Experimental Installation Manual Subaru EA-022

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Ignition System Basics

The goal of any ignition system in a four-stroke engine is to start the combustion event so that peak pressure, as a result of combustion, occurs between 10 & 17 degrees after top dead center (ATDC) of the piston travel. This is the generally accepted range and the starting point when talking about ignition systems. From here we work backwards to understand how ignition systems work and what improvements can be made in order to get the most out of the engine.

Dual Magneto System Review

Traditional aircraft engines use a dual, or two, Magneto Ignition System (MIS). Both magnetos are timed to fire at a preset degree before Top Dead Center (TDC). The two magneto system can be made up of a number of combinations: one impulse coupled magneto and one direct drive magneto; two impulse coupled magnetos; or two magnetos that have some kind of "starting help" device like a shower of sparks or "Slick-Start" system. No matter the combination, the magnetos are responsible for supplying energy to the spark plugs causing a "spark" which is used to ignite a fuel/air mixture inside of the cylinder. For decades, this kind of ignition system has been used quite successfully in aircraft engines. Traditional aircraft ignition systems, however, have remained stagnant in technological development and because of their inherent limitations, hand-cuffed the engine's ability to deliver peak performance.

Magnetos have two big limitations: one, they produce a relatively small amount of energy; and two, they can only provide that energy (or spark) at a fixed time point in the crank-shaft rotation. Magnetos typically can provide 12,000V through about 5 degrees of crank rotation at the spark plug – less during the start sequence (6,000-8,000 volts during starting). The fixed time point where the spark occurs means that the magneto cannot adjust the spark event to compensate for variances in fuel/air mixtures. As fuel/air mixtures varies (either because of altitude, air density, fuel density, etc.), the time required to develop peak pressure from combustion also changes. If the ignition event timing doesn't change, then the time where peak pressure occurs MUST change. When this happens, the experience is typically a loss of power.

EIS Overview & Primer

There are two principle differences between a magneto (MIS) and an electronic ignition system (EIS): one, an EIS is able to deliver much higher energy to the spark plug for a long period of time (70,000V through about 20 degrees of crank rotation) at any RPM; and two, an EIS is able to vary the ignition timing based on changes in the fuel/air mixture.

The very large voltage supplied to the spark plugs comes from using larger coils. The EIS's ability to deliver that voltage at any RPM is because the output from the EIS is

NOT dependent on engine RPM, but the battery supply. The high energy voltage from the EIS allows for a larger gap in the spark plug – insuring a big, long duration, high quality spark. This spark will then have the ability to ignite typically any kind of fuel/air mixture that passes by the spark plug. This is particularly important for hot-start applications, where the fuel/air mixture is corrupt in some way, caused by the high temperature, poor fuel quality, or any combination thereof.

The ability to vary spark timing is also critical. Any good propulsion engineer will pontificate that the way to develop power out of an engine is directly related to the amount of air that can be put into the combustion chamber (fuel can always be metered). Aircraft engines battle this problem constantly with changing altitude and poorly designed intake systems. A good way of measuring the amount of air in the combustion chamber is by measuring Manifold Absolute Pressure (MAP). This directly correlates to the amount of air available for combustion. The EIS looks at MAP, and adjusts timing based on this to optimize the location (or degree of crank position) for the spark event to occur. The Electroair EIS uses the vacuum advance curve found in Figure 1 for adjusting timing based on MAP.

