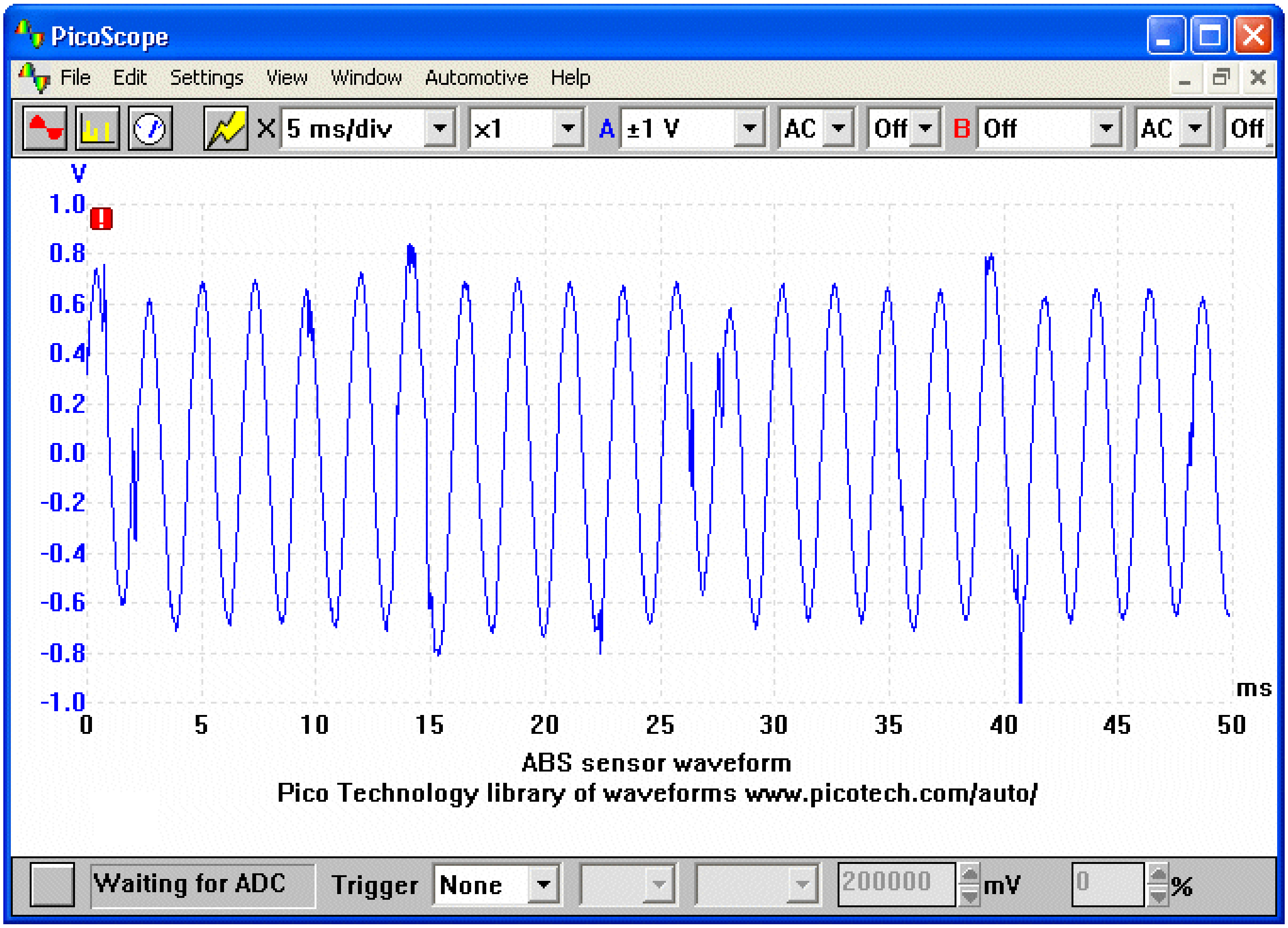
PICO SCOPE
REFERENCE WAVEFORM LIBRARY

Menu

Waveform Library contents courtesy of
Pico Technology

ANTI-LOCK BRAKING SYSTEM (ABS)

Menu



Anti-Lock Braking System Reference Waveform Notes

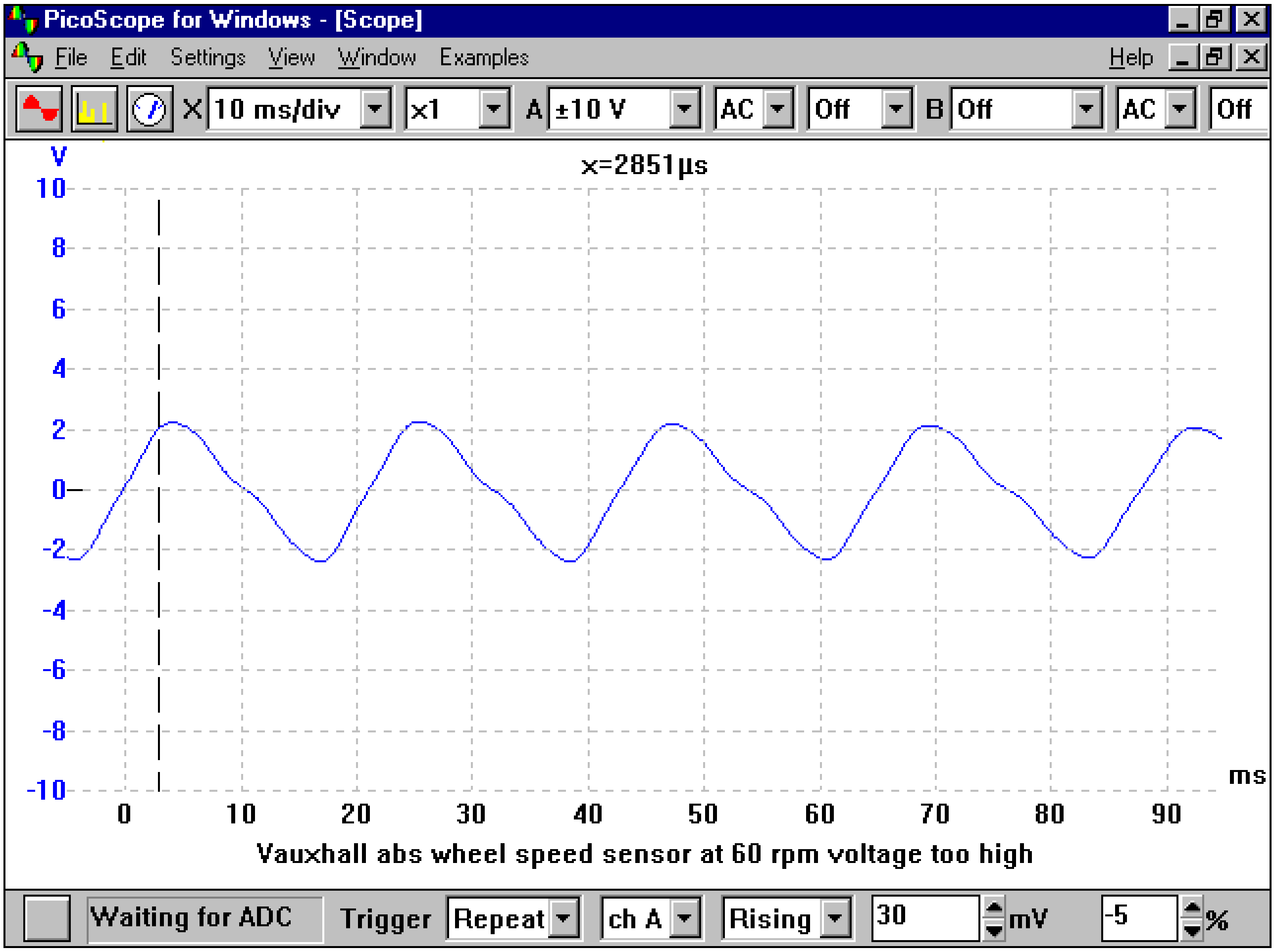
The Anti-lock Braking System (ABS) relies upon information coming in from the sensors fitted to the hub assemblies.

If under heavy braking the ABS Electronic Control Module (ECM) loses a signal from one of the road wheels, it assumes that the wheel has locked and releases that brake momentarily until it sees the signal return. It is therefore imperative that the sensors are capable of providing a signal to the ABS ECM.

The operation of an ABS sensor is not unlike that of a crank angle sensor, using a small pick-up that is affected by the movement of a phonic wheel, moving in close proximity. The relationship between the phonic wheel and the sensor result in the production of a continuous Alternating Current (AC) 'sine wave' that can be monitored on an oscilloscope. The sensor, recognisable by its two electrical connections (some may have a coaxial braided outer shield) will produce an output that can be monitored and measured on the oscilloscope.

PICO SCOPE

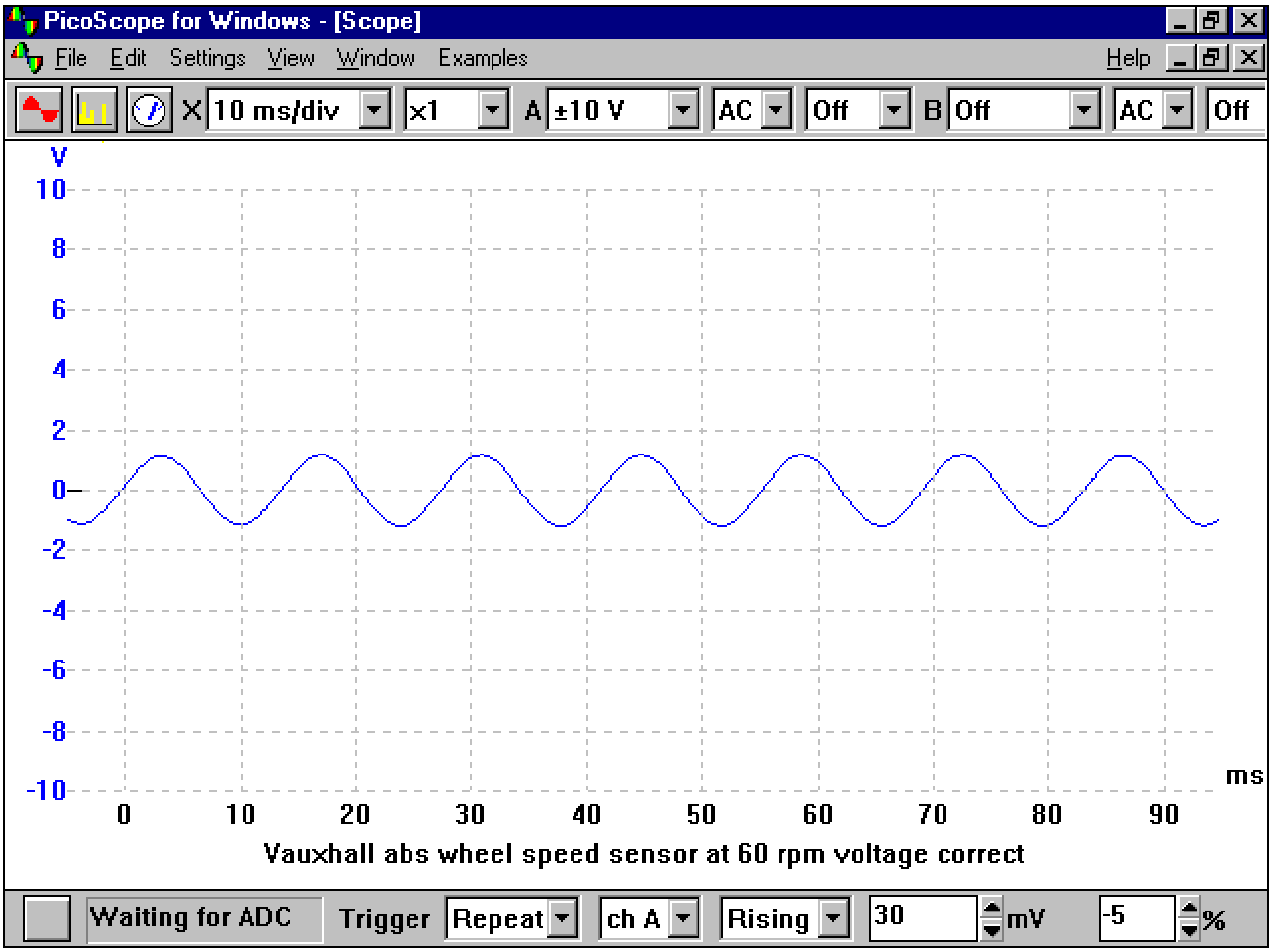
ABS SENSOR **Menu**



ABS Sensor (Vauxhall – Voltage too HIGH) Reference Waveform

PICO SCOPE

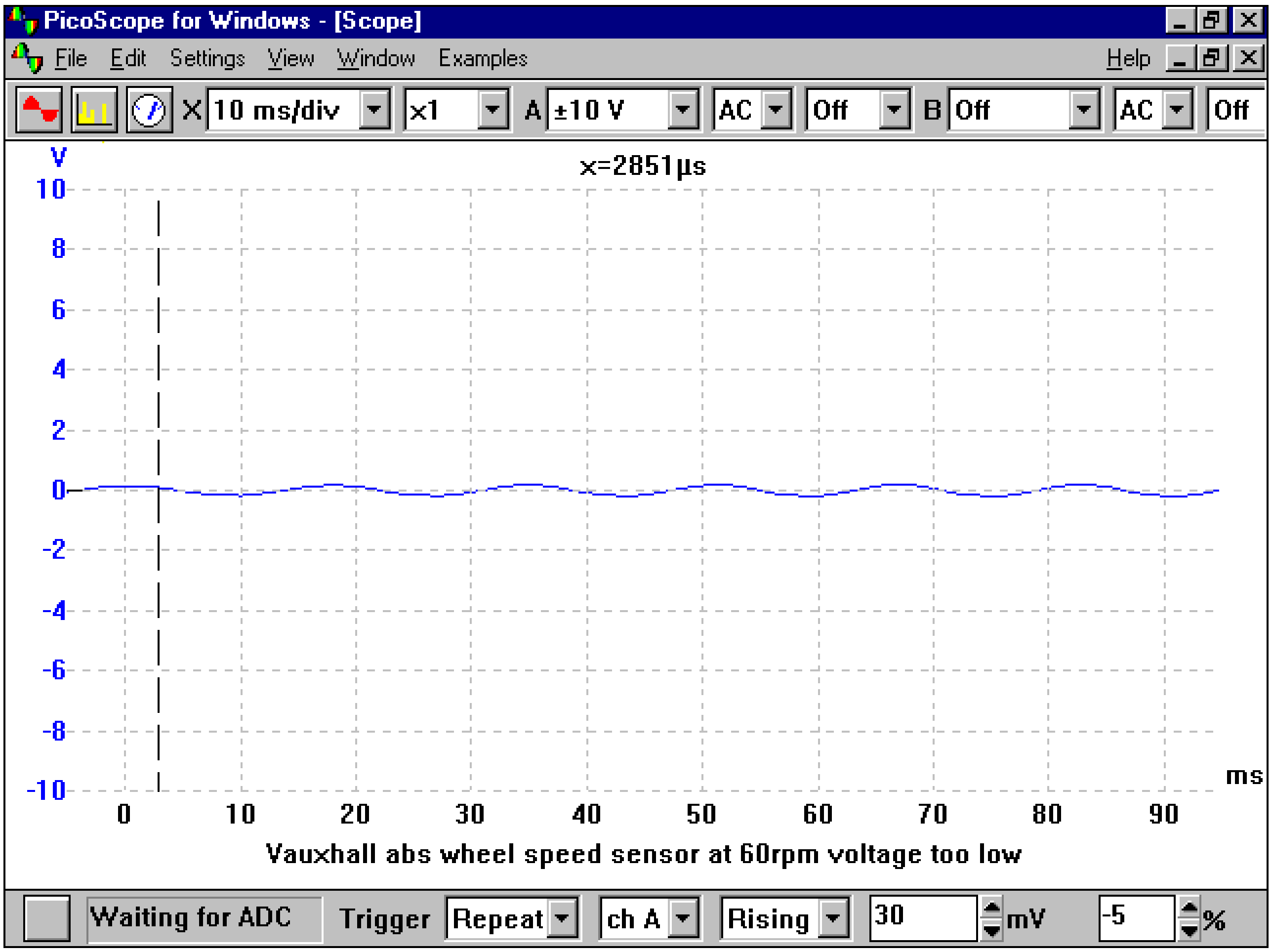
ABS SENSOR **Menu**



ABS Sensor (Vauxhall – Voltage NORMAL) Reference Waveform

PICO SCOPE

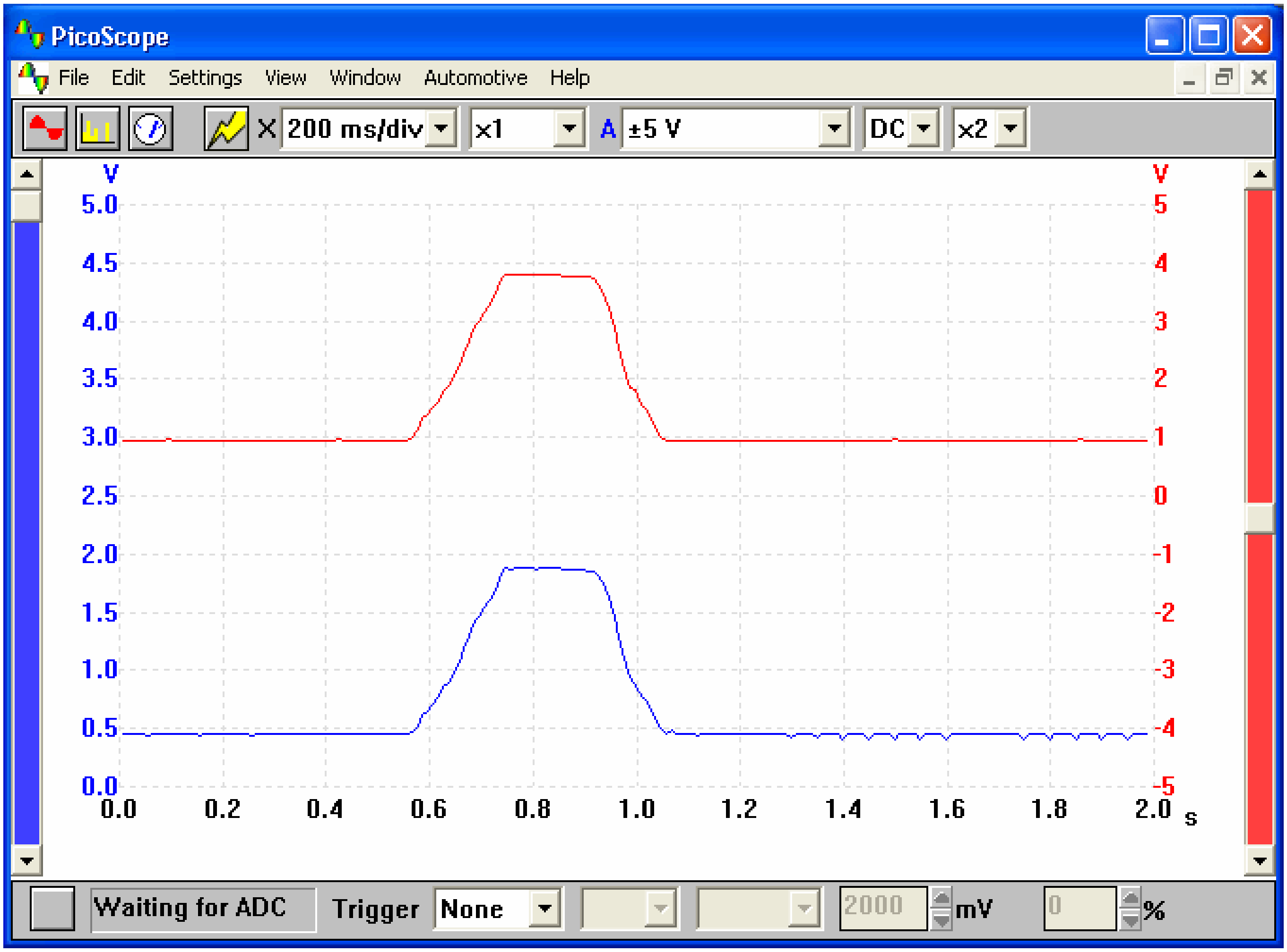
ABS SENSOR **Menu**



ABS Sensor (Vauxhall – Voltage too LOW) Reference Waveform

ACCELERATOR PEDAL POSITION

Menu

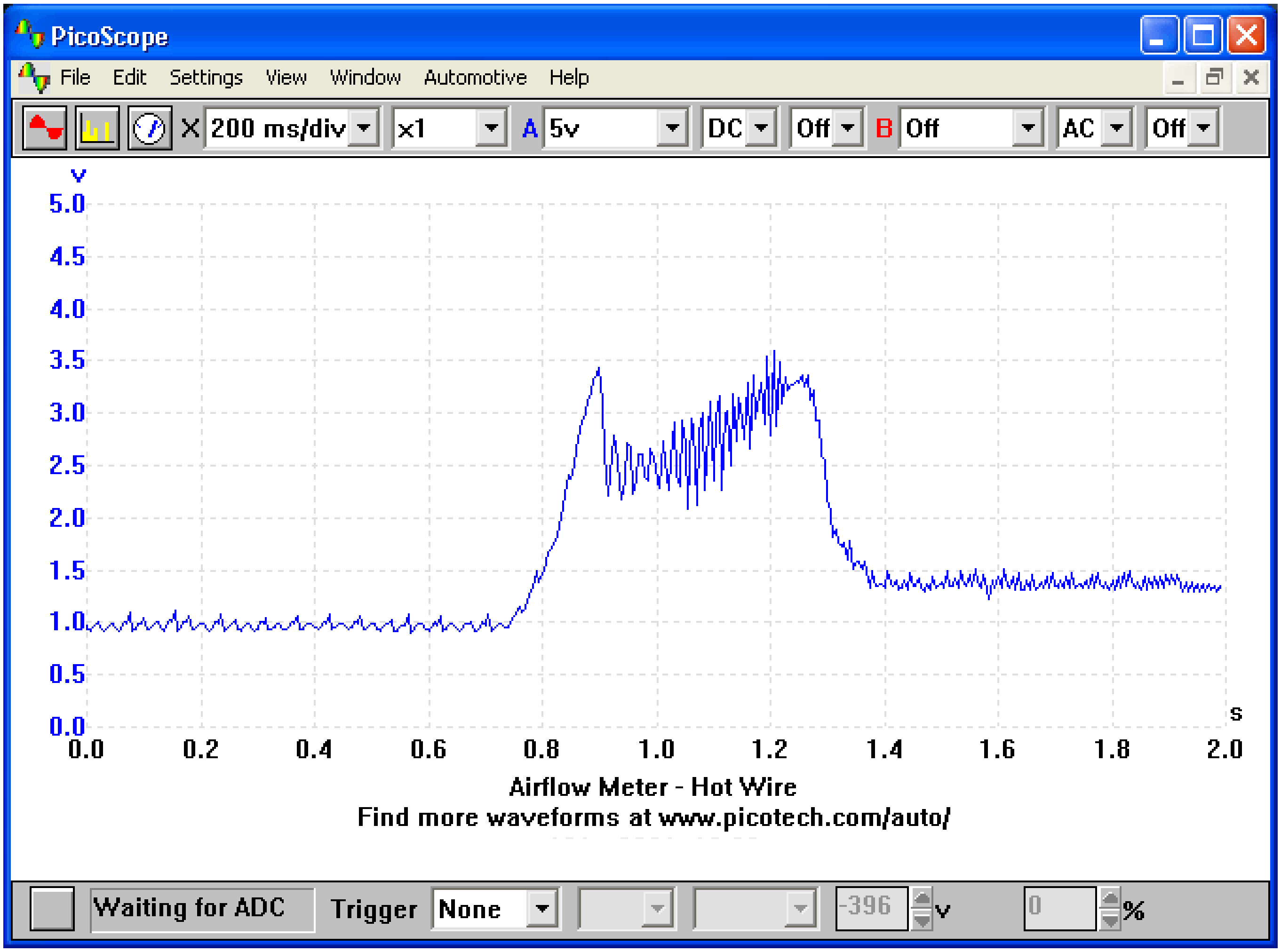


Reference Waveform Notes – Accelerator Pedal Position Sensor

In this example the Accelerator Pedal Position sensor (APP) is of the potentiometer type. It receives two reference voltages from the Powertrain Control Module (PCM), having two ground wires and two signal wires that send a varying voltage back to the PCM relating to accelerator pedal position. The signal voltage sent back to the PCM may vary from manufacturer to manufacturer but will probably never be greater than 5 volts.

AIR FLOW METER / AIR MASS METER

Menu



Reference Waveform Notes – Air Flow/Mass Meter (Hot Wire)

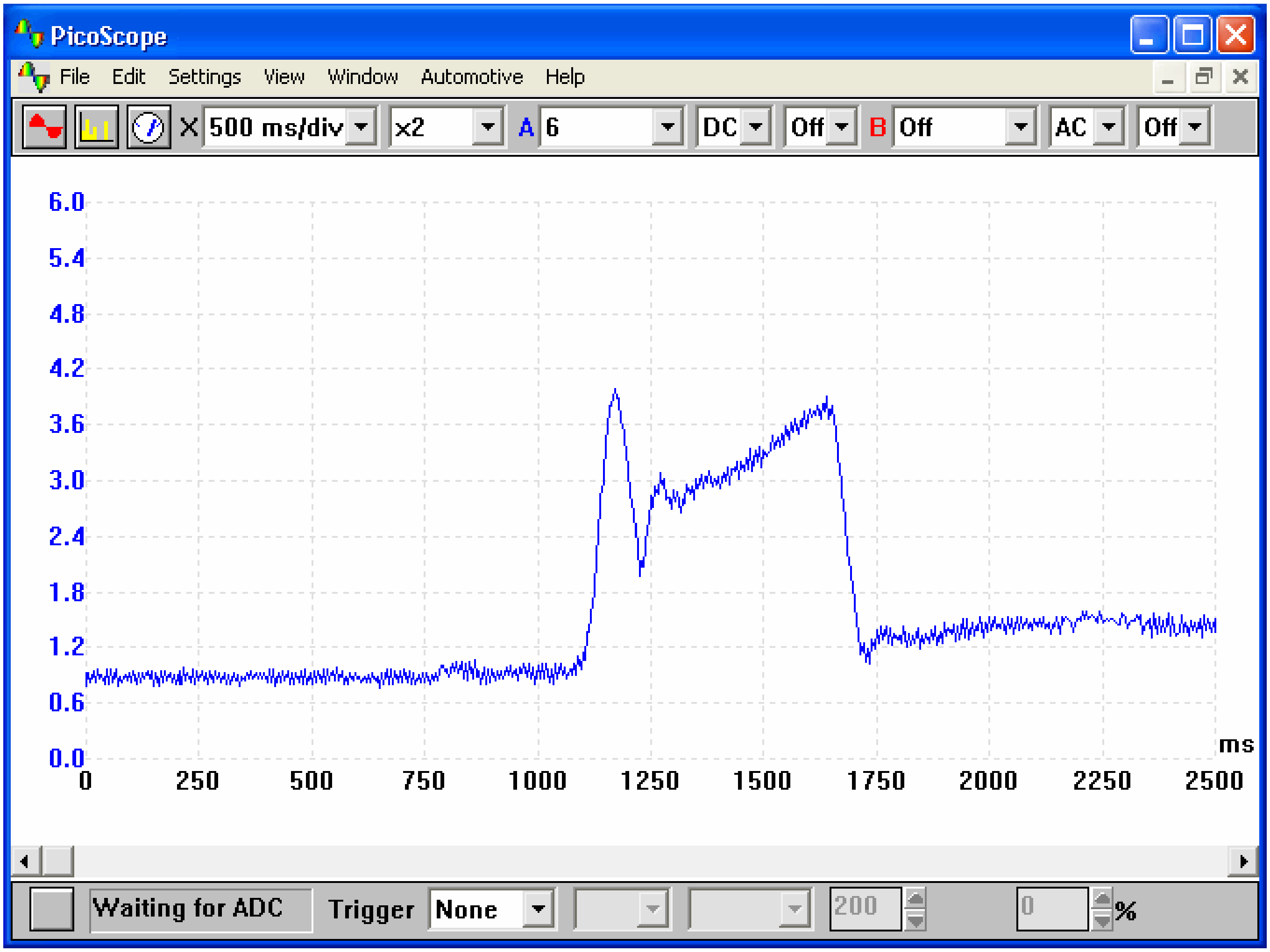
The voltage output from the Air Flow Meter (AFM) should be linear to airflow and this can be measured on an oscilloscope and should look similar to the example shown.

The waveform should show approximately 1.0 Volt when the engine is at idle, this voltage will rise as the engine is accelerated and air volume is increased producing an initial peak. This peak is due to the initial influx of air and drops momentarily before the voltage is seen to rise again to another peak of approximately 4.0 to 4.5 Volts. This voltage will however depend on how hard the engine is accelerated; a lower voltage is not necessarily a fault within the AFM.

On deceleration the voltage will drop sharply as the throttle butterfly closes, reducing the airflow, and the engine returns back to idle. The final voltage will drop gradually on an engine fitted with idle speed control valve as this will slowly return the engine back to base idle as an anti-stall characteristic. This function normally only affects the engine speed from around 1200 rpm back to the idle setting.

A time base of approximately 2 seconds plus is used, this enables the operator to view the AFM's output voltage on one screen, from idle, through acceleration and back to idle again. The 'hash' on the waveform is due to the vacuum change from the induction pulses as the engine is running.

AIR FLOW METER (Air Vane) Menu



Reference Waveform Notes – Air Flow Meter (Air Vane)

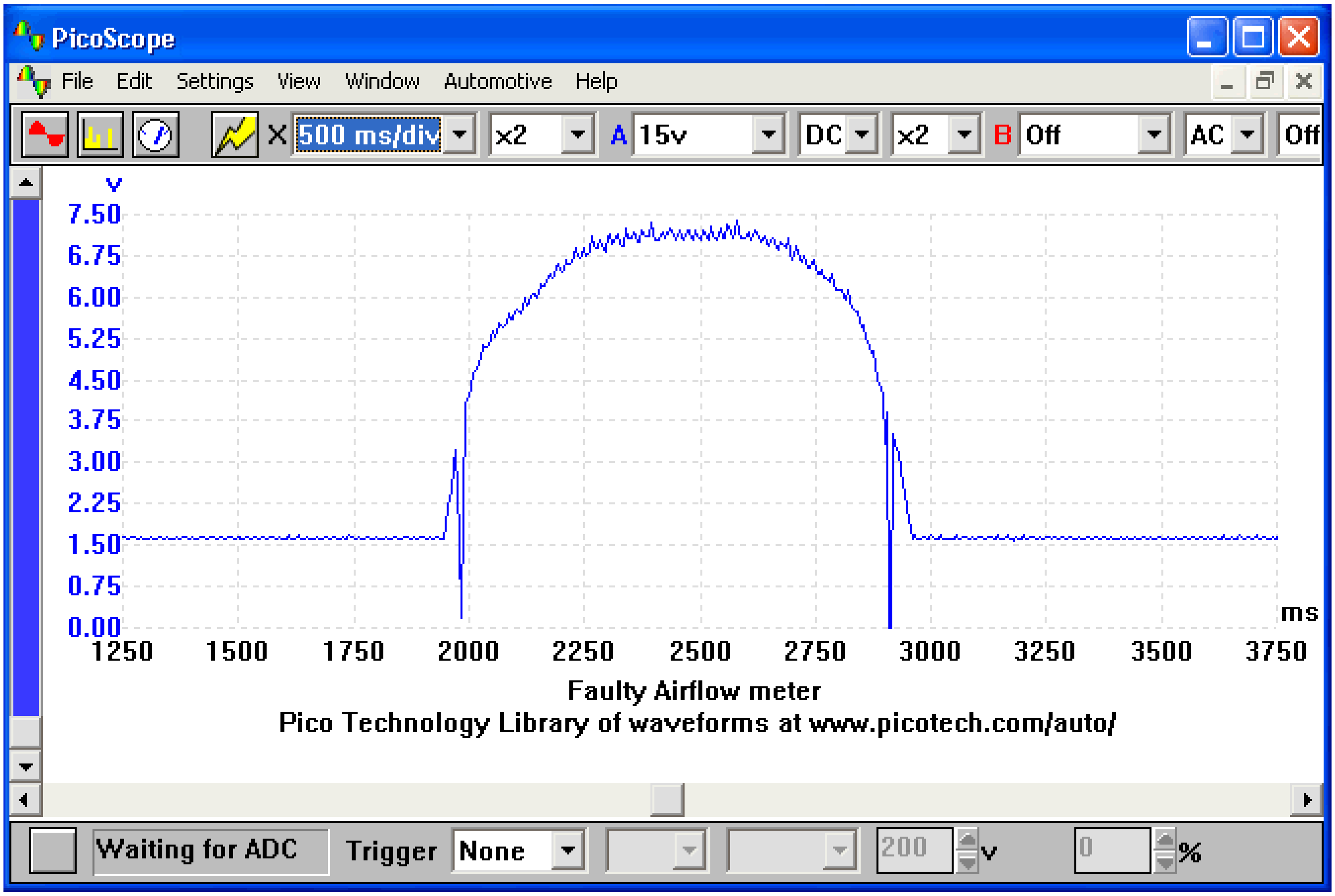
The voltage output from the internal track of the Air Flow Meter (AFM) should be linear to flap movement; this can be measured on an oscilloscope and should look similar to the example shown.

The waveform should show approximately 1.0 volt when the engine is at idle, this voltage will rise as the engine is accelerated and will produce an initial peak. This peak is due to the natural inertia of the air vane and drops momentarily before the voltage is seen to rise again to a peak of approximately 4.0 to 4.5 volts. This voltage will however depend on ho hard the engine is accelerated so a lower voltage is not necessarily a fault within the AFM. On deceleration the voltage will drop sharply as the wiper arm, in contact with the carbon track, returns back to the idle position. This voltage may in some cases 'dip' below the initial voltage before returning to idle voltage. A gradual drop will be seen on an engine fitted with an idle speed control valve as this will slowly return the engine back to base idle as an anti-stall characteristic.

A time base of approximately 2 seconds plus is used, this enables the operator to view the AFM's movement on one screen, from idle, through acceleration and back to idle again. The waveform should be clean with no 'drop-out' in the voltage, as this indicates a lack of electrical continuity. A good example of this is shown on the 'Faulty 12 volt AFM' example waveform. This is common on an AFM with a dirty or faulty carbon track. The problem will show as a 'flat spot' or hesitation when the vehicle is driven, this is a typical problem on vehicles with high mileage that have spent the majority of their working life with the throttle in one predominant position. The 'hash' on the waveform is due to the vacuum change from the induction pulses as the engine is running.

AIR FLOW METER – (12 Volt Type)

Menu



Reference Waveform Notes – Air Flow Meter (Faulty Air Vane)

This particular Air Flow Meter (AFM) was used on early electronic injection systems and has the same operational qualities as the later 5 volt systems. The voltage should be seen to rise as the air vane is moved with no breaks or loss of continuity. The example shown clearly demonstrates that just as the vane moves a loss of contact is seen with the same fault occurring again as the throttle is released and the engine returns to idle.

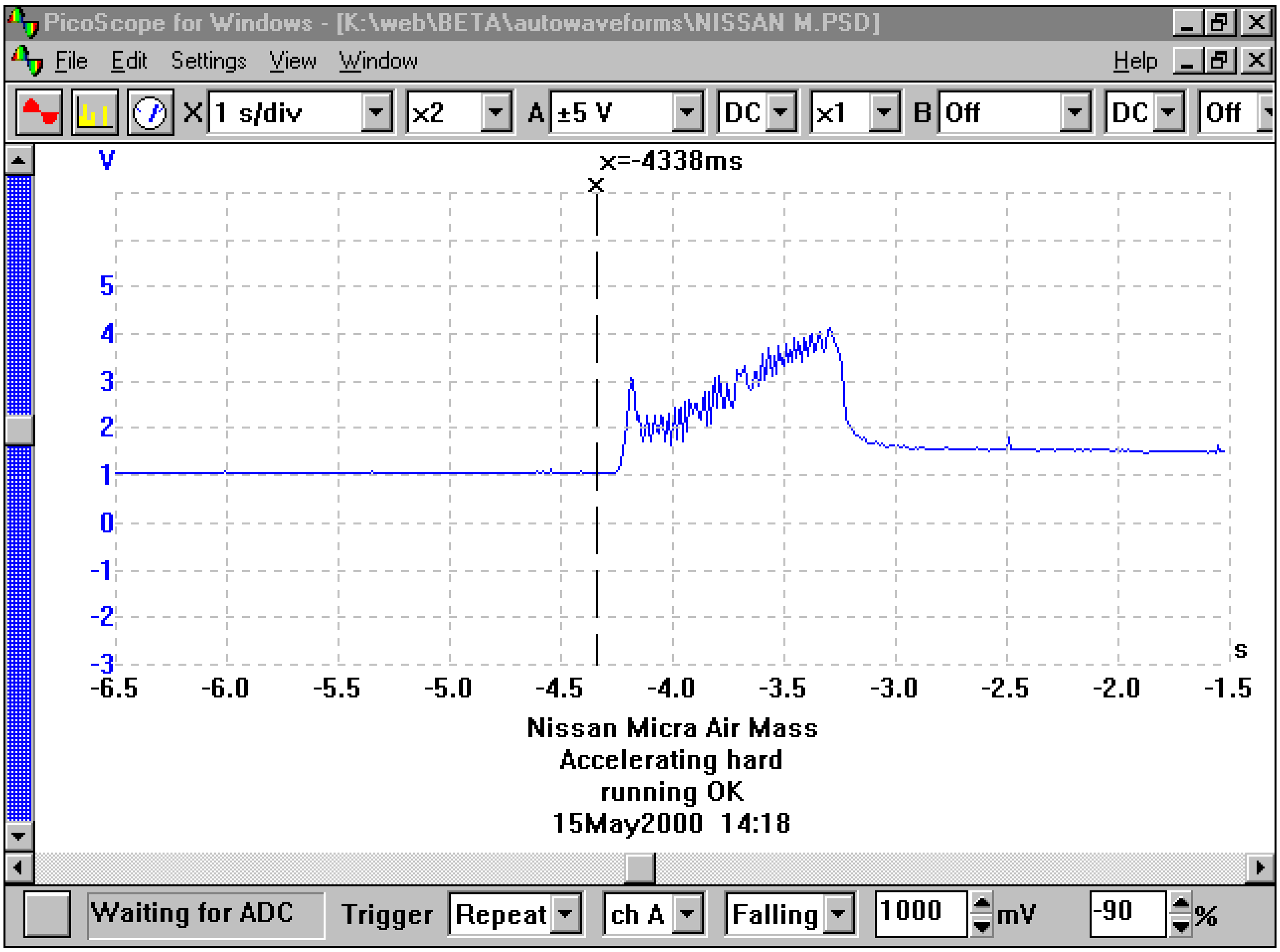
A time base of approximately 2 seconds plus is used, this enables the operator to view the AFM's movement on one screen, from idle, through acceleration and back to idle again.

An AFM with this particular output would produce 'flat-spots' or 'hesitations' when driven. As the carbon tile has sustained damage the only way to rectify this problem is to change the unit for a new one. Removal of the plastic cover will invariably show the white plastic of the tile clearly visible through the carbon track; however this may only become apparent when the track is cleaned with a solvent spray such as carburettor cleaner.

