“Amethyst”

Performance Mappable Ignition System

Instructions for
Installation and Configuration

Revision 1.85

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Severe engine damage can result if ignition timing is either excessively advanced or excessively retarded. Aldon Automotive can accept no liability for injury or damage to property resulting from the use of this product.

We strongly recommend that you use the data in your car's workshop manual as the starting point for centrifugal and vacuum advance settings, and only deviate from these settings cautiously and in small steps. If you are not 100% confident in your ability to set the timing correctly, you should entrust this work to a reputable garage.

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1. Introduction

Aldon Automotive's “Amethyst” mappable ignition system is designed to replace the centrifugal and vacuum advance units of a traditional distributor. It provides full user control of advance characteristics via a PC connected to its USB interface.

Amethyst takes its inputs from the car's distributor and inlet manifold. The centrifugal advance mechanism must be locked in position so that each trigger pulse is generated at the same crankshaft angle. The vacuum pipe from the inlet manifold should be connected to the Manifold Absolute Pressure sensor on the unit (where fitted), instead of the original vacuum advance unit.

For best accuracy, the Amethyst unit should be used in conjunction with an Aldon Ignitor. However, conventional points can be used, as can most types of optical and other electronic input.

Amethyst offers two main advantages over traditional advance mechanisms. First, it is possible to match the advance characteristic much more precisely to the engine's requirements. Second, the unit does not suffer the friction and wear associated with traditional advance mechanisms, so its output is fully repeatable. Any given combination of RPM and load will always result in exactly the same advance.

Limitations

Amethyst is not suitable for use with coils of less than 1.5 ohms resistance.

Amethyst works by measuring the time between pairs of pulses from the distributor and generating a spark slightly before the next pulse is due. Because of this, it is unsuitable for engines with unequal firing intervals. This affects only a few engines, generally V-twins, V4's and a few V6's.

Amethyst is suitable for 12v negative earth vehicles only.

2. Installation

2.1 Locking the centrifugal advance mechanism

The first step is to disable the centrifugal advance mechanism, so that every trigger pulse from the distributor to the Amethyst unit occurs at the same crankshaft angle. It is usually most sensible to lock the distributor in the fully advanced position, since this is the natural position for the advance weights. The mechanism can be locked in this position with lock wire, with rubber O-rings, or with light extension springs pulling the mechanism round to full advance.

Fig. 1. Advance mechanism locked using O-rings

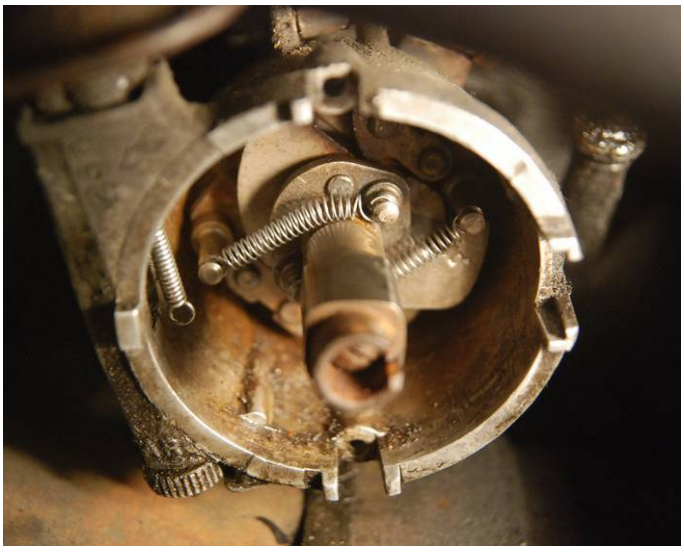


Fig. 2. Advance mechanism locked using springs

If you are using points, you will no longer need the condenser, so discard it. Furthermore, the dwell angle is unimportant so far as the Amethyst unit is concerned, since it will generate the correct dwell electronically.

The engine will have to be re-timed, so that the trigger pulse is generated at the vehicle manufacturer's static timing point. However, this step can wait until the unit is installed.

2.2 Installing Amethyst

The unit should be located well away from sources of moisture, heat and electrical interference. Ideally, it should be mounted fairly high up in the engine bay, well away from road dirt, and not too close to the exhaust, coil or HT leads.

Fig. 3. Amethyst unit

The wires on the unit should be connected as shown below.

The unit may be destroyed if the wires are connected incorrectly.

Thick black:	Earth
Red:	+12v from a switched line
Yellow:	Coil LT minus terminal *(don't connect this yet)*. ***Note that the coil must have a resistance of at least 1.5 ohms.***
Green:	Sense input
Thin black:	Immobiliser/map select input

Note: The immobiliser/map select wire is the one at the far end of the unit, adjacent to the green wire.

2.2.1 Using Amethyst with an Aldon Ignitor

If you are using Amethyst in combination with an Aldon Ignitor, connect the green wire from the Amethyst unit to the black wire from the Ignitor.

2.2.2 Input from points

If you are using points, the green wire should be connected to the contact breaker.

Note: The Amethyst unit will supply about 20mA through a set of points. This is much lower than the current that points usually have to handle, and it should extend their life considerably. However, points also require a certain minimum current (known as a "wetting current") if they are to operate reliably. In most cases, the current supplied by Amethyst is sufficient for this. If you find that the unit triggers intermittently from your points, we recommend that you connect a 100 ohm 2 watt resistor as shown in fig. 4 below, in order to increase the current through the points when they are closed.

