT SEEN (F only) or TACH 1/0(D only)

SETUP MODE ENTRY

LCD BRIGHTNESS

LCD CONTRAST

GAUGE BUTTON SELECT, GAUGE1 or GAUGE4

LOP CONTROL. New for V30 software

LOP MAX MANIFOLD PRESSURE. New for V30 software

LOP IGNITION ADVANCE. New for V30 software

LOP LEAN FUEL ENABLE or DISABLE. Renamed in V30 software

LOP LEAN FUEL %. Renamed in V30 software.

CRANK IGN RETARD (F only)

FUEL TRIM #1 (option must be activated)

FUEL TRIM #2 (option must be activated)

FUEL TRIM #3 (option must be activated)

FUEL TRIM #4 (option must be activated)

LEAN WARNING

A/C FAST IDLE or NITROUS RETARD (F only, not used in aviation applications)

PIN 13 INPUT selects use of aux input on some systems typically this window will not be used for aviation applications with new additional LOP windows above.

O2 TYPE (standard or wideband)

IDLE FUEL AMOUNT (not used on aviation typically)

IDLE TP LOCATION (not used on aviation typically)

RADIATOR FAN ON

RADIATOR FAN OFF

FAST IDLE SWITCH (not used in aviation applications)

RPM SWITCH ON AT (usually used on Honda VTEC engines)

FUELCUT BELOW TP (not used in aviation applications)

FUELCUT/RPM

FUELCUT/MANPRESS

VALUES LOCK ON/OFF

CLOSED LOOP ON/OFF

CL LO RPM LIMIT

CL HI RPM LIMIT

CL MAP LO

CL MAP HI

KNOCK MAX RPM (E, F only)

KNOCK SENSE (E, F only)

KNOCK RETARD (E, F only)  
 MAGNET POSITION (E, F only)  
 LCD BRIGHTNESS  
 LCD CONTRAST  
 START CYCLES  
 START 32 points  
 RPM IGN (E,F only) 38 points  
 IGN RET-ADV/LOAD (E,F only) 64 points  
 ENGINE TEMP 32 points  
 MANIFOLD PRESS or TP 64 points  
 RPM FUEL 38 points  
 ACC PUMP SENSE  
 ACC PUMP LO RPM  
 ACC PUMP HI RPM  
 then, back to GAUGE.

The parameters will automatically loop back to the opposite end upon reaching one of the end selections. By holding down either the right or left parameter select buttons for more than 2 seconds, ranges will advance at the rate of 8 per second until the button is released at the desired location. The << button advances left at 20 frames per touch and can be held down for extremely fast scrolling.

Within each parameter, there are a number of ranges with a corresponding value number beside it. This value number is the one that will be changed to alter the injector pulse width. ie. RPM FUEL 2500, 157.

RPM FUEL is the parameter, 2500 is the range and 157 is the value. The value number may be any number between 0 and 255 on most parameters, however some parameters have limits. The larger the number, the more fuel will be injected at that parameter and range.

To change a value, use one of the 4 buttons labeled +1, +10, -1, -10. Each button will change the value in the window each time it is depressed by that amount. IE. With a 157 in the window, Pressing the -10 button once will change the value to 147. The +10 and -10 buttons should only be used for quick, radical adjustments. Again, by holding down these buttons for more than 2 seconds, values may be changed quickly to the desired figure. Don't play with these unless you want to change the value. **The VALUES LOCK feature must be selected OFF in order to adjust any values.**

## Gauge Modes

Calling up the gauge modes allows you to see in real-time, the sensor inputs to the EM-5. This is useful for diagnosing sensor problems as well as programming. **If you encounter a strange problem or misfire, always select the gauge modes first to see if everything makes logical sense.** Most problems can be quickly diagnosed here if you understand the system. Gauge modes update at approximately twice per second.

## Gauge1 Mode and Error (ERR) Codes

**If you are in any parameter in the LCD Programmer you can push the GAUGE button to jump to gauge1 mode. Push the GAUGE button again and the programmer will jump back to the parameter that you came from.**

Starting in V29 software, you can also reconfigure the programmer to go to either gauge 1 or gauge 4 mode when the gauge button is pressed. Use the +1 button to toggle when in the windows below:



GAUGE BUTTON  
SELECT GAUGE 1



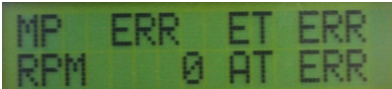
GAUGE BUTTON  
SELECT GAUGE 4

Gauge 1 or 4 mode can be accessed by pressing the gauge button once.



```
MP 9.11 ET106°F
RPM 0 AT 72°F
```

Gauge 1 mode



```
MP ERR ET ERR
RPM 0 AT ERR
```

Gauge 1 mode showing error codes

MP displays engine vacuum in inches mercury absolute. The MP reading will change to ERR if the map sensor loses its connection on the ground or power wires. If you see ERR check the connector at the sensor and also check the wires for breakage. The sensor may have failed also. ET and AT are engine and air temp readings which will also read ERR if the circuit is broken. For MAP and temp sensors, ERR will stay displayed even if the fault was momentary. You can attempt to clear ERR by pressing the +10 button when in Gauge1 or 4 mode. If the ERR clears, then the problem was intermittent, and if the ERR stays displayed then there is a problem such as a broken wire or damaged sensor. **Never attempt to fly the aircraft with ERR codes displayed on the ground!**

## Gauge 2 mode

Gauge 2 mode can be accessed by pressing the right button (>) once when in gauge 1 mode.



```
KNOB- 2% AP 0
DUTY 0% IGN-10°
```

Gauge 2 mode

Knob indicates the mixture knob position, +/- 50%. 0% (no correction) is with the witness mark straight up at the 12 o'clock position.

AP indicates the acceleration pump feature, which adds extra fuel as the throttle opens. AP should read zero when the throttle is steady. The AP number should increase above zero as the throttle is opened. If AP reads a value higher than zero when the throttle is stable, the throttle position sensor may be faulty.

Duty Cycle (DUTY) refers to the amount of time that the injector remains open in relation to how much time is available at that rpm before the next injection cycle begins. If the engine is missing or running rough check DUTY for unstable readings. This may indicate a bad sensor or wiring issue.

**The maximum continuous duty cycle should never exceed 85%.**

## Ignition (IGN) F Models Only (Fuel only models will not display ignition parameters)

A positive sign indicates that the ignition timing is **after** TDC. If timing is after TDC, ignition programming could be wrong, or the knock sensor could be set too sensitive, picking up engine noise. Having ignition timing after TDC will cause major loss of power and possible engine damage.

IGN



```
IGN- 8°
```

 IGNBTDC.JPG

A negative sign indicates that the ignition timing is before TDC. Ignition is normally BTDC.



```
IGN+10°
```

 IGNATDC.JPG

If you need to get to gauge2 from any parameter you can do the following. Push GAUGE, then the > button to get to gauge2, then the < button back to gauge1, then push GAUGE button to return to the previous parameter.

### Gauge 3 Mode

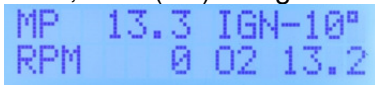
Gauge 3 mode is accessed by pressing the right button (>) once, when in Gauge 2 mode. The top line displays battery voltage and throttle position (TP). Second line displays the A/F ratio and barometric pressure.



