EM-5 F Aviation Ignition System Installation and Basic Tuning.
July 4/19.

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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This manual covers the ignition portion of the EM-5 F system for 4 and 6 cylinder 4 stroke applications.

Please read the entire manual before beginning installation.

Use the generic installation guide below only for engines that we don't supply dedicated magnet/ Hall sensor mounts for.

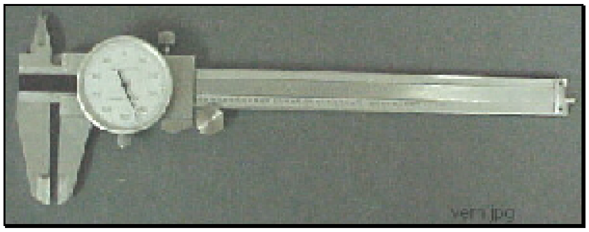
Use the applicable separate Hall sensor/ magnet mounting instructions that come with your Lycoming, Jabiru or Rotax kit.

System Description

The F system is an integrated fuel injection and ignition system. Engine spark timing is fully programmable for both RPM and load (manifold pressure). Programming is done with the SDS programmer. Triggering is accomplished with magnets attached to the flywheel, crankshaft pulley or supplied timing disc and a Hall effect sensor fitted to the engine case.

Theory of Operation
Two triggering magnets are used on 4 cylinder and 3 triggering magnets are used on 6 cylinder applications. One sync magnet is also used to synchronize the computer with the engine so the computer knows which coil to fire. As each magnet passes the Hall sensor, a pulse is sent to the ECU. The ECU determines the exact rpm and manifold pressure, sums the programmed spark retard values and calculates the appropriate delay for the specific conditions at that instant, then triggers each coil to fire at the precise time. Each coil fires two cylinders simultaneously, while one cylinder is on compression, the other on exhaust.

Once the system has been calibrated using a timing light and setting the MAGNET POSITION value with the LCD programmer, gauge 2 mode will display the actual ignition timing in degrees BTDC in real time. Programming can then be accomplished in the simplest possible terms to understand.



Use this end to check hole depth when drilling holes for magnets

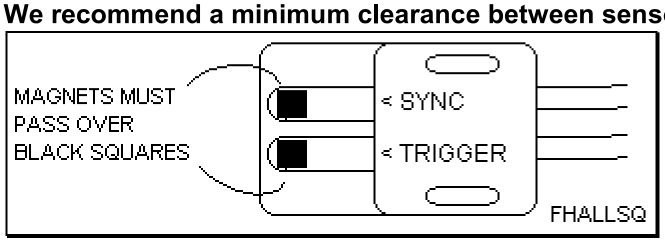
Vernier calipers as shown above.

Drill press.
1/8 inch drill bit.
5 minute epoxy.
Tools to remove crank pulley.
Centerpunch.
Use of a lathe is highly recommended.

Magnets
The magnets are very easy to chip, so handle them carefully. They also stick to anything ferrous, making them easy to lose. Magnets also stick together tightly. Separate them with your fingers.

Mounting the Hall Sensor
Some important tips:

1. **You MUST decide where the Hall sensor will be mounted before mounting any magnets.**
2. **This is the most important part of the system installation.**
3. **Mounting the Hall sensor requires fabricating a very solid bracket that will not vibrate or deflect.**
4. **Build a mounting bracket that is strong enough to lift the whole engine.**
5. **The Hall sensor can be mounted anywhere around the pulley that is most convenient, and then the magnets will be positioned relative to where the Hall sensor is mounted.**
6. **Pulley must be thick enough to drill magnet holes at least .120" or 3mm in depth with a 1/8" diameter drill bit.**
7. **We recommend a minimum clearance between sensor and magnet of 1mm or .040"**



Try to find a location that will minimize the span of the mounting bracket, so the bracket is shorter and therefore stronger. Look for two bolts on the case or timing cover that you can span with some thick aluminum plate. The sensor may be mounted to face either the front or the rear of the pulley depending on where the triggering magnets would be best located and clearance from other interfering items. Usually mounting the Hall sensor behind the crank pulley is the best place, and will make building a bracket much easier. Mounting the Hall sensor on the front side of the pulley will require longer mounting bolts and a stronger bracket to stop vibration. Also front mounting may make changing the belts difficult.

The Hall sensor assembly should be positioned so that the sensor element clears the crankshaft pulley surface by 2 to 3mm or .060" to .120". The square black sensor element must be placed so that the magnets on the crank pulley spin over its center with 1 to 1.5mm or .040" to .060" clearance. Magnets should protrude about 1 to 1.5 mm or .040" to .060" past the pulley face if made from ferrous material and may be mounted flush if made from aluminum. The sensor

bracket should be initially positioned in the center of its adjustment slot to allow maximum movement in or out for final placement once the magnets are in the pulley. The sensor is supplied with #10-32 Allen bolts.
The wire leading from the sensor should be securely wire- tied every few inches to avoid vibration breakages.

