E-MAG Electronic Ignition

Product Documentation

Series 200-6X

Installation and Operating Guide

Lycoming™ & Continental™ Style
6 Cylinder Engines
(Experimental Version)

V 200-6X .031

Changes to Manual: Changes, corrections, and supplements may be made at any time (see version number on cover page – bottom right). Refer to E-MAG's web page "Downloads" for the most recent version.

Alerts and Service Notes: Prior to installation and operation, review all applicable Alerts and Service Notes affecting your equipment. See E-MAG web site https://emagair.com/service-notes/.

Experimental Aircraft Only: Series 200-6X ignitions are not certified and are not approved for installation on certificated aircraft.

Warranty: E-MAG electronic ignitions are warranted for one (1) year from the date of purchase. E-MAG will repair or replace ignition modules within the warranty period that, in E-MAG's sole opinion, have not been subjected to abuse or attempted field repairs. This warranty is limited to the purchase price of E-MAG hardware and does not cover the engine or other engine components that may be affected by defects or failure of the system. Do not attempt to open or separate the ignition case sections. Doing so will void your ignition warranty.

CAUTION: The aircraft operator has the SOLE responsibility of determining how to appropriately and safely configure and control engine and ignition operation. Nothing stated by E-MAG in this manual, its employees, owners, agents, representatives, or affiliates should be construed as overriding or invalidating the engine manufacturer's instructions. E-MAG has NOT performed testing on the wide variety of engines in popular use and cannot offer specific advice as to proper/suitable ignition configuration.

Notwithstanding engine manufacturer approval of certain engines to burn auto/alternative fuels, such endorsements almost certainly presume operation with fixed magneto timing – and not variable firing electronic ignition. Operators are SOLELY RESPONSIBILITY for independently verifying proper engine behavior with standard and/or alternative fuels including the ignition setup AS CONFIGURED BY THE OPERATOR.

Ignition Markings: Model Designations - are etched into a flat section of the circular nose where it meets the electronics case:

- The letter "C" or "L" indicating a model compatible with most Continental™ or Lycoming™ style engines.
- Or a full model number ending with letter C or L indicating compatibility with most Continental™ or Lycoming™ style engines
    - 200-6XC
    - 200-6XL
- Other part numbers may appear in the same area (disregard).

System Serial Number - is etched into the electronics case directly below the LED.

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Using This Manual:

This manual will include supplemental notes, comments, and tips that will appear as *blue* text.

Some segments are specific to Continental™ or Lycoming™ engines. Such segments will be identified with the bracketed notation "[Continental™]" or "[Lycoming™]" and colored as shown. The "Lycoming™" reference applies to Lycoming™ and Lycoming-like engines. Please note - as used throughout this manual:

Lycoming is a registered trademark of Avco Corporation.
Continental is a registered trademark of Continental Motors Group™.

Exercise care when handling the ignitions, engine, and propeller. There is a significant risk of burn, electrical shock, injury, or even death. This manual may offer safety suggestions, but it is NOT to be considered a complete list of the potential hazards, NOR is it presented as a complete set of safety precautions that should be followed.

RISK OF EQUIPMENT DAMAGE: [***IMPORTANT***] Firing the ignition without all high voltage loops in place, risks damaging the coils and/or electrical shock to the handler. If incurred, such damage may not be immediately evident. High voltage loops include the circuit from a given coil tower, to plug wire, to plug, to engine block, to companion plug, to companion plug wire, to companion coil tower. Each pair of cylinders (1&2, 3&4, 5&6) constitutes a separate high voltage loop.

ID	Date	Summary of Principal Changes
V 200-6X.31	5/25/19	Initial Product Release - disregard all previous materials. Note: This ignition version includes two operating modes (fixed and variable firing). Both modes share common position and processer-based control logic elements. Redundancy is provided by having two autonomous (left/right) ignitions, and up to three sources of operating power. Experimental versions DO NOT have discrete logic circuitry for each mode.

Setup is the installation procedure that will match three ignition reference to your engine:

Ignition Reference	Engine Reference
TC setpoint	Engine top center for cylinders 1&2
MIN setpoint	Manufacturer's recommended firing angle
DIR setting	Engine direction of rotation

A fourth ignition reference (MAX setpoint) can be evaluated and adjusted later. The default Setup value for MAX will be sufficient for initial operation.

The Setup outline below refers to several operations and references that are covered in more detail later in the manaul. For convenience, those sections are linked to the outline with the following heading key:

SP – Setpoints
SW – Setup and Control Switches
LED – LED and Tone Signals
CW – Control Wiring
PW – Spark Plug Wiring
N# – Setup Note # (N1, N2, etc).

Note 1: Wire the ignition Control Plug and cockpit switches prior to starting Setup. **SW, CW**
Note 2: [Lycoming™] If present, remove the magneto spacer and longer mounting studs. Replace with short studs (# 31C12).

Setup:

1) Verify bus power is OFF and Kill Switch is OFF (grounded). **CW, SW**
2) Pre-position prop to the engine top center position. **N1**
3) With ignition in hand (not installed) connect the circular Control Plug. **CW**
4) Turn bus power ON. *(If LED is RED, power ignition OFF and inspect/correct).* **SW, LED**
5) Turn ignition **rotor** by hand to locate the ignition TC "vicinity" (YELLOW LED/tone). **SP, LED**
6) Turn bus power OFF. **SW**
7) Check Orientation - rotate ignition **body** so rotor lugs align with rubber cushions in the engine, and test fit. *Reposition the receiver cup/gear in the engine, as needed, for favorable alignment.* **N2**
8) Insert the ignition (with gasket) and secure mounting clamps finger tight.
9) Turn bus power ON. **SW**
10) Rotate ignition body to re-acquire the TC YELLOW LED/tone. **SP, LED, N3**
11) Tighten ignition mounting clamps to 17 ft lbs.
12) Check/Change DIR setting:
    a) Move prop (engine) to the 20-25-degree region before TC.
    b) If you find BLUE/WHITE LED setpoints in this general area **skip to Step 13.** **SP**
    c) If you don't find BLUE/WHITE setpoints - change ignition program direction (DIR) as follows:

i) With GREEN LED showing, press/hold the Button for ten seconds- LED will go dark. **SW**

ii) Release button - LED will turn RED or GREEN (disregard color for now).

iii) Rotate the prop a short distance in the normal operating direction - note the LED color (RED or GREEN) while moving.

iv) Verify the same color remains after you stop*. If needed, nudge prop in the normal direction to recover the correct color.*

v) Quick-press the Button. The new DIR setting will be stored, and the LED will resume normal signaling. Return to the beginning of this section 12) a). **SW**

13) Check or Move MIN (BLUE) and MAX (WHITE) setpoints. **LED, SP**

i) Checking setpoints - Position the prop (engine) to the setpoint color you want to check – MIN for example (BLUE). If BLUE engine position matches the manufacturers recommended mag firing position - leave it. If not, move the BLUE setpoint as follows:

ii) Moving setpoints: **N4**

(1) With the setpoint color showing (BLUE example) **press/hold** the Button. **LED, SW, N4**

(2) Continue the hold while you **move** the prop (engine) to the new setpoint. **SP, N3**

(3) Then **Release** the Button. The LED will remain (BLUE example), indicating placement at the newly stored setpoint. **LED, SW, N4** *Confirm by rocking the prop and it will signal GREEN-BLUE-GREEN as* you rock back and forth over the updated (MIN) setpoint.

iii) Initial setpoints:

(1) Set MIN at engine manufacturers recommended magneto firing angle**.** **SP**

(2) Set MAX at ignition default 5-degrees ahead of MIN, or less (installer discretion). **SP**

14) Basic setup is complete. Prior to operation:

a) Connect plugs and plug wires. **PW**

b) Connect manifold pressure (MAP) plumbing.

c) Install blast tube cooling – as appropriate.

d) Perform Pull-Thru test.