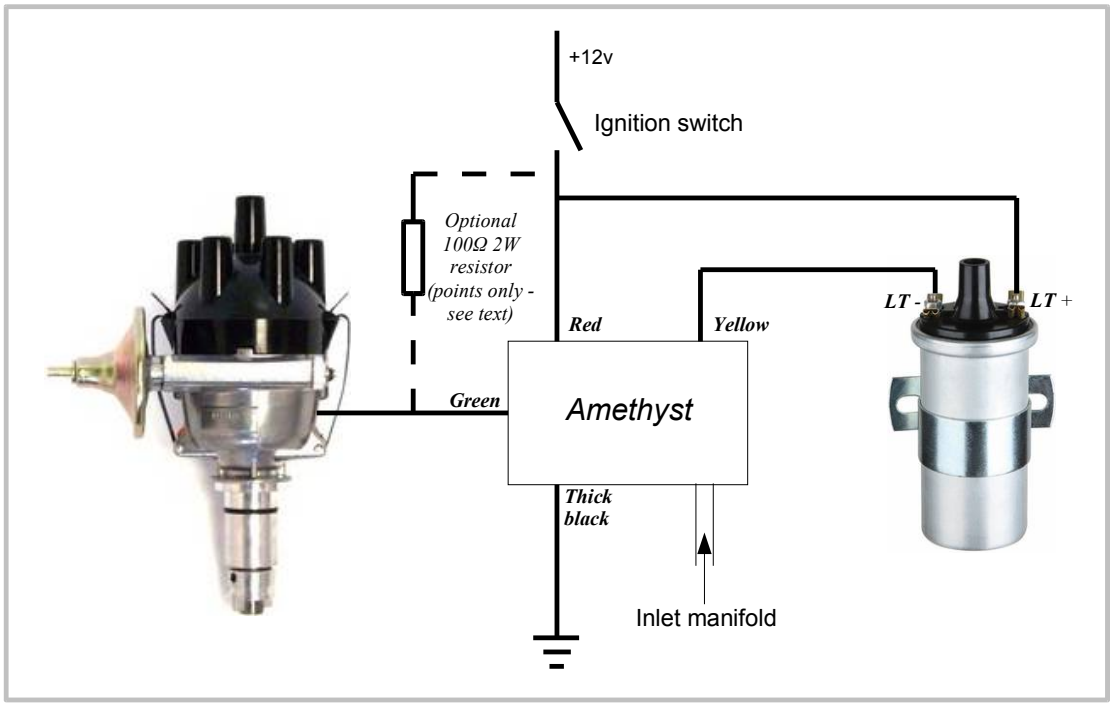


Fig. 4. Wiring diagram

2.2.3 Proprietary optical inputs

If your car has an electronic ignition system with an optical input, such as Lumenition or Piranha, it is often possible to use the existing optical "chopper" to trigger the Amethyst unit. This is described in Appendix D.

2.2.4 *Reluctors*

Many distributors from the 1970s onwards were fitted with reluctors rather than points. A reluctor is a coil of wire wound round a soft iron former, very similar to the head of a magnetic tape recorder. As a tooth in the distributor sweeps past the reluctor, the magnetic flux in the iron former changes and a voltage pulse is generated.

Usually, the reluctor output can be connected directly to the green wire on the Amethyst unit. However, it is essential that a type 1N4004 diode (or higher specification, e.g. 1N4005, 1N4006 or 1N4007) be connected as shown below. This will protect the Amethyst unit from high voltages generated by the reluctor at high RPM. ***Failure to include this diode may result in irreparable damage to the Amethyst unit.***

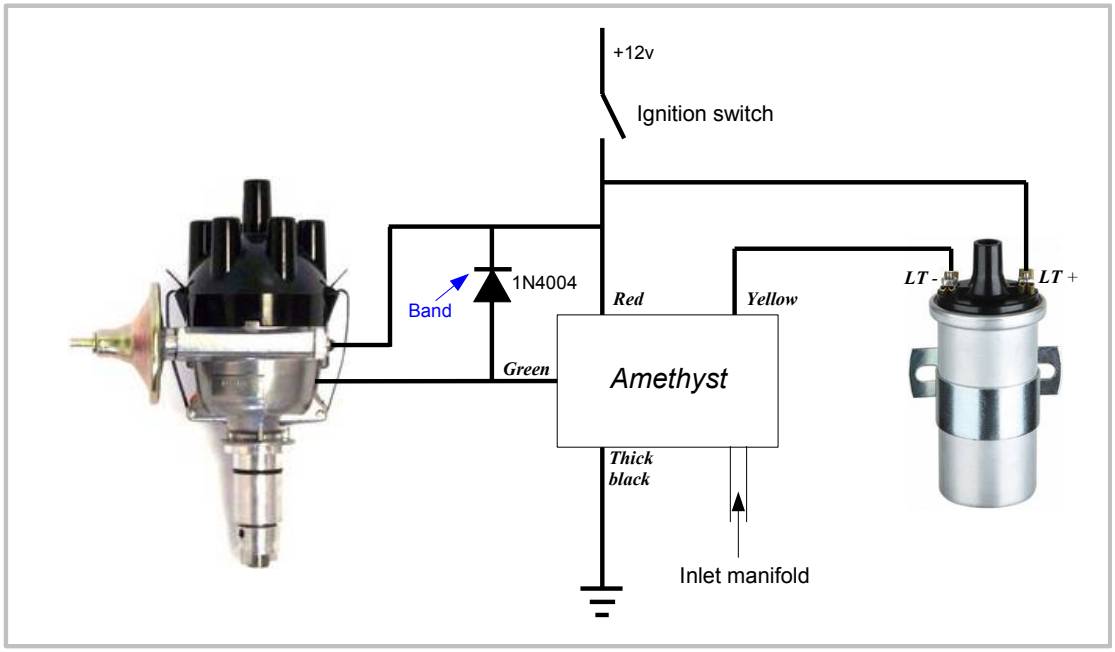


Fig. 5. Using Amethyst with reluctor input

The voltage generated by a reluctor is proportional to RPM. No voltage at all is generated when the engine is stationary. It is therefore impossible to set static timing with a reluctor input. Instead, you will have to start the engine and adjust the timing using a strobe light.

2.2.5 *Other electronic inputs*

Although we cannot guarantee compatibility in all cases, Amethyst can be triggered from most types of electronic input. The trigger requirements of are described in Appendix E.

2.3 The immobiliser/map select wire

By default, the built-in immobiliser is turned off. You can turn it on under software control (see section 3.4). If the immobiliser is turned on, the thin black wire will need to be touched to a +12v supply, at least momentarily, before the unit will allow the engine to start.

You can connect this wire to a hidden switch or, if you can prefer, you can connect it to one of the vehicle's existing switches. This way, you can install the system such that the car will start only if (for example) the interior light has been turned on momentarily, or the gear lever has been touched against reverse.

The same wire may instead be used to switch "on the fly" between pairs of ignition maps. This option is described in section 3.5.

If you do not intend to use either the immobiliser or the map select feature, you can leave this wire unconnected.

2.4 Vacuum, boost and throttle position sensors

If you are using vacuum advance, or measuring boost on a supercharged engine, connect a length of vacuum pipe from the vacuum take-off on the inlet manifold to the manifold pressure sensor on the Amethyst unit. Alternatively, if you are using a Throttle Position Sensor (TPS), connect the multi-way connector from the Amethyst unit to your TPS.

If you are using none of these, you can leave the vacuum sensor (or boost, or TPS) disconnected.

2.5 Re-setting the timing

Note that this step cannot be carried out if your distributor is fitted with a reluctor.