Crank pulley
Check for TDC marks on the pulley and timing cover. It is best to remove the #1 spark plug, and insert a piece of welding rod into the cylinder, and then verify that the TDC marks are actually correct on the pulley and timing cover.
If the pulley has no marks for TDC, then put the #1 piston to TDC, and make your own marks on the timing cover and pulley. It's a good idea to paint the pulley timing marks with some white paint or correction fluid (white-out), so that they are easy to see with a timing light.

If the engine is not at TDC #1 when marking the pulley for magnet placement, the magnets will be in the wrong position and the engine will not run correctly nor will timing read correctly in the programmer.

Locating the position of the #1Magnet (both 4 and 6 cylinder) Very Important.
You should first know the direction of rotation of the engine when it is running.

Rotate the crankshaft to TDC #1 and leave it there.

Draw an arrow on the pulley to indicate direction of rotation.

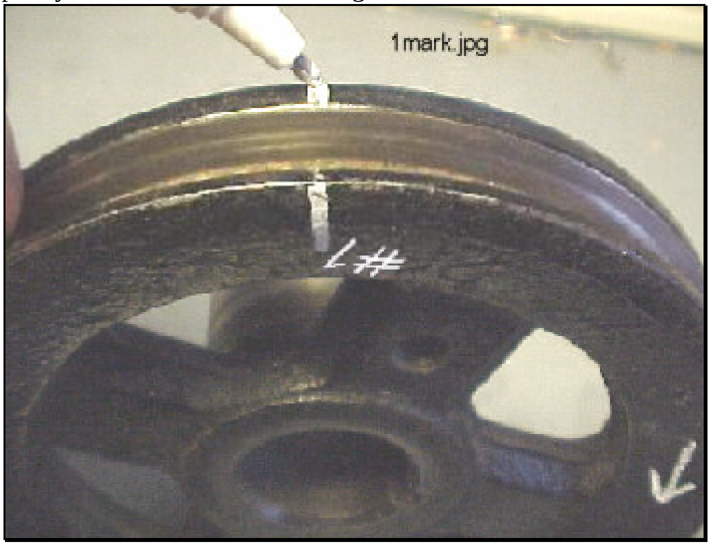
The #1 magnet should positioned approximately 80 degrees from the Hall sensor, in the direction of the arrow. You must mark the pulley at this location. In this example the #1 magnet location is approximately in the five o'clock position. You do not need to be perfectly accurate here, so anywhere from 75 to 85 degrees is acceptable. You can use the 80 degree cardboard template to help locate the position of the #1 magnet.

In this example, the engine rotates clockwise as shown by the arrow marked on the pulley.
In this photo the crank is at TDC #1.

1MAGNET.JPG

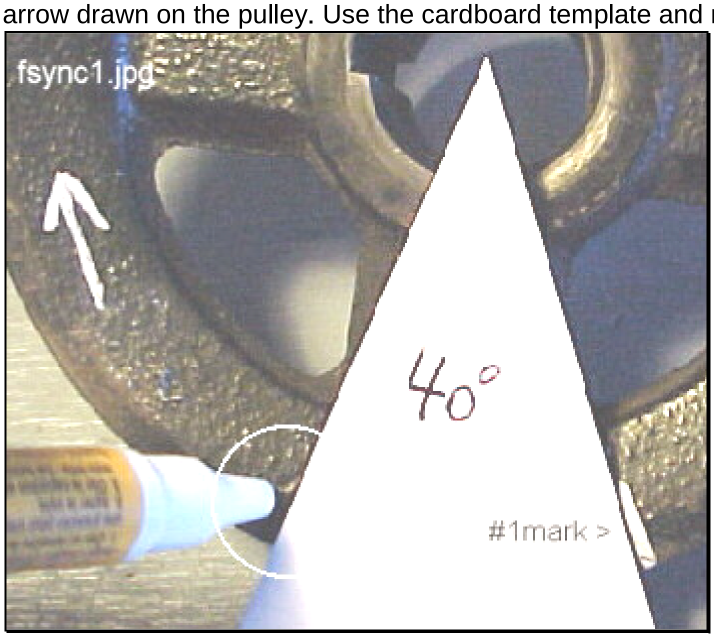
The pulley can now be removed.

Using a marking pen, draw the #1 magnet mark through the belt groove around to the back side of the pulley. In this installation the magnet will be in the back side.



Locating the position of the sync magnet (both 4 and 6 cylinder)

