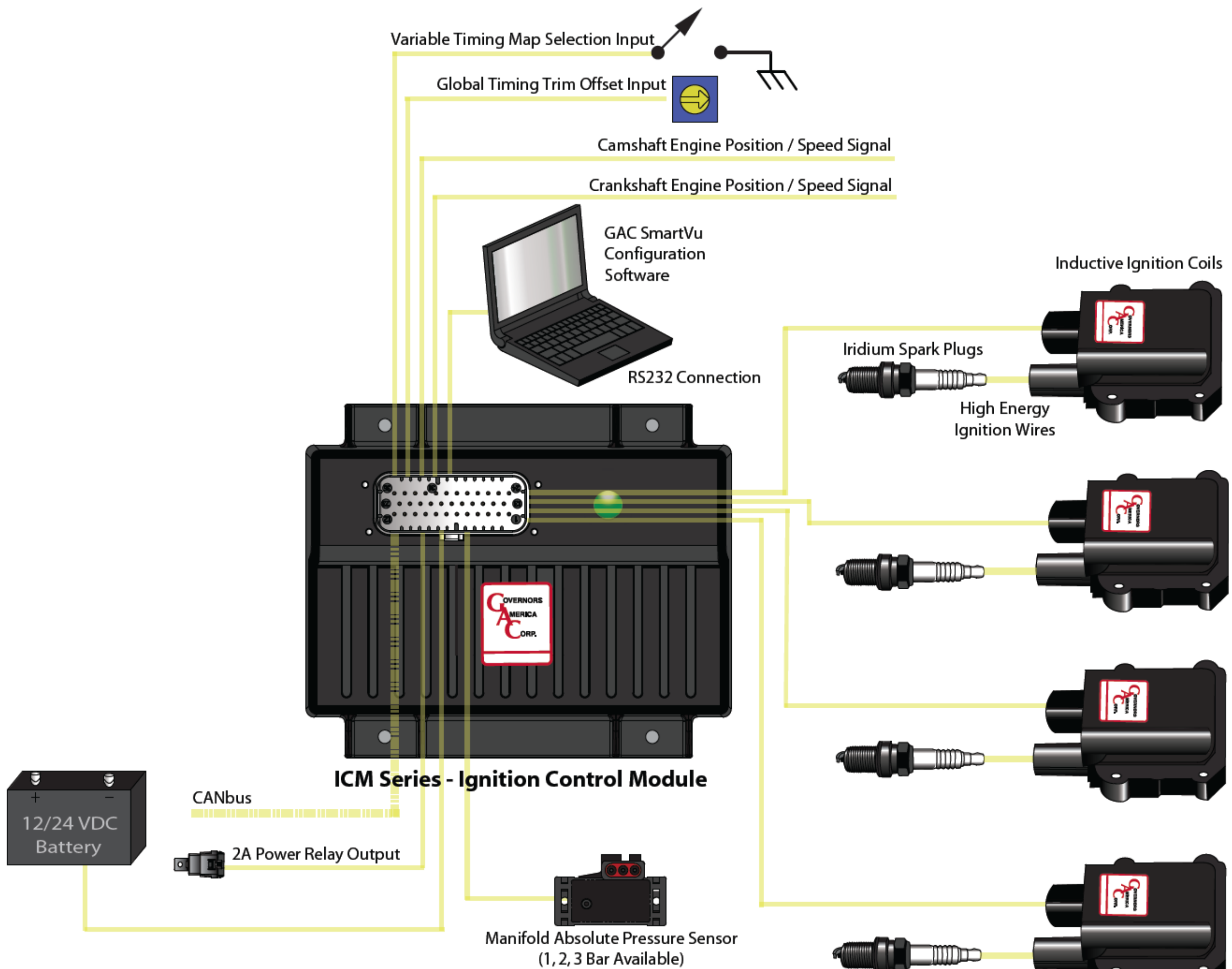
ICM200
Ignition Control Module

GOVERNORS AMERICA CORP.™

PRODUCT USER GUIDE



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1 Introduction

The Ignition Control Module (ICM) 200-series is an intelligent electronic control module which is part of GAC's distributor-less ignition system. The ICM triggers an inductive coil by charging the coil with the appropriate amount of energy for high voltage induction into the engines' spark plugs. Among the features of the ICM are:

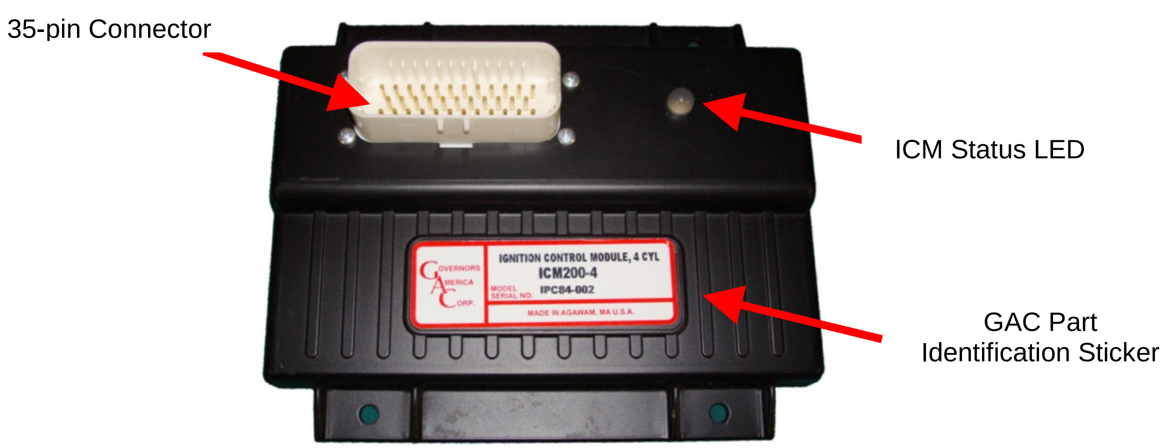
- 12 and 24VDC Compatible
- Inductive spark coils
- Two configurable timing maps with selection switch
- In-field timing trim adjustment with user LED feedback and no special tools
- Engine sensor and data monitoring:
  - Manifold absolute pressure input (1, 2, or 3 Bar)
  - Two speed inputs for cam and/or crank (Hall Effect of variable reluctance)
- Power relay output (2A)
- Easy configuration and customization using GAC's SmartVU software
- High reliability

The ICM200 uses either a camshaft position sensor or crankshaft position sensor to determine correct ignition timing. Using this engine position reference along with the Manifold Absolute Pressure (MAP) sensor to determine engine load, the ICM200 can accurately control spark timing for gaseous fueled engines. The ICM200 also has the ability to automatically detect the dwell time for each coil and adjust the spark timing accordingly.

GAC's configuration software, SmartVU, available on **www.governors-america.com**, allows the user to set overspeed limits, the number of cylinders, whether the system is a sequential or wasted-spark ignition type, and set up the various triggering arrangements with ease and repeatability.

In addition to these features, the ICM200 is ruggedly designed with a cast aluminum sealed case (rated to IP-67) to fit in a variety of engine environments. The ICM200 is designed to be highly reliable and includes protection against reverse battery voltage, transient voltages, accidental short circuits and a loss of engine position input or battery supply. A representation of the ICM is shown in the following figure.

ICM200 Identification



2 Product Variations

The Ignition Control Module (ICM) can directly drive up to 8 individual GAC inductive spark coils (single and dual output versions available). The cylinder configuration can either be set up to 8 for sequential, or 16 for wasted-spark (also known as dual-spark). The following table provides detail of the various ICM variations GAC has to offer.

Product Selection Table

	Maximum Number of Cylinders	
Model	**Sequential**	**Wasted-spark**
ICM200-4	4	8
ICM200-6	6	12
ICM200-8	8	16

3 Operational Description

3.1 Power

The ICM200 is designed for both 12 and 24 VDC applications and will operate ranging from 6.5 to 33 VDC. The ICM200 includes a low-side driver output capable of supporting up to 2A of continuous current which is used to control the ignition coil power relay. In the event of an overspeed condition, the ICM200 will remove power to this relay in order to shutdown the engine.

Since the ICM200 controls the inductive spark coils based on current, dwell time changes due to battery voltage levels are automatically compensated for. Although this compensation is provided, low voltage can occur during cranking which may cause misfire. The ICM includes the ability to limit the maximum dwell time per coil as a safety precaution using GAC's SmartVU software.

3.2 Timing Overview

The ICM200 engine position and speed reference come from either a camshaft position sensor which is reading a timing triggering wheel or a crankshaft position sensor and flywheel timing wheel (40-1 or 60-2). These sensors can be of either the Hall Effect or variable reluctance variety. Depending on the triggering method desired and which sensor inputs are available, the ICM has the ability to support both sequential and wasted-spark ignition arrangements.

Wasted-spark ignitions fire each of the spark plugs twice per cycle; one on the compression stroke and the second is 'wasted' because it occurs during the exhaust cycle. Wasted-spark ignition has the advantage of simplifying triggering arrangements and is used with dual output coils which fire two cylinders simultaneously. Sequential spark ignitions fire each of the spark plugs once per cycle using single output coils.

If the wasted-spark ignition configuration is desired, a camshaft signal is not required. For sequential ignitions, a camshaft signal is only required to give the 1st cylinder reference which can be a single tooth wheel or be the cylinder number + 1 type. Alternate triggering wheel configurations are available; contact GAC for assistance.