Make sure Kill Switch stays OFF until all high-voltage connections (plugs, plug-wires, coil) are in place. Firing plugs without all high-voltage connections risks damaging the coil.

Setpoints (SP):

(see Fig A)

1) **TC** (YELLOW LED) – A mechanically stored (rotate/clamp) ignition index that aligns with engine top center index. *(ref. flywheel, flange, engine mfg. instruction.). see TC Locator Appendix 2.*

2) **MIN** (BLUE LED) – Ignition firing position that is set to match engine mfg. recommended (magneto) firing angle - typically 20 to 25 degrees before top center:

a) Marks the low advance (high power) end of the firing range in Variable Mode.

b) Marks the fixed firing position in Fixed Mode.

4) **MAX** (WHITE LED) – Marks the high advance (cruise power) end of the Variable Mode firing range. The factory default setting for MAX is 5 degrees ahead of MIN.
5) **DIR** – The ignition's current operating direction (rotation).

Note 1: Default setpoints (MIN-20 degrees, MAX-5 degrees before MIN):
- *a) Both defaults will be restored if ignition program is reloaded/updated.*
- *b) Both defaults will be restored if you change ignition (DIR) direction.*
- *c) MAX default will be restored if you change MIN.*
- *d) Changing MAX does not alter other setpoints. So save your MAX change (if any) for last.*

Setup and Control Switches (SW):

1) **Configuration Button** ("Button") is located beneath a black plastic screw cap on the end face of the ignition. The Button is used when changing ignition DIR and when moving MIN and MAX setpoints.
2) **Mode Switch** – Fixed Mode or Variable Mode is selected by a single cockpit Mode Switch that controls both left and right (Series 200) ignitions. Fixed Mode is enabled when the Mode Switch applies a 1K bias resistance to each kill circuit.
   a) **Fixed Mode** - Mode Switch "FIX" will fire plugs at the MIN firing position. *RPM must be above cranking speeds – i.e. you cannot start in Fixed Mode.*
   b) **Variable Mode** - Mode Switch "VAR" allows RPM and MAP inputs to vary the firing position in a range between the MIN and MAX boundaries.
3) **Power Test Switch** - A cockpit interrupt used to test the ignition internal alternator. A switchable circuit breaker or separate test switch can perform this function.
4) **Kill Switch** (p-lead switch) - The traditional cockpit ignition ON/OFF (Left/Right) test switch is unchanged. The Mode Switch does not interfere or alter Kill Switch operation. The Kill Switch OFF position connects the E-MAG kill wire (p-lead) to ground. The ON position un-grounds the kill wire. *Note: All other connections from previous installations (tach, shower of sparks, etc.) must be removed from kill switch wiring.*

LED and Tone Signals (LED):

1) **RED LED indicates CAUTION**. When ignition is powered ON and kill switch is ON the unit is capable of firing plugs ("HOT").
   a) Steady RED indicates Variable Mode HOT.
   b) Blinking RED indicates Fixed Mode HOT.
2) Other LED colors are enabled by turning kill switch to OFF (ground p-lead). Plug firing is blocked when displaying other colors. Background color is GREEN.

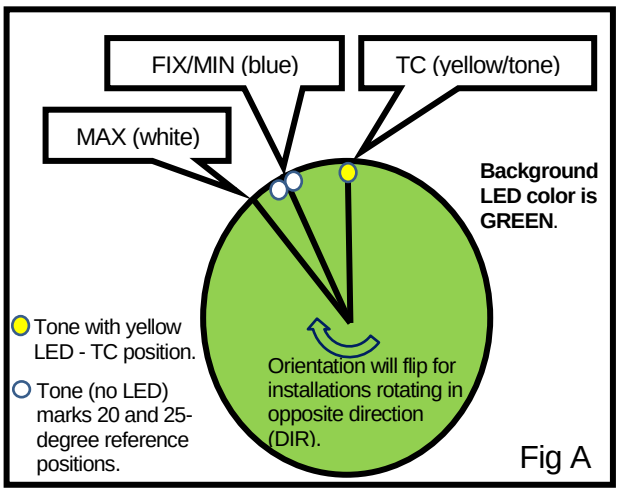

Fig A

a) Ignition setpoints:
   i) **YELLOW** (with tone) signals ignition TC setpoint.
   ii) **BLUE** signals MIN setpoint, the lower end of the firing range in Variable Mode as well as the fixed firing position in Fixed Mode.
   iii) **WHITE** signals MAX setpoint, the upper end of the Variable Mode firing range.

3) Tone will sound at:
   a) Ignition TC (with YELLOW LED).
   b) Ignition 20 and 25-degree positions (no LED change). After clamping (Setup step 11) these tones will signal engine 20 and 25-degree positions – see Fig A. **Their sole purpose is to help installers (Continental engines in particular) locate appropriate MIN (BLUE) and MAX (WHITE) engine positions during setup. As needed, other engine positions (18, 22, 29, 35, etc.) can be extrapolated from these tone positions.**

Control Wiring (CW):

1) Standard circular Mil plug connector (PT06A-10-6S-SR or similar). This is a solder style plug with strain relief clamp for installation with new or pre-existing (20 AWG) wire.
2) Optional circular plug connector with pig tail – circular connector (PT06P-10-6S or similar) with 72" of wire soldered and potted – see color references below and wiring schematic at the end of the manual.

Pin "A" on circular plug **(Pig-Tail red wire)** - connects to your 14 or 28-volt aircraft bus. Route thru a power test switch and suitable circuit protection. Possibilities are:
1) A separate 5-amp fuse and separate power test switch.
2) A 5-amp switchable circuit breaker, which can satisfy both circuit protection and power test duties.

Pin "B" (Pig-Tail black wire) - connects to the cockpit panel ground.
Pins "C" and "D" (Pig-Tail white and green 22AWG) – stow for future use.
Pin "E" (Pig-Tail yellow wire) - connects to your cockpit kill switch (p-lead ignition ON/OFF). To turn ignition OFF, ground the p-lead with the switch. To turn ignition ON, un-ground the p-lead Kill Switch (*).
Pin "F" (Pig-Tail blue wire) – connects to tach instrument.

(*) Mode Switch: Series 200-6X ignitions can use a secondary cockpit ignition switch to enable Fixed Mode or Variable Mode operation. A bias signal sent over the existing kill wire (pin E) is all that's needed. The bias signal is produced by a 1K ohm resistor that connects the kill lead to ground by way of the included Mode Switch - detailed later in the manual.

*Note 1: Shower or vibrator type starting aids are **not compatible** and may damage your E-MAG – remove before installation.*

Note 2: E-MAG p-lead wire does not make radio noise


Circular plug (ignition)


Circular plug (cable)

and does not require shielding. If replacing a magneto, your existing shielded p-lead wire can be re-used. If doing so, the outer shield needs to be trimmed clean and kept well clear of all other terminations.

Note 3: All E-MAGs are "starting ignitions". In a dual installation, or if replacing a non-starting magneto, revise your starting procedures, and/or remove any key switch starting blocks (remove the jumper on the back of the key switch) to your E-MAGs.

Note 4: Whenever the aircraft bus is powered ON, the ignition is "awake". It draws a small amount of current (approx. 40 milliamps) even when not firing plugs. Use the master bus switch (or breakers if necessary) to power down the ignitions when not in use.

Note 5: DO NOT power the ignition ON when you have a ground battery charger connected to the bus.

Note 6: Collect your tack signal from only one, not both, ignitions unless your instrument has provisions for two (separate) tach inputs. Unlike a magneto, your E-MAG will produce a tack signal even when kill switch is turned to OFF.