PICO SCOPE

AIRFLOW / MASS METER

Menu

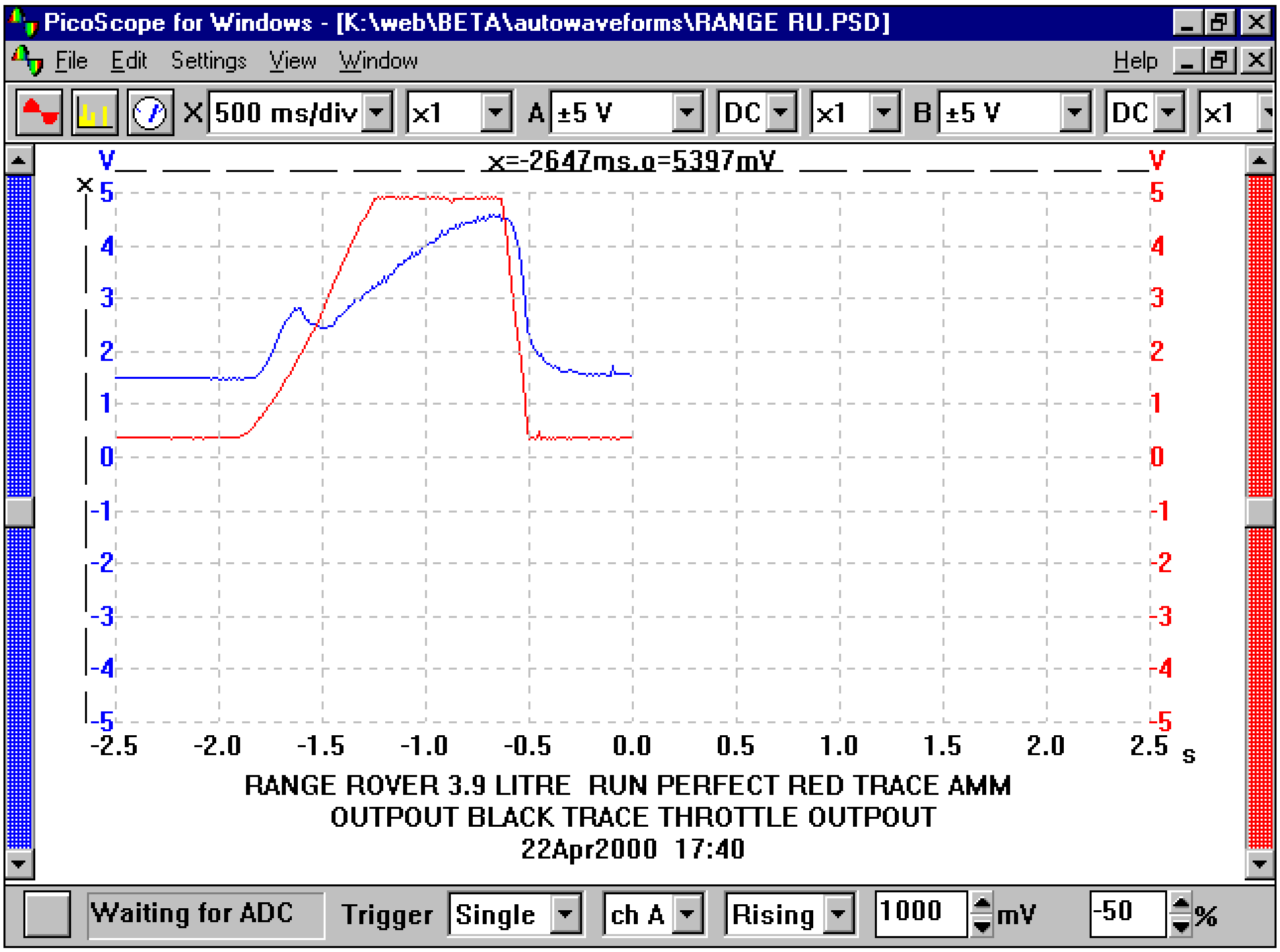


Airflow/Mass Meter (Nissan Micra – Hard Acceleration) Reference Waveform

PICO SCOPE

AIRFLOW / MASS METER

Menu

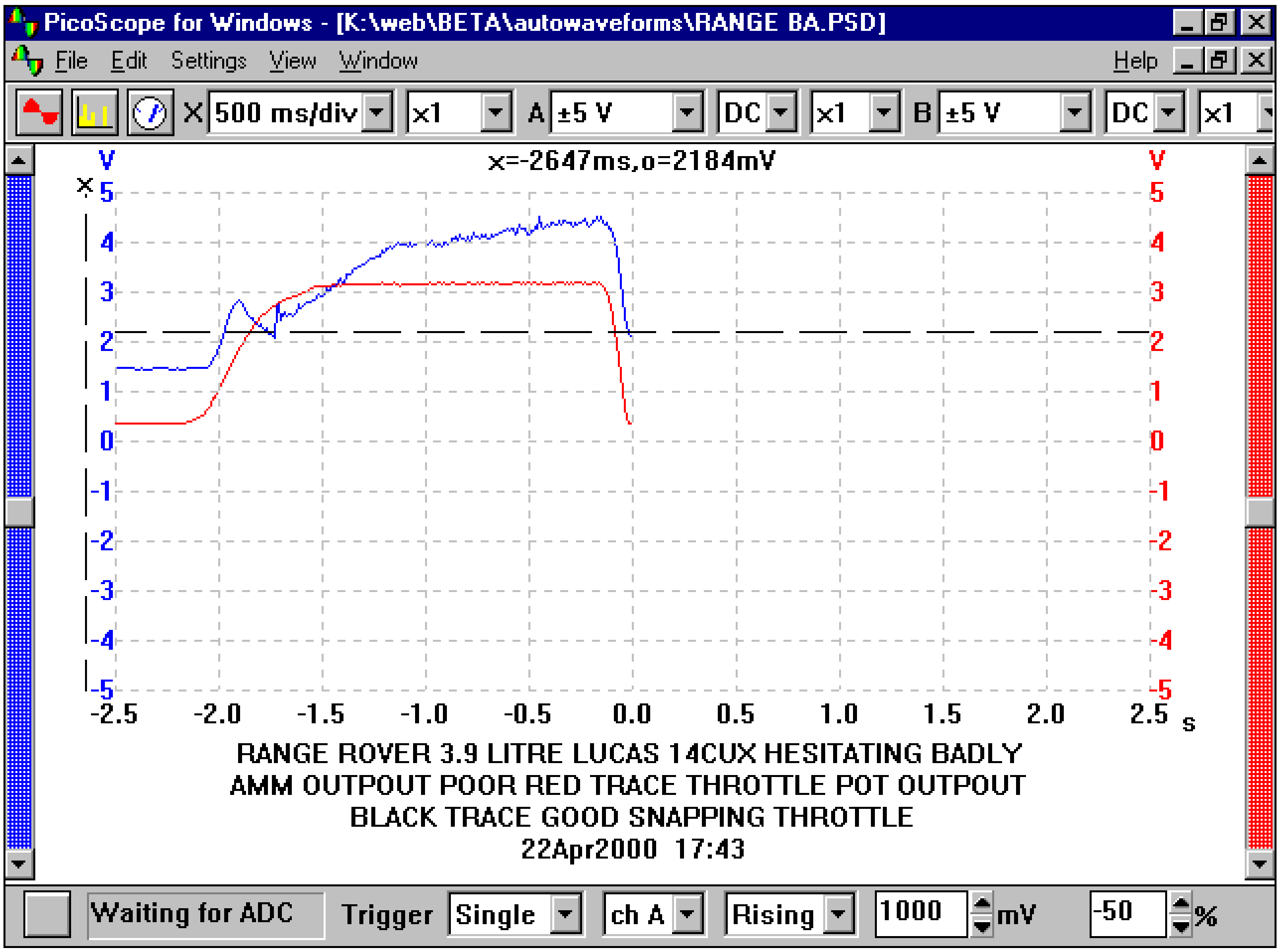


Airflow/Mass Meter (Range Rover 3.9L) Reference Waveform

PICO SCOPE

AIRFLOW / MASS METER

Menu

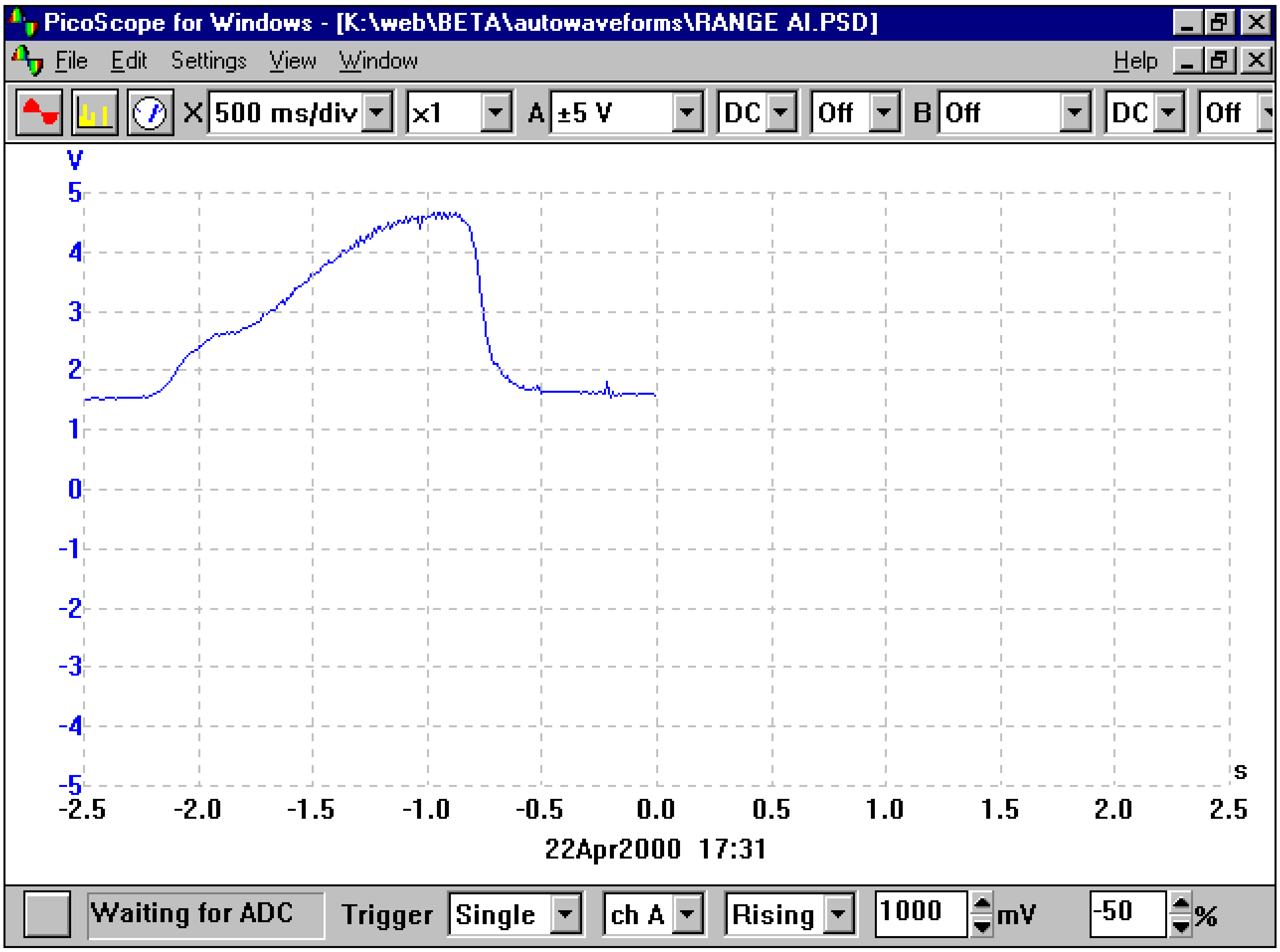


Airflow/Mass Meter + TPS (Range Rover 3.9L – Hesitating Badly) Reference Waveform

PICO SCOPE

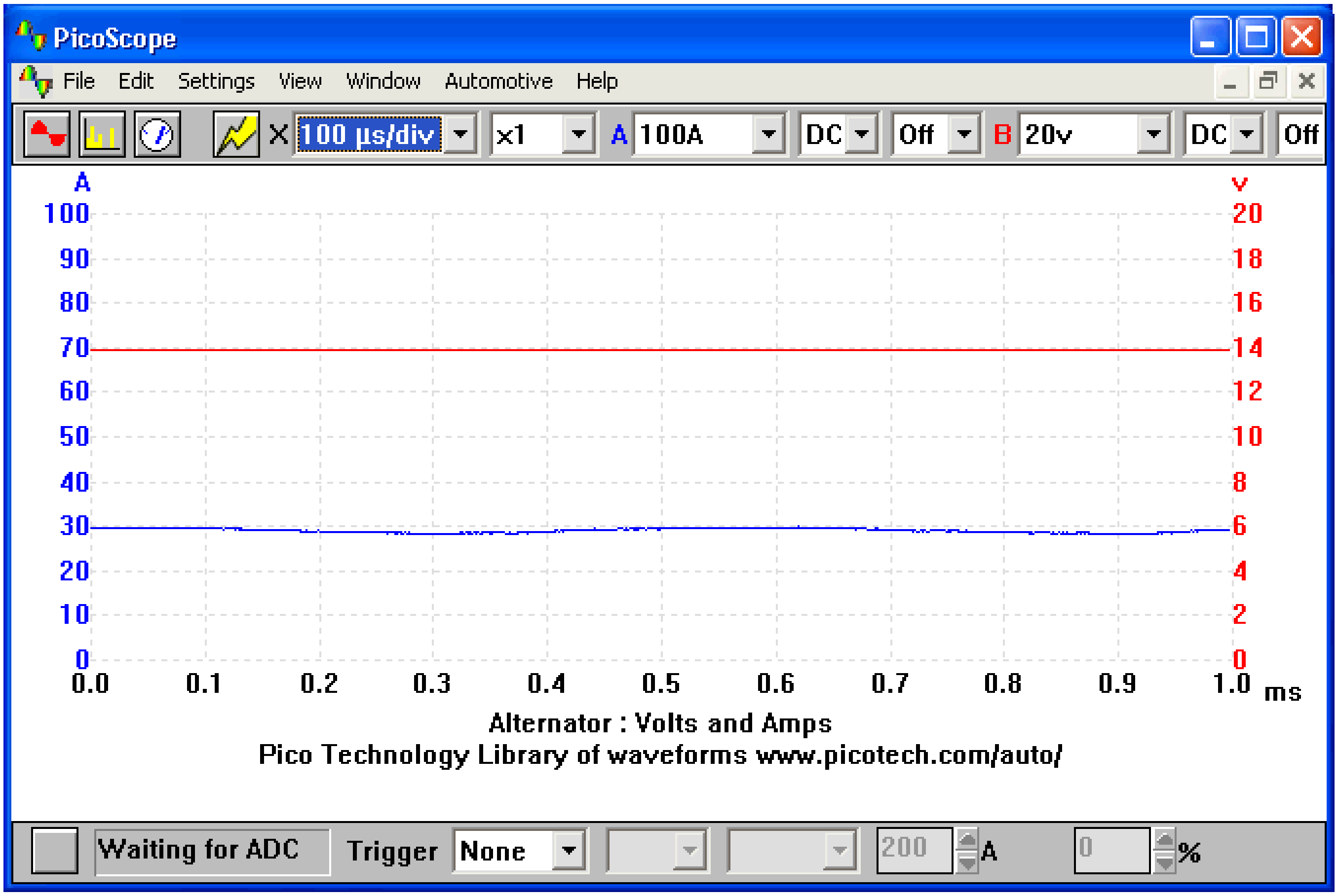
AIRFLOW / MASS METER

[Menu]



Airflow/Mass Meter (Range Rover 3.9L – Bad AFM Waveform Trace) Reference Waveform

ATERNATOR VOLTS / AMPS **Menu**



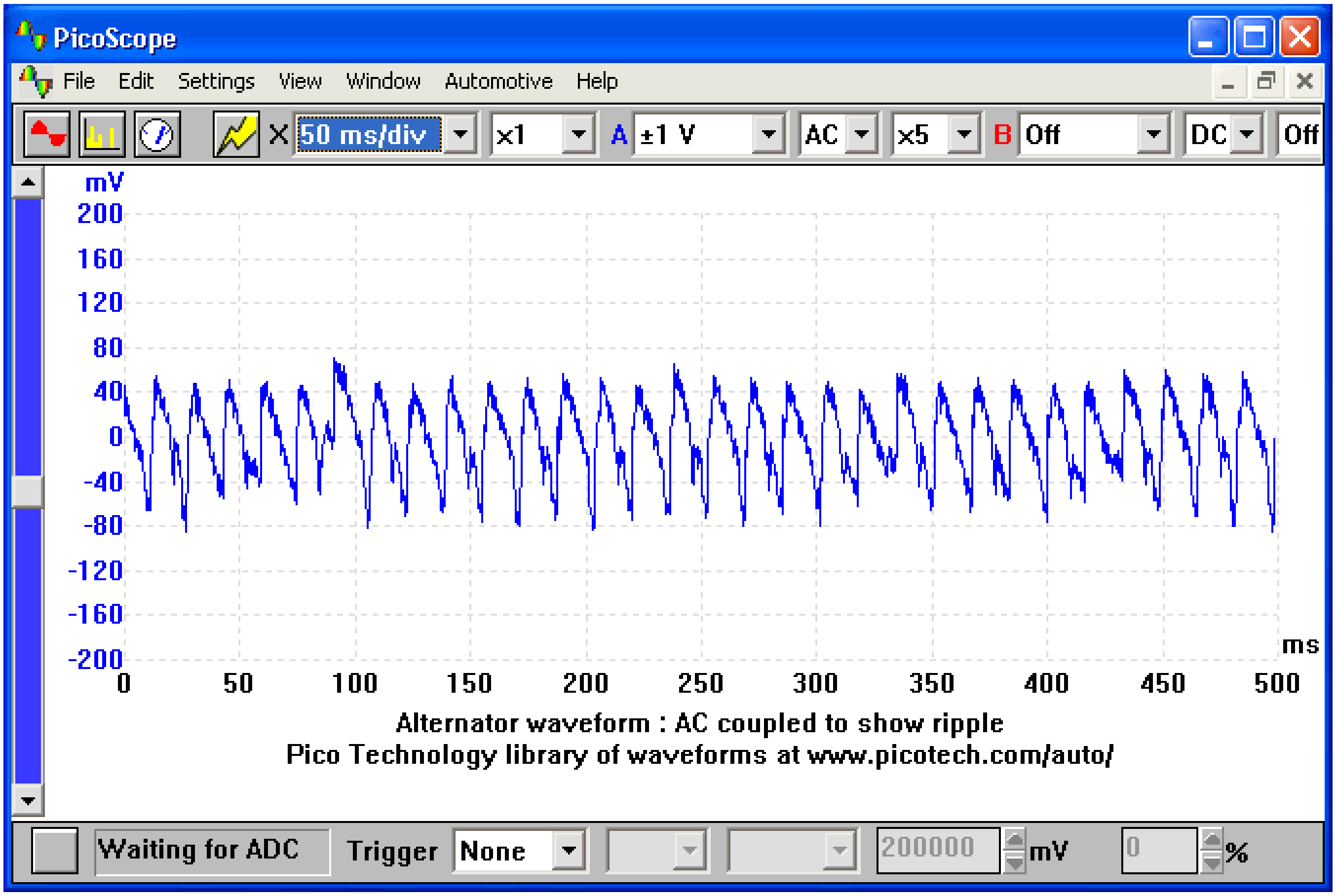
Reference Waveforms Notes – Alternator Volts/Amps (DC Coupled to show levels)

It is important that the alternator is capable of delivering the correct voltage and current output. The recommended regulated voltage will vary slightly between motor manufacturers but will invariably be between 13.5 - 15.0 volts. It is equally important that the system is neither under nor over charging.

The current available from the alternator will also vary depending on the type of alternator fitted. The current seen will depend on the state of charge of the battery and what loads are switched on. If the alternator has a specific problem that is reducing the current, such as a faulty diode, this would not be seen using the 20 amp minimum or by a drop in the regulated voltage, however it would be found when the alternator waveform was monitored.

ATERNATOR VOLTS / AMPS

Menu



Reference Waveforms Notes – Alternator (AC Coupled to show Ripple)

The example waveform illustrates the rectified output from the alternator.

The contents of this waveform show:-

- The output is correct and that there is no fault within the phase windings or the diodes (rectifier pack).
- The three phases from the alternator have been rectified to Direct Current (DC) from its original Alternating Current (AC) and that the three phases that contribute towards the alternators output are all functioning.

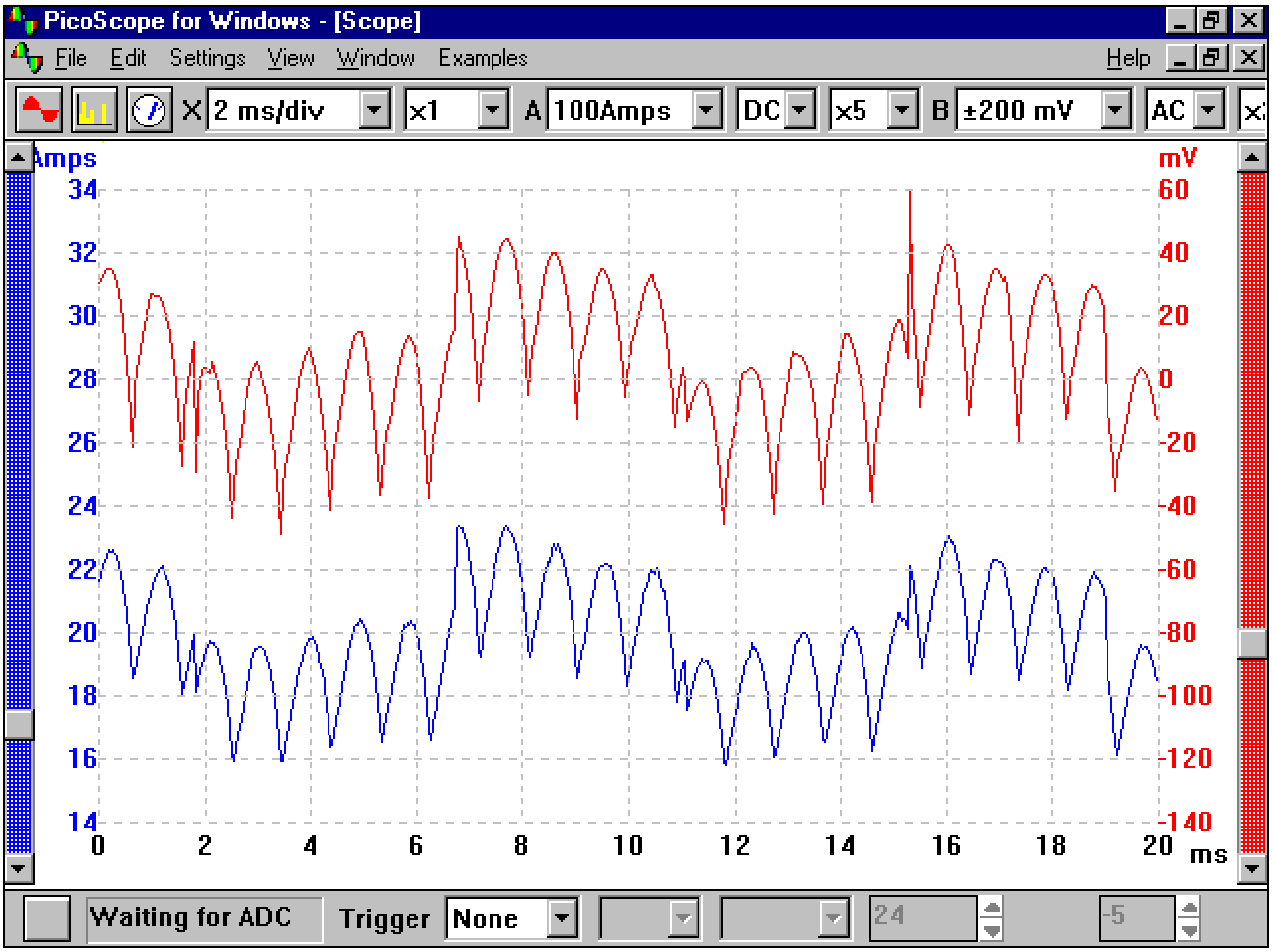
If the alternator was suffering from a diode fault, long downward 'tails' will appear from the trace at regular intervals and 33% of the total current output will be lost. A fault within one of the three phases will show a similar picture to the one illustrated but is three or four times the height, with the base to peak voltage in excess of 1 volt.

The voltage scale at the side of the oscilloscope is not representative of the charging voltage, but is representative of the upper and lower limits of the DC ripple. The 'amplitude' of the waveform will vary under different conditions with a full charged battery showing a 'flatter' picture, while a discharged battery will show an exaggerated amplitude until the battery is charged.

PICO SCOPE

ALTERNATOR OUTPUT

Menu

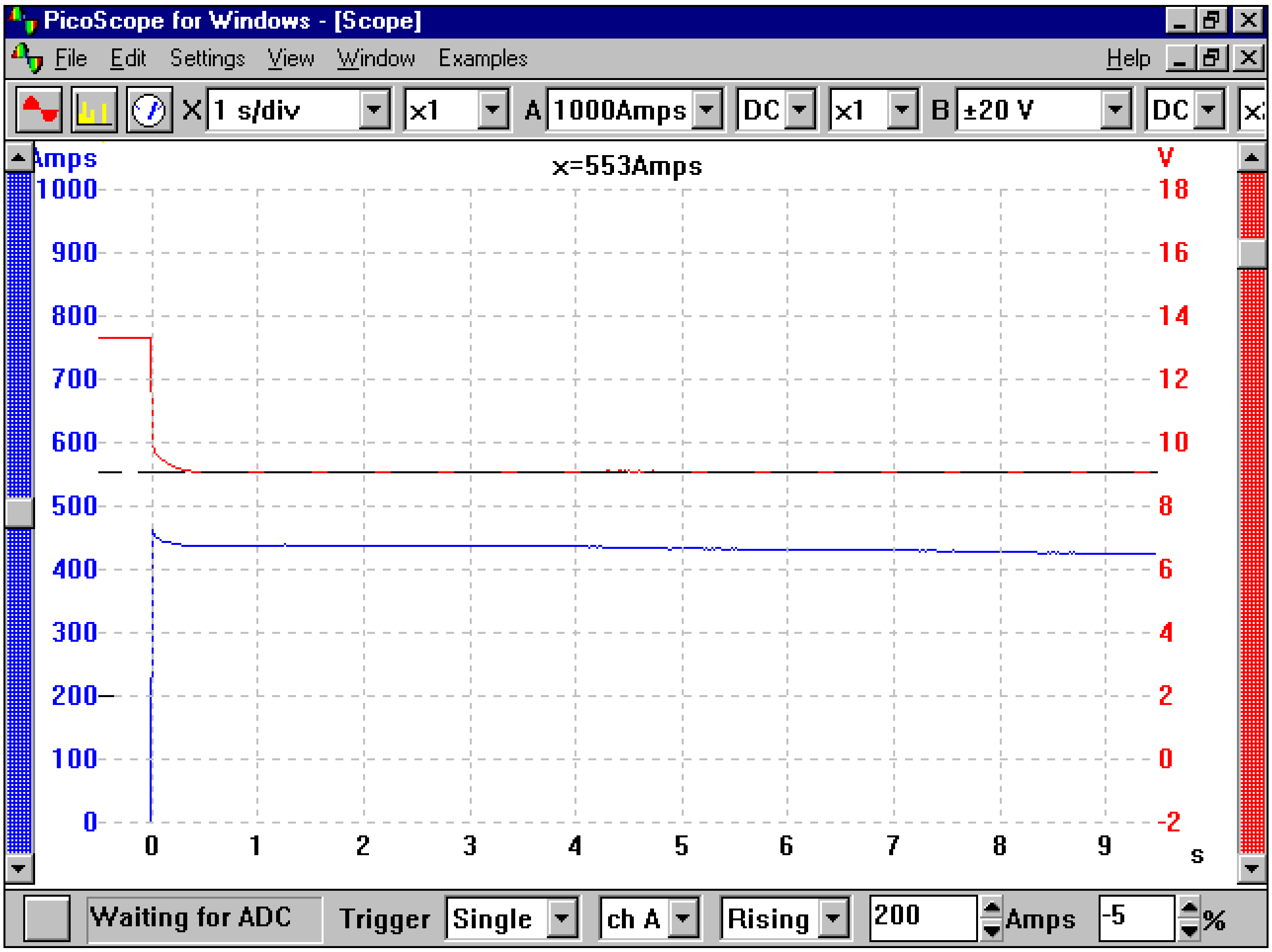


Alternator Output (Suzuki Vitara – AC Coupled to show Ripple) Reference Waveform

PICO SCOPE

BATTERY DISCHARGE TEST

Menu

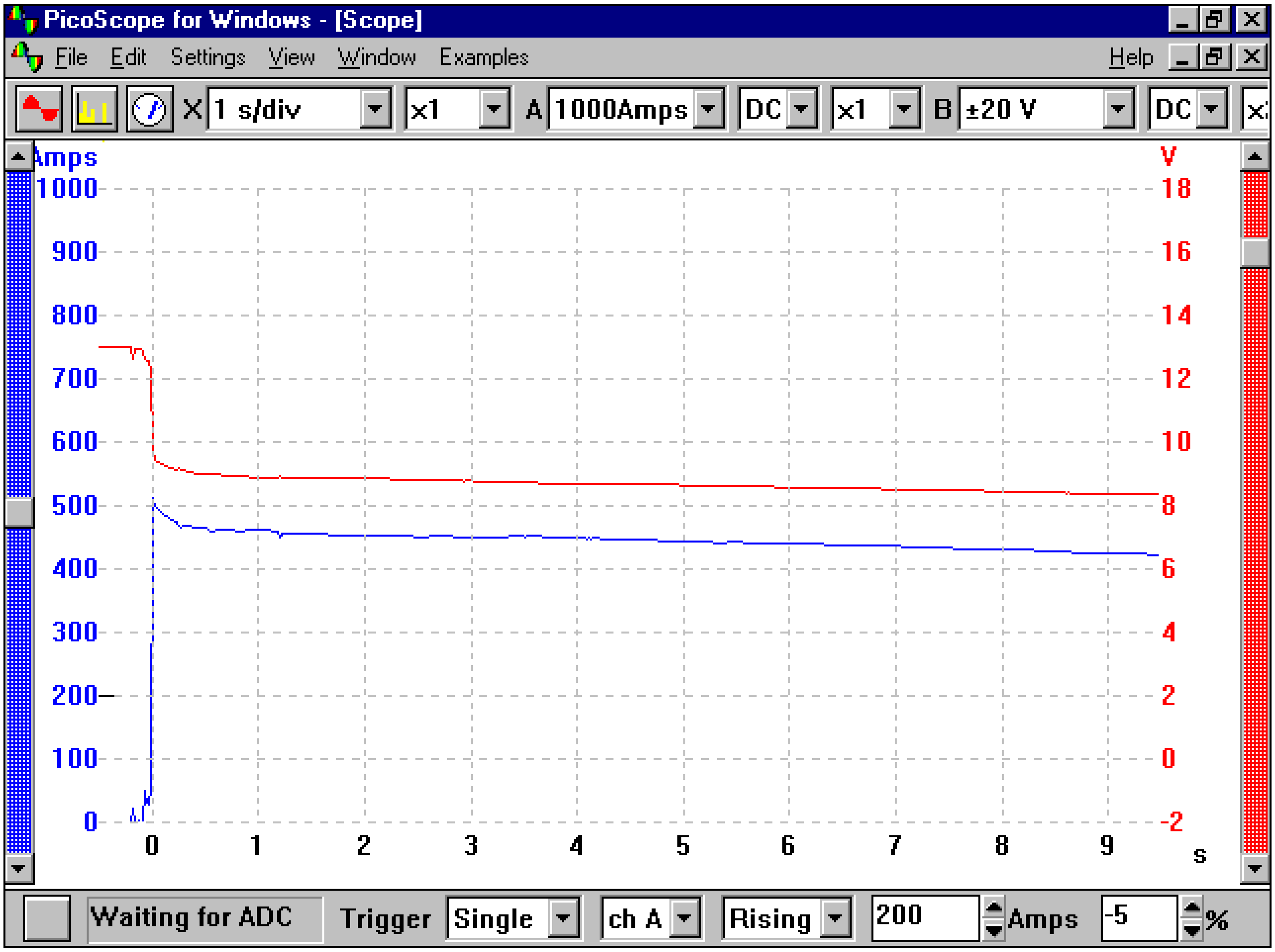


Battery Discharge Test – Normal Battery Reference Waveform

PICO SCOPE

BATTERY DISCHARGE TEST

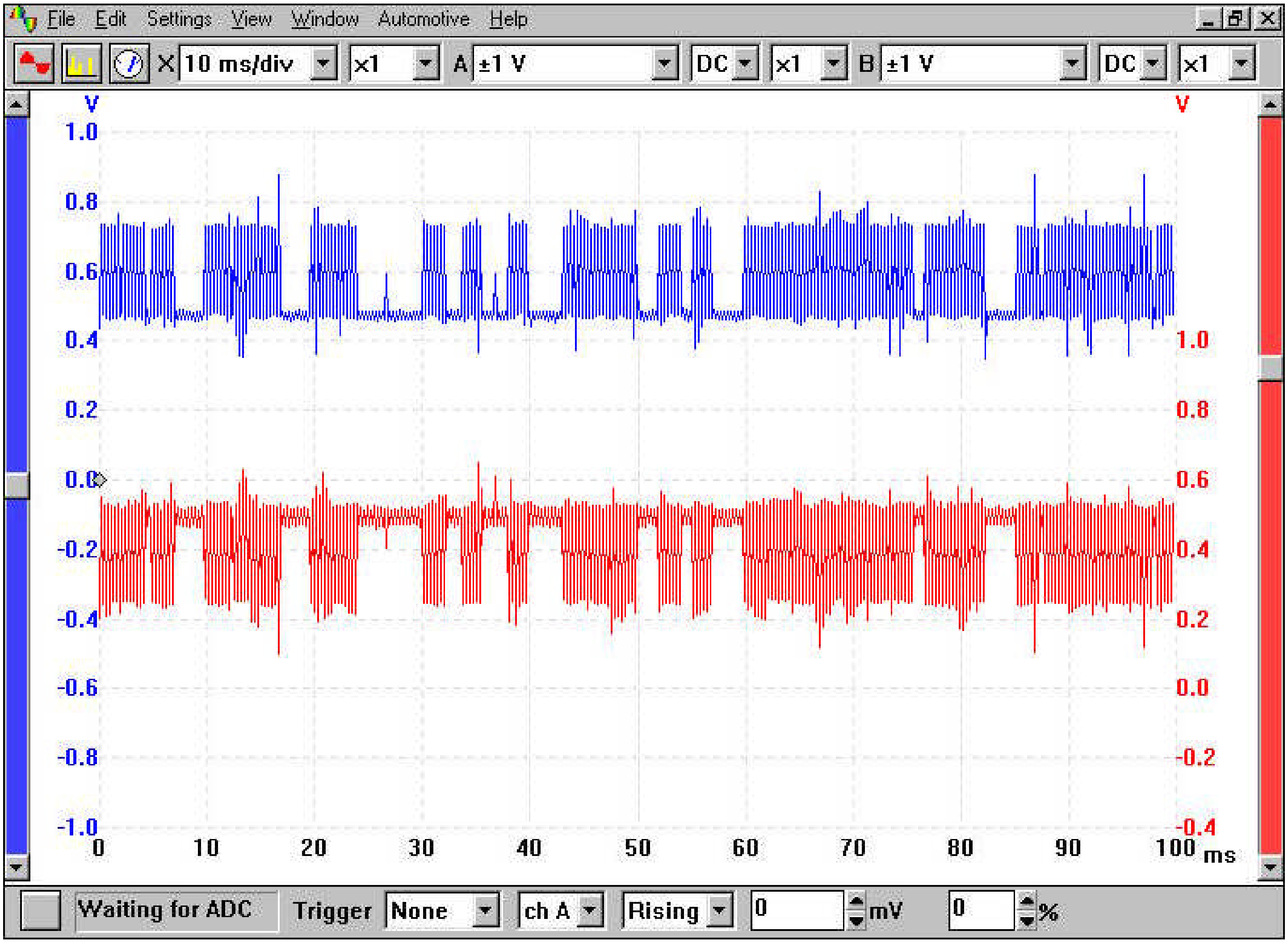
Menu



Battery Discharge Test – Defective Battery Reference Waveform

PICO SCOPE

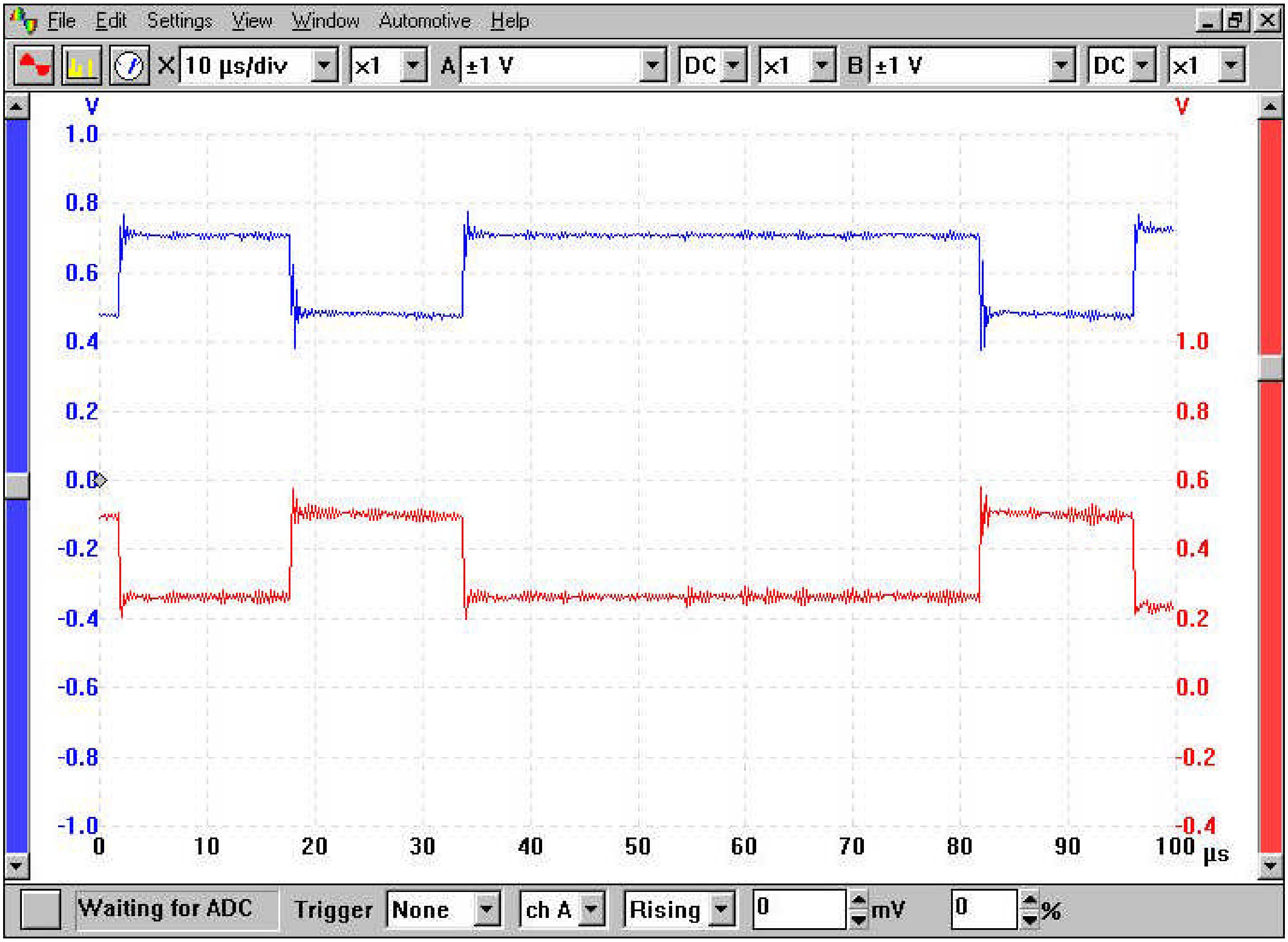
CAN BUS [**Menu**]



CAN BUS – VDB (CAN – High and CAN – Low) Reference Waveform

PICO SCOPE

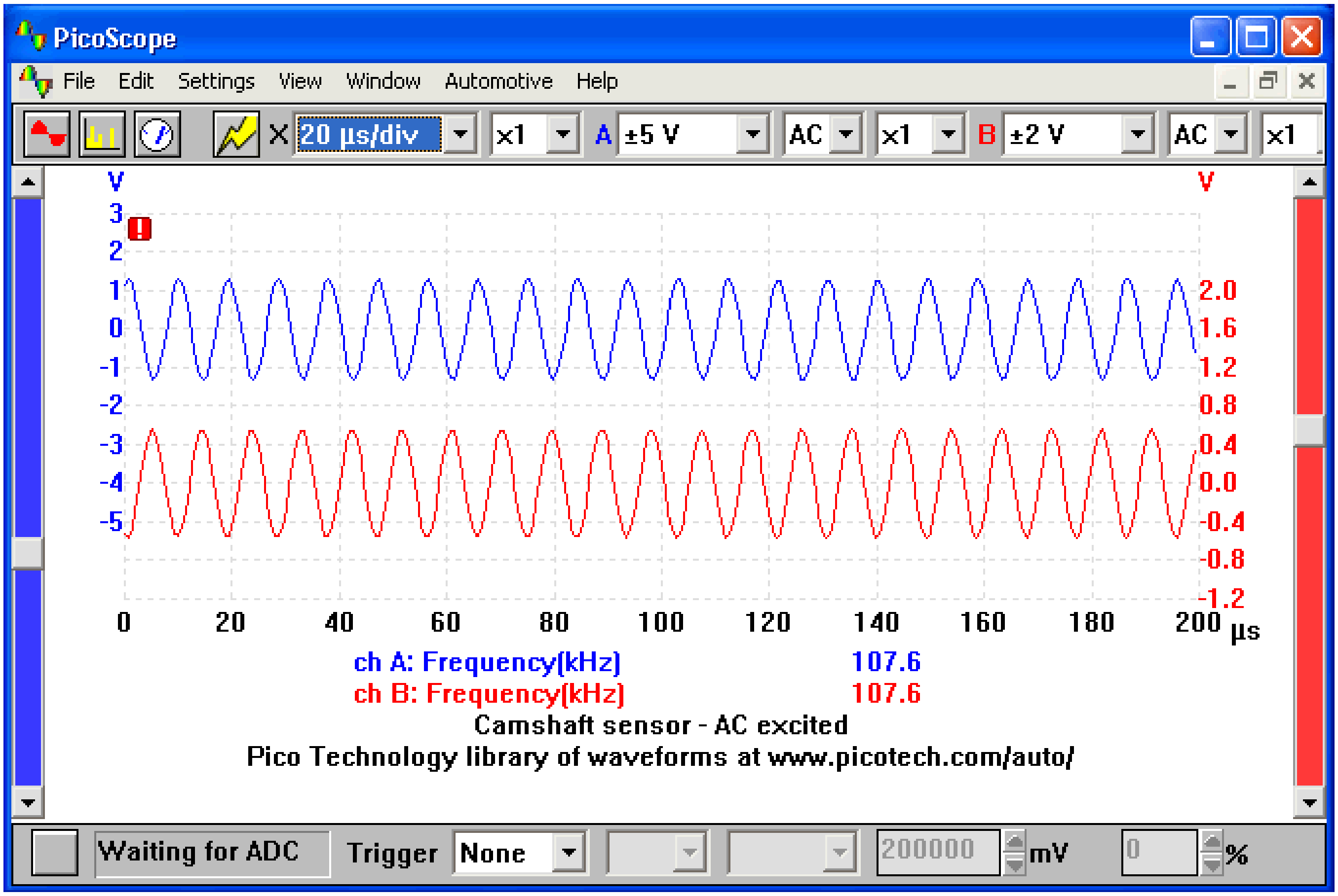
CAN BUS **Menu**



CAN BUS – VDB (CAN – High and CAN – Low) Detailed View Reference Waveform

CAMSHAFT SENSOR

Menu



Reference Waveform Notes - Camshaft Sensor (AC Excited) Waveform Notes

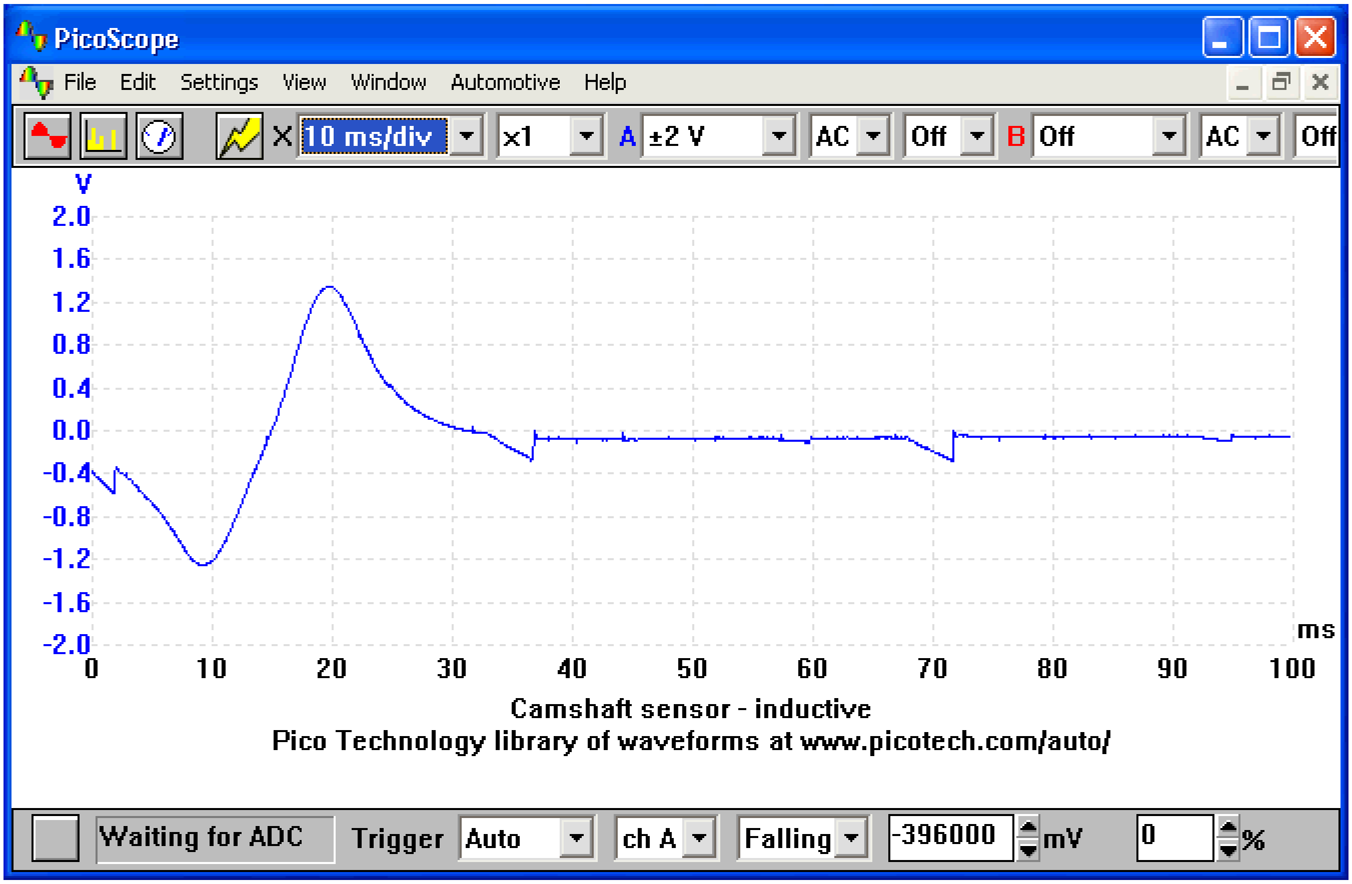
This type of sensor is used on some of the Vauxhall ECO TEC engines. This Cylinder Identification (CID) sensor differs in operation from the other inductive sensors by having an Alternating Current (AC) voltage supply to the CID sensor.

