Perfect Power

www.perfectpower.com

Smart Tuner

SMT 6

Developer's Manual

Version: 1.7

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1. ENGINE SIGNALS

The SMT6 is an advancement of the UNI5 (SMT5) unit, with many features added.

This section gives an overview of the various applications. The applications are separated by the way the SMT6 is wired in to the car:

a) Piggy-back: The unit modifies the input or output signals of the existing ECU. The signals are routed THROUGH the SMT6, which necessitates the cutting of some wires.
b) Stand alone: The unit "tees" in to some engine signals for the purpose of measuring them, and produces its own outputs for the assistance of the engine and its driver. Typical applications are adding extra injectors, or producing mapped ignition for a carbureted engine.

1.1 ENGINE SIGNAL COMPATIBILITY

Normally no one pays attention to the signals. Connect them, and it works! However, since you want to use them and the SMT6 you must understand them, it is vital to know what they are.

1.2 IGNITION PICKUPS

These are the sensor(s) mounted on the crank, or the CAM, or inside the distributor. They give information as to the crank position, and cylinder identification. The input trigger level can be set. The pickup input(s) can take any signal, which passes a threshold of:

High level: 2.5 volt

Low level: 0.1 volt

The input impedance is 10K Ohm, which is great for "tapping in", but has to be lowered for standalone magnetic pickups. The following pickups are available:

Magnetic (reluctance) sensor:

A 2 wire + screen device, outputs a bipolar signal. The signal must be greater than 4.0 volts. The signal amplitude depends on the distance and the speed of turning. Check that the amplitude is greater than positive 4.0 volts during starting. Use a 470 to 1K Ohm "LOADING" resistor to reduce possible interference from the ignition.

Optical sensor:

A 3-wire device: ground, signal, supply. The signal output is normally a "dry" switch. This means it connects to ground at specific times, but no signal comes out of it, unless a "pull-up" is used. The pull-up can be provided by the ECU. If not, then an external pull-up must be used. The pull-up can be to the battery, or +5 volts, whatever is available.

Hall effect sensor:

A 3-wire device, same as above.

The following sensors can pickup different "teeth" pattern, which differ between each manufacturer:

UNIFORM TEETH PICKUP

The teeth (or holes) are distributed evenly around the track. Each point has the same width. This signal can be used for recognition of the RPM, and for advancing and retarding. A second sensor is required when used in a wasted spark application.

MISSING TEETH PICKUP

This is a single wheel with 36 to 60 teeth, and one (or two) teeth missing to identify a particular cylinder. The SMT6 can recognize this signal for piggy-back application, and this signal can be modified. This signal is not useful for standalone ignition application. A derivative of this pickup is the "double ended" signal (both wires have a signal), which can be simulated in a piggy-back application.

2 UNIFORM TEETH PICKUPS

One pickup has the firing information (IG1IN), and the other has the cylinder information (IG2IN). Both signals can be advanced or retarded.

ODD TEETH PICKUP

This is a signal, with a non-uniform pattern around the track. This signal can be used for picking up the RPM, but this signal can only be retarded. The length of each pickup pulse is not important.

1.3 ANALOG SIGNALS

This is a voltage in the range from 0-5 volts (or 0-10 volts), which contain information such as temperature, airflow; throttle position and manifold pressure (AMP). The SMT6 can use these signals, and it can map them.

1.4 DIGITAL FREQUENCY SIGNALS

This is a signal, which swings from 0 to 5 volts. The frequency contains the information. Such signals are transmitted from airflow sensors. The SMT6 can work with such a frequency signal.

1.5 IGNITION OUTPUT SIGNALS

This is a signal from the ECU to the external ignition "trigger" amplifier. The signal may go from 0 to approx. 3 volts. When high (2.5 volts) current flows through the coil. The SMT6 can recognize this signal. However, if this signal results in a "feedback" signal on a different wire to signal to the ECU the current flow through the coil, then this signal can't be modified in the piggy-back mode.

1.6 DIGITAL PWM SIGNAL

This signal swings from 0 to 5 or from 0 to 12 volts. The WIDTH contains information. Such signal is used for opening idle motors, cam switching and turbo waste gate control. Depending on the application, such signal can be modified.

2. PIGGY-BACK APPLICATIONS

A piggy-back system relies on the standard ECU. The signals to and from it are modified within the operating parameters of the standard ECU. Thus the achievements are modest, but nevertheless worthwhile if any engine modification was performed, or when the stock engine must be tuned to its absolute peak. The piggy-back mode is particular important for "environmental" tuning to reduce emissions and fuel consumption.

The following section catalogs the various engine signals, since the SMT6 has to understand (and modify!) them.

2.1 IGNITION MODIFICATION WITH UNIFORM TEETH PICKUP

The IG1IN input takes this signal. You can choose the trigger edge. You need not connect a second pickup signal. The modified input signal is available on IG1OUT, and a special bipolar output is produced on IG1SP. Operating modes are: 10,11,12,13

2.2 IGNITION WITH MISSING TOOTH PICKUP

The IG1IN input connects to it in mode 1. The modified input is available on IG1OUT and on IG1SP outputs, and an INVERTED signal on IG2OUT. The outputs are square waves. The inverted signal is used to simulate a "balanced" input to the ECU.

2.3 IGNITION WITH ODD TEETH PICKUP

This signal can consist of various length and varying patterns. It must repeat within 2 turns of the crank. The teeth per turn entry are the amount of teeth (or holes) per TWO crank turns. This signal can only be retarded, which is sufficient for superchargers and turbo's. If advancing is required, then the pickup must be advanced, and the SMT6 retarded with an equal amount.

2.4 ANALOG AIRFLOW METER MODIFICATION

The airflow meter output is routed through the SMT6, and the output is offset compensated and mapped. The signal range is from 0 to 10 volts. The manual refers to this as analog fuel tuning, and any other analog signal can be mapped.

2.5 FREQUENCY (DIGITAL) AIRFLOW METER MODIFICATION

This signal is square wave; the frequency contains the airflow information. This signal can be modified, but not in the missing tooth method. The input is on IG2IN, and output at IG2OUT. This operation requires mode=10.

2.6 AMP (MANIFOLD PRESSURE) MODIFICATION

This is an analog signal in the range 0-10 volts. Same as airflow meter mods.

2.7 CLOSED LOOP LAMBDA TUNING

Most engines run in closed loop lambda, at least up to 2500 RPM. The output of the lambda (oxygen) sensor is routed through the SMT6, and the signal can be mapped. Due to the highly un-linear characteristic of the sensor, caution must prevail. The analog limits should be used to restrict the signal swing in to areas where the ECU detects a fault.

2.8 ENGINE TEMPERATURE TUNING

Yes, this is possible. A cold engine runs richer, and if this is the desired effect, then this signal can be mapped. Some modern engines apply some logic and prevent successful tuning. Technically this is an analog signal tuning.

2.9 ROAD SPEED GOVERNOR

The road speed is signal originating from the drive train. Some manufacturers restrict the max speed. Such a speed restriction can be raised or lowered in mode=11. Consider the safety aspects when raising the speed restriction!

3. STANDALONE APPLICATIONS

These applications are not limited to the following examples. PERFECT POWER has a complete range of STAND ALONE controllers in the XMS4 range, with many more uses and features. However, the SMT6 can perform some of them.

3.1 FUEL INJECTION

This is active in any mode. It requires the map deflection inputs (A_DEFL + IG1IN) signal to select a map value, and a manifold pressure input. The later is not required if the F_AMP map is set to 1.00. Then the injector output is activated every "teeth per fire". Alternative, all map values can be set to the same value, and the output can be activated via the F_AMP map only. The "Nox inject" function must be off.

3.2 TURBO FUELLER OR FUEL INJECTION

This is a device, which adds fuel through an extra set of injector(s). The amount of fuel can be mapped. This is useful for turbo and supercharger applications. This operation is active in ALL operating modes.

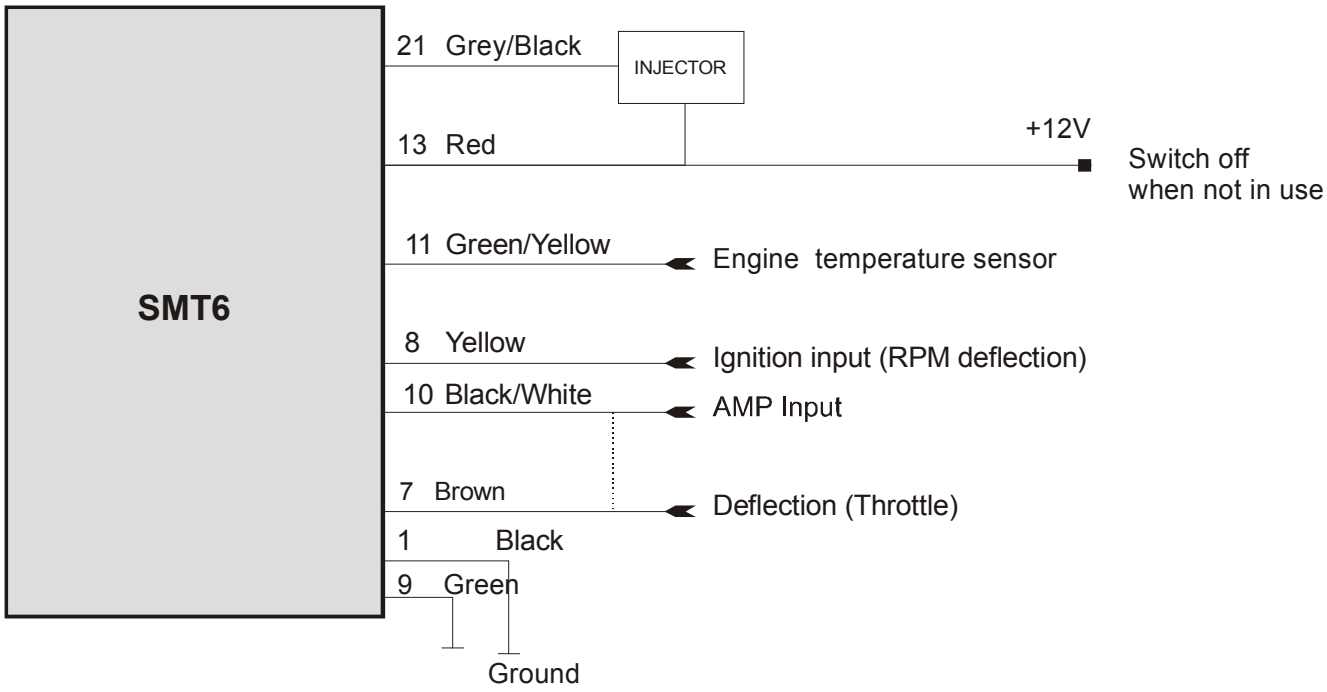


FIGURE 1. TURBO FUELLER BLOCK DIAGRAM

3.3 REV GUARD

It is a method to restrict the RPM. Actually it monitors the RPM, and raises the output AUXOUT when the limit is exceeded. You can switch off the ignition, or put an indication on for gear change.