Note 7: Tach signal is a 3 pulse/rev, low true, 33% duty cycle, 10-12-volt pulse. Signal is present even when the ignition is p-leaded OFF. E-MAG's tach output is a courtesy feature, unrelated to the ignition's primary purpose. Due to the variety of instrument options available, our ability to support and troubleshoot interface issues is limited. We will post the most common suggestions/remedies in our Trouble Shooting Guide (download from web site).

Our recommended wiring schematic is shown at the end of this manual. Other wiring schemes may be proposed by others from time to time. Please understand our ongoing testing, maintenance, revisions, and support is based on our recommended configuration only. **We DO NOT TEST OR SUPPORT** alternative wiring schemes. If used, our ability to provide knowledgeable or timely support may be limited.

Spark Plug Wiring (PW):

As with any wasted-spark ignition, E-MAGs fire spark plugs in pairs. Cylinders 1&2, 3&4, 5&6 are paired with plug leads connected to both ends of a double ended coil "Bank".

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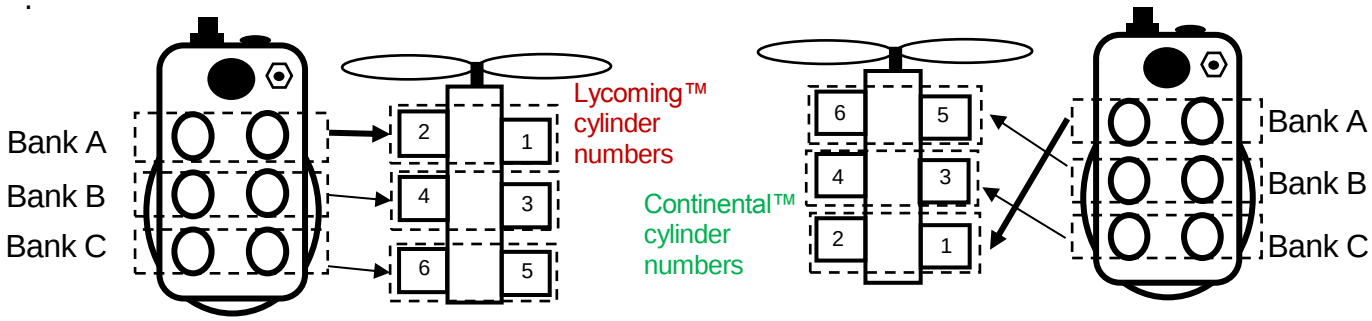


[Lycoming™] engines:
1) *Always - route Bank A to cylinders 1&2.*
2) *Most will route Bank B to 3&4, Bank C to 5&6 as shown.*

[Continental™] engines:
1) *Always - route Bank A to cylinders 1&2.*
2) *Most will route Bank B to 5&6, Bank C to 3&4 as shown.*

Note 1 : Due to the variety of applications in different engines, some lead re-assignment of Banks B and C may be necessary. The Pull-Thru test [highly recommended] is the best way to verify plug firing conforms to the engine manufacturer's firing order.

Note 2: Ignition Bank firing sequence is A-B-C regardless of the direction of the engine/ignition drive interface.

Setup Notes (N#):

N1 - **Top center and other engine position markings:**
[Lycoming™]: On Lycoming™ (direct drive) engines, position marks (TC, 20, 25, etc.) may be stamped on the PROP SIDE of the flywheel. These marks align with a hole in the starter mounting case. You may also find position marks on the ENGINE SIDE of the flywheel. These marks align with the upper engine case seam. Consult your engine documentation for the procedure to locate engine position marks.

[Continental™]: On Continental™ engines, position marks on the prop flange and gear inspection ports may not be suitable for timing purposes. Consult your engine manual for manufacturers instruction. See Appendix 2 - TC Locator.

N2 – **Ignition orientation:**
Stationing the ignition for a different mounting angle is fairly easy. Pull the receiver cup out of the accessory case and reinsert at a more favorable angle. Position is limited only by the tooth spacing of the gear on the back of the receiver cup. If tooth spacing is too coarse and does not allow an intermediate position, simply rotate the gear 180 degrees before reinserting. You can then access the mid-points of the earlier gear tooth restriction.

[Lycoming™]: Lycoming™ receiver cup has a pilot bearing to support the rear of the receiver cup assembly. This bearing must be nursed out as you remove the receiver. Gentle rocking motion, while pulling outward, may be required.

[Continental™]: Continental™ receivers are supported by a large bushing and will ease in and out with little effort.

In both instances, take care with the rubber cushions. If they drop into the accessory case retrieval can be problematic.

N3 – **Approach Direction:**
Instructions to move the engine to TC, MIN or MAX engine positions, don't mention approaching those targets in the direction of normal rotation. Installers are free to do so, but it should not be necessary in most instances.

N4 – Moving MIN or MAX Setpoints:
The procedure for moving a MIN or MAX setpoint is simple but strict in two respects:

1) Make certain the Button press/hold is done with the setpoint color (BLUE or WHITE) showing (i.e. **not** the background green color).
2) The "hold" must be uninterrupted until you reach the new engine position. If the Button hold is relaxed in route, the setpoint will attach to an unintended release point.

A clumsy "move" sequence can be mis-read as a DIR change sequence, as both procedures start with a Button press/hold. Such errors are easy to correct but careful execution will prevent them in the first place.

Manifold Pressure (MAP):

In Variable Mode, manifold pressure and RPM are used to calculate proper firing advance. Ignition comes with 3' of 1/8" ID x 1/4" OD silicone tubing for manifold pressure connection**.** Thread the 1/8" barbed nipple (packed separately) in the brass fitting next to the Control Plug header. Brass fitting can be removed to reveal a 1/8" NPT in the ignition case if you prefer different hardware. Route the MAP tube to a convenient connection point on the engine, or a MAP header if used. The ignition has both electronic and mechanical MAP pulse dampeners built in.


MAP-1/8" Barb (shown) or 1/8 NPT if brass fitting is removed.

With **normally aspirated** engines, the MAP tube is a fail-safe input. Meaning if the MAP plumbing comes loose or fails, plug firing in Variable Mode will automatically retard to a very flyable, but slightly less efficient, firing position. If installing two ignitions, run a single MAP tube to the accessory area, and then tee the line to each ignition. If you have a manifold pressure gauge, tee into that existing line for your pressure source.

With **turbo normalized or boosted** engines, MAP plumbing is NOT considered fail-safe. A MAP plumbing failure can, in certain conditions, call for more ignition advance than is necessary, appropriate, or safe. Excess advance can result in loss of power, overheating, and/or damage to the engine. For this reason:

1) The MAP plumbing for two ignitions should not share a common feed. Using separate MAP plumbing for each ignition will minimize the effect of a MAP plumbing failure on one side.
2) The cockpit **Mode Switch** is a simple and effective override that will bypass the MAP input (plumbing failures) and set the ignition to Fixed Mode firing (where MAP input is not a factor) – see Mode Switch elsewhere in this manual.

[Lycoming™] cylinders have a primer port that can be used to access manifold pressure. Use a standard 1/8" pipe fitting and a short length (3 or more inches) of metal primer tubing (not provided) at the cylinder before transitioning to the MAP tubing.

[Continental™] *Connect MAP tube to the fitting near your induction air control.*

Auto Plugs and Adapters:

Aircraft engines are typically tapped for 18mm thread spark plugs. To use 14mm automotive style plugs, we provide Auto Plug Adapters. There are numerous auto spark plug styles and temperature ranges available through various outlets. E-MAG has NOT studied the relative durability or performance of different plugs. Customers need to monitor plug condition and evaluate and adjust as necessary. We offer the following list of plug and adapters that have a history of good service. Set plug gaps at 0.030" to 0.035".

Long Reach (LR) vs. Short Reach (SR) Cylinders


SR LR LRX

Cylinders are made with two different spark plug thread depths. Match spark plugs and plug adapters to the cylinder depth when ordering.