The Electronic Control Module (ECM) supplies a very high frequency at around 150 KHz (2500 cycles per second) to an exciter coil that is located in close proximity to a rotating disc. The disc is located at the end of the camshaft and has a section removed that when 'open' allows the frequency to excite the receptor (through mutual inductance) and returns the signal to the ECM, indicating the position of number 1 cylinder.

As the frequency is so fast, the time scale should be set as fast as possible so as the oscilloscope can capture the frequency.
The CID sensor is used as a reference for the ECM to determine the camshaft's position, from which the correct timing for the sequential fuel injection can be determined.

CAMSHAFT SENSOR

Menu



Reference Waveform Notes - Camshaft Sensor (Inductive)

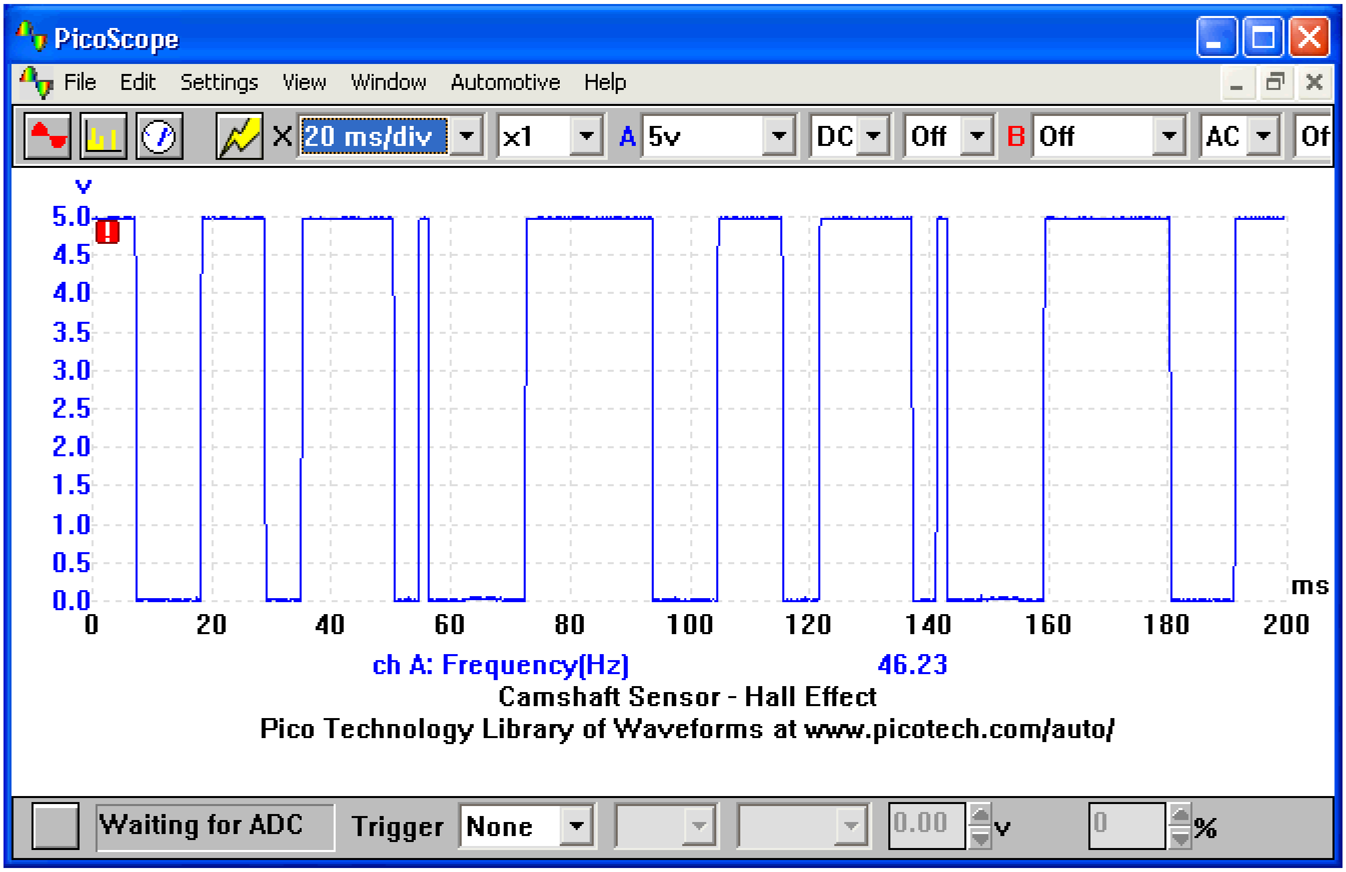
The camshaft sensor is sometimes referred to as the Cylinder Identification (CID) sensor or a 'phase' sensor and is used as a reference to time the sequential fuel injection by the Electronic Control Module (ECM). This particular type of sensor generates its own signal and therefore does not require a voltage supply to power it and is recognisable by its two electrical connections with the occasional addition of a coaxial shielding wire.

The voltage produced by the camshaft sensor will be determined by several factors, these being the engine's speed, the proximity of the metal rotor to the pick-up and the strength of the magnetic field offered by the sensor. The ECM needs to see the signal when the engine is started for its reference, if absent it can alter the point at which the fuel is injected. The driver of the vehicle may not be aware that the vehicle has a problem if the CID sensor fails as the drivability may not be affected.

The characteristics of a good inductive camshaft sensor waveform is a sine wave that increases in magnitude as the engine speed is increased and usually provides one signal per 720° of crankshaft rotation (360° of camshaft rotation). The voltage will be approximately 0.5 volts peak to peak while the engine is cranking, rising to around 2.5 volts peak to peak at idle as seen in the example show above.

CAMSHAFT SENSOR

[Menu](#)



Reference Waveform Notes - Camshaft Sensor (Hall Effect)

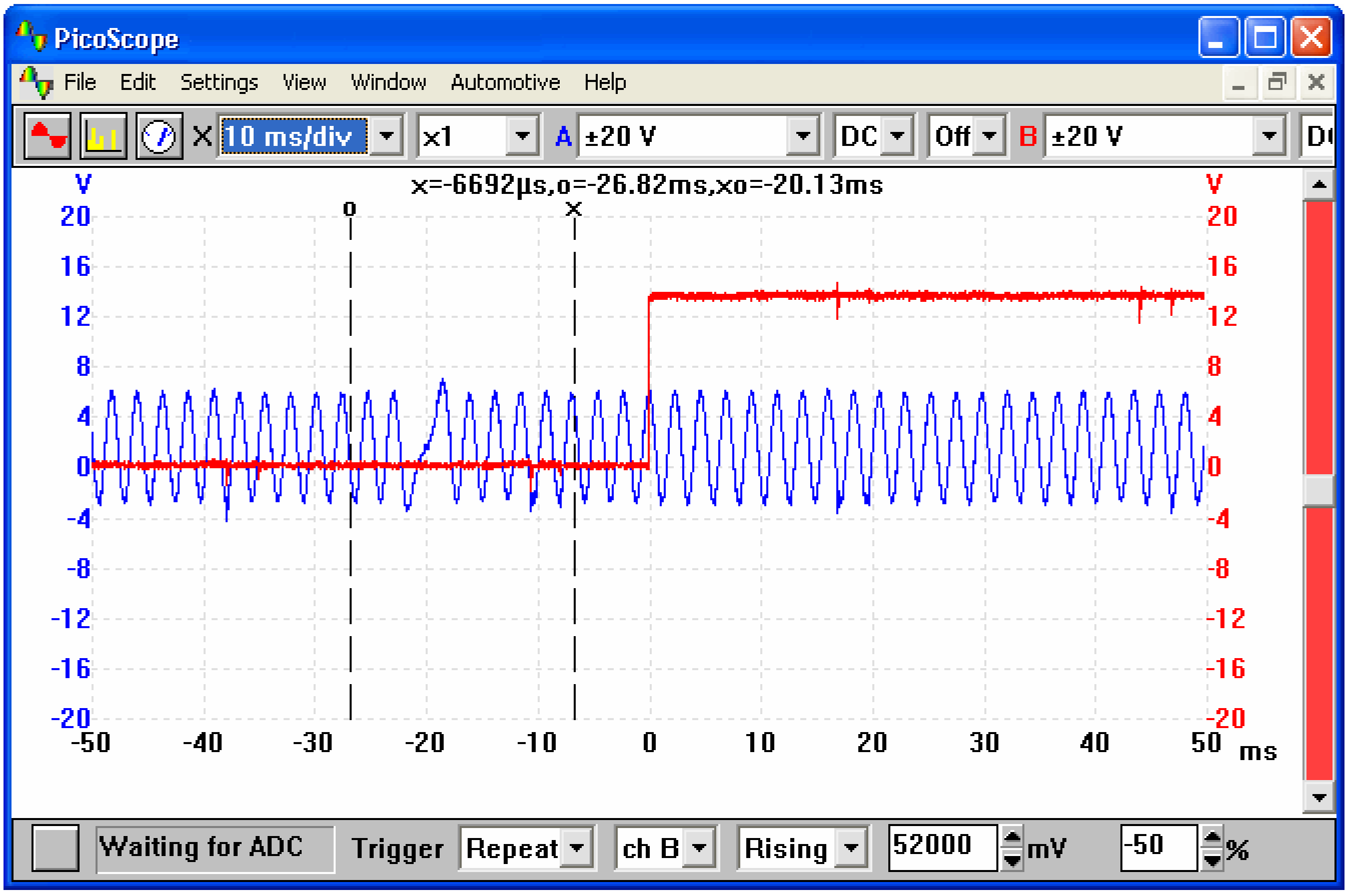
The camshaft sensor is sometimes referred to as the Cylinder Identification (CID) sensor and is used as a reference to time the sequential fuel injection. The signal waveform can be either a permanent magnetic sine wave or in this particular case a digital square wave.

The Electronic Control Module (ECM) needs to see the signal when the engine is started for its reference, if absent it can put the ECM into 'limp-home'.

The characteristics of a good Hall effect waveform are clean, sharp switching and as with all other Hall units have 3 electrical connections.

CAMSHAFT SENSOR

Menu



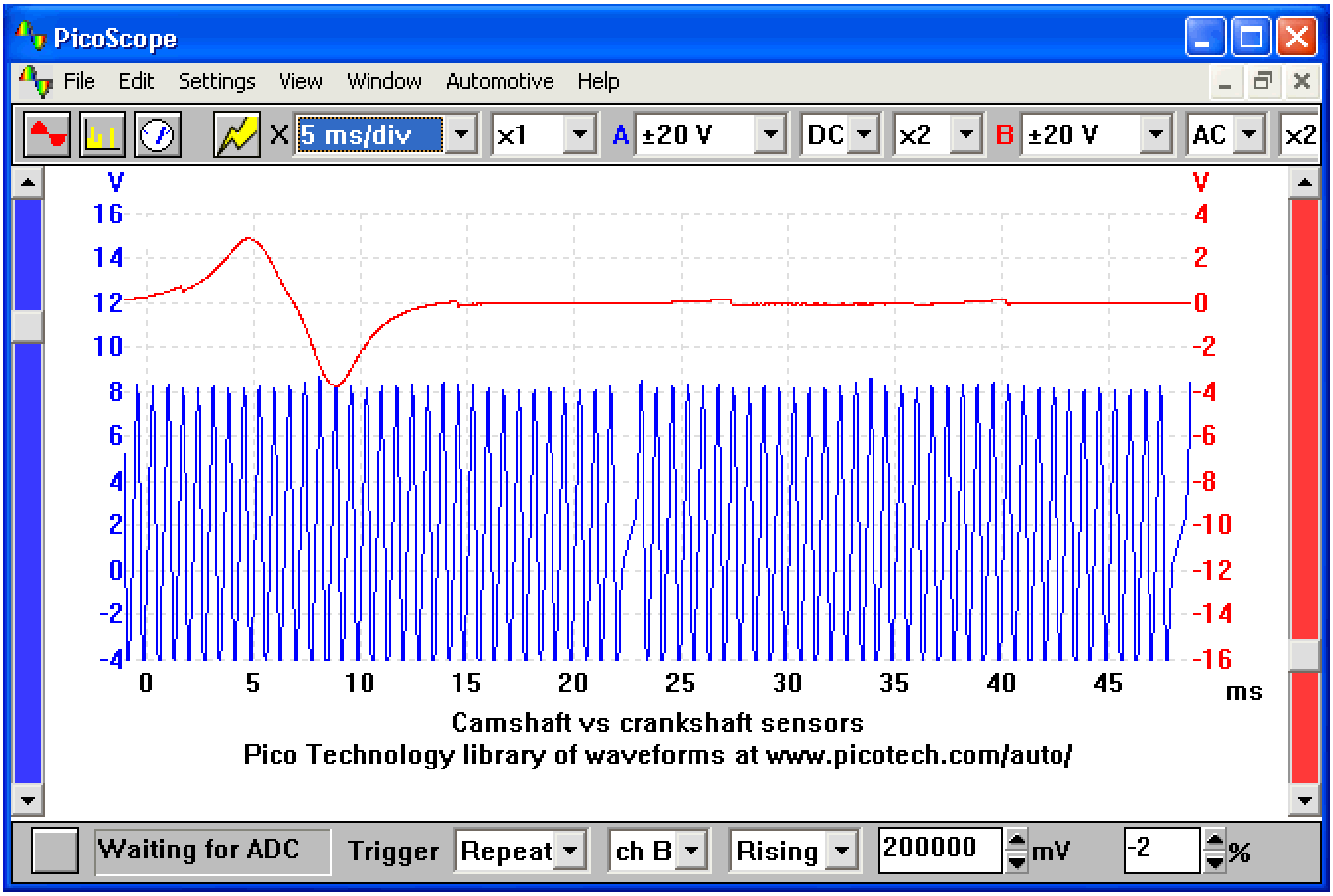
Reference Waveform Notes - Camshaft Sensor (3.8L Ford Mustang)

This waveform was captured from a 3.8L Ford Mustang.

The waveform is from setting a Ford CMP on the Mustang after sealing the timing cover.

CAMSHAFT SENSOR

Menu



Reference Waveform Notes - Camshaft Sensor (Dual Trace of Camshaft Sensor/Crankshaft Sensor)

In this particular instance we are observing the relationship between the signal from the Crank Angle Sensor (CAS) and the Camshaft Sensor or Cylinder Identification sensor (CID).

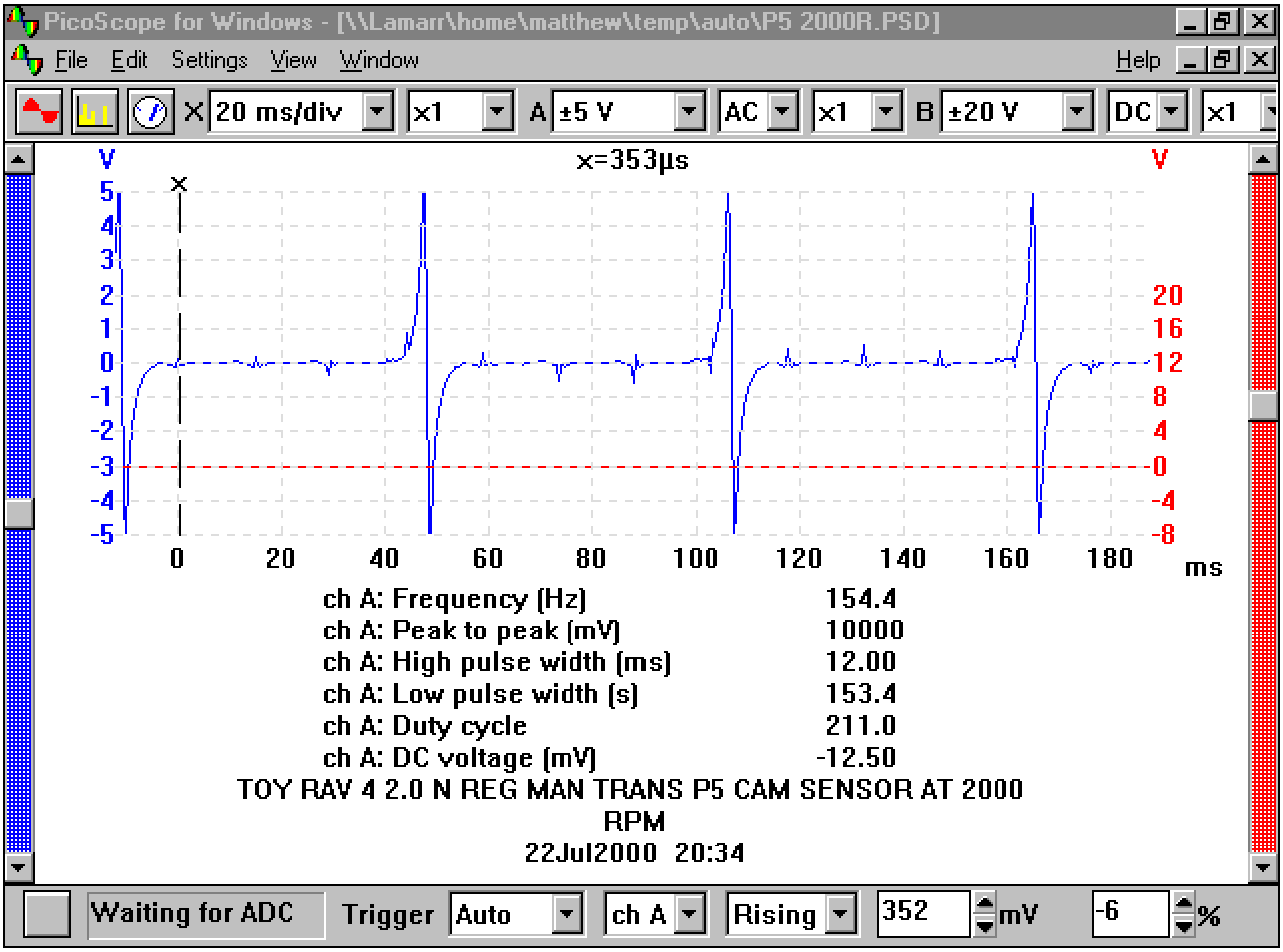
The waveforms will be an alternating current (AC) its voltages will be seen to increase with engine speed. The gap in the CAS picture is due to the 'missing tooth' in the flywheel (or reluctor) and is used as a reference for the Electronic Control Module (ECM) to ascertain the engines position. Some systems use two reference points per revolution. The CID sensor or a 'phase' sensor is used as a reference to time the sequential fuel injection by the ECM. This sensor as with the CAS generates its own signal and therefore do not require a voltage supply to power them. Recognisable by their two electrical connections. Some systems may however have a coaxial braid.

The ECM needs to see a signal from the CID when the engine is started for its reference, if absent it can alter the point at which the fuel is injected.

PICO SCOPE

CAMSHAFT SENSOR

Menu

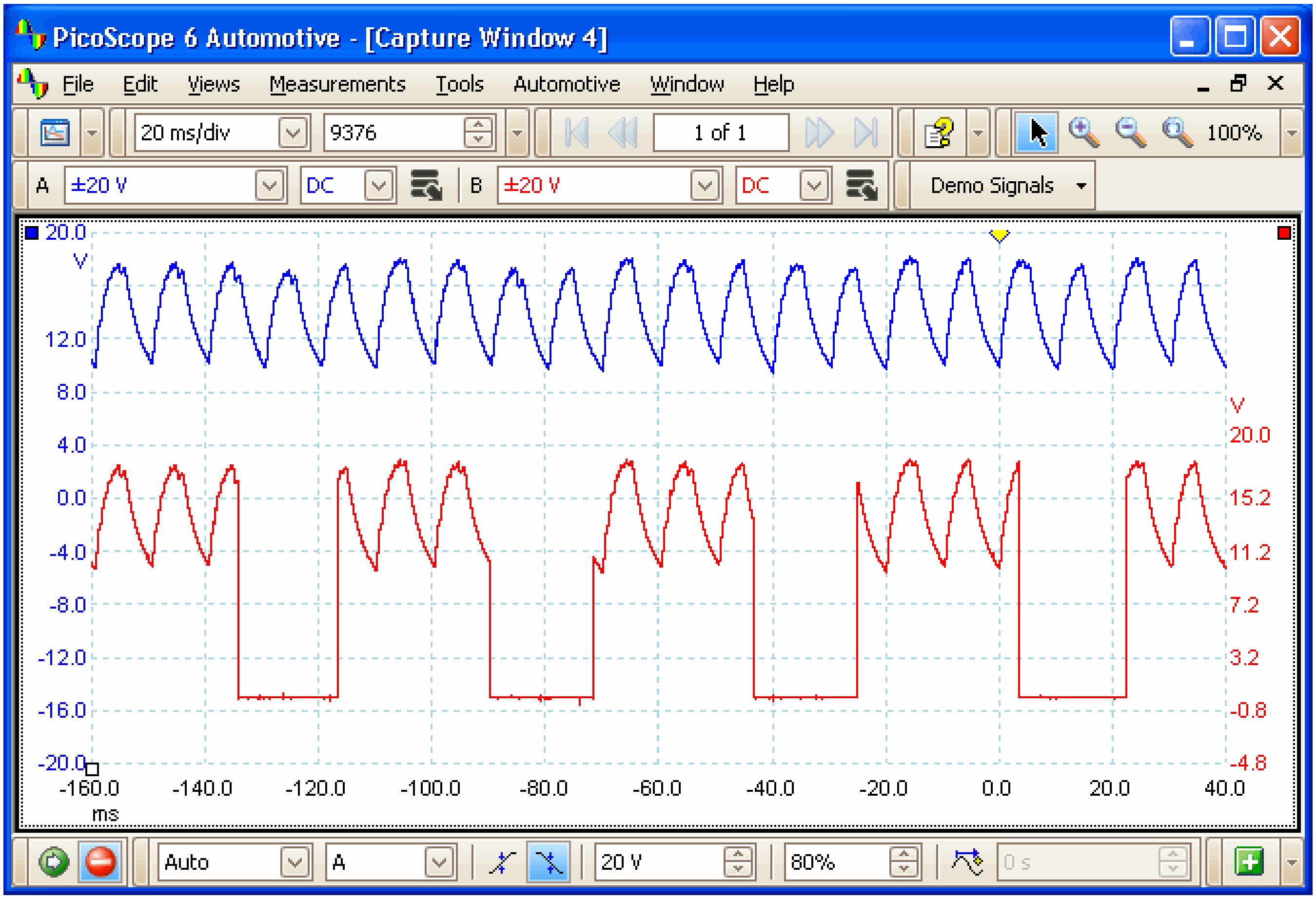


Toyota RAV 4 1995 (Camshaft Sensor at 2500 RPM) Reference Waveform

PICO SCOPE

CAMSHAFT SENSOR – Hall Effect Sensor (Waveform 1)

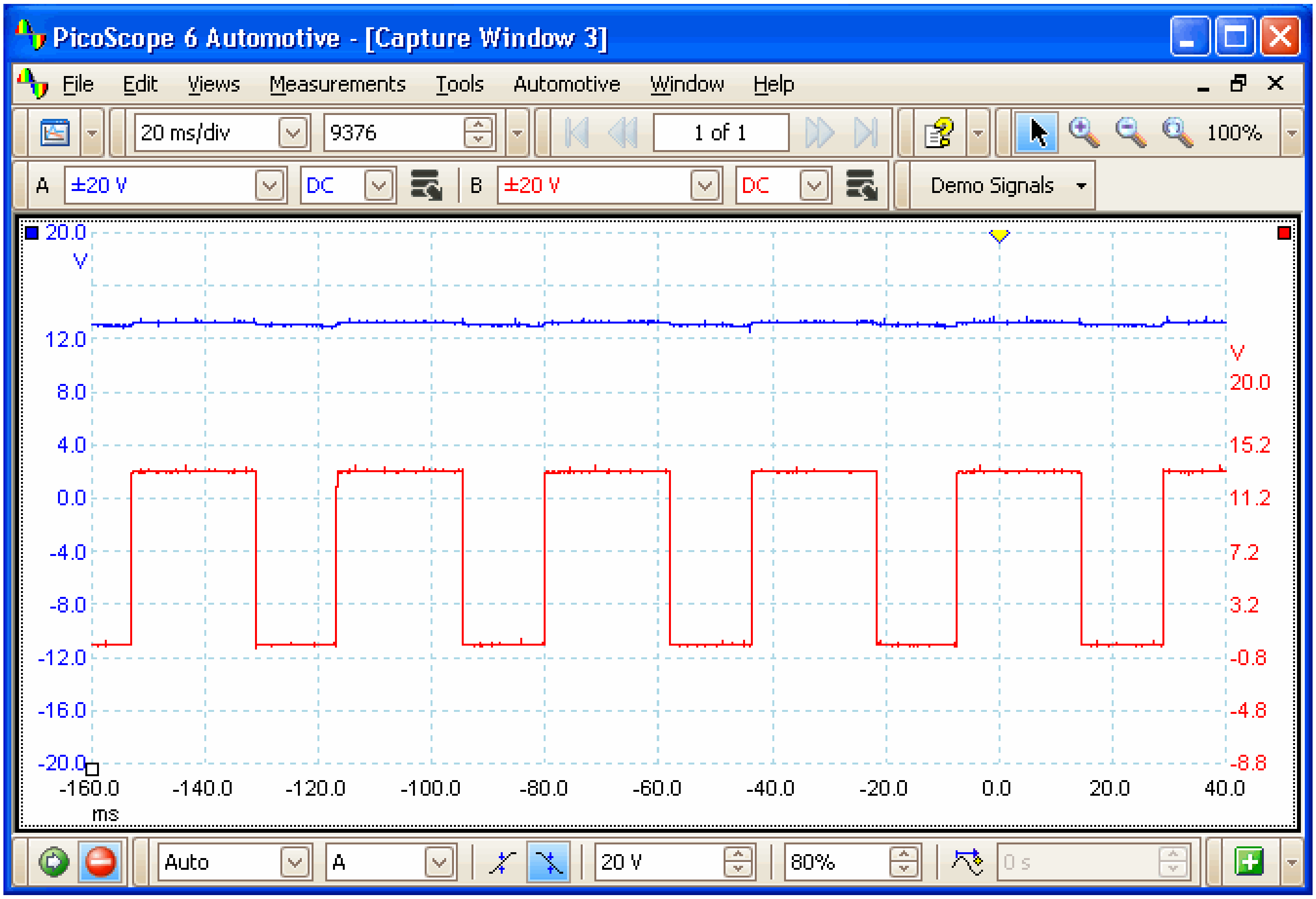
Menu



Audi Coupe 2.0L (Faulty Hall Effect Sensor due to faulty main relay) Reference Waveform
Waveform captured with PICO 6 BETA software

CAMSHAFT SENSOR – Hall Effect Sensor (Waveform 2)

Menu



Reference Waveform Notes - Camshaft Sensor – Hall Effect Sensor (Audi Coupe) Main Relay Repaired Waveform Captured with PICO 6 BETA Software

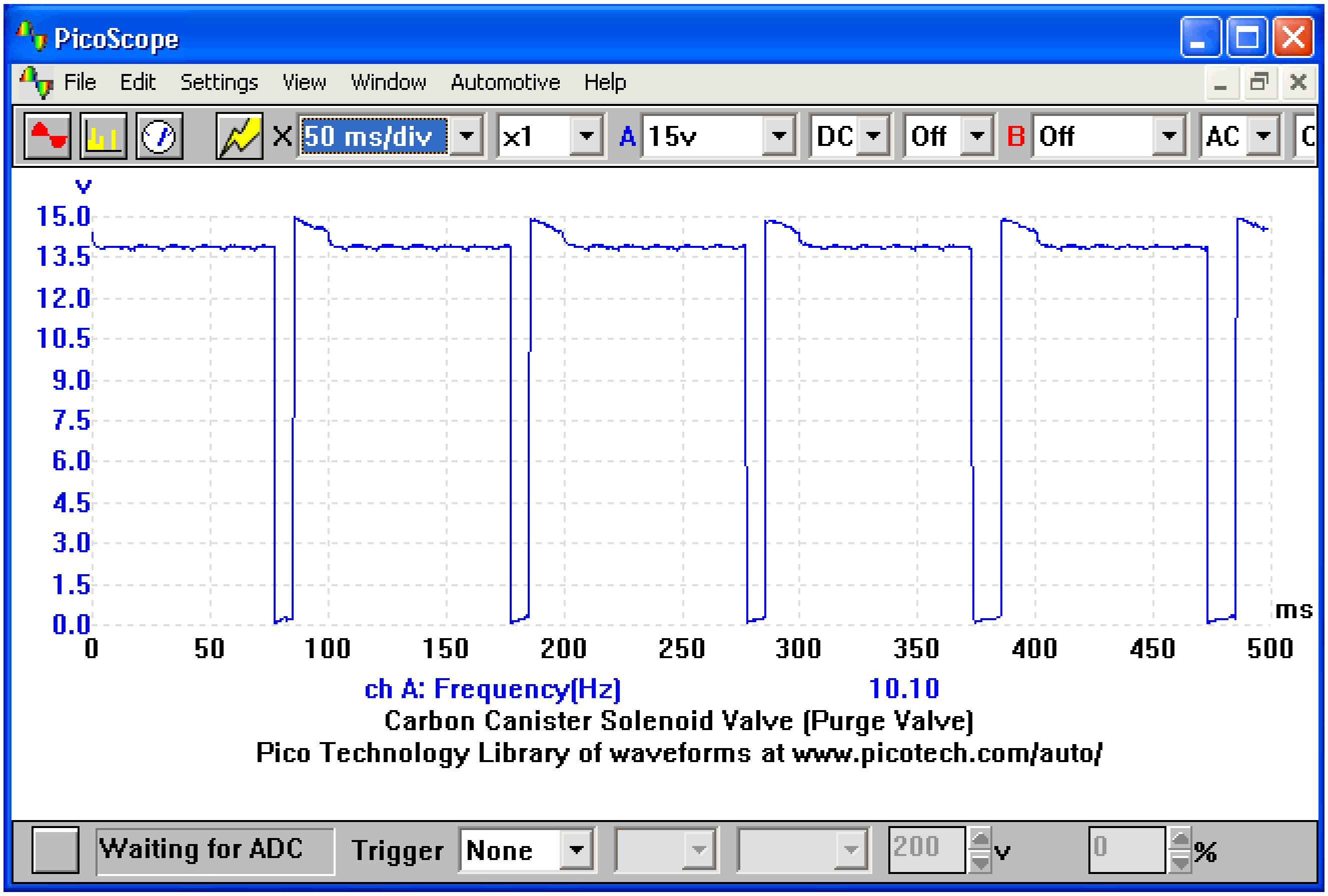
The above waveforms are from an Audi Coupe 2.0. In both waveforms, Chan A (blue trace) shows the camshaft position sensor battery wire; Chan B (red trace) shows the CPS output wire.

Waveform 1 shows the faulty waveform. The fault was due to the main relay. Waveform 2 shows the same signals once the relay had been repaired.

Thanks to Philip Cockburn of E.J. Cockburn & Sons for contributing this waveform.

CARBON CANISTER SOLENOID VALVE

Menu



Reference Waveform Notes - Carbon Canister Solenoid Valve

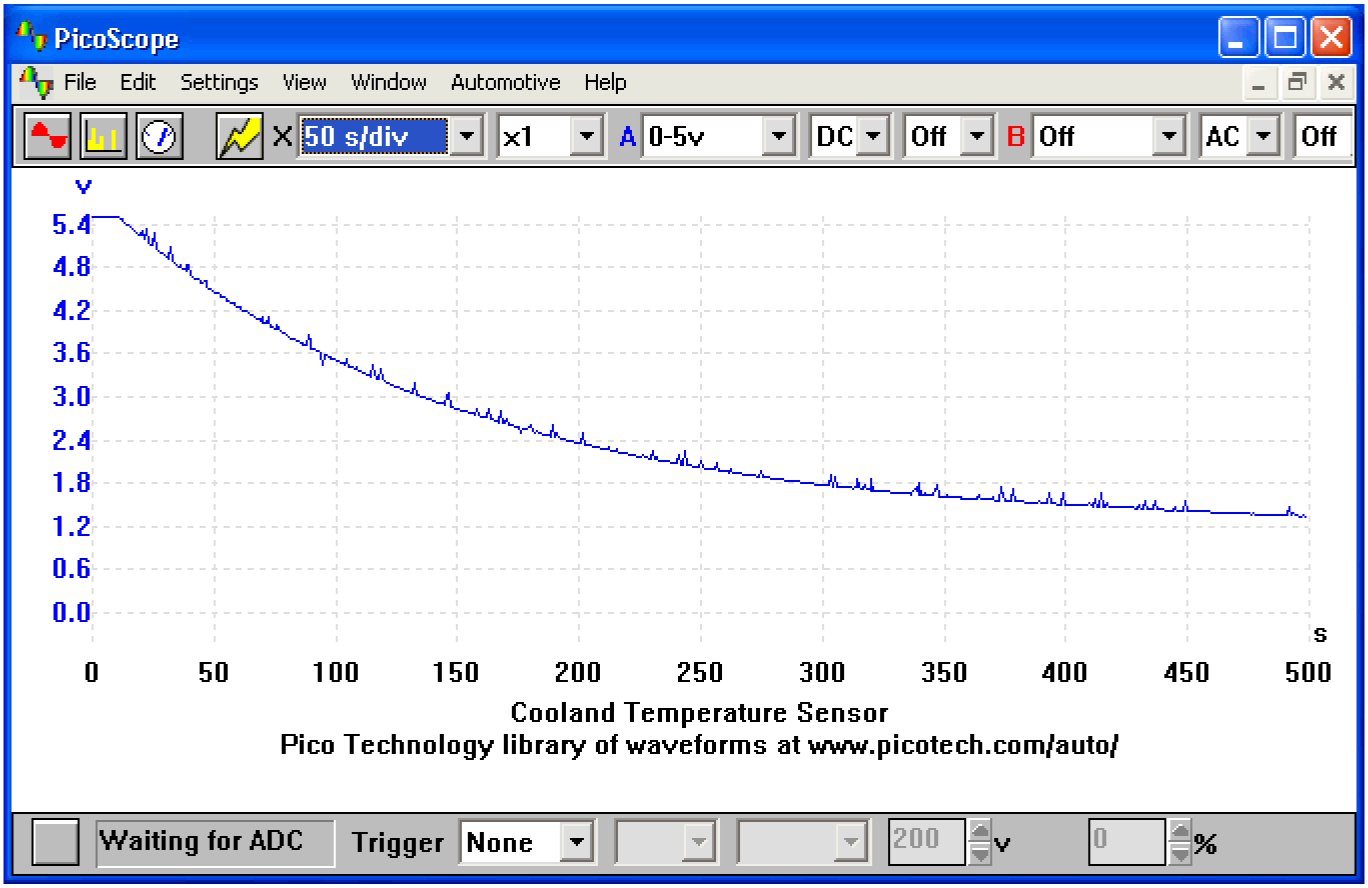
This canister contains active charcoal or active carbon granules. Most evaporation control systems reduce the emission of fuel vapour during the time the vehicle is idling in traffic or parked in strong sunshine by absorbing the vapour fumes into the carbon canister. Once the engine is at its normal operating temperature the stored hydrocarbons are released into the inlet manifold where they become part of the combustible air/fuel mixture.

The control for allowing the hydrocarbons to be released into the inlet manifold through a cut off valve can be achieved electrically or by vacuum. The operating principal is the same for both; our example is from the electronic solenoid type.

The electronic solenoid is controlled by the Electronic Control Module (ECM) by switching the earth path to ground under specified conditions. The purge valve/carbon canister has a 12 volt supply and its switching can be seen in the example waveform.

COOLANT TEMPERATURE SENSOR – 5 VOLT NTC

Menu



Reference Waveform Notes - Coolant Temperature Sensor (5Volt NTC Type)

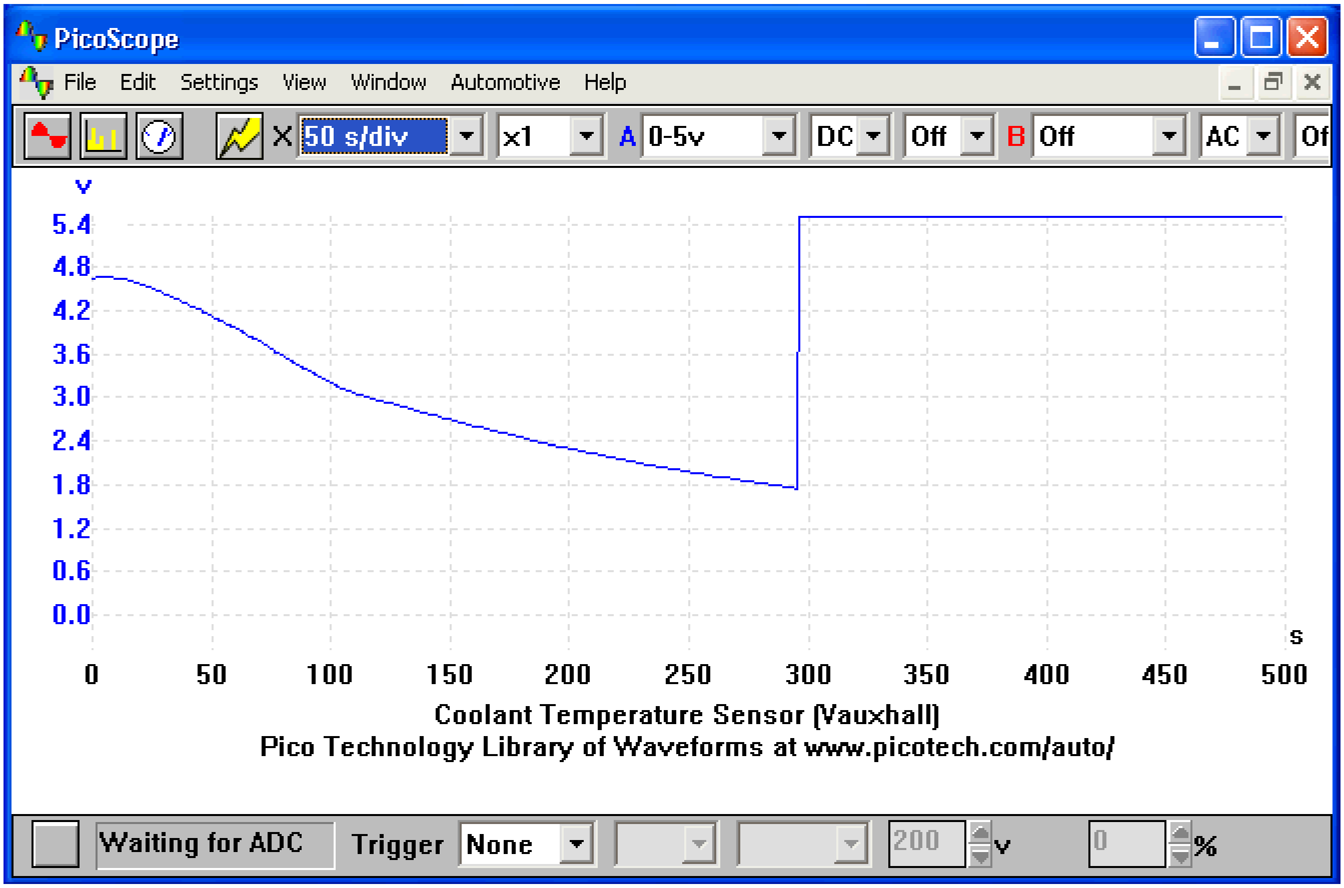
The Coolant Temperature Sensor (CTS) will invariably be a two wire device with a voltage supply at approximately 5 volts. The sensor itself has the ability to alter its resistance with engine temperature change. The majority of sensors have a Negative Temperature Coefficient (NTC) which results in the resistance of the component decreasing as the temperature increases. The resistance change will therefore alter the voltage seen at the sensor and can be monitored for any discrepancies across its operational range.

By selecting a time scale of 500 seconds, connect the oscilloscope to the sensor and observe the output voltage. Start the engine and in the majority of cases the voltage will start in the region of 3 to 4 volts however this voltage will depend on the temperature of the engine, as the temperature increases the resistance decreases and the voltage will also be seen to drop. The rate of voltage change is usually linear with no sudden changes to the voltage, if the CTS displays a fault at certain temperature, this is the only true way of detecting it.

The Vauxhall Simtec system has a point at which the voltage alters dramatically during the warm up period and this is part of the ECU software programming.