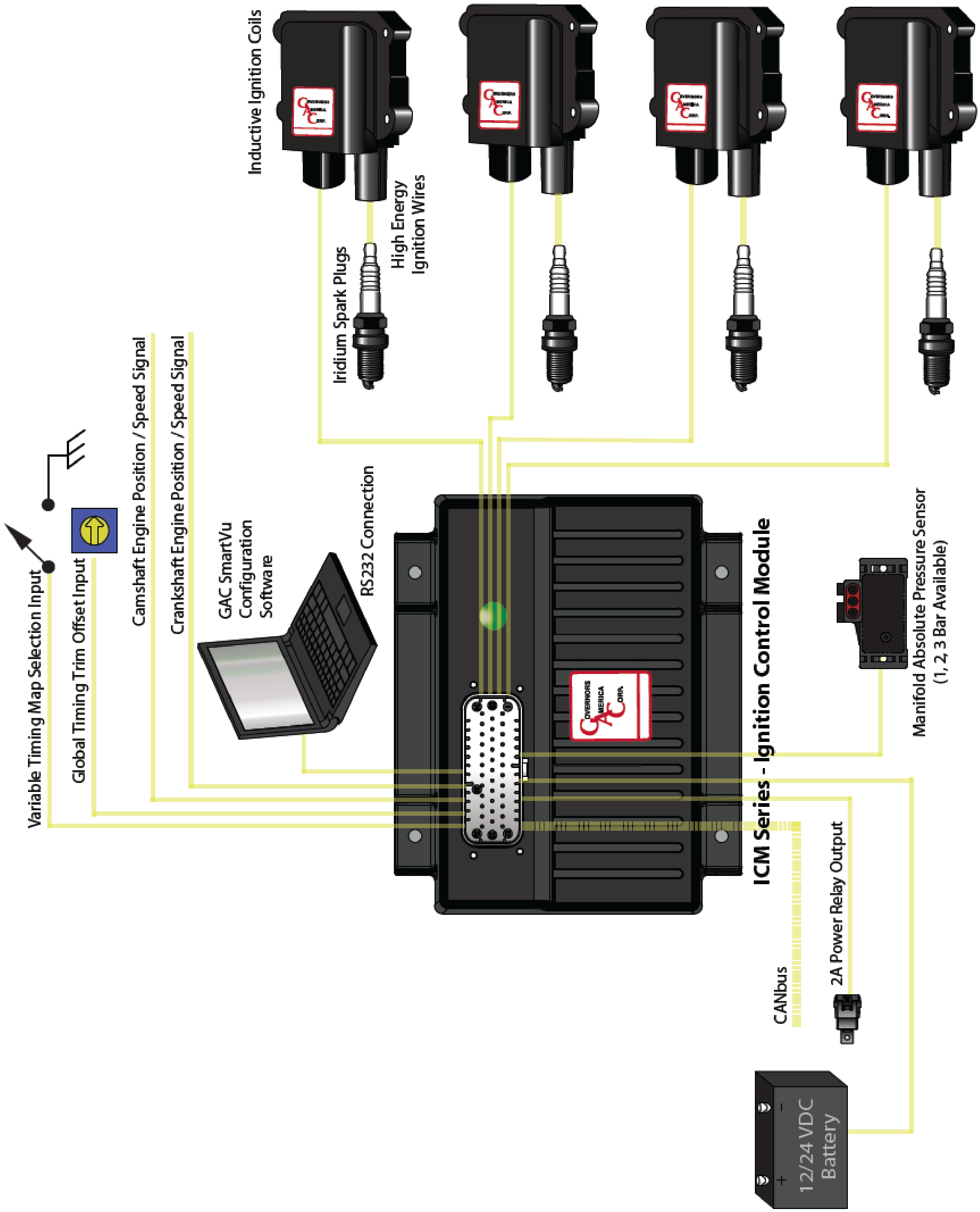
3.2.1 Timing Maps

The variable timing maps provide ignition timing based on real-time engine load and speed conditions. The ICM can store two separate timing maps which are set up using GAC's SmartVU software. These maps are fully configurable for engine speed and manifold absolute pressure (indication of engine load). The maps are selectable through a discrete input into the ICM. Applying ground to this input will select the 2nd timing map. If a global timing advance or retard is needed; the user can set the 2nd timing map identically to the 1st map with the desired offset.

3.2.2 Timing Trim Adjustment

The ICM200 has the standard fixed timing and offset angle parameters but also offers the ability of altering the timing in-field after initial setup using a potentiometer. The adjustment globally advances or retards the timing for the engine to account for changing fuel qualities or other factors. SmartVU is used to enable the feature as well as define the timing trim window which has a maximum range of 10 degrees of either timing advance or retard. The current trim angle offset is indicated to the user by flashing the LED on the ICM. The LED will blink green the number of degrees of advance, blink red the number of degrees of retard, or remain a steady green for a zero trim angle or if the trim function is disabled.

4 System Interconnect Diagram



5 ICM Components and Optional Equipment

5.1 ICM & Related GAC Components Table

Component	GAC Part Number	Description
Ignition Control Module (ICM)	ICM200-4	ICM - 4 cylinder sequential, 8 cylinder wasted-spark
	ICM200-6	ICM - 6 cylinder sequential, 12 cylinder wasted-spark
	ICM200-8	ICM - 8 cylinder sequential, 16 cylinder wasted-spark
	ICM200-12	ICM –12 Cylinder sequential, 24 cylinder wasted spark
ICM Mating Connector	EC1500	Connector and terminals
Trigger Wheel (Sequential Firing 24-1)	GR104	Standard timing wheel; 68mm
Ignition Coils (Sequential)	CL602	1 per cylinder, each coil has a single secondary output
Ignition Coils (Wasted-spark)	CL603	1 per 2 cylinders, each coil has two outputs on the secondary side
Ignition Coil Mating Connector (Sequential)	EC1504	Connector and terminals
Ignition Coil Mating Connector (Wasted-spark)	EC1517	Connector and terminals
Spark Plugs	SPG100-001	Spark Plug special CNG (Iridium)
Spark Plug Wire Kits	SPW100	Single spark plug wire (order x quantity)
Manifold Absolute Pressure (MAP) Sensors	SPM200-1B	MAP - 1 Bar
	SPM201-2B	MAP - 2 Bar
	SPM202-3B	MAP - 3 Bar
Manifold Absolute Pressure (MAP) Mating Connector	EC1509	Mating Connector MAP - 1 Bar
	EC1510	Mating Connector MAP - 2 Bar
	EC1511	Mating Connector MAP - 3 Bar
Engine Position Sensors	SCI100	Inductive, 90 degree
	SCI101	Inductive, Straight
	SCI102	Hall Effect, 90 Degree
	SCI103	Hall Effect, 90 Degree
Engine Position Sensor Mating Connectors	EC1504	For SCI100 – 2 position
	EC1518	For SCI101 – 2 position
	EC1503	For SCI102 – 3 position
	EC1519	For SCI103 – 3 position
Power Control Relay	RLY02-1009	Power Relay Kit, 12V only, 1-pole, N.O.
	RLY02-1011	Power Relay Kit, 24V only, 1-pole, N.O.
	EC1506	Relay Mating Connector
RS-232 PC Interface	EC1516	DB-9 Female Connector & Backshell
	EAM204	USB to RS232 adapter
Fuse Mating Connector Kit	EC1505	Fuse Holder Assembly – ATC

Component Selection Information

The following sections provide detail on sizing or choosing the various components offered from GAC for the ICM200 series controller.

5.1.1 Trigger Wheel

Trigger wheels provide angular timing and speed references for the ignition control module. Trigger wheels are typically designated with two numbers (e.g., 60-2, 4+1, etc.). The first number represents the number of teeth the wheel would have if evenly spaced around the wheel. The second number represents the number of missing or additional teeth on the trigger wheel. For example, a 60-2 is spaced for 60 teeth with two removed (i.e., 58 teeth). A 4+1 wheel is evenly spaced for four teeth with one addition tooth (i.e., 5 teeth).

For the ICM, there are two valid types of trigger wheels, “cam” and “crank”. The cam trigger wheel is mechanically connected to the camshaft and turns one revolution for each complete firing cycle of the engine (i.e., two crankshaft revolutions equals one camshaft revolution). The crank trigger wheel is mechanically connected to the crankshaft and turns twice for every complete firing cycle of the engine. The ICM is designed to use either a camshaft trigger wheel, or a crankshaft trigger wheel.

The cam trigger wheel allows the ICM to use sequential firing. If only the crank trigger wheel is chosen, the ICM will use a wasted-spark configuration, as there is no way to decipher the combustion from exhaust stroke.

5.1.2 Engine Sensors

Although each of the sensors offered by GAC has been fully validated and approved for use with the ICM, there is always the option of using an alternate supplier as long as the sensor is equivalent in electrical characteristics. The application and installation information provided in following sections greater detail on selecting the appropriate sensors.

5.1.2.1 Manifold Absolute Pressure (MAP) sensor

A pressure sensitive electronic circuit inside the MAP sensor monitors the movement of the internal diaphragm and generates a voltage signal that changes in proportion to intake manifold pressure. This produces an analog voltage signal that typically ranges from 0.5 to 4.5 volts. The output voltage usually increases when the throttle is opened and vacuum drops. The Manifold Absolute Pressure (MAP) sensor is a key sensor because it is used to determine engine load. It is optional if none of the multi-dimensional timing maps based on engine speed vs. load are desired.