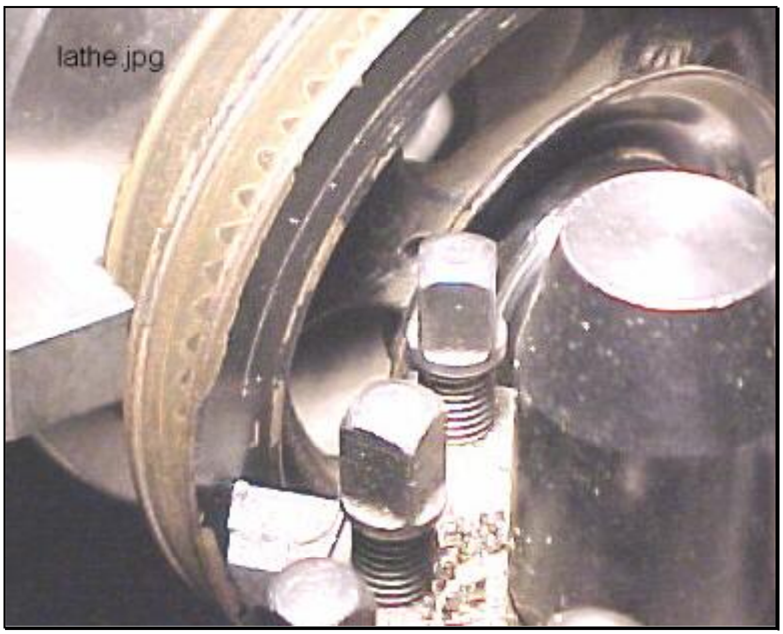
The location of the sync magnet is 40 degrees from the #1 magnet mark in the direction of the arrow drawn on the pulley. Use the cardboard template and mark the pulley.



Using a marking pen, draw the sync magnet mark through the belt groove around to the back side of the pulley. In this installation the magnet will be in the back side.

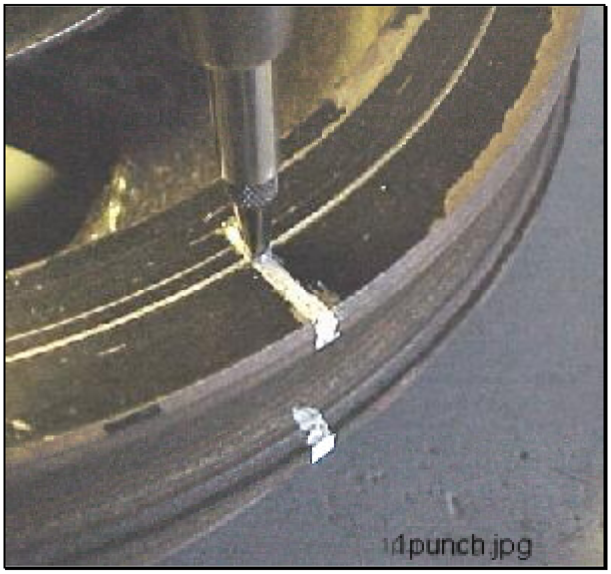
FSYNC2.JPG

Lightly scribe a groove around the pulley with a lathe on the surface of the pulley where the magnets will be mounted. In this case on the back side of pulley.

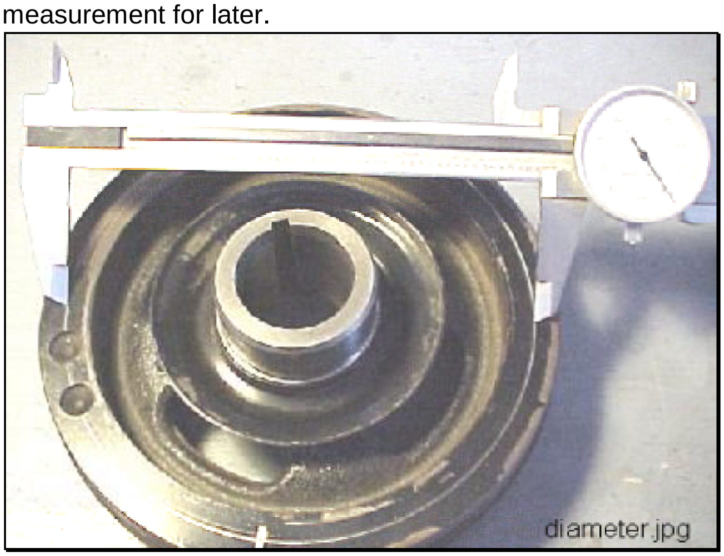


Pulley in the lathe. We recommend that you don’t run the lathe motor, just rotate the chuck by hand slowly, with only light pressure on the cutting tool.

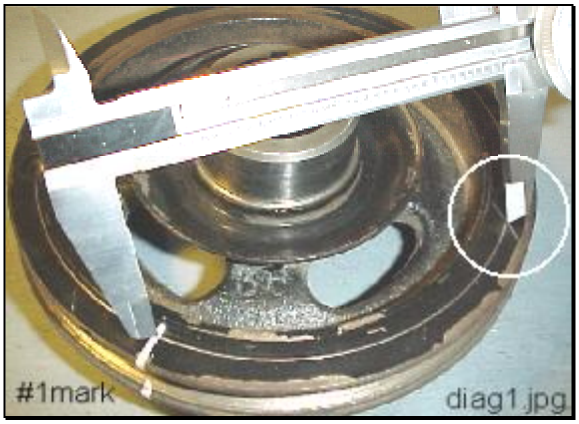
Centerpunch the pulley where the #1 mark crosses the scribed line in the pulley. This punch mark will **later** be drilled for the #1 magnet. Also centerpunch the pulley where the sync mark crosses the scribed line in the pulley. This punch mark will later be drilled for the sync magnet.