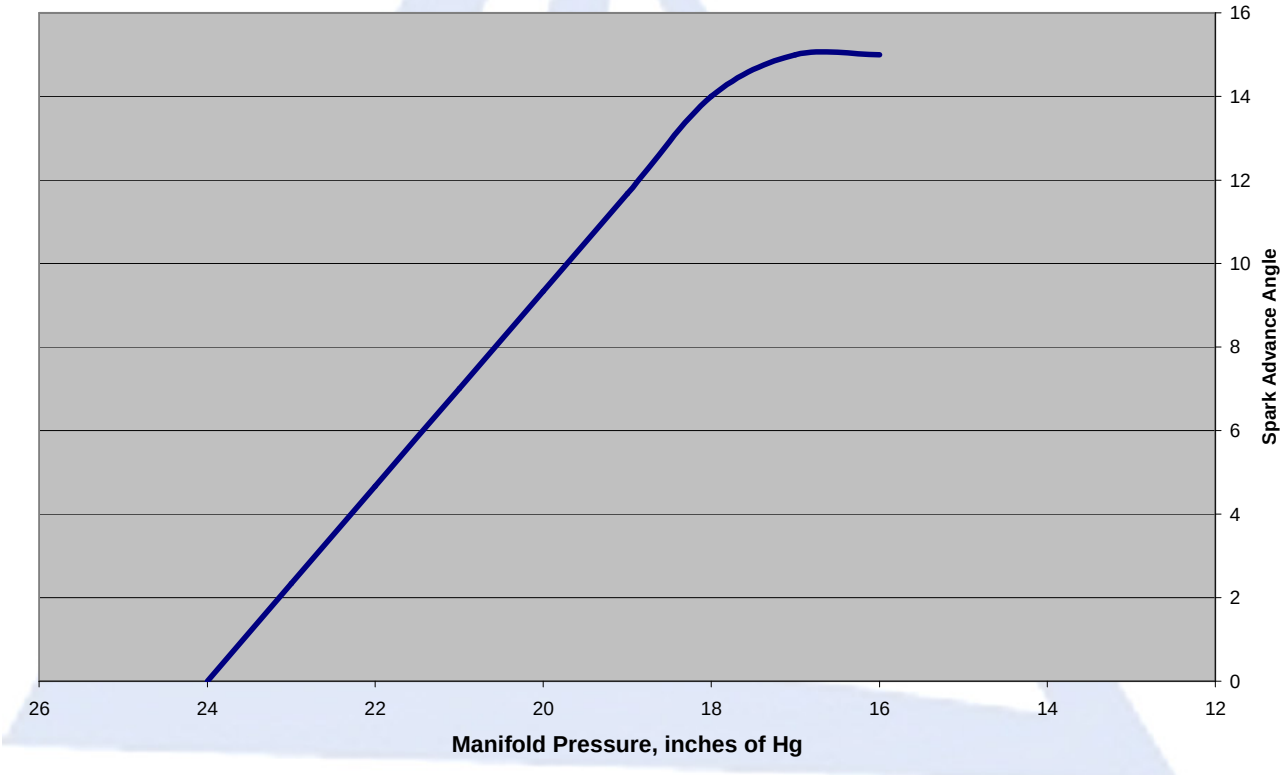


Figure 1: Vacuum Advance Curve

How the Electroair EIS Works

The Electroair EIS fires the spark plugs directly from the coils, not through a distributor. This is accomplished by using multiple coils, each with two spark terminals. The coil

terminals are connected to the spark plugs, allowing one cylinder to fire on compression while its companion cylinder fires simultaneously on exhaust. Open spark gaps in the rotor and cap are eliminated, making wear and moisture problems a thing of the past.

What sets the Electroair Electronic Ignition System apart from others is the ability to charge multiple ignition coils at the same time. This increased dwell time means that full spark energy is available over the entire RPM range (up to 9600 RPM at 12 volts). Unlike capacitive discharge systems that only put out one very short spark, the EIS puts out a full energy, long burning spark at the highest and most critical engine speeds. Long burn times assure effective burning of even rich fuel mixtures.

The EIS Controller includes dual digital microprocessors using patented spark algorithms, which takes the electrical signal from the crankshaft (or mag timing housing) sensor, identifies top-dead center, and then keeps track of the remaining rotation. The EIS determines engine speed and computes the spark advance using the settings pre-set at the factory for the engine as a base-line. Settings from the factory are preset for the engine's certified placarded timing. Additionally, the EIS receives engine manifold pressure information and advances the ignition to compensate for altitude and throttle position.

Beyond the synchronization and firing the plugs at the correct advance angle, the EIS also computes the exact dwell time to produce 9 amps of coil current. Coil charging is dynamically measured, so changes in RPM, battery voltage, or temperature are accounted for on every spark. This corrects any errors that are caused by battery voltage or coil temperature changes and insures maximum spark energy.