Note: The above system injects parallel.

3.4 NITROUS CONTROLLER

The injector drive output can be activated proportional via the INJECT map. The output "pulses" a relay, which in turn regulates the nitrous (and fuel) proportional. The repeat frequency is 38Hz. The duty cycle is the injection map value multiplied by the F_AMP map value.

Same as fuel injection, but the NOX INJECT: 4 (ON).

3.5 SETPOINT OUTPUT

The SMT6 has 4 set points, which all result in the AUXOUT (orange) wire to be activated when any of the set points is acceded.

RPM limit
Engine temperature
Manifold pressure
Throttle (deflection) input

The output becomes active when any of the above limits is exceeded, and goes inactive if all inputs are below the threshold. Inputs can be disabled. This feature is useful to activate fans, alert a driver to adverse engine conditions, or do whatever desired with the above set points.

To disable the set points:

RPM Limit: 0
Temperature limit: 255
AMP Limit: 255
Deflection limit: 255

3.6 FUEL INJECTION

The SMT6 can be used as a fuel injection controller via the INJECT map. The injector output can drive 6 Amps, which is sufficient for 6 x 16 ohm injectors. The injector output is the product of the injection map (throttle and RPM) and the F_AMP map (manifold pressure). Note that no cold start or temperature compensation is applied. Full facilities are available in the PRS range of products.

3.7 IGNITION + FUEL INJECTION SYSTEM

The fuel can be injected as described above. The ignition output is activated in the same fashion as in the ignition controller description above.

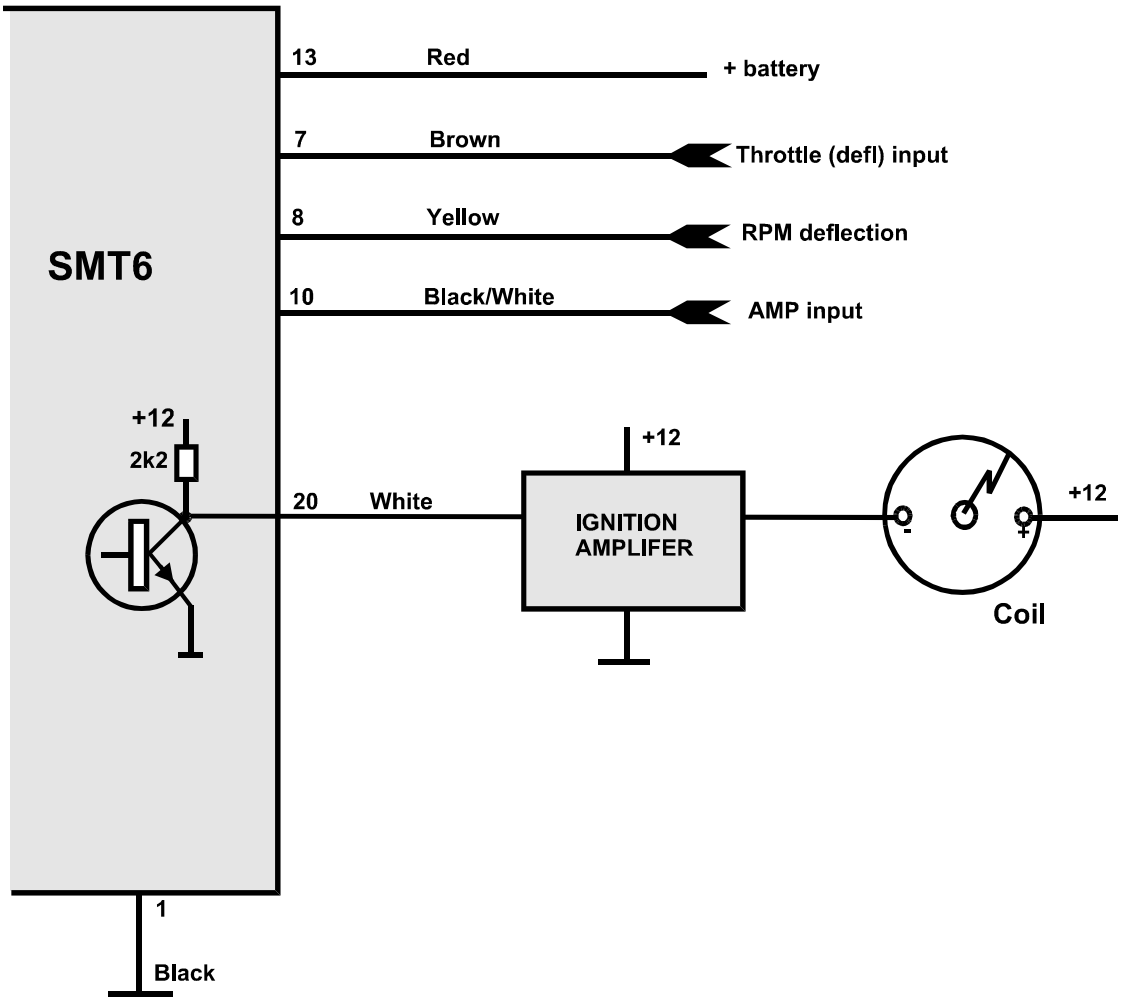


FIGURE 2. SINGLE COIL IGNITION

Note: The output polarity can be set to suit your amplifier.

4. DEVELOPING AN PIGGY-BACK APPLICATION

The SMT6 is shipped to end customers with a WIRING DIAGRAM. The purpose of this manual is to help a developer to develop such wiring diagram for a particular engine, if it is not available from PERFECTPOWER.

A copy of a blank wiring diagram template is included in the back of this manual, and must be filled out and returned to PERFECTPOWER.

Manufacturers do not like the SMT, for obvious reasons. It adds, "tune ability" to the engine, which in the wrong hands can damage the engine. Therefore, manufacturers PROTECT the engine against intrusion by the SMART TUNER.
A developer is therefore faced with 2 challenges:

4.1 CAN THE SMT6 BE APPLIED TO THE ENGINE

This is a very technical decision, and requires knowledge of the standard ECU, electronic knowledge, an oscilloscope, patience, the wiring diagram of the particular model, and a good understanding of the engine (ECU) theory. Some engines you can't "break" in because all wires are "protected". As the engine manufacturer designs new protection in, PERFECTPOWER invents the counter measure. There is a continuous updating of SMT models to take care of new model cars. Therefore, this step confirms that the engine does not detect the SMT, and that the input/output signals are compatible with the ECU. The items to watch for are: polarities, trigger level, drive impedance, balanced inputs and offset

4.2 CAN THE SMT6 ACHIEVE THE DESIRED EFFECT

This depends largely on the desired effect one requires. Some engines are PERFECT, and there is nothing one can do to improve it. However, once the air filter, exhaust, or cams are changed, then the SMT can tune the engine to the new operating conditions. Assuming that the SMT can be applied to it (step 1). Engines are very often not perfect, or can be improved easily. That is because engine manufacturers have different design criteria. Sometimes engines are de-tuned to make them or the gearbox safe. Or they have to fall in a required performance bracket for tax purposes in a different country, or they are simple "Monday" cars, or the engine tolerances play up (or down), or a better fuel is used. The reasons are endless, and the price of the ECU, and it capabilities, play a major role. Any ignition modification may be counteracted by knock-sensor technology if it results in detonation. If a 50% increase in fuel is required (boosted engines), then it is very likely that the ECU will not allow this, because it was not designed for it. The extra fuel can be added with the EXTRA injector placed in the air-intake.

We are often asked if the SMT violates the emission rules. Most countries have something against "tuning" the engine, and therefore the SMT is illegal. But this does not mean that it violates the emission standards.

To the contrary, it most of the time improves the emission, because an engine is "PERFECTLY" tuned. Of course this MUST be verified with proper instrumentation (gas analyzer?) and in the extreme cases certified by the authorities.

The SMT6 is a great tool to tune standard engines, and achieve small gains (5-25%) in power and/or fuel consumption. Best fitted to smaller engines, which have less protection, and are not well tuned.

The PURPOSE of the SMT6 is to add TUNEABILITY or ACESSEBILITY to and otherwise "SEALED" ECU without "chip" changes. The PURPOSE of this manual is to facilitate this.

With the latest addition of the AFR display and the engine temperature input, it is not possible to tune the engine for economy applications and exceed the environmental specification.

The tuning (for whatever purpose!) is not covered by this manual.

4.3 INSTRUMENTS REQUIRED

- Normal workshop tools
- A dual trace oscilloscope, preferred with storage
- A Multimeter
- An OXYGEN (Lambda, AFR) Scanner (if the engine has not got one!)
- Resistors: 100 to 4k7, 1/4 watt
- A Dyno is not absolute necessary, but map help to "iron" out flat spots, or to hold the engine at a particular spot for some time.
- A wiring diagram of the ECU connections is nice!