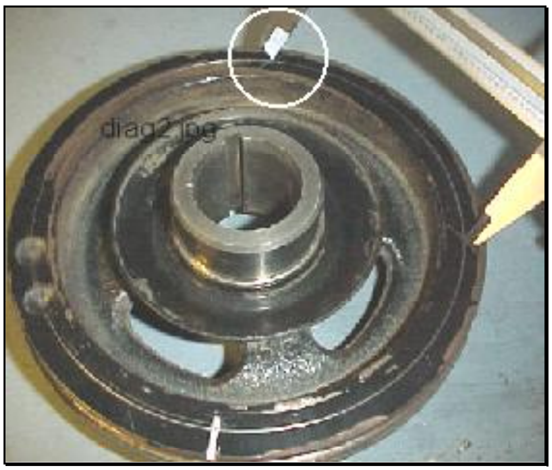
Using dial calipers, precisely measure the diameter of the scribed circle. Write down this measurement for later.



Locations of remaining trigger magnets
4 cylinder engines only:
On 4 cylinder engines one more trigger magnet is used 180 degrees from #1 mark.
The diameter of the lathe scribed circle divided by 1.414 will give the dimension of 4 equidistant points along this scribed line when using calipers or dividers.
Example:
The pulley below has a scribed diameter of 5.340 inches. 5.340 divided by 1.414 equals 3.776 inches. In the photos the calipers are spread to 3.776, so in two steps we can locate the position of the second magnet. Do this step carefully and be as accurate as possible.



Scribe an arc with the calipers.



Scribe another arc at the top. This point is 180 degrees from the #1 mark on the pulley. This point can be center punched for drilling.

See drilling holes for magnets section.

Locations of remaining trigger magnets
6 cylinder engines:
On 6 cylinder engines two more trigger magnets are used, 120, and 240 degrees from the #1 mark.
To calculate the straight line distance between 3 magnet points use the following method:
Measure the diameter of the lathe scribed circle, divide this number by 2, then multiply by 1.732.

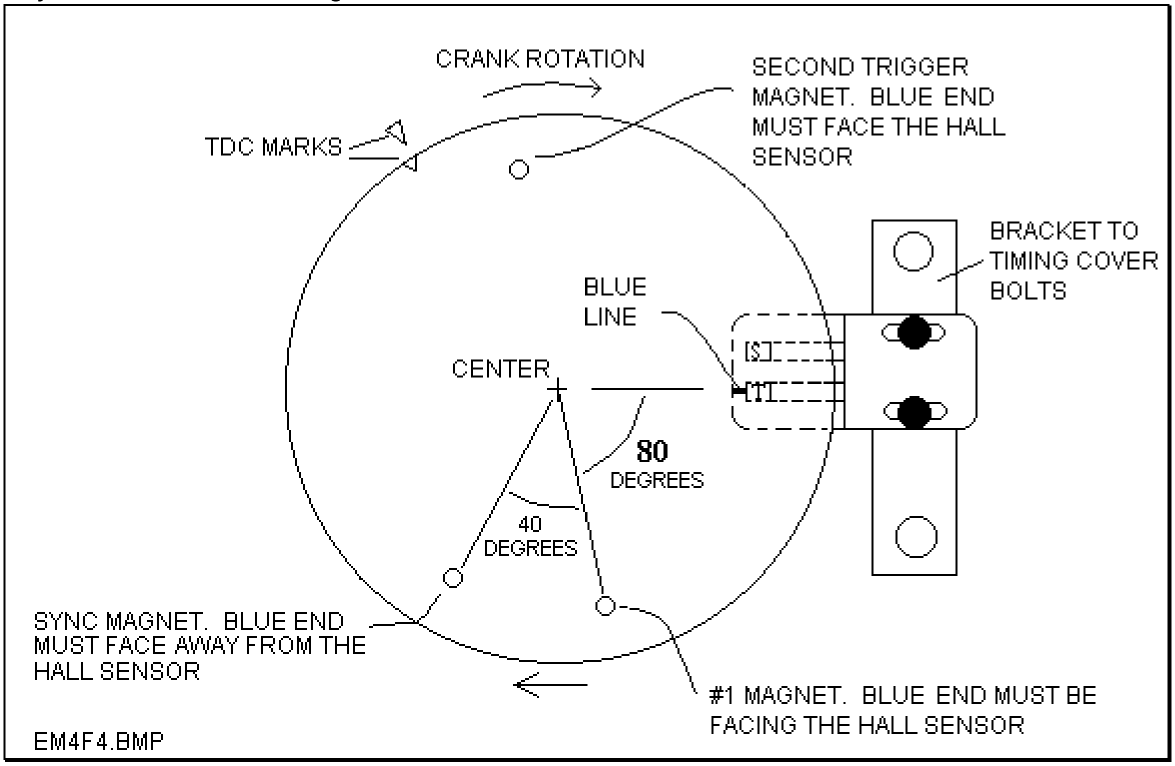
Example:
The pulley below has a scribed diameter of 5.340 inches.
5.340 ÷ 2 = 2.67
2.67 x 1.732 = 4.624

In the photos the calipers are spread to 4.624, so in two steps we can locate the position of the two remaining magnets. Do this step carefully and be as accurate as possible.