COOLANT TEMPERATURE SENSOR

Menu



Reference Waveform Notes - Coolant Temperature Sensor (Vauxhall Simtec System)

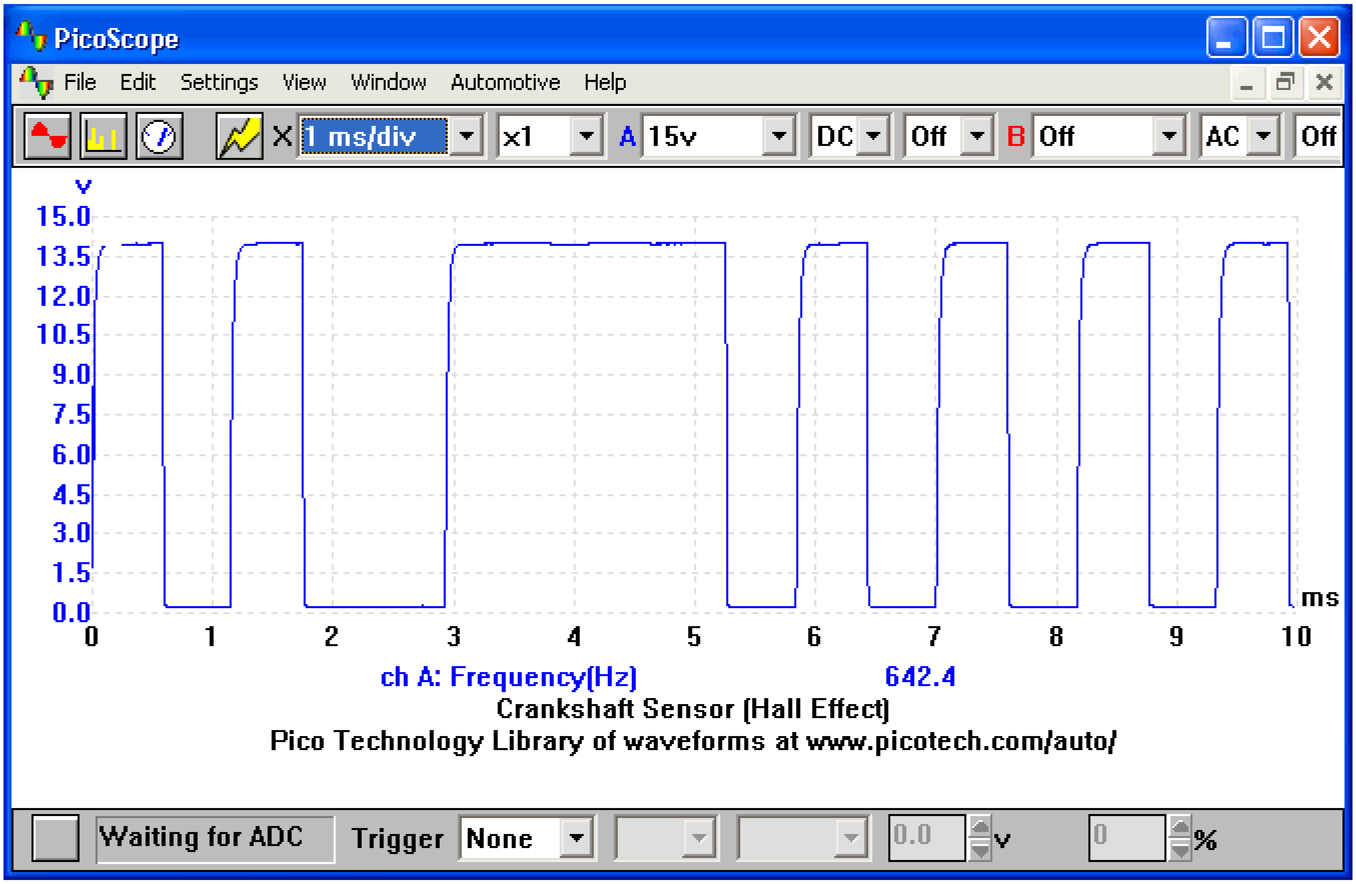
In this particular instance we are observing the relationship between the signal from the Crank Angle Sensor (CAS) and the Camshaft Sensor or Cylinder Identification sensor (CID).

The Coolant Temperature Sensor (CTS) on this particular vehicle has completely different voltage characteristic to that on a conventional system. On the conventional CTS, the voltage will be seen to drop as the engine temperature increases. When cold the voltage will be approximately 3 to 4 volts, once normal operating temperature is achieved this voltage will be around 1 volt. The quoted voltages are however manufacturer specific. Most temperature sensors will have a Negative Temperature Coefficient (NTC) so the voltage decreases with an increase in engine temperature. Positive Temperature Coefficient (PTC) sensors will have an increasing voltage as the temperature rises.

The CTS used in the Multec system on the Vauxhall Vectra 1.6 Lt. engine has a distinctive waveform when viewed on the oscilloscope. The voltage seen at the CTS will display a conventional voltage reduction, until the engine reaches 40° - 50°C at which point the voltage rises dramatically due to internal switching inside the Electronic Control Module (ECM). The reason for the voltage change is that at higher operating temperatures (50°C plus), the ECM is now able to offer finer control with the increased voltage.

CRANKSHAFT SENSOR

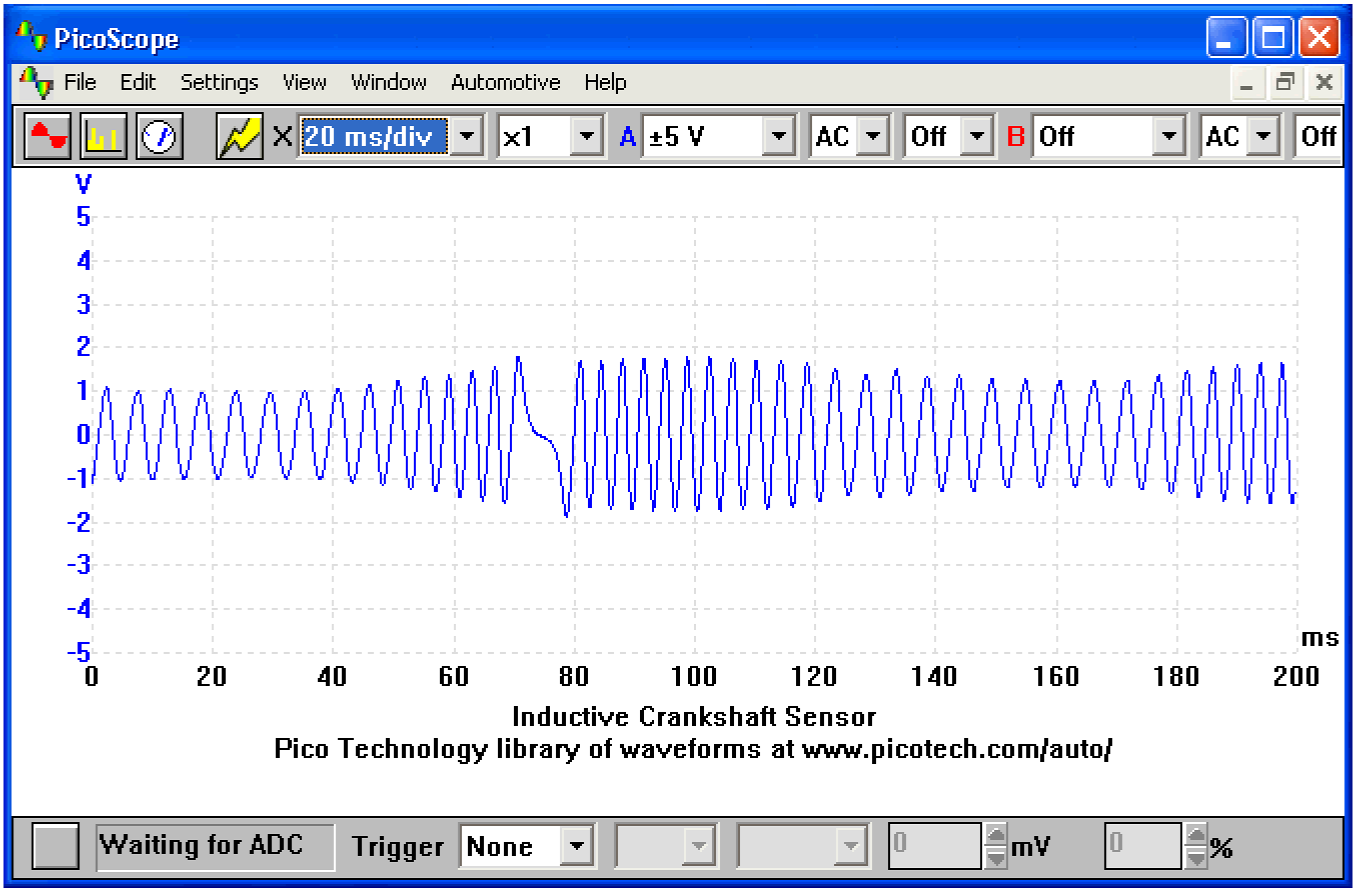
Menu



Reference Waveform Notes - Crankshaft Sensor (Hall Effect)

This system type is used on some Vauxhall Vectra 2.0 Lt. fitted with a Simtec 56.5 engine management system. The Crank Angle Sensor (CAS) has a voltage supply which is switches the output relative to the engine speed. This system should not however be confused with the Simtec system which uses a frequency modulated signal (AC excited).

CRANKSHAFT SENSOR Menu

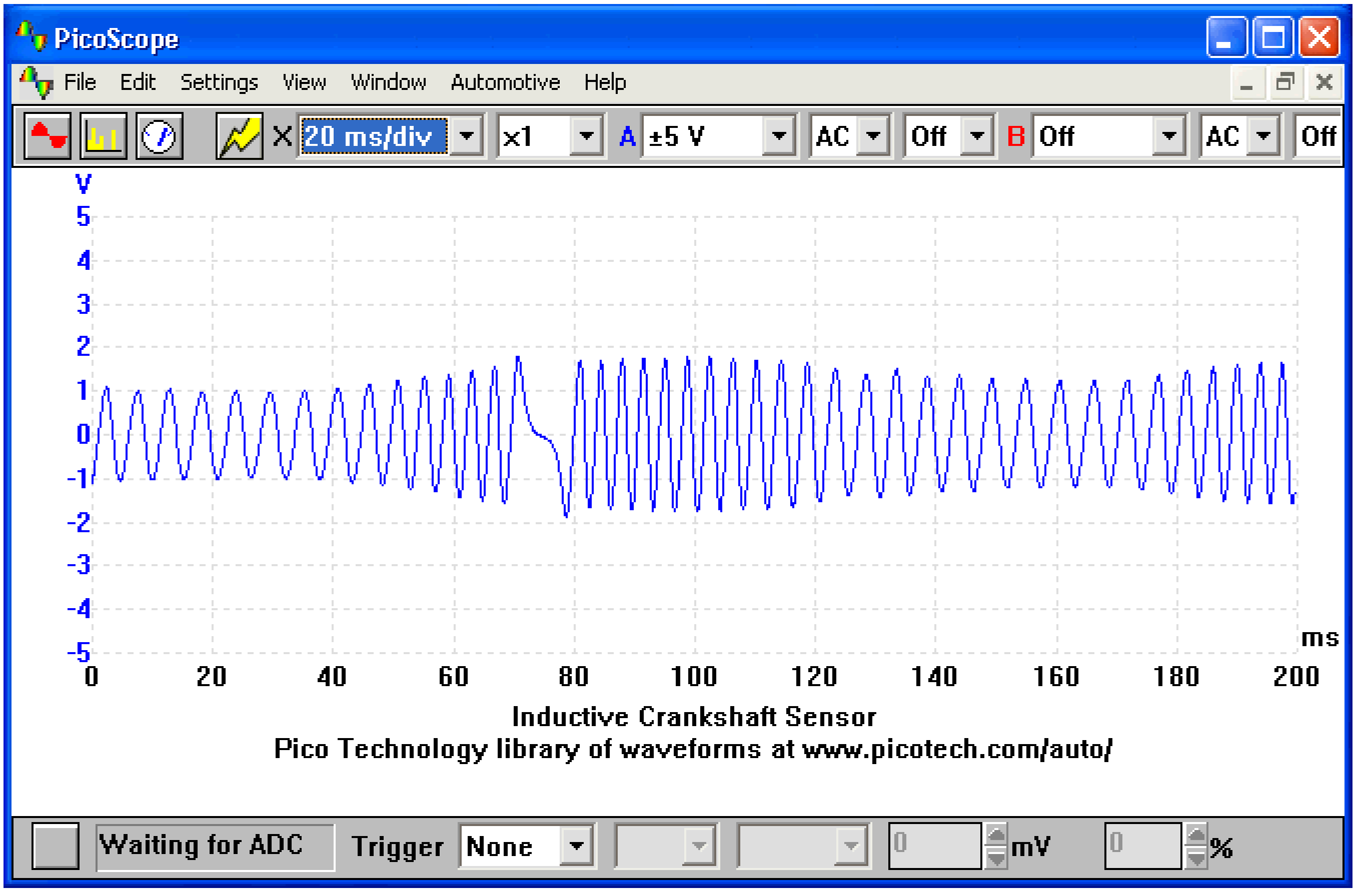


Reference Waveform Notes - Crankshaft Sensor (Inductive – Engine Cranking)

In this particular waveform we can evaluate the output voltage from the Crank Angle Sensor (CAS). The voltage will differ between manufacturers, proximity and engine speed. The main reason for evaluating this waveform is to monitor the output when the engine fails to start due to a loss of primary triggering. The waveform will be an Alternating Current (AC) its voltage will be low when cranking and seen to increase with engine speed. The gap in the picture is due to the 'missing tooth' in the flywheel or reluctor and is used as a reference for the ECM to ascertain the engines position. Some systems use two reference points per revolution. The minimum voltage requirement is crucial as while a small AC voltage may be present, it may be insufficient to trigger the primary circuit.

CRANKSHAFT SENSOR

Menu



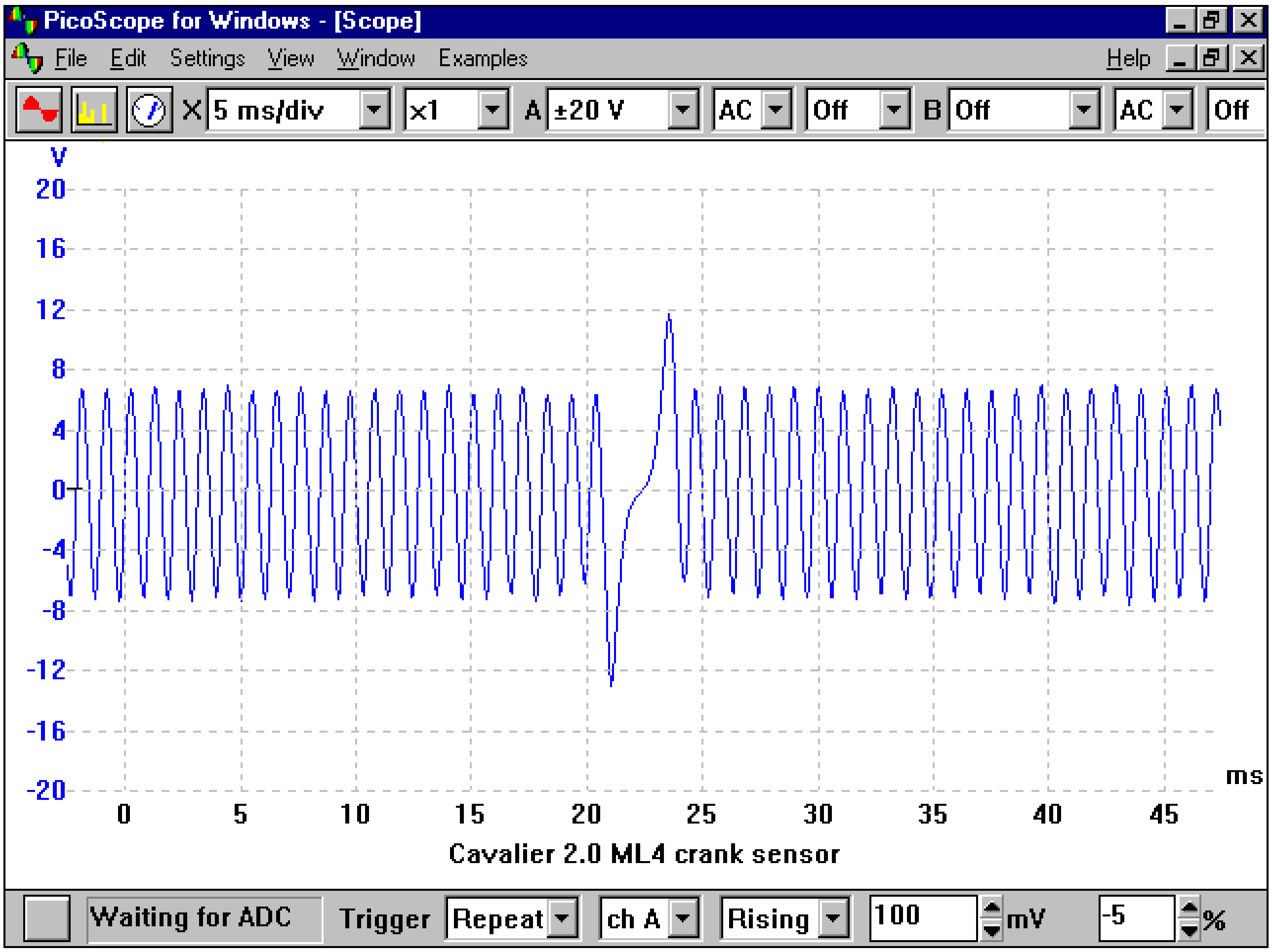
Reference Waveform Notes - Crankshaft Sensor (Inductive – Engine Running)

In this particular waveform we can evaluate the output voltage from the Crank Angle Sensor (CAS). The voltage will differ between manufacturers, its proximity and engine speed. The main reason for evaluating this waveform is to monitor the output when the engine stops due to a loss of High Tension voltage (HT). The waveform will be an Alternating Current (AC) its voltage will be seen to increase with engine speed. The gap in the picture is due to the 'missing tooth' in the flywheel or reluctor and is used as a reference for the Electronic Control Module (ECM) to ascertain the engines position. Some systems use two reference points per revolution.

PICO SCOPE

CRANKSHAFT SENSOR

Menu

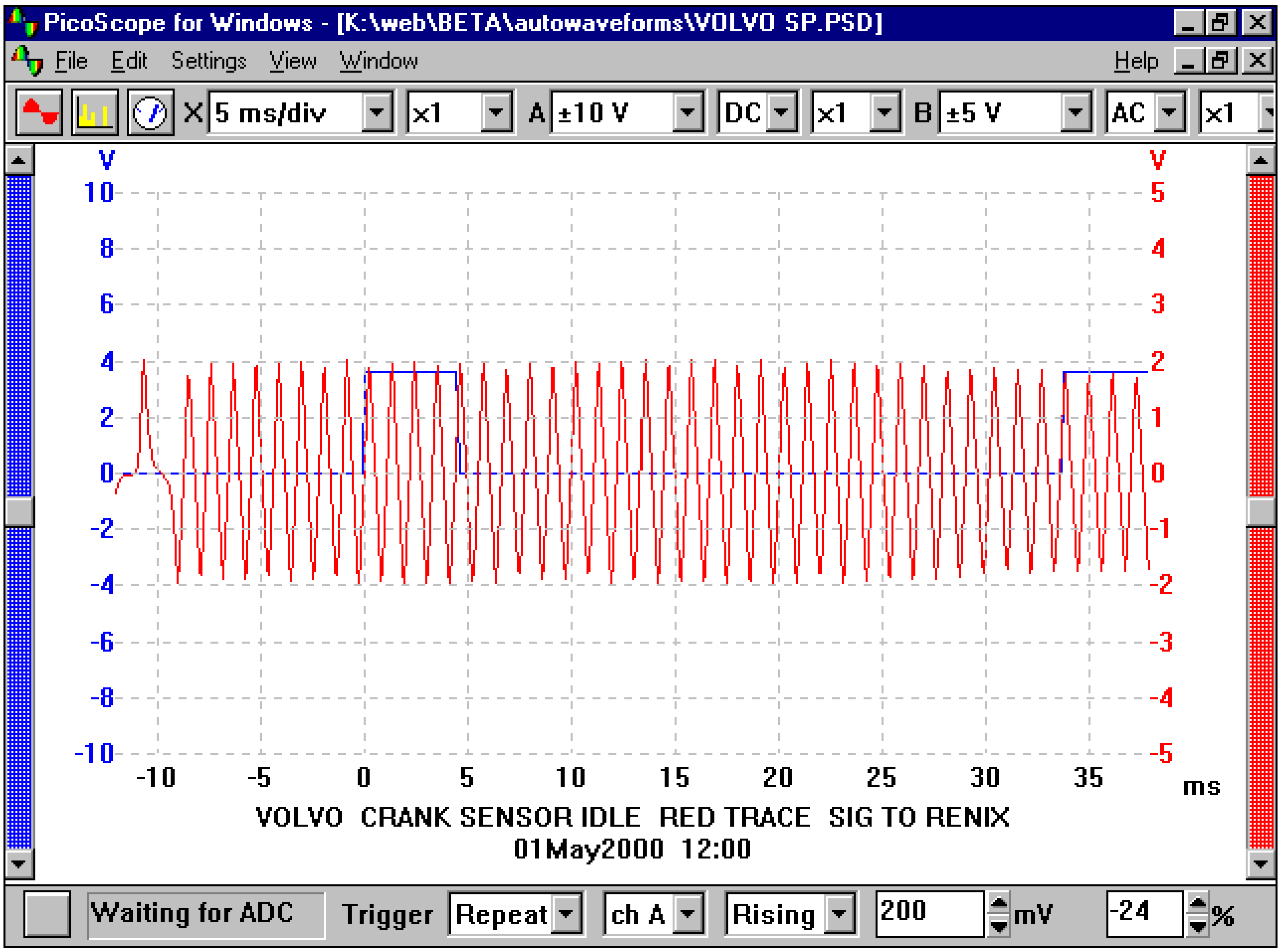


Crankshaft Sensor – Inductive (Cavalier 2.0L ML4) Reference Waveform

PICO SCOPE

CRANKSHAFT SENSOR - Inductive

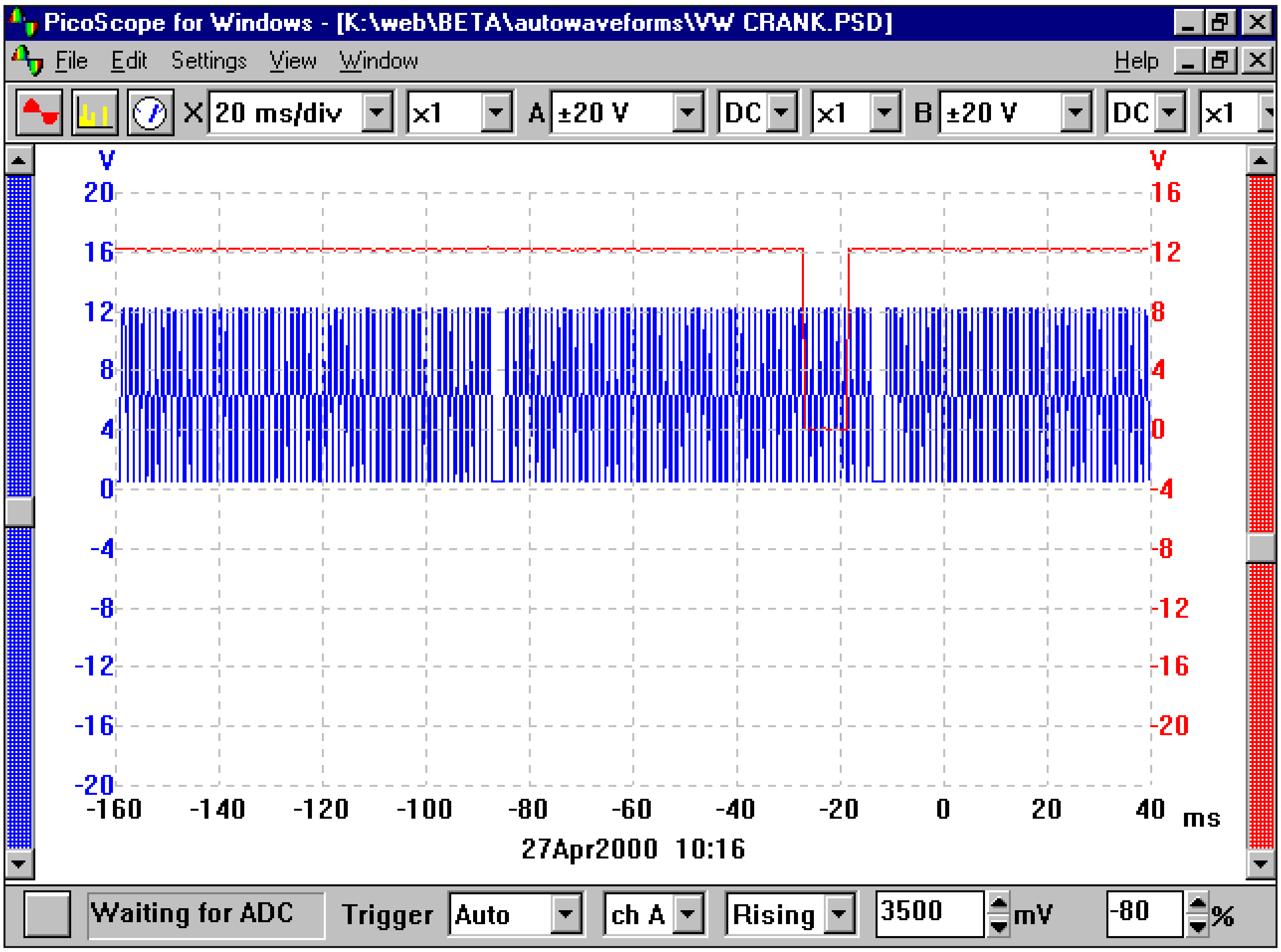
[Menu]



Volvo 1.7L Single Point Injection (Crankshaft Sensor / ECU Ignition Trigger) Reference Waveform

PICO SCOPE

CRANKSHAFT SENSOR – Hall Effect **Menu**

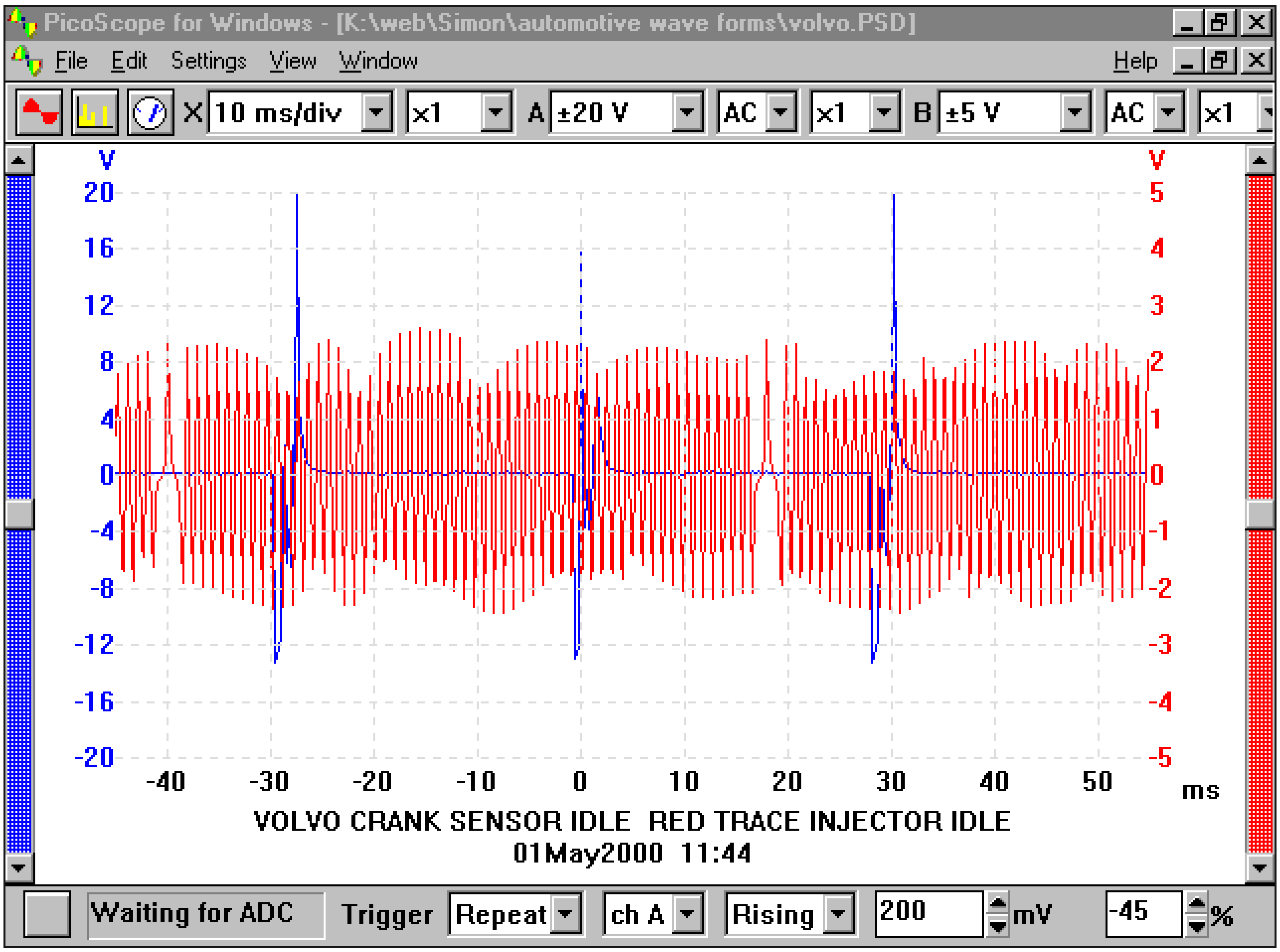


VW Golf GTI 1996 2.0L (Crank-Hall Effect / Distributor Output-Camshaft ID) Reference Waveform

PICO SCOPE

CRANKSHAFT SENSOR – Inductive

Menu

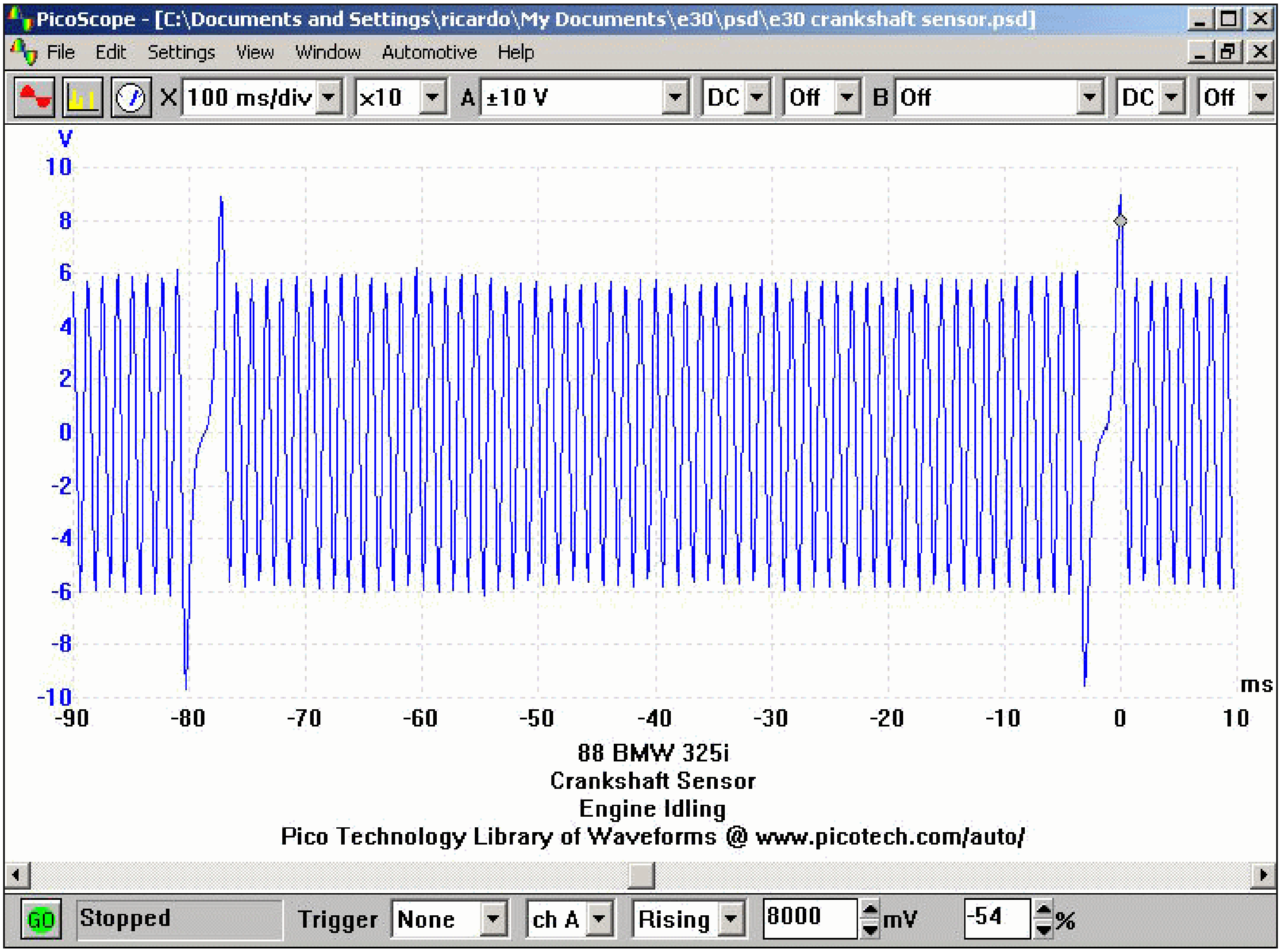


Volvo (Crankshaft Sensor and Injector Signals at idle) Reference Waveform

PICO SCOPE

CRANKSHAFT SENSOR – Inductive

Menu

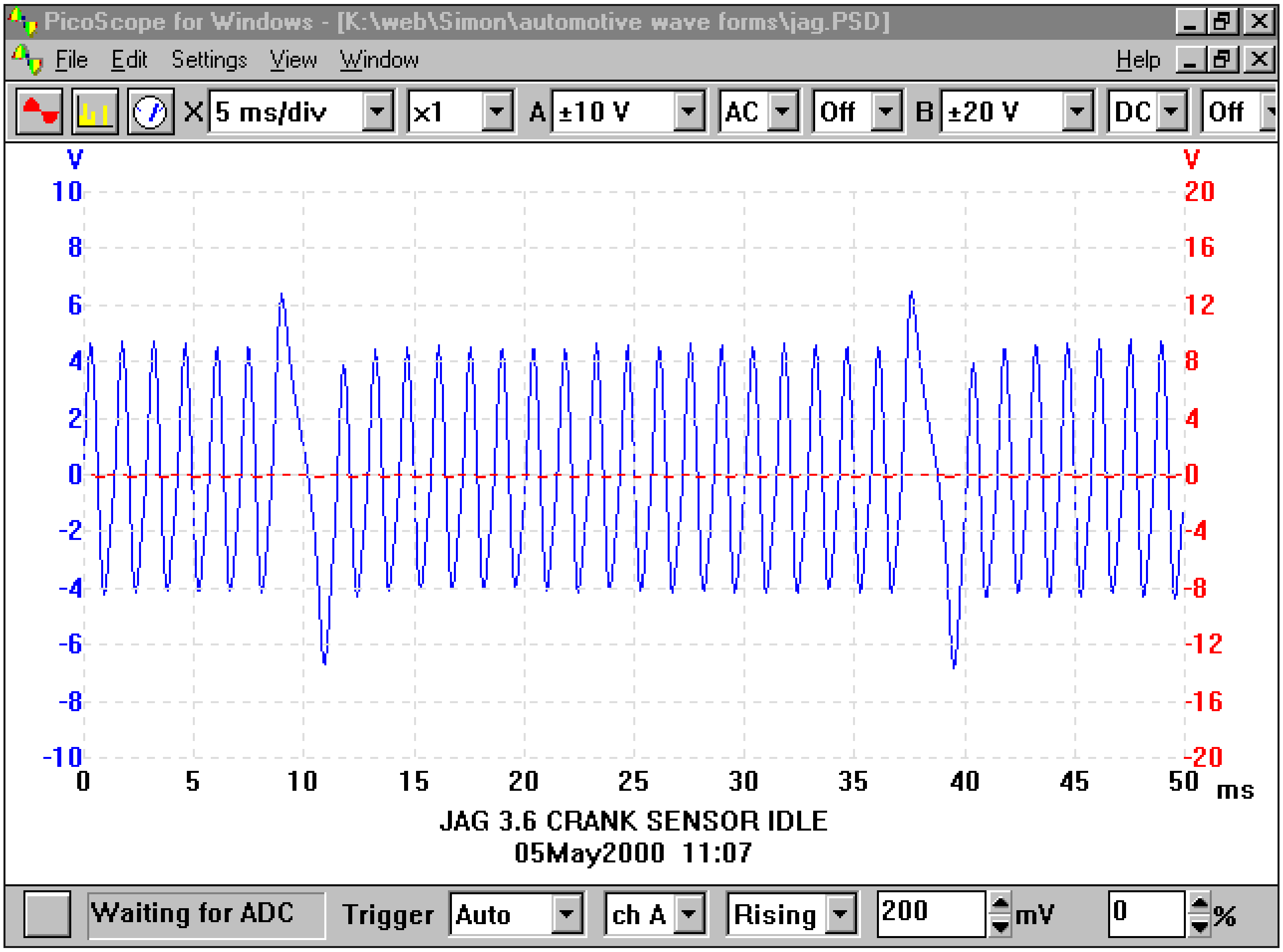


BMW 325i 1988 (Crankshaft Sensor - Inductive at idle) Reference Waveform

PICO SCOPE

CRANKSHAFT SENSOR – Inductive

Menu

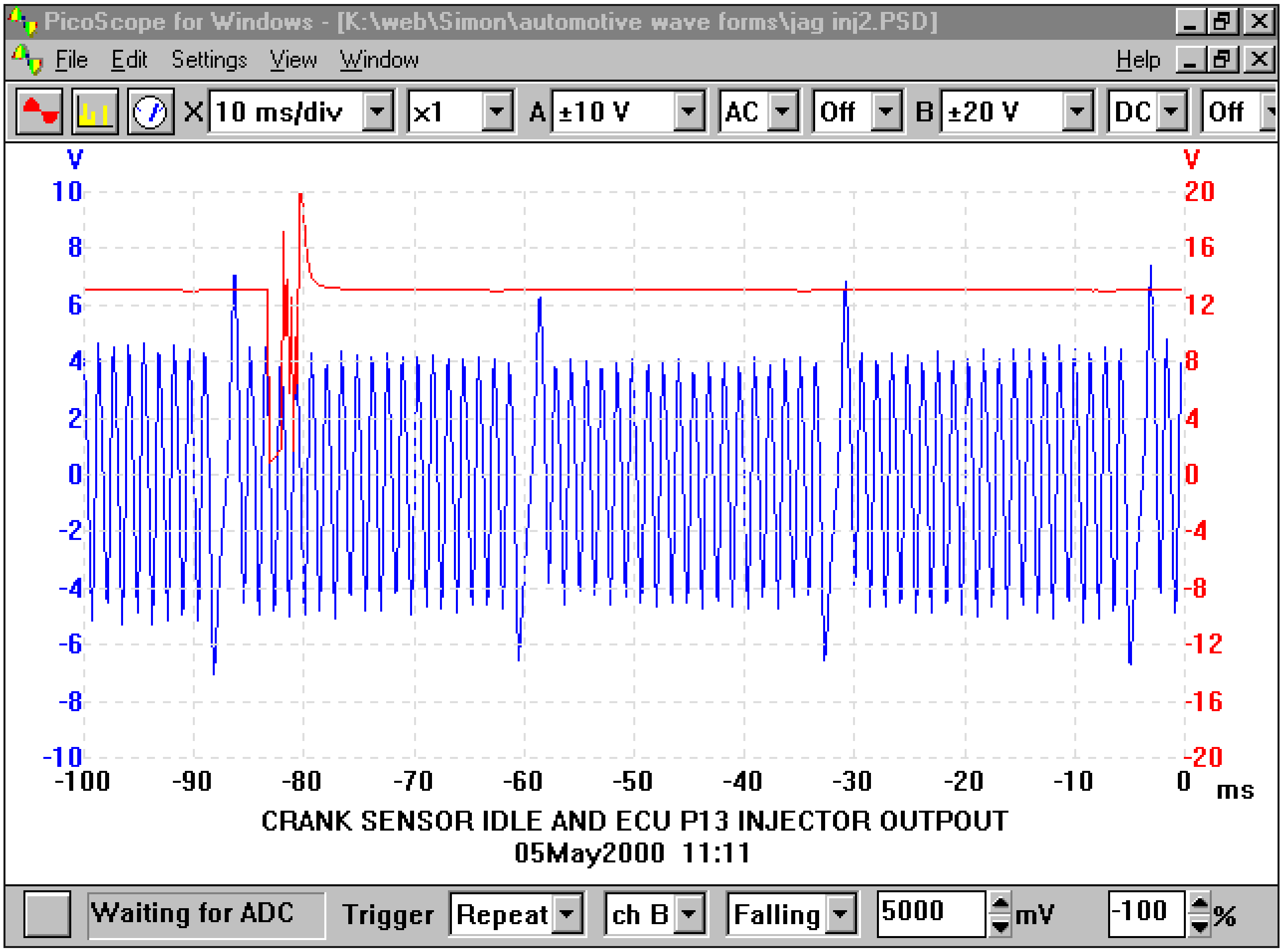


Jaguar 3.6L (Crankshaft Sensor - Inductive at idle) Reference Waveform

PICO SCOPE

Crankshaft Sensor – Inductive

Menu

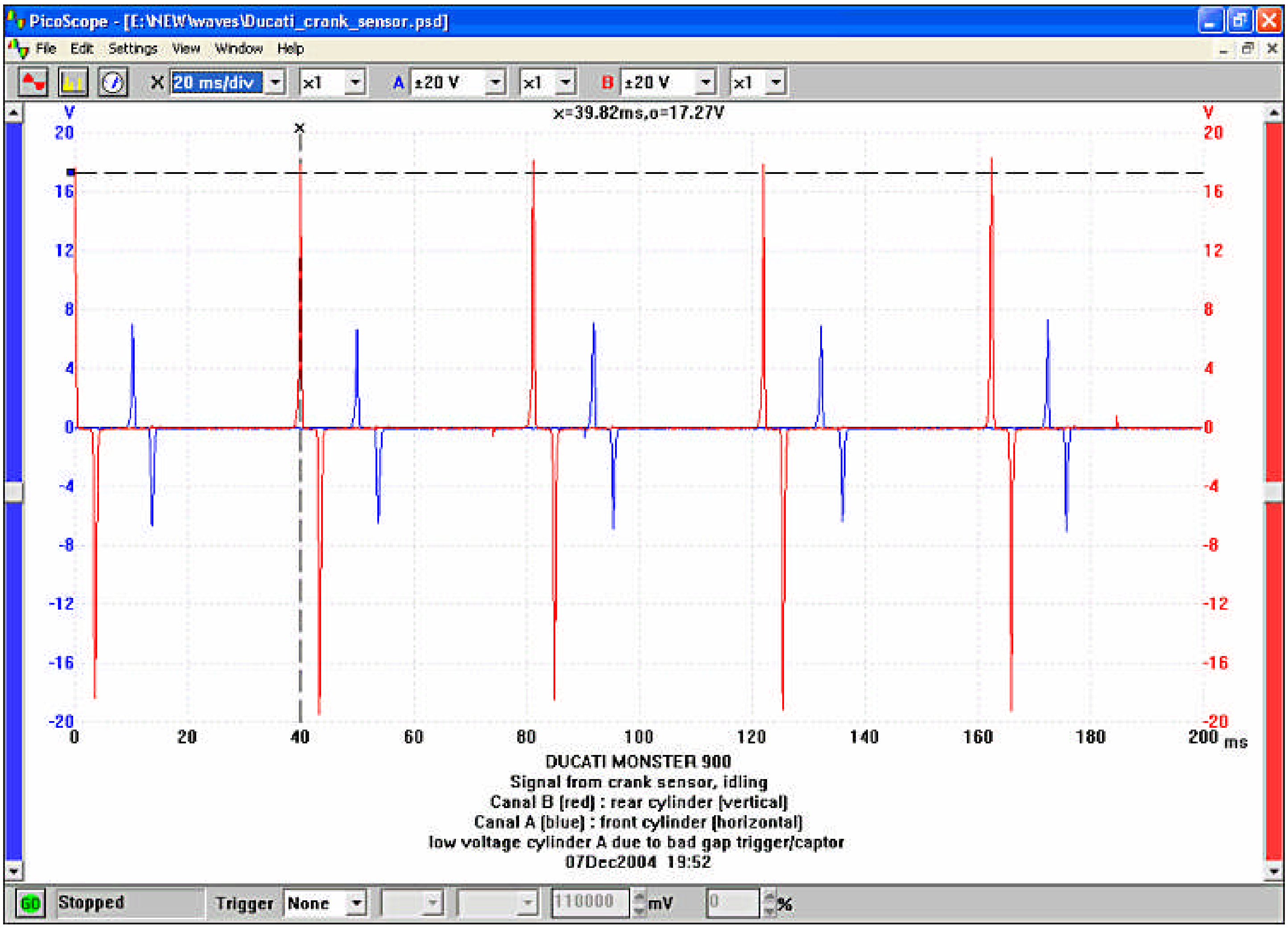


Jaguar 3.6L (Crankshaft Sensor - Inductive / ECU Injector Output at idle) Reference Waveform