Ensure that the yellow lead is disconnected from the coil. Remove or loosen the spark plugs to make the engine easier to turn accurately. Now turn on the ignition. The LED on the Amethyst unit should be on when the coil is on (i.e. with the points closed on a traditional system), and off when the coil is off. You should see the LED turn on and off as you turn the engine by hand.

Adjust the distributor so that the LED turns off just as the engine passes the vehicle manufacturer's specified timing point.

At this point, you can re-fit or tighten the spark plugs, connect the yellow wire to the coil LT terminal and start the engine. The Amethyst unit contains a default map

which should at least allow the engine to run. Almost immediately, the unit will switch from *start mode* into *run mode*, which means that it is constantly computing the timing advance required. When the unit enters run mode, the LED goes out.

2.6 Spark plug gaps

The plug gaps specified for classic cars (typically around 0.6mm / 0.025 inch) were limited by the capabilities of traditional ignition systems. Your coil will generate a much higher HT voltage with Amethyst than with points and condenser, so it will often be possible to open up the plug gaps, giving improved efficiency. Gaps up to 0.8mm will normally work well.

3. Configuration

Install the Amethyst application onto your PC from the supplied USB stick. With the stick attached to the PC, move to the folder created from it and double-click on the "Amethyst Ignition" application. Within a few seconds, a window will appear showing the control panel for Amethyst.

Next, connect the Amethyst unit to the PC via the supplied USB lead. Turn on the ignition, but do not start the engine. The ignition must always be left switched on whilst the Amethyst unit is being configured.

Note: When a PC is connected to an Amethyst unit for the first time, the PC will recognise that a new USB Human Interface Device has been found. This procedure is completely automatic, exactly the same as when a new mouse, keyboard or memory stick is connected. Within a few seconds, the PC will tell you that the new hardware is installed and ready for use.

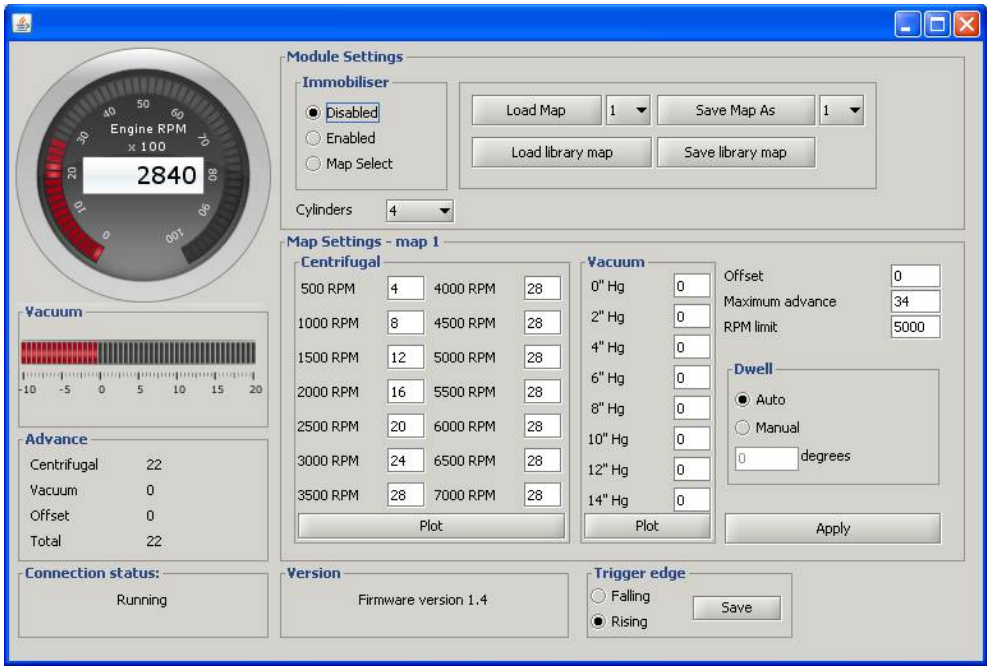
Note: It is safe to leave the ignition on for any length of time with the Amethyst unit installed. The handbooks for many older cars advise against leaving the ignition switched on with the engine stopped, since this can cause the coil to overheat. Amethyst does not supply any current to the coil until the engine is started, so the ignition can safely be left switched on indefinitely.

The Amethyst display is split into three sections:

(i) The information on the left-hand side is constantly updated: engine RPM, the current vacuum reading in inches of mercury (or boost in bar if you have the boost version of Amethyst, or throttle position reading if your Amethyst unit is fitted with a throttle position sensor), and the advance that Amethyst has calculated in crankshaft degrees. You can also see the current unit status, which is either *disconnected*, *immobilised*, *start mode*, *running* or *rev limit*.

(ii) The information in the top panel applies to the Amethyst unit as a whole: the number of cylinders and whether the immobiliser is enabled or disabled. You can use the "Load map" and "Save map" buttons to load and store up to eight ignition maps.

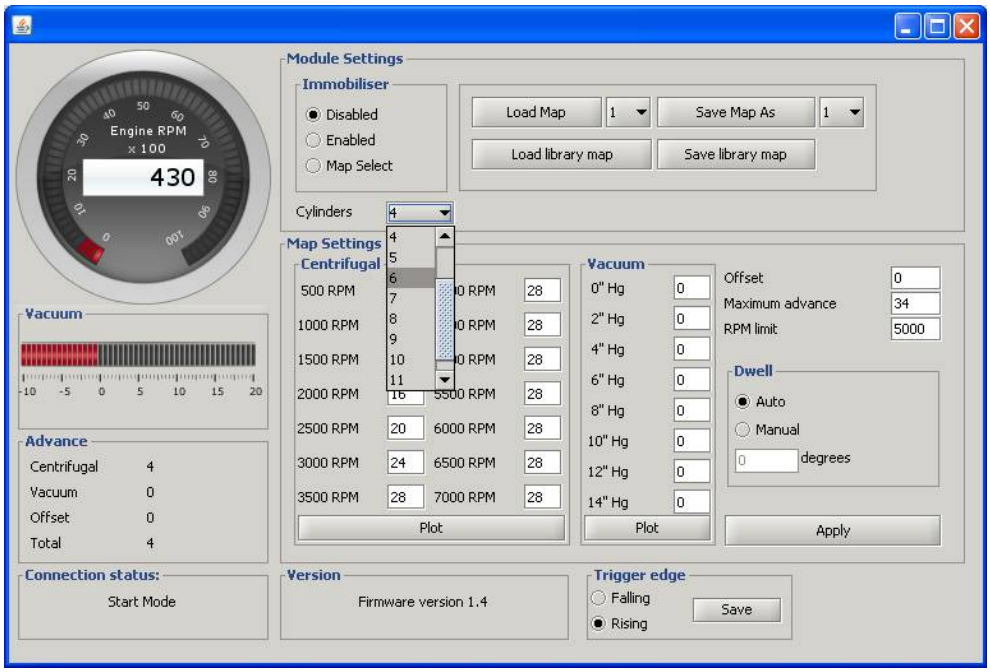
(iii) The information in the bottom panel applies to the current map: advance settings at various RPM and vacuum points, an advance offset, the maximum permitted advance, and an RPM limit. You can also specify a dwell angle here, although the unit calculates dwell automatically by default.