Gauge 3 mode

### Gauge 4 mode

Gauge 4 mode is accessed by pressing the right button (>) once, when in Gauge 3 mode. This gauge mode displays the most popular engine information on one screen. Manifold pressure, RPM, AFR (O2) and ignition timing



Gauge 4 mode

END OF GAUGE MODE SECTION

\*\*\*\*\*

### Basic SDS Fuel Tuning

Important programming and tuning tips:

CLOSED LOOP **MUST** be turned OFF, and it is normally off when shipped from the factory. We highly recommend using a mixture meter to aid in tuning.



Let the engine reach full operating temperature before fine tuning any MAP or RPM values. If you try reprogramming while the ECU is still adding extra fuel for warmup, you are wasting your time and getting off track.

You must vary only one parameter at a time and observe the AFR meter. If you change both rpm and MAP, you don't know which parameter is affecting the air/fuel ratio. Hold MAP constant and vary rpm or vice versa, never both.

**It's vitally important that you understand- injector open time (the amount of fuel injected) is a result of the RPM FUEL value TIMES the MAP FUEL value. RPM values address fueling changes related to volumetric efficiency (engine breathing). MAP values address load. These are two separate parameters which come together in the ECU to determine how much fuel is injected.**

Make absolutely sure that fuel pressure is staying where it should, that all injectors flow the same volume, have good patterns and that injectors, filters and pumps have sufficient flow rates to feed your engine at full power. **No amount of programming will fix inadequate fuel flow caused by a mechanical fuel system problem.**

The fuel tuning has been written in the sequence that we recommend tuning the system. RPM FUEL first, followed by Manifold Pressure, Acc pump, Engine Temp, Start, closed loop and fuel cutoffs/limits.

The amount of fuel injected by the EM-5 is determined by the values in rpm fuel, manifold pressure, acc pump, engine temperature, start, air temperature. Once, the engine is at full operating temperature, the main values that determine the fuel mixture are RPM FUEL and Manifold Pressure. Most of the Manifold Pressure values can be left at their factory settings when the RPM FUEL values are set properly. RPM FUEL values are where programming should begin.

## RPM Fuel

The rpm band is divided into 38 ranges, either 100 or 250 rpm apart. **This parameter is where the main fuel programming is done in SDS systems.** The variables which ultimately determine the RPM FUEL values are engine displacement, injector flow rate and volumetric efficiency of the engine. Volumetric efficiency varies with RPM. As a result, RPM FUEL values will vary accordingly. If a richer mixture is desired at certain RPM's, the RPM FUEL value will need to be increased. There should not be large changes in adjacent values in RPM Fuel, rather smooth transitions.

```
RPM FUEL  02LOG
2500 165  --.-
```

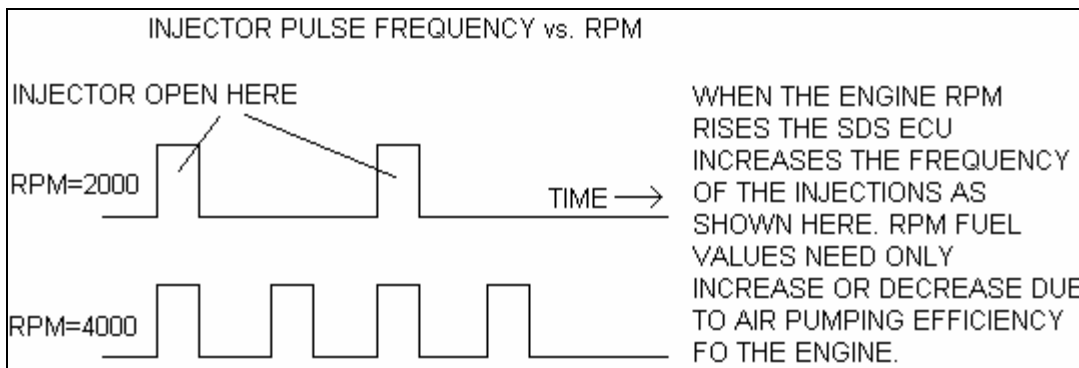
Your system has a base map entered for the recommended injector flow rate or for the injectors included in your kit.

Often people have their RPM FUEL values incorrect and find themselves having to re-slope the entire 64 manifold pressure values, which can lead to further problems. When the RPM FUEL values are setup correctly, the majority of manifold pressure values can be left unchanged, thus greatly simplifying tuning of the engine.

If you double the RPM FUEL value, this will double the pulse width of the injector pulse. If you wanted to make the mixture 10% richer then you would simply add 10% to the RPM FUEL value. Example: RPM FUEL value was 100, and is then changed to 110. This would add 10% more fuel to the mixture.

**It is important to note that the number of injections are doubled when the rpm is doubled regardless of the values entered. See figure 4.**

With V31+ software, the maximum RPM fuel value is 350 where prior versions maximum was 255.





## Startup Procedure

Make sure that fuel at the correct pressure is present at the injectors. Turn on ignition and computer power. Crank the engine, rotate mixture knob richer while cranking. If engine does not fire, see troubleshooting section. You may also have to increase the START values to get the engine to fire.

Once the engine is running, use the mixture knob to get a smooth idle. Let the engine warm up to normal operating temperature. Once warmed up, attempt to set the knob near the center position (12 o'clock). To do this will most likely require adjustments to the RPM FUEL values. If the knob is on the rich side of 12 o'clock, the RPM FUEL values are too low and vice versa.

**On F systems, you must set the MAGNET POSITION parameter as soon as the engine is idling smoothly before performing any other adjustments. Refer to that section of the F manual.**

## Fine tuning RPM FUEL values

We normally want to aim for around 12 to 1 AFRs and this is best determined using a wideband AFR meter. You can read the AFRs in gauge 3 or 4 screens. AFR is displayed as O2 in Gauge 4 as shown below.



```
MP 13.3 IGN-10°
RPM 0 02 13.2
```

## Correcting the Mixture Using a Wideband AFR Meter

Example #1: At 2500 RPM say, we have an RPM FUEL value of 108. The A/F ratio is 14.7, but we would like to make the A/F ratio 13.5.

Correction= $14.7/13.5$

Correction= 1.09.

Now we multiply the RPM FUEL value by 1.09.

$108 \times 1.09=117.7$ . Round off to 118.

Example #2: At 2000 RPM say, we have an RPM FUEL value of 108. The A/F ratio is 12.5, but we would like to make the A/F ratio 13.5.

Correction= $12.5/13.5$

Correction= 0.93

Now we multiply the RPM FUEL value by 0.93.

$108 \times 0.93=100.44$ . Round off to 100.

With a wideband sensor, best power will usually occur with an A/F ratio of around 12.5:1, however automotive type engines may not tolerate running this lean due to piston thermal considerations and air cooled aircraft engines may not cool sufficiently. We recommend most engines be set up to run around 11 to 11.5 AFR during high power conditions- WOT, takeoff and climb. **See the appropriate supplemental manual for your engine type for more detailed specific information.**

## Manifold Pressure, MAP or MP

There are 64 programmable ranges in the manifold pressure chart for adjusting fuel. Data in the manifold pressure chart determines the relationship intake manifold pressure and the amount of fuel injected. Aviation EM-5 systems are calibrated in inches of mercury absolute. There are 3 different MAP sensors used with the system which cover a different range of pressures. All units are pre-programmed with a standard MAP value chart depending on the MAP sensor used. These values should be close, so most initial programming is usually done on the RPM FUEL values. **MAP values generally increase in a near linear fashion as manifold pressure increases.** Your MAP values should never go up and down like a sawtooth!