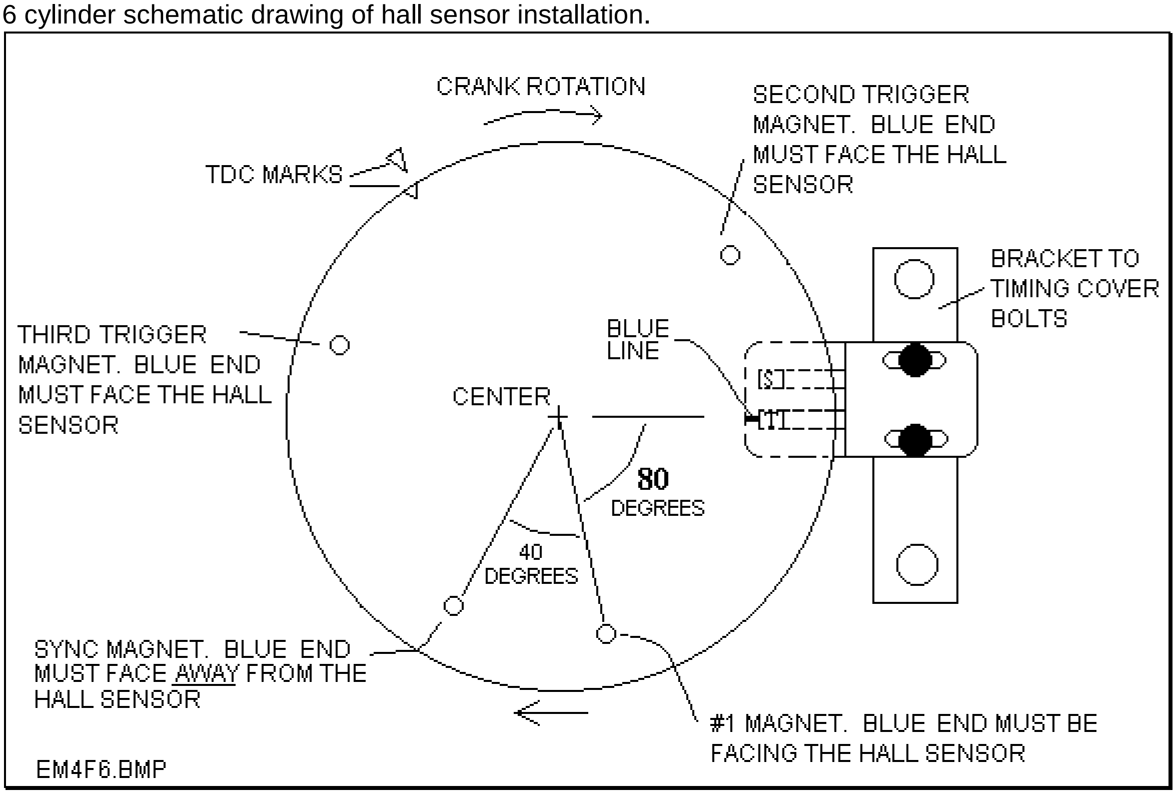
Scribe an arc with calipers and center punch this location for drilling.

Scribe the last point with calipers and center punch this location for drilling.

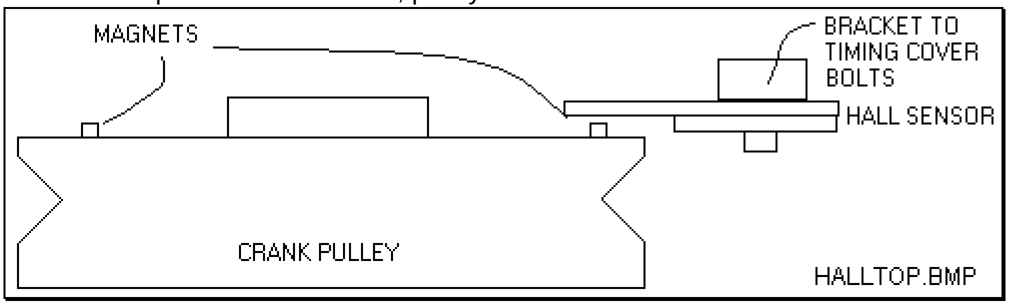
4 cylinder schematic drawing of a hall sensor installation.



6 cylinder schematic drawing of hall sensor installation.



Schematic top view of hall sensor, pulley and bracket.