Note: The following screen shots were taken using the vacuum version of Amethyst. If you have the boost version, the screen will display pressure from -0.5 to 1.5 bar instead. If you have the TPS version, the screen will display throttle angle, from 0 to 90 degrees.

3.1 Setting the number of cylinders

The first step is to make sure that the number of cylinders is correct, otherwise the RPM calculations will be wrong. New Amethyst units are programmed for four cylinders by default. If this is wrong, select the correct number from the drop-down list and press "Apply".



3.2 Loading, changing and saving maps

3.2.1 The current map

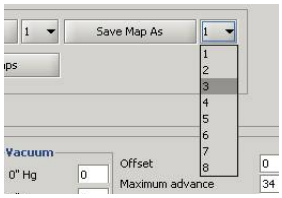
The *current map* is always displayed in the "Map Settings" box. This set of figures controls the timing whenever the engine is running. To make any changes to the current map, type in the figures required and press "Apply".

Note that the current map will be lost when the ignition is turned off. If you want to keep the changes you have made, you will have to save the map to the Amethyst unit's internal flash memory.

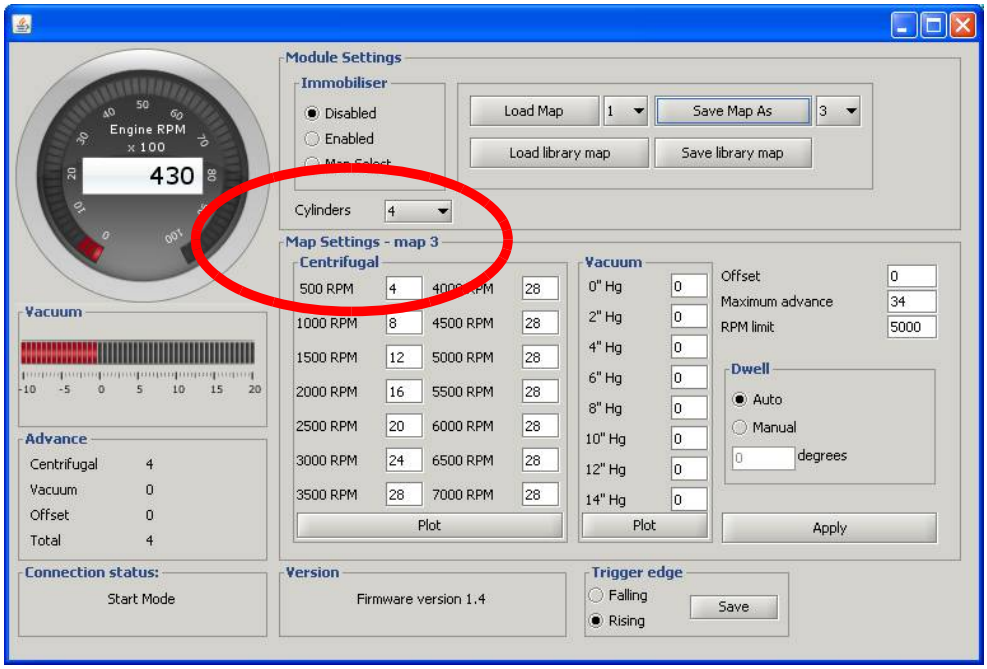
3.2.2 Stored maps

The Amethyst unit stores eight maps in flash memory. Any map can be loaded (i.e. it becomes the current map) by selecting the map number from the drop-down menu and pressing "Load Map". The current map can be saved to any of the eight locations by

selecting a number from the drop-down menu and pressing “Save Map As...” The unit will then load this map the next time the ignition is started.



For example, if you store the current map as map 3, then map 3 will be loaded as the current map the next time the unit is started.



3.2.3 Default maps and the null map

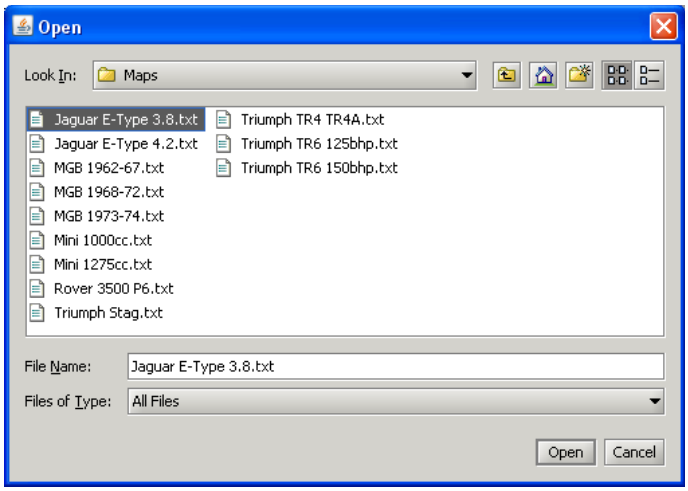
By default, maps 1-7 contain the advance figures shown in these screen shots. Map 8 is a null map, meaning that the advance figures are all set to zero. This can be used to set the timing dynamically with a strobe light. With no advance or retard whatsoever, the strobe light should illuminate the same timing point regardless of RPM. This will confirm whether the distributor advance mechanism has been locked successfully, and can also be used to show whether any slack has been taken up between the crankshaft and the distributor drive.

Even though map 8 is null by default, you can still use it as a regular ignition map, storing advance figures of your choice.

3.2.4 Library maps

An unlimited number of maps may be stored on a PC, and transferred to the Amethyst unit via the USB interface. Each map is stored as a file on the PC's disk. Library maps for certain popular cars can be downloaded from www.aldonamethyst.co.uk. The list of library maps is updated from time to time.

To load a library map, press “Load library map” and navigate to the file required. Then press “Open”.



Once you have loaded a library map, you will still have to press "Apply" to send the new map to the Amethyst unit, and "Save Map As" to write it to flash memory so that it is preserved the next time the engine is started.