1) [Lycoming™] Long Reach (LR) engines can be identified by yellow paint applied to the fins near the spark plug hole.
2) LR or SR cylinders can also be identified by the aircraft spark plug call-out for the particular engine. If it has the letter "M" - as in RE**M**XXX, you will need SR plugs and adapters. If it has the letter "B" as in RE**B**XXX, you will need LR or LRX plugs and adapters.
3) The thread lengths of plug adapters are as follows:
   a) Short Reach ("SR") external threaded section is approx. 1/2".
   b) Long Reach ("LR" and "LRX") external threaded section is approx. 3/4".

Note: [Continental™] LRX adapter is an LR adapter with the hex head extended ¼" to facilitate socket attachment (removal only) on Continental™ 550s, and possibly others, where the plug hole is recessed, and standard sockets may not reach.

Spark Plugs - See Appendix 1 for specific spark plug recommendations.

IMPORTANT: Remember to **FIRST** install spark plug in the adapter (fully seated and finger tight). **THEN,** insert the combined plug/adapter assembly in the engine and tighten to **18 ft/lb** (standard auto plug torque) through the spark plug ONLY. **Do NOT torque the adapter itself.** If you torque the adapters directly, stress will be focused underneath the adapter head and it can fail during installation. Such failures are not covered under warranty. Use anti-seize (sparingly) on the outer/engine side of adapters.

Harness Fabrication (plug wires):

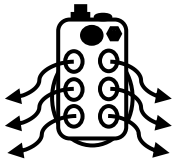
Trim-To-Fit Harness

Our lead kits use our custom low-noise plug wire that is not shielded. We have no (zero) reports of noise problems from customers using this wire (properly installed and in good condition). If you do hear spark noise, something is not installed or functioning properly. Plug "clicking" noise over the radio is a useful maintenance signal. Something is loose or worn and arcing - which causes radio clicking noise. Leads should be kept separated. Do NOT bundle them together which can cause them to be inductively coupled. Wire looms can be purchased at auto parts stores, but a simple

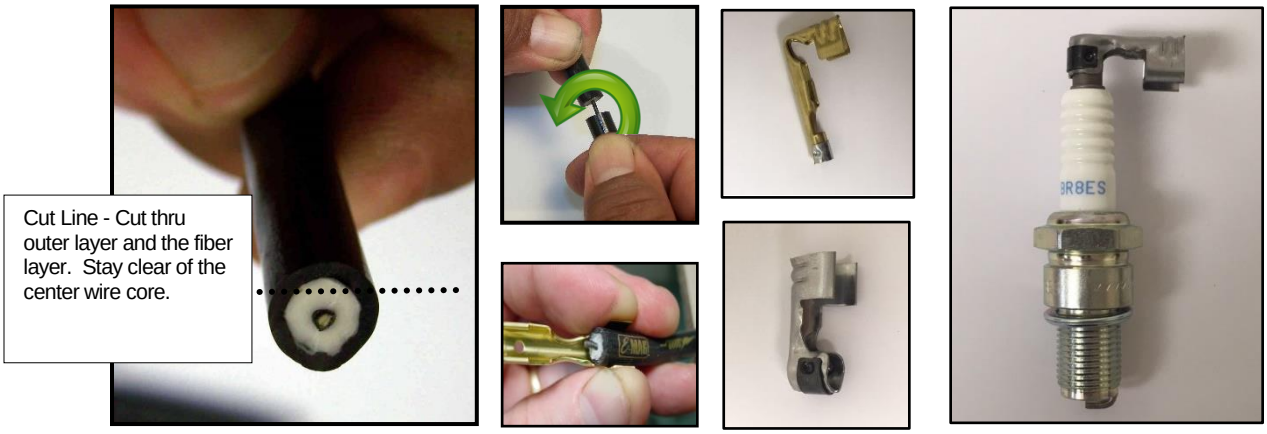
separator can be fabricated out of tie-wraps and ¼" segments of leftover MAP sensor hose.

Criss-Cross vs. Up-Down
It's relatively immaterial whether you route plug leads in the traditional magneto criss-cross fashion (one ignition wired to alternating upper and lower plugs) or one ignition firing all the upper plugs and the other ignition firing all the lower plugs

Organizing leads
Because plugs in each bank fire simultaneously, the coil attachments, within each bank, are interchangeable. Example: Plug wires for cylinders 1&2 can attach to either coil tower of Bank A. This flexibility can reduce congestion and wiring cross-over at the back of the ignition when attachments favor routing to the left and right sides of the engine.



Lead Fabrication - Trimming
The red (or black) outer jacket and the white inner layers are separated by a reinforcing fiber weave. The conductive element is a spiral wound filament around a Kevlar core (avoid when trimming). Use a razor blade to trim the OUTERMOST red and fiber layers ONLY 3/4" from the end, all the way around the wire. Avoid cutting anywhere near the center core. The white insulation layer separates easily as you twist the trimmed outer jacket. Twisting the cut end counter-clockwise will help to avoid unwinding the spiral core.
Note 1: The center core is easily nicked and weakened by contact with a Stripping tool or a blade. DO NOT use the wire stripping station on the crimp tool.



Terminals and Boots
The short terminals and rounded boots are for the spark plug connection. The longer terminals and flat-backed boots are for the coil connection.
Coil ends - First, run the wire through the boot so you have a couple of inches extended. This will give you room to work the wire and terminal. A light coating of **SILICONE SPRAY** (not included) is required to lubricate the wire as you work it through the boot.
Plug ends – You can crimp the terminal to the wire and then insert the assembly into the boot with silicone spray lubrication.

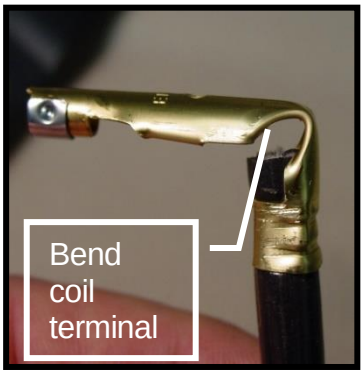
Note 1: It is best to push the boot down the wire (rather than pulling) to avoid straining the wire core.
Note 2: You can push on the heel of the coil boot to straighten the passage as you push the wire through. Free the terminals from their strips with wire cutters. The terminals are NOT finger friendly. They will easily cut if not handled carefully.

Pre-Crimp - Fold the ¾" of exposed wire core back against the lead and position it in the crook between the terminal ears. Then finger pinch the terminal ears to 1) provide a preliminary snug fit, and 2) reduce the spread between the ears so they fit in the "W Crimp" station of the crimping tool. Position so you have at least 1/8" of plug wire past the terminal ears.

Final Crimp - Crimp the terminal using the W Crimp Station on the Tool. Position the ears so they feed toward the side with the "W" point. The ears will roll back toward each other and imbed themselves in the outer jacket as the Final Crimp is formed. Push (not pull) the terminal to final position inside the boot.

Coil terminals will need to be bent 90 degrees (at the narrow section) before positioning in the boot.

Resistance Check - Verify the finished leads are assembled correctly with a simple ohm check. Each lead should produce roughly 180 ohms of resistance per foot of plug wire. To check, disconnect the leads at both ends so you can make (firm) ohmmeter contact with the terminals on each end. Watch the ohmmeter display while you exercise each end vigorously (twist/bend/tug) to see if the reading jumps significantly (several times the normal range). To repair a crimped terminal end, simply snip off the bad end (assuming you have an inch or so to spare) and replace with a new terminal.

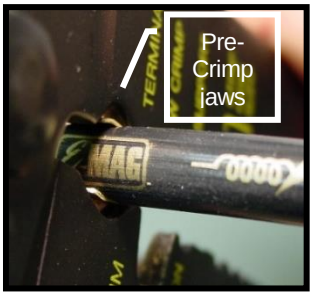


Note 1: Resistance checks are also recommended at annual inspection. It tests the condition of the conductive components, but it does not check the electrical insulation, which is another way that wires can fail. A visual inspection of plug wire is recommended, especially in areas of possible chafing.