MANIFOLD PRESS  
27.4 106

The more open the throttle is, the higher the manifold pressure, so the manifold pressure values must be higher. SDS delivers a longer injection pulse to get more fuel into the cylinder. By adjusting the manifold pressure values from their default, you can change the mixture of the engine at different pressures to achieve best power or economy.

Use Gauge 1 mode to see what manifold pressure range the engine is running in, then use the < > keys on the programmer to move to the range you want by adjusting the values if desired.

## Lean Warning

This feature allows some protection against a lean condition at higher throttle openings. You must have a wideband meter that has an analog output connected to the SDS main harness gray wire and a TPS installed for this feature to operate. This feature may not be reliable with leaded fuels since they affect operation of O2 sensors. If enabled, the system will monitor the O2 sensor voltage, and when throttle position is 35 or higher, and if the mixture is leaner than approximately 14 to 1 for 2 seconds, then an ERR message will be displayed in Gauge 3 and Gauge 4 modes in place of A/F or O2 volts. Also this will turn on the check engine light output on the ecu. The ERR message and check light remain until you manually clear them by pressing +10 while in Gauge1 mode. The ERR message and check light also clear when SDS is powered down.

There are 3 settings for this parameter:

1. Disabled. Correct setting when no O2 sensor is connected to the SDS ecu.
2. Enabled. Turns on Check light, and displays ERR in Gauge modes. Does not add fuel.
3. Enabled + add fuel. This does the same as the Enabled setting, plus when the ERR occurs, 25% will be added to the fuel mixture above throttle position 35. This may help prevent engine damage by allowing the tuner time to acknowledge the problem and close the throttle. To clear the ERR message press +10 while in Gauge1 mode, then this will remove the extra 25% fuel. Then further tuning or troubleshooting should be done.

LEAN WARNING  
DISABLED

**We recommend that lean warning be disabled on engines which will routinely be running lean of peak (LOP).**

**Lean Warning should be set to Disabled when there is no TPS installed.**

**Lean Warning may not function long term when Leaded fuel is used since the lead may foul the O2 sensor. Lean warning will not function unless a TPS is used.**

The Lean Warning will not function if O2 Type setting is "NONE".

## LCD Brightness and Contrast

On systems made after Aug. 20/17, there are 8 settings for the LCD backlighting brightness, from 0 to 7. Use the +1/-1 buttons to increase or decrease brightness for ambient cockpit lighting conditions.

LCD BRIGHTNESS  
4

LCD CONTRAST  
10

There are 16 contrast levels available, from 0 to 15. This feature can help optimize viewing at different viewing angles and also during temperature extremes. High temperature can affect the contrast so an adjustment may be needed to compensate. Use the +/- buttons to increment or decrement the setting.

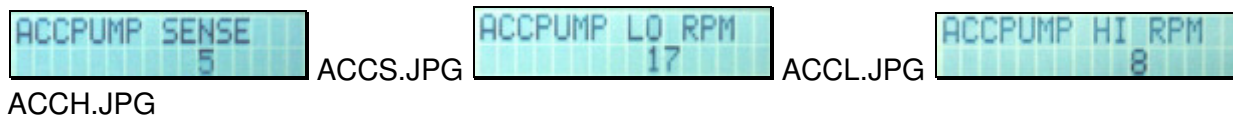
## Idle

Best to adjust RPM FUEL values first to get the best idle mixture. For the most stable idle you will need a rich mixture. If you have a wideband meter, a good target mixture for idle is 12 to 13. Don't adjust fuel numbers because the engine is idling too fast. If the engine is idling too fast, adjust the airflow on the throttle plate assembly, then recheck and adjust the RPM FUEL ranges where the engine is idling. Usually keeping RPM FUEL numbers from 500 through 1200 equal is also a good idea. This will help keep the idle from surging up and down.

If idle still seems a bit unstable, then you may need to also adjust a few MANIFOLD PRESSURE values to improve smoothness. To do this, press the Gauge button to see gauge1 mode, note the MP reading on the top left. Then scroll left and into the manifold pressure values, just above and below where the engine is idling at, and make the values all equal. We have done this by default around 10" vacuum, but some adjustment might be needed. If the MP fluctuates over more than 3 ranges, you may have to install a .025 to .035 inch orifice in the MAP sensor line to help average and stabilize the vacuum seen by the SDS computer.

## Acceleration Pump (ACC Pump)

You must have a TPS installed to have this function active. ACC PUMP values help give smooth throttle response when the throttle is opened quickly. There are three adjustments to make for the acceleration pump. Adjustment should be done when the engine is at normal operating temperature.



The ACCPUMP LO RPM value controls action from 0 to 1800 rpm. With the engine idling, quickly open the throttle. If the engine hesitates, change the value. If the hesitation is worse, you have changed the value the wrong way. Find the value that gives the best quick throttle response.

Next is to adjust the ACC PUMP SENSE. This is very important just out of the idle range. Set this control by opening the throttle slowly from the idle position. Adjust for the smoothest acceleration. 1 is least sensitive, 8 is most sensitive.

The ACCPUMP HI RPM setting controls action above 1800 rpm. Snap the throttle open quickly above 1800 rpm. If the engine hesitates, change the value. If the hesitation is worse, you have changed the value the wrong way. Repeat this procedure until engine response is acceptable.

Acc pump values are generally between 5 and 50 on most applications. The ACCPUMP LO RPM is usually a higher value than ACCPUMP HI RPM.

## Engine Temperature (ENGINE TEMP, ET)



There are 32 ranges under this parameter which determine the amount of extra fuel injected to compensate for a cold engine during warmup. Liquid cooled engines use a water temp sensor and air cooled engines use a cylinder head temp sensor to supply a signal to the EM-5. The function of this parameter is similar to a choke on a carburetor.

You should aim for a 0 value when the engine is at normal operating temperature. Most engines will not require extra fuel after 100-140 degrees F. The values should decrease in a fairly linear fashion from cold to operating temperature then have 0's entered above this threshold. Temperatures can be displayed in F or C.

As a reference, a value of 127 would add 50% to the pulse width and a 255 entered will double the pulse width.

By flicking back between Gauge 1 mode and ENGINE TEMPERATURE you can make adjustments while the engine is warming up. Each time the EM-5 updates to a new ET in gauge mode, you can go to that ENGINE TEMPERATURE range in the programmer. Now turn the knob richer and leaner and note where the engine starts to run rough on each side of 12 o'clock. If it runs rough say at 10 and 2 o'clock, you probably have the engine temp values about right. If not, adjust the ENGINE TEMP value at the engine temp displayed currently in Gauge1 mode.

### Start (START)



Start enrichment is provided for under the START and START CYCLES parameters. The EM-5 reads the signal from the engine temperature sensor, looks up the START value at that temperature range, and injects extra fuel for a certain number of engine cycles after the EM-5 detects crank rotation. This function is activated every time that the engine is started, no matter what the engine temperature is. However, if there is a zero at the current temperature range, no extra fuel will be added. START values are critical for proper starting, especially in cold climates.

At colder temperatures, the values are high, tapering off as the engine warms up. At temperatures over 100 to 140°F, most engines do not require much extra fuel so the values should be low or 0 here. Experimentation is required for a satisfactory setup here.

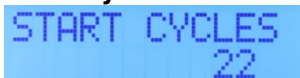
**It is best to not open the throttle during cranking, especially in cold temperatures. Opening the throttle will cause a leaner mixture during cranking. The engine needs a rich mixture to start.**

Tuning all the START values will take many days in very cold climates. You can usually only tune one value per day, and you will have to wait for colder weather to adjust the colder ranges.