Maps can be stored to the PC using “Save library map”.

The library map format is described in Appendix C.

3.3 Creating ignition maps

Amethyst calculates the advance required by summing three numbers, all of which are specified in crankshaft degrees:

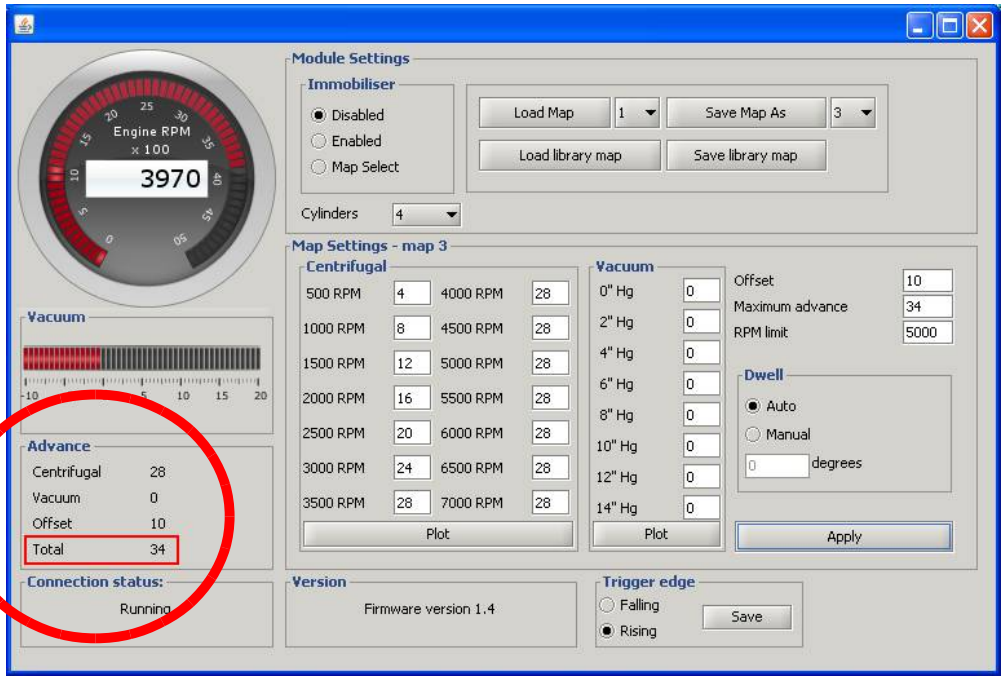
- an offset, which is constant. Changing the offset allows the entire map to be advanced or retarded without altering its shape. The offset can be either positive or negative (i.e. either an advance or a retard)

- a centrifugal figure, which is calculated by reference to a table of advance against RPM. Linear interpolation is used when the measured RPM falls between two defined points. The centrifugal advance figures must be positive.

- a load figure, which is calculated by reference to a table of advance against manifold vacuum (or boost on units fitted with a boost sensor, or throttle position on units fitted with a Throttle Position Sensor). Linear interpolation is used when the measured vacuum (or boost, or throttle position) falls between two defined points. These advance figures can be either positive or negative.

The unit has fourteen RPM points (500 RPM increments from 500 RPM to 7,000 RPM) and eight load points (from zero to 14 inches mercury). Thus the entire advance characteristic is specified in 23 numbers (1 offset, 14 centrifugal, 8 load).

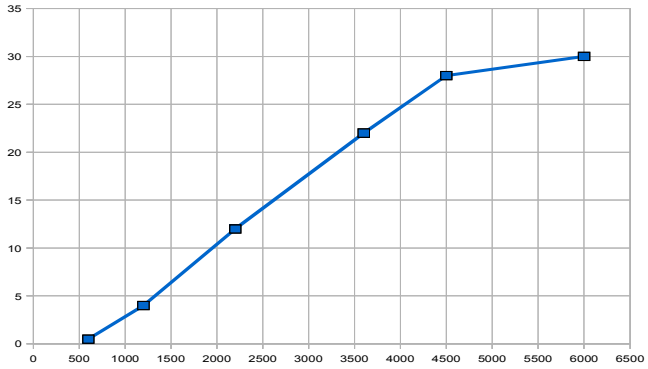
In addition, each map contains a maximum advance figure, as a precaution against advance calculations which might harm the engine. By default, the maximum advance is 34 degrees. If the total of offset plus centrifugal advance plus vacuum advance exceeds the maximum advance, then the total advance will be limited accordingly:



3.3.1 Ignition map example

One typical curve (1973-74 MGB) specifies the following advance requirements, in addition to the static advance of 6°:

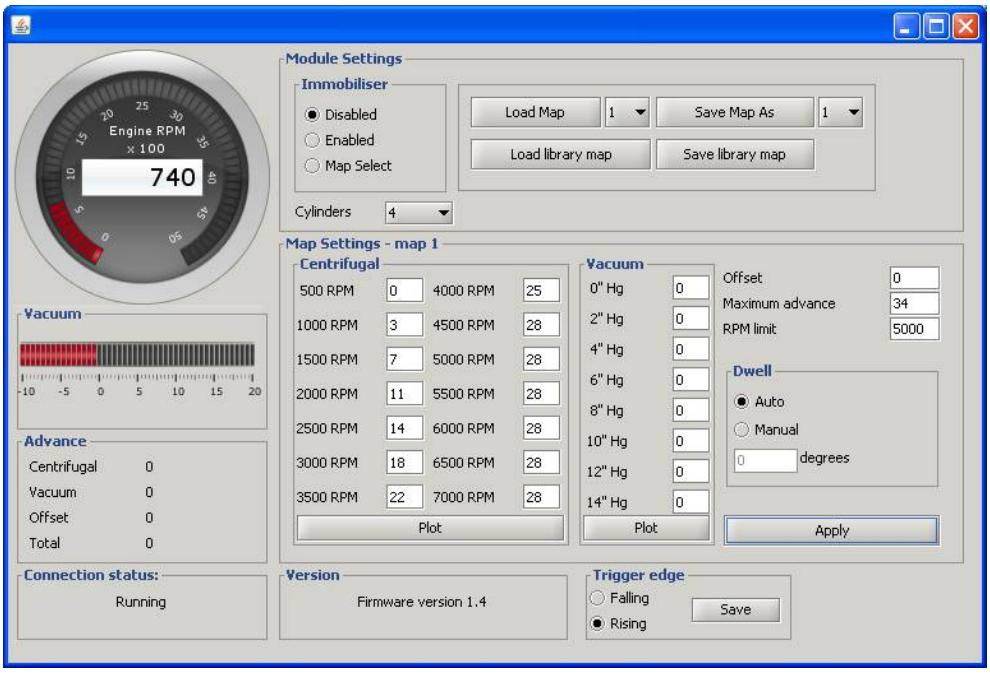
600 RPM	0.5°	3,600 RPM	22°
1,200 RPM	4°	4,500 RPM	28°
2,200 RPM	12°	6,000 RPM	30°



