

MX1 Electrical System

The MX1 system comes with two Engine Control Units (ECUs) and one Engine Management System (EMS) that connects the two separate systems to the engine.

EMS

The EMS is housed in a black anodized extruded aluminum case. One end has two 37 pin connectors, one for each ECU to plug into. Both ECUs are identical and can be connected to either port. The other end has one 37 pin connector and one 12 pin connector. The 37 pin connector is for the main engine control harness. It connects directly to the firewall junction (FWJ1), and from the firewall forward to all the engine sensors and controls. The 12 pin connector is the main power and ground connections, along with connections for switching systems and moving the prop.

Engine Control

IGN 12V+ is the main power supply for the ignition system. It is protected by a 20amp circuit breaker. IGN GND is the main ground for the system. Both power and ground use 14AWG wire. IGN A is switched 12V that powers the low pressure fuel pump A and relay coil for fuel pump A. IGN B is switched 12V that powers the low pressure fuel pump B, relay coil for fuel pump B, and all the other relay coils to switch inputs and outputs from system A to system B. Both IGN A and IGN B use 20AWG wire and connect to one side of a DPDT switch to use as A/B system select. TACH A is a tachometer signal generated by ECU A. TACH B is a tachometer signal generated by ECU B. Both signals are a 12V square wave with two pluses per revolution. They are switched on the other side of the DPDT switch so the tachometer reads the signal from the system the pilot has selected.

Prop Control

PROP 12V+ is the main power supply for the electric prop pitch control. It is electrically separate system from the ignition system and is protected by a 10amp circuit breaker. PROP GND is the main ground for the prop. It connects to the outer slip ring and the ground bus. Both power and ground use 16AWG wire. PROP FAST is momentary switched 12V that powers the prop fast relay coil. PROP SLOW is momentary switched 12V that powers the prop slow relay coil. Both PROP FAST and PROP SLOW use 20AWG and should not be connected to 12V at the same time. PROP CTRL is $\pm 12V$ to move the motor. When PROP FAST is selected, PROP CTRL becomes 12V and the motor moves the blades toward fine pitch and allows the engine to run fast. When PROP SLOW is selected, PROP CTRL becomes -12V, that is 12V below ground, and the motor moves the blades the other way toward more coarse pitch and the engine runs slower. -12V is generated by a DC converter housed inside the EMS box.

MX1-ECU

Each ECU is housed in a clear anodized extruded aluminum case with flanged endplates and mounting holes. One end has a 37 pin connector for inputs and outputs and one 1/8" manifold air pressure port. The 37 pin connector gets attached with a flat 37 conductor cable to the EMS box that is located directly above or below ECU. The manifold air

pressure port uses 7/64" rubber vacuum tubing that monitors the pressure inside the intake manifold. Tubing from both computers is attached with a tee with a 1/4" tube running to the intake manifold. Any leaks in the system can be detected by an improper reading on a manifold pressure gauge. The other end has a 9 pin port for loading firmware, and 3 LEDs. The outer two LEDs indicate the spark function. They light up on when the ECU is turned on. Each time that spark channel is fired the LED turns off for 3 milliseconds. You might see them flicker a little bit while the engine is running because the amount of time they are off is too fast to see in real time. The middle LED indicates a warm-up setting. Depending on engine temperature and air temperature this LED may or may not be on.

HARNES 1

Distributorless Ignition (VR1 and VR2)

The ECU uses a 60-2 trigger wheel and a variable reluctance sensor to determine position and speed of the engine. The trigger wheel is made from laser cut steel and has 60 teeth with 2 consecutive teeth missing. The teeth are same width as the gap between them and spaced evenly around the outside of the wheel. The wheel is attached to the crankshaft, either the flywheel side, or the pulley side depending on application. The VR sensor is a magnet wrapped in wire. As the tooth goes by the end of the sensor, a magnetic field moves towards it, generating voltage across the two ends of the wire. As the tooth moves away the magnetic field moves away from the end and voltage reverses. This is seen by the ECU as an alternating current sine wave. The end of the sensor is shaped like a chisel to focus it and create a stronger signal. The speed of the wheel and gap between the sensor and the tooth determine the amplitude so it is important for the gap to be set from .010-.015" to get a reliable signal at cranking speeds.

Throttle Position Sensor (TPS)

The throttle body has a sensor to determine throttle position. The ECU only uses this during cranking. If the throttle is above 80% it cuts the fuel to clear out a flooded condition. Both computers share the same sensor as it is not used once the engine has started.

Coolant Temperature (CLT)

The coolant temperature is a closed element style GM temperature sender. It is located on the water cross-over pipe on top of the engine. It threads into a 3/8"NPT bung and has a black weatherproof metripack connector. The signal is used by the ECU to calculate fuel enrichment during cranking and warm-up. Both computers share the same sensor as it is not used once engine is warmed up.