Systems will do 1 injection of fuel at key-on, when the Start value is greater than 0 at any temperature. This will improve cold starting.

Aviation systems have special software to allow manual priming without the engine turning over. You may stroke the throttle a few times in cold conditions to open the injectors momentarily. This acts just like a primer and may aid starting in very cold climates. **Close the throttle when cranking, even if you prime.**

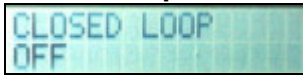
### Start Cycles



The value entered under START CYCLES determines how many engine cycles START enrichment lasts for. This is the number of crank revolutions times 2 on a 4 stroke engine. Some engines require start enrichment lasting a long time, others only require a short start enrichment period. The larger the value under START CYCLES, the longer the enrichment period. This is adjustable between 0 and 255, but a value of 40 is probably as high as you would ever need, and do not set this below 10 because too low a value will make the START function expire too quickly.

Both START and START CYCLES must be set carefully. If the engine fires immediately at any temperature, the START values are good. If the engine takes a lot of cranking to get running, the START values may be too low. If the engine starts quickly but then stalls after a few seconds, there are two possibilities; either the START CYCLES value is too low or when the start cycles have expired, the ENGINE TEMPERATURE values are too low. Once the start injection cycles have occurred (usually 3-10 seconds), the EM-5 relies on ENGINE TEMPERATURE values for warmup enrichment. **These two parameters should not be confused.** The START function is automatically reset after the engine stops turning.

### Closed Loop



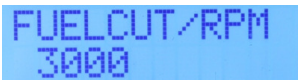
CLOSED LOOP  
OFF

Generally in aviation applications, we do not use the closed loop function as this targets stoichiometric mixture which equates to peak EGT. We recommend you leave closed loop turned off at all times.

### Fuel Cutoff, Rev and MAP Limiting

RPM and MAP limiting in SDS are very harsh so it is not recommended that you constantly hit the rev and MAP limits with SDS. These limits are intended for protection only, primarily for propeller governor or blade loss conditions. Set them slightly higher than your maximum limits so you don't run into them in normal operation.

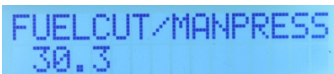
### Fuel Cut /RPM



FUELCUT/RPM  
3000

This will limit the RPM's of the engine by cutting off fuel if the engine attempts to rev higher than the setting. For example if the FUELCUT/RPM was set to 3000, then fuel would cut off at 3050 or 3125 RPM's depending on rpm steps in your programmer. Adjustments are in 100 or 250 RPM increments.

### Fuel Cut/ MAP



FUELCUT/MANPRESS  
30.3

Generally only used on forced induction engines. This will limit the amount of manifold pressure to protect the engine from over-boosting resulting from a malfunctioning wastegate etc by cutting off fuel injections when manifold pressure exceeds this setting. For example, if you are running around 40 inches MAP you should set this parameter to around 42 or 43 inches, so the engine will not hit the limit under normal conditions.

Factory setting is NO CUT which disables this feature, so it will not affect the system. **If this parameter is adjusted to a low MAP range, it can cut off all fuel causing a no start condition.**

### Fuel Cut/ Below TP



FUELCUT BELOW TP  
NO CUT

This parameter is used to cut off fuel when gliding with the throttle closed. It is in operation only when the engine is above 2000 rpm and a TP value is entered in the window. When it is set to NO CUT the function is disabled. This parameter is usually not used in aviation applications.

### RPM Switch



RPM SWITCH ON AT  
3000

This feature is usually used on Honda VTEC engines to control the VTEC solenoid.



## Values Lock



This feature allows you to lock out the programmer function to prevent accidental changes to your values. To lock your values, select VALUES LOCK window in the LCD programmer. The +1 and -1 buttons are used to select it to the ON or OFF position. When you are done programming for a while or plan to disconnect the programmer always engage VALUES LOCK ON. **You cannot program the system with VALUES LOCK ON selected.**

## Optional Individual Cylinder Fuel Trim (4 cylinder)

This option, when activated through a discrete pin code for each burn#, allows the user to add or subtract to the injector pulse width on each cylinder usually based on EGT readings. **Leave the FUEL TRIM value at zero until all other programming is complete.** You should only use this feature if you have an engine monitor with individual EGT probes for each cylinder. It's generally designed for engines which have unequal mixture distribution, running Lean of Peak (LOP). When set correctly, all cylinders should peak at the same time.



You can trim each cylinder +/- 10% using the +1 or -1 buttons. Scroll right to access the trim windows for cylinders 2, 3 and 4. For 6 cylinder systems, see the 6 cylinder supplement for trim instructions and wiring.

## Setup Mode



This window makes Setup Mode easier to enter than prior versions. There are many windows in here that configure the system for particular applications.

**Never change Config settings unless instructed to do so from the factory, as these settings can alter the system in many ways and make the system not run properly or not run at all.**

## Optional Fuel Flow Output to Engine Monitors

SDS EM-5 ECUs with V26.1 or higher software have the capability to output a fuel pulse signal similar to electro/mechanical flow meters. This capability is also activated through a discrete PIN number for each individual software burn# once the option is paid for.

Output to your engine monitor is via the brown wire on pin 2 of the injector drive harness plug.

In SETUP MODE, (see setup mode section), scroll right with the > button until you have this windows displayed:



```
SETUP FUEL PULSE  
OUT 340
```

SETUP FUEL PULSE OUT. This calibrates the output to the engine monitor to fine tune the fuel flow and totalizer amounts depending on injector flow rate. The normal range of values is about 150 to 450. Maximum is 655. **A higher number here = a lower displayed fuel flow.** Use the +/- 1 button to change the value.

We can provide you with an **approximate** value to enter for your injector type. **Fine tuning and calibration of this value is up to the user. Never rely on the fuel flow readings or totalizer amount until calibration tests verify the accuracy of the displayed information!** For Dynon engine monitors, we recommend a value of 29,000. You can tweak either the SDS or Dynon value to calibrate.

To calibrate, on aircraft with two fuel tanks, we recommend filling the tanks and doing all ground running, takeoff and climb on one tank. Once you get to cruise altitude and set cruise power, switch tanks and fly for one hour, preferably at the same power setting, note the displayed FF. Switch to the other tank at the one hour mark and use this tank for the rest of the flight and ground running prior to shutdown. Refill the cruise tank first and note the amount taken. See how well this compares with the indicated FF in cruise. Fill the other tank and see how the total amount taken agrees with the totalizer amount. Tweak as required several times until you're satisfied with the accuracy of the displayed amounts.

Scroll right one more place to see:



```
SETUP FUEL PULSE  
INJ LAG 1180
```

SETUP FUEL PULSE INJ LAG. This calibrates the ECU for injector latency or lag time which is the amount of time it takes for the injector to open after current is applied to it. This number is usually between about 1000 and 2000. We can provide you with the number to enter for the 2 types of injectors we offer.

## Dual ECU Programmer Functions

If you have the dual ECU board option with 2 boards in one enclosure, you'll have a special panel mount programmer to go with it. This programmer has added circuits and a 2<sup>nd</sup> DB-9 connector to communicate with the two ECU boards, eliminating the need for two programmers

### New for 2020, SDS EFI AERO programmer unit.

#### New features:

Two new keys, PROG AB and LOP eliminate two toggle switches used in prior systems.