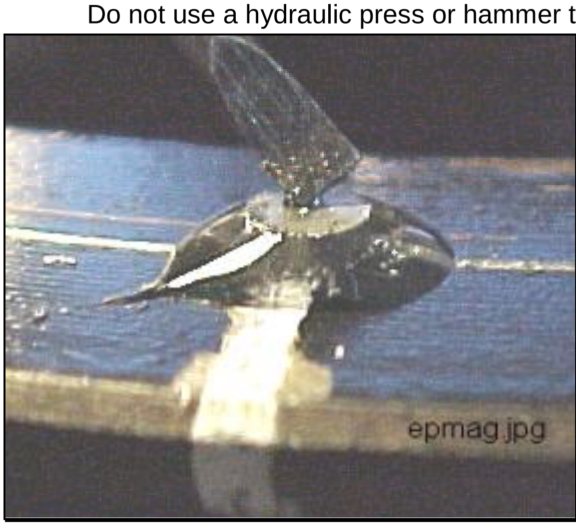


Drilling holes for magnets
Drilled holes should all be the same depth, so drill slowly and measure depth carefully. Magnet holes are best drilled with a #30 drill bit which is 0.1285" diameter. A 1/8" bit may also be used but can be a sometimes too tight, making the magnet & epoxy difficult to fit into the hole, due to hydraulic effect.
Often times the magnets will spring up out of the hole, so it's a good idea to have a heavy object to place over the magnets to hold them down in the holes until the epoxy glue has dried.

The magnets are 4.7mm or .187" long. Depth of the hole should allow the top of the magnet to sit about 1.5mm or .060" above the surface of the pulley, so hole depth should be about 3 to 3.5mm or .120" to .135" deep. Drill carefully and check the depth of the hole with the end of the calipers.

If the magnets need to be flush with the pulley surface, then air gap to the Hall sensor will need to be reduced because of a weaker magnetic field. This will make Hall sensor alignment more difficult. Flush mounting is not recommended unless the pulley is aluminum.

Gluing magnets
IMPORTANT!
Trigger magnets go into the holes with the BLUE end visible, facing the hall sensor.
The Sync magnet goes into the hole with the BLUE end inside the pulley, facing away from the hall sensor.
Insert a magnet into the hole without epoxy first to see if it will fit. If not, drill holes with #30 drill bit.
Do not use a hydraulic press or hammer to push in the magnets. This will break the magnets.



Holes should be clean and dry. Mix some 5 minute epoxy, then fill each hole with epoxy, then push the magnets into the holes. Have a heavy object you can place over top of the magnets to hold them down until the epoxy dries.

The pulley and Hall sensor can now be installed on the engine. **Make sure the pulley will rotate without touching the magnets**. Air gap from magnets to the sensor should be about 1 to 1.5mm or .040” to .060”. Magnets must pass over the small black square in the Hall sensor, so this can be adjusted by loosening the mounting bolts then sliding the sensor until the black square is across from one of the magnets.

Coil pack mounting and care

Wiring connections

Hall sensor plugs into the EM-5 as show here:

Inj drive main harness **Hall** programmer

ECUPLUGS.JPG

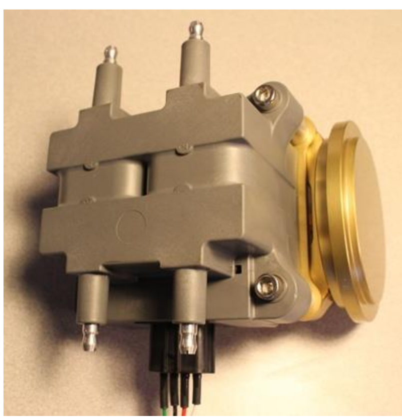
Coil pack:

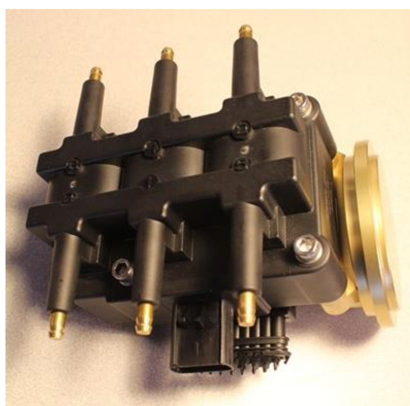
Red to +12V key switched. For 4 cyl coil pack you should use a **10 Amp fuse/ breaker. 6 cyl coil packs should use a 15 Amp fuse/ breaker.** Leave this wire unconnected until you have the hall sensor installed and all magnets are aligned and being seen for 2 to 3 degrees of crank rotation. The fuse could save the coil pack from damage caused by incorrectly installed magnets and hall sensor. **Always disconnect this wire when rotating the crankshaft to check Hall sensor and magnet alignment.**

Black to Ground.

Black 2 or 3 conductor plug to main harness marked CP.

Coil Packs





4 Cylinder on mag cover mount 6 Cylinder on mag cover mount

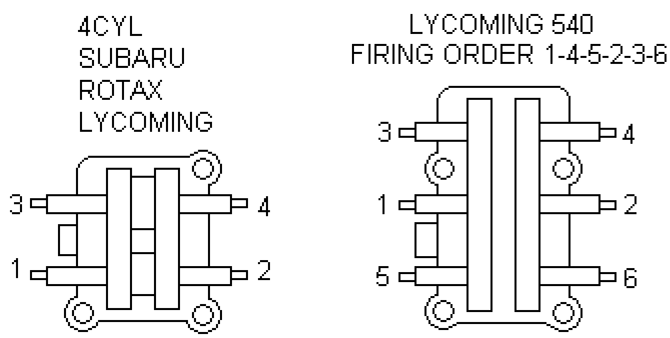
The 4 cylinder coil pack has the drive transistors built into the pack and are directly triggered by the ECU. The 6 cylinder coil pack uses an external module mounted to the coil support/ heat sink. Do not remove this module from the heat sink plate.