Intake Air Temperature (IAT1 and IAT2)

The intake air temperature is an open element style GM temperature sender. It is located on the air intake just before the throttle body. It has 3/8"NPT threads and is screwed into a rubber grommet on the intake pipe. It is connected by a gray weatherproof metripack connector. The signal is used by the ECU to calculate the air density. Each ECU has a

separate sensor.

Low Pressure Fuel Pump (LPFP1 and LPFP2)

The low pressure fuel pumps are small solid state electric pumps made by Facet. They have AN6 male flare fittings on either end and are plumbed in series. Max pressure is 4-6psi and they draw about 1 amp each. They allow fuel to flow through when off or in the event of pump failure. The pilot selects which fuel pump is running with the A/B switch.

High Pressure Fuel Pump (HPFP1 and HPFP2)

The high pressure fuel pumps are inline electric pumps made by Walbro. They are plumbed in parallel and have check valves built into the unit. The pilot selects which fuel pump is used with the A/B switch. The computer controls when the high pressure fuel pump is on. When the system is first turned on it will run the fuel pump for a few seconds to prime the system. After the priming pulse, the ECU will turn the fuel pump on when the engine is cranking or running, and turn the pump off when the engine is stopped.

Injectors (INJ1, INJ2, INJ3, INJ4)

The fuel injectors are stock Subaru 280cc top feed fuel injectors. Each injector has a gray weatherproof connector. The system uses simultaneous injection. All 4 injectors are opened at the same time once for each 720° of rotation. Duration is calculated using air density, pressure, and RPM.

Ignition Coil(SPARK)

The ignition uses a stock Subaru coil in a wasted spark setup. The coil houses two separate ignition coils and has a dark gray weatherproof connector. One coil fires cylinder #1 and #2, the other fires #3 and #4. Firing order is #1, #3, #2, and #4 for every 720° of rotation. Spark timing is calculated using the VR sensor and manifold pressure to determine ignition advance for engine speed and load. During cranking, the ignition timing is set to 10° BTDC.

HARNES 2

VDO Gauges (WATER TEMP, OIL TEMP, OIL PRESSURE, TRANS TEMP)

Harness #2 includes wiring for engine monitoring gauges. VDO gauges must use the correct VDO sender. Senders are available with either a standard ground or a floating ground. Standard ground use one wire to the gauge and it grounds through the engine. Floating ground has two terminals and the ground is isolated from its mounting location. Space in the firewall CPC connectors has been reserved for the additional ground wire adjacent to the signal wire for each gauge.

	Range	Resistance	Mounting	2 1/16" Gauge P/N	Sender P/N
Water Temperature	250°F	10-180Ω	1/8-27NPT	310-105	323-095
Oil Temperature	300°F	10-180Ω	1/8-27NPT	310-106	323-057

	Range	Resistance	Mounting	2 1/16" Gauge P/N	Sender P/N
Oil Pressure	100psi	10-180Ω	1/8-27NPT	350-106	360-086
Transmission Temperature	300°F	10-180Ω	1/8-27NPT	310-106	323-057

Exhaust Gas Temperature (EGT#1+, EGT#1-, EGT#2+, EGT#2-, EGT#3+, EGT#3-, EGT#4+, EGT#4-)

The wiring harness accommodates up to 4 EGT probes. Each probe is a standard 48" K-type thermocouple. Thermocouples provide a small amount of voltage between the two leads when they are heated; yellow is positive, red is negative. The thermocouple has a predetermined resistance in the wire and can not be cut shorter, but the very end may be removed and replaced with different style connector. Cylinders 2 & 4 are too far from the firewall to reach so there are 2 sets of wires that go to the front of the engine where you can connect the thermocouples. Cylinders 1 & 3 are closer and you can insert them directly into the CPC firewall plug.

Prop Control (PROP GROUND, PROP CONTROL, PROP SENSE)

The EMS box contains the components to control the CAP 220. The prop is controlled through three slip rings on the back of the prop. The outer ring is prop ground. The middle ring is the prop control; either 12V or negative 12V. This moves the motor inside the back and forth. The inner ring is prop sense; for the future development of a prop pitch gauge.

Inside the CAP 220 are limit blocks to stop the carrier from reaching the end of travel. Each block has a limit switch that turns off the power to the motor before it physically hits the hard stop. The standard height block allows the engine to turn between approximately 3000-5500 rpm at full throttle.

Alternator Field (ALT FLD)

The alternator field control powers the internal regulator in the alternator.

Starter Solenoid (START SOL)

The starter solenoid engages the starter.

Landing Lamp (LAND LAMP +, LAND LAMP GND)

Two 16 AWG wires have been included to hook up a landing lamp in the front of the cowling. 16AWG will support up to 120watts of lightbulbs.