Built in Fault LED, replaces separate panel mounted LED.

Works with single or dual ecu's.

LOP LED indicator.

Higher contrast white on blue LCD display.



### LOP key operation



Pressing the LOP key will activate the function in the EM-5 ecu and will advance ignition timing and lean fuel depending on the settings. Note that LOP will be enabled but for the LOP advance and Fuel Leaning to occur a few conditions must be met: Manifold Pressure must be equal or less than LOP MAX MANIFOLD PRESSURE setting.

Engine RPM's must be high enough. There is no need for LOP at low engine RPM's like idle or taxi conditions.

Engine RPM's must be 1500 or higher on systems set for 100 rpm incremented rpm ranges (typical lyc & conti). For high revving engines (auto engine conversions & geared), SDS is set for 250 rpm increments, the minimum rpm is 2200.

Also note that if using PIN13 and your own toggle switch to activate LOP then the key will not function. And if using PIN13, the blue LED will light when the PIN13 input sees 6 volts or higher.

### Fault LED



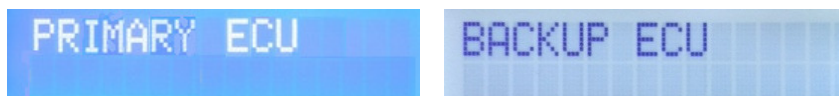
This takes over in place of the SDS panel mounted check engine light. If this LED is flashing, then check Gauge1 screen RPM, MAP and Temperature readings to see if any display ERR. If none do, then the fault is likely low main voltage which may be common if electronics are powered up but the engine is not running. In Gauge screens you can press the plus key to attempt to clear and faults (ERR) if the fault is

still lit check voltage in gauge3 mode, if below 12.5 V then voltage is the cause of the fault LED flashing

### A B Prog key



On Dual board EM-5 systems, this key is used to access and program each ecu separately. LED's indicate which ecu is being accessed, green for A (primary) ecu, and yellow for B (backup) ecu. This key replaces a toggle switch used on older systems. This key serves no function on single ecu systems.



The programmer will remember where it was when switched, which allows you to be able to most quickly duplicate values in both ECUs. The screens above will come up for about 2 seconds when switched to show you which ECU board you are accessing.

**Please note: the programmer selection switch does not switch which ECU is running the engine, the switch only allows programmer access to each ECU.**

## Dual board ecu's, Duplicating values into the Backup Ecu.

We generally recommend that you duplicate all values in both ECUs with a few exceptions:

Magnet Position: This value will be different in the Backup ecu vs. the Primary ecu.

On 4cyl engines: In the backup ecu set the Acc Pump Sense to 1, Acc Pump Lo RPM and Acc Pump Hi RPM to **zero**, due to the backup ecu not being connected to the Throttle Position sensor.

## Fuel ECU Switch

When running dual ECU boards, this toggle switch activates relays which switch operation of the injectors from one ECU board to the other. In normal operation, one board is always firing the top spark plugs, the other fires the bottom plugs. The ECU select switch only switches the injector connection over to the other board. If one ECU board fails, you'll lose one set of plugs but the engine should continue to run.

The recommended ECU checking procedure is to start the check on the backup ECU. At idle, Switch the ECU selector switch from Backup to Primary. If the engine continues to run, both ECUs are working. Now you can switch coil power off on the #1 coil pack. Switch that one back on and then switch off #2 coil pack power. If the engine continues to run, both coil packs are working. **Be sure to check that both coil power switches are back on prior to takeoff.**

## Default Protection Values (Important)

You may have noticed that there are some strange values entered in your ECU(s) at the far ends of the MAP and temp sensor ranges. These are there to allow the ECU to continue to run the engine at near full power in the event of a shorted or open MAP or temp sensor failure. **Do not change these values!** These are in ranges that the ECUs will never operate in during normal circumstances and will not affect day to day running of the engine. These are zeroes at the coldest Engine Temperature range, and 100's in the bottom few Manifold Pressure ranges.

## RPM, MAP, Fuel Delivery, Duty Cycle, Injector concerns

If your mixture still leans out under high power conditions no matter how large your MAP and RPM values are, the system is not at fault. Check for fuel delivery problems. Check the duty cycle first in gauge 2 mode at full power. If it's over 100%, you have a problem with the injectors, pump or regulator. **If your fuel pressure does not keep up with demand, the engine will not run correctly no matter how you program the system.** If your injectors are too small, the same thing applies. At full throttle and high rpm, the mixture should be fairly rich- around 11.5 to 12.5 AFR.

If your values go all over the place with huge steps or deviations, you are probably doing something very wrong. Most well mapped engines have smooth transitions from one step to the next. Look at the sample maps in your manual. If you are really stuck, send us your values, and we can usually suggest some constructive changes.

END OF BASIC TUNING INFORMATION SECTION

\*\*\*\*\*

## EM-5 Aviation System ECU Pinouts

### DB25

Pin 1	Switched 12V power ECU, Red 20 ga.
2	TPS 5V
3	Knob 5V
4	MAP 5V
5	Future use, brown.
6	MAP signal
7	Air temp +
8	Coil trigger 8 cyl. Channel A
9	Coil trigger 4 cyl./6 cyl. Channel A, Channel C 8 cyl.
10	Coil trigger 6 cyl. Channel B, Channel D 8 cyl.
11	Coil trigger 4 cyl. Channel B, 6 cyl. Channel C, 8 cyl. Channel B
12	5V tach output, Green 20ga
13	Ignition advance/ LOP switch enable input, blue 20 ga.
14	Mixture knob ground
15	MAP ground
16	Air temp ground
17	Engine temp ground
18	ECU ground, black 20 ga.
19	Mixture knob signal
20	Engine temp +
21	TPS signal
22	12V tach output, yellow 20 ga.
23	Future use, purple, not used now, for future use.
24	O2 sensor input, gray 20 ga.
25	TPS ground

### DB9 Hall Sensor

Pin 3	Ground
4	Trigger signal
5	+5V
8	Synch signal

### Wire colors Sheathed Cable

2 conductor- White + or power, Blue ground

3 conductor- Orange + or power, White signal, Blue ground

4 conductor (Hall sensor) Orange +5V, White trigger signal, Blue ground, Green synch signal



# Diagnosing Problems and Troubleshooting

## Check Engine Light

**Software in the EM-5 can detect some but not all problems with the following sensors:**

MAP sensor: Power or ground connections, broken or intermittent.

Engine and air temperature sensors: Open or short circuit.

Hall sensor/RPM error problem: Caused by missed magnet or vibrating hall sensor mount.

Low battery voltage: If below 12.5 volts, will turn on the LED.

Lean warning(if enabled): If lean mixture occurs at high throttle for 2 seconds.

Check Gauge modes for “ERR” readings to see which sensor has a problem.

RPM, temperature, MAP sensor errors, even if occurring for a very short period of time, will leave the check engine light turned on so the user can see there was a problem. You can attempt to clear the error and light by pressing the +10 button in Gauge1 mode, and if the light stays lit, the problem still exists. If the light turns off, the problem may be intermittent and you should check electrical connections at the faulty sensor, or check hall sensor alignment if gauge mode shows an RPM ERR message. **Never fly the aircraft if the check engine light stays on after starting and the battery voltage is above 12.5V.**

Low battery voltage will not lock the light on, instead the light will turn off when the battery voltage goes above 12.5 volts. It will be normal to have the light turned on while the ignition is turned on but the engine is not running, since battery voltage is usually under 12.5 volts.