5. FUEL MODIFICATIONS

Most engines operate in "closed loop" oxygen (lambda) control up to a certain RPM and a certain throttle position for partial power. More modern engines run closed loop at full power with a different (wide band) oxygen sensor.

5.1 LAMBDA TUNING

This is required if tuning is needed in the "closed loop" operating mode of the engine. The oxygen sensor has a voltage output of 0.2 to 1.00 volts, which can be "tuned" up or down as required. Some ECU's respond slowly to the input, some are fast! Locate sensor, and trace wire to the ECU. Measure with voltmeter while engine idles: it should read 0.5 volts, or fluctuate up/down around 0.5 volts.

Two functional different connections are possible.

a) Run the Lambda signal through the SMT6 as any other analog signal: INPUT@AIN, pin6, blue, OUTPUT@AOUT, pin 18, violet. This requires the use of the analog limits to make clever use of the Lambda range.
b) Use the Lambda display input as the analog source (Lambda Tune: Y). The output is on AOUT, but the input is on pin 22, black/brown. The Lambda display is from the input. In this mode the SMT6 makes use of the increased Lambda resolution and a special algorithm (un-linear) is used for tuning. This method requires no analog limit.

5.2 AIRFLOW METER TUNING

This is required for tuning outside the closed loop-operating mode of the ECU. There are THREE kinds of AIRFLOW meters:

A) The voltage output meter. Output is from 0.5 to 7.5 volt according to airflow.
B) The frequency output meter. Output is a frequency according to airflow
C) The current output meter. The current changes according to airflow

Locate airflow meter and output wire. Then measure with scope.

If B) frequency meter: use MODE=10
If A) voltage meter: use any MODE.

If a wire is not found which changes with airflow, then it may be a type C) current meter. Place a 100-470 ohm in SERIES with the wire (from ECU wiring diagram) and measure the voltage ACCROSS the resistor. If it changes with airflow, then it is a type C) current meter. Use any MODE.

5.3 MANIFOLD PRESSURE TUNING

This is required for tuning outside the closed loop operation of the ECU. The output of a manifold pressure sensor is normally 0.2 to 4.8 volts with 5 volts feed. This range corresponds to the full (vacuum to atmospheric or boost) pressure range.

The SMT6 can tune the AMP (analog) in any mode.

5.4 EXTRA INJECTOR TUNING

This is required for tuning outside the closed loop operations of the ECU and when the ECU fuel is limited by fuel pressure, injector size, and mapping or otherwise. It is recommended for large power increases as a result of SUPERCHARGING or fitting a TURBO.

An Extra injector (up to 6 x 16 ohms) is placed in the manifold and activated under the (F2) injection map from the SMT6.

5.5 ENGINE TEMPERATURE TUNING

Most ECU's enrich the fuel mixture and advance the timing for cold engines. The engine temperature sensor must be routed through the SMT6. Before doing that, check if the sensor requires a "pull-up" by measuring the sensor output with the ECU connected, and without. If the voltage drops to zero, then a pull-up is required (to +5V, or to +12V) which restores the voltage to the level it was with the ECU connected. Some ECU's detect the low engine temperature after 30 minutes as "illogical" and indicate a "service fault".

5.6 AIR TEMPERATURE TUNING

Some engines don't have air temperature sensors and rely on warmed up manifolds and other mechanical means to keep the air at a relative constant temperature. Turbo charged and intercooled engines will have an air temperature sensor because the temperature varies by a considerate amount. Most ECU's make the mixture leaner at higher temperatures, because the air density is less. This can be used for tuning. The air temperature sensor may require a pull-up as above.

5.7 ENVIRONMENTAL TUNING

Only analog signals such as Lambda, airflow meter and manifold pressure signals are tuned. The tuning is done via the analog map AND the engine temperature. In most cases the engine is “leaned out” to the absolute extreme under control of the engine temperature.

Special application notes are available. See: **Lambda Tuning**. A word of caution: Do not expect too much. It is possible to “lean out” engines, and to conserve fuel. The gains may be in the 5 – 20% range.

However, older engines can be modernized and made environmentally friendly.

6. IGNITION MODIFICATIONS

This requires patience.

The word pickup is used often: it means a pickup sensor, either magnetic (reluctance), Optical, or Hall sensor. The SMT6 can handle all types.

Engines, which operate on a “closed loop” knock sensor system, can't be ignition tuned, unless the knock sensor is disabled, which is not desirable!

Engines with a distributor require one pickup.

Engines without a distributor require two pickups, or one missing tooth pickup (which transmits TDC and firing information). Locate pickup(s) and check: If it is missing tooth:

Use MODE=1

If it is not, use: MODE=10, 11, or 12.

The choice of mode depends on the nature of the signals.
Put an oscilloscope on both signals, and trigger on the "TDC" or reference signal. Then count teeth in-between, and relate everything to a single RPM. If the distance (in degrees) between the reference signal and the firing signal is smaller than the intended modification, then use MODE=10 or 11.
If not, use MODE=12 (two ignitions).

In some instances it may be advisable to shift the reference signal only. Consult PERFECTPOWER!

A special circumstance exists if the missing tooth "gap" is more than once per revolution. Consult PERFECTPOWER for advice.

In order to confirm that the SMT6 can handle the ignition signals, it is advisable to "TEE" in the SMT6 inputs, and monitoring the inputs and outputs of the SMT6 in the correct mode. Confirm this on all signals and change polarity, trigger level and mode until the signal outputs are confirmed.

7. OPERATING MODES

The SMT6 has various input and output signals, which are assigned to a specific function (operation) by a MODE specification. A wrong mode is indicated on the PC display.

The AIN to AOUT signal path is always assigned to the FUEL MAP, regardless of the operating mode.

The following modes can be specified:

MODE=1 Missing tooth operation

The pickup is from a multi-tooth wheel, with one or two teeth missing. The output signal can be advanced or retarded to a max. of 2 teeth.

MODE=10 Single ignition advance and retard + frequency fuel

The ignition pickup is from a single sensor, magnetic or optical, which can be advanced or retarded. The signal must be "uniform", and it must repeat every engine turn (or very two turns). Multiple "teeth" or trigger points per firing are allowed. The frequency signal of an airflow meter can be tuned for fuel.

MODE=11 Single ignition advance and retard + road speed governor

The ignition pickup is from a single sensor, magnetic or optical, which can be advanced or retarded. The signal must be "uniform", and it must repeat every engine turn (or very two turns). Multiple "teeth" or trigger points per firing are allowed. The road speed governor allows to move gear-switching points and remove (or shift) the road speed governor.

MODE=12 Two ignition advance and retard

Both ignition inputs can be advanced or retarded. The RPM is derived from the CB1 (RPM Deflection) input, and the ignition advance and retard timing is calculated from it, and then applied to BOTH ignition outputs.

MODE=13 Single ignition advance and retard + PWM fuel

The ignition pickup is from a single sensor, magnetic or optical, which can be advanced or retarded. Same as mode=10 or mode=11. The duty cycle of a frequency signal (CAM or boost control) can be controlled from the fuel map.

MODE = 20 Odd signal retard

The ignition pickup is from a single sensor with "odd" tooth pattern. The pattern is only repeated every crank or every second crank turn. This signal is only retarded.

Note that this mode uses the global settings differently:

Operations mode	:	20
Cylinders	:	4,6,8
Teeth per turn	:	Teeth per 2 crank turns
Teeth per turn	:	Injection position

The "odd" signal refers to un-even length, uneven amounts of triggers, and un-even pulse distribution of the input signal. The pulse "train" is repeated to the output, but can be "delayed = retarded" up to the minimum input pulse width.

One of the preceding modes must be specified in the GLOBAL SCREEN (F4). Details of the various SMT6 functions are provided in the following pages.

8. GENERAL CONNECTIONS

POWER

The SMT is powered from a "switched" +12V (+8 to +16V) battery. It takes, depending on the operating mode, 0.02 - 0.1 Amps.

Ground, Chassis, -12V:	Black	Pin	1
+Battery, +12V:	Red	Pin	13

RS232 CONNECTIONS

Once the SMT has power, the RS232 port to the computer (PC) or laptop is working. A three-pin connector provides:

Ground, Chassis, -12V:	Pin	1
SMT6 RX (input):	Pin	2
SMT6 TX (output):	Pin	3

The protocol to the unit is propriety, and the unit will only respond to the SMT DOS or the WINDOWS program.

A connection cable, SMT to D9 PC, is available from the manufacturer.

A good communications link up is indicated by the display of some numbers in the left side of the screen.

The port number can be set.

9. MAP DEFLECTION SIGNALS

The SMT6 has 3 maps (screens). The maps contain settings (sites). A cursor indicates which map point is accessed during engine operation. In order to "move" the cursor, the SMT6 has various DEFLECTION inputs. If a map is not used, then the deflection input can be left open. However, the map values must be set to the "OFF" or "NON-ACTIVE" values as indicated below.

Analog deflection input:	BROWN	pin 7
RPM deflection (and ignition):	YELLOW	pin 8
Engine temperature input:	green/yellow	pin 11
Manifold pressure (AMP) input:	Black/White	pin 10

9.1 ANALOG DEFLECTION

The signal input range is from 0 to +5 Volts. The map deflection can be "calibrated" to respond to any portion of the input range. See: DOS or WINDOWS manuals. The analog deflection is normally connected to the throttle or the manifold pressure sensor. It can be connected to an ANALOG airflow meter, which gives a DC voltage out proportional to the airflow. Important is that the analog deflection input somehow shows the engine "loading". If the analog deflection is not used, then it should be connected to ground.

9.2 RPM DEFLECTION

This input serves also as the IG1IN (Ignition #1 input). It must be connected to a signal, which normally repeats every 360 degrees, or every 720 degrees in special circumstances.