High Resolution Crankshaft Position Sensor

The EIS uses a single, high resolution, 60-minus-2 tooth crankshaft position trigger wheel. The trigger wheel is either installed in a timing mechanism that is installed in a mag hole (aka Mag Timing Housing or MTH), or a trigger wheel is installed directly on the crankshaft just behind the prop flange. This affords resolution unheard of in any other electronic ignition available today, offering spark accuracy of ¼ degree of crankshaft rotation. This accuracy means the system is ideal for the most demanding engine applications – *that's why the Electroair EIS has accomplished altitude and speed records in the industry.*

In summary, the Electroair EIS delivers more power because:

- Spark timing is precisely controlled under all conditions, including rapid engine acceleration.
- Longer dwell time and better propagation allows the engine to run better on various mixture settings.
- Accurate spark timing allows sustained engine operation closer to desired peak power timing.
- 100% spark energy up to 9600 RPM on 6 cylinder applications (at 12 volts).
- Longer spark duration!
- Built-in timing program.

- No power draining magnetos to drive.
- No moving parts to wear out or adjust.

Spark Plug Discussion

The installation manual specifies the recommended gap for the engine application. This gap will be larger than a typical aircraft plug gap because of the higher energy output from the EIS. This is perfectly acceptable with the EIS ignition charging method, since the high load of the cylinder pressure will allow the voltage to be quite high at the electrode; the gap will keep the plug from seeing an over-voltage situation.

The EIS system uses an *inductive* long duration charging method for the coils. Electroair's experience has drawn us to the following guidelines for spark plug selection:

- Select aircraft spark plugs that will work with the EIS. For Lycoming engines, Electroair has found that the REM37BY (or equivalent) plugs work the best because they are easier to gap to the range required and fit the broadest heat range recommended by the engine manufacturers. (Fine wire plugs are also an excellent choice for Lycoming engines). For Continental Engines requiring long reach spark plugs, off-the-shelf fine wire spark plugs will generally be the easiest to adjust the gap. Electroair strongly recommends verifying the heat range for the engine and using the appropriate plugs.
- Electroair manufactures aviation spark plugs that are gapped at the factory to Electroair's recommended wide gap of 0.036 inches. Electroair manufactures massive electrode and fine wire spark plugs for various applications. The spark plug information can be found on the Electroair website (www.electroair.net). Electroair spark plugs have been FAA approved for use with Electroair's certified EIS-61000 ignition systems. These plugs are only approved for use with Electroair's EIS. Electroair spark plugs should not be used with magnetos.

EIS Kit Contents & Requirements

System Requirements:

1. 12V electrical system (please advise if using a 24V system)
2. A desire to increase power and improve fuel efficiency!

Kit Contents:

1. ___EIS Controller
2. ___Coil Pack (two coils for 4-cylinder)
3. ___P/N EA-021, Timing Wheel/Cog Pulley Assembly (includes pick-up)
4. ___0.5ml bottle of Loctite 242 (packed with EIS Controller)
5. ___P/N EA-022, Subaru Installation Manual

Other items you will need:

1. A toggle switch for powering EIS, a 2 amp, a 10 amp circuit breaker.
2. One set of spark plug wires for particular Subaru engine.
3. Tools and knowledge of accessing the engine compartment and ignition system.
4. Basic tools and standard hardware required for mounting EIS controller & coil pack.
5. Electrical tools for cutting, stripping and terminating various wiring with Molex type connections. Also recommended is a good selection of cable ties for harness routing and tie-off.

Overview of EIS Installation

Thank you for purchasing an Electroair Ignition System. Electroair is confident that you will be happy with the performance of the EIS. The next several pages are a step-by-step process of installing the EIS. Electroair hopes the experience is enjoyable and that this manual will provide clear direction and guidance through the installation process. This manual will cover the following general installation steps:

1. General Overview and recommendations
2. Removal of old ignition components
3. Set-up and installation of the Timing Wheel/Cog Pulley Assembly
4. Installation of the EIS Controller and Coil Pack
5. Spark Plug Harness
6. Wiring
7. Final installation steps
8. Options

Electroair strongly recommends reading through this entire installation procedure before installing the EIS on the aircraft. Make sure that any questions are answered before the actual installation. Also, make sure any extra components needed, e.g. cable ties, circuit breakers, switch terminations, etc., are all available. Above all else, use good common sense and judgment. An electronic ignition system is a high voltage device. If an EIS is improperly installed or misfired, severe damage could be caused to the EIS, aircraft, or installer including bodily injury or death.