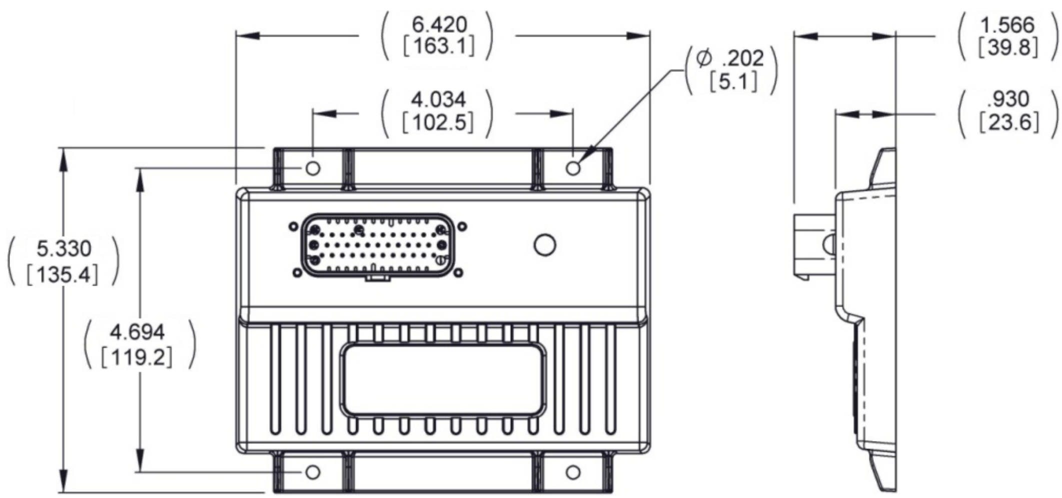
6 Component Information & Installation

6.1 ICM200 Controller

The ICM200 is environmentally sealed, has a wide operating temperature range and can be mounted directly to the engine on a flat plate in an area that does not exceed the unit's environmental specifications. The mounting hole patterns and controller dimensions are shown in the following figure:

ICM Dimensions

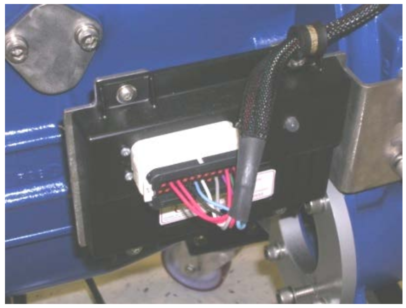
Dimensions shown as in. [mm]



6.1.1 Application Considerations

- Do not select a mounting location on or near areas of high temperature components such as, exhaust systems and turbochargers.
  - The max ambient operating temperature of the controller is 257° F [125° C].
- If the ICM is not mounted to a bulkhead ensure the mounting bracket is designed to withstand vibration using vibration isolators, dampers, standoffs or multi-point mounting as needed.
  - The ICM has been tested to 10G's @ 20 – 2000 Hz but excessive vibration can cause damage to harnessing due to chafing and other factors.
  - Select a bracket material and geometry that supports the ICM securely without flexing due to vibration.
- Allow a minimum of 3 in. [76.2 mm] in front of the controller to for harness connection and serviceability.
- When selecting a mounting location ensure the ICM status indication LED is clearly visible for diagnostic and troubleshooting purposes.
- Mount the ICM so that the connectors are not facing upward in order to avoid possible water intrusion.
- Select a flat surface or bracket for mounting the ICM to avoid flexing the controller packaging during installation. An example of an ICM mounted is shown in the following figure**.**

ICM Bracket Mounted



- Mount the ICM in a location clear from walkways and steps so that the controller will not be damaged during routine maintenance and operation.
- Choose mounting hardware using the dimensions shown (i.e. Diameter < 0.202 in. [5.1 mm]).

6.1.2 Installation Instructions

1. Clean the mounting area from any debris prior to mounting the ICM.
2. Mount the ICM to the selected location using a bracket or a direct to bulkhead mounting scheme using the dimensions and application information provided.
    - If stand-offs or vibration isolators are required, make sure these are in place prior to proceeding.
3. Insert the mounting hardware selected into the four holes on the ICM.
    - Pre-drill and tap the locations as required prior to installation.
4. Torque the selected mounting hardware down without applying excessive force to avoid damaging the mounting tabs or flexing the controller.
    - Ensure that each of the mounting bolts / screws is torqued evenly and gradually.

6.2 Ignition Coils, Wires, and Spark Plugs

The ICM can control two different varieties of ignition coils. There is a standard sequential firing single output coil and a dual output coil for wasted-spark applications. The two variations are shown in the following figure.

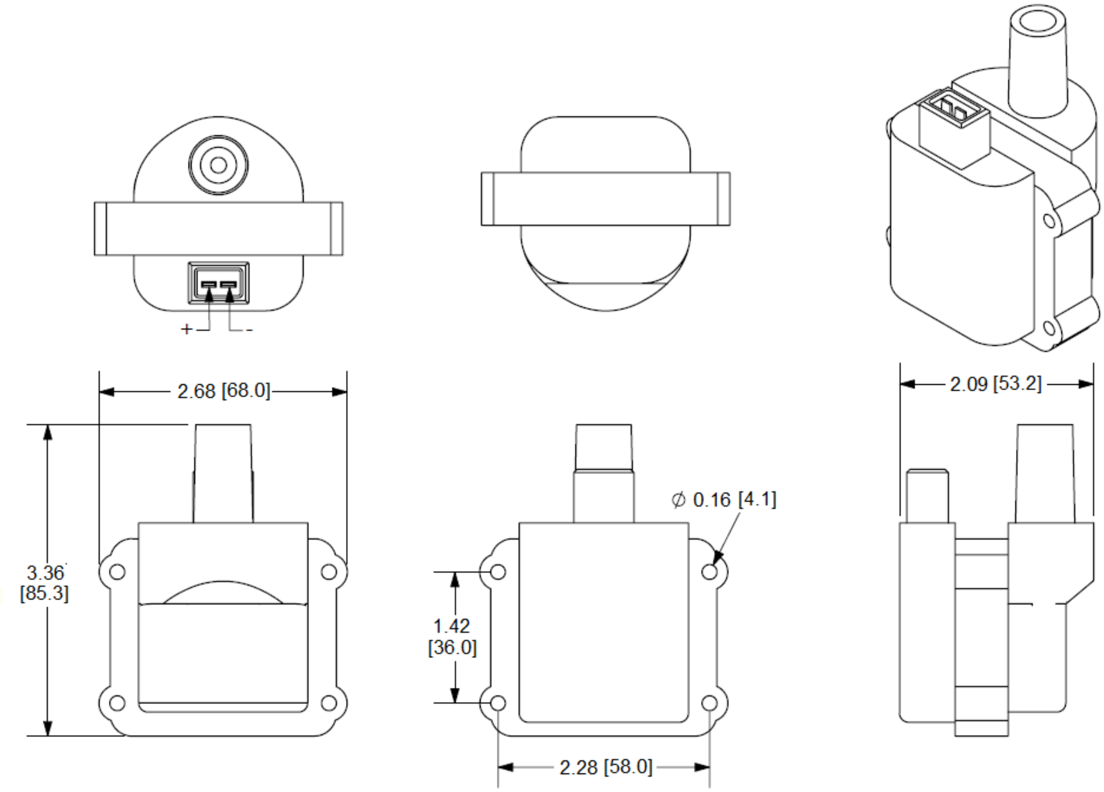
Ignition Coil Identification

(Sequential, Single Output) (Wasted-spark, Dual Output)

The mounting hole patterns and dimensions are shown in the following figures.

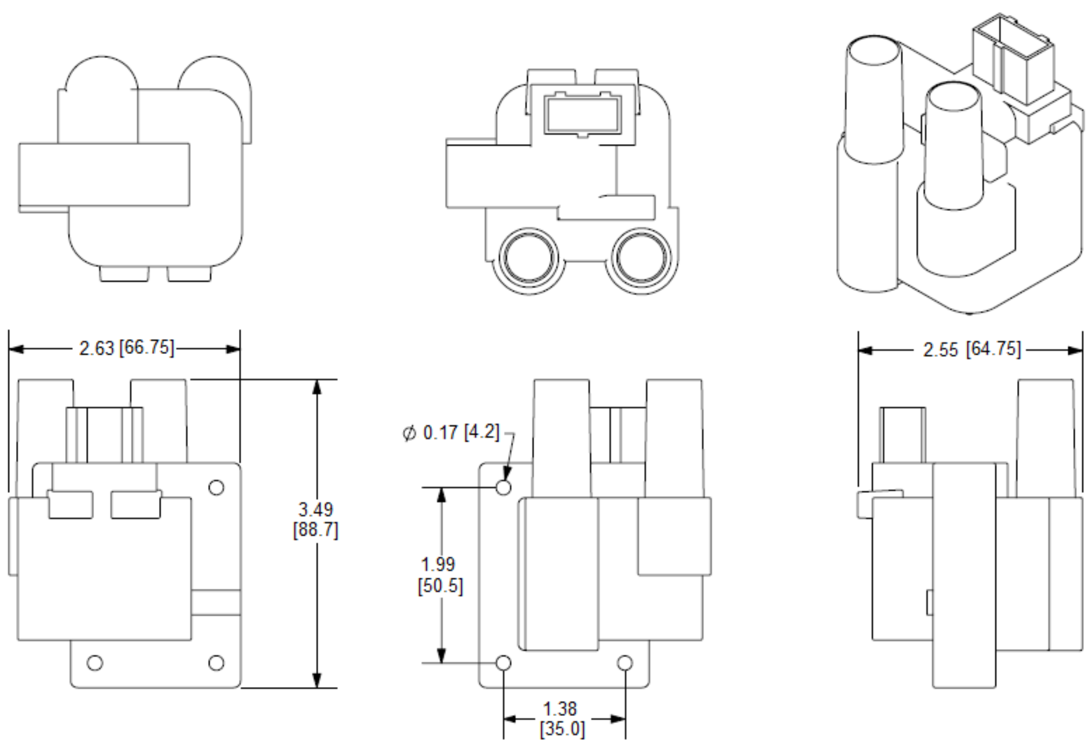
Ignition Coil Dimensions – Single Output