The pickup level can be specified in the global screen:

LOW LEVL. IN:	Y	0.1 Volts
LOW LEVL. IN:	_	2.5 Volts

The input polarity can be specified:

POS.IN.POL:	y	triggers on positive edge
POS.IN.POL:	_	triggers on negative edge

The way the SMT6 interprets the signal is set in the OPERATING MODE:

OPERATIONS MODE:	1-9	MISSING TOOTH
	10-30	NORMAL (non-missing tooth)

Other settings influence the RPM deflection:

Cylinders:
Teeth per rev:
Teeth per fire:

If every item is set correctly, then the SMT6 displays a CORRECT and STABLE RPM. The correctness is of minor importance, the stability is VITAL.

The RPM range can be set (calibrated) to span the desired tuning range of 300 to 10000 RPM for non_missing tooth and 600 to 10000 RPM for missing tooth applications.

The lowest RPM position is not useable. Instead the input is copied to the output to overcome starting problems.

9.3 ENGINE TEMPERATURE DEFLECTION

The green/yellow wire can sense any NTC sensor, and it can be calibrated to show the correct temperature. The values in the A_ENGT map are multiplied with the ANALOG map and then applied to the input signal. If the A_ENGT map is not required, then all entries should be set to 1.00.

The A_ENGT map changes the EFFECTIVNESS of the ANALOG map values. Thus the analog map can come in to effect with warm or cold engine temperature. The input can be connected to an AIR TEMPERATURE SENSOR.

As a matter of principle, the input can be connected to any analog signal in the range from 0-5 volts. It can be calibrated in to any "display" as long as the reading stays in the 3 digit range.

9.4 AMP DEFLECTION

The black/white wire can sense any input signal in the range from 0-5 volts. If not used ground the input. This input signal affects the:

INJECTION MAP
IGNITION MAP

If the signal is not needed, then values in the respective maps must be set as follows:

F_AMP (Injection)	1.00
I_AMP (Ignition)	0

The input can be connected to any other signal source, as long as the 0-5 volts range is met, and the signal presents the engine load. We do not recommend that a potentiometer be used for manually changing the ignition or injection while driving.

10. ANALOG FUEL TUNING

This function is included in every SMT mode.

The analog input range is 0 to +10 Volts, corresponding to the same output range. Higher signals cannot be accommodated without external circuitry. The connections are:

ANALOG INPUT	:	BLUE	PIN	6
ANALOG OUTPUT	:	VIOLET	PIN	18

The analog output is derived:

ANALOG OUTPUT = ANALOG INPUT +- OFFSET +- (FUEL MAP VALUE * A_ENGT)

The offset is specified on the global (F3) screen, and the fuel map value is the value selected by the ANALOG and RPM DEFLECTION signals.

The engine temperature selects the A_ENGT value.

The output can be limited by the two global (F3) screen parameters:

UPPER ANALOG LIMIT	:
LOWER ANALOG LIMIT	:

The entry is in volts!

If the "Lambda Tune: Y" option is used, then the AIN (Pin 6, blue) wire is disconnected, and the input signal is taken from the Lambda input (pin 22, black/brown). The input is processed through a special "un-linear" algorithm. See: **Lambda Tuning**.

11. EXTERNAL INJECTOR ACTIVATION

The SMT6 has one output, which can drive one to 6 injectors of 16ohms. The total injector current is limited to 7 Amps, and an optional heat sink must be installed on the cooling tab (if the injector current is too high). However, since the extra injector(s) is not activated continuously, it is advisable to measure (touch!) the cooling tap during injector activation, and if touchable, no heat sink is required. The injector output driver is temperature protected, and will switch "OFF" if it gets approx. 100 degree C.

The outputs are:

INJECT	Grey/Black	Pin	21
PGND	Green	Pin	9

The following diagram explains the connection:

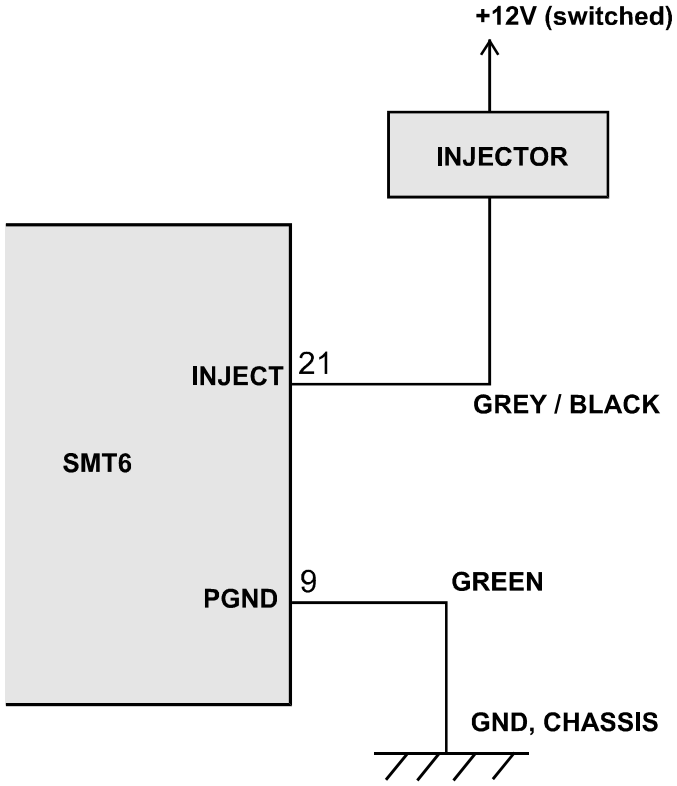


FIGURE 3. CONNECTION

Note: The PGND – Connection draws the injector current of 1-7 Amps. This wire should be connected to the chassis or battery – away from the SMT.GND (Black) wire.

The injector activation is specified on the INJECTOR screen (F2).

Injection length per ignition is:

INJLENGTH = MAP * 0,1ms * F_AMP

12. FREQUENCY FUEL TUNING

The SMT6 MODE = 10 activates a single ignition signal retard/advance AND the FREQUENCY FUEL modification. In this mode the frequency on the IG2IN is copied to the IG2OUT with the analog fuel modification applied. This mode of fuel tuning is needed for frequency airflow meters, which output a frequency signal proportional to the airflow.

The SMT6 has the following operating range:

High freq or speed: Ø (=Low)
10Hz to 3300Hz (3.3kHz)

High freq or speed: 1 (=High)
80Hz to 18000Hz (18kHz)

The active parameters are:

Cylinders	:	sets rpm of fuel map
Teeth per firing	:	as above
Fuel map	:	
Frequency deviation	:	changes the frequency range
A_ENGT	:	changes the effectiveness of the analog map

Note: The SMT Version 6 does not require ignition input or analog deflection, except to select a fuel map modification value. The analog fuel tuning output is active.

Frequency input	:	White / Red	Pin	5
Frequency output	:	White / Blue	Pin	17

Note: A pull-up (blue / black, pin 14, 15) may be used on the input for optical or hall sensors.

Note: A positive number increases the frequency and the fuel.

13. ONE IGNITION INPUT SIGNAL

In SMT6 MODE=10, 11, and 12 and 13

IG1IN	YELLOW	Pin	8
IG1OUT	WHITE	Pin	20

are the prime ignition (CB1) input and output signals. The input trigger level (SEE: RPM DEFLECTION) and input and output polarity can be specified.

The IG1IN signal serves as a map deflection input, and it requires that the signal repeats every engine turn.

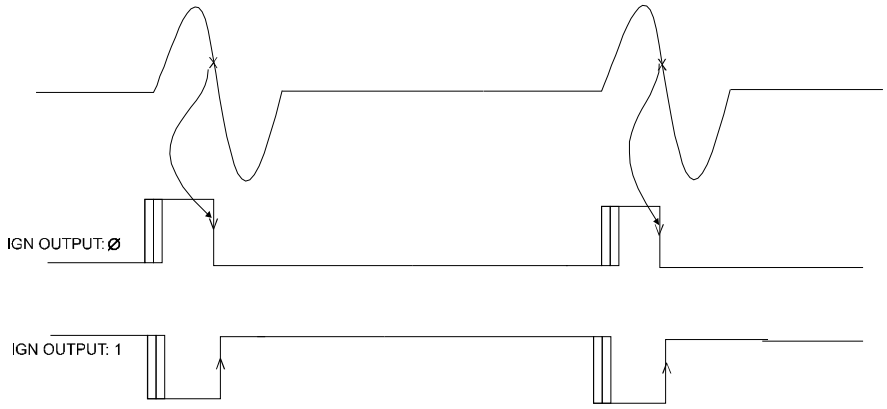
The output is affected by:

Cylinders:
Teeth per firing:
Input polarity
Output polarity
Interlaced

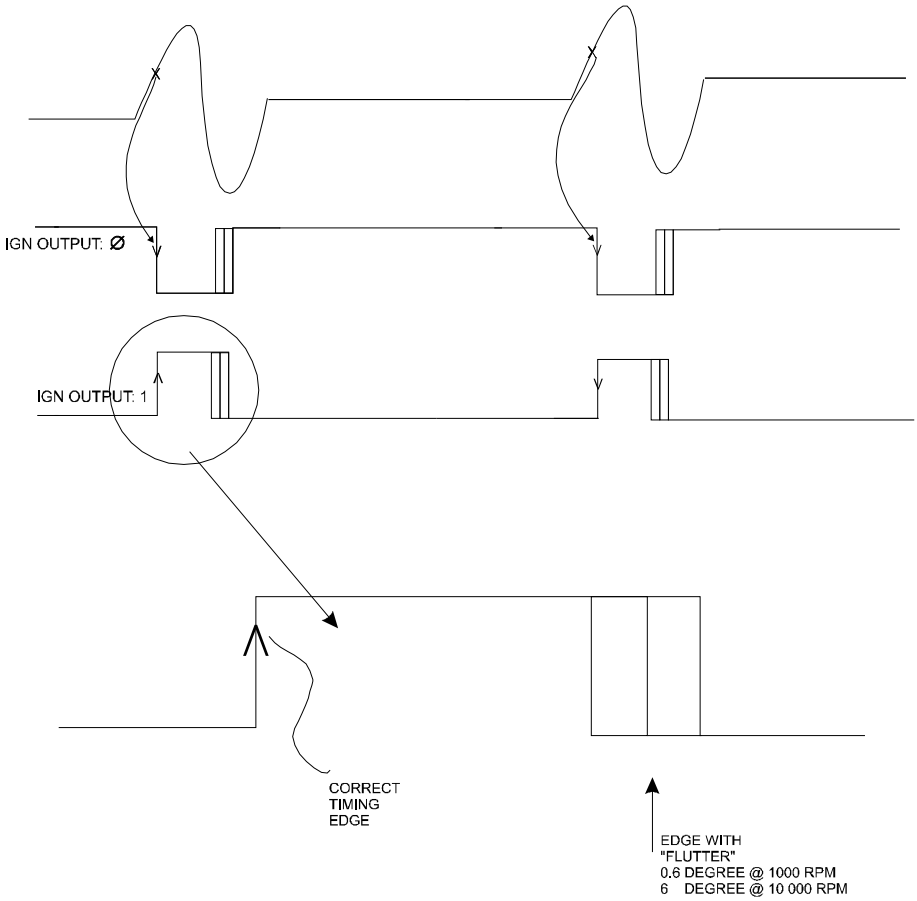
At RPM position zero (bottom map row) the output signal is copied from the input, and no timing is applied. This allows the changing of input and output polarity, until the engine starts and runs. At this point the RPM indication should be correct.

The BIPOLAR (MAGN) INP parameter is active, but does not change the output drastically; it only changes the input trigger level.

Ign input: polarity ∅ SMT Mode = 10



Ign input: polarity 1 SMT Mode = 10



It is obvious from the above that an input and output edge combination is chosen from the one that does not have the "flutter" at the firing edge (trigger edge).

14. TWO IGNITION INPUT SIGNALS

The second ignition input and output is available in SMT MODE=12. For the first ignition input and output, SEE: ONE IGNITION INPUT SIGNAL

The connections are:

IG2IN	WHITE/RED	Pin	5
IG2OUT	WHITE/BLUE	Pin	17

The timing for this output is calculated from CB1 (IG1IN) and applied to the IG2OUT. That is to say that the IG2IN signal can be any signal (Cam?) but it will be advanced or retarded in SYNCH with the IG1OUT signal.

The polarity and level settings in the global (F4) screen apply to the second ignition.

A timing diagram shows it.

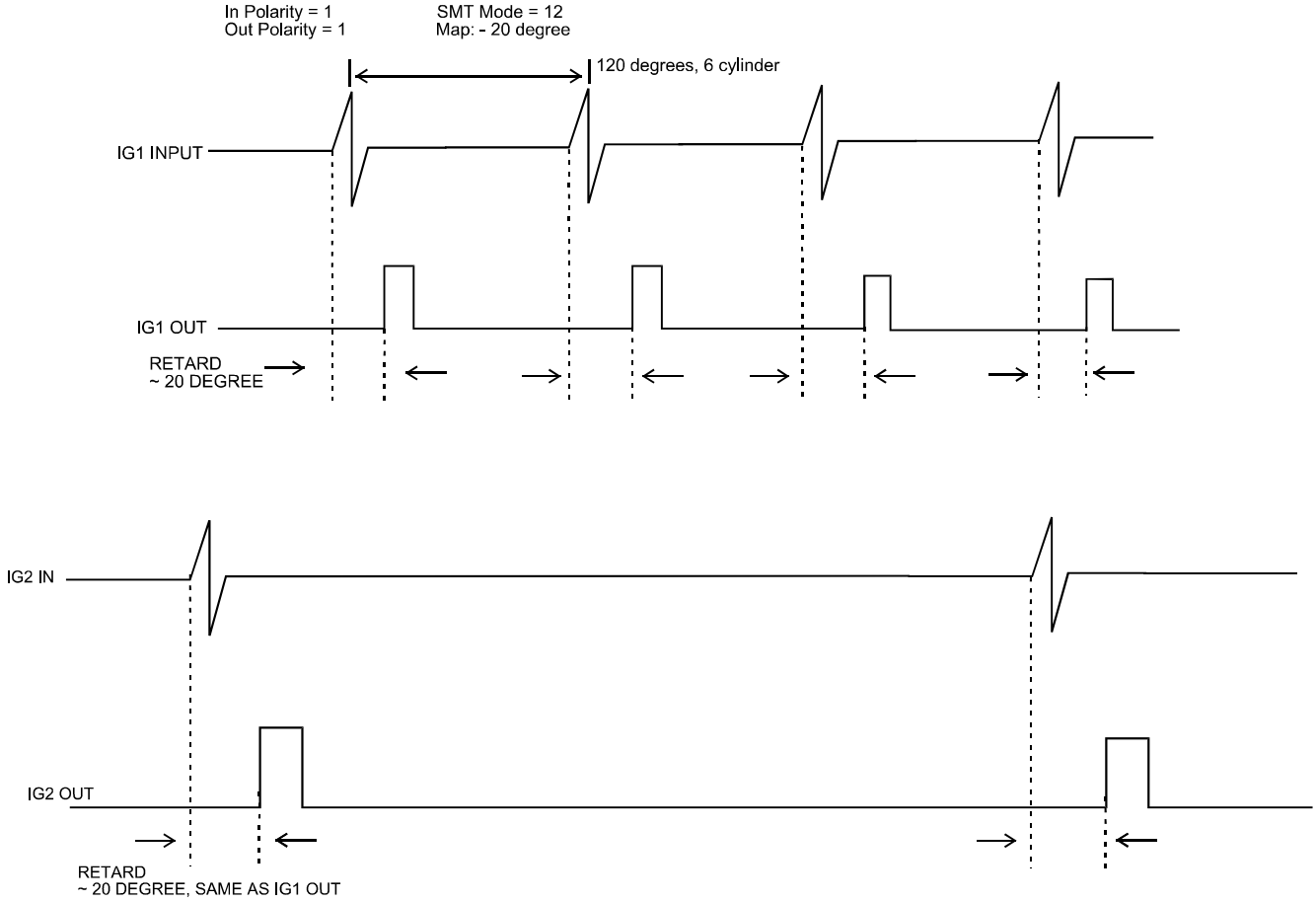


FIGURE 4. TIMING DIAGRAM

15. MISSING TOOTH APPLICATIONS

This operation is specified with MODE=1.

	INPUT:	IG1IN	yellow	pin 8
	OUTPUT:	IG1OUT	white	pin 20
Secondary	OUTPUT:	IG2OUT	white/blue	pin 17
Bipolar	OUTPUT:	IG1SP	pink	pin 19

The IG1IN signal serves as a map deflection input, and requires that the signal repeats every engine turn. This is normally the case with crankshaft triggers. Consult the factory if you have a missing tooth CAM trigger, which repeats every two turns.

The output has the same characteristics as the input signal, but it is a 12V square wave.

The input/output is affected by:

- Ign input polarity:
- Ign output polarity:
- Bipolar (Magn.) inp:
- One missing tooth:
- Teeth per turn:
- Teeth per firing:

At RPM position zero (bottom map row) the output signal is copied from the input to the output and timing is applied (regardless of your map entry!). This is particular convenient for starting the engine, and for "first time" testing.

Set the bottom RPM scale to 3000 RPM (RS 3000), and try to start the engine. Change polarity and trigger level until the engine runs smoothly. You may "tee" in the IG1IN signal first, and then monitor the output IG1OUT for matching the input.

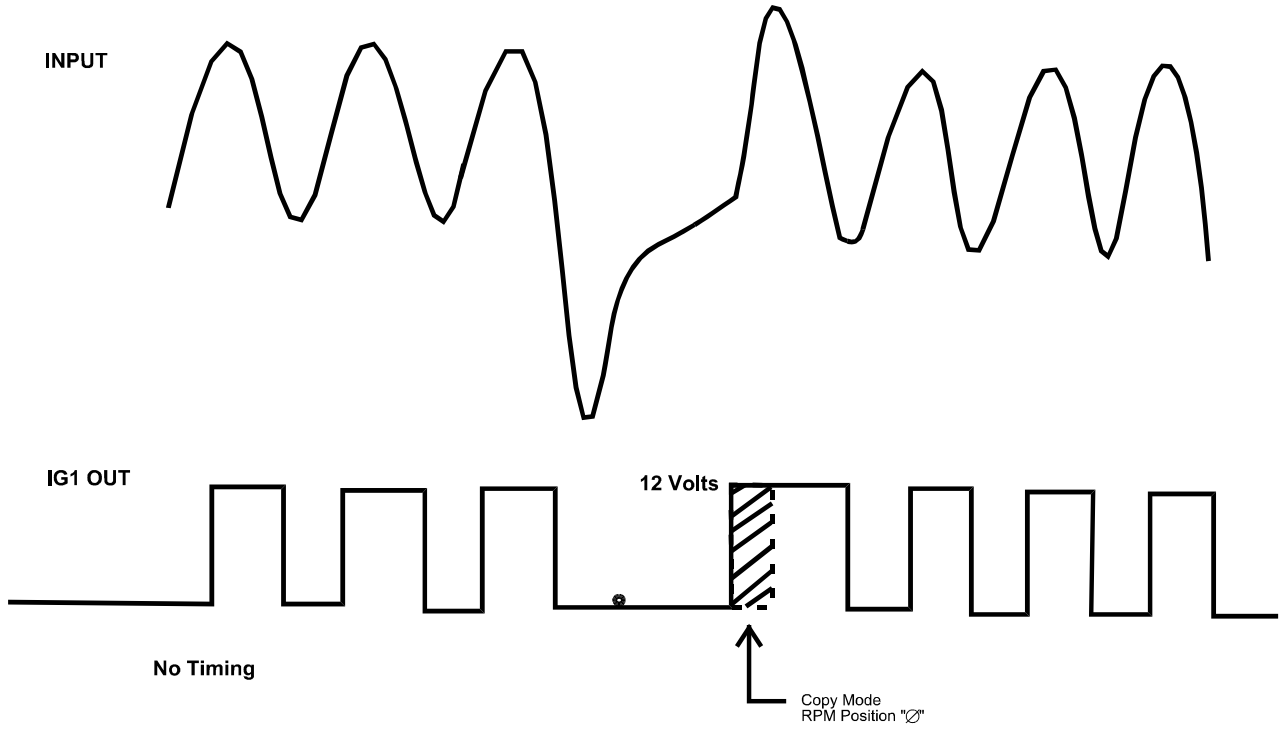
Depending on what signal your ECU requires, you may try the alternative output:

Bipolar OUTPUT:	IG1SP	pink	pin 19

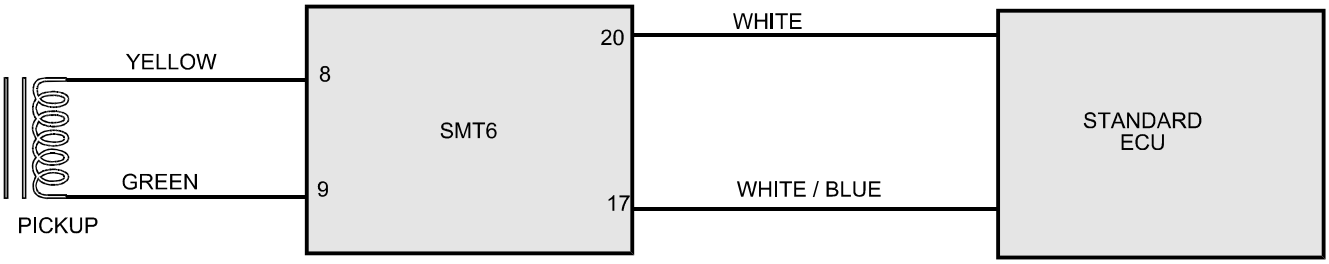
This IG1SP signal swings from -8 volts to +8 volts.

The second output is IG2OUT. It is an INVERSION of the IG1OUT signal. Some ECU's with "balanced" inputs require two "opposing" input signals to trigger.

The following picture shows a good input trigger signal, with the output shown without any timing applied. The output can be retarded and advanced by up to two teeth (minus one degree). The output contains one or two missing teeth as specified, regardless of the input signal.



Wiring for "Balanced" output:



Note: The Injector drive is not available when using a balanced input. The green wire (pin 9) is shared with injector drive, and the high injector current may interfere with the input signal.

16. ROAD SPEED GOVERNOR

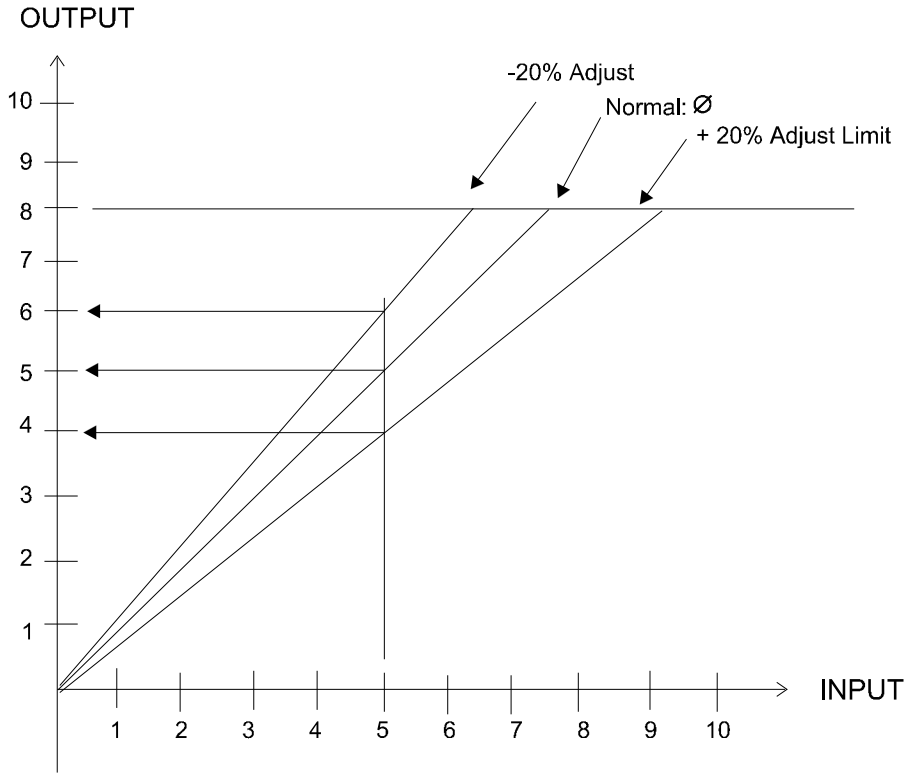
The road speed governor is selected with MODE=11. That is to say it works with the single ignition system.

Input:	IG2IN	WHITE/RED	Pin	5
Output:	IG2OUT	WHITE/BLUE	Pin	17

The following parameters are active for ROAD SPEED GOVERNOR ONLY:

HIGH FREQ OR SPEED:
UPPER SPEED LIMIT:

Note: The road speed governor requires no map deflection or RPM deflection inputs.



Physical frequency limit of the output signal:

High freq or speed:	0	1
Output frequency limit:	3kHz	17kHz

Note: The upper limit on the global screen (F4) is a "period" measurement, but the preceding graph depicts it as a "frequency" limit. By using the "SS" SET SPEED command while the vehicle is traveling just before the <u>Actual</u> speed limit, the period is properly calculated and set.

The above graph shows that the output "slope" can be proportionally adjusted, which would affect the gear-change points and the road speed governor. By limiting the output frequency, only the road speed governor is affected. However, both the frequency (speed) adjusts AND the speed limit can be used simultaneously to achieve any desired effect.

To deviate the upper speed limit: enter Ø. A very low speed limit is a large number.

17. INTERLACED INPUTS (AND OUTPUTS)

The INTERLACED operation is specified on the global (F4) screen. It assumes that the RPM per firing is measured over TWO input trigger points. This is normally the case with a 4 cylinder wasted spark ignition signal, which looks like:

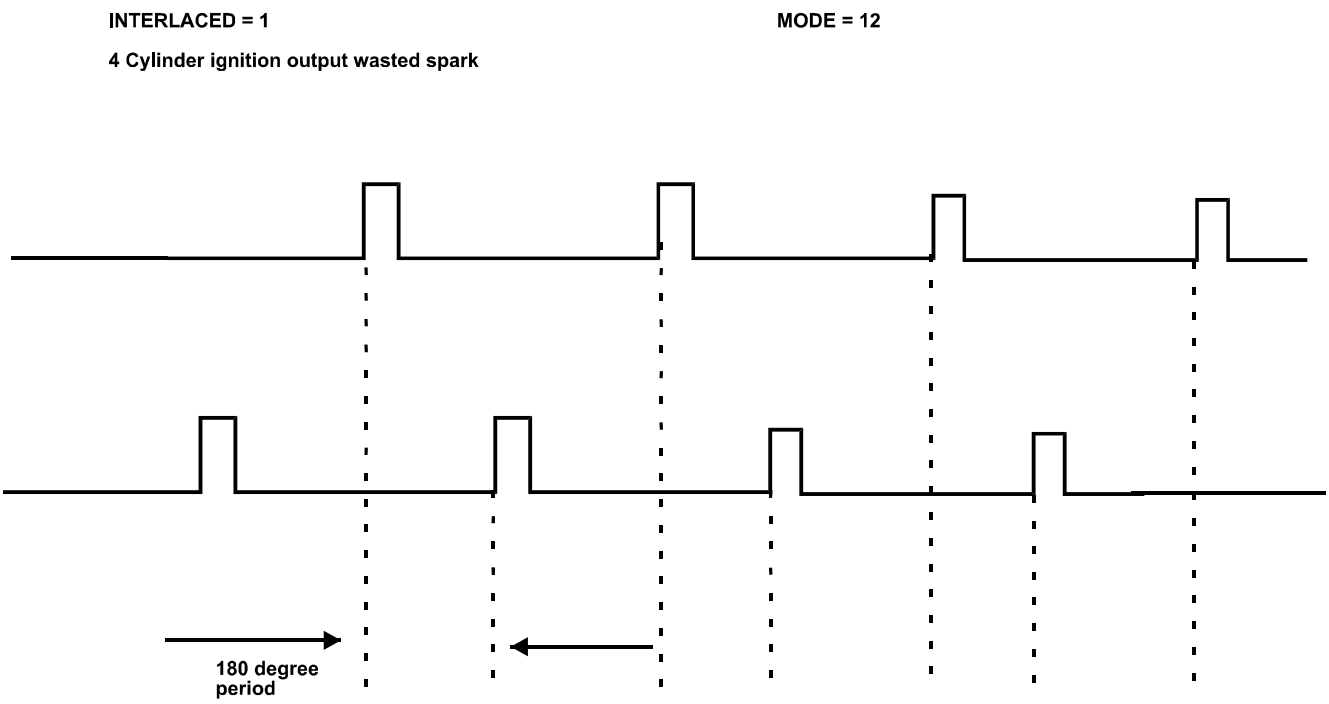


FIGURE 5. INTERLACED INPUTS AND OUTPUTS

Therefore, the interlaced operations mode is the same as specifying:

TEETH PER FIRING: 0.5

This is not possible, of course. However, the following results in the same RPM indication:

TEETH PER FIRING: 2 INTERLACED: 1
TEETH PER FIRING: 1 INTERLACED: 0

The interlaced mode applies to 4 cylinder wasted spark output modification! Other applications were not envisaged!