The following figures can be read off the graph:

500 RPM	0°	3,000 RPM	17.5°
1,000 RPM	3°	3,500 RPM	22°
1,500 RPM	7°	4,000 RPM	24.5°
2,000 RPM	11°	4,500 RPM	28°
2,500 RPM	14°	5,000 RPM	28°

These map points are then entered as shown below:



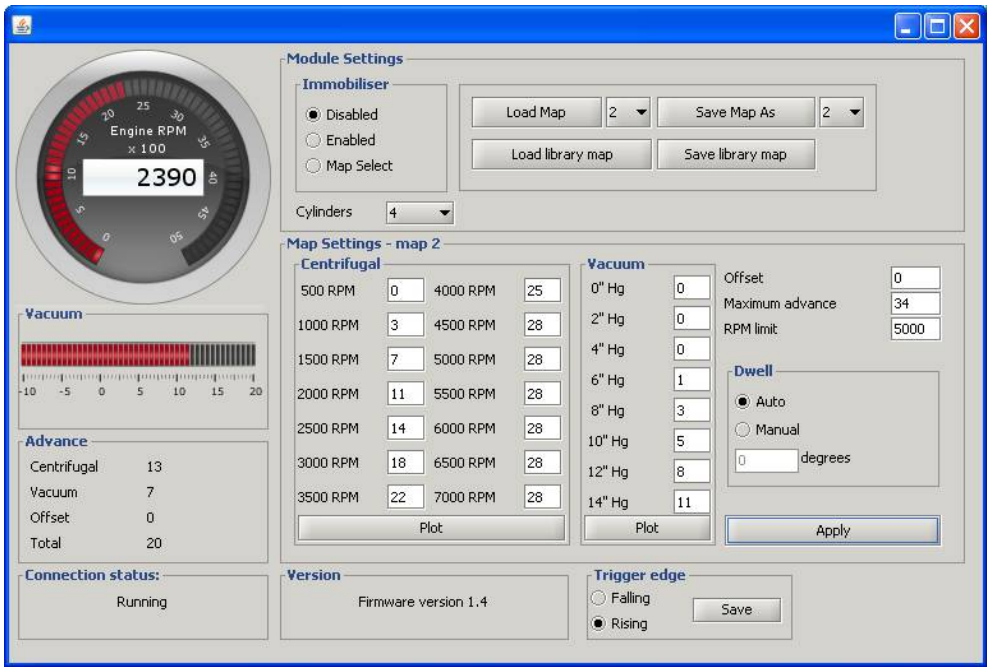
You can review the shape of your ignition map by pressing the "Plot" button:

To send this information from the PC to the Amethyst unit so that the engine runs with these settings, press "Apply".

To write the map to the Amethyst unit's flash memory, so that it will still be there the next time the engine is started, select a map number from the drop-down menu and press "Save Map As..." As described in section 3.2.2, you can store your map to any of the eight locations.

3.3.2 Vacuum advance

Vacuum advance characteristics can be entered in exactly the same way. An example is shown below. Note that there is approximately 11" Hg of manifold vacuum in this case, typical of an engine running at part throttle:



If your Amethyst unit is fitted with a TPS, you will see load points labelled from 0 to 90 degrees, rather than from 0 to 14 inches of mercury. If you have a boost sensor instead of a vacuum sensor, your will see the load points labelled from -0.5 to 1.5 bar.

You can review the shape of your load curve by pressing the "Plot" button.

Note: Starting with firmware version 1.8, no vacuum advance (or boost, or throttle angle) is applied below 1,000 RPM, and the amount of advance applied is tapered off between 1,500 RPM and 1,000 RPM. This means that the vacuum sensor can be

connected directly to the inlet manifold with no risk of full advance being applied at idle.

3.3.3 Rev limit

The built-in rev limiter can be set from 2,000 RPM to 9,999 RPM. A "soft" rev limiter is used, which progressively cuts out more and more sparks as the limit is exceeded. The ignition is cut out completely if the rev limit is exceeded by more than 500 RPM.

If the rev limit is exceeded, the LED on the Amethyst unit will light.

3.3.4 Dwell configuration

The unit automatically calculates dwell, so as to provide a strong spark at all times without causing the coil to become unnecessarily hot at low RPM. In nearly all cases, you can leave auto dwell selected. However, if you wish to specify a dwell angle, you can do so by selecting "Manual", entering the required figure in the box and pressing "Apply". Dwell angles are specified in distributor degrees.

The rules used for dwell calculation are explained in Appendix B.

3.4 Immobiliser configuration

By default, the immobiliser is disabled. To enable it, select "Enabled" and press "Apply". When the immobiliser is enabled, the immobiliser/map select wire will need to be touched to +12v, at least momentarily, before the Amethyst unit will allow the engine to start.

3.5 Map select mode

The immobiliser/map select input can be configured to swap between pairs of maps instead of being used as an immobiliser. Using this feature, you can change between maps at the flick of a switch, without needing to have a PC connected to the USB port. The map pairs are maps 1 and 2; 3 and 4; 5 and 6; and 7 and 8.

To enter map select mode, choose "Map Select" and press "Apply".

In map select mode, when the immobiliser/map select lead is disconnected, the unit will always run with an *odd-numbered* map. When the immobiliser/map select lead is connected to +12v, the unit will always run with an *even-numbered* map.

If the unit is operating in map select mode with the immobiliser/map select switch open (i.e. odd-numbered maps), the LED will flash once every few seconds. In map

select mode with the switch closed (even-numbered maps), the LED will flash twice every few seconds.

3.6 Trigger edge configuration

By default, the Amethyst unit triggers on the rising edge of the signal from the distributor, i.e. from 0v to +12v. If you are using points, this will happen when the points open. This setting can be left unchanged with most electronic inputs, including Aldon Ignitors and reluctors.

If you are using an optical input such as Lumenition, you might find it more convenient to configure the unit to trigger from the falling edge instead, so as to minimise the angle through which the distributor must be turned to set the static timing.

Appendix A: Troubleshooting

If your Amethyst unit does not seem to work correctly, the following steps should help you to determine where the problem lies.