Dimensions shown as in. [mm]



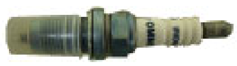
Ignition Coil Dimensions – Dual Output

Dimensions shown as in. [mm]



As part of the total ignition system, GAC also supplies spark plugs for various applications. These iridium spark plugs are designed for longevity in extreme operating conditions and varying fuel types. GAC also provides ignition wires, as shown in the following representation:

Spark Plugs

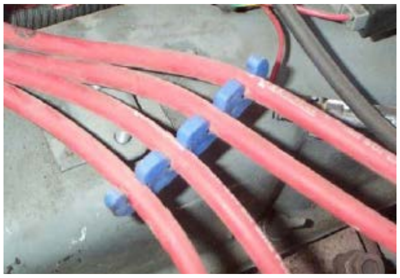


Ignition Wires

6.2.1 Application Considerations

- Mount the ignition coils using a minimum of 2 of the 4 mounting holes.
- Ensure the mounting bracket / hardware is designed to withstand vibration using vibration isolators, dampers, standoffs or multi-point mounting as needed.
- Route the ignition wires so that they are separated from each other to avoid cross-fire.

Ignition Wire Separation



- Route the ignition wires away from the remainder of the harnessing to avoid electrical interference.
- Mount the coils so that the connectors are not facing upward in order to avoid possible water intrusion as shown in the following mis-application example:

Ignition Coils Bracket Mounted Incorrectly

- Choose mounting hardware appropriately using the dimensions provided.
- When installing the coils choose mounting hardware and a location that ensures a good ground path between the ignition coils and the spark plugs.

6.2.2 Installation Instructions

1. Disconnect the fuel and battery supply to the engine prior to installing the ignition system.
2. Clean the mounting areas from any debris prior to mounting the coils and installing the spark plugs.
3. Mount the coils to their appropriate locations using a bracket or a direct-to-bulkhead mounting scheme.
   - If stand-offs or vibration isolators are required, make sure these are in place prior to proceeding.
   - Take caution not to over-torque the hardware for the coils during installation.
4. Install the spark plugs using a spark plug wrench to the appropriate torque value.
5. Connect the spark plug wires between the ignition coils and the spark plugs.
   - Pay attention to the application instructions specific to the ignition wiring.
6. Reconnect the fuel source to the engine fuel system, but do not enable.

7 Engine Sensor Information & Installation

7.1 Camshaft / Crankshaft Position Sensor & Timing Trigger Wheel

The camshaft / crankshaft position sensor is used to measure rotational speed as well as angular position of the engine. GAC offers a Hall Effect version of the position sensor or a variable reluctance version. A representation of the variable reluctance and Hall Effect versions of the sensor available from GAC are shown below.

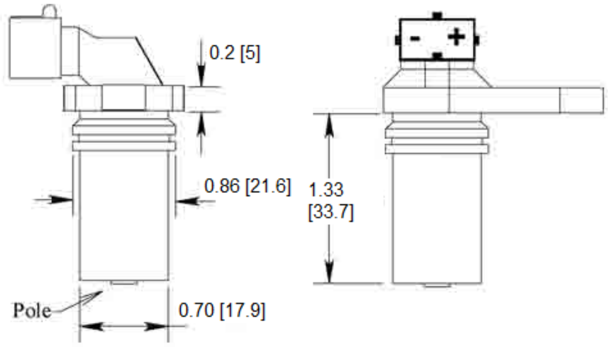
Variable Reluctance Engine Position Sensors

Hall Effect Engine Position Sensors

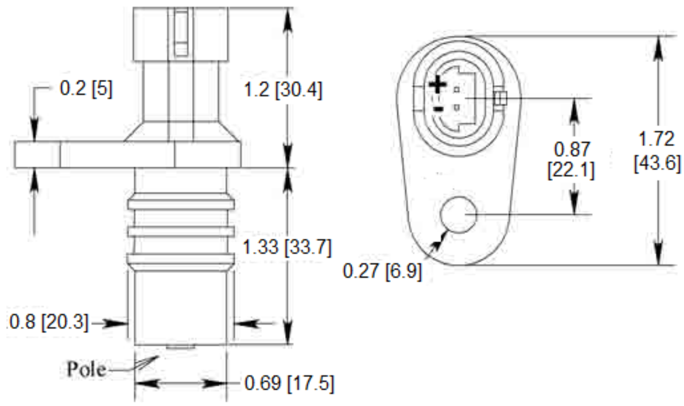
The dimensions of each of the sensors are shown in the following figures. Use this information and the dimensions of the trigger wheel to create a bracket that will be acceptable to your application.

Engine Position Sensor Mounting Dimensions
All Dimensions shown as in. [mm]

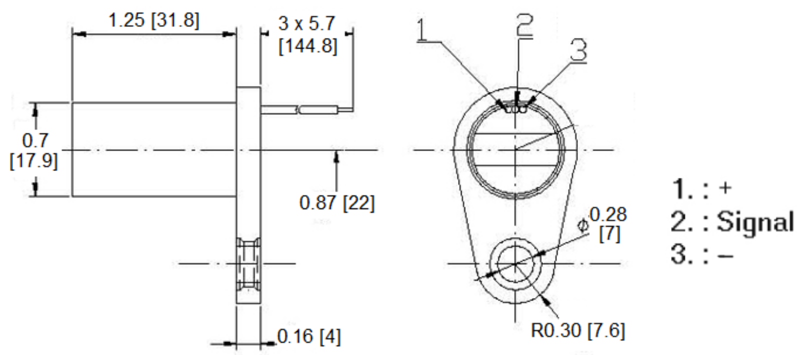
SCI100: Variable Reluctance Sensor (90°)



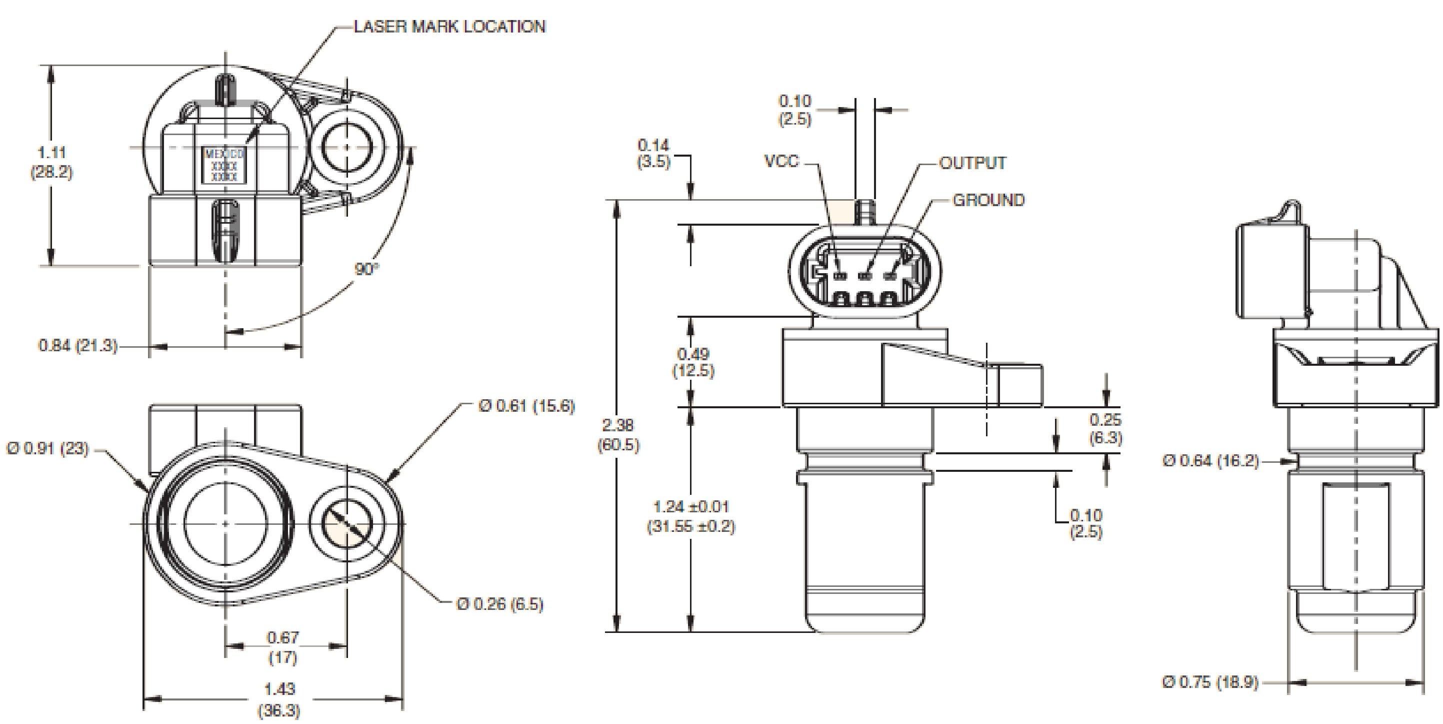
SCI101: Variable Reluctance Sensor (180°)