Tachometer Output

The coil packs supplied on aviation systems have no tach output pin but there are two sources for a tach signal available on the DB25 connector on the ECU:

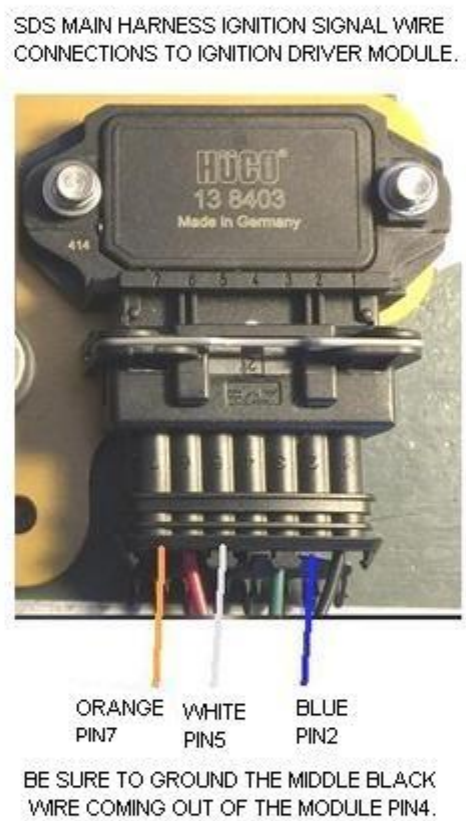
1. Pin 22 (yellow) outputs a 12V tach signal, 2 pulses per crank rev on 4 cylinder systems and 3 pulses on 6 cylinder models.

Pin 12 (green) outputs a 5V tach signal, 2 pulses per crank rev on 4 cylinder systems and 3 pulses per crank rev on 6 cylinder models.



Plug wire hookups on 4 and 6 cylinder engines. Jabiru 2200 and 3300 engines also use the same hookup.

If you are running twin coil packs, you should run a plug wire from each coil pack to each plug on a cylinder. This provides maximum redundancy in the event that one coil pack fails.



6 cylinder coil pack module wire hookup 4 Cylinder coil pack wire hookup

MAGNET SEEN / NOT SEEN & Aligning the Hall Sensor

Top line is used for checking trigger magnets.
Bottom line is used for checking the sync magnet.
MAGF.JPG

Important! Disconnect the red power wire to the coil pack to disable the spark while rotating the crankshaft.
From gauge1 mode push the ‘>’ button 3 times. The LCD Screen will read MAGNET SEEN or MAGNET NOT SEEN. As a magnet passes the Hall sensor, the graphic will change from NOT SEEN to SEEN.
Rotate the pulley so a magnet is over the sensor. Loosen the Hall sensor mounting bolts and reposition the sensor until the SEEN graphic is displayed with the magnet lined up. Tighten the sensor bolts. Recheck by turning the crankshaft by hand, As each magnet passes the sensor, the display should change to SEEN momentarily. **Each magnet should be SEEN for at least 2 to 3 degrees of crank rotation.**

This window has no use once the engine is running, since the sampling rate of the programmer is only about twice per second.

Make sure that there is at least 1mm clearance between the magnets and the Hall sensor before starting the engine.

Magnet Position

Initial Setup - VERY IMPORTANT
This step requires a timing light. The best timing light to use, is one that does not have a delay knob. Delay lights may not work properly with waste spark ignitions. If you only have a delay type light set the delay to 0. The flywheel/ timing disc and block must have timing marks on them. The timing light inductive pickup clamp can also be connected onto the ground wire of the coil pack unit if clipping to the spark plug wires does not work well.

This involves calling up the MAGNET POSITION parameter using the programmer**. This step should be performed as soon as the engine is fired up and idling. Ignition timing is meaningless without first setting the MAGNET POSITION parameter properly.**
A value of between 70 and 90 entered should allow the engine to be started. 80 would be a good starting point and is where the system is factory set.

STEP 1. Using the Programmer set the following parameters:
RPM IGNITION 500 to a value of 10.
RPM IGNITION 750 to a value of 10.
RPM IGNITION 1000 to a value of 10.
RPM IGNITION 1100 to a value of 10.
RPM IGNITION 1200 to a value of 10.

STEP 2. Make sure that all IGN RET-ADV/LOAD values below boost are 0.
STEP 3. Start the engine and keep it running around 1000 rpm.
STEP 4. Connect a timing light.
STEP 5. Change the MAGNET POSITION value until the timing light reads 10 degrees BTDC.

Once the MAGNET POSITION is set, it does not have to be changed again- it is only to tell the ECU what the "distance" between the #1 MAGNET and Hall sensor is. Once the above 5 steps are completed, you can program any of the ignition values.

MAGNET POSITION may need to be adjusted if the Hall sensor is removed for engine repairs if you have the adjustable type. After it is installed again, the above procedure should be completed again so the ignition timing is the same as before.