Harness Terminations

The terminals on both ends of the plug wire are secured by a spring steel outer band with a detent. Verify that you feel and/or hear the steel band detent **snap-lock** as the terminal slips over the connecting post:

1) **Coil Terminals** - The coil terminal post inside the tower has 3 grooves. As you push the circular terminal onto the post, you will feel and/or hear a series of sharp clicks as the terminal detent snaps over these grooves.
2) **Plug Terminals**: Spark plugs have an hourglass shaped cap. You will feel and/or hear a sharp click as the terminal snaps over the plug cap.



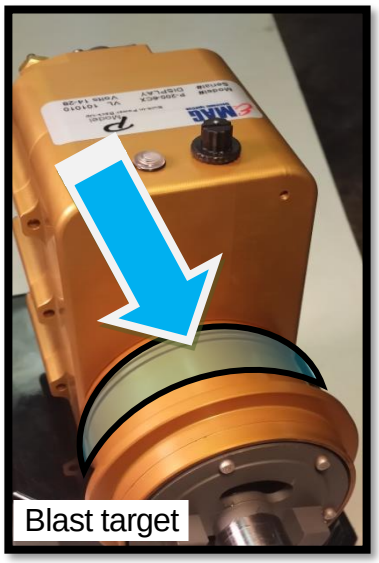
In either case, **if you don't feel and/or hear the terminal snap,** remove and inspect for irregularities or damage. If needed, replacement terminals can be provided by E-MAG.
If not properly secured the leads can come lose, which risks interrupting ignition operation,

and can damage the ignition coil. NEVER operate the ignition (fire plugs) without ALL high voltage loops (coil to wires to plugs to engine to plug to wire to coil) secured in place.

Note1: After plug wires are connected, verify the boot sleeve is fully inserted over the spark plug and coil towers and is relaxed, i.e. not "compressed" such that it's left pushing the boot away from the terminal.

Note 2: When removing the wires from either end, pull the boot/terminal straight off the post. If you use the 90-degree boot to lever/pry/bend the terminal off the post, you can distort and weaken the terminal spring retention clip.

Prior to First Start:



Check Blast Tube Cooling

E-MAGs are designed for a high-heat environment, but there are still thermal limitations and benefits to keeping the equipment as cool as possible. Blast tube cooling is a simple way to reduce operating temperatures, and we consider it mandatory (not applicable to rear facing installations on the cold side of the deck). Blast tubes should be directed at the round neck, immediately behind the mounting flange.

The mere presence of blast-tubes does not guarantee they are operable and/or effective. After initial operations, operators can verify the ignitions are within temperature guidelines (under 200F during flight). A thermal reactive label is installed on the electronics case. Alternatively, a thermal probe can verify ignition case temperatures at the forward section of the electronics (box shaped) compartment.

Electrical System Condition

E-MAG's power dip protection helps guard against severe voltage drops that occur when the starter motor is engaged. However, in the event of a compromised electrical system (low battery, long cable runs, corroded terminals, cold engine, etc.) bus voltage may not rebound as the starter speeds up (as is normal). A properly designed and functioning electrical system is essential for the ignition to work properly. If bus voltage stays below safe levels, a built-in power dip safety circuit will not allow the ignition to fire (per design). The starter is the largest load on the electrical bus. Keeping non-essential loads turned OFF during start will help.

Pull-Thru Test:

The Pull-Thru test will confirm 1) plug wire assignments, 2) basic operation of firing circuits, and 3) correct DIR as follows:

1. Remove all spark plugs from the engine and reconnect them to the plug leads.
2. *IMPORTANT* Rest each plug on the engine case or convenient location such that the metal jacket of each plug is grounded to the engine block. *Alternatively, the plug metal*

jackets can be wired to the engine block or they can be bundled (wired) directly to each other.

3. One ignition at a time: Turn bus power ON, Kill Switch ON, and Mode Switch to VAR. LED will be steady RED. Ignition MUST be in Variable Mode for starting (i.e. Pull-Thru test). Rotate the prop by hand in the normal direction of travel and confirm all plug pairs fire in proper sequence. Any deviation indicates a wiring or setup error.
   - Both plugs for cylinders 1&2 (Bank A) fire at the starting lag position (4 degrees after TC).
   - Both plugs for Bank (B or C) fire 120 degrees later – see Note 3.
   - Both plugs for Bank (C or B) fire 240 degrees later – see Note 3.

Note 1: Plugs will not fire:

i) When the engine is rotated the wrong direction.
ii) If ignition DIR is not configured to match engine rotation (change DIR – Setup step 5) a).
iii) When Mode Switch is in FIX position and engine is moving at hand pull-thru speeds.

Note 2: Multi-Strike. At cranking speeds, the ignition uses a (5) rapid strike sequence for each bank. This means the Pull-Thu Test will not produce the familiar single spark "click". Instead, you'll hear the plugs "buzz" - the sound of a multi-strike sequence.

Note 3: Plug wiring and pull-thru overview:

1) Both Lycoming™ and Continental™, Bank A always connects to cylinders 1&2.
2) Bank B and C connections are limited - B to 3&4 and C to 5&6, or vice-versa. Due to Bank firing (plug pairs vs. single plugs) installers will be verifying only one plug (of the firing Bank pair) matches the engine manufacturers firing order.

Tuning MAX:

Orientation:

- *Operating the ignition in Variable Mode (Mode Switch "VAR") can improve engine efficiency by enabling automatic adjustment of the plug firing position. The range of automatic adjustment is capped by the MAX setting. MAX will be either the default (5 degrees ahead), or a different MAX position as set by the operator. The default is a modest setting for most engines. Tuning MAX can, and likely will, improve efficiency but it' is not required for basic operation, especially in Fixed Mode where variable firing is not a factor.*
- *Engine and installation conditions vary widely. Operators need to confirm the suitability of their MAX setting, including the factory default. The effects of a given MAX setting will be most evident, and useful for tuning purposes, in cruise conditions (RPM above 2400 and MAP 22" or below) where spark advance is greatest.*
- Operators need to be mindful of the engine manufacturer's temperature recommendations and red-lines. It should also be understood that improving efficiency (extracting more energy from a given amount of fuel) means a certain amount of additional heat may be generated. Tuning

MAX changes the range of firing positions and this *may (or may not)* affect CHTs, most notably in cruise. *As a relatively new feature, published engine manufacturer guidelines for tuning MAX (specifically) may be ambiguous, or more likely non-existent.*

- As a **GENERAL FRAMEWORK ONLY,** MAX adjustments can be guided by engine efficiencies and CHTs at cruise power settings – keeping in mind the limitations of CHT readings. Ignition advance is a significant, but not the only factor influencing CHTs. Baffling, mixture, prop, cylinder design, cylinder break-in, air temperature, air density, humidity, fuel type, induction boost, and more can all affect the indicated CHT. Every installation should be considered unique – assume nothing.

Establish a baseline
An initial period of operation in Fixed Mode (Mode Switch to "FIX" after start-up) will allow you to establish an operating baseline with plug firing at the manufacturer's recommended position. The ignition will still provide higher spark energy and that alone can affect engine behavior. Temperature issues encountered in Fixed Mode, if any, suggests a need for correction outside the ignition area – baffling, fuel, etc. These should be addressed before enabling Variable Mode.

Tuning Actions – Adjust MAX setpoint (affecting Variable Mode only)
1) Extending the firing range (move MAX further ahead of MIN) typically increases cruise CHTs, and up to a point, can improve efficiency. *Overly aggressive settings can be hazardous to the engine.*
2) Restricting the firing range (move MAX closer to MIN) typically decrease cruise CHTs and may or may not reduce efficiency.