SCI102: Hall Effect Sensor (90°), connector not shown

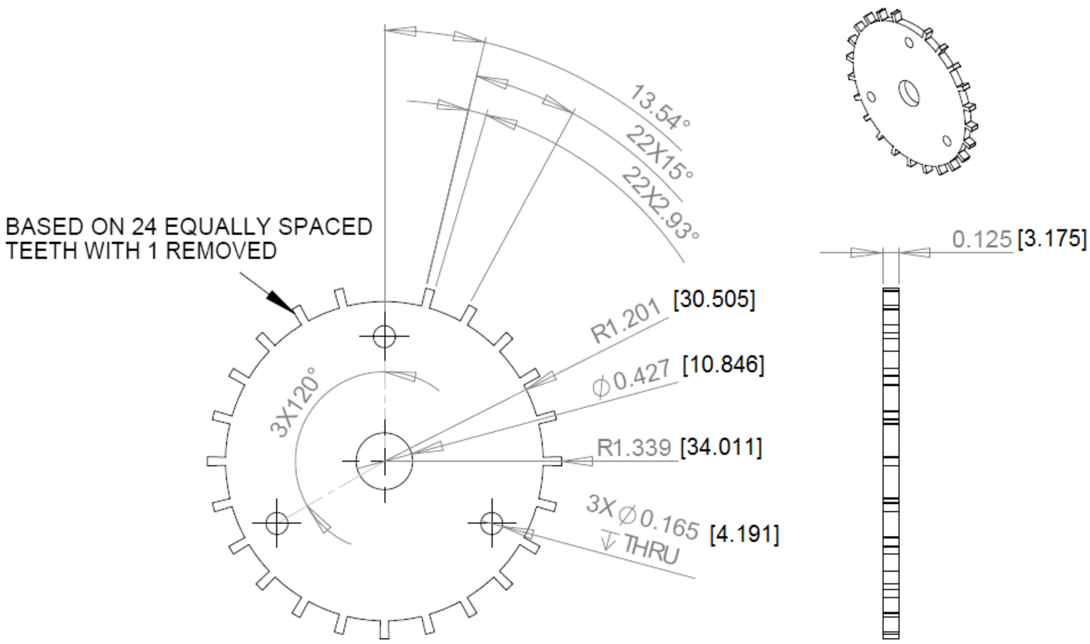


SCI103: Hall Effect Sensor (90°)



GAC offers a 24-1 camshaft trigger wheel for customers who choose to purchase it. The trigger wheel is a multi-tooth design, providing high RPM resolution for accuracy and quicker engine start.

Camshaft 24-1 Trigger Wheel – Small 2.68 in. [68mm]
Dimensions shown as in. [mm]



GAC does not offer large camshaft or crankshaft trigger wheels at the time of publication, but is compatible with many universal selection types. Contact GAC for further assistance.

7.1.1 Application Considerations

The following sections cover the application considerations for the engine position sensor, as well as, the camshaft and/or crankshaft trigger wheels depending on your installation type.

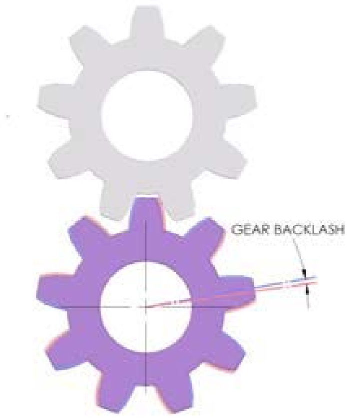
7.1.1.1 Engine Position Sensor

- Care must be taken when installing the engine position sensor since, any errors in installation can lead directly to uneven cylinder firing, incorrect timing, poor starting, misfires and sensor damage.
- The sensor should be left in its packaging until immediately prior to installation in order to avoid metal fragments from becoming attached to the end of the sensor.
- The sensor has an O-ring and is installed by pushing it into place. Take caution not to force the sensor into the mounting location to avoid damage.
- Make sure the engine position sensor is rigidly supported. The bracket should not flex.

7.1.1.2 Camshaft Trigger wheel

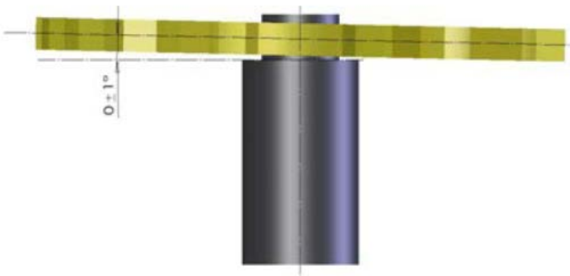
- Choose a half speed shaft with minimal gear lash between the engine crankshaft and the 1/2 speed shaft selected; this may not appear with the engine stopped or at various speeds. Excessive gear lash or slop, can cause idling instability, poor performance, misfire and poor emissions. Gear backlash is shown in the following figure:

Gear Backlash



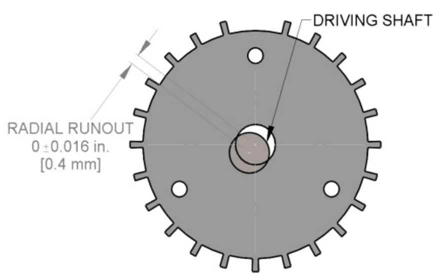
- The disk must be square within 1 degree to the axis of the shaft that drives it. Too much tolerance here will cause timing scatter and periodic spark dropouts.

Trigger wheel Angle



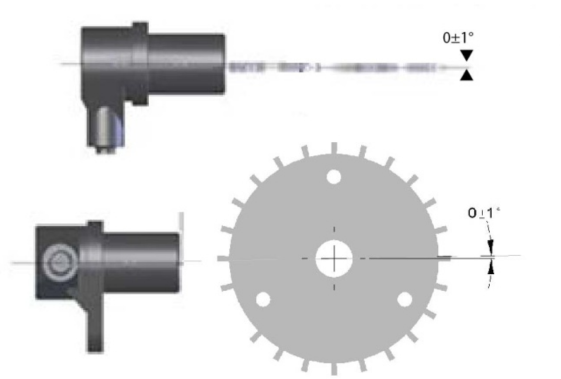
- The mask must be concentric with the shaft within 0.016 in. [0.4 mm] to avoid radial runout as shown in the following depiction of a universal trigger wheel. Runout will cause the wheel to contact and damage the sensor, or force the need to run excessive air gap.

Radial Runout



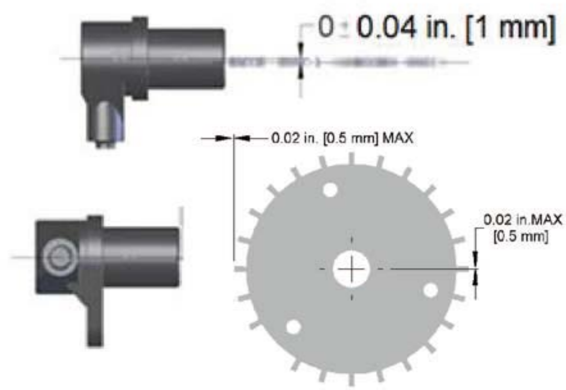
- The sensor and trigger wheel must be square within one degree. Failure to ensure this specification is a common error resulting in damaged sensors, poor starting and timing scatter as shown in the following figure:

Sensor Squareness



- The centerline of the small trigger wheel and sensor must be within 0.04 in. [1 mm]. A line drawn from the center of the bolt hole through the center of the sensor face must extend through the center of the disk. For large trigger wheels the sensor must be aligned within 0.02 in [0.5 mm] at a gap of 0.04 in. [1 mm]. This is shown in the following representations.

Sensor to Trigger Wheel Alignment



7.1.1.3 Crankshaft Trigger Wheel

- The trigger wheel must be square within one degree. The sensor must be 0.02 in [0.5 mm] to 0.04 in. [1 mm] away from the disk surface. Failure to ensure this specification is a common error resulting in damaged sensors, poor starting and timing scatter. Typical selections for the crankshaft trigger wheels are shown following.

Crankshaft Triggering Wheel

- For a universal trigger wheel, with the engine at TDC, the center of the signature tooth should line up with the center of the engine speed sensor.