If the advance / retard of the two ignition signals is required, then mode = 12 must be specified.

18. MAX READINGS

The SMT6 can record:

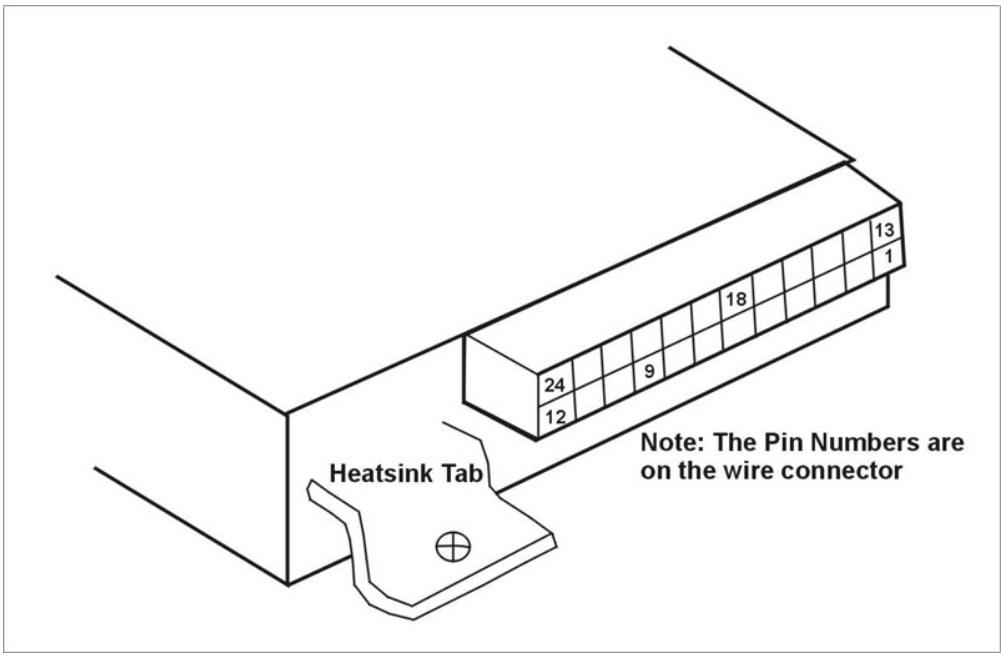
a) MAX RPM
b) MAX manifold pressure AMP
c) MAX engine temperature

The maximum RPM is recorded as an absolute measurement. That is to say it does not depend on the calibration.

The AMP and engine temperature recording depends on the calibration. This requires that you reset the max. readings after changing the calibration.

19. WIRING

The SMT6 units has a 24 way connector:



SMT6	DESCRIPTION	COLOUR
1	Ground, GND, Chassis	Black
2	RX-Input	
3	TX-Output	
4	Map switching	Grey
5	IG2IN	White / Red
6	AIN, Analog input	Blue
7	A-DEFL, Analog deflection input	Brown
8	IG1IN, Also RPM deflection	Yellow
9	Ground (for Extra Injector Driver)	Green
10	AMP input	Black / White
11	Engine Temp	Green / Yellow
12	NC	
13	+13V, Battery	Red
14	Pull-up 4K7	Blue / Black
15	Pull-up 4K7	Blue / Black
16	AUXOUT	Orange
17	IG2OUT	White / Blue
18	AOUT, Analog output	Violet
19	IG1SP, Bipolar output of IG1	Pink
20	IG1OUT	White
21	Extra Injector Output	Grey / Black
22	Oxygen input	Black / Brown
23	NC	
24	NC	

20. PULSE WIDTH MODULATION

The SMT Mode = 13 activates a single ignition retard/advance AND the PWM FUEL modification. In this mode of fuel tuning an independent input frequency is copied to the output, but the DUTY CYCLE of the input is modified with a value from the fuel map.

This mode is called for tuning values and solenoid opening times, such as proportional CAM control, and boost regulation control.

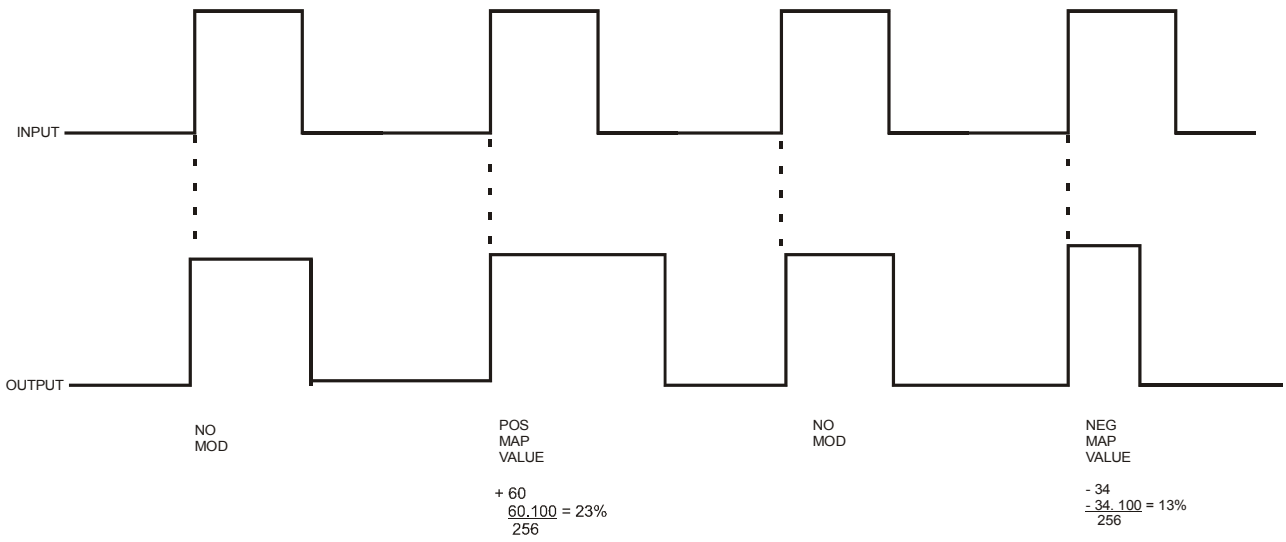
The following parameters are active:

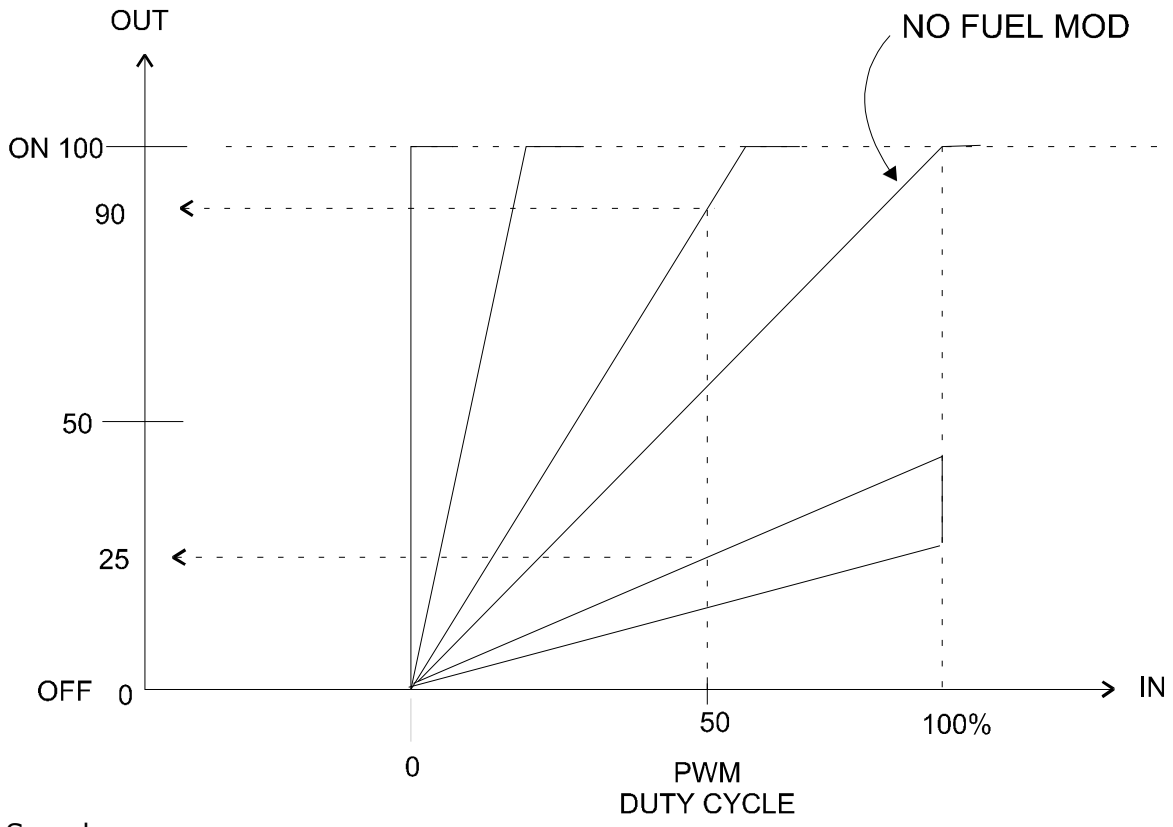
High freq or speed:
Fuel map values:

Note: The SMT Version 6 does not require rpm or analog deflection, except to select a fuel map value other than in the bottom row.

PWM input	:	White/Red	pin 5
PWM output	:	White /Blue	pin 17

Note: A positive number lengthens the duty cycle.





Samples:

Input duty cycle = 50%
A output: Positive modulation + 40% = 102 results in 90% out
B output: Negative modulation – 25% = 54 results in 25% out

21. SELF TESTING

The SMT6 can be tested by unskilled personal without any test equipment, but a special test connector. The test connector is available from your supplier.