PICO SCOPE

CRANKSHAFT SENSOR

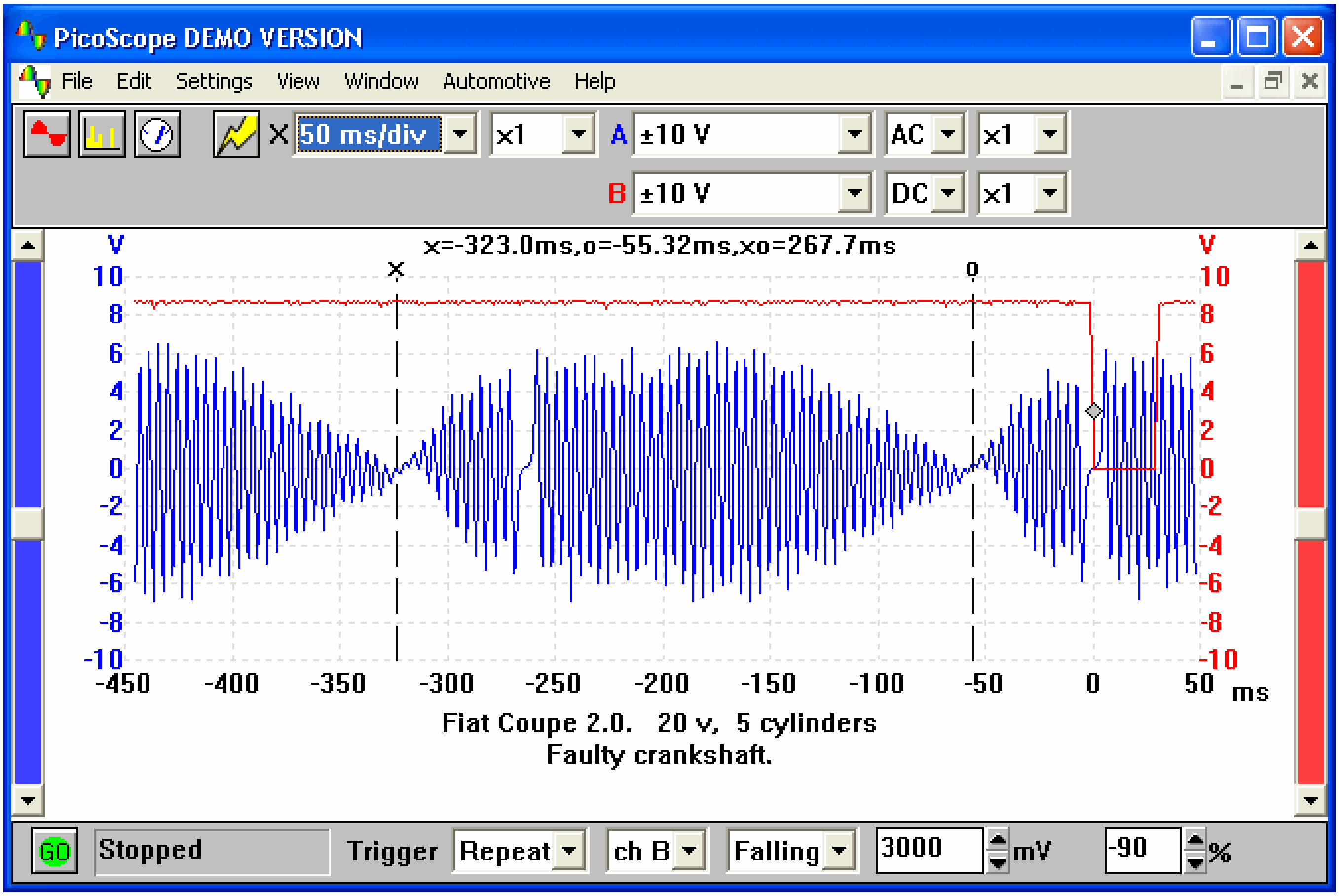
Menu



Ducati Monster 900 (CHA Front Cylinder, CHB Rear Cylinder) at idle Reference Waveform

CRANKSHAFT SENSOR

Menu



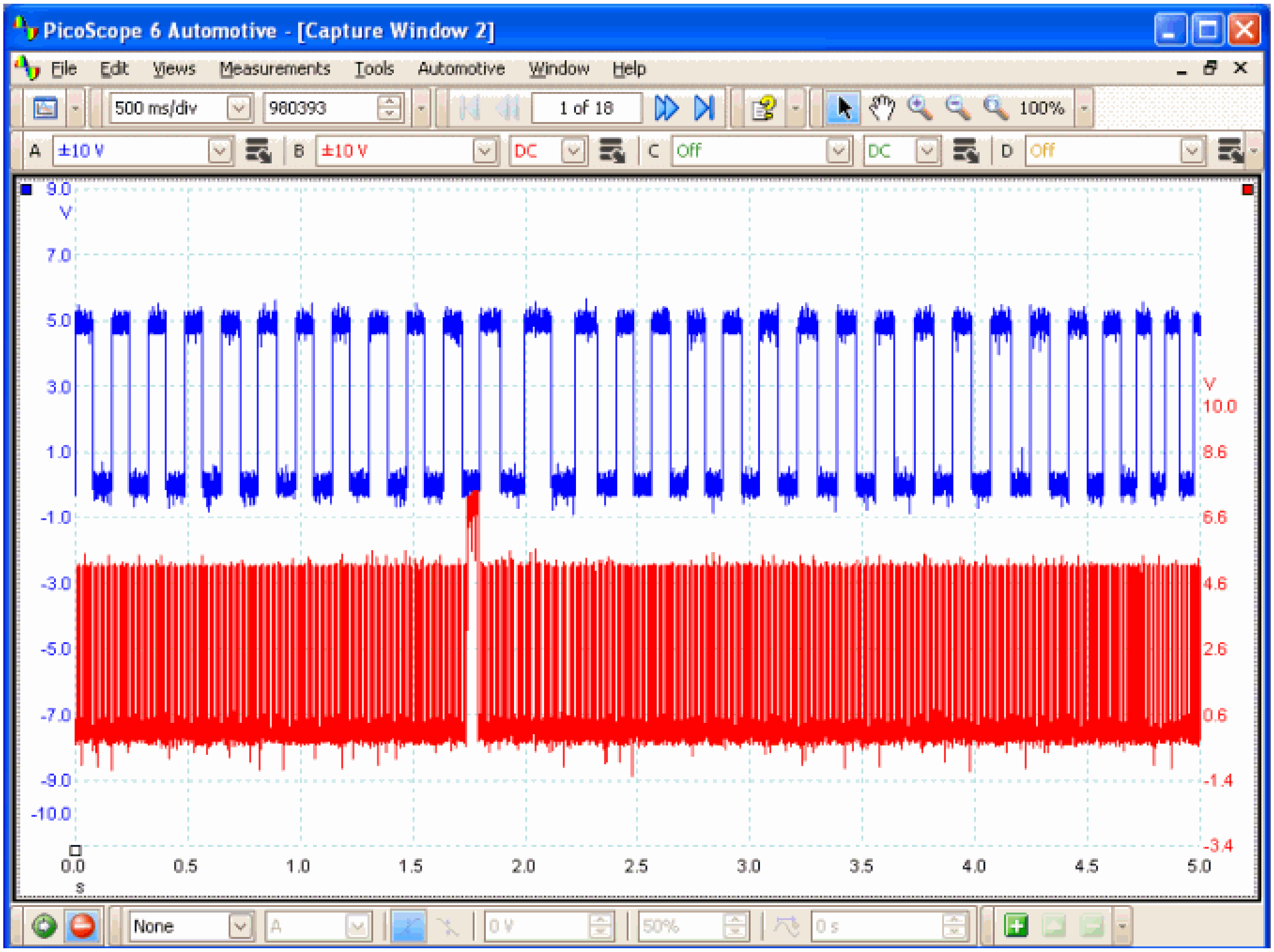
Reference Waveform Notes - Crank Sensor/Cam Sensor (Fiat Coupe 20V 5 Cyl. – Faulty Crankshaft)

The above waveform is a camshaft and crankshaft waveform from a Fiat Coupe (20V, 5 Cylinder).

The camshaft signal (channel B) is normal, but the crankshaft signal (channel A) decays away to near zero every revolution of the engine. This is caused by the flywheel moving away from the sensor. Possible causes are damage to the flywheel or serious mechanical damage to the crankshaft.

CRANKSHAFT SENSOR

Menu



Reference Waveform Notes - Crankshaft Sensor (Jeep Cherokee 4.0L – Faulty Crankshaft Sensor) Waveform captured with PICO 6 BETA Software

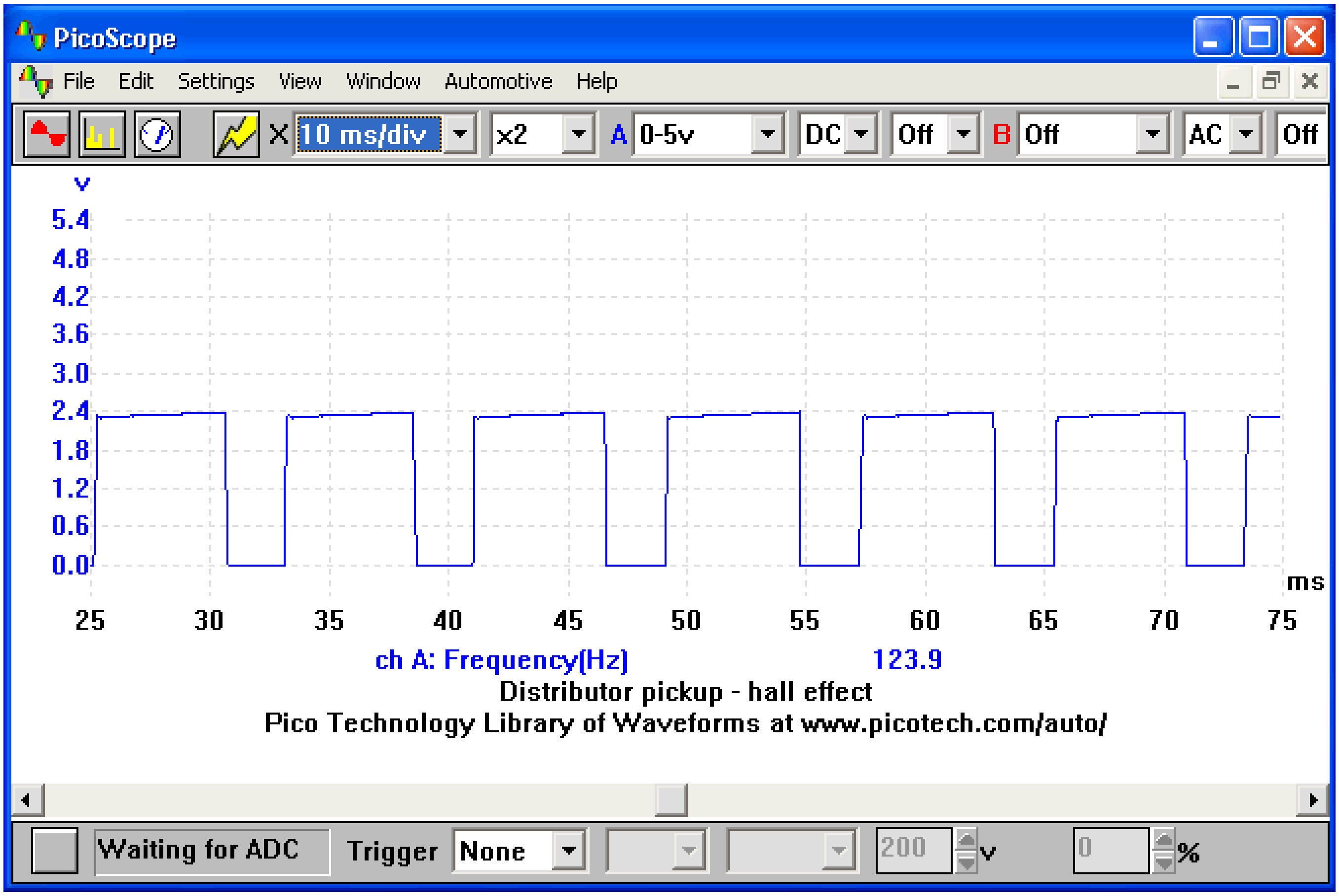
These waveforms are from a 1991 Jeep Cherokee 4.0 with an intermittent stall, hesitation and no start. Naturally the Jeep would not act up in the bay once the scope was hooked up, however, a short road test flushed out a single bump symptom.

A Pico Scope 3223 two channel automotive oscilloscope was used to capture the waveforms. The time base was set to display 5 seconds on each screen. Each channel was set to take a sample every 5 microseconds — a total of 980,393 samples per screen. In total 18 screens were recorded. (The Pico Scope Automotive software is capable of storing up to 32 screens so even after capturing 90 seconds of waveform there was still plenty of room in the waveform buffer.)

Several pre and post symptom CKP failures were captured during the short road test, including the actual failure that caused the symptom.

DISTRIBUTOR PICKUP – HALL EFFECT

Menu



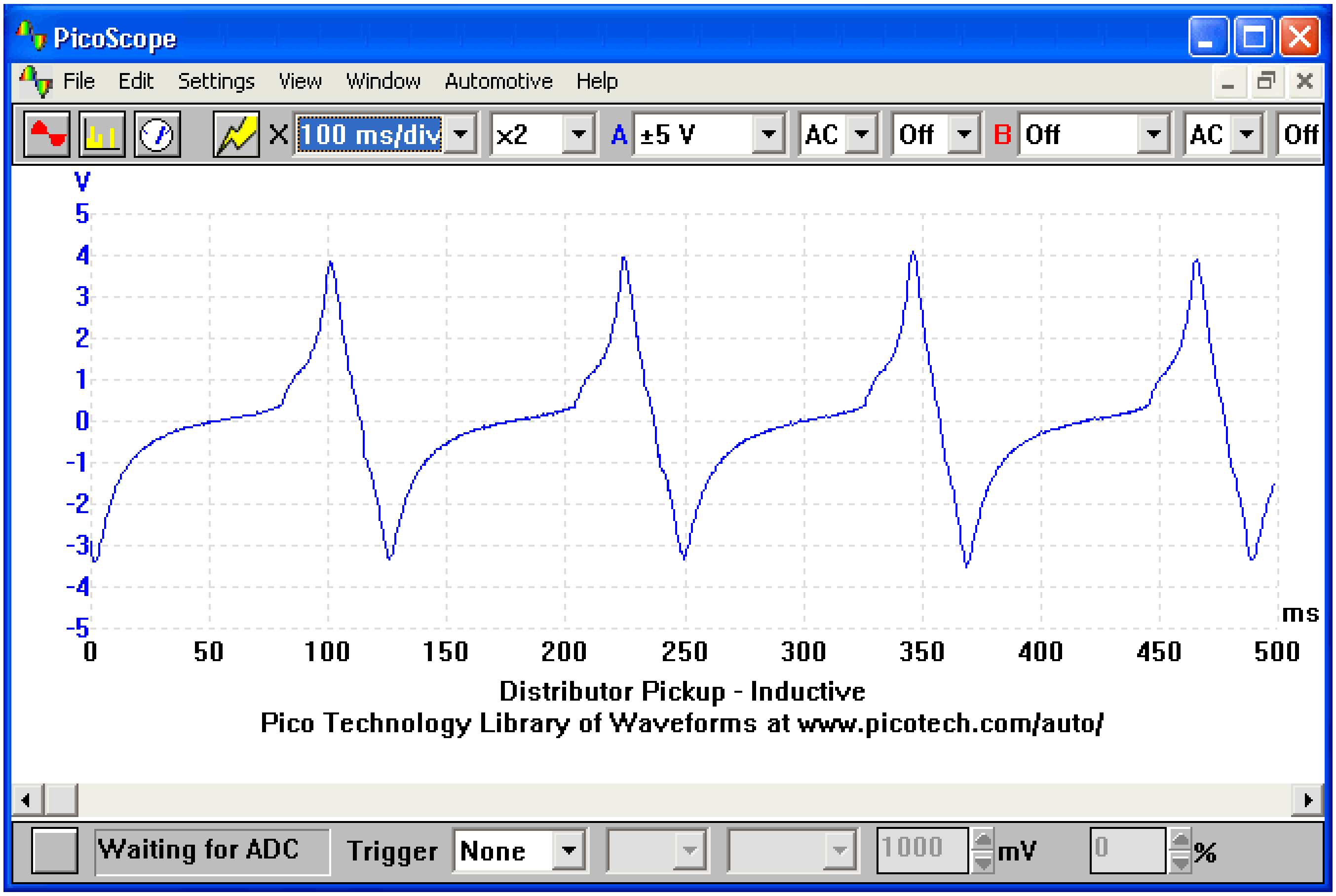
Reference Waveform Notes - Distributor Pickup (Hall Effect)

This form of trigger device is a simple digital 'on / off' switch which produces a Square wave output that is recognised and processed by the ignition control module. The trigger has a rotating metal disc with openings; this passes between the electromagnet and the semiconductor. The effect of a magnetic field that is able to pass through one of the 'windows' will stop the flow of voltage. When the 'window' is closed the flow is reinstated. This action will produce a digital square wave that is understood by the Electronic Control Unit (ECM) or amplifier.

The sensor will have its characteristic three connections which are: a live supply voltage, an earth and the output signal. The square wave when monitored on an oscilloscope may vary in amplitude; this is not thought to be a problem as it is the frequency that is important, not the height of the voltage. When the voltage from the Hall effect trigger drops to zero volts, it fires the coil. This occurs when the 'window' on the metallic rotating vane opens.

DISTRIBUTOR PICKUP – INDUCTIVE

Menu



Reference Waveform Notes - Distributor Pickup – Inductive (Engine Cranking)

This particular type of pick-up generates its own signal and therefore does not require a voltage supply to power it. Recognisable by its two electrical connections, the pick-up is used as a signal to trigger the ignition amplifier or Electronic Control Module (ECM).

This type of pick-up could be described as a small alternator because the output voltage rises as the metal rotor approaches the winding, sharply dropping through zero volts as the two components are aligned and producing a voltage in the opposite phase as the rotor passes. The waveform is known as a sine wave.

The cranking voltage produced by the pick-up will be determined by several factors, these being :

- Cranking speed - the voltage produced will be approximately 2 to 3 volts when cranking at a speed of around 250 RPM
- The proximity of the metal rotor to the pick-up winding. An average air gap will be in the order of 8 to 14 thou, a larger air gap will reduce the strength of the magnetic field seen by the winding and the output voltage will be subsequently reduced.
- The strength of the magnetic field offered by the magnet. The strength of this magnetic field determines the effect it has as it 'cuts' through the windings and the output voltage will be

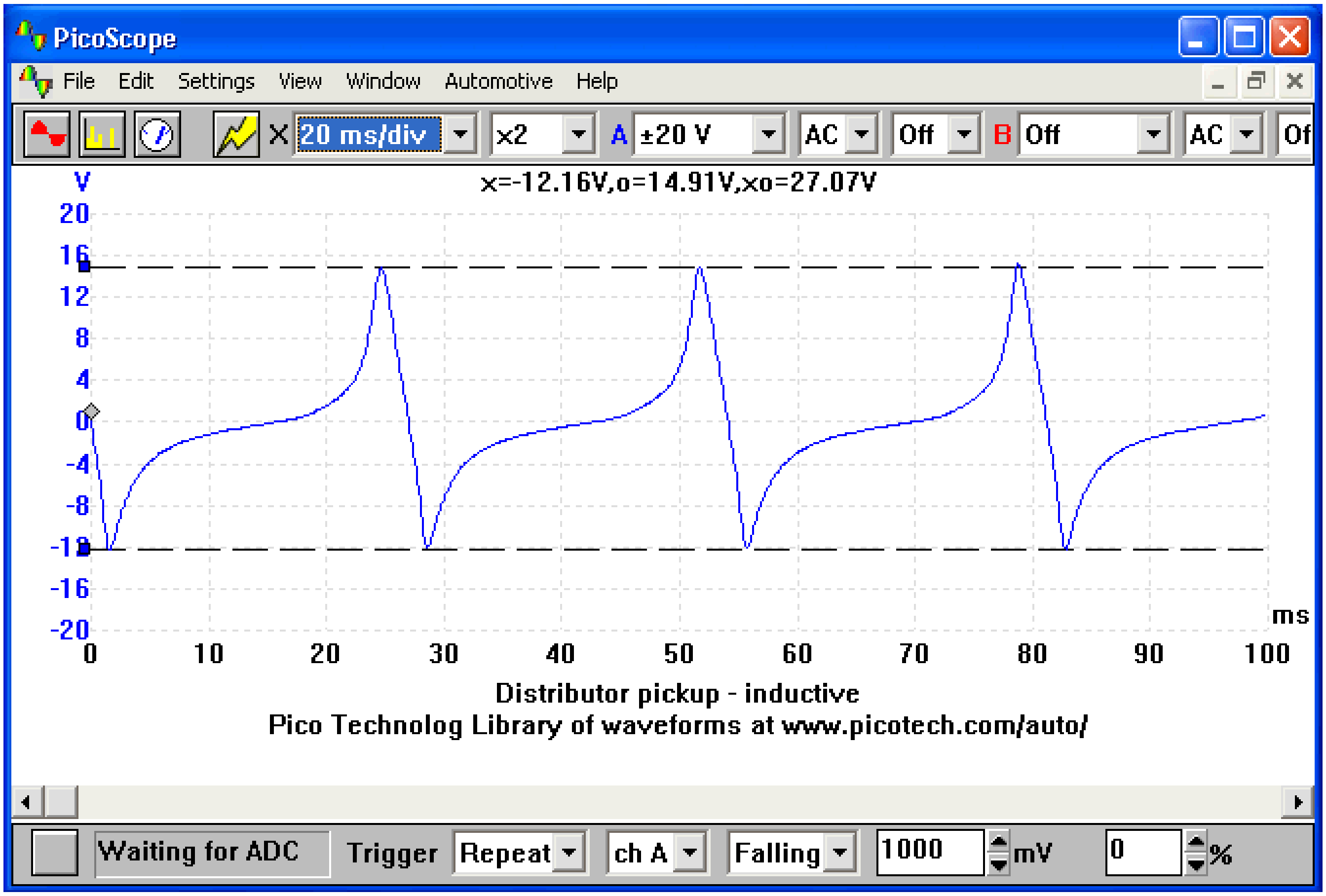
reduced accordingly.

A difference between the positive and the negative voltages may also be apparent as the negative side of the sine wave is sometimes attenuated when connected to the amplifier circuit, but will produce perfect AC when disconnected and tested under cranking conditions.

The majority of pick-up's will produce approximately 3 volts peak to peak and this figure is widely accepted to be the minimum requirement to trigger the amplifier / ECM, this voltage will also however be manufacturer and model specific and may differ slightly.

DISTRIBUTOR PICKUP – INDUCTIVE

Menu



Reference Waveform Notes - Distributor Pickup - Inductive (Engine Running)

This particular type of pick-up generates its own signal and therefore does not require a voltage supply to power it. Recognisable by its two electrical connections, the pick-up is used as a signal to trigger the ignition amplifier or Electronic Control Module (ECM). As the metal rotor spins, a magnetic field is altered which induces an Alternating Current (AC) voltage from the pick-up. This type of pick-up could be described as a small alternator because the output voltage rises as the metal rotor approaches the winding, sharply dropping through zero volts as the two components are aligned and producing a voltage in the opposite phase as the rotor passes. The waveform is known as a sine wave.

The voltage produced by the pick-up will be determined by several factors, these being :-

- Engine speed - the voltage produced will rise from as low as 2 to 3 volts when cranking to over 50 volts, at higher engine speeds.
- The proximity of the metal rotor to the pick-up winding. An average air gap will be in the order of 8 to 14 thou, a larger air gap will reduce the strength of the magnetic field seen by the winding and the output voltage will be subsequently reduced.
- The strength of the magnetic field offered by the magnet. The strength of this magnetic field determines the effect it has as it 'cuts' through the windings and the output voltage will be

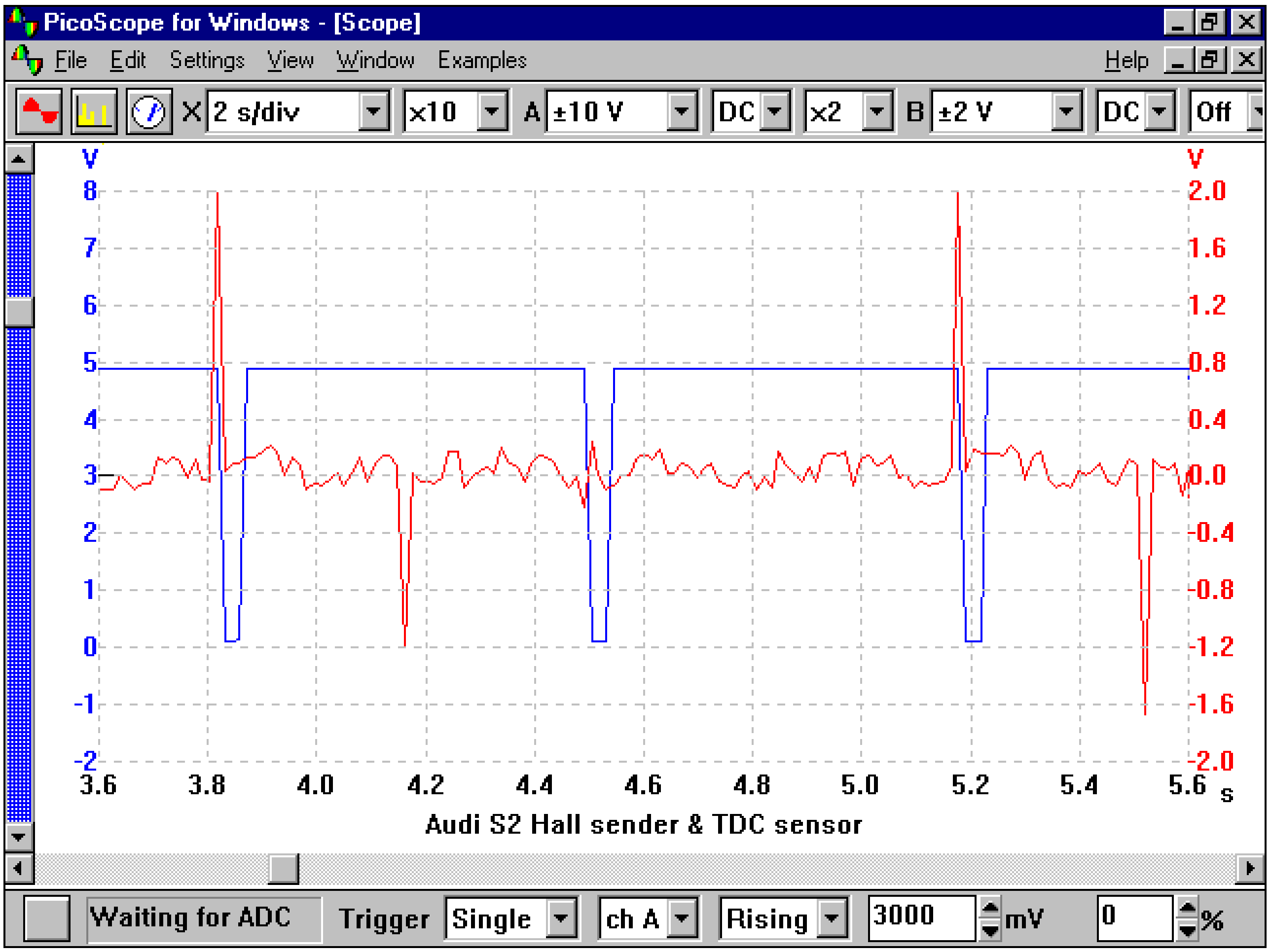
reduced accordingly.

A difference between the positive and the negative voltages may also be apparent as the negative side of the sine wave is sometimes attenuate when connected to the amplifier circuit, but will produce perfect AC when disconnected and tested under cranking conditions.

PICO SCOPE

DISTRIBUTOR PICKUP – Hall Effect

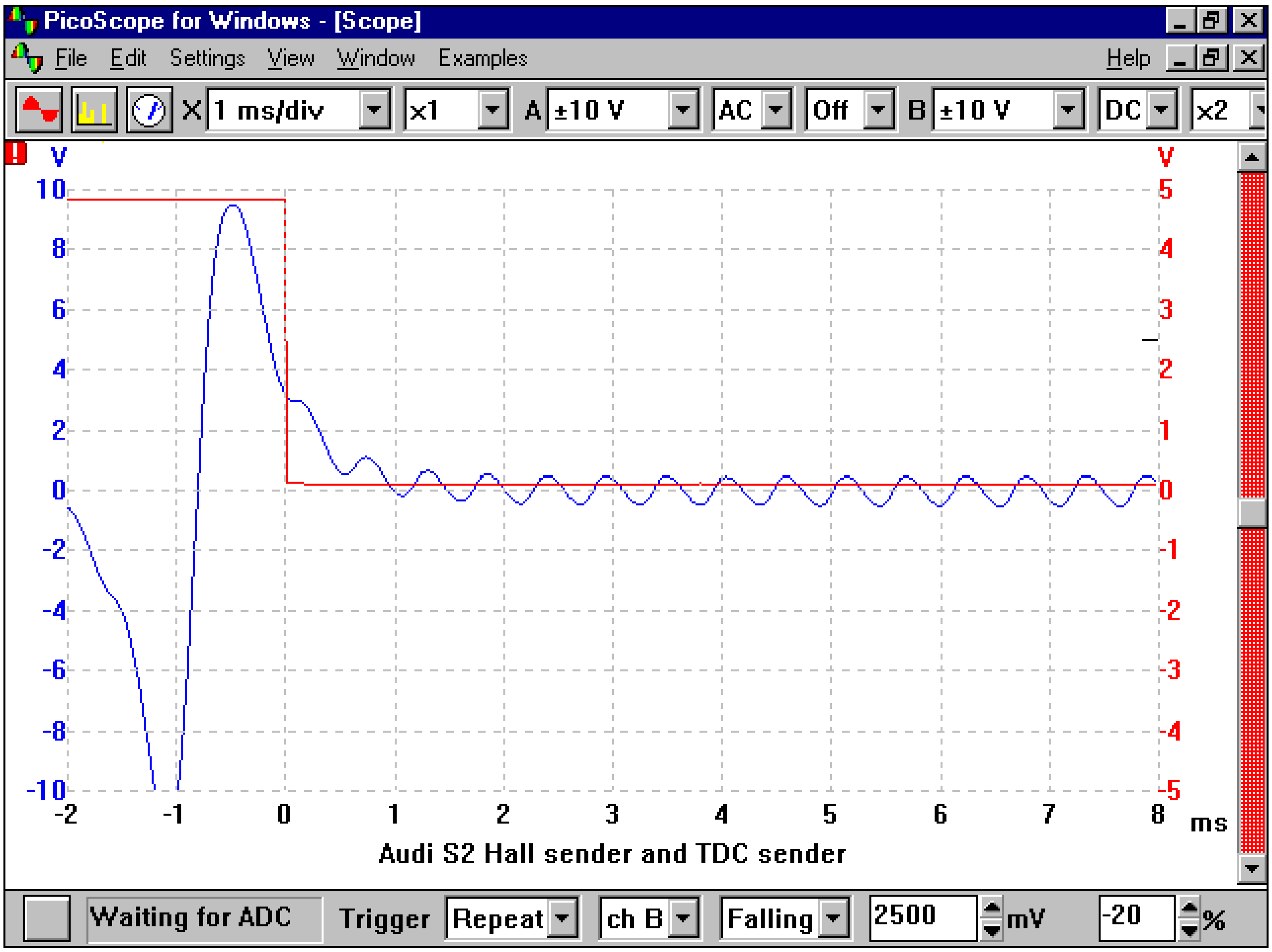
Menu



Distributor Pickup (Audi S2 - Hall Sender and TDC Sensor) Reference Waveform

PICO SCOPE

DISTRIBUTOR PICKUP – Hall Effect Menu

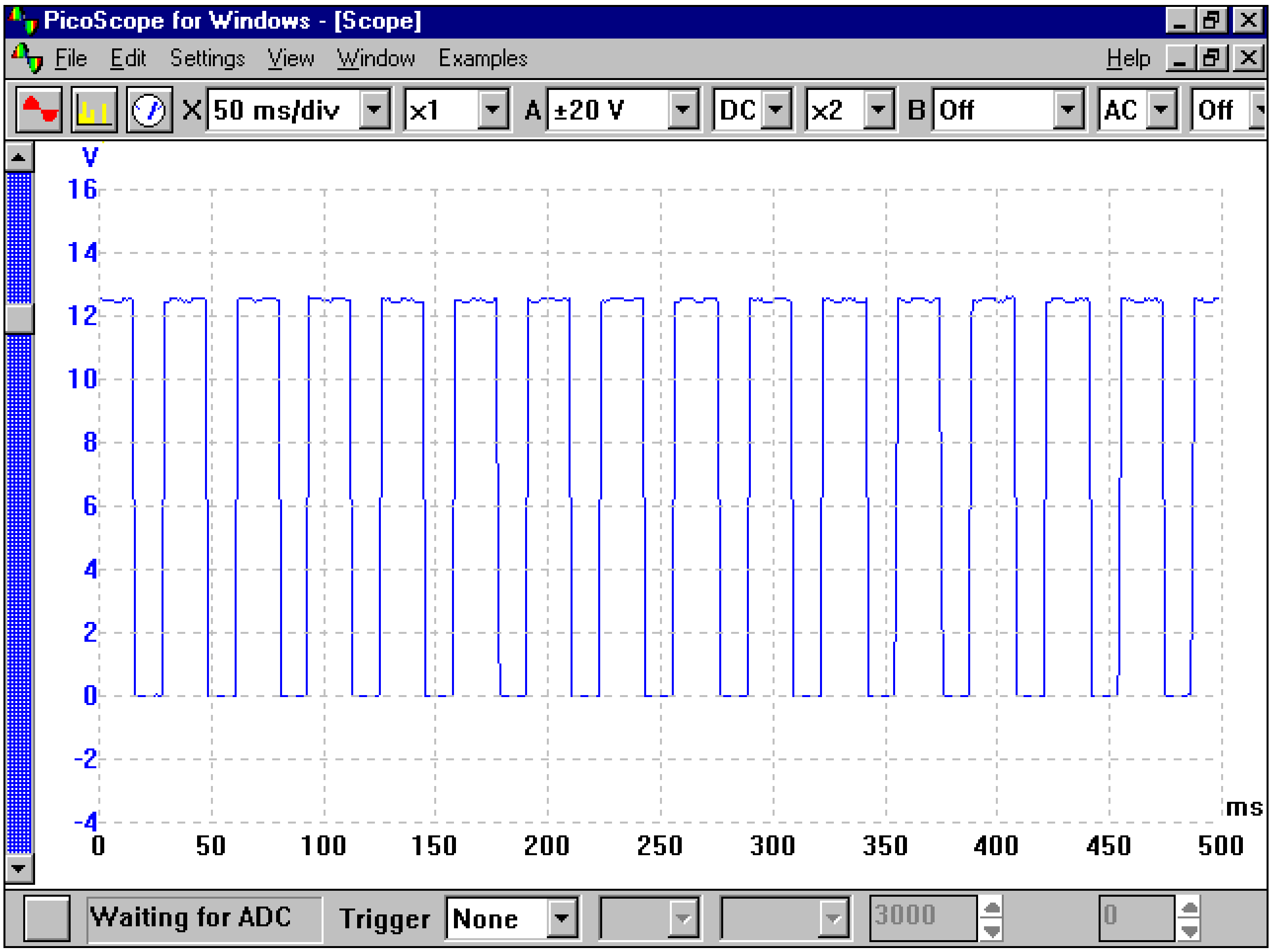


Distributor Pickup – (Audi S2 - Hall Sender / TDC Sensor - detail timing view) Reference Waveform

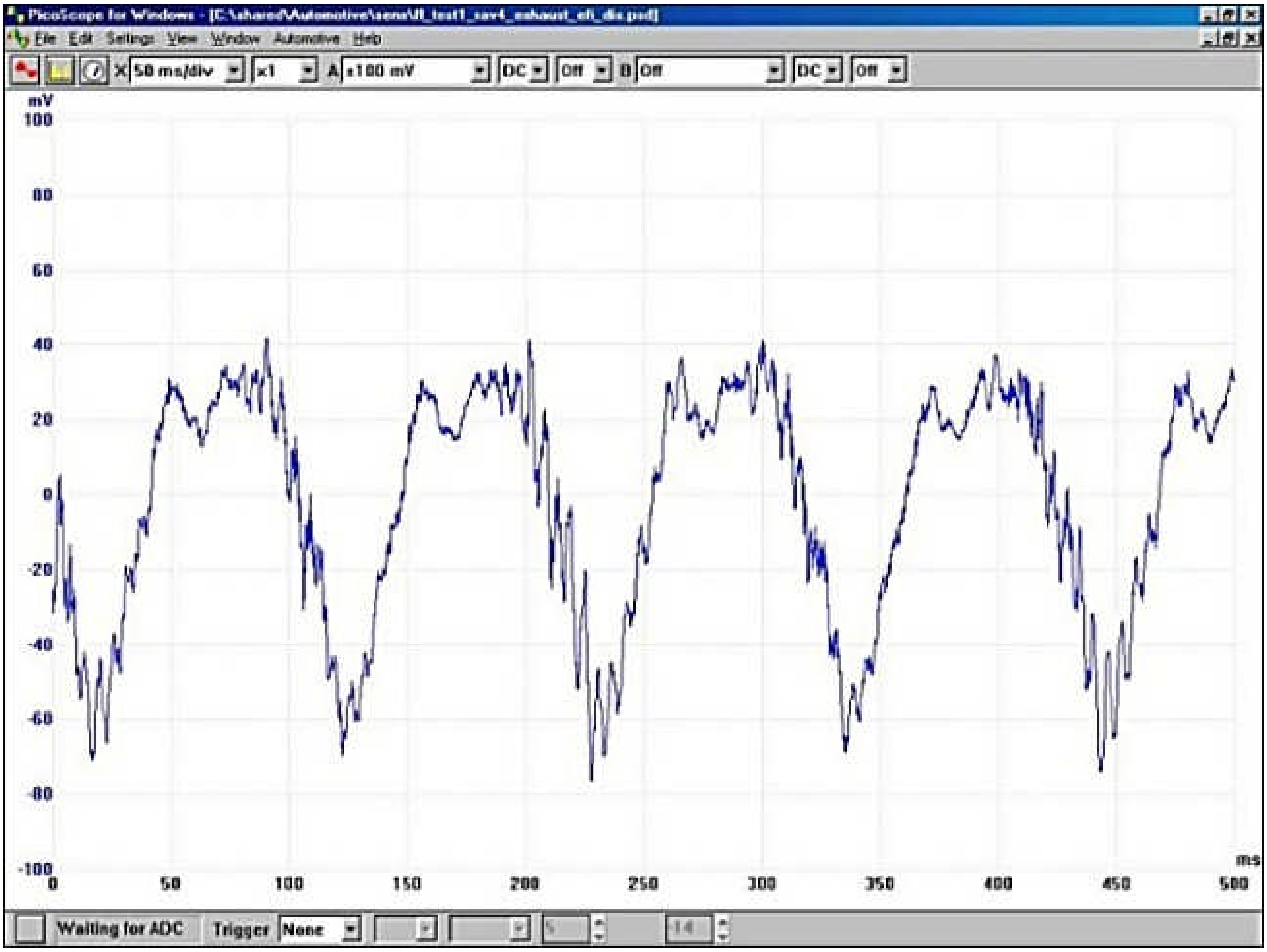
PICO SCOPE

DISTRIBUTOR PICKUP – Hall Effect

Menu



Distributor Pickup – Hall Effect (VW Passat - Hall Sender) Reference Waveform

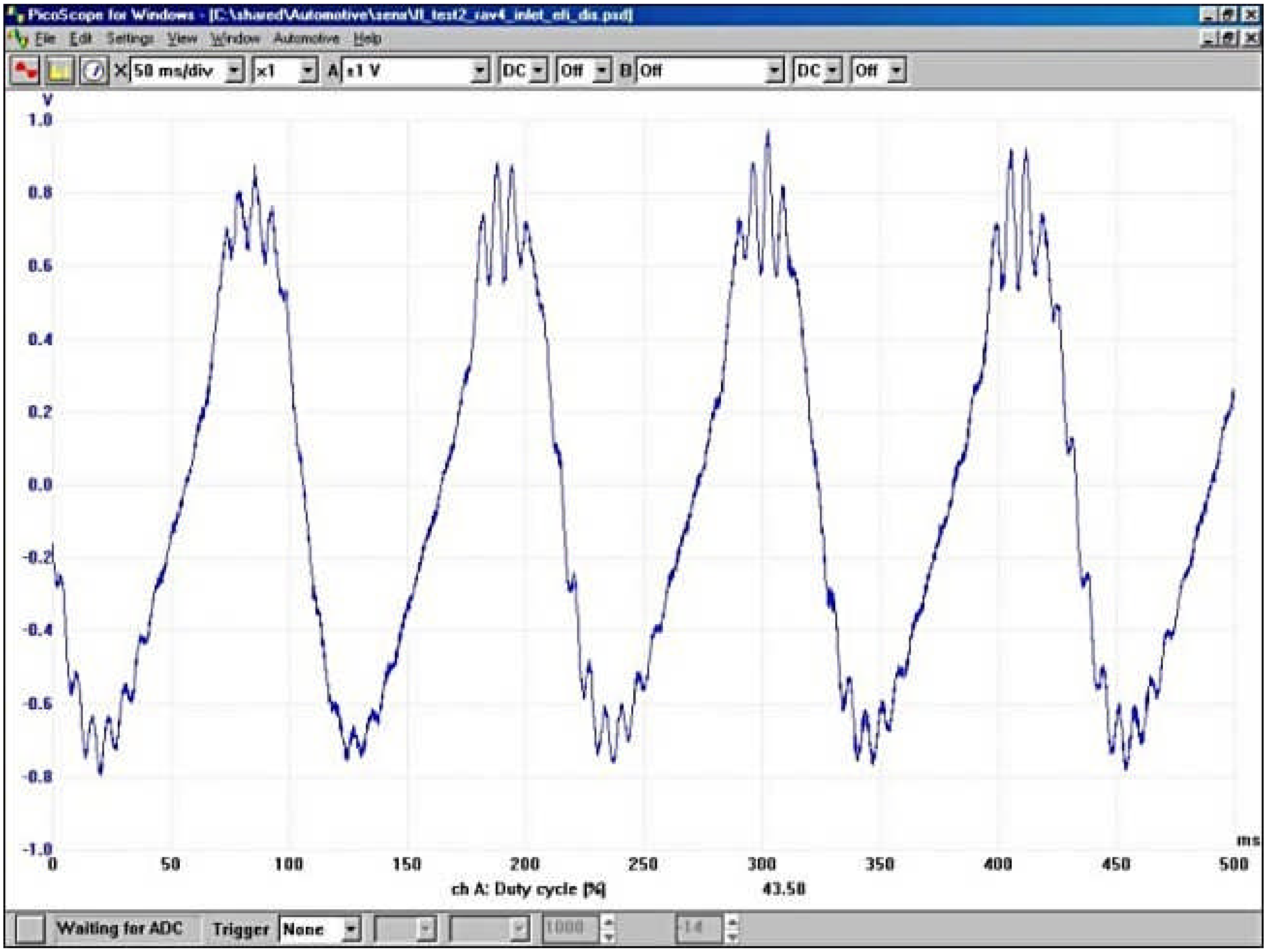


Reference Waveform Notes - FirstLook Diagnostic Sensor (Toyota RAV 4 – Engine Cranking)

The automotive waveform above shows engine cranking (injection disabled) on a Toyota Rav4. This waveform was produced using the SenX FirstLook diagnostic sensor positioned in the exhaust tailpipe.