Ignition Programming

SERIOUS ENGINE DAMAGE CAN OCCUR with improper values entered. Excessively retarded timing can cause high exhaust gas temperatures while advanced timing can lead to pre-ignition and detonation. **Default values may not be correct for your engine!**

RPM IGNITION

This is where the main ignition programming of the system is done. For example, if you want timing at 20 degrees BTDC at 2500 RPM go to RPM IGNITION 2500 and enter 20.

IGN RET-ADV/LOAD

This parameter allows programming of 64 points of ignition retard and advance with reference to load on the engine. Load information is from the MAP sensor. RET refers to retard, and ADV refers to advance.

On systems using 1 bar MAP sensors all the IGN RET-ADV/LOAD values are set to zero from the factory. Systems with 2 or 3 bar MAP sensors have some retard programmed in higher MAP ranges.

Adding retard in high ranges of IGN RET-ADV/LOAD will help prevent detonation on turbo or high compression normally aspirated engines. Push the +10 or +1 buttons to increase the amount of ignition retard. If too much retard is programmed, power output from the engine will be reduced significantly, and detonation may still occur. Total ignition timing should not be less than 15 degrees, since this could shorten the life of some engine components.

Advance can be programmed by pushing the -1 and -10 buttons on the programmer.
To program ignition timing, two parameters RPM IGN and IGN RET-ADV/LOAD are used.

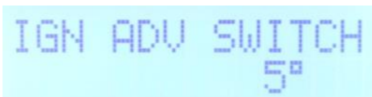
Important- Total timing is a result of the RPM IGNITION value minus any RETARD or plus any ADVANCE.

Values for IGN RET-ADV/LOAD are limited to a maximum 25 degrees advance, and a maximum 25 degrees retard.

Advance Switch Pin 13

Aviation systems can re-purpose pin 13 (blue wire) to enable an external advance switch to be added. Your system should already be configured for this. If not, use the +/-1 buttons to choose this option.

Feed 12V to this wire via a small toggle switch. When this pin sees 12V, it will **add** the amount of advance you input as below, to the mapped timing values.



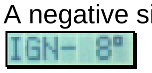
This is useful for LOP operation to optimize the peak cylinder pressure point for maximum efficiency. The switch could also be used in to run high and low octane fuel such as Mogas and 100LL. Leave the switch off for Mogas and on for 100LL to maximize power without detonation.

Be aware that too much advance can cause detonation and serious engine damage!

Knock

We generally do not use knock control on opposed, air cooled aviation engines due to the high mechanical noise present (can false trigger the sensor) and the fact the heads are so far apart physically. We generally do not recommend using knock sensors in aviation applications due to the difficulty in setting it up correctly for most users.

Gauge 2 Mode IGN display
You can watch the ignition timing in gauge 2 mode while the engine is running.
A negative sign indicates that the ignition timing is before TDC. Ignition is normally BTDC.



A positive sign before the ignition degree number indicates that the ignition timing is after TDC.

If timing is after TDC, then too much retard has been programmed into the system. Having ignition timing after TDC will cause major loss off power and possible engine damage.

Testing the coil pack for spark (4 cylinder) Caution high voltage!

Never test for spark by just removing the plug wires! Coil damage may result.

Connect the black wire to ground and the red wire to +12 volts.
Touch +12v momentarily to the input marked A on the black connector. There should be a spark from the 1-2 coil. Move the spark plug wires to the 3-4 coil and momentarily apply +12 volts to the input marked B on the black connector. There should be a spark from the 3-4 coil.

Testing the coil pack for spark (6 cylinder) Caution high voltage!
Clamp spare spark plugs together and plug in ignition wires to the coil under test.
Connect the black wire to ground and the red wire to +12 volts.
Move the spark plug wires to the 1-2 coil and momentarily apply +12 volts to the input marked A on the black connector. There should be a spark from the A coil.
Move the spark plug wires to the 3-4 coil and momentarily apply +12 volts to the input marked B on the black connector. There should be a spark from the B coil.
Move the spark plug wires to the 5-6 coil and momentarily apply +12 volts to the input marked C on the black connector. There should be a spark from the C coil.

Troubleshooting

Spark plugs
We recommend resistor type spark plugs only. Non resistor type may cause electrical interference.

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.

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 gauge1 mode.

Will not start:
1. Check power and ground connections.
2. Check Hall sensor alignment.

Runs but no power:

1. Magnets positioned incorrectly, so timing is retarded too much. Check timing with a timing light (non-knob or non-delay type).
2. RPM IGNITION values are too low.

RPM ERR message or engine miss:
1. Check alignment of Hall sensor over magnets. Loosen Hall sensor mounting bolts and try adjusting Hall sensor.
2. Check Hall sensor air gap. Should be close to .040- .100”
3. Interference from plug wires. Try a different brand of spark plug wires.
4. Make sure that all SDS sensor wiring and Hall sensor cable is not close to spark plug wires or any high current/voltage wires.
5. Check spark plug gap, possibly too large. Reduce to confirm.

Coil pack fuse blows all the time:
1. Hall sensor and magnets not aligned.

I only received one magnet:
1. The magnets stick together really well. Separate them with your fingers.