7.1.2 Installation Instructions

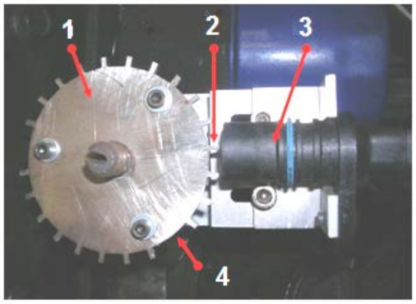
The following sections cover the installation instructions for the camshaft or crankshaft trigger wheel approach. Refer to the section that represents your application type.

7.1.2.1 Camshaft Trigger Wheel

1. Manually turn the engine to top dead center (TDC) combustion of cylinder 1
2. Install the trigger wheel (24-1 from GAC) onto the selected ½ speed shaft.
3. Place the camshaft position sensor into the bracket used to position the sensor correctly.
   - Take caution not to damage the sensor or the seal (if used).
4. Mount and adjust the sensor / trigger wheel so that it is pointing at the 4th tooth after the gap on the trigger wheel.
   - If the normal rotation of the trigger wheel will be clockwise, then mount the sensor at the 4th tooth, counting in the counter clockwise direction.
   - The following figure shows a typical installation of the trigger wheel and the camshaft position sensor:

Example of Trigger Wheel and Sensor Mounted

#	Description
1	24-1 Cam Trigger Wheel
2	Fourth Tooth
3	Variable Reluctance Sensor
4	Missing Tooth



5. Ensure the sensor is mounted squarely and aligned correctly per the application considerations and tighten the trigger wheel bolt.
   - If needed, shims can be used to adjust the sensor orientation.
6. Using a bolt or similar hardware gently torque the sensor down in place using the single eyelet.
   - Take caution not to change the orientation of the sensor or over-torque the mounting tab / eyelet and cause damage to the sensor.

7.1.2.2 Crankshaft Trigger Wheel

1. Manually turn the engine to top dead center (TDC) combustion of cylinder 1.
2. Remove any pulleys that are mounted to the harmonic balancer.
3. Check the surface to which the crank trigger wheel will be mounted to ensure that it is smooth and free of any excess dirt or oil. Clean the surface of the balancer, if necessary.
4. Install the crankshaft trigger wheel using appropriately selected hardware according to manufacturer's recommendations.
5. Place the engine position sensor into the bracket used to position the sensor correctly.
   - Take caution not to damage the sensor or the seal (if used).

6. Mount and adjust the sensor / trigger wheel so that it is pointing at the signature tooth after the gap on the trigger wheel as shown on the previous figure (if universal trigger wheel used).
7. Ensure the sensor is mounted squarely, and aligned correctly per the application considerations and tighten the trigger wheel bolt(s).
   - If needed, shims can be used to adjust the sensor orientation since it must be from 0.5 to 1.0mm away from the trigger wheel surface.
   - Also verify that the sensor is centered longitudinally on the wheel. If it is off more than .050” or so, the block bracket must be re-shimmed appropriately.
8. Using a bolt or similar hardware gently torque the sensor down in place using the single eyelet.
   - Take caution not to change the orientation of the sensor or over-torque the mounting tab / eyelet and cause damage to the sensor.
9. Reinstall the lower crank pulley.
10. Bolt up the lower pulley. Torque to the proper specifications. The use of Loctite or lock-washers is recommended.
    - Make sure the trigger wheel is still in the intended alignment position with the crank sensor.

7.2 Manifold Absolute Pressure Sensor (MAP)

The Manifold Absolute Pressure sensor from GAC is available in three different pressure ranges (1 bar, 2 bar, 3 bar) supporting up to 30 psig of boost as detailed in the parts list section. Typically, naturally aspirated engines use the 1 bar model. All three variations have the same mounting footprint and instructions. A representation of the Manifold Absolute Pressure sensor (MAP) is shown in the following figure.

Manifold Absolute Pressure Sensor Identification

7.2.1 Application Considerations

- The MAP sensor is not required in the event that the multi-dimensional timing maps based on engine speed and calculated engine load are undesired. The maps can still be used to vary timing based on engine speed alone. If the MAP sensor is not used, it is good practice to tie the input signal at the ICM to sensor ground to avoid unwanted interaction.
- The MAP sensor has a 6.4mm [0.25 in.] plastic hose barb fitting which can be plumbed directly into the intake manifold using a port or by using a vacuum hose in between the fitting and the sensor.
  - If you are installing the sensor directly to the intake manifold the sensor nozzle must not be angled greater than 60 degrees from vertical to avoid water intake into the nozzle.
  - If you are remotely installing the Manifold Absolute Pressure sensor away from the intake manifold ensure the selected location is higher than the vacuum connection point.

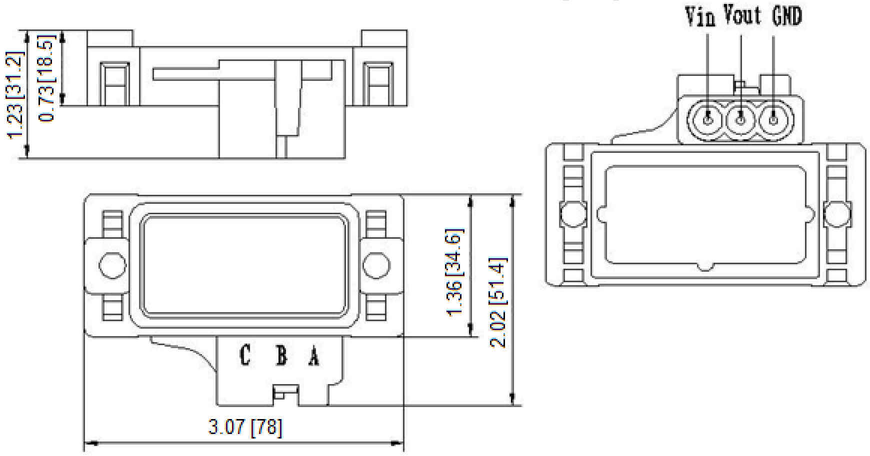
- Ensure the port is the correct size to ensure a good o-ring seal.

- The recommendation is to mount the sensor with the barb pointing downward to avoid moisture buildup in the sensor orifice which may lead to incorrect readings. An example of the MAP installation is provided in the following figure:

MAP Installed

- The MAP sensor has a two bolt mounting pattern and dimensions as shown in the following figure. Use this template when determining the appropriate mounting location / pattern and bolt selection.

Manifold Absolute Pressure Sensor Dimensions
Dimensions shown as in. [mm]



7.2.2 Installation Instructions

1. Lubricate the O-ring seal on the MAP sensor to ensure it is not damaged during installation.

2. Install the MAP sensor onto the appropriate location on or near the intake manifold using the 5mm thru-holes and the selected mounting hardware.

   - Do not over torque the assembly down and ensure that the barb fitting is not damaged during installation and is free from obstruction.

3. If the sensor is remote mounted, install the barb fitting on the intake manifold which should a 6.4 mm [0.25 in.] barb fitting.

   - Install a section of hose from the intake manifold to the MAP sensor.

   - Ensure the vacuum hose is positioned and cut to the appropriate length to avoid kinks or low points in the line.

- Avoid routing the vacuum hose next to high temperature components such as turbo-chargers and exhaust systems.

8 Electrical Connections

8.1 ICM Connector Definition & Recommended Wiring Table

Pin	Description	Comment	Wire
1	*Not Used*	*Not Used*	*N/A*
2	Ignition Coil 8	Ignition Coil 8 Output Driver	16 AWG
3	Ignition Coil 4	Ignition Coil 4 Output Driver	16 AWG
4	*Not Used*	*Not Used*	*N/A*
5	Ignition Coil 6	Ignition Coil 6 Output Driver	16 AWG
6	Ignition Coil 2	Ignition Coil 2 Output Driver	16 AWG
7	*Not Used*	*Not Used*	*N/A*
8	Ignition Coil 7	Ignition Coil 7 Output Driver	16 AWG
9	Ignition Coil 3	Ignition Coil 3 Output Driver	16 AWG
10	*Not Used*	*Not Used*	*N/A*
11	Ignition Coil 5	Ignition Coil 5 Output Driver	16 AWG
12	Ignition Coil 1	Ignition Coil 1 Output Driver	16 AWG
13	Battery Ground	Ground for 12 or 24 VDC Power	16 AWG
14	Crank Wheel Sensor Signal	Position Signal for Ignition Firing from Crank Wheel	20 AWG Shielded / Twisted Pair
15	Crank Wheel Ground	Crankshaft Wheel Sensor Ground	
16	Cam Wheel Sensor Signal	Position Signal for Ignition Firing from Cam Wheel	20 AWG Shielded / Twisted Pair
17	Cam Wheel Ground	Ground for the Camshaft Wheel Sensor	
18	CAN High	CAN Communication Port	20 AWG Shielded / Twisted Pair
19	CAN Low	CAN Communication Port	
20	RS-232 Ground	RS-232 Communication Port	20 AWG
21	RS-232 Transmit	RS-232 Communication Port	20 AWG
22	*Not Used*	*Not Used*	*N/A*
23	Ignition Coil Power Output	Ignition Coil Power Relay Output (Low-Side)	18 AWG
24	Battery Positive	12 or 24 VDC Power Input	18 AWG
25	2nd Timing Map Switch	2nd Timing Map Enable Input	20 AWG
26	*Not Used*	*Not Used*	*N/A*
27	Manifold Absolute Pressure	0-5 VDC Signal from MAP Sensor	20 AWG
28	Trim Pot	0-5 VDC Signal from Timing Trim Angle Pot	20 AWG
29	*Not Used*	*Not Used*	*N/A*
30	Analog GND	Analog Reference Signal for Sensors	20 AWG
31	Analog GND	Analog Reference Signal for Sensors	20 AWG
32	Analog Power	5 VDC Power for Analog Sensors (MAP, Trim, etc.)	20 AWG
33	Speed Sensor Power	5 VDC Power for Cam and/or Crank Wheel Sensors	20 AWG
34	RS-232 Receive	RS-232 Communication Port	20 AWG
35	*Not Used*	*Not Used*	*N/A*