PC connection

The ignition must be switched on for the Amethyst unit to connect to the PC.

Phase errors

If the Amethyst unit seems to be triggering badly out of phase, the trigger edge might be set incorrectly.

Input circuit test

When the unit is in start mode, the LED should be on with the points closed (or the electronic equivalent) and off with the points open, as described in section 2.3. When you crank the engine on the starter, you should see the LED flash on and off until the engine fires.

If the LED does not flash, you can test the input circuit as follows:

1. Disconnect the green wire.
2. Turn the ignition on. The LED should not light.
3. Connect the green wire to earth. The LED should now turn on.

If the LED does not turn on and off in response to the green wire being grounded and released, the unit is defective.

You can optionally connect the green wire to earth via a multimeter on its current setting. You should find that the Amethyst unit supplies about 20mA.

Output circuit test

If no sparks are generated, even though the LED flashes when the engine is being cranked, you can check the Amethyst output circuit as follows:

1. Disconnect the yellow lead from the coil.
2. Connect the yellow lead to the vehicle positive supply via a low-wattage 12v bulb. A tail light bulb will suffice.
3. Turn the engine over on the starter. You should see the bulb flash on and off.

If the bulb does not flash, the Amethyst unit is defective.

Appendix B: Dwell calculation

The amount of energy stored in an ignition coil depends on the length of time that the points are closed. If they are closed for a very short time (less than a couple of milliseconds) there will only be enough energy to produce a weak spark, or perhaps none at all. If they are closed for longer than a few milliseconds, the coil becomes saturated, which means that it holds the maximum energy possible for its size. If the points remain closed beyond this time, the only effect is to heat up the coil.

With a traditional ignition system, the dwell angle specifies the distributor angle through which the points are closed. This has to be set such that, at maximum RPM, the points remain closed for long enough to ensure sufficient energy in the coil to produce adequately strong sparks. However, this means that the points stay closed for much longer than necessary at lower RPM.

Amethyst calculates a suitable dwell *time* rather than using a fixed dwell *angle*. This allows the coil to run cooler at low RPM and may contribute to improved reliability. The unit calculates dwell time based on the number of cylinders and the rev limit, and assumes that the coil should be on for 80% of the time at maximum RPM. This is equivalent to a dwell angle of 72° with a four-cylinder engine, 48° with a six, or 36° with an eight.

The dwell time calculated is then applied regardless of RPM. This ensures that strong sparks are generated, but also enables the coil to run cool at lower RPM.

You can specify a dwell angle manually if required. However, the unit will still convert this into a dwell time based on the RPM limit that you specify, and apply that dwell time throughout the RPM range.

Appendix C: Library map file format

Each library map is stored as a text file. A typical example is shown below:

```
// Aldon Amethyst ignition map
// MGB 1973-74

CYLINDERS          4
REVLIMIT           5500
ADVLIMIT           34
OFFSET             0
CENTRIFUGAL        0,3,7,11,14,18,22,25,28,28,28,28,28,28
VACUUM             0,0,0,1,3,5,8,11
```

The figures opposite the CENTRIFUGAL heading specify advance at the fourteen RPM points, beginning at 500RPM. The VACUUM figures specify advance at the eight load points, beginning at 0" Hg (or 0 bar boost, or 0 degrees of throttle angle).

Each of the headings can be abbreviated to its first two letters, for example AD for the advance limit or CY for the number of cylinders.

Any line that does not begin with CYLINDERS, REVLIMIT, ADVLIMIT, OFFSET, CENTRIFUGAL or VACUUM, or their abbreviations, is ignored. In the example above, we have used "//" to denote a comment. Comments can be used to record what vehicle the map is for, when the map was created and from what information, and whether the map has been modified from standard.

Appendix D. Using Amethyst with optical triggers

Amethyst units are in use on cars fitted with Lumenition, Piranha and Crane XR700 optical inputs. In all cases, the original amplifier is discarded, and the optical trigger in the distributor is connected directly to the Amethyst green wire.

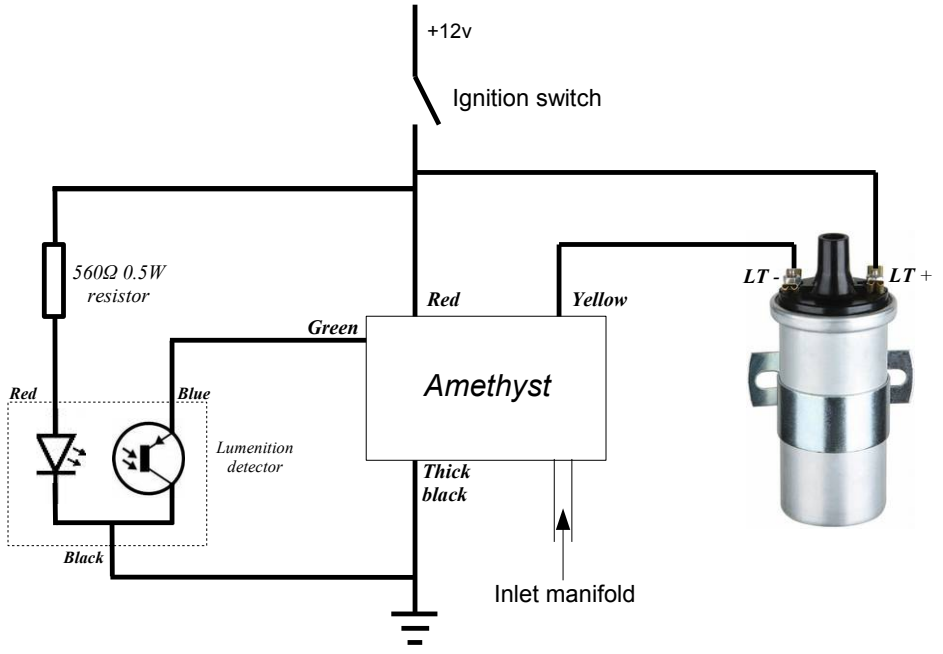
As described in section 3.6, you might find it more convenient to trigger from the falling edge of the signal from the detector. Triggering from the default rising edge will work, but you might find it necessary to turn the distributor through a larger angle in order to set the static timing.

Optical inputs consist of an LED, the "chopper" and a photodiode. Since the original ignition amplifier is discarded, it is necessary to set up a seperate current supply to the LED. Do not connect the LED directly to the +12v supply, since this will probably destroy it. The LED can safely be connected to the +12v supply via the supplied 560 ohm resistor.