**Some problems cannot be detected such as MAP sensor broken signal wire. Just because the LED is turned off doesn't mean everything is good with the system. SDS cannot detect faulty O2 sensors. SDS cannot detect all sensor problems.**

Water entering the computer can be a common problem with improper installations. Remove the lid of the EM-5 and inspect the inside for water, or corrosion. Water, which has dried, leaves a white residue on the circuit board. Water may still be present under or inside connectors, which will cause random symptoms and running problems. The EM-5 may operate fine once dried out or may need to be sent in for repair.

The four gauge modes permit monitoring of the primary sensor inputs to the EM-5 in real-time. Rpm should be stable, agreeing with the factory tach. Spurious rpm readings usually indicate ignition or triggering interference, or a Hall sensor problem. **Don't attempt to fly with unstable rpm readings or RPM ERR codes displayed in the programmer.**

Manifold pressure should increase as the throttle is opened at a given rpm. Opening the throttle should increase the TP number. The TP number should not change if the throttle is not moving.

Engine and air temps should roughly agree with the ambient temperature if the engine has been shut down overnight.

Switching to gauge 2 mode allows you to monitor the mixture knob position. It should read 0 at the straight up position. You should be able to get the reading to change from -49% to +49% by turning fully to both stops.

In Gauge 2 mode, acceleration pump operation is verified by snapping the throttle open. The AP number should rapidly increase until movement is stopped then the number should rapidly decrease to 0 again. The AP number should always be 0 unless the throttle is being moved. Rough running and a fluctuating TP or AP reading without throttle movement indicates a TPS problem usually. **Don't attempt to fly with unstable TP/AP readings displayed in the programmer.**

When encountering problems which can be identified to be linked with a specific area or function, always go to that section in the manual first and re-read it.

## Symptoms- Fuel Problems

### Engine will not start:

1. Check FUELCUT/MANPRESS parameter. Should read NO LIMIT.
2. Try turning mixture knob richer while cranking. START values might have to be increased.
3. Check all connections on EM-5 main harness, ignition.
4. Check both ground wires from EM-5, one from main harness and one from injector drive harness.
5. Check MP reading in Gauge1 mode. If between 0 to 10 inches, check MAP sensor connector for broken wires, or bad contact in the terminals. Try new MAP sensor
6. Check for +12V to injectors while engine is cranking.
7. Check if the programmer goes blank during cranking. Check battery voltage. Should be at least 9 volts while cranking, and 12.0 volts when not cranking.
8. Check for spark.
9. Check ignition timing while engine is cranking.
10. Check if the fuel pump is running.
11. If fuel pump relay is used, check connections.
12. Check for fuel flow out of regulator drain to return of fuel tank.
13. Check for injectors clicking.
14. Check FUELCUT/RPM parameter. Should read NO LIMIT, or a high RPM.
15. Check compression and camshaft timing.
16. Check Hall sensor gap and alignment with magnets.
17. If using a noid light, make sure all of the injector plugs are unplugged from every injector. Check +12v supply to injectors and check grounds on ECU. Use noid lights as a last resort. LED noid lights are much better than incandescent.

It is highly unlikely that there is a problem with the EM-5, since many ECU's in the past have been returned with "no fuel" symptoms, but they work just fine so check all of the above carefully.

### Will not rev up or has Miss:

1. Check ACCPUMP values. May be too high.
2. Check AP number in gauge 2 mode. Should be zero when throttle is stable. Check this with engine running. May only show up at certain RPM's.
3. Check for leaking fuel pressure regulator diaphragm. If fuel in vacuum reference hose then replace the regulator.
4. Check for bad values in RPM or MAP parameters. Could be crossing a bad value anywhere.
5. Hall sensor mount is vibrating. Stronger bracket required. Watch RPM reading in gauge 1 for ERR message.
6. Check FUELCUT/MANPRESS and FUELCUT/RPM parameters.
7. Check resistance of all spark plug wires. Possible poor crimp at the end of a wire causing arcing.
8. Try a different brand of spark plug wires.
9. If Knock sensor is being used, Knock Sense value may be too high. If there is no knock sensor on the SDS, system set Knock Sense to 1, and Knock Retard to zero.

### Unstable RPM reading in Gauge 1 mode.

Check hall sensor alignments and magnets. Bracket must not vibrate or flex.

### Idle speed too high:

1. Throttle stop may be set to hold open throttle plate. Make adjustment.
2. Vacuum leak.

### Idle speed too slow:

1. Mixture could be too rich or too lean. Adjust fuel values for fastest idle speed, then if idle speed is still too slow, adjust throttle stop or air bypass screw for faster idle speed.

### Rough idle:

1. Bad ignition wire arcing to ground.
2. Mixture needs to be rich for best idle. Try adjusting fuel values until too rich then lower the values until engine is smooth.

3. Bad injector or bad cylinder. Unplug each injector to isolate.
4. Do engine compression check. Look for engine mechanical problem.
5. Bad connection at MAP sensor. Unplug and plug in the connector a few times.
6. MAP sensor vacuum line not connected or connected to the wrong area on the intake manifold or throttle body.
7. See below, Not Running on all Cylinders section

#### Cuts Out at High Power:

1. Fuel pump not adequate.
2. Injector flow rate too low.
3. Check FUELCUT/MANPRESS parameter. Adjust and try again or set to NO LIMIT.
4. Fuel lines or filter plugged or too small.
5. Check for fuel flow volume out of regulator drain to return of fuel tank.
6. Engine is crossing an improper value.
7. Fuel tank not vented. Remove filler cap check for suction.
8. Bad injector ground connection. Do Ohms check from chassis to pin 8 of white connector.
9. Check fuel pressure, should be 45-50 psi.
10. If system is using a knock sensor then Knock sensor may be activating and reducing the ignition timing too much. Try higher octane fuel or try lower Knock Sense value.

#### Not Running on all Cylinders:

1. Check each injector for clicking sound.
2. Not an ignition coil problem if only one cylinder is dead, so likely mechanical, injector, or wiring problem.
3. Bad ignition wire arcing to ground.
4. Bad spark plug.
5. 6cyl, Check 7-pin connector at coilpack assembly to make sure connector is plugged in fully, make sure it is latched on both sides. 6cyl, check coil pack 4 pin connector to make sure its latched.

#### Runs but lacks power:

1. Check camshaft timing.
2. TPS vibrating and is activating the ACC PUMP function. Watch AP in Gauge2 mode. Should read zero when throttle is steady. Set both ACC PUMP values to zero and see if problem goes away.
3. Check TPS hookup and ACC PUMP values for too high a value.
4. Mixture far too rich or lean. Increase or decrease all RPM FUEL values to correct or adjust knob.
5. Fuel tank not vented. Remove filler cap, check for suction.
6. Check timing with a timing light, magnets could be mounted incorrectly.
7. (F only). RPM IGN (ignition timing) values too low.
8. Make sure closed loop is OFF
9. If system is using a knock sensor then Knock sensor may be activating and reducing the ignition timing too much. Try higher octane fuel or try lower Knock Sense value.

#### Programmer display is blank:

1. Check power and ground connections on black and red wires of main harness.
2. TPS connections are wrong. Try unplugging the TPS and MAP connectors.
3. Programmer cable is damaged.
4. If ECU is a dual board unit, only the primary provides power to the programmer, so the Primary ecu board must be powered up for the programmer unit to display data and operate.