Please contact Electroair (517-552-9390 or sales@electroair.net) with any questions during this installation process. Good luck and happy flying!!

Electroair

Installation of EIS

1. General overview and recommendations:

a. Read through the entire installation instructions before beginning the installation to make sure each step is understood. **Contact Electroair** (517-552-9390 or sales@electroair.net) with any questions or items that are unclear.
b. Review your own skill set. If this is the first time installing an ignition system of any kind, Electroair recommends having someone available with some ignition experience in order to help.
c. If installing a Crank Shaft Timing Wheel (CSTW), Electroair strongly recommends having help in this procedure. There are instances where two sets of hands are useful. Electroair also recommends that one of the installers be familiar with removing and installing components on engines.
d. Always use good safety and work practices. Use appropriate safety equipment (glasses, etc.) and precautions. The EIS is a high voltage system and if installed or tested incorrectly can cause substantial damage to both the system and the installer.

2. Removal of old ignition components:

a. Remove cowling. Verify that Master Switch is off and battery is disconnected.
b. Remove ignition harness from spark plugs.
c. Remove ignition computer & coils.
d. Remove the factory COG pulley.
   i. Mark the belts prior to removal of pulley so you can install the new pulley in the same position as the old pulley.
e. Remove pick-up from the hole in the intake manifold.

3. Set-up & Installation of Timing Wheel/Cog Pulley Assembly:

a. Install new COG pulley in the same position as the old pulley; reinstall the belts.
b. Install pick-up insert into the hole located in the intake manifold & tighten bolt to hold it in place.
c. Install new ½ inch pick-up into the pick-up insert
   i. The new pick-up will slide into the insert
   ii. Gap the pick-up using a 0.015 inch feeler gage.
   iii. Tighten the set-screws to hold the pick-up in place.
d. Rotate the engine until number one cylinder is on Top Dead Center (TDC). The keyway on the COG will be pointed at the three o'clock position.
e. This should place the trailing edge of the 11th tooth past the two missing teeth (clockwise direction from the missing teeth) directly under the center of the magnetic pick-up. This will verify that the COG pulley has been set-up correctly.

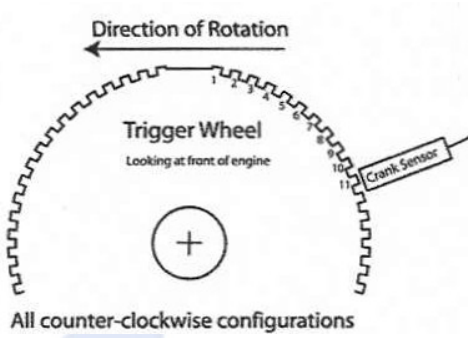


Figure 2: Trigger Wheel Timing

f. The engine now timed correctly.

4. Installation of EIS Controller and Coil Pack:

a. Select appropriate locations for the EIS Controller and Coil Pack to be mounted.

i. Remove harness attached to EIS Controller and set aside for later installation.

ii. Install the EIS Controller where temperatures will not exceed 150℉. Because of this, Electroair recommends that the EIS Controller be mounted on the cockpit side of the firewall with the shortest practical distance from the coil pack for the wiring harness runs. Dimensions for the controller are shown in figure 2:

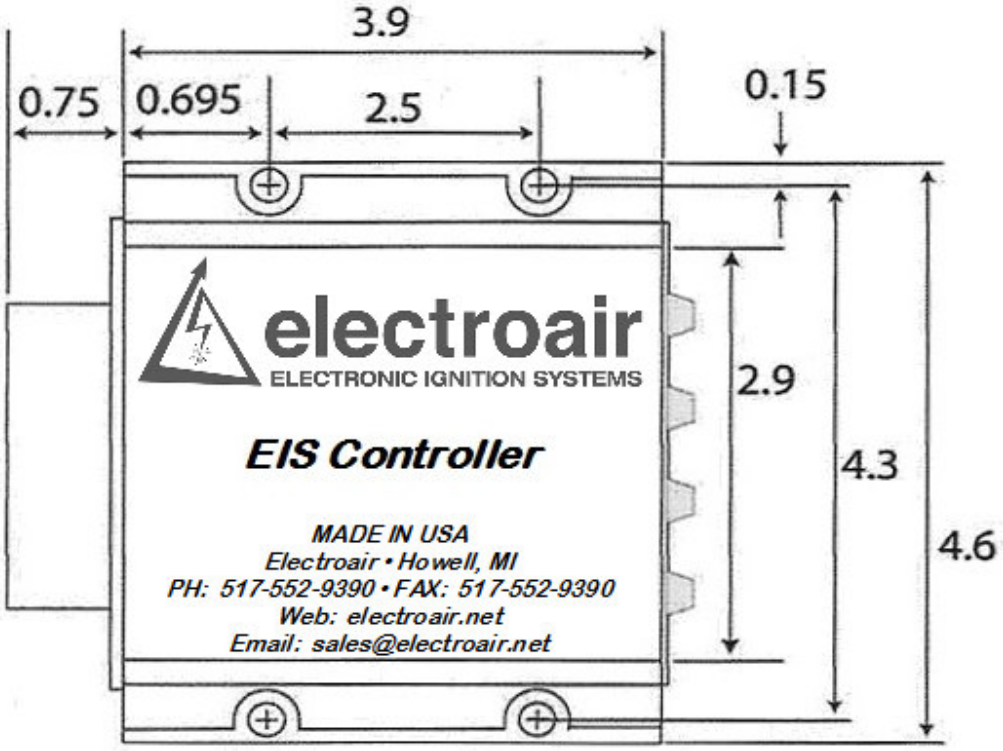


Figure 3: EIS Controller Dimensions

iii. The EIS Controller uses a case ground as a secondary ground. To complete the path for the secondary ground, scrap some of the anodize coating from

around one of the mounting holes. Route a separate ground wire from the Buss ground and attach at the point on the controller where the anodize coating has been removed. (Typically, the ground wire would be terminated with an eyelet and installed under the head of one of the mounting screws). Verify continuity to Ground.

iv. Mount the coil pack on top of the Intake Manifold (same location as the old coil pack). This will insure that the spark plug wire harness will fit correctly. If the mounting holes do not line up, you may fabricate a small bracket to complete this installation. The unit also comes with a ground wire which will be installed in section 6. Coil Pack dimensions are below:

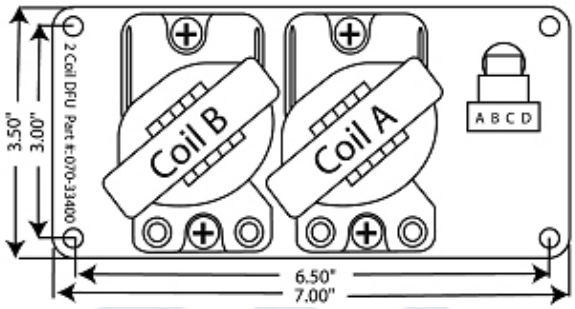


Figure 4: Coil Pack Dimensions

v. Prior to any drilling, verify that there is clearance from any components on the other side of the firewall.

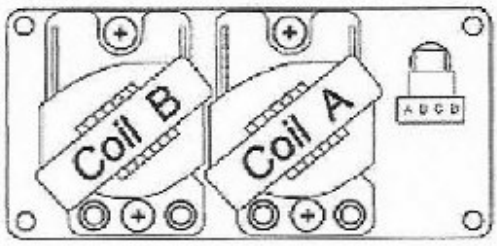
b. After all considerations have been made regarding the placement of the EIS Controller and Coil Pack, drill the mounting hole and install both units using standard AN hardware.