Lumenition

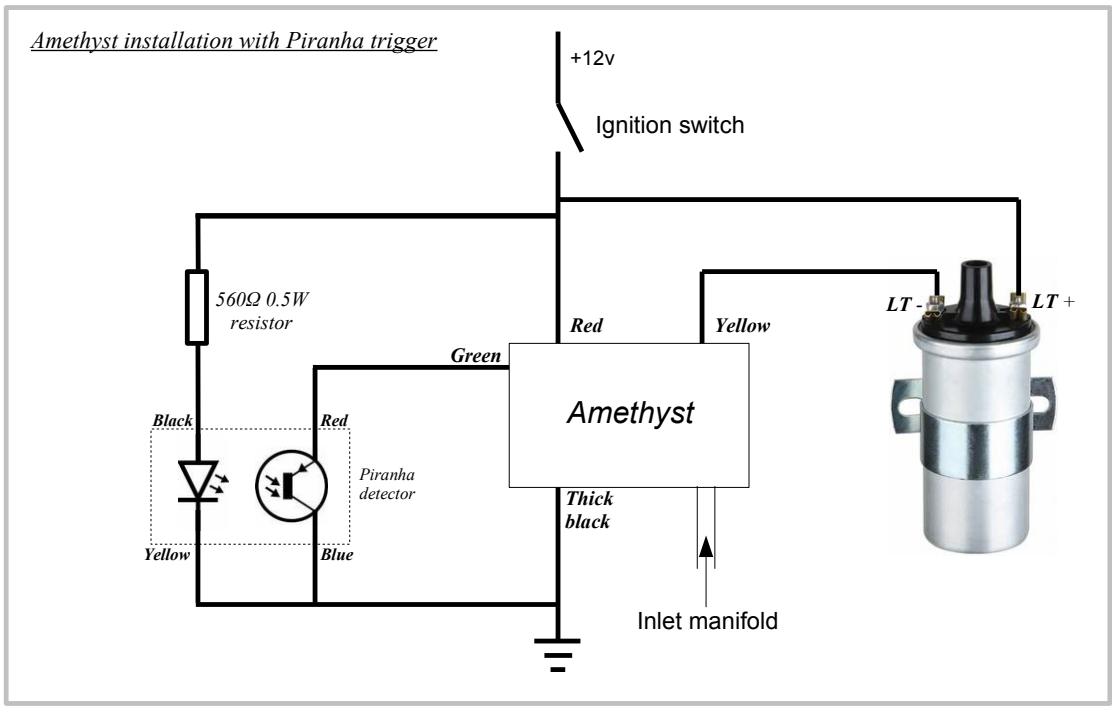
Connect the Lumenition detector to the Amethyst unit as shown below:

Amethyst installation with Lumenition Optronic trigger



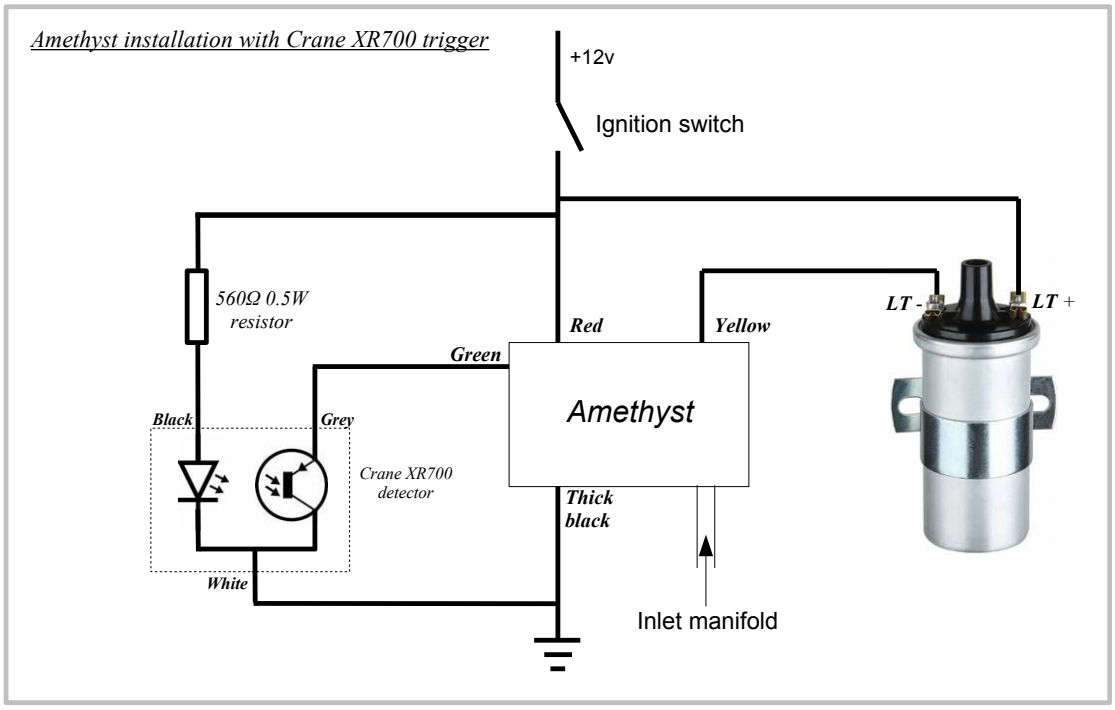
Piranha / Newtronic

Connections are as shown below:



Crane XR700

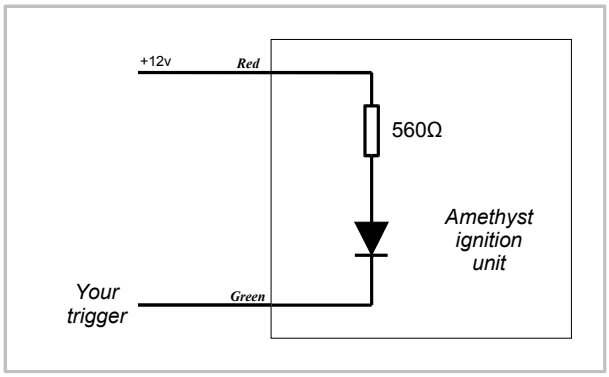
Connections are as shown below:



Appendix E: General trigger requirements

It is theoretically possible to make Amethyst trigger from almost any type of distributor or crankshaft position sensor.

The equivalent trigger circuit of the Amethyst unit is as shown below:



If the circuitry connected to the green wire draws 3mA or more, Amethyst will read this as “points closed”. The input pulse must be of least 50µs duration.

If you connect your Amethyst unit to an input trigger that we have not encountered before, please consider letting us know so that we can add it to our documentation.