Start Variable Mode operations (Mode Switch to "VAR") with a conservative, factory default, or less, MAX setting. You might then **test with gradual 2-degree extensions**. STOP extending MAX at the **lowest** setting where either:
1) You start to see (cruise) efficiency gains flatten.
2) Cruise CHTs stabilize at your target temperature:
   a) Above the level experienced in Fixed Mode cruise.
   b) Well below the manufacturer recommended temps for take-off and climb (maximum power).
3) As a final step, we recommend lowering the MAX setting a small amount. Your goal is the **least** (not the most) aggressive setting that optimizes efficiency.

Note 1: Mode Switch - When you enable Variable Mode (Mode Switch "VAR") to test different MAX settings, you always have the option of switching to Fixed Mode (Mode Switch "FIX") and return to your previously established fixed firing baseline. The Mode Switch can be operated at any time, other than startup, when Variable Mode is required.

Note 2: Alternative (auto) Fuels: CAUTION - Notwithstanding engine manufacturer approval of some engines to burn auto/alternative fuels, such approvals almost certainly presume operation with fixed magneto firing - not high-energy variable firing electronic ignition. Operators need to independently validate proper engine behavior with different fuels and adjust ignition as needed. In

general, auto fuel burns faster than avgas and is, in effect, a timing change. An offsetting adjustment (lower advance) may be necessary for proper operation.

Operating Notes:

Mode Switch

Start engine with Mode Switch set to VAR (plugs will not fire at cranking speeds in FIX Mode). The Mode Switch does NOT replace or interfere with traditional ignition ON/OFF test (kill) switches. Rather, it's a simple in-flight control that switches between Fixed Mode (ON) and Variable Mode (ON).

Engine Management

The high energy spark and variable firing of an electronic ignition will change engine behavior in significant ways.

Starting

1) Turn ON bus power to the ignition (presumably your main power switch).
2) Turn ON the ignition Kill Switch (un-ground p-lead kill wire).
3) Verify Mode Switch is set to VAR.
4) Start the engine.
   a) Priming (plunger type - plumbed to each cylinder) is not recommended and should not be needed. Boost pump ON just long enough to see pressure rise, then boost pump OFF. For hot starts, boost pump may not be needed at all.
   b) Start with minimal (barely cracked) throttle and mixture settings. Increase settings gradually, and as little as necessary, to find a starting position that best suits your engine.
5) Lean-limit and mixture control.
   a) The familiar seat-of-your-pants technique for setting mixture (lean to rough then richen) may no longer work. The lean-rough boundary will be shifted (far leaner) or it may disappear entirely. High-energy spark can ignite far leaner mixtures and that will shift the lean-rough boundary.

Note 1: Wasted Side Firing - As with any wasted spark system Series 200 fires plugs in pairs. On any given cycle, one cylinder (within the pair) is in the "firing" position. At that moment, the companion cylinder is between the intake and exhaust strokes (both valves open). If fuel vapor is present in the companion cylinder (due to priming, excess throttle/mixture, or any other reason) the wasted side vapor can ignite. This is called a "wasted side firing". It's sometimes mistaken as a backfire or a kick-back, which is different. Wasted side firing is easily remedied by adjusting your starting procedure to eliminate excess fuel. We recommend starting with minimal throttle and mixture settings, no priming, fuel boost pump (if present) only long enough to see pressure rise. For hot starts, forego boost pump altogether. Modify these settings as needed, but as little as possible to achieve quick and consistent starts.

Ignition Checks

Your ignition checklist will be extended to include two new features. The E-MAG internal alternator and Mode Switch are new.

Routine pre-flight left/right run-up check will add:

1) Alternator Run-Up Check is new and specific to E-MAG. E-MAGs have an internal alternator that operates in parallel with power from the aircraft bus. The ignition automatically transitions between aircraft power and internal power as needed. Aircraft power is needed for starting and perhaps for low idle speeds. Test basic alternator function as follows:
   a) When running on one side (roughly 1700 rpm during your traditional L/R check:
      i) Turn ignition power test switch OFF for 2-3 seconds and back ON. The engine should run smooth during the outage – this verifies the internal alternator is working.
      ii) Repeat with the other ignition.
      iii) Any rough or degraded behavior indicates a problem - not suitable for flight.
3) Mode Switch Check (VAR/FIX) is new and specific to E-MAG Series 200. *Run-up check for Mode Switch is optional for non-boosted engines*. **"**VAR" will be your setting for most operations and is required for start-up.
   a) At roughly 1700 rpm (... continuation of above):
      i) Turn Mode Switch from VAR to FIX for 2-3 seconds and then back to VAR. The engine should run smooth in both positions. The firing position may change with Mode Switch transitions, so a slight shift in rpm might be expected.
      ii) Repeat Mode Switch check on the other side.
      iii) *Any rough or degraded behavior indicates a problem - not suitable for flight*.

Cut-Out Test - after installation, engine maintenance, and at annual inspection:

I. The Cut-Out Test is new and serves as a stress test of the system (see Note 1) in challenging conditions - low rpm and no aircraft bus power to the ignition. Alternator output will vary with engine rpm. Verify the engine will operate at speeds below your in-flight idle - typically in the range of 1100 rpm, but the lower the cut-out speed the better. Your ground idle can go much lower, so the Cut-Out Test is a ground based (only) test.
   i) Operating on one ignition, lower engine speed to 1200 rpm. Cut bus power to the ignition. Slight rpm my dip may be expected with lower spark energy.
   ii) Very slowly lower the engine rpm until the engine quits - note the cut-out speed. A log-book entry can help track cut-out trends over time.
   iii) Repeat Cut-Out test on the other ignition and then with both ignitions.

Note 1: The Cut-Out test marks the low-speed boundary of the entire system when the ignition is unpowered. Ignition alternator output and spark energy will be reduced at low speeds. Spark energy is a significant, but not the only factor affecting cut-out speeds. Mis-adjusted idle mixture fowled or partially fowled plugs, induction leaks, mis-adjusted prop, and other factors can affect (elevate) cut-out speeds. Keep this in mind if elevated cut-out speeds are detected. E-MAG bench tests (open air) every ignition spark down to 700 rpm prior to shipment. This is well below most in-flight idle speeds. You may also find the ignition will self-power down to your lowest ground idle speed. If so, your log entry can reflect no cut-out at that rpm.

Note 2: When performing a Cut-Out test, allow the engine to come to a stop and let the ignition fully power down. Re-applying bus power, or activating the other ignition, at the last moment to

keep the engine running may not restore full operation and is unlike the power failure event being tested