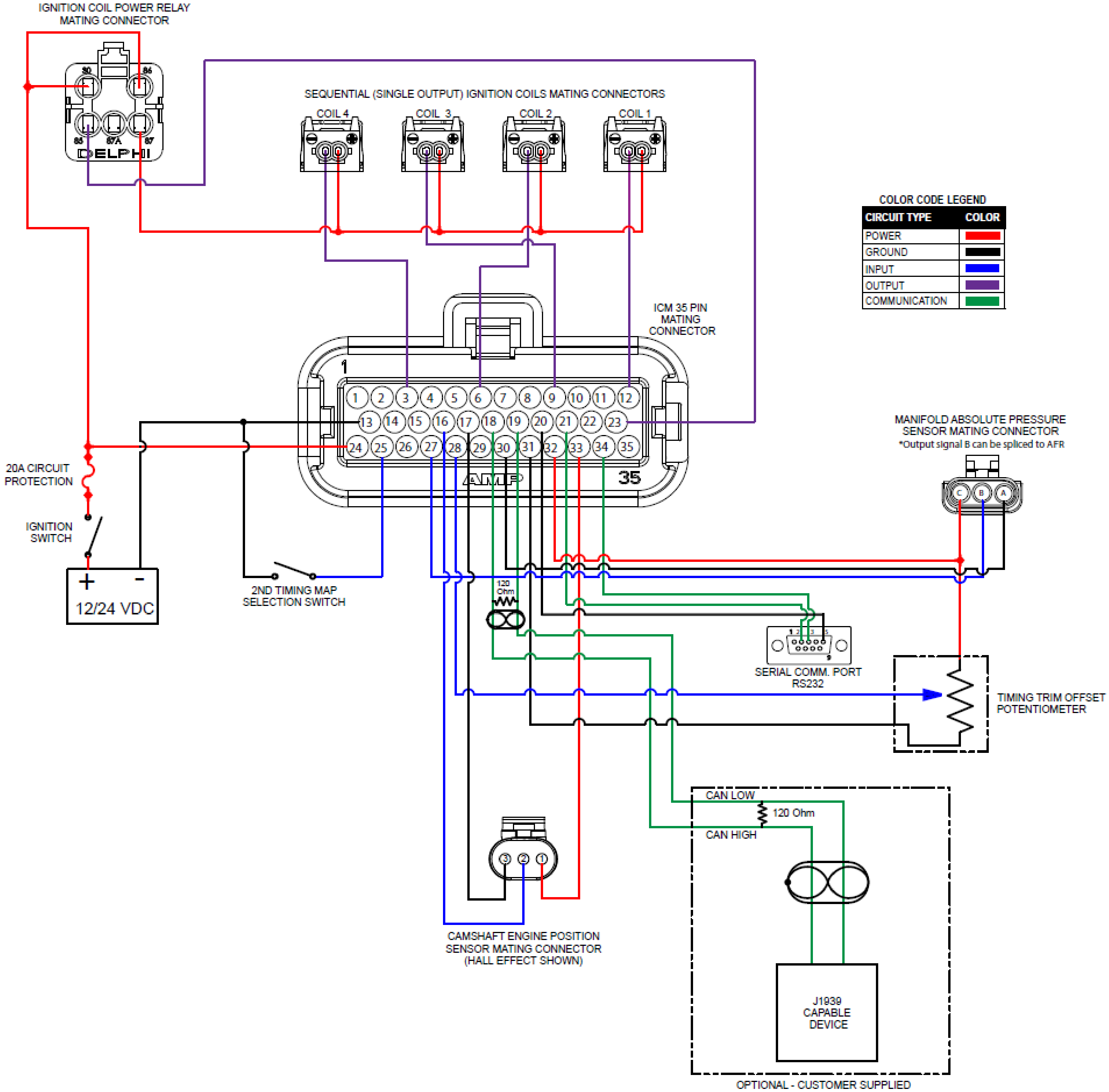
- *GAC recommends shields for Crank/Cam Wheel Sensor and CANbus be terminated on one side closest to the largest block of metal (e.g., the engine).*
- *Not all of the circuits will apply to your particular application.*

8.2 Wiring Diagrams

The following figure s are system wiring diagrams which detail the basic system schematic and mating connector representations for typical applications of the ICM.

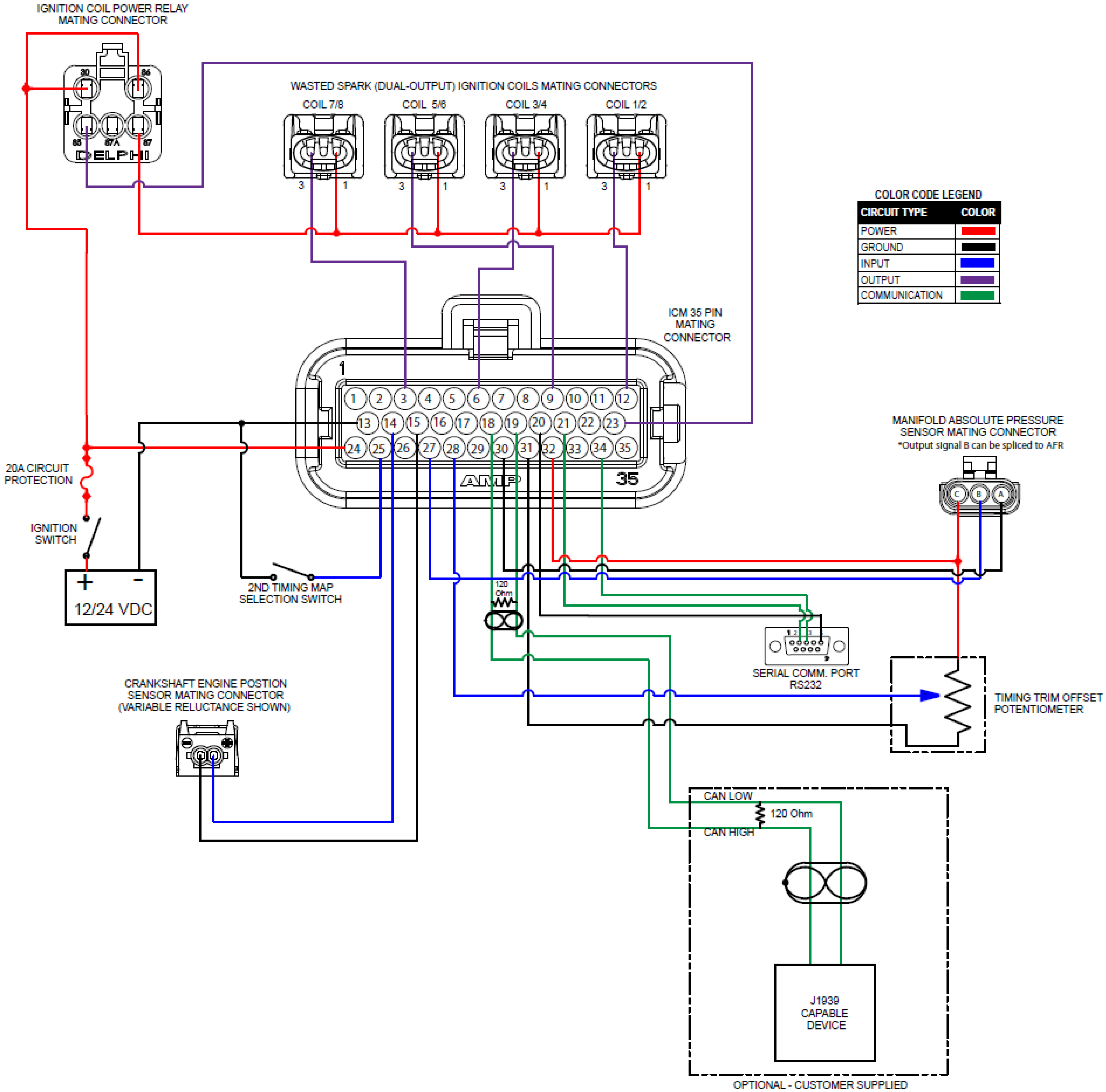
Sequential Firing - ICM Wiring Diagram

(4-cylinder shown, refer to "ICM Connector Definition and Recommended Wiring" for other circuits)



Wasted-Spark - ICM Wiring Diagram

(8-cylinder shown, refer to "ICM Connector Definition and Recommended Wiring" for other circuits)



8.3 System Interface Information

The following sections provide greater detail on the basic system wiring information for the ICM series controllers and some additional detail not covered in previous sections.

8.3.1 System Power

The ICM should be wired through a switched (On / Off Switch) DC power source of 8 to 32VDC and circuit protected with a 20 Amp fuse or circuit breaker.