FIRSTLOOK DIAGNOSTIC SENSOR

Menu

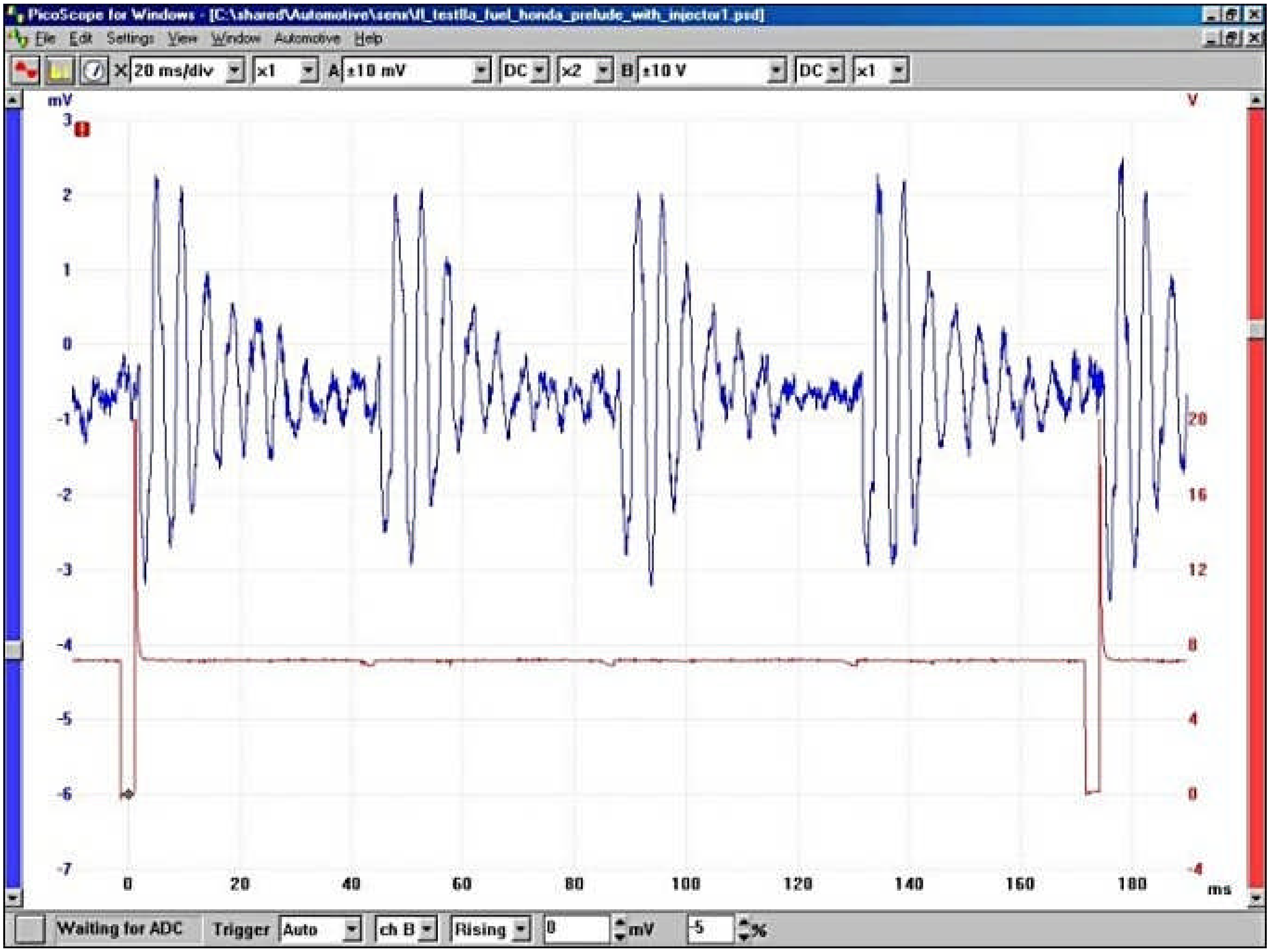


Reference Waveform Notes - FirstLook Diagnostic Sensor (Toyota RAV 4 – Engine Cranking)

The automotive waveform above shows engine cranking (injection disabled) on a Toyota Rav4. This waveform was produced using the SenX FirstLook engine diagnostic sensor positioned on the inlet manifold.

FIRSTLOOK DIAGNOSTIC SENSOR

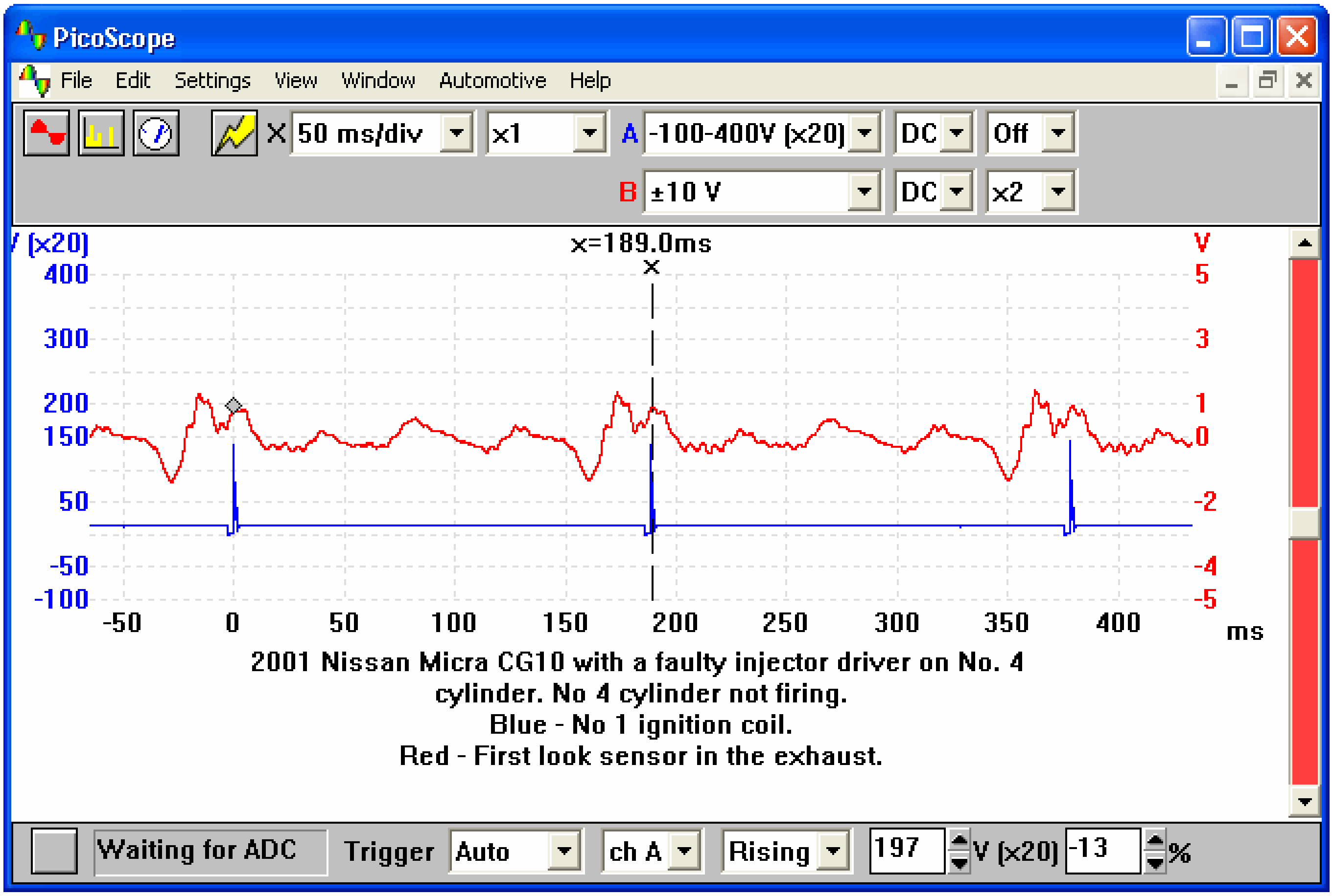
Menu



Reference Waveform Notes - FirstLook Sensor (Honda Prelude – Fuel Pressure Regulator/Injector)

The automotive waveform above was produced using the SenX FirstLook engine diagnostic sensor on the fuel pressure regulator of a Honda Prelude (channel A), triggered from injector 1 (channel B).

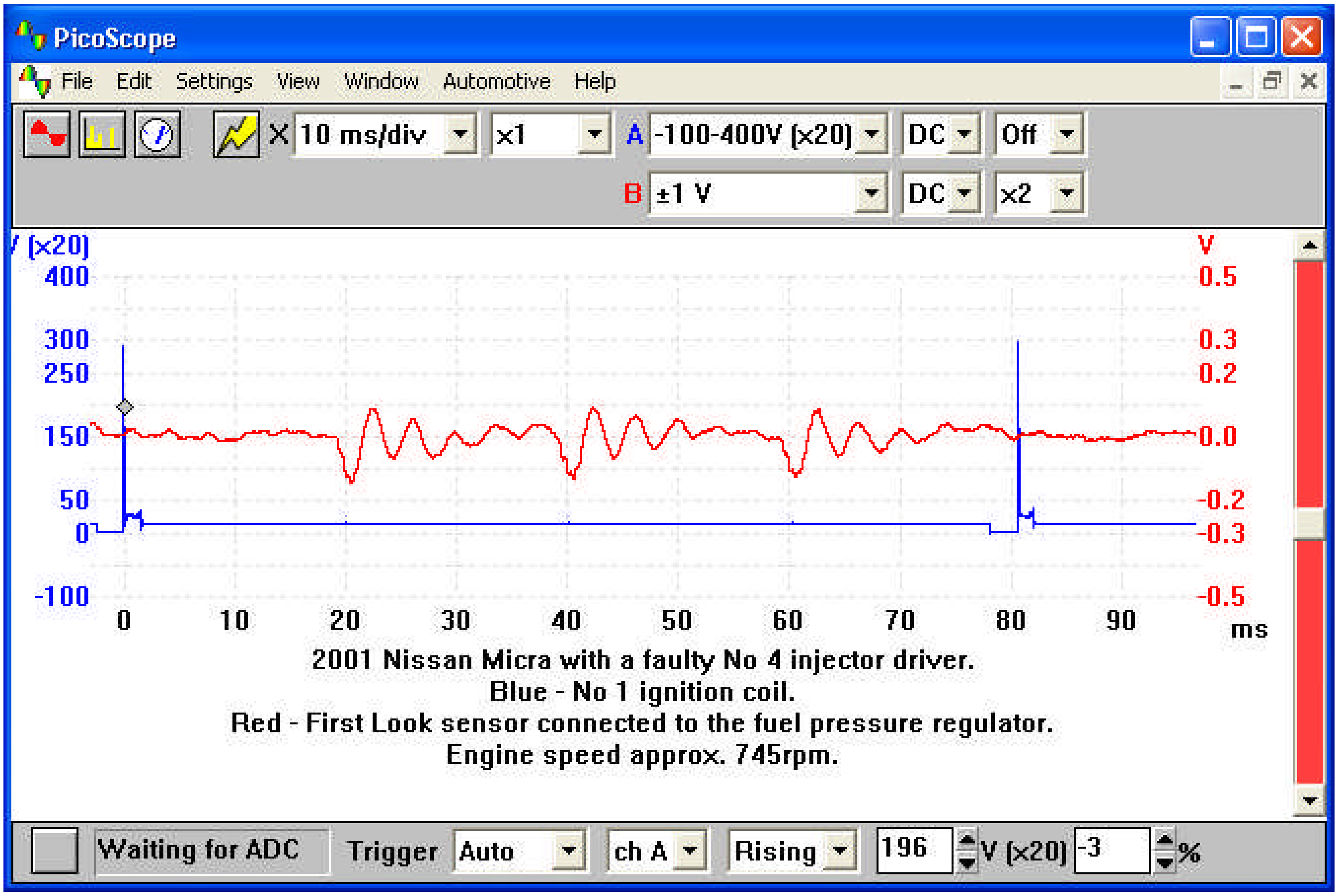
FIRSTLOOK DIAGNOSTIC SENSOR – Waveform 1 (Sensor in Exhaust) Menu



Reference Waveform Notes - FirstLook Diagnostic Sensor (Nissan Micra – Faulty Injector Driver)

See waveform explanation in next page.

FIRSTLOOK DIAGNOSTIC SENSOR – Waveform 2 (Sensor on Fuel Pressure Regulator) [Menu]



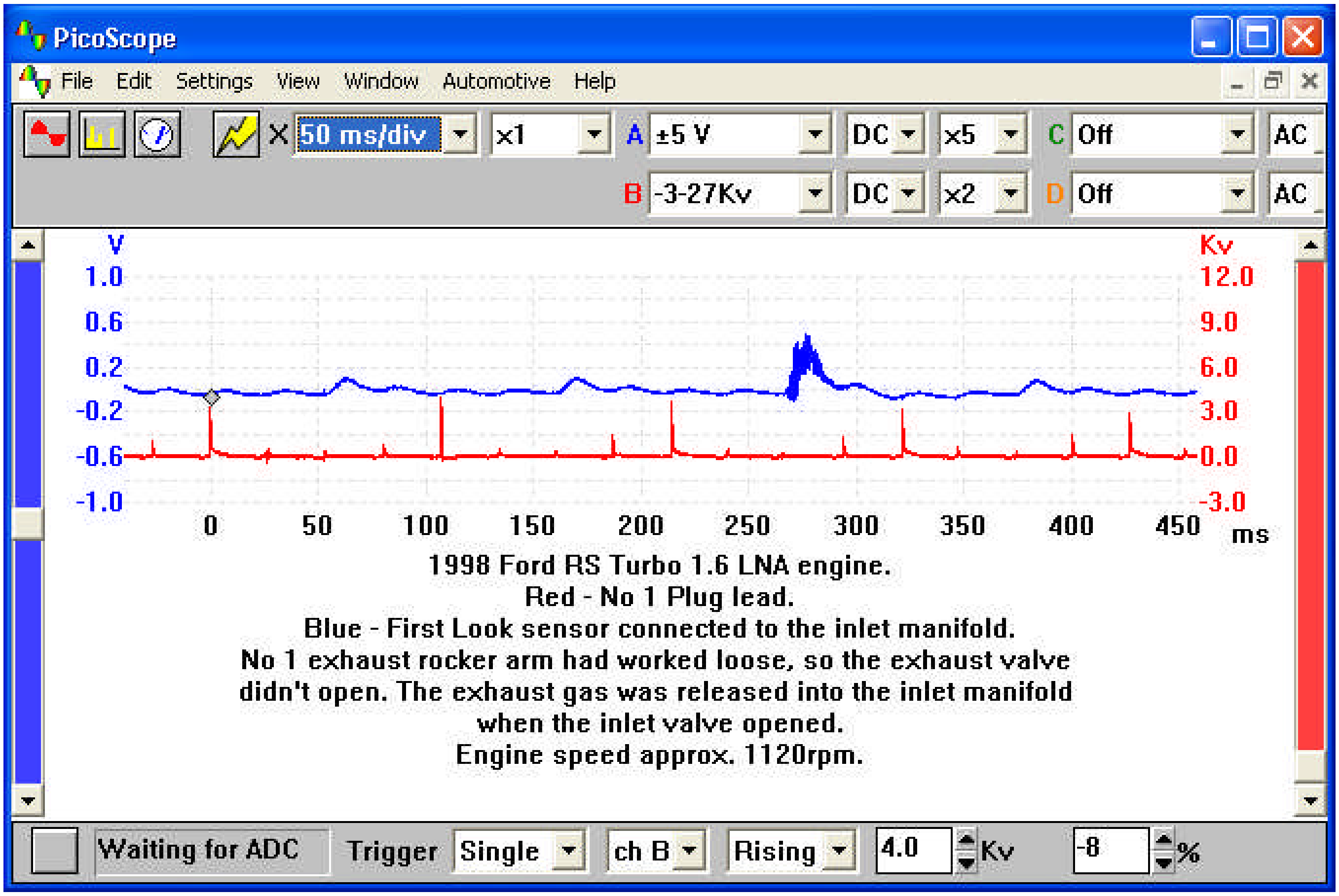
FirstLook Diagnostic Sensor (Nissan Micra – Faulty Injector Driver) Reference Waveform Notes

The above waveforms show a Nissan Micra with a faulty injector: the injector driver for cylinder number 4 was found to be faulty which meant the injector was not opening.

Waveform 1 is with the FirstLook sensor on the exhaust and it shows a big difference in exhaust pressure between cylinders 3 and 2 as there is no combustion taking place in cylinder 4. Firing order is 1342. The blue trace shows ignition on cylinder 1 (when cylinder 1 is firing cylinder 4 is on its exhaust stroke). Waveform 2 is with the FirstLook sensor connected to the fuel pressure regulator and it shows that the fuel pressure on the rail does not drop when injector number 4 is supposed to open.

These waveforms were contributed by Andrew Clarkson from John Clarkson Auto Services.

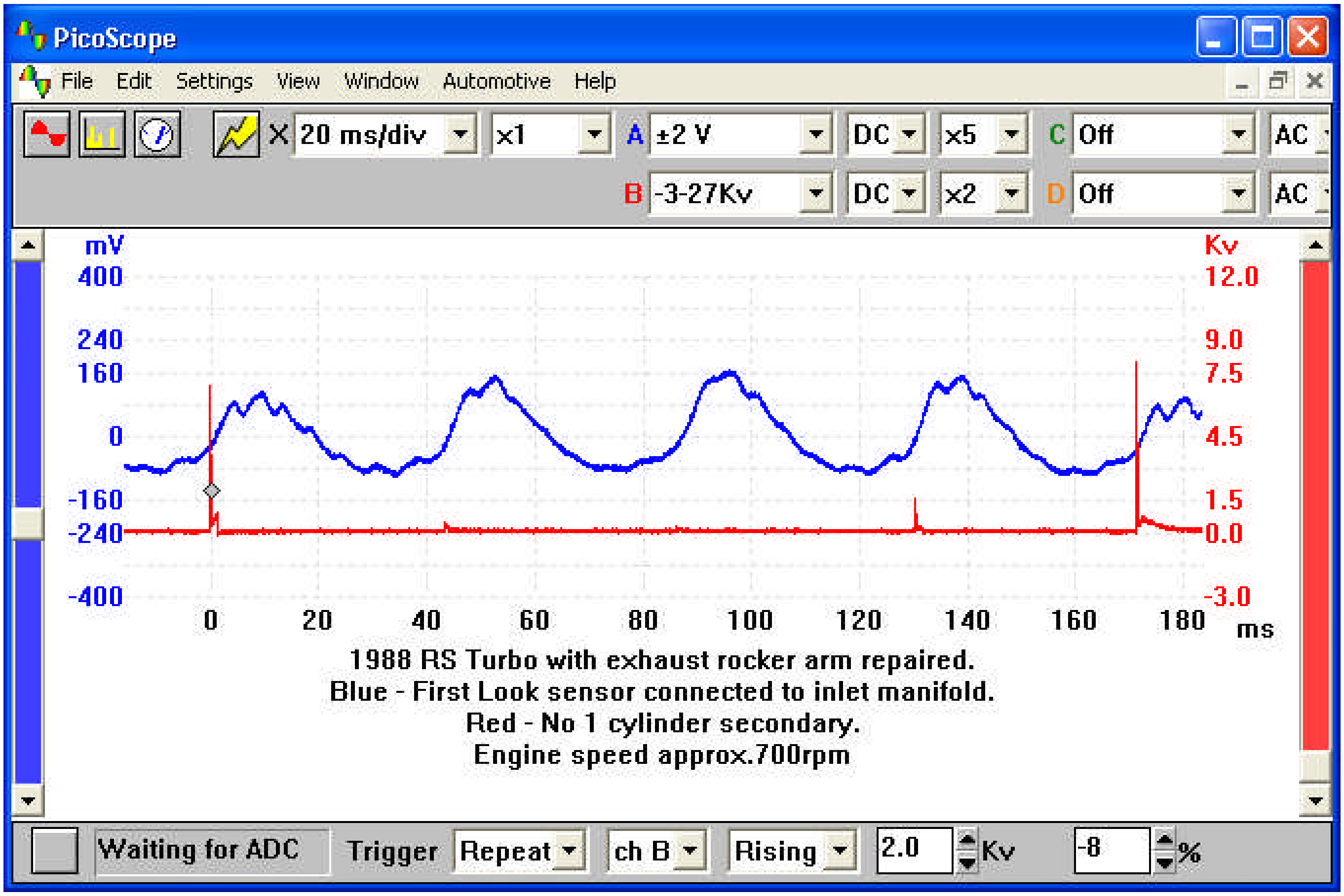
FIRSTLOOK DIAGNOSTIC SENSOR – Waveform 1 (Ford RS Turbo with loose rocker arm) Menu



Reference Waveform Notes - FirstLook Diagnostic Sensor (Ford RS Turbo 1.6L – Loose Rocker Arm)

See waveform explanation in next page.

FIRSTLOOK DIAGNOSTIC SENSOR – Waveform 2 (Ford RS Turbo repaired rocker arm) Menu



FirstLook Sensor (Ford RS Turbo 1.6L – Repaired Loose Rocker Arm) Reference Waveform Notes

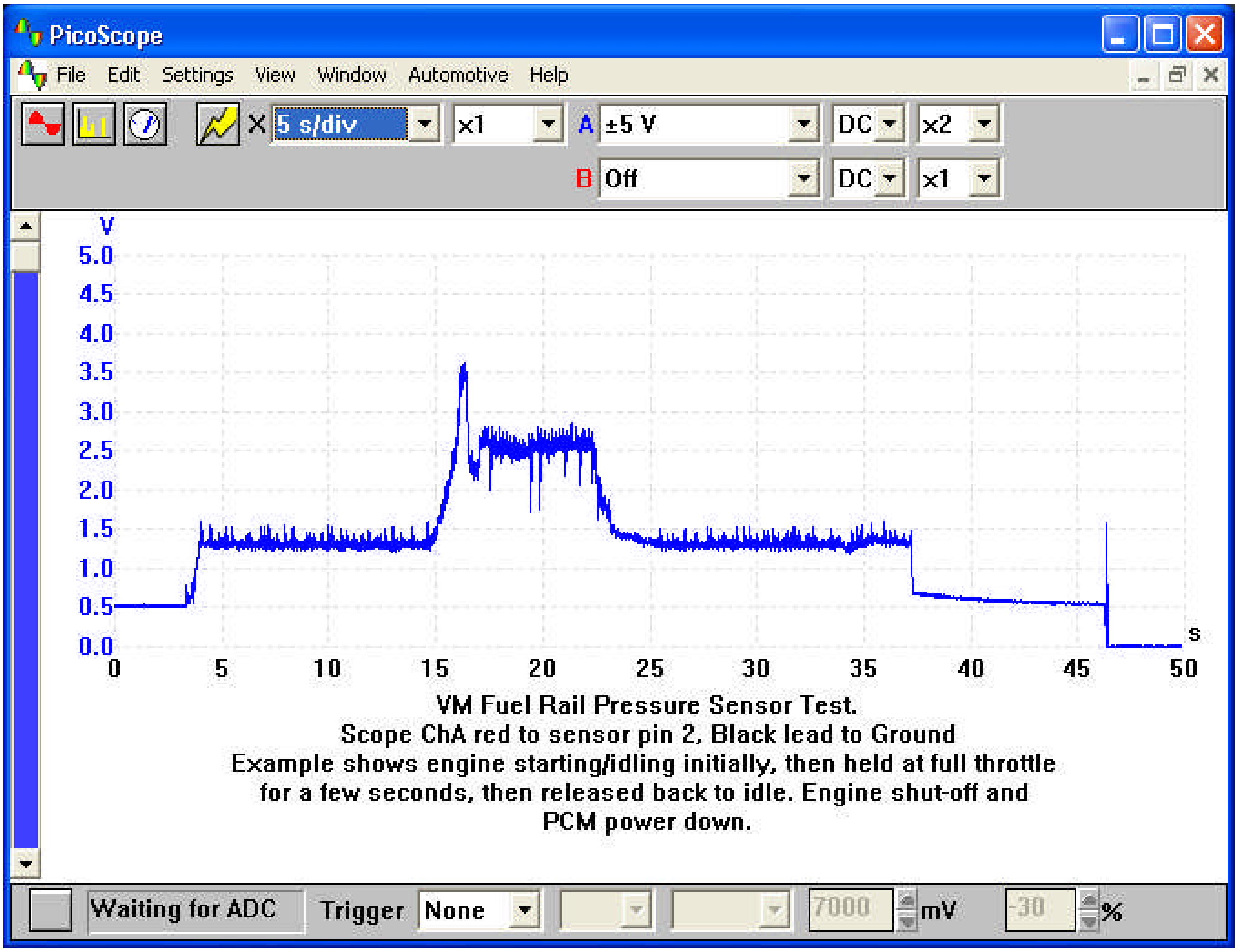
In both of the above waveforms, the FirstLook sensor was connected to the inlet manifold and to Channel A on the oscilloscope. Channel B of the oscilloscope was connected to the number 1 plug lead.

The RS Turbo had a loose rocker arm for cylinder number 1 which meant the exhaust valve wasn’t opening at all. The exhaust gases were then expelled into the inlet manifold as soon as the inlet valve opened. This can be seen quite nicely in waveform 1. Waveform 2 shows the resulting waveform once the rocker arm had been repaired.

These waveforms were contributed by Andrew Clarkson from John Clarkson Auto Services.

FUEL PRESSURE SENSOR – COMMON RAIL DIESEL

Menu



Reference Waveform Notes - Fuel Pressure Sensor (Common Rail Diesel)

This waveform shows a test of the fuel system on a common rail diesel engine, using the fuel rail pressure sensor.

The PCM varies the rail pressure between about 280 bar at idle and 1600 bar at full speed and load. The sensor is the feedback component in a control loop, and informs the PCM what pressure is in the rail. The PCM can then tell the pump to increase or decrease output accordingly.

The PCM controls the pressure regulator or “M-Prop” valve on the pump to control pump pressure. When you press the pedal, the PCM will immediately calculate how much fuel to give the engine based on speed, load, etc. and the internal calibration table. This fuelling table is specifically for that engine/vehicle combination. The sensor gives a continual feedback of rail pressure so that the PCM can make any pressure adjustments almost instantaneously.

We can analyse the performance of the system by graphing the output of the sensor against time, whilst we start, run, accelerate, hold at full speed, and return to idle. We finally switch off and wait for PCM power down (normally around 10 seconds after key-off). The scope is best set to a slow time base in chart recorder mode.

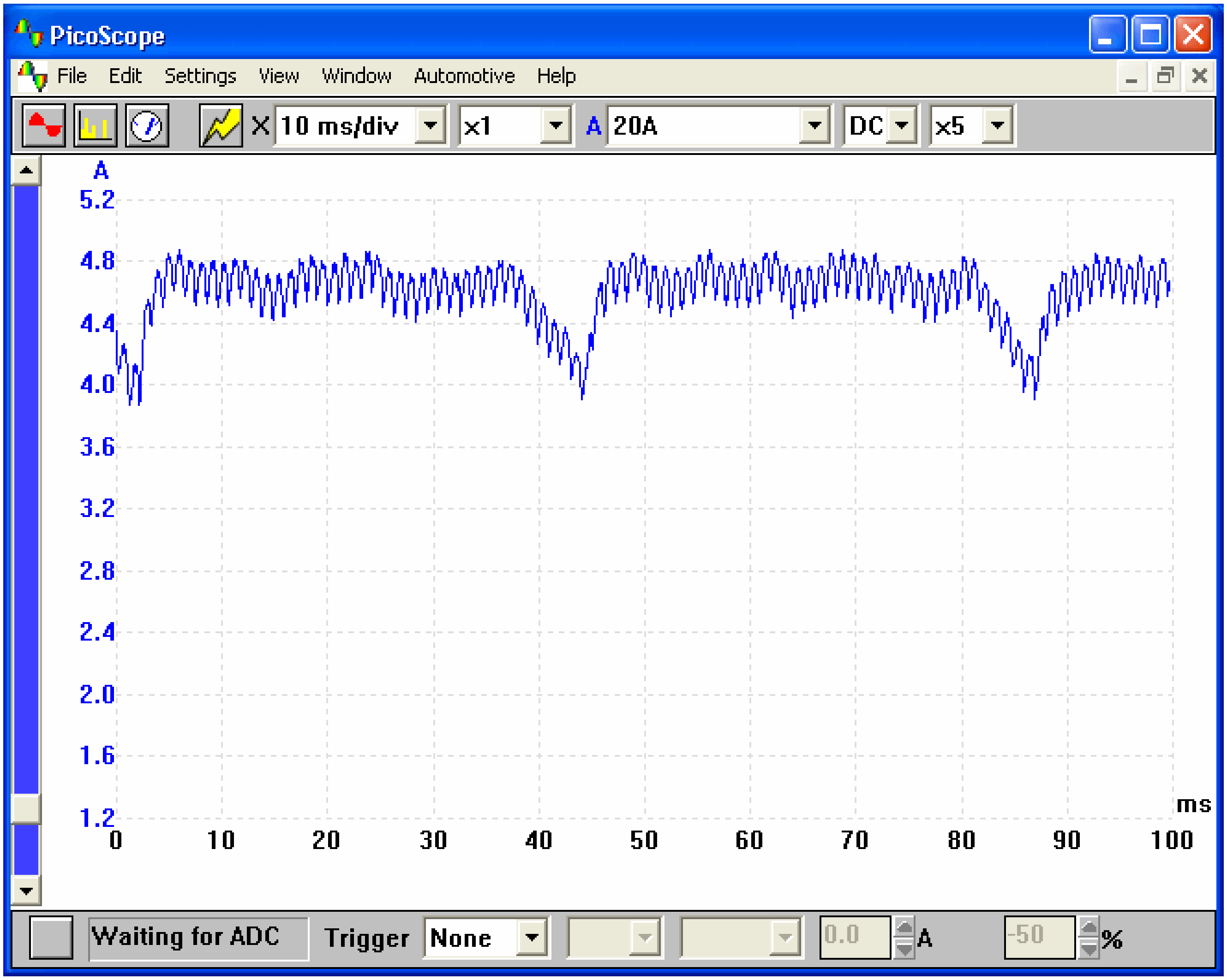
The waveform starts on the left just after key-on, where the voltage is 0.5 V, corresponding to a pressure of 0 bar. The sensor does this to provide a plausibility check: it should never normally read 0 V, so if it does, it has failed.

When we start the engine, the voltage rises to about 1.3 V, which corresponds to about 280 bar, a common value at idle. We then put the pedal to the floor, and the PCM immediately adds a shot of fuel to accelerate the engine to red-line, where it is held by the speed governor. The voltage then settles back to a lower value, about 2.5 V, until we release the pedal back to idle, when it settles back to 1.3 V as at the start. We then key-off and the engine stops.

Note how the signal drops slowly back to 0.5 V over about 10 seconds, before the PCM powers down near the right-hand end of the waveform. If the voltage drops very quickly to 0.5 V, then the residual pressure is leaking away too quickly, and may indicate a problem with the system — for example, a leaky injector, or a leak back through the pump.

Remember that this test is done on an unloaded engine. On a fully loaded engine the centre section of the graph will rise well above 2.5 V. It won't go above 4.5 V, as this represents about 1600 bar. Again, this is a plausibility check on the sensor: if it goes to 5 V (the sensor supply voltage), there could be a fault with the sensor.

FUEL PUMP WAVEFORM Menu

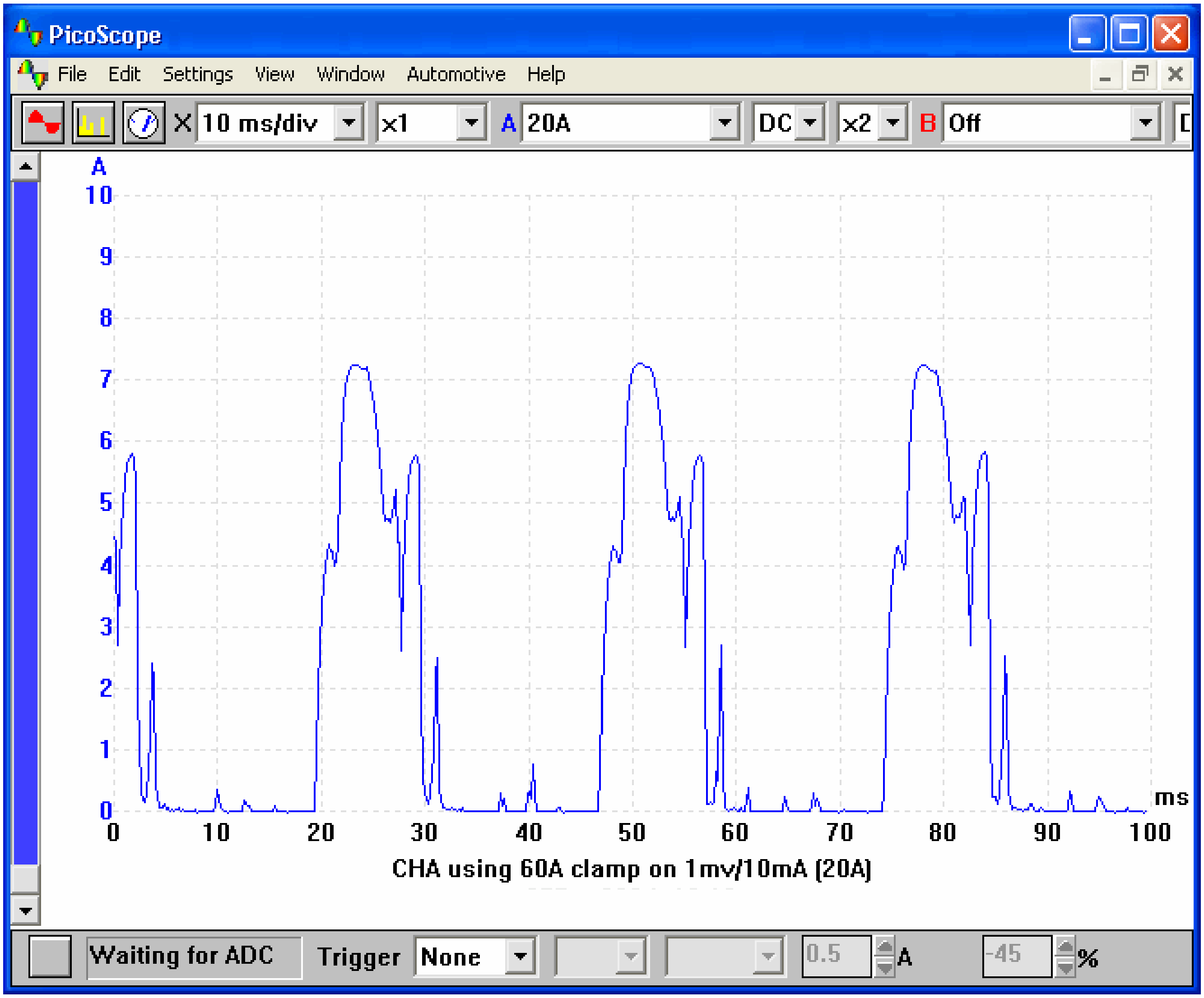


Reference Waveform Notes - Fuel Pump (Honda Prelude 2.2L 2002 – Faulty Fuel Pump)

This waveform is from a 2002, 2.2L SOHC Honda Prelude.

The vehicle had an intermittent no-start condition after a hot soak. When the vehicle cooled the car started. After start-up, the waveform was normal. As the engine ran for a few minutes the waveform took on this pattern. It appears the commutator, brushes or armature winding has developed an open or high resistance.

FUEL PUMP WAVEFORM – Waveform 1 (Faulty Fuel Pump) [Menu]

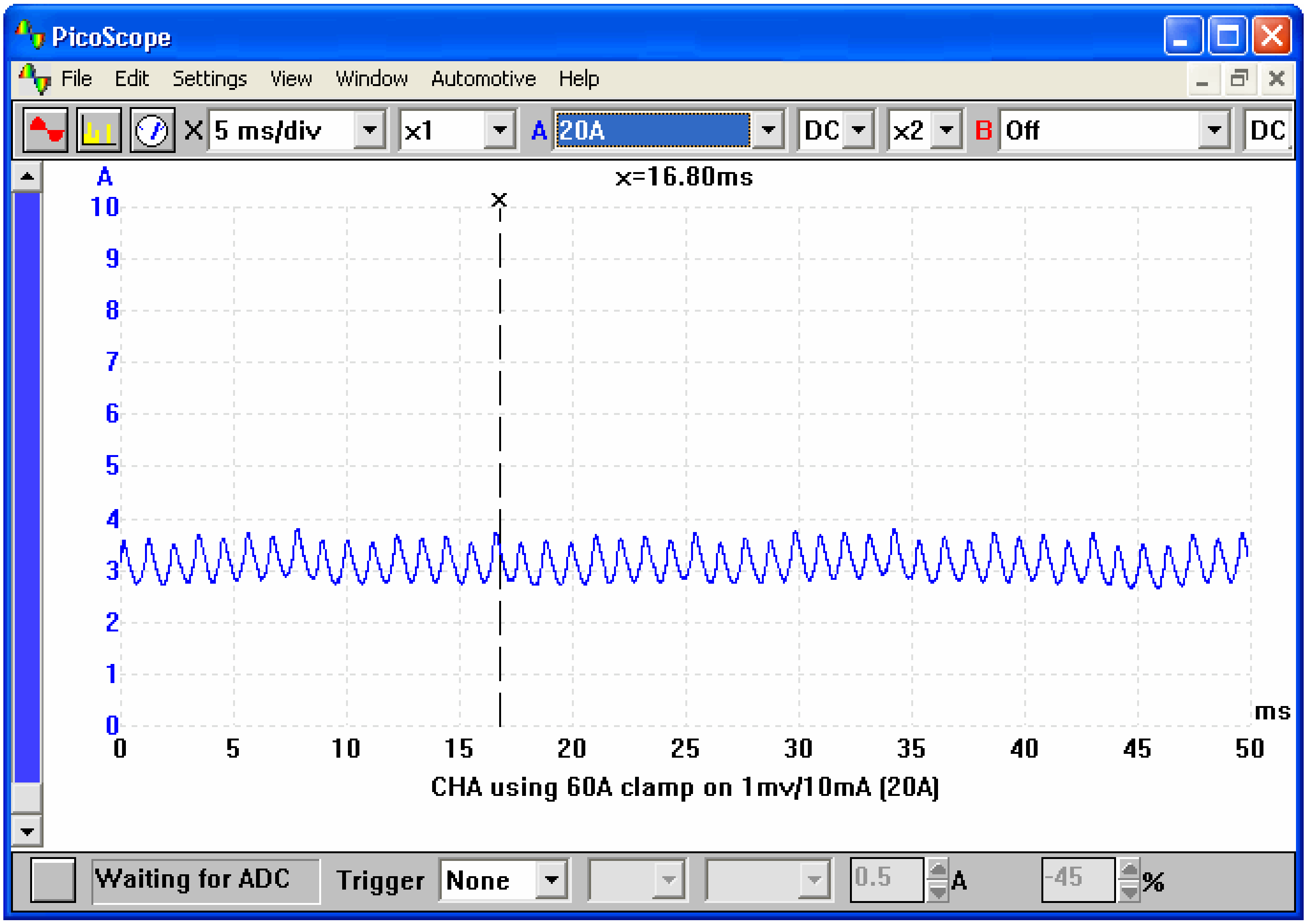


Reference Waveform Notes - Fuel Pump (Oldsmobile 1991 – Faulty Fuel Pump)

See waveform explanation in next page.