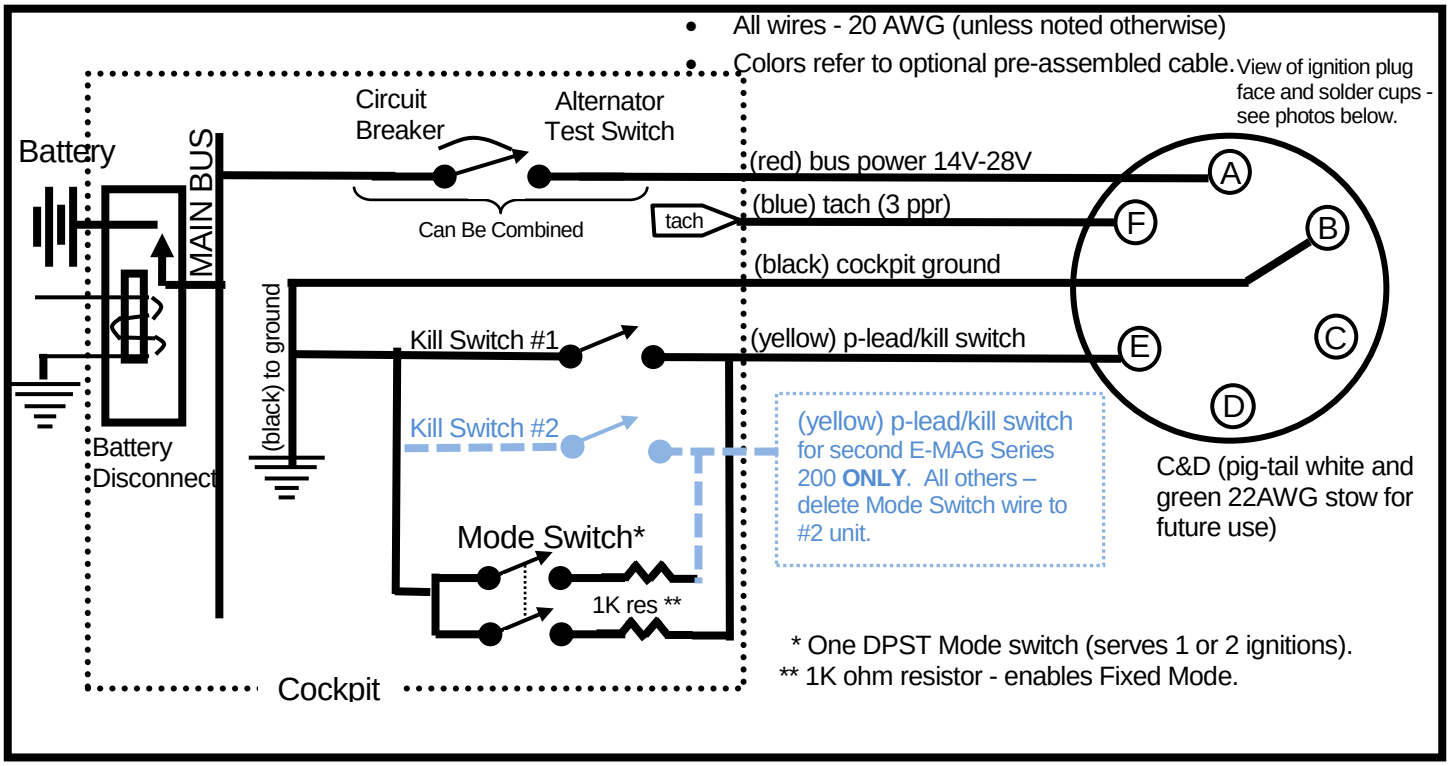
Emergency Prop Starting
A low battery that barely "bumps" the starter motor, or can only "click" the solenoid, should have enough energy to power the ignition for prop starting. However, if the battery is totally dead, the low speed of a prop-start will not be fast enough for the internal alternator to power the ignition. In such cases, a 9-volt flashlight battery can provide temporary current (only needed on one ignition) for prop starting. For **details see web site Tips and Tricks. Caution: Do not attempt a prop start unless you are trained and are comfortable with the procedure.**

Maintenance:

Condition Inspection (annual)

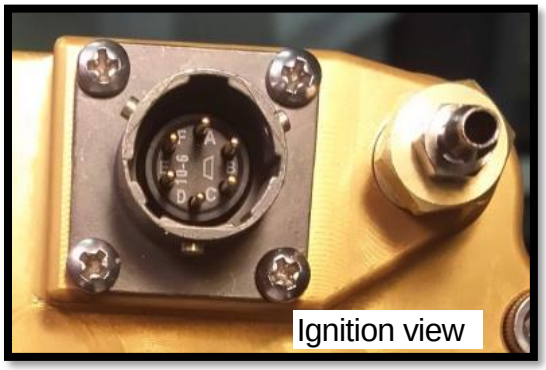
1) Confirm Setup Reference positions prior to removal. Note discrepancies (if any) from prior settings.
2) Check E-MAG web site for the most recent Manual (www.emagair.com/downloads), Service Notes (www.emagair.com/service-notes), and verify equipment is current with all updates.
3) Ignitions come with a thermal sticker that will trip (turn from a light egg shell white color to gray or gray/black) as case temperatures exceed 200 degrees (F). Gray/black or solid black indicates a period of significant over-temp. If tripped, review blast cooling and/or other cooling impediments. Operating temperatures should be kept below 200 degrees.
4) Ohm Check all plug wires and examine for evidence of wear or chafing.
5) Remove and inspect spark plugs for signs of unusual wear or build-up. Replace plugs at 125 hrs. Re-gap plugs per instructions. When re-installing auto style plugs with auto plug adapters, review plug/adapter installation guidelines. Ref. Appendix 1.
6) Remove ignition and examine shaft for bearing play - *disassembly is not necessary.* Look for excessive lateral and axial play. Shaft rotation should be free, with no catching, flat spots, or grinding. Inspect drive cushions, which can get hard over time.
7) Reinstall the ignition - see Setup instructions.
8) Verify proper operation including:
    a) Perform Ignition Checks on each ignition:
        i) Basic Alternator Check
        ii) Internal Alternator Minimum Cut-out Speed Check
        iii) Mode Switch Check

Wiring Diagram (CW, SW):



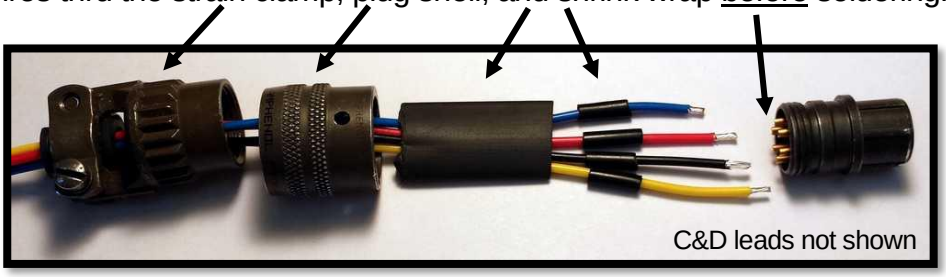

Control plug cable end


Optional potted pig-tail plug


Ignition view


Solder cup view

[left] Solder cup pins on back of standard control plug. Pin orientation matches the schematic above, and is marked on the inner face of the plug itself. When assembling the Std. connector, remember to pre-position wires thru the strain clamp, plug shell, and shrink wrap <u>before</u> soldering.


C&D leads not shown

Appendix 1 – Spark Plugs & Adapters:

Short Reach Plugs (uses SR plug adapter)

1) NGK Spark Plug BR8ES 2.5mm center electrode. Stock #3961 has a solid terminal tip (preferred). Stock #5422 has a screw on tip – if used make sure the tip is well secured.
2) NGK Spark Plug BR8EIX iridium electrode with solid tip.

Long Reach Plugs (uses LR or LRX adapters)

1) Denso Spark Plug IKH01-27 (stock #5750) has an iridium electrode with a solid terminal tip. IKH27 (stock #5347) has an iridium electrode with a threaded tip – if this type is used make sure the tip is well secured.
   [Continental™] The LRX adapter has an extended hex head to help with some Continental™ (550) engines that have a tight recess around the plug hole. The LRX extension provides socket access should you need to remove the adapter (**not** for tightening the adapter directly) – see below.

IMPORTANT: Remember to **FIRST** install spark plug in the adapter (fully seated and finger tight). **THEN,** insert the combined plug/adapter assembly in the engine and tighten to **18 ft/lb** (standard auto plug torque) through the spark plug ONLY. **Do NOT torque the adapter itself.** If you torque the adapters directly, stress will be focused underneath the adapter head and it can fail during installation. Such failures are not covered under warranty. Use anti-seize (sparingly) on the outer/engine side of adapters.

Operators need to monitor spark plug condition and adjust the plug temperature range as needed. The temperature rating is indicated by the NGK "8" or the Denso "27" reference in the part number. If selecting a different range, remember that lower numbers indicate hotter ratings, and higher numbers indicate cooler ratings.