8.3.2 Ignition Coil Power Relay (2A - LSO) & Overspeed

The ICM has a dedicated output channel (pin 23) to connect an external power relay. The output provides a ground trigger to close the relay. The ignition power relay contacts then close to provide battery voltage to the ignition coils. This relay can also be used for a fuel shutoff valve or other safety device for additional engine protection.

The overspeed function provides emergency shutdown by discontinuing the firing sequence and opening the power control relay. If the ignition coils and a gas valve are powered through the relay and the engine trips the overspeed setpoint the relay will open the contacts and shutdown the engine. When the engine is shutdown due to overspeed, the diagnostic LED will blink yellow to indicate the condition. A power cycle will be needed to clear the condition and resume normal operation.

WARNING

This is not a replacement for mechanical fail-safe. In the event of an overspeed shutdown, it is important to determine the root cause of the overspeed and to take corrective action to fix the problem. Also, care must be taken upon engine restart to vent trapped fuel.

8.3.3 Trim Potentiometer Input

Ignition timing can be trimmed via a 0-5 VDC analog input. When trim is enabled, the timing can be adjusted up to ±10°, which globally offsets the current timing angle. The ICM displays the trim angle is by the blinking the diagnostic LED. The procedure is covered in greater detail in subsequent sections.

8.3.4 2nd Timing Map Selection Input

An input is available to select between the standard timing map (map 1) and a 2nd timing map (map 2). The 2nd timing map input activates when pin 25 is connected to ground. This input is designed for dual fuel applications where separate timing maps are required for propane and natural gas.

8.3.5 Communications

Two communications ports are available on the ICM: RS-232 / Modbus and CAN / J1939:

- RS-232 / Modbus: The RS-232 inputs are used to configure the ICM using GAC's SmartVU software. A DB9-F is the standard mating connector for diagnostic information.
- CAN / J1939: The CAN output supports J1939 protocol for individual cylinder dwell times. The ICM is not designed to be the end of line device on the CANbus. If the ICM is located at the end of the CANbus trunk ensure that a 120Ω termination resistor is placed across CAN H and CAN L (pins 18 and 19). As with all CANbus applications there needs to be a matching 120Ω resistor at the other end of the trunk for a total parallel resistance of 60Ω.

8.4 Timing Triggering

Both crankshaft and camshaft triggering wheel inputs are designed to interface to most Hall Effect and variable reluctance sensors. A regulated 5 VDC output is available on pin 33 for a powered Hall Effect sensor.

The signal output of the sensor is wired to the cam/crank input; the ground side is wired to ground. If the sensor is a variable reluctance magnetic pickup, then the polarity does not matter unless shared with other devices. The offset angle parameter calibrates the sensor with respect to TDC. Whenever a change is made to the crank or cam sensor, ignition timing should be re-verified.

There is a direct relationship between the number of cylinders and the number of coils. If the crank trigger wheel is selected, the ICM will automatically use wasted-spark and as such utilize only half the ignition channels. If a cam trigger wheel is chosen, the ICM will pair each cylinder with its own ignition output channel.

- Example: On an 8 cylinder engine with crank trigger wheel the ICM will use output channels 1, 2, 3 & 4.
- Example: On an 8 cylinder engine with a cam trigger wheel will use output channels 1 through 8.

8.5 Coils

Each ignition coil driver channel provides up to 15 Amps to the inductive coil. The output to the coil can be configured via SmartVU for sequential or wasted-spark operation. The ICM fires each channel sequentially, starting with 1 and ending at the last configured cylinder.

- Example: For a 4 cylinder engine with the coil firing sequence as 1, 2, 3, 4; the ICM will fire channel 1 when it synchronizes with the extra or missing tooth on the trigger wheel.

Care must be taken when wiring output channels to the ignition coils to insure the correct engine firing order. When running in wasted-spark mode, the synchronization point is the same with respect to coil 1. Companion cylinders must be wired in series. Example, on a 4 cylinder engine where companion cylinders are 1&4, 2&3, the cylinder pairs are wired in series.

- The ICM will only trigger coil output channels when speed is detected by one of the two speed inputs, and after synchronization has occurred.

8.5.1 Firing Order

Firing order is engine dependent; always verify the firing order before proceeding with controller wiring. Examples of 4, 6, and 8 cylinder firing orders with the coil output numbers are given in the table below:

Firing Order Examples for 4, 6, and 8 Cylinder Engines

	Number of Cylinders					
Output Channel	4-cyl Waste	4-cyl Seq.	6-cyl Waste	6-cyl Seq.	8-cyl Waste	8-cyl Seq.
1	1,4	1	1,6	1	1,6	1
2	3,2	3	5,2	5	5,2	5
3	--	4	3,4	3	4,7	4
4	--	2	--	6	3,8	3
5	--	--	--	2	--	6
6	--	--	--	4	--	2
7	--	--	--	--	--	7
8	--	--	--	--	--	8

The ICM fires the output channels in order (i.e., 1, 2, 3, 4, 5, etc.) Special care needs to be taken when wiring the coils to make sure it is in the correct firing order. Cross check the firing order with the engine manufacturer. Use the example table to help in mapping the coil number to the cylinder number.

Example Cross-Reference Chart for Coil # vs. Firing Order

ICM Coil Firing Sequence	Cable Color or Number	Engine Firing Order
1		**1**
2		
3		
4		
5		
6		
7		
8		

9 ICM Configuration & Calibration Procedure

This information is contained in the SmartVU Product User Guide available on www.governors-america.com. The guide will cover the basics of connecting to the controller and the required first time setup instructions. In addition, it covers diagnostic and troubleshooting information as well as advanced feature functionality.

10 ICM LED Indicator

The ICM is equipped with a multi-color LED. The LED provides basic troubleshooting and timing information. See the table below for details:

LED Description

LED State	Functional Description
OFF	The ICM200 is powered down.
Solid GREEN	Normal operation; trim pot is currently disabled, or set to zero degrees.
Blinking RED	Normal operation; trim pot is enabled - the LED flashes once for each degree of trim retarded. The blink rate is ¾ of a second on then off. The angle is repeated every 10 seconds.
Blinking GREEN	Normal operation; trim pot is enabled - the LED flashes once for each degree of trim advanced. The blink rate is ¾ of a second on then off. The angle is repeated every 10 seconds.
Blinking YELLOW	An overspeed or an E-STOP condition has occurred; power must be cycled to clear this condition

11 Symptom Troubleshooting

Problem	Actions / Possible Solutions
Engine does not start (during cranking):	1. Verify that the LED on the ICM200 is not blinking yellow. 2. Recheck all trigger wheel Parameters, Coil Current, Offset Angle, Overspeed, and Timing Angle/Map Settings. 3. Verify that the fuel controller and/or fuel are on and is being supplied to the engine.
Engine does not start well (after cranking):	1. If engine does not sound smooth, or if a backfire occurs, then shut down immediately and check the following: a. Verify that the Coils are wired in the correct sequence. Coil #1 must be wired to the cylinder fired after the “Cylinder 1” reference tooth, with all other coils wired sequentially after. b. Incorrect Offset Angle and Timing Angle values can create an extreme retard or advance condition; verify the angles as recommended by the engine manufacturer. c. Verify mounting of trigger wheel. 2. Using a timing light, check the engine timing on cylinder 1 to make sure it is within an acceptable range to start the engine. 3. Battery Voltage may be too low. If the voltage is below 8 volts while cranking, recharge the battery. 4. Make sure the fuel system is actively delivering fuel to the system and is tuned.
Engine is not running at the correct timing while running:	1. Adjust the Offset Angle with a timing light until desired timing is reached. 2. Make sure that all the ignition coils are connected.
Misfires are occurring while the engine is running:	1. Make sure that the Maximum Dwell Time is sufficiently high to allow the current to fully charge the coils. 2. Increase the Coil Current slowly until all cylinders are firing properly and consistently.

** If the troubleshooting is related to communication issues with the ICM using the SmartVU configuration tool, refer to the SmartVU Product User Guide troubleshooting section for further information.*

12 Specifications

PERFORMANCE	
Steady State Accuracy	± 1° Crankshaft Angle
ENVIRONMENTAL	
Temperature Range	-40° to +125°C [-40° to +257°F]
Relative Humidity	Up to 95%
INPUT/OUTPUT	
Power	12-24 VDC Battery Systems (6.5 to 33VDC)
Polarity	Negative Ground (Case Isolated)
Reverse Voltage Protection	Up to 600 VDC
Power Consumption	100 mA max. Continuous plus ignition coil current
Engine Position Sensor Input	Hall Effect or variable reluctance
Ignition Coil Current	15 Amps Peak
Manifold Absolute Pressure / Timing Trim Pot. Input	0-5 VDC
RELIABILITY	
Vibration	10G @ 20-2000Hz
Shock	20G Peak Acceleration
Functional Test	100%
PARAMETERS	
Offset Angle	0-360° Crankshaft Angle
Timing Angle	0-360°
Number of Cylinders	1-8 sequential, 2-16 wasted-spark
Maximum Dwell Time	1-100 ms
Ignition Coil Current	0-15 Amps
Overspeed	0-5000 RPM
Timing Trim Adjustment	-10° to 10°
Crank Trigger Wheel Setup	40 – 1, 60 – 2, others…
Cam Trigger Wheel Setup	#Cyl + 1, 24-1, others…