FUEL PUMP WAVEFORM – Waveform 2 (New Fuel Pump)

Menu



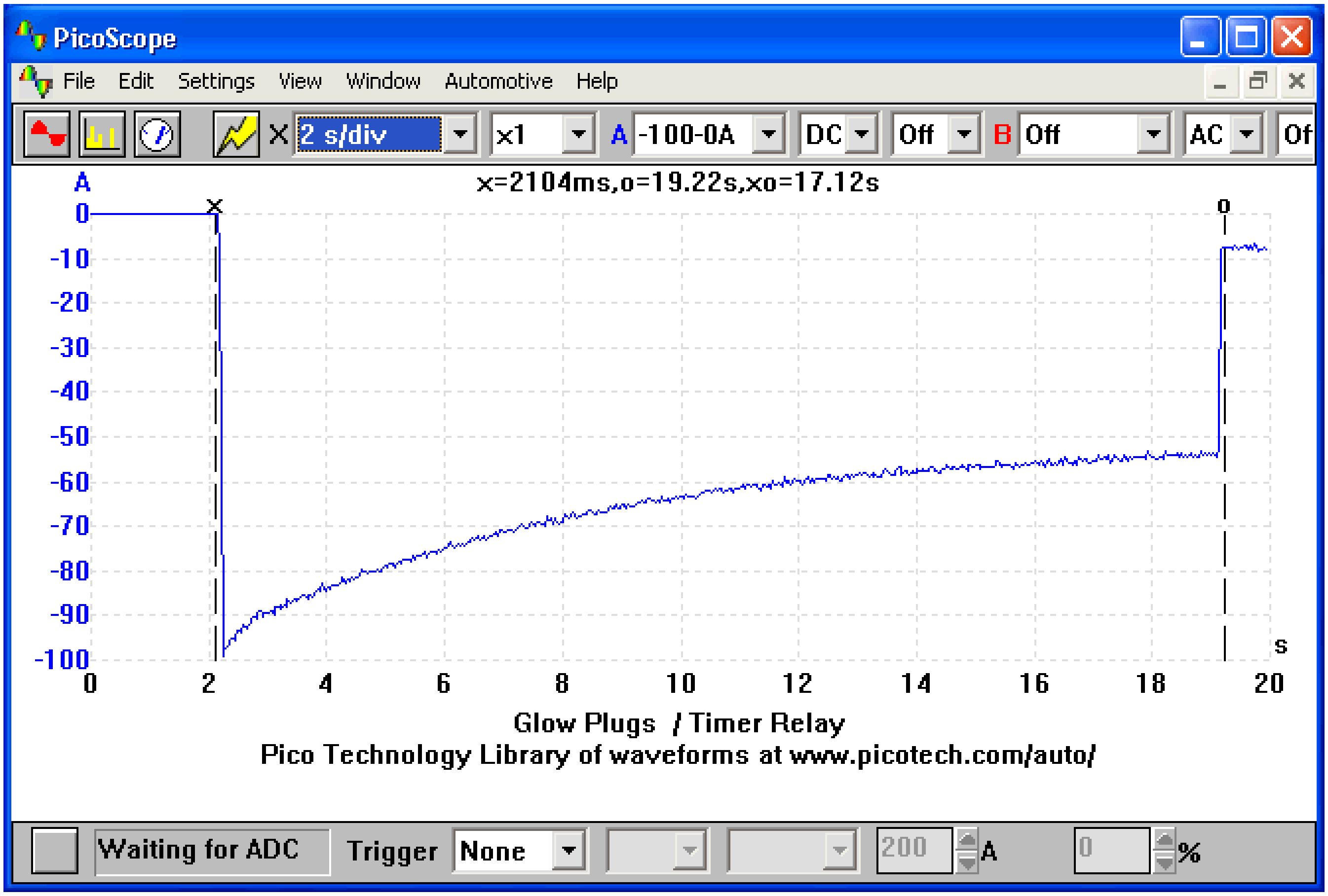
Fuel Pump (Oldsmobile 1991 – New Fuel Pump) - Reference Waveform Notes

These Fuel Pump waveforms were captured from a 1991 Oldsmobile.

Figure 1 shows the output from the old fuel pump. The fuel pump was then replaced. Figure 2 shows the output from the new fuel pump.

GLOW PLUGS / TIMER RELAY WAVEFORM

Menu



Reference Waveform Notes - Glow Plugs / Timer Relay

This test is conducted to evaluate the condition of the glow plugs (this example is a 4 cylinder engine) and to measure the 'on time', which is controlled by the timer relay. A typical glow (or heater) plug will have a high initial current draw that will gradually drop, stabilising at constant amperage. The current draw will be dependent on the wattage rating of the glow plug. This data is available in the appropriate diesel data books.

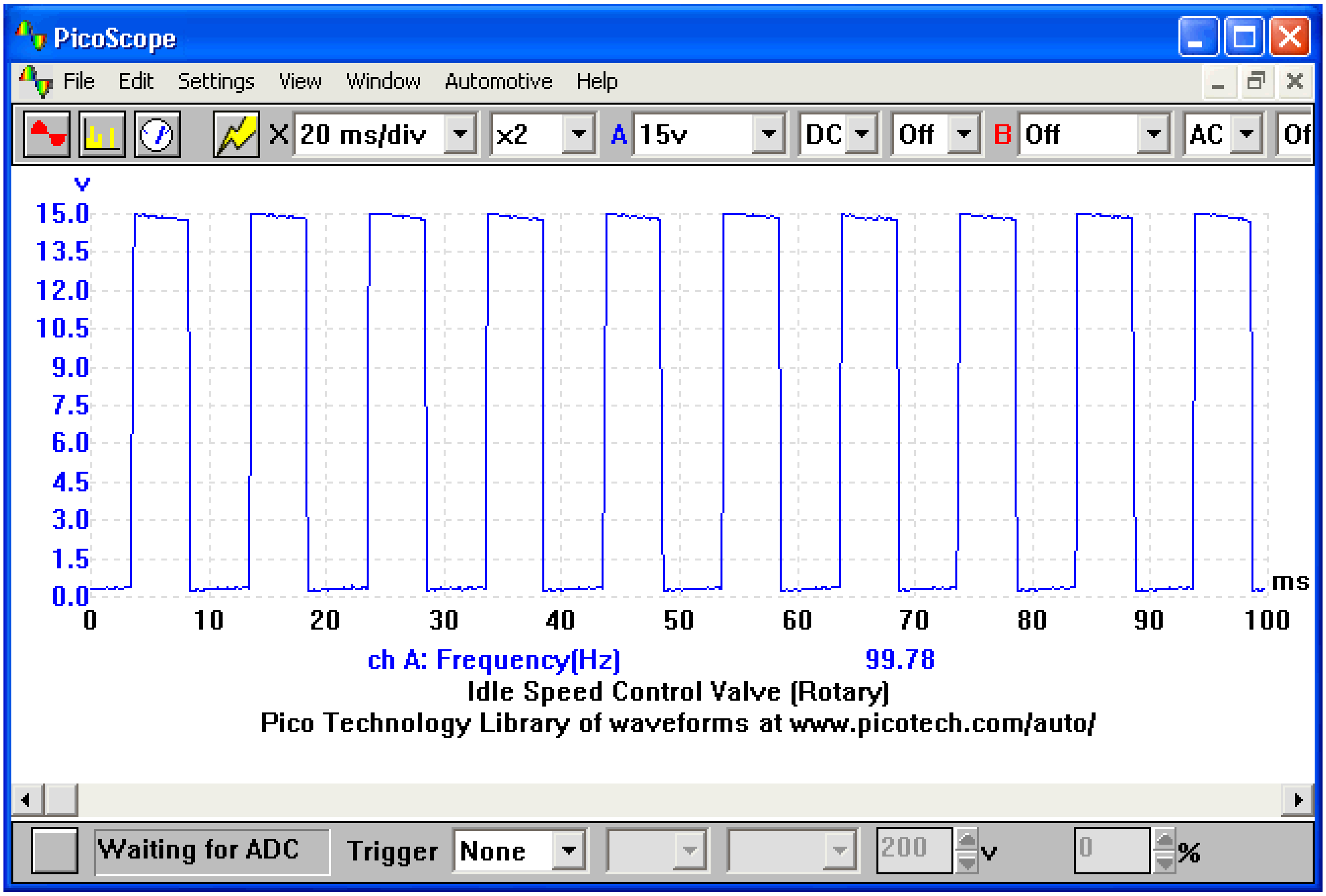
Once the wattage has been ascertained, multiply it by the number of cylinders and use Watts law to calculate the expected stabilised current.
Example:-

Each glow plug = 150 watts 4 glow plugs = 600 watts
Watts divided by volts: 600 watts divided by 12 volts = 50 amps

The length of time that the glow plugs are operational can be measured from the initial drop in current to the switch off point; in this case it is around 17 seconds.

IDLE SPEED CONTROL VALVE - ROTARY

Menu



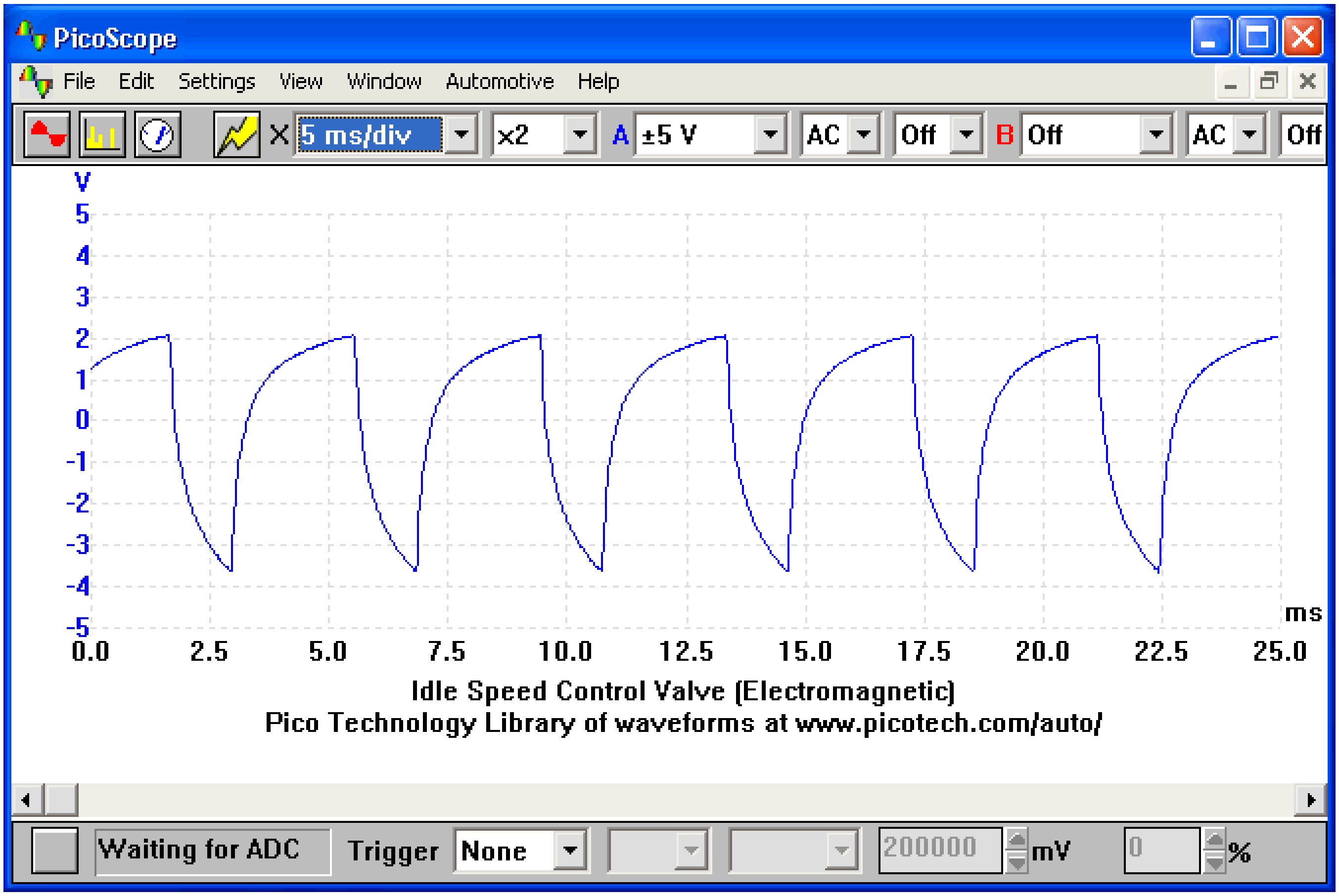
Reference Waveform Notes - Idle Speed Control Valve (Rotary)

The rotary Idle Speed Control Valve (ISCV) will have 2 or 3 electrical connections, with a voltage supply at battery voltage and either a single or a double switched earth path. The rate at which the earth path is switched is determined by the Electronic Control Module (ECM) to maintain a prerequisite speed according to its programming.

The valve will form an air by-pass past the throttle butterfly, to form a controlled air bleed within the induction tract. If the engine has an adjustable air by-pass and an ISCV, it may require a specific routine to balance the two air paths. The rotary valve will have the choice of either single or twin earth paths, the single being pulled one way electrically and returned to its closed position via a spring; the double switched earth system will switch the valve in both directions. This can be monitored on a dual trace oscilloscope. As the example waveform shows the earth path is switched and the resultant picture is produced. Probing onto the supply side will produce a straight line at charging voltage and when the earth circuit is monitored a square wave will be seen. The frequency can also be measured.

IDLE SPEED CONTROL VALVE - ELECTROMAGNETIC

Menu



Reference Waveform Notes - Idle Speed Control Valve (Electromagnetic)

The Electromagnetic Idle Speed Control Valve (ISCV) will have 2 electrical connections, with a voltage supply at battery voltage and a switched earth path. The rate at which the earth path is switched is determined by the Electronic Control Module (ECM) to maintain a prerequisite speed according to its programming.

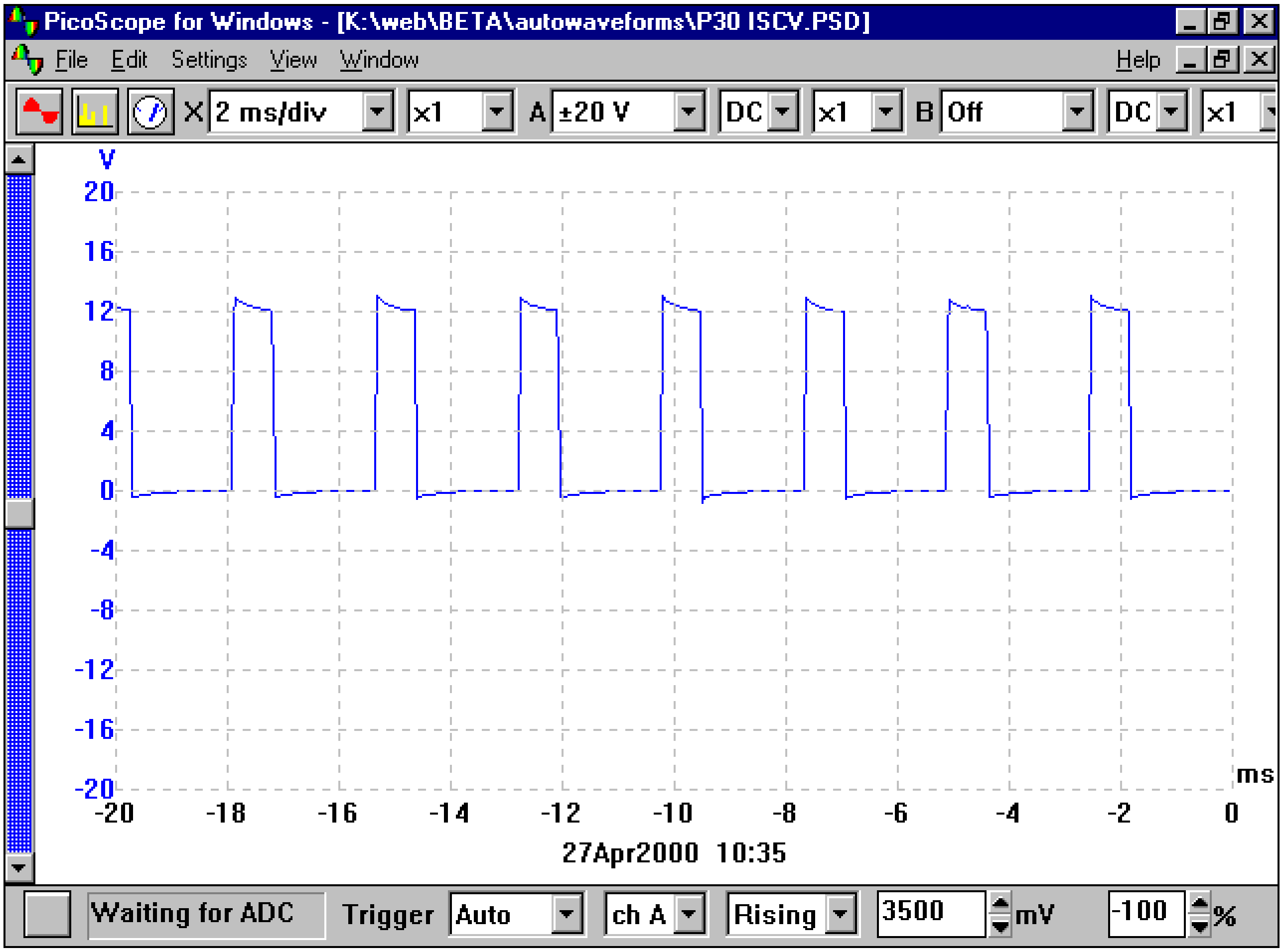
The valve will form an air by-pass around the throttle butterfly, to form a controlled air bleed within the induction tract. If the engine has an adjustable air by-pass and an ISCV, it may require a specific routine to balance the two air paths.

As the example waveform shows the earth path is switched and the resultant picture is produced. Probing onto the supply side will produce a straight line at charging voltage and when the earth circuit is monitored a 'saw tooth' waveform will be seen.

PICO SCOPE

IDLE SPEED CONTROL VALVE - ROTARY

Menu

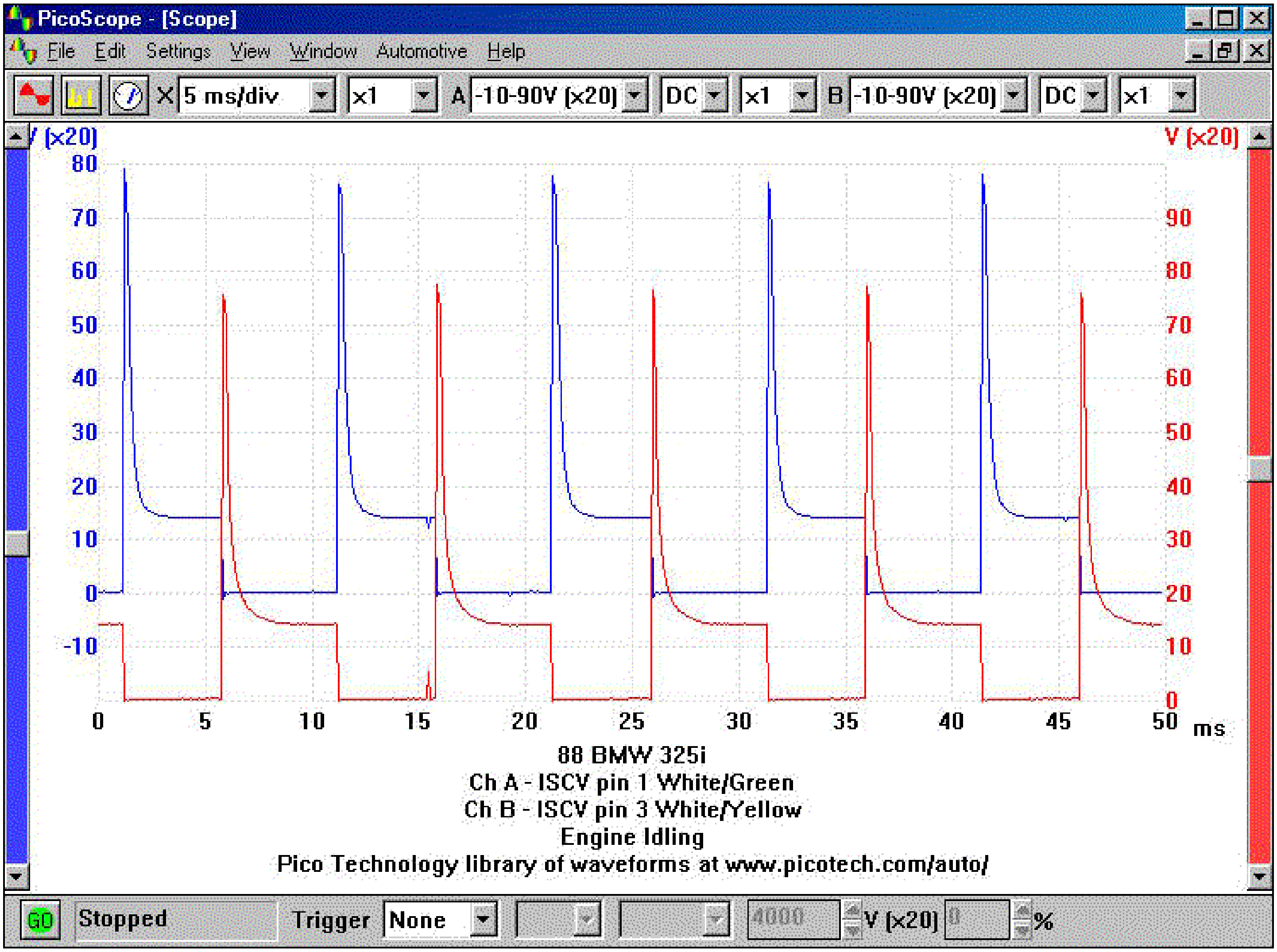


Idle Speed Control Valve (Rotary) Reference Waveform

PICO SCOPE

IDLE SPEED CONTROL VALVE - ROTARY

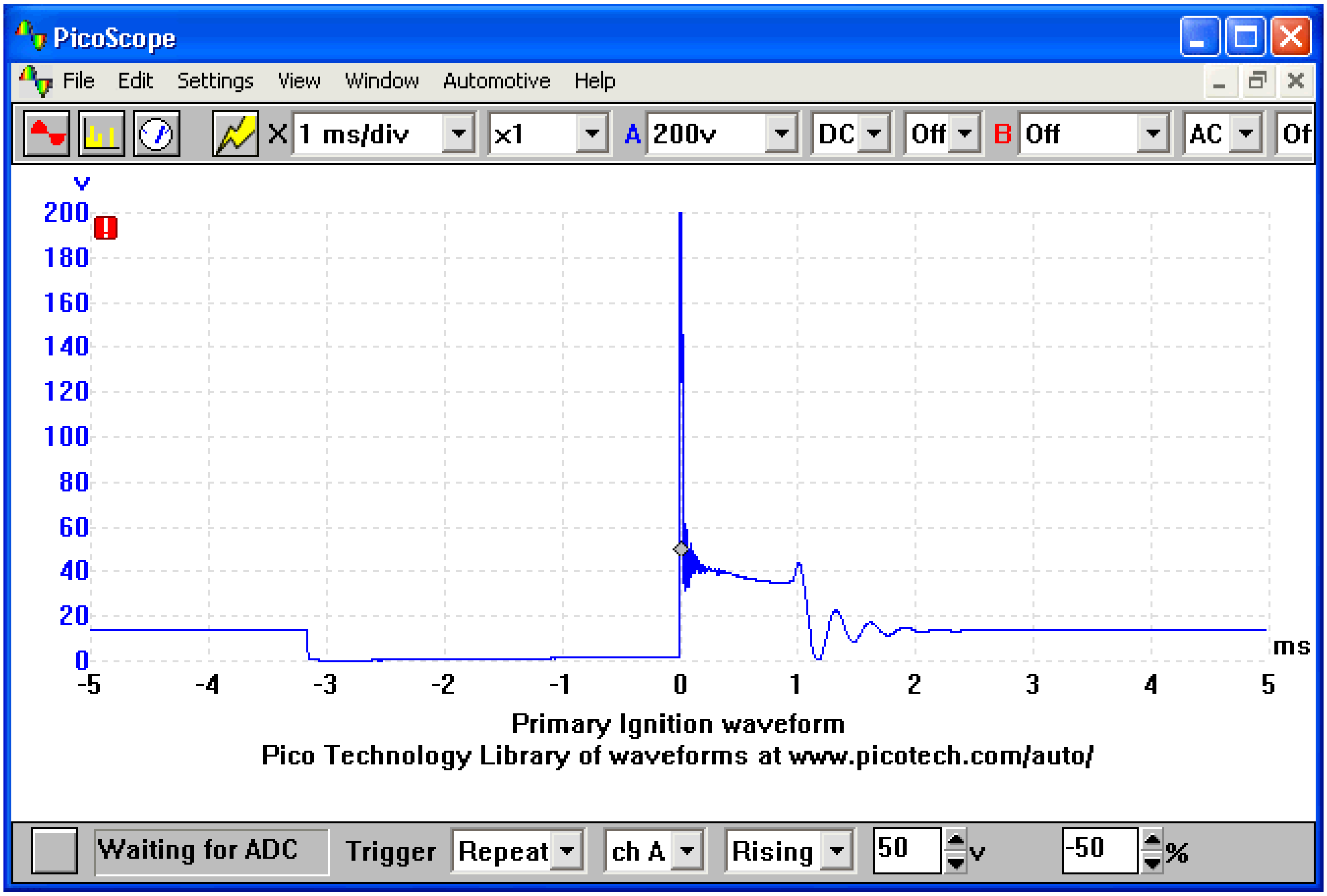
Menu



Idle Speed Control Valve (Rotary) BMW 325i 1988 Reference Waveform

IGNITION WAVEFORMS - PRIMARY

Menu



Reference Waveform Notes – Ignition Primary

The Ignition Primary is looking at and measuring the readings seen on the negative side of the coil. The earth path of the ignition coil can produce over 350 volts. Within the waveform there are several sections that need closer examination and it is therefore important to select the correct voltage scale.

In the waveform shown, the horizontal voltage line (Primary Spark Line) in the centre of the oscilloscope screen is at a fairly constant voltage of approximately 40 volts, which then drops sharply into what is referred to as the Coil Oscillations. The length of the afore mentioned line is the 'Spark Duration' or 'Burn Time', which in this particular case is 1 ms.

The coil oscillations should display a minimum number of 4 - 5 peaks (both upper and lower) should be clearly visible. A loss of peaks on this oscillation shows that the coil needs substituting for another of comparable values.

There is no current in the coils primary's circuit until the dwell period, when the coil is earthed and the voltage seen drops to zero volts.

The dwell period is controlled by the ignition amplifier and the length of the dwell is determined by the time it takes to build up to approximately 8 amps.

When this pre-determined current has been reached, the amplifier stops increasing the primary current building and this is maintained until the earth is removed from the coil, at the precise moment of ignition.

The high vertical line at the centre of the trace is over 200 volts; this is called the 'Induced Voltage'. Further information is available on the example 'Induced Voltage' waveform.

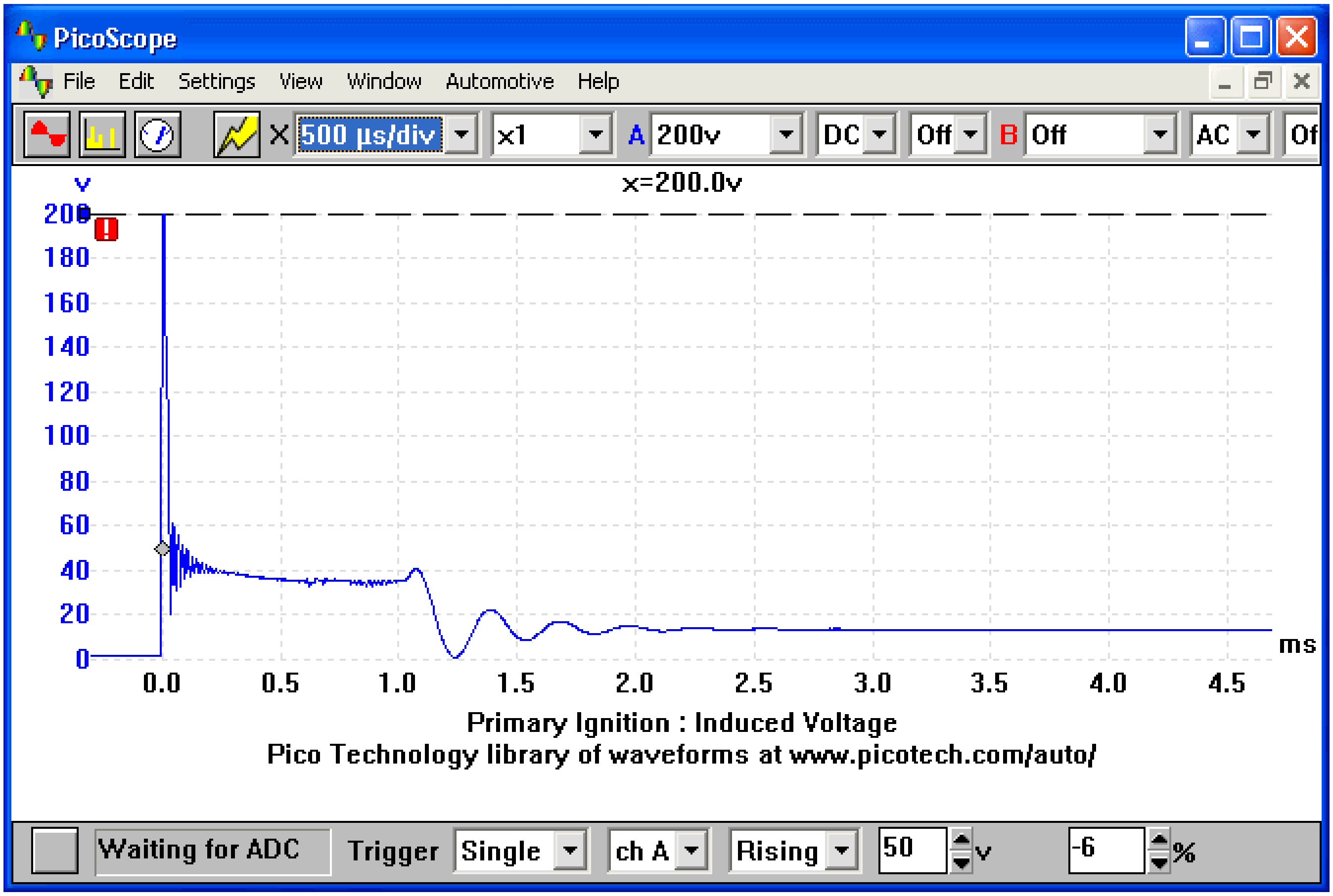
All these sections of the primary trace are also illustrated in individual waveforms within the Ignition Waveforms menu.

The coil's High Tension (HT) output will be proportional to the induced voltage. The height of the induced voltage is sometimes referred to as the Primary Peak Volts.

A low (0 - 50) voltage scale is required to observe the spark line and the Coil Oscillations, while a higher voltage of 0 - 400 volts be will required to check the Induced Voltage.

IGNITION WAVEFORMS - PRIMARY

Menu



Reference Waveform Notes – Ignition Primary (Induced Voltage)

The vertical lines within this trace measured using the 'X' cursor, can be seen at 200 volts, in fact it is know that this voltage does measure 250 volts but only a 10x adaptor for the oscilloscope was available at the time of taking this waveform. This is called the 'Induced Voltage' and is produced by a process called 'Magnetic Inductance'.

The principal is based around a magnetic field (or flux) being produced when the coil negative terminal earth circuit is completed by the amplifier. When the circuit is complete, a magnetic field is produced and builds up until the coil magnetic field is maximized. At the point of ignition, the coil earth circuit is removed and the magnetic field or flux collapses across the coil windings, which in turn induces a voltage of 150 - 350 volts.

The height of the induced voltage (sometimes referred to as the Primary Peak Volts) will be determined by the following points:-

- The number of turns in the primary circuit.
- The strength of the magnetic flux, which is proportionate to the current in the primary circuit.
- The rate of collapse, which is determined by the speed of the switching of the earth path.

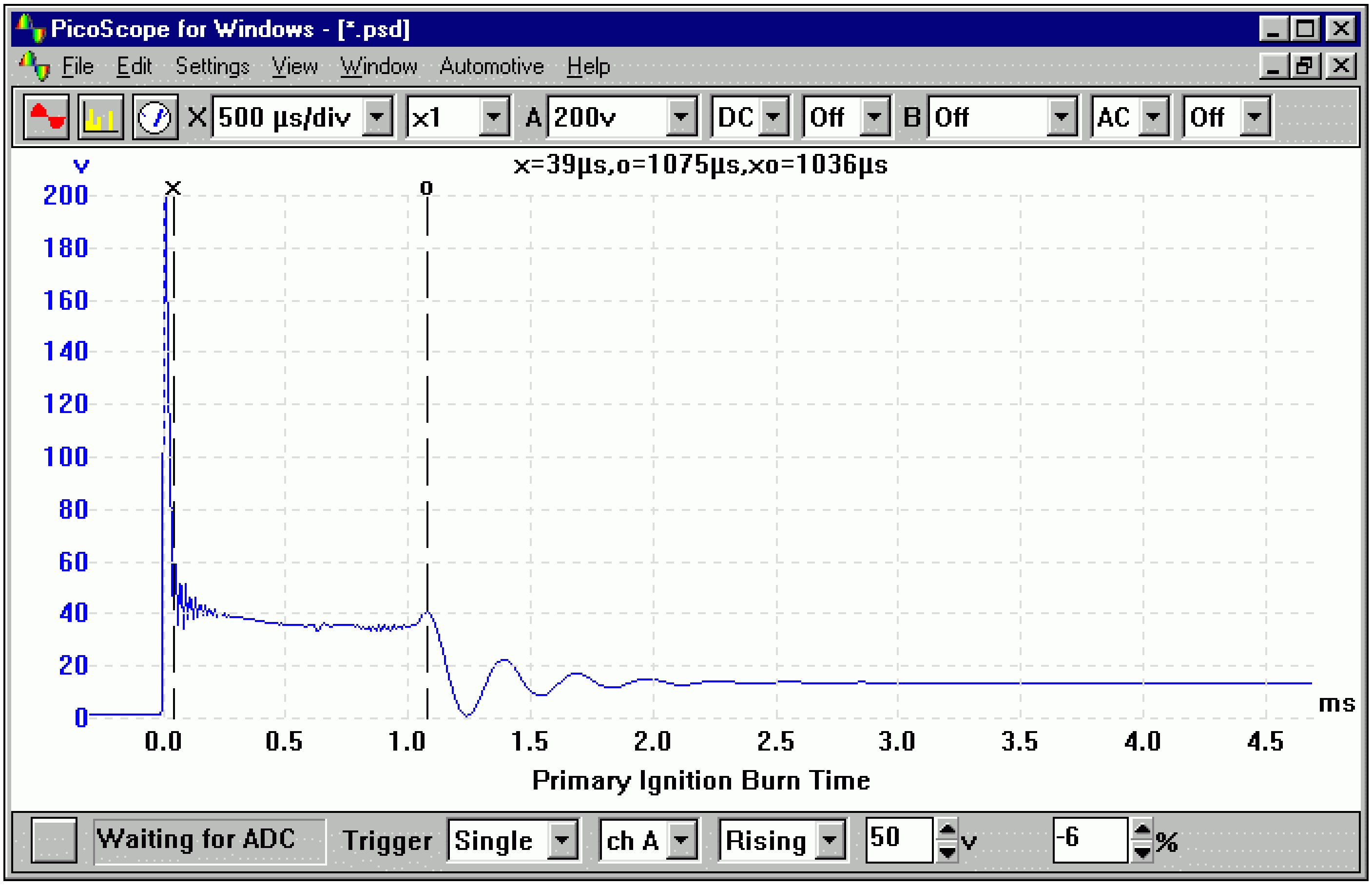
A lower than anticipated induced voltage will result in a low coil output. The High Tension (HT) output will be proportionate to the induced voltage.

Use the settings shown in the example waveform to pre-set the oscilloscope to measure the voltages.

PICO SCOPE

IGNITION WAVEFORMS - PRIMARY

Menu

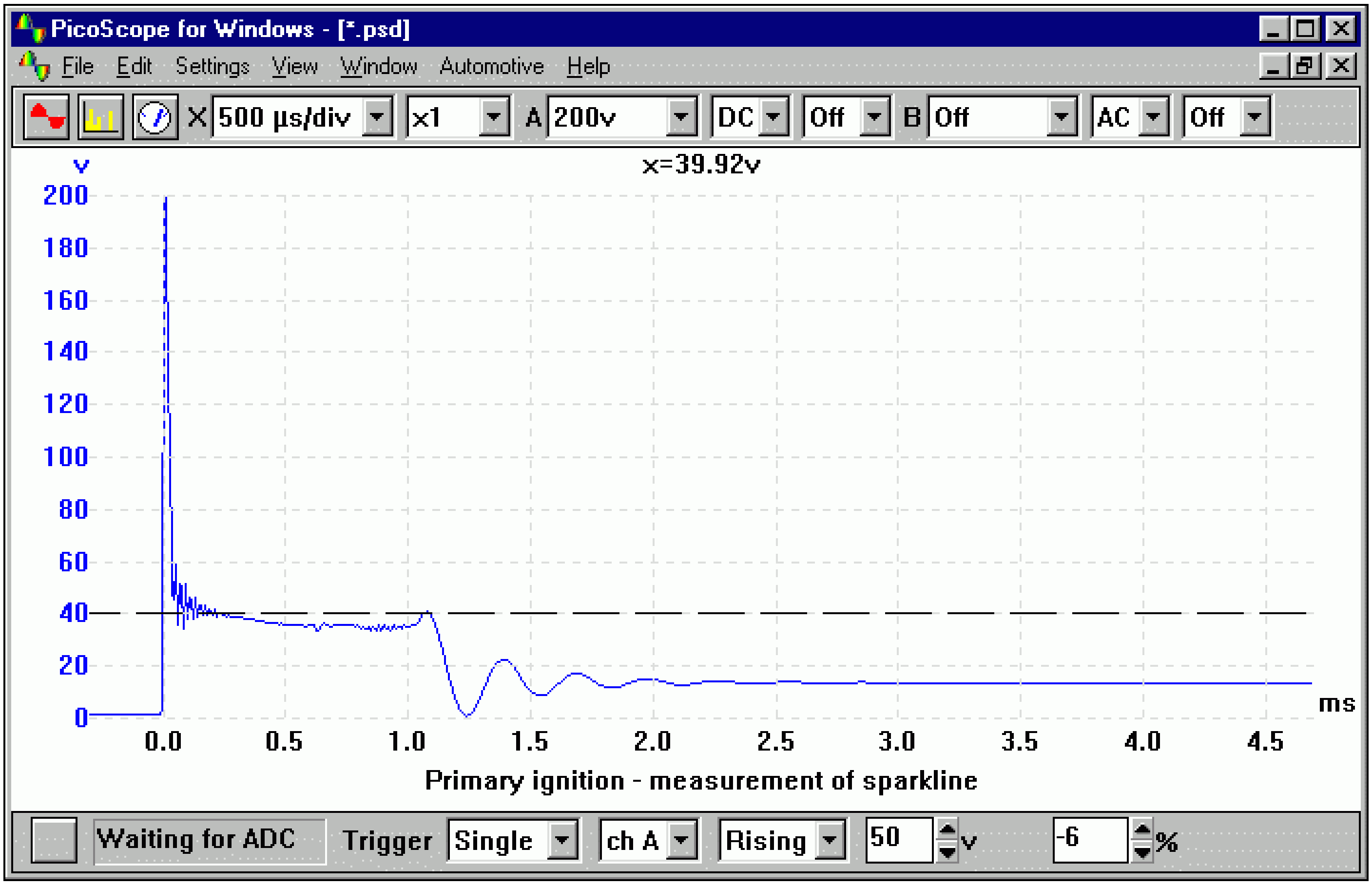


Ignition Primary - (Measurement of Burn Time) Reference Waveform

PICO SCOPE

IGNITION WAVEFORMS - PRIMARY

Menu

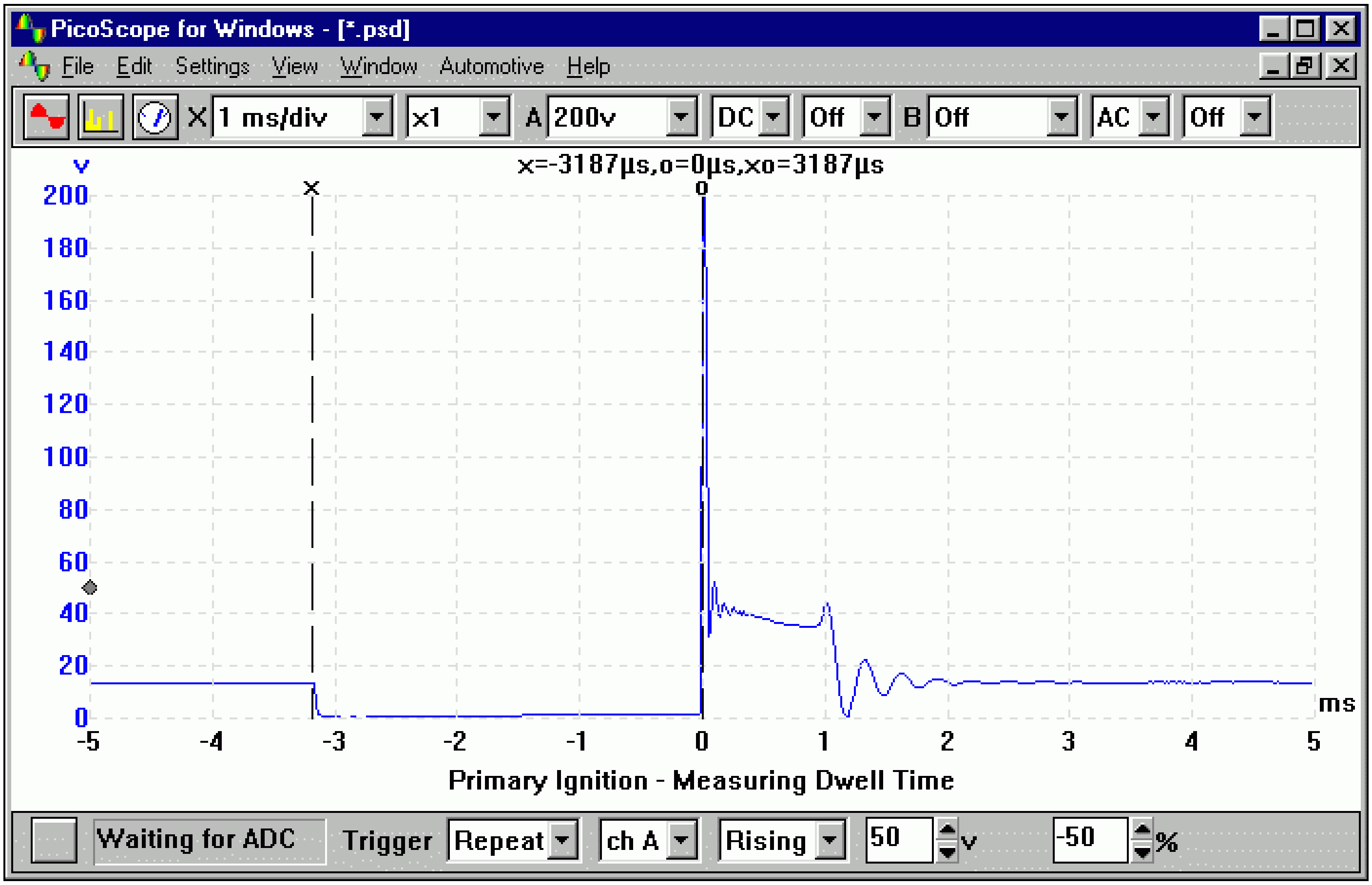


Ignition Primary - (Measurement of Spark Line) Reference Waveform

PICO SCOPE

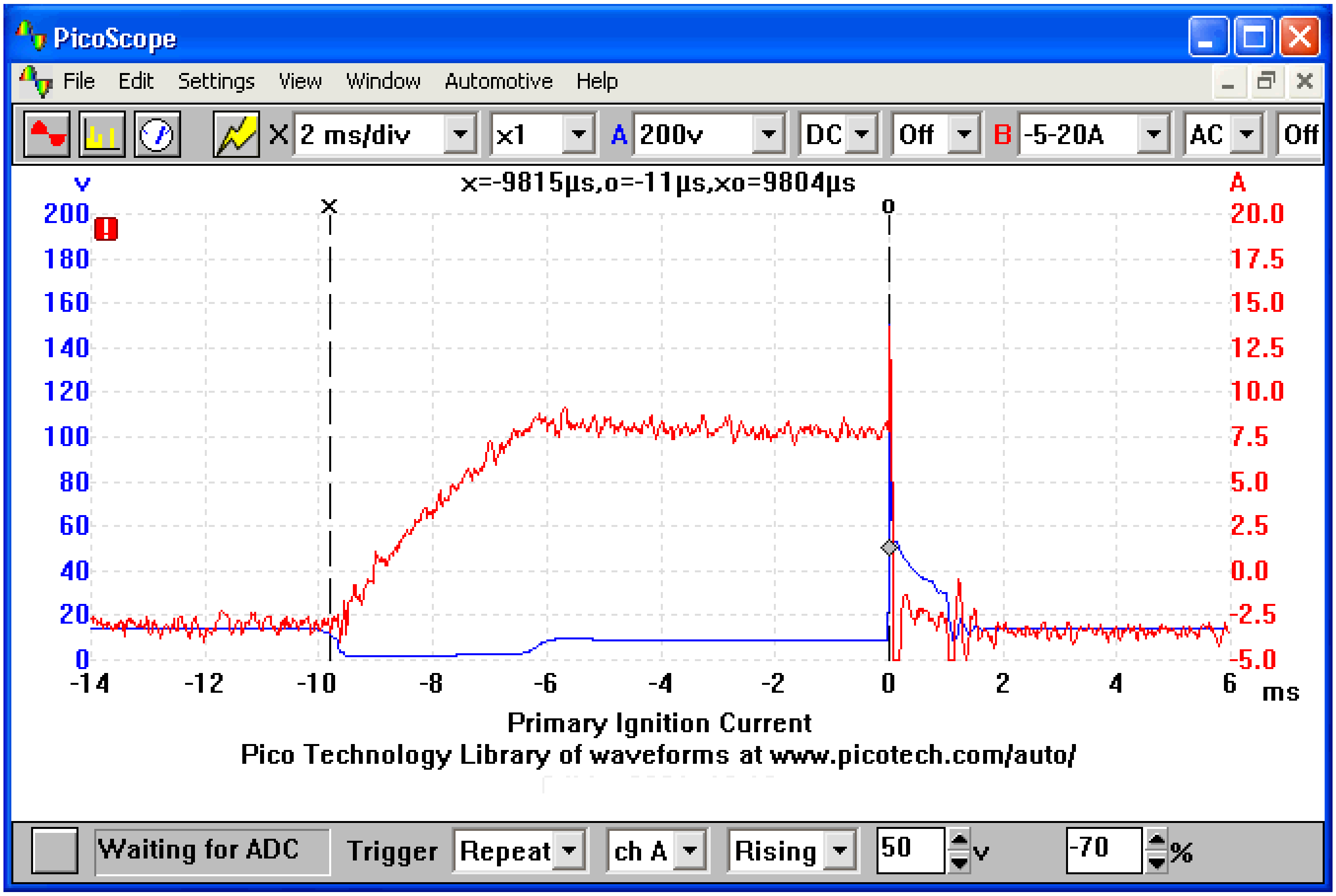
IGNITION WAVEFORMS - PRIMARY

Menu



Ignition Primary - (Measurement of Dwell Time) Reference Waveform

IGNITION WAVEFORMS – PRIMARY (Primary Voltage / Primary Current) [Menu]