Recommended Electrical Tools and Wiring Guidelines

Current Draw vs. Wire Size vs. Breaker size

MPS electrical drawings include wire sizes for the complete engine system. For builder added components such as flight instruments and radios, we recommend using the following table to determine wire size of most short lengths found in the airplane cabin. First determine the amount of current used by the device by measuring with an ammeter

or by finding the max current in documentation from the manufacturer. Once the load per circuit is added, choose an appropriate size circuit breaker. Then choose the wire size based on the circuit breaker size, not the actual load each of the devices use. Due to mechanical strength of a single wire, 20 AWG is the smallest size recommended for wires not supported in bundles. Many devices such as radios and trim systems may have multiple conductor harnesses made from wires smaller than 20, and that is acceptable.

AWG	AMPS
2	108
4	81
6	60
8	44
10	33
12	25
14	19
16	13
18	9
20	6

Batteries

The MX1 engine management system uses a maximum 11 amps of power to run the two computers, 4 fuel pumps, and entire spark and injector systems. When deciding which batteries to use, we recommend determining the amount of reserve capacity needed in event of alternator failure. As an example, the FAA requires 2 hours of battery reserve for certified engines that are electronically controlled. Currently we recommend using two Odyssey PC 925 that have 28 amp hours each.

Wire

MPS recommends using the following Mil-spec TFE wires for your aircraft.

MIL-W-22759-16 DuPont Tefzel Insulated Wire
Conductor: Stranded Tinned Copper.
Insulation: Extruded Ethylene Tetrafluoroethylene
Temperature Rating: -65°C TO 150°C
Size: 24 – 00 AWG

This is a quality stranded wire with a durable insulation. It is available in many colors but most aircraft suppliers have large quantities of white and sell it by the foot at a reasonable price.

Wire Cutters

TFE wire does not require special wire cutters. Any tool made for copper wire will work fine. For smaller sizes, use a small pair of cutters with a flush cut. Larger gauge wires need a cable cutter to achieve a clean flush cut.

Wire Strippers

Another handy tool to have in your tool box is a good pair of wire strippers. Ideal has a

product called the Stripmaster which cuts and removes the insulation in one action. There are a special set of blades for the Stripmaster made for the tougher Teflon insulation without damaging the conductor. For larger gauge wire, a sharp X-Acto knife can be used to carefully cut the insulation off without nicking the conductors.

Wire Crimpers

The best wire crimpers are made by Tyco Electronics, the Amp Procrimper II. It features a ratcheting handle, with interchangeable dies for push on and ring terminals, cpc contacts, and d-subminiature contacts.

Shielded Wire

Tefzel wire is also available with one or multiple Tefzel insulated conductor wires shielded with a tin plated copper braid and another layer of Tefzel on the outside. All sensitive circuits such as the VR sensors, spark coil trigger and injectors have shielded wire. Strobe and radio wires should be all shielded as well.

Solder Sleeves

Raychem solder sleeves are a great way to terminate the braided shield to ground. They consist of a heat shrinkable sleeve with a ring of solder and a insulated wire. Using a heat gun, the solder will melt and flow between the braid and termination wire while the sleeve shrinks and seals both ends. Then you can terminate an insulated wire instead of having to unbraid the shield or using a fragile uninsulated drain wire.

Lacing Tape—Not Zip Ties

Hard plastic zip ties have sharp edges and can cut through the wire insulation over time due to vibration. Wire bundles should be hand tied with Breyden lacing tape. It is available from most aircraft or wire suppliers and is impregnated with microcrystalline fungicidal wax for knot retention. It is made to MIL-T-43435 Type I Finish B, and is available in natural/off white or black.

Firewall Junctions, CPC

The two engine harnesses use a Circular Plastic Connector (CPC) to go through the firewall. The housing is made from a fire retardant, self extinguishing thermoplastic. The plug's ring twists onto the panel mounted receptacle and locks in place. There are up to 37 separate pin and socket connections, each supporting up to 13 amps of current. The contacts are gold plated for corrosion resistance. Each contact clicks into place and is further supported with a stain relief once complete. A simple removal tool is available to take out pins and sockets without damaging the housing.

Firewall Terminals

The ground, power, and the lead coming back from the alternator go through firewall terminals. Available in black or red thermoplastic housings, they provide a solid and reliable connection that can be quickly removed with a wrench or socket. The firewall terminal's stud is made from a tin-plated copper alloy that allows the terminal to support up to 250 amps continuous. The recommended torque is 100 in-lbs on the 5/16" alternator

stud, 190 in-lbs on the 3/8" power and ground. The manufacturer has a lifetime warranty; if you damage it during installation let us know and we can get a free replacement. A flexible plastic boot covers the stud when installed to prevent an accidental short.

Molex .093

The connections to the relay box uses a .093 pin and socket connector made by Molex. The housing is made from a white nylon and is polarized so it only plugs in the correct way. The pins and socket terminals can carry up to 14 amps continuous.