#### SDS EFI in Window:

1. TPS connections are wrong. Try unplugging the TPS cable.
2. Power has been interrupted or EM-5 has reset.
3. Do resistance check of ignition wires. Possible bad crimp at end of wire.
4. Spark plug wires causing EMI (interference). Try different brand of wires. **Must use Suppression type plug wires with SDS.**
5. Check for loose spark plug wires.

6. Move sensor wires away from ignition.
7. Don't ground solenoids or other devices at the same place as the EM-5 ground.
8. Move EM-5 further away from engine.
9. Solenoid switching may cause this. Disable any solenoids, relays, motors etc. Diodes can be connected across solenoids to absorb electrical spikes. Call us for help.
10. Using non-resistor spark plugs. **You must use resistor plugs with SDS.**

Strange characters or black bar across the top of the LCD window:

1. Programmer cable damaged, common problem. New cable can be found at most computer stores.
2. Measure the resistance of all spark plug wires. Possible poor crimp at the end of a wire causing arcing, or bad insulation causing arcing to ground. Replace or repair any wire that has a much higher resistance than the others.
3. Interference from spark plug wires. Try different brand of plug wires. **Must use Suppression type plug wires with SDS.**
4. Programmer data being interfered with. Don't run cable with other wiring.
5. Loose programmer cable connection.
6. Change spark plugs to resistor type. **Non-resistor types cause electrical noise.**
7. Programmer was plugged into EM-5 AFTER the EM-5 was powered up.
8. Move ground connection to EM-5 to a different location.
9. Check main harness connection to EM-5.

Engine fills up with fuel:

1. Bad EM-5 ground wire connection.
2. Check for leaking fuel pressure regulator diaphragm.

Won't run over 2000 rpm:

1. Check FUELCUT BELOW TP limit. Aircraft applications set to NO CUT.

Will not rev up or has Miss:

1. Check ACCPUMP values. May be too high.
2. Check AP number in gauge2 mode. Should be zero when throttle is stable. Check this with engine running. May only show up at certain RPM's.
3. Check for leaking fuel pressure regulator diaphragm. If fuel in vacuum reference hose, replace the regulator.
4. Check for bad values in RPM or MAP parameters. Could be crossing a bad value anywhere.
5. Hall sensor mount is vibrating. Stronger bracket required. Watch RPM reading in Gauge1 for ERR message.
6. Check FUELCUT/MANPRESS and FUELCUT/RPM parameters.
7. Check resistance of all spark plug wires. Possible poor crimp at the end of a wire causing arcing.
8. Try a different brand of spark plug wires. **Must use Suppression type plug wires with SDS.**
9. If Knock sensor is being used, Knock Sense value may be too high. If there is no knock sensor on the SDS system set Knock Sense to 1, and Knock Retard to zero.

Unstable RPM reading in Gauge 1 mode.

1. On "D" systems using a tach wire to the coil, some types may cause double triggering in the tach circuit of the ecu. You may have to install a Hall sensor to give the ECU a clean tach signal.
2. On "F" systems, check Hall sensor alignments and magnets. Bracket must not vibrate or flex.

Idle speed too high:

1. Throttle stop may be set to hold open throttle plate. Make adjustment.
2. Vacuum leak.

Idle speed too slow:

1. Adjust throttle stop screw.

2. Mixture could be too rich or too lean. Adjust fuel values for fastest idle speed, then if idle speed is still too slow, adjust throttle stop or air bypass screw for faster idle speed.

#### Rough idle:

1. Bad ignition wire arcing to ground.
2. Mixture needs to be rich for best idle. Try adjusting fuel values until too rich, then lower the values until engine is smooth.
3. Bad injector or bad cylinder. Unplug each injector to isolate.
4. Do engine compression check. Look for engine mechanical problem.
5. Bad connection at MAP sensor. Unplug and plug in the connector a few times.
6. MAP sensor vacuum line not connected or connected to the wrong area on the intake manifold or throttle body.

#### Cuts Out at High Power:

1. Fuel pump not adequate.
2. Injector flow rate too low.
3. Check FUELCUT/MANPRESS parameter. Adjust and try again or set to NO LIMIT.
4. Fuel lines or filter plugged or too small.
5. Check for fuel flow out of regulator drain to return of fuel tank.
6. Engine is crossing an improper value.
7. Fuel pressure too high, injectors won't open.
8. Fuel tank not vented. Remove filler cap check for suction.
9. Bad injector ground connection. Do Ohms check from chassis to pin 8 of white connector.
10. Install a fuel pressure gauge.
11. Reduce spark plug gap. Ignition voltage may not be high enough for stock plug gap specification.
12. If system is using a knock sensor then Knock sensor may be activating and reducing the ignition timing too much. Try higher octane fuel or try lower Knock Sense value.

#### Not Running on all Cylinders:

1. Check each injector for clicking sound.
2. Bad ignition wire arcing to ground.

#### Runs but lacks power:

1. Check camshaft condition.
2. TPS vibrating and is activating the ACC PUMP function. Watch AP in Gauge2 mode. Should read zero when throttle is steady. Set both ACC PUMP values to zero and see if problem goes away.
3. Check TPS hookup and ACC PUMP values for too high a value.
4. Mixture far too rich or lean. Increase or decrease all RPM FUEL values to correct or adjust knob.
5. Fuel tank not vented. Remove filler cap, check for suction.
6. (F only). Check timing with a timing light, magnets could be mounted incorrectly.
7. (F only). RPM IGN (ignition timing) values too low.
8. Check that closed loop is turned OFF.
9. If system is using a knock sensor then Knock sensor may be activating and reducing the ignition timing too much. Try higher octane fuel or try lower Knock Sense value.

#### Programmer display is blank:

1. Check power and ground connections on black and red wires of main harness.
2. TPS connections are wrong. Try unplugging the TPS cable.
3. Programmer cable is damaged.
4. If +12V has been accidentally shorted to the EM-5 case, the circuit board may need repair, due to a broken ground circuit.

#### SDS EFI in Window:

1. TPS connections are wrong. Try unplugging the TPS cable.
2. Power has been interrupted or EM-5 has reset.



3. Do resistance check of ignition wires. Possible bad crimp at end of wire.
4. Spark plug wires causing EMI(interference). Try different brand of wires. **Must use Suppression type plug wires with SDS.**
5. Check for loose spark plug wires.
6. Move sensor wires away from ignition.
7. Don't ground solenoids or other devices at the same place as the EM-5 ground.
8. Move EM-5 further away from engine.
9. Solenoid switching may cause this. Disable any solenoids, relays, motors etc. Diodes can be connected across solenoids to absorb electrical spikes. Call us for help.

Strange characters or black bar across the top of the LCD window:

1. Programmer cable damaged, common problem. New cable can be found at most computer stores.
2. Measure the resistance of all spark plug wires. Possible poor crimp at the end of a wire causing arcing, or bad insulation causing arcing to ground. Replace or repair any wire that has a much higher resistance than the others.
3. Interference from spark plug wires. Try different brand of plug wires. **Must use Suppression type plug wires with SDS.**
4. Programmer data being interfered with. Don't run cable with other wiring.
5. Loose programmer cable connection.
6. Change spark plugs to resistor type. Non-resistor type cause electrical noise.
7. Programmer was plugged into EM-5 after the EM-5 was powered up.
8. Move ground connection to EM-5 to a different location.
9. Check main harness connection to EM-5.