Appendix 2 – Engine TC Locator :

[Lycoming™] engines have marks on the flywheel to locate TC and engine positions in the 20 to 25-degree range. Setup References (MIN and MAX) can be located by counting "X" number of ring-gear teeth relative to those marks (360 / # teeth = degrees per tooth). **These engines may have little need for TC Locator.**
[Continental™] engine require supplemental hardware to locate TC and plug firing positions – ref mfg. instructions. TC Locator will help locate engine TC.

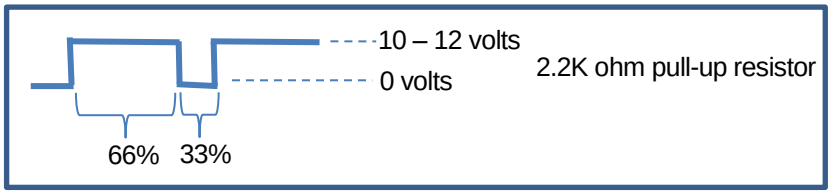
After all circular control plug wiring is installed and tested:

1) If not already installed, temporarily mount one ignition at any convenient orientation.
2) Remove spark plugs from Bank A cylinders #1 and #2. *Engine movement will be easier if you also remove one plug from each of the other cylinders.* Move the engine so piston #1 is near bottom of the stroke. *No need to track #1 compression – either stroke will work.* Insert the threaded piston stop tool in either plug hole of cylinder #1.
3) Verify power is OFF, Kill Switch OFF. Then connect the ignition circular plug and verify the LED is dark (OFF). Locate the Configuration Button ("Button") under the black protective cap. **Press and hold the Button <u>while</u> you turn bus power ON.** Continue hold until LED turns **blue** - then release. The LED will turn blue with a periodic green pulse, confirming you're in TC Locator mode.
4) Slowly rotate the prop either direction until the piston <u>gently</u> contacts the stop. Quick-press the Button and the LED will switch to green with a periodic blue pulse.
5) Slowly rotate prop in the other* direction until the piston <u>gently</u> contacts the stop. Quick-press the Button and the LED will switch to steady green, indicating the ignition has calculated the TC *(and 180-degree)* positions. Keep bus power ON.
6) Remove the stop tool. *Backing the prop (piston) away from the stop will make it easier to unscrew.* Then continue movement in the last (Step 5) direction. The LED will turn red and sound tone (red/tone) at engine TC – see Note 1.
7) Exit TC Locator by turning bus power OFF. *If proceeding to Setup - leave prop in the red/tone (TC) location.*
8) Remove ignition - proceed to Setup Step 3. *If the current clamped position was set by a previous installation (thru Setup Step 11), the ignition can remain in place - proceed to Setup Step Setup 12.*

**Note 1: TC Locator will produce a red/tone signal at both the TC target position as well as the 180-degree position. Step 6 says to continue movement in the last (Step 5) direction to arrive at TC. If you move in the wrong (Step 4) direction, you will arrive at the 180-degree red/tone position. Easy check - confirm red/tone corresponds to cylinder #1 piston at top center - not bottom center (or reference TC mark on prop flange/flywheel).*
Note 2: Using TC Locator to verify an existing clamped ignition position:
*1) Follow steps 2-6 to locate <u>engine</u> TC (**red**/tone). Don't move engine.*
*2) Power cycle the ignition OFF/ON to exit TC Locator and enter normal LED signaling. <u>Ignition</u> TC (**yellow**/tone) should be at the same or very nearby location..*
Note 3: IF a stable and visible (cowl ON and cowl OFF) location can be found, it may be helpful to add a permanent reference for engine TC.

Appendix 3 – Electrical Specifications

1) Bus power – circular connector pin A (red)
   a) Minimum - 9 volts
   b) Maximum - 48 volts
   c) Current draw from bus:
      i) less than 0.5 amp (normal operating conditions)
      ii) less than 1.0 amp (maximum draw with no-op internal alternator)
2) Tach – circular connector pin F (blue)



Appendix 4 - Installation Checklist:

Series 200-6X (Experimental) ignitions provide

1) High-energy spark.
2) Redundant operating power – an internal alternator as well as a connection to the aircraft power bus.
3) Variable Mode (VAR) and Fixed Mode (FIX) firing capability. Firing modes are controlled by a single cockpit Mode Switch. *Both fixed and variable modes share common position and processer-based logic elements.*
4) Single module. All elements (electronics, position, power, coils) are housed in a single assembly.

Installing your E-MAG ignition will require

1) Attaching three (four if you use the tach) wire connections from the ignition Control Plug.
2) Installing spark plugs, plug adapters, and a trim-to-fit harness.
3) Installing a manifold pressure tube connection.
4) Blast tube cooling.
5) Installing your E-MAG ignition on the engine.
6) Locate set-up position references.
7) Test, tune, and monitor to ensure proper operation.

What's included

200-6X (Lycoming™ or Continental™ version) ignition set includes:

1) 1 ignition module.
2) 1 Standard Control Plug connector kit (solder connections w strain relief clamp)
   a) Circular plug - 6 pin female.
   b) 2" of 1/8" heat shrink tubing.
   a) 3" of 3/8" heat shrink tubing.
1) MAP connections (1/8" barb fitting, 10-32 female, and 1/8" NPT female):
   a) 1/8" hose barb can be used with the 1/8" ID tubing provided, or it can be removed to access:
      i) 10-32 female thread fitting, that can be removed to access:
      ii) 1/8" NPT female thread in the ignition case.
   b) 36" silicone MAP tube (1/8"ID x 1/4" OD).
   c) 3 each, nylon tube clamps for ¼" OD MAP tube.
2) Ignition gasket.
3) Mode Switch kit – controls 1 or 2 model 200 ignitions.

Auto Plug Adapter set includes

1) 6 auto plug adapters - specify "LR" long-reach, "SR" short-reach, or "LRX" (certain Continental™ engines) adapters when ordering.
2) 6 copper gaskets.

Trim-to-fit harness set includes

1) 26' of custom E-MAG low noise plug wire.
2) 6 coil boots.
3) 6 plug boots.

4) 8 coil terminals (two extras).
5) 8 plug terminals (two extras).
6) 1 crimp tool.

Optional Parts **specify when ordering**

1) Circular control plug with pre-wired pig-tail – 72" wire bundle. Wires are epoxy potted in a shorter connector head (in lieu of Standard Control Plug above). This eliminates soldering wires to the standard connector. We suggest the standard connector kit if you already have imbedded wiring to the ignition(s).
2) Mounting Studs – [Lycoming™] Shorter (1-5/8", # 31C-13) studs will be needed to replace the longer ones you will remove along with your old impulse spacers.
3) Mounting Clamps – 200-6X have a 0.19" thick flange that requires compatible clamps.
   a) If replacing thick flange magnetos, such as the 0.31" thick flanges on some Continental™/Bendix styles, your old clamps will not work.
   b) Some Continental™/Bendix style clamps (#535847) have a shallow reach that will not provide suitable contact surface. Continental™ clamp #630535 has a longer reach.

Installation supplies and tools needed

1) Silicone spray – used when fabricating trim-to-fit harness.
2) Ohm meter - recommended (but not required) to test spark plug wires after assembly.
3) Solder iron and rosin core solder for control wires (not needed if ordering pre-wired Control Plug).

Other hardware and fittings NOT included

1) Fittings to attach the manifold pressure plumbing to the engine.
2) P-lead switch to control the ignition ON/OFF function (you can re-use an existing switch).
3) Fuse or breaker for bus protection and/or power test switch.
4) Blast Tube cooling (new or re-use existing).
5) Spark Plugs – readily available at auto parts outlets. Recommendations listed later in the manual.
6) Spark plug wire supports and wire separators.
7) Ignition mounting clamps. You may or may not be able to re-use existing clamps. See discussion elsewhere in the manual.