5. Spark Plugs and Spark Plug Wire Harness:

a. The spark plugs that will be connected to Electronic Ignition System can now be installed.
   i. Electroair recommends that using new spark plugs. If the old spark plugs are being reused, make sure that they are clean.
   ii. Gap the spark plugs to 0.028 to 0.036 inches. Check the engine application data to verify that the spark plugs can be used on the engine.

b. Use the new spark plug harness from the kit and install using the following guidelines.
   i. Route the spark plug wires from the coil pack to the spark plugs. Make sure to keep spark plug wire routings away from exhaust pipes and do not run two wires parallel to each other without a minimum of ¼ inch of separation between the wires.
   ii. To finish the connection, install the spark plug end first.
   iii. Attach the other end of the spark plug wires to the coil pack at their appropriate coil tower. Reference the engine firing order. The drawing below shows the Coil Tower ID numbers. The firing order for a four-cylinder coil pack is A1-B1-A2-B2. The firing order for a six-cylinder coil pack is A1-B1-

C1-A2-B2-C2. Connect the spark plug wires using that firing order. **Note: specific cylinders need to be connected to specific coil towers. Please contact Electroair with any questions.**



B2 B1 A2 A1

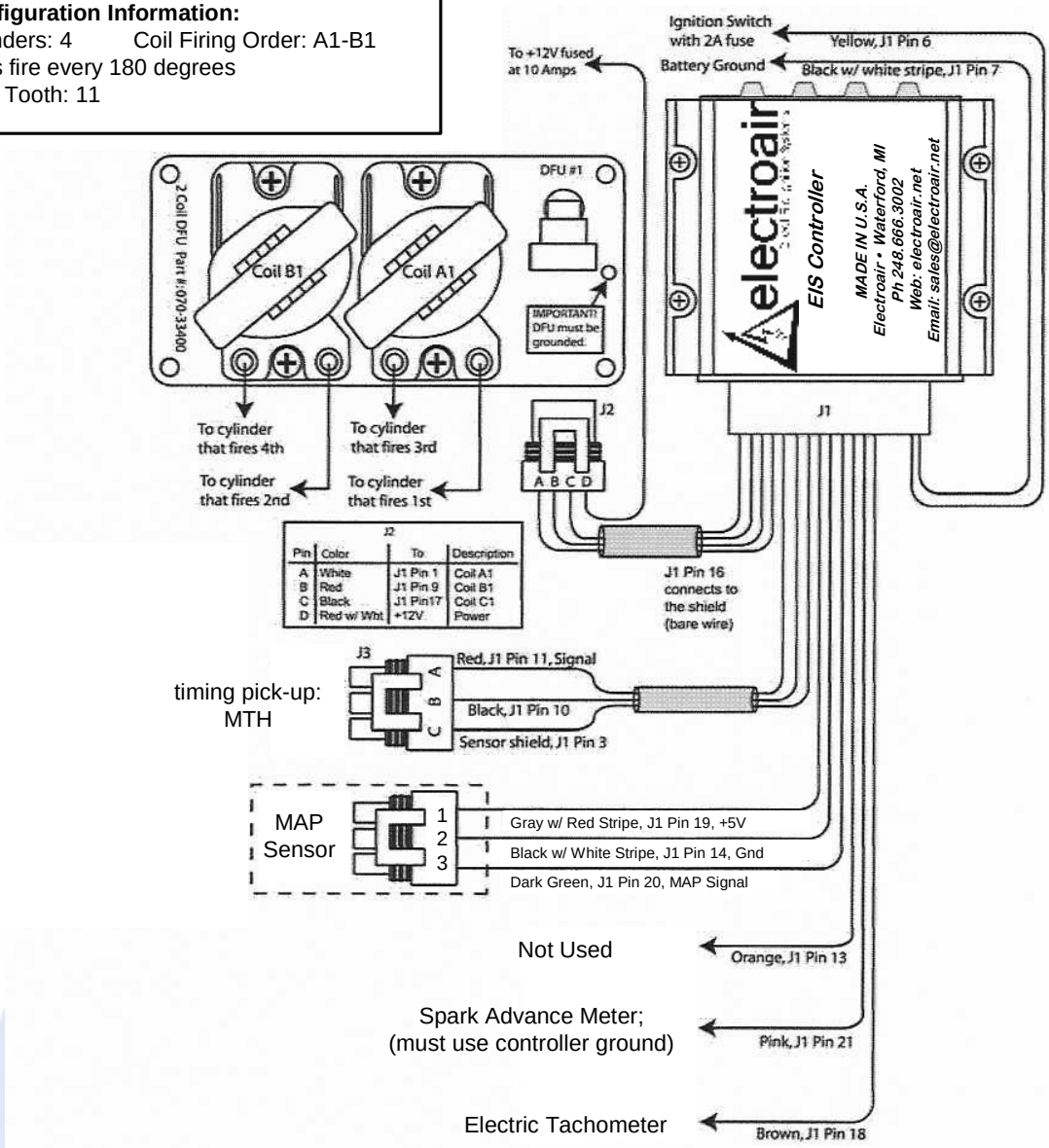
Coil Tower ID's for 4-cylinder

6. Wiring Hook-Up:

a. **Verify that the master switch is off and battery is disconnected.**
b. The electrical connections that will be made are as follows:
   i. Ground for Coil Pack
   ii. Timing sensor
   iii. Coil Pack
   iv. Switched Power & Ground for EIS Controller
c. Notes: The main harness is not completely assembled so it can be installed through tight clearances such as a hole in the fire wall. Terminal ends for the Timing Pick-up have been supplied. A supply of terminals for switches, circuit breakers, and the bus bar. The main harness has been tied off into five separate bundles. Each bundle is labeled 1,2,3,4, & 5. Work with each harness bundle separately. A wiring diagram with pin-out information has been supplied on the pages 10 & 11 of this section for reference. **CAUTION:** Follow these wiring instructions very carefully to insure a correct hook-up of the EIS. Skipping ahead or taking short cuts increases the risk of an incorrect installation and either a poor performing EIS or the possibility of damaging equipment. Please contact Electroair (517-552-9390 or sales@electroair.net) with have any questions.
d. Connect the Coil Pack ground wire to an airframe or battery (preferred) ground. The Coil Pack ground wire is the black wire that is fastened on the Coil Pack base plate. This wire will need to be appropriately terminated at the ground connection (a connector is not provided for this). **CAUTION: The Coil Pack MUST be grounded. Failure to ground the Coil Pack may result in SEVERE ELECTRICAL SHOCK! Also, a poorly grounded Coil Pack may result in poor engine performance and can cause ENGINE DAMAGE.**