Engine fills up with fuel:

1. Bad EM-5 ground wire connection on DB25 main harness. Move ground to another place or clean connection.
2. Check for leaking fuel pressure regulator diaphragm.

Won't run over 2000 rpm:

1. Check FUELCUT BELOW TP limit. Set to a lower value, or set to NO CUT.

**If problems persist, and you are calling for help, we may be able to help you better if you write down your values and send them to us. This may help narrow down the problem much faster. The last page in this manual is for writing down your values.**

Don't ground the SDS EM-5 to the engine. Engine ground may be noisy and cause the EM-5 to malfunction. Ground it to the chassis of the aircraft or to a grounding buss. Be sure to sand off any paint where the connection is.

**Make sure the EM-5 is permanently grounded to the airframe and never put a switch in any ground circuit of any SDS component. If a component needs a switch, it should always be on the positive(+) wire.**

**Spark plug wires, and Interference Problems**

**Always use radio suppression type spark plug wires. NEVER use solid core wires.**

**Recommended wires:**

MSD superconductor.

NGK.

OEM or factory carbon string.

Accel 8.8 yellow.

**For engines with coil-on-plug ignition coils be sure to use resistor type spark plugs. Resistor plugs usually have 5Kohms resistance. NGK resistor plugs will have the letter R in the part number. Non resistor plugs can create electrical noise and cause interference problems.**

**Important! Wires which have caused interference problems in the past are Nology, Mallory and Taylor, so we do not recommend these.** If you have these wires and are having problems try a different brand of wires. Ignition interference problems usually show up as strange characters in the programmer screen, rough running, misfiring or an RPM ERR code in Gauge 1 mode.

### **Factory default programmed values**

If you have running problems or have trouble programming the system, you may want to restore all the factory values. You will have to scroll through all the ranges in the programmer and check or re-enter the factory values. Factory values are shown in the following pages. Be sure to select the proper page. There is a page for each of the three different MAP sensors, so you must know which MAP sensor you have.

### **Tech Help**

For technical assistance contact your dealer or:  
Racetech Inc.

#5, 304 Noorduyn Park (Springbank Airport)

Calgary, Alberta, Canada T3Z 3S8

Phone 403-671-4015

E-mail [racetech1@telus.net](mailto:racetech1@telus.net) Website: [www.sdsefi.com](http://www.sdsefi.com)

**When calling for help you should know which system you have. We offer 2 different systems, "D" is fuel only, "F" fuel & multi coil ignition.**

### **Warranty and Use of Products**

Since SDS cannot control the installation or use of its products, we accept no responsibility for damage, loss or personal injury while using our products. By using SDS products the user understands and accepts this.

All SDS electronic components are guaranteed to be free from defects in workmanship and material for a period of 3 years from the date of sale to original purchaser if installed according to this manual. SDS shall make the sole determination with regards to all warranty claims.

Components are not covered if they have been altered in any way, physically damaged, subjected to moisture or incorrectly connected.

### **Repairs**

- 1. Please call or email Racetech before returning any SDS components for checking or repair.**
- 2. Please ship parts to us via FEDEX or UPS AIR or regular US Post.**
- 3. DO NOT ship parts to us via UPS ground. You'll be responsible for brokerage fees otherwise.**
- 4. Please write on the box and waybill "FOR WARRANTY REPAIR, MADE IN CANADA".**
- 5. Items shipped to us for warranty checks or testing which are working properly will be subject to a \$40.00US charge plus shipping.**

Prior authorization is required before any warranty or returned item is accepted. Defective components will be repaired or replaced as soon as possible at the discretion of Racetech.

### **Returns**

No returns are accepted after 30 days and all returned goods are subject to a 15% restocking fee as well as a charge for any damaged components, cut wires or missing items.

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### **Courier Shipping**

Items for warranty or repair should be shipped to:

Racetech Inc.

#5, 304 Noorduyn Park (Springbank Airport)

Calgary, Alberta, Canada T3Z 3S8

Phone 403-671-4015

E-mail: [racetech1@telus.net](mailto:racetech1@telus.net) Website: [www.sdsefi.com](http://www.sdsefi.com)

Please call or email us before sending parts for checking or repair.

Please write on the box and waybill "FOR WARRANTY REPAIR, MADE IN CANADA"

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### **Mail Shipping**

Items for warranty or repair should be shipped to:

Racetech Inc.

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### **Tach Output Frequency**

For setting up your engine monitor or steam type tachometer, 4 cylinder systems output 2 pulses per crank rev, 6 cylinder systems are 3 pulses per rev and 8 cylinder are 4 pulses per rev.

Yellow wire from DB25 outputs a 12V tach signal, green wire outputs a 5V tach signal.

### **Warnings**

#### **Warning Regarding Vertical Power VP-X and SDS**

It has come to our attention that the VP-X electronic switching/ circuit breaker box does not use average current draw over several seconds to trip breakers like conventional thermal breakers do. It may trip during normal operation due to peak current transients over only a few milliseconds. This can lead the pulsing current of the ignition coils and injectors to trigger the breaker far below nominal current levels. We believe this could cause a serious flight safety issue and engine stoppage. Be sure to set the breaker values on the VP-X far higher than the nominal current draw on these circuits. Be aware that average current draw can increase with rpm and load so ground running may not allow complete testing of this condition if static rpm is lower than flight rpm and engine shutdown could occur in flight. Breakers are to protect the wiring, not the device. We recommend each 4 cylinder coil pack have a rating of at least 15 amps assigned when using the VP-X, each 6 cylinder coil pack at least 20 amps, 4 cylinder injector power at 15 amps, 6 cylinder at 20 amps and 8 cylinder at 25 amps. **These are only recommendations, use this information at your own risk and these values should be thoroughly tested prior to flight at WOT and maximum rpm the engine will see in flight.**

### **Revisions**

June 1,21 Rev2, add switch orientation for 4cyl relaybox. Edit schematic showing switch on gnd side.  
May 12/20 V31 update info regarding RPM Fuel. Some changes to troubleshooting.  
Dec 12/19, add DB pinout.  
Dec 12/19, V30 software updates.  
Oct. 15/19. Air temperature type changed on Lycoming engines with new photo added.



**Write down your values here**

MAN PRES	VAL	RPM FUEL	VAL	ENG TEMP	VAL	START	VAL	RPM IGN	VAL	RET/LOAD	VAL
		500						500			
		750						750			
		1000						1000			
		1100						1100			
		1200						1200			
		1300						1300			
		1400						1400			
		1500						1500			
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		4000						4000			
		4100				ACCPUMPLORPM		4100			
		4200				ACCPUMPHIRPM		4200			
		4300				ACCPUMPSENSE		4300			
		4400				START CYCLES		4400			
		4500				MAGNET POSITION		4500			
						KNOCK RETARD					
						KNOCK SENSE					
						CL MAP HI					
						CL MAP LO					
						CL RPM HI					
						CL RPM LO					
						CLOSED LOOP					
						FUELCUT/MANPRESS					
						FUELCUT/RPM					
						FUELCUT BELOW TP					
						FAST IDLE SWITCH					
						IDLE TP LOCATION					
						IDLE FUEL AMOUNT					
						O2 TYPE					
						PIN 13 INPUT					
						LEAN WARN					
						TRIM 1					
						TRIM 2					
						TRIM 3					
						TRIM 4					
						CRANK RETARD					
						LOP LEAN FUEL%					
						LOP IGN ADV					
						LOP MAX MP					
						LOP CTRL					