TSMT6: SMT (6) SELF TEST Digital Data Systems (Pty) Ltd

AnaDefl :4.08V
Delay: 1535.700

An.Input: 0.12V
A.Output: 0.12V
Lambda: 0.00V
AMP: 0.06V
Engt.Inp: 0.02V

Start Test -> G
Initials: kfl

Port = 1

StoreSel: A

Command:

Test	#	Output	U-Lim	L-Lim	Input	Result
AI-DEFL/PUP	1	0.500	4.850	3.800	4.098	PASSED
AI-INPUT	2	1.500	1.600	1.400	1.451	PASSED
AI-INPUT	3	9.500	9.600	9.400	9.451	PASSED
AI-AMP	4	5.000	2.600	2.400	2.471	PASSED
AI-ENGT	5	3.000	1.100	0.800	0.922	PASSED
AI-ENGT	6	9.500	3.150	2.850	3.000	PASSED
IGISP-OXYIN	7	5.000	0.750	0.550	0.672	PASSED
LOW POS CB1	8	33.000	18.000	10.000	15.200	PASSED
LOW NEG CB1	9	44.000	150.000	100.000	113.400	PASSED
LOW POS CB2	10	55.000	18.000	10.000	13.800	PASSED
LOW NEG CB2	11	11.000	200.000	150.000	178.700	PASSED
HIGH NEG CB1	12	22.000	50.000	20.000	25.600	PASSED
HIGH NEG CB2	13	33.000	60.000	30.000	43.000	PASSED
INJECT ACT.	14	99.000	50.000			STORE B
AUXOUT TEST	15	30.000	40.000	20.000	25.900	PASSED

Error: ALL PASSED, DONE

Test: kfl dtdt
061920021355 061920021351

Install the test program (DOS:TSMT6) and
Run it TSMT6
Start a test by "G" (enter)
The unit must pass all tests

22. KEYWORD INDEX

Pickup — A device which produces an output (change) in relation to the crank position.

Optical pickup — Normally located in a distributor. It has three wires, +12 signal, GND. The signal output requires a "pull-up" resistor to + 12 Volts (4k7 to 10k) and then the signal wire "jumps" between GND and +10 volts when the crank turns.

Magnetic pickup — Has 2 wires + a shield. The shield (screen) must be connected to the ECU GND and not to the engine. One wire goes to the GND of the ECU, the other has positive/negative signal when the shaft is turned. These pickups are found on the crank or in the distributor.

Missing tooth Pickup — Located on the crank, it has multiple teeth (24-60) per turn and one or two teeth missing. The missing teeth (gap) signifies a defined crank position (TDC or other).

Interlinked signals — This means that a crank trigger signal has a defined relationship to a cam signal, and if this relationship is "modified" then the ECU assumes that the cam has slipped and the ignitions are stopped, or the ECU "misbehaves" otherwise.

Analog fuel tuning — An analog signal (e.g.: 0-10V) is modified via the fuel map.

Frequency fuel Tuning — A frequency signal (e.g.: 10Hz to 18kHz) is modified via the fuel map.

PWM fuel tuning — A PWM signal is modified via the fuel map.

PWM signal — A signal with an unimportant frequency, where the information is contained in the "duty cycle". The SMT copies the frequency, but modifies the duty cycle. Used for proportional CAM variations and boost control.

Injector activation — The SMT can drive up to 7 amps, which are 8 x 16ohm, or 4 x 8 ohm, or 2 x 4 ohm injectors. The injectors are activated proportional to Rpm and the map values.

Road speed governor — This is not the RPM limit of the ECU, but a signal derived from the transmission train, which changes proportional to the road speed. This signal is used for automatic gearbox shifting and to limit the max. wad speed via the ECU.

Interlaced — The ignition on a 4 cylinder wasted spark system is "interlaced".

Self Test — The SMT performs an internal self test when power is applied. However, a special self test feature can be performed via a PC and a test harness which checks every input / output for the correct performance.

Injection	A method to add more fuel to the engine through an ADDITIONAL injector(s) which must be mounted somewhere in the manifold, preferable BEFORE the butterfly. The injection output is optional and must be ordered.
Map	A file, which can be loaded in to the SMT6, describing the modification done to the fuel, injection, and ignition. The SMT6 can hold two MAP sets, each set has a fuel injection and ignition map.
Mode	A method to "configure" the SMART TUNER SMT6 to perform a specific task.
Developer	A dealer or user who wants to develop his own application for an engine without a WIRING DIAGRAM.
Wiring diagram	A standard form of SMT6 wiring, which shows all wires, location of ECU, ECU connector, and library used for setup.
Odd retard	An operating mode (20), which allows the retarding of "odd" signals.
Dwell time	Used with ignition output. It is the time the current flows in the coil.

22.1 ROAD SPEED GOVERNOR

Road speed deviation:
In mode=11, which activates the road speed circuit, the output frequency (road speed signal) can be deviated by the specified percentage.

Road speed limit:
This restricts the output frequency (road speed signal) to the specified "period". For details see: **Road speed governor.**

22.2 FUEL AND IGNITION AFFECTING VARIABLES

Analog zero:
This is the "offset" between the analog input (AIN) and the analog output (AOUT).It can be used to make the complete fuel map richer or leaner.

Ignition dwell time:
Adjusts the dwell time of ignition for ignition management applications.

Fuel upper limit:
This is a voltage specification, which restricts the output to rise above the specified value. This is good for tuning "LAMBDA", or it prevents the ECU from displaying a "service fault".

Fuel lower limit:
Same as above, but the lower limit. The output voltage is prevented from falling below this value.

22.3 GENERAL SYSTEM VARIABLES

Operating mode:
1 Missing tooth operation
10 Single ignition + frequency fuel
11 Single ignition + road speed governor
12 Two ignition
13 Single ignition + PWM fuel
20 Odd retard

The operating modes must be set to one of the above numbers. Any other entry results in a "BAD MODE" display.

Cylinders:
Any amount of cylinders can be specified. This entry affects the RPM indication, and the ignition calculation in degrees.

Teeth per revolution:
The amount of trigger signals per revolution (360 degrees), including any missing teeth!

Teeth per firing:
Amount of trigger signals between firings.

22.4 IGNITION

The ignition modification is specified in the IGNITION screen (F3). The maximum deviation is:
Mode=1: +- 2 teeth
Mode>1: +-180/cylinders.

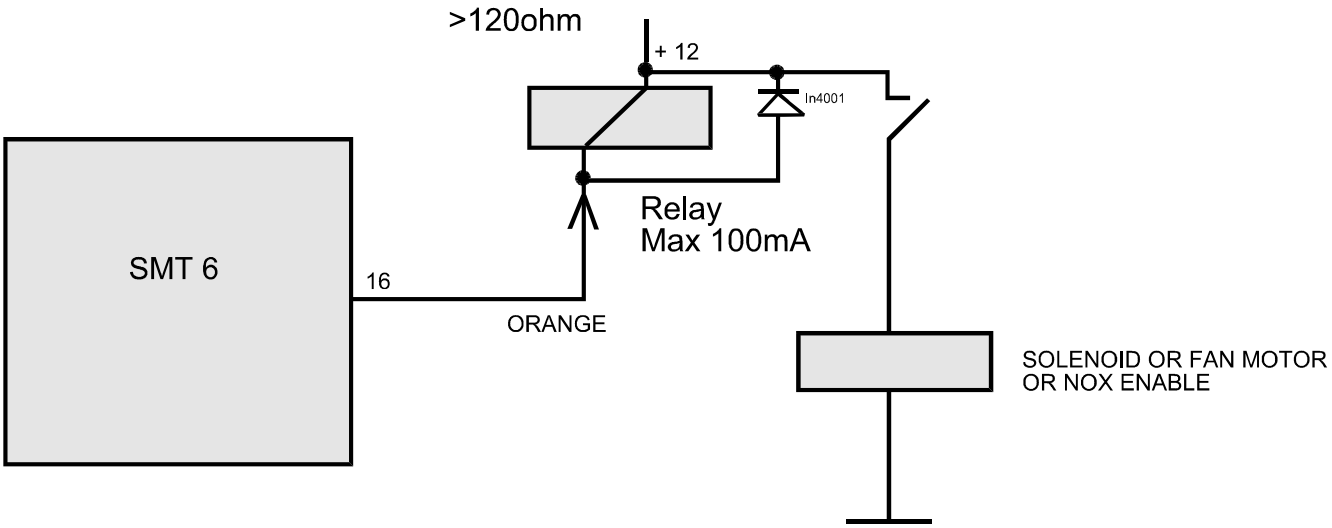
Ign. adv. limit: This entry restricts the ADVANCE map entry.

Ign. ret. limit: This entry restricts the RETARD map entry.

22.5 SETPOINT SWITCHING

SMT6 can switch the AUXOUT wire (orange) according to the limits (4) variable on the global screen. The output is rated at 100mA, and it goes low when the RPM is higher than the limit. The following limits are available:

RPM Limit:
Temperature Limit:
AMP Limit:
Deflection (throttle) limit:



The Switching is NON-Proportional.

FIGURE 6. SET POINT SWITCHING

22.6 SYSTEM BIT SETTINGS

Pos in pol : y enables positive triggering on the input.

Pos out pol : y enables positive triggering on the output.

In most applications input and output polarity should be the same.

Low level in : Used to switch input trigger from 2,5V to 0,1V for smaller trigger signals.

High freq : Change bandwidth of frequency load detection from 10-3,3kHz to 80-18kHz.

Low deviation : Changes map deviations by a factor of 4.

Inter laced : Modifies RPM reading for interlaced signals.

One missing tooth: Specifies that missing tooth signal is single tooth rather than two.

Multi coil : For multiple coil outputs in ignition management applications.

Lambda input : Redirects analog fuel input to the lambda sensor.

Lambda unl : Fuel modifications on maps change the output according to a non-linear curve.