e. Verify that the screws holding the coils and ground wire in place are tightened and securely in place.

f. Connect the EIS Controller harness assembly to the EIS Controller. Begin routing the various harness bundles from here.
g. Route harness bundle #2 to the Timing Sensor on the COG Pulley.
   i. If the COG Pulley/Timing Wheel Assy. has been installed and/or routed correctly, there will have a black, three-way connector coming from the magnetic pick-up. Route bundle #2 to that three-way connector.
   ii. Bundle #2 has already been terminated to go into the appropriate mating connector body that will attach to the magnetic pick-up harness. Once bundle #2 has been routed past any tight clearances (such as a hole in the fire wall), install the supplied connector body to the terminated wires. The wires go into the following connector cavities:
      1. Red wire goes into cavity 'A'
      2. Black wire goes into cavity 'B'
      3. Bare wire goes into cavity 'C'
   iii. An audible 'click' will be heard when the terminated wires have been properly installed into the connector body and the wire should not be able to be pulled out.
   iv. Loop any excess wire and cable tie or clamp the loop to a convenient location that does not interfere with any components (a location on the inside of the firewall is suggested).
   v. Connect bundle #2 (now terminated with a connector body) to the connector from the magnetic pick-up. Verify that the connection is secure.
h. Route harness bundle #3 to the Coil Pack.
   i. Separate the 'Red w/ White Stripe' wire from the other wires that are bundled (gray wrap) and terminated with a four-way connector (this wire is for power).
   ii. Loop any excess wire of the gray bundle and cable tie or clamp the loop to a convenient location that does not interfere with any components (a location on the inside of the firewall is suggested).
   iii. Connect the four-way connector to the mating connector on the Coil Pack.
   iv. Route the 'Red w/ White Stripe' wire through a 10 amp breaker to the Essential Bus Bar. Trim and terminate as required.
i. Toggle Switch Set-Up: Route harness bundle #4 to Essential Bus Bar for switch termination.
   i. Trim & Terminate the 'Black w/ White Stripe' wire to the bus ground.
   ii. Trim & Terminate the 'Yellow' wire to a panel mounted switch that is protected with a 2 amp breaker. Label panel mounted switch "Electronic Ignition System", and proper "ON/OFF" orientation. This switch should be a SPST switch.
   iii. Connect the 2-amp breaker to Essential Bus Bar.
j. Bundles #1 & #5 contains MAP Sensor wires (bundle #1), two extra outputs for an electric tach and a spark advance meter (bundle #5: spark advance uses two wires: pink for signal & black for controller ground). These bundles should be looped and tied to an appropriate place inside the cockpit for later use. Alternatively, bundle #5 can trimmed out of the harness connector if those options will not be used. Wiring diagrams for the electric tach and/or spark advance meter are supplied. Please contact the factory for more details.

Configuration Information:
Cylinders: 4 Coil Firing Order: A1-B1
Coils fire every 180 degrees
TDC Tooth: 11



4-Cylinder Electrical Overview

7. Final Installation Steps:

a. Calibration and Timing settings: The EIS has been pre-set at the factory based on the information given when the order was placed and should not need any adjustment in the field. Please contact Electroair if it felt that the unit is not performing optimally.
b. Re-attach and reinstall any connections or components that were removed or loosened during this installation.
c. Secure all new wires, harness, connections and lines to prevent failures due to vibration.
d. Connect battery connections and close any open circuit breakers.
e. Recover all tools that may have been used ('floating' tools inside the aircraft is dangerous).
f. Proceed to the operational section and perform a test run-up before flying.

8. Installation Options available from Electroair:

a. ***EARHB32E Massive Electrode Spark Plug:*** This plug is Electroair's version of the standard RHM32E spark plug. The EARHB32E plug is manufactured with a 0.036 inch air gap. The EARHB32E spark plug can be installed on the engines that are approved for the RHB32E spark plug, but can only be operated by an Electroair EIS. Please contact Electroair or one of our distributors for current pricing and availability of this spark plug.
b. ***EARHB32S Single Fine Wire Spark Plug:*** This plug is Electroair's version of the standard RHB32S spark plug. The EARHB32S is manufactured with a 0.036 inch air gap. The EARHB32S spark plug can be installed on the engines that are approved for the RHB32S spark plug, but can only be operated by an Electroair EIS. Please contact Electroair or one of our distributors for current pricing and availability of this spark plug.
c. ***EAREM37HE Massive Electrode Spark Plug:*** This plug is Electroair's version of the standard REM37BY spark plug. The EAREM37HE plug is manufactured with a 0.036 inch air gap. The EAREM37HE spark plug can be installed on the engines that are approved for the REM37BY spark plug, but can only be operated by an Electroair EIS. Please contact Electroair or one of our distributors for current pricing and availability of this spark plug.
d. ***EARHM38SE Single Fine Wire Spark Plug:*** This plug is Electroair's version of the standard RHM38S spark plug. The EARHM38SE is manufactured with a 0.036 inch air gap. The EARHM38SE spark plug can be installed on the engines that are approved for the RHM38S spark plug, but can only be operated by an Electroair EIS. Please contact Electroair or one of our distributors for current pricing and availability of this spark plug.

Glossary and Abbreviations:

AD(s) – Airworthiness Directive(s)
AFM – Aircraft Flight Manual
AFMS – Aircraft Flight Manual Supplement
ALS – Aircraft Limitations Section
AML – Approved Model List
APU – Auxiliary Power Unit
BTDC – Before Top Dead Center
CFR – Code of Federal Regulations
CSTW – Crank Shaft Trigger Wheel
EIS – Electronic Ignition System
FAA – Federal Aviation Administration
Ignition Timing – is the process of setting the angle relative to piston position and crankshaft angular velocity that a spark will occur in the combustion chamber near the end of the compression stroke.
MAG – magneto
MAP – Manifold Absolute Pressure
May/Should – an optional requirement
MTH – Mag Timing Housing
Must/Shall – a mandatory requirement
RPM – Revolutions per Minute
POH – Pilot's Operating Handbook
STC – Supplemental Type Certificate
TDC – Top Dead Center

Log of Revisions:

Revision	Date of Revision	Description of Revision	Approved by	Date of Approval
00		Skipped		
01		Initial Release		
02	10/24/2014	ECO 1116-0099		05/27/2015

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