Reference Waveform Notes - Ignition Primary (Primary Volts / Primary Current)

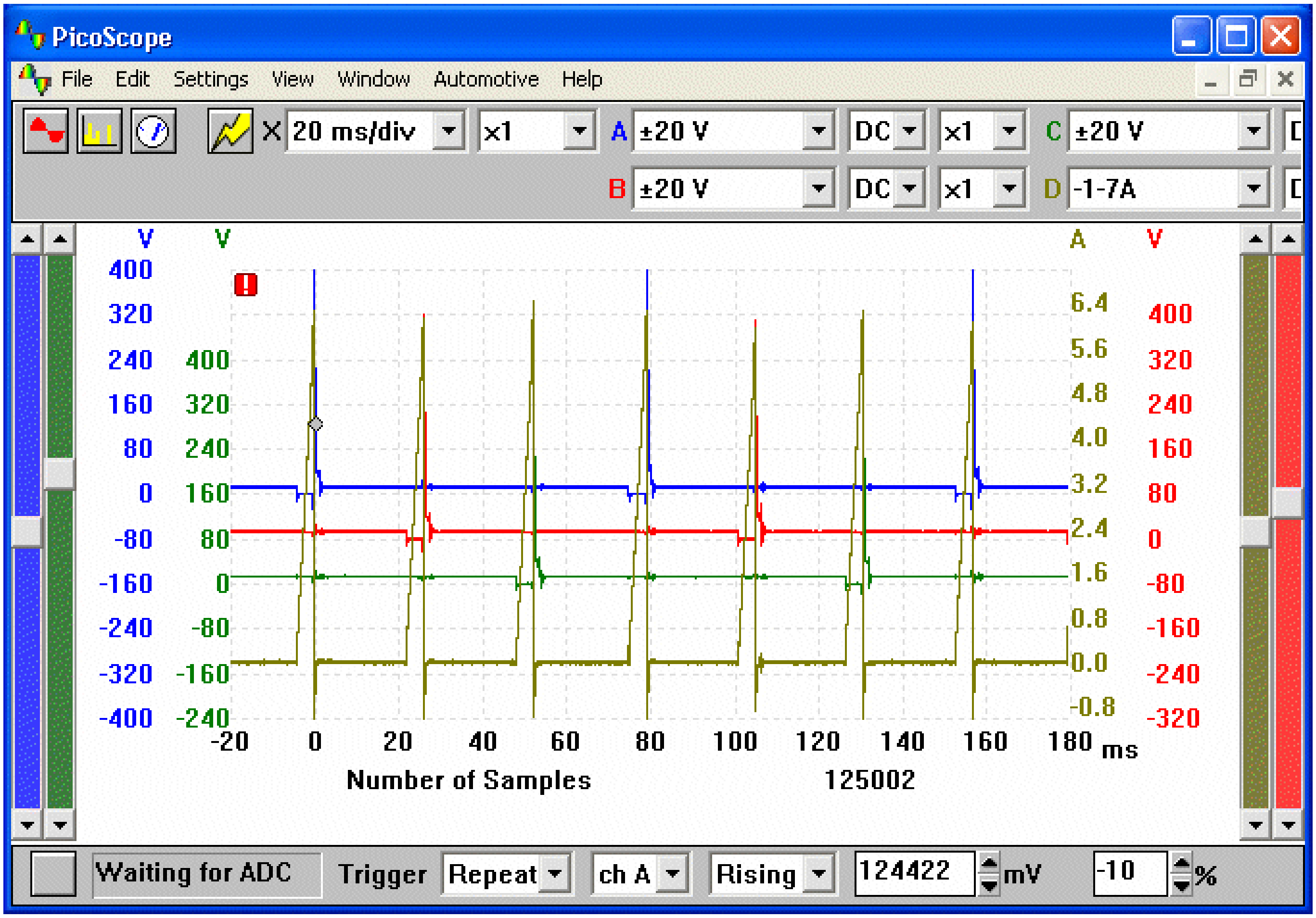
From the example waveform, the current limiting circuit can be seen in operation. The current switches on as the dwell period starts and rises until the requisite 8 amps is achieved within the primary circuit, at which point the current is maintained until it is released at the point of ignition.

The dwell will expand as the engine revs are increased; this is to maintain a constant coil saturation time, hence the term 'constant energy'.

If the 'X' cursor was placed at the beginning of the dwell period and the 'O' cursor placed on the induced voltage line, the coil saturation time can be measured. This will remain exactly the same regardless of engine speed.

IGNITION WAVEFORMS – PRIMARY (COP IGNITION)

Menu



Reference Waveform Notes - Ignition (COP Ignition – Dodge Intrepid 3.5L V6)

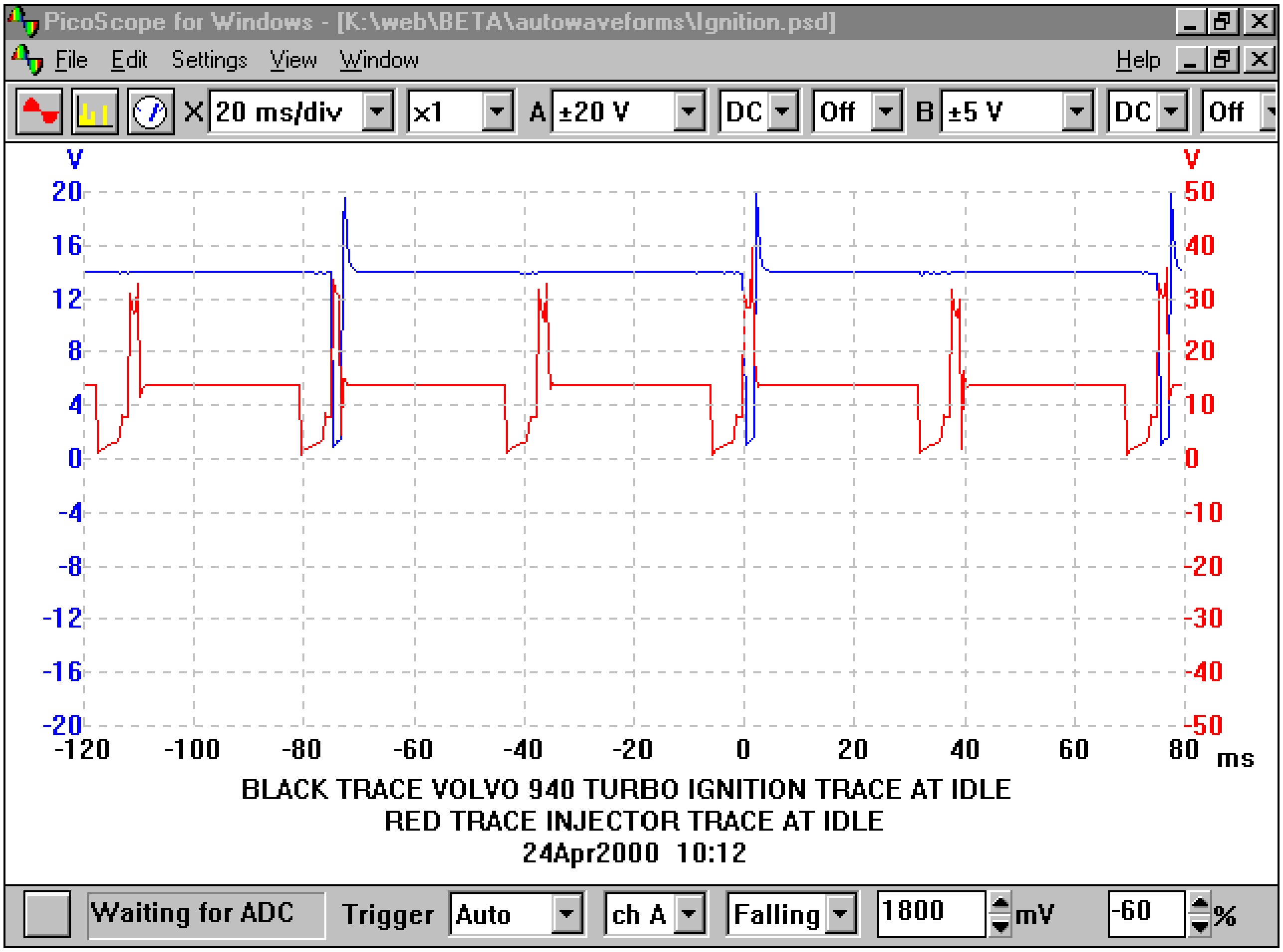
This waveform was captured from a 1997 Dodge Intrepid 3.5 V6.

This Vehicle has COP ignition. **Chan A**, **Chan B** and **Chan C** are the primary voltage of the individual cylinders of one bank of the V6 and **Chan D** is the primary current draw from all 3 coils on that bank.

PICO SCOPE

IGNITION WAVEFORMS – PRIMARY / INJECTOR

Menu

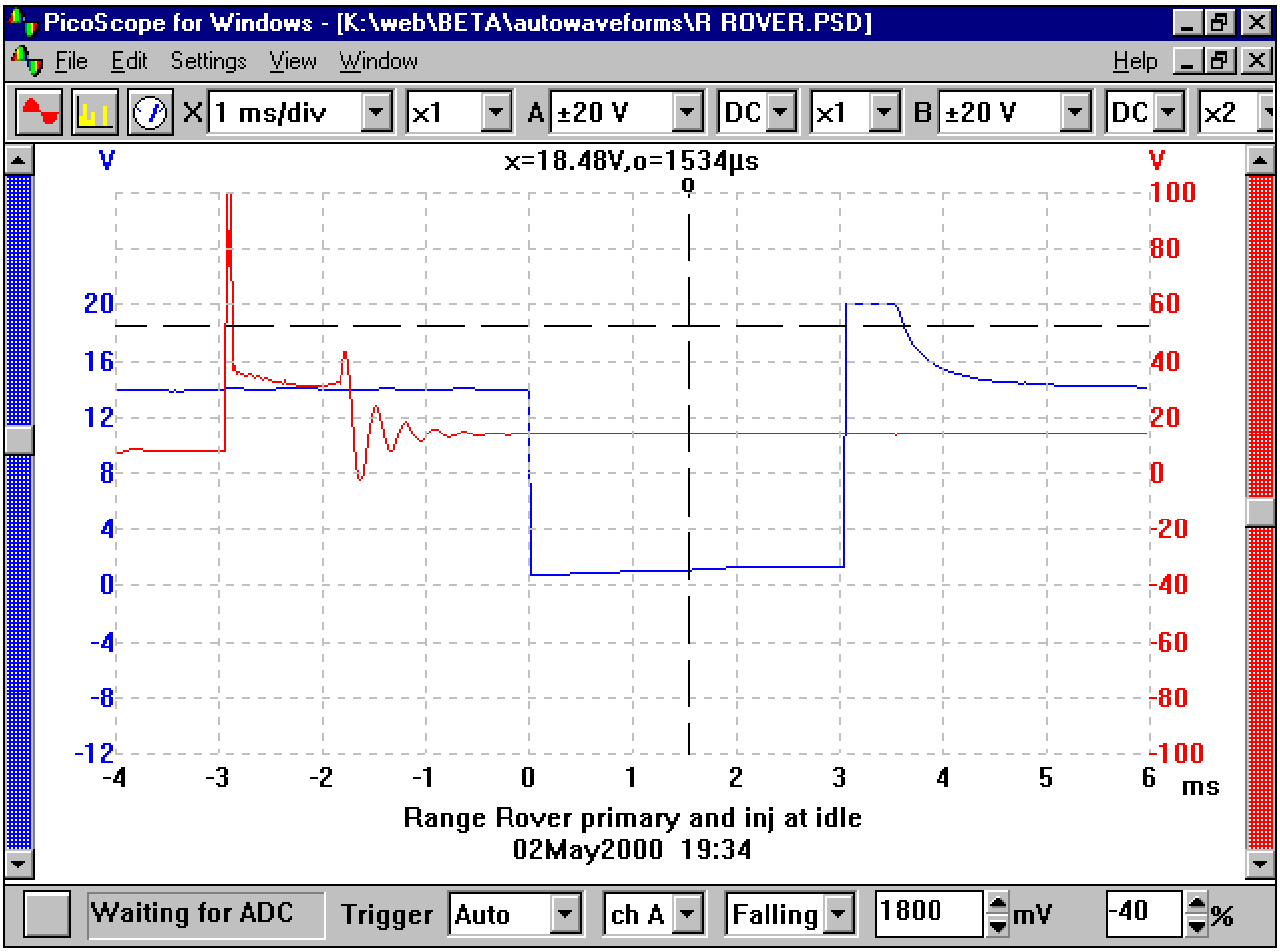


Ignition Primary (Volvo 940 Turbo – Ignition Primary / Injector at idle) Reference Waveform

PICO SCOPE

IGNITION WAVEFORMS – PRIMARY / INJECTOR

Menu

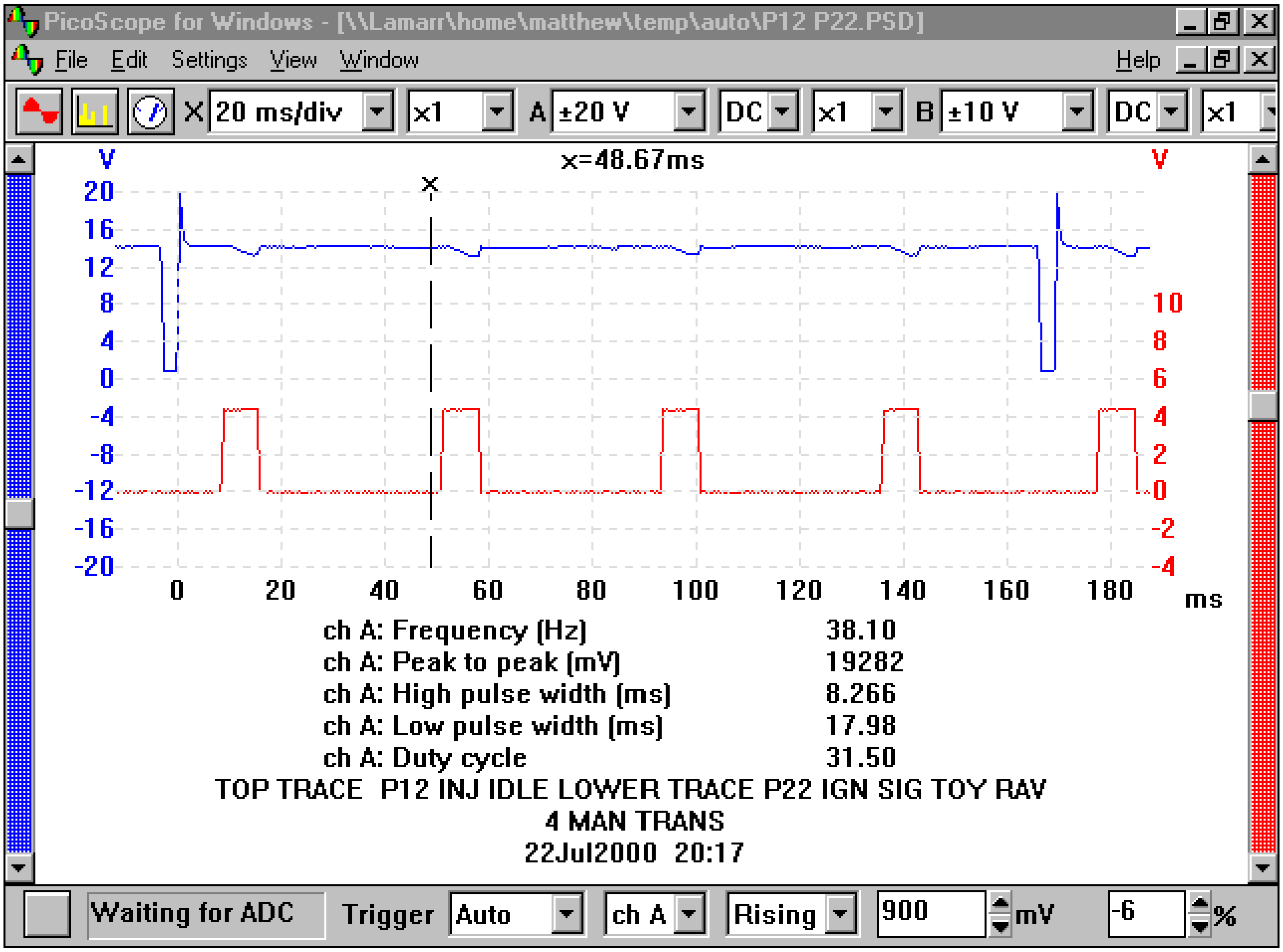


Ignition Primary (Range Rover – Ignition Primary / Injector at idle) Reference Waveform

PICO SCOPE

IGNITION WAVEFORMS – PRIMARY / INJECTOR

Menu

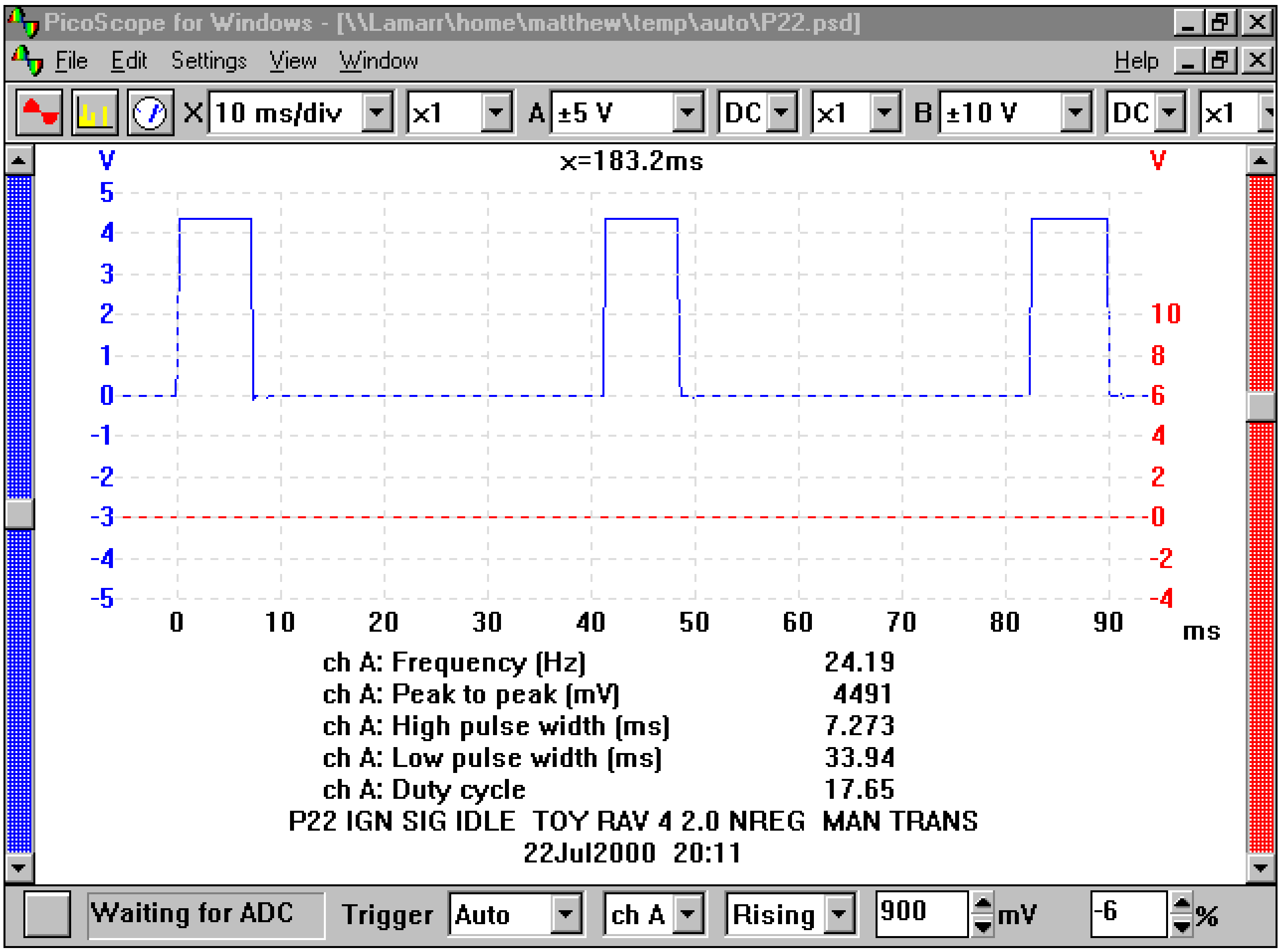


Ignition Primary (Toyota RAV 4 2.0L 1995 – Primary (IGN) / Injector at idle) Reference Waveform

PICO SCOPE

IGNITION WAVEFORMS – PRIMARY

Menu

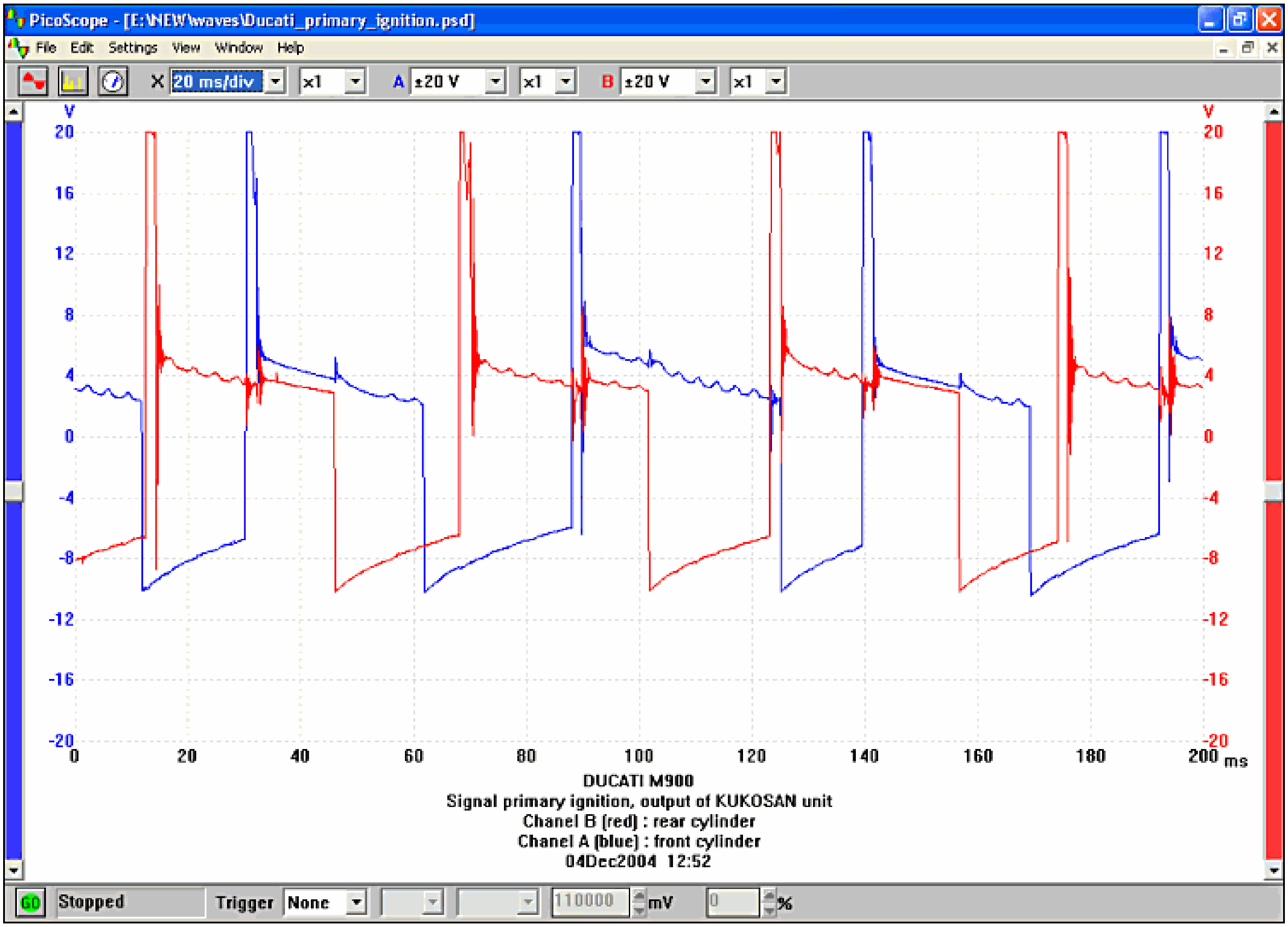


Ignition Primary (Toyota RAV 4 2.0L 1995 – (IGN from ECU) Reference Waveform

PICO SCOPE

IGNITION WAVEFORMS – PRIMARY

Menu

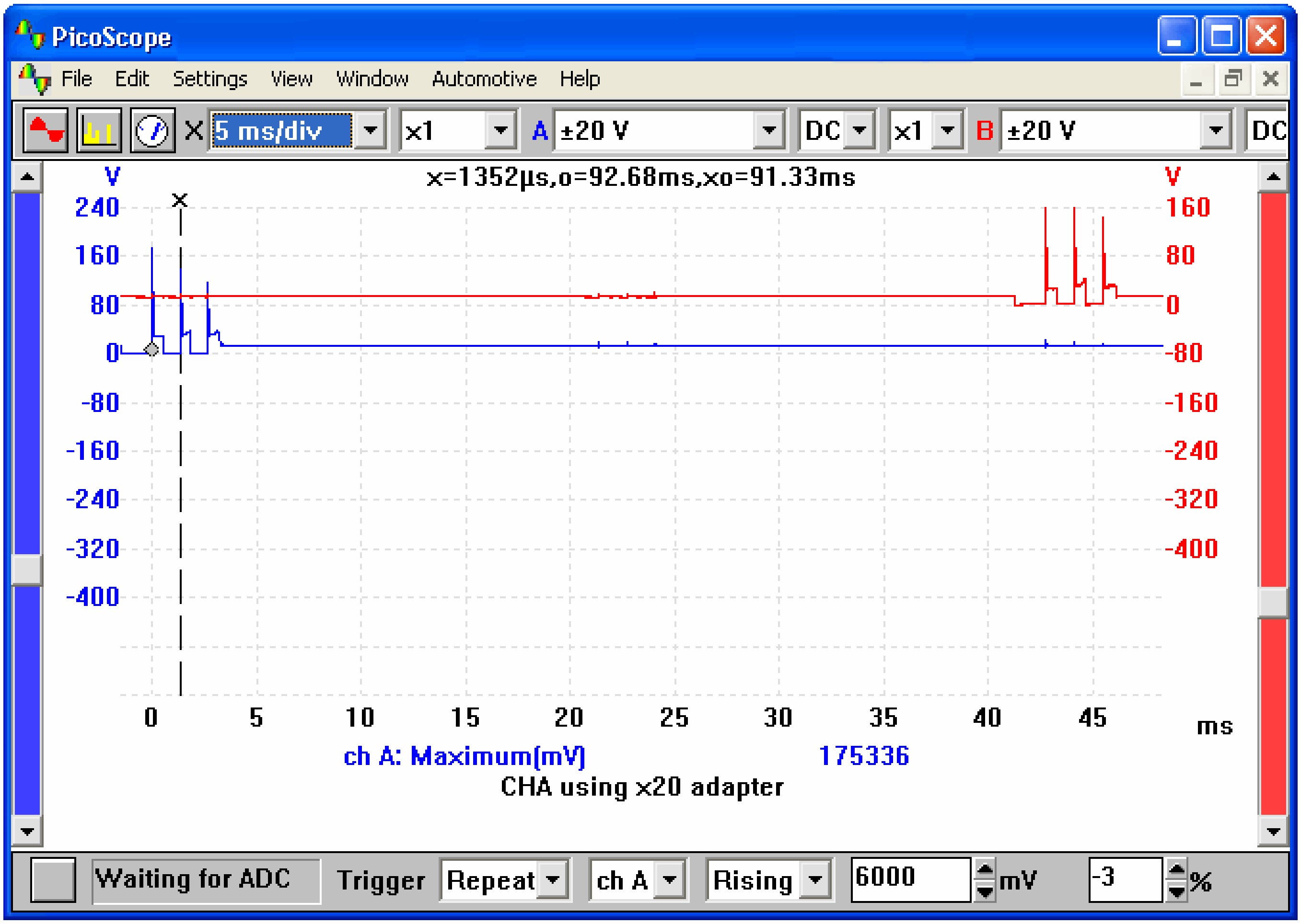


Ignition Primary (Ducati Monster 900) Reference Waveform

PICO SCOPE

IGNITION WAVEFORMS – PRIMARY

Menu

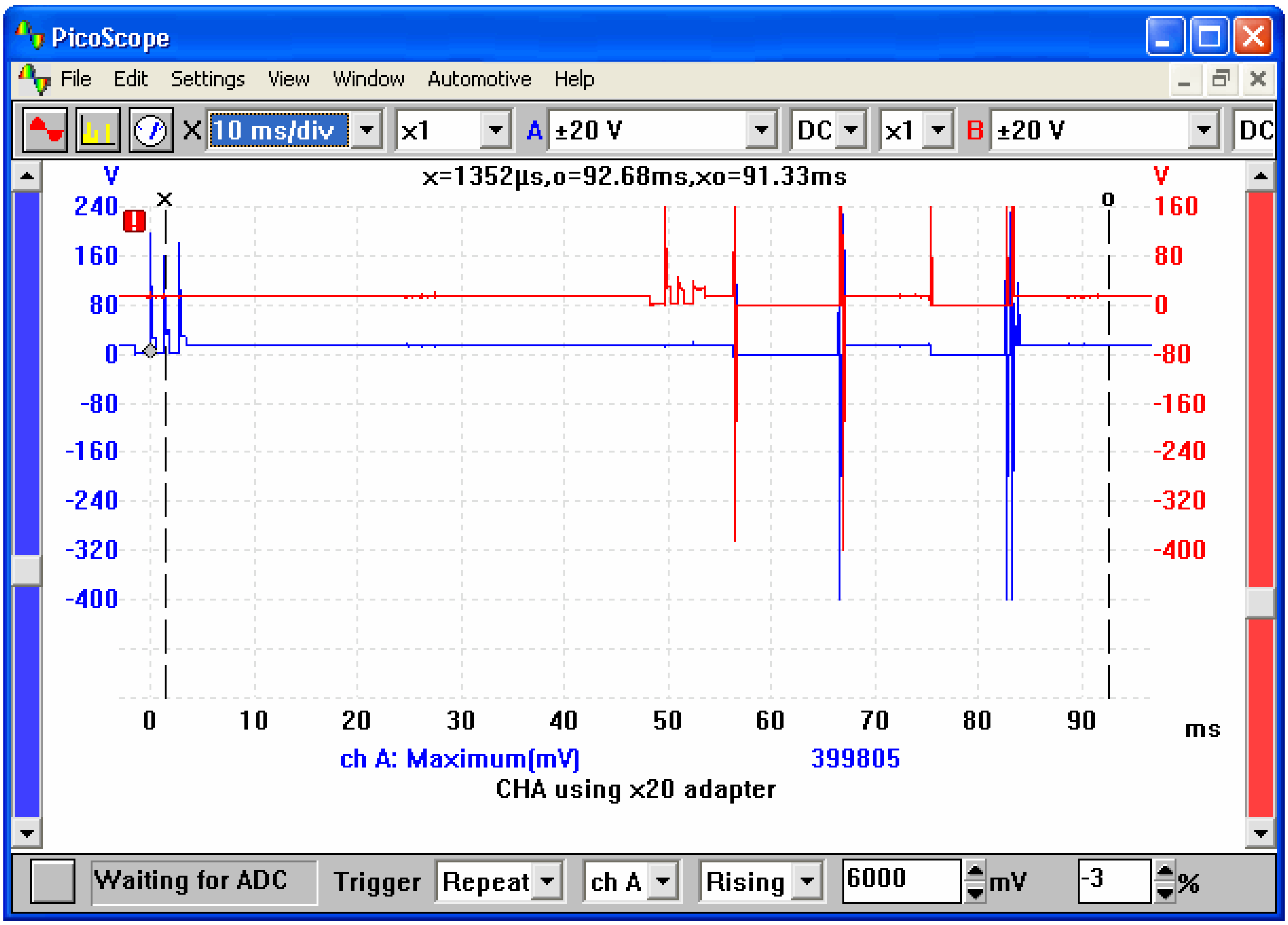


Ignition Primary (Ford F150 – Engine Misfiring) Reference Waveform

PICO SCOPE

IGNITION WAVEFORMS – PRIMARY

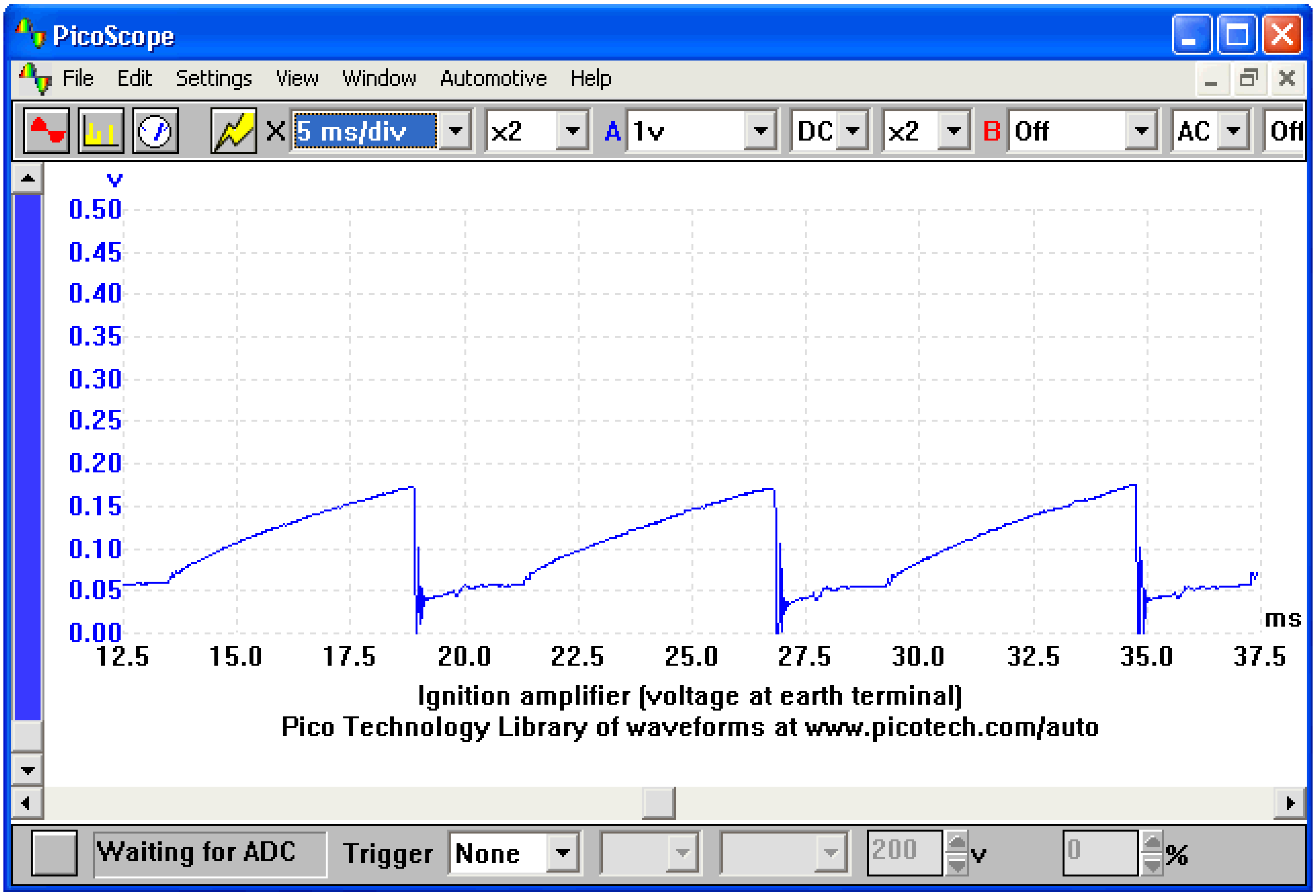
Menu



Ignition Primary (Ford F150 – Engine Misfiring while power braking) Reference Waveform

IGNITION AMPLIFIER EARTH

Menu



Reference Waveform Notes - Ignition Amplifier

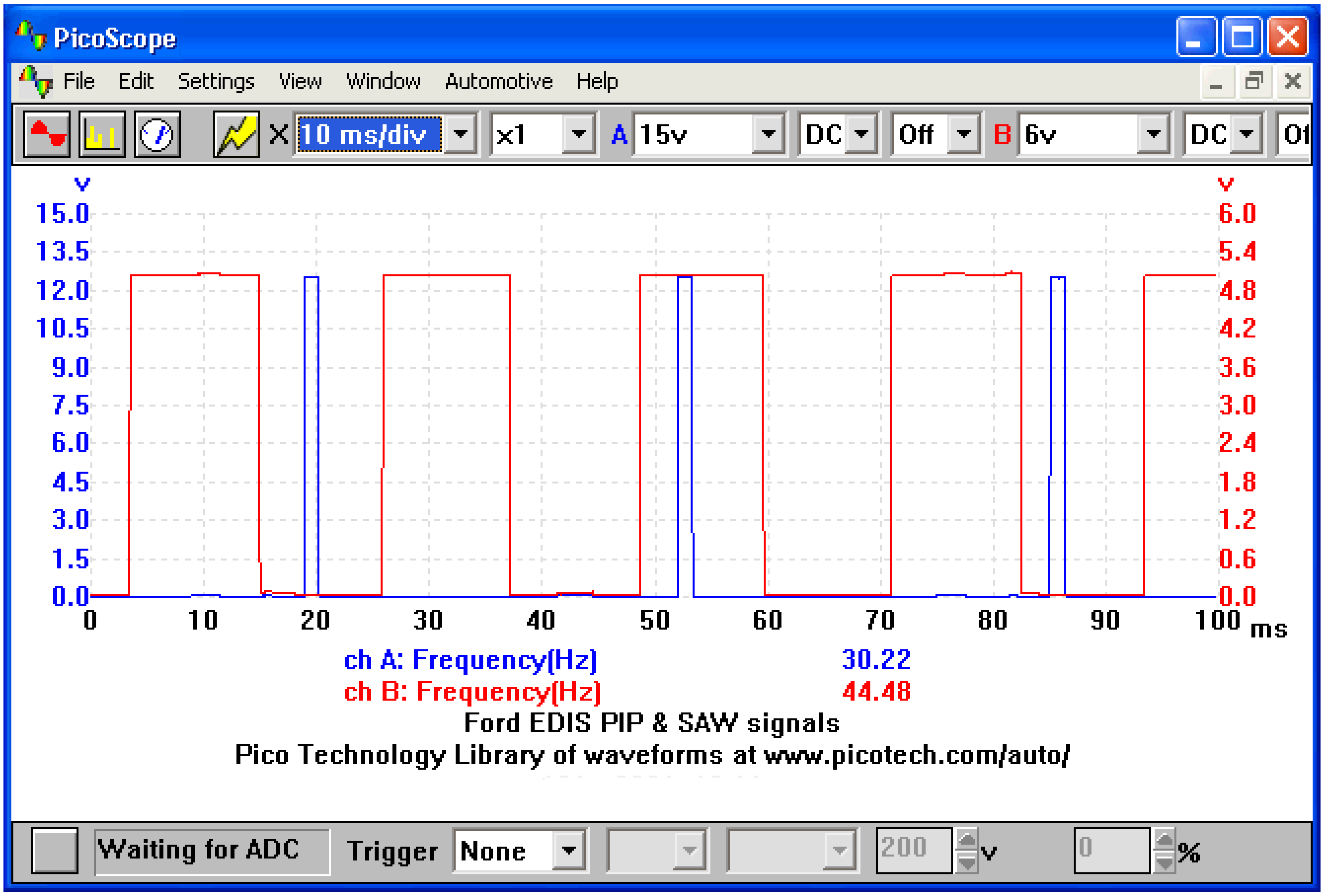
The earthing on the ignition amplifier (also referred to as the module or the igniter) is vital to the operation of the ignition system and is often overlooked as an area for potential problems.

The earth connection, if not in good condition, can cause a reduction in the primary current that will effect the current limiting (or dwell control) circuit. It is therefore vital that this important connection is tested and rectified if it is found to be outside of its operational limits. An earth return circuit can only be tested while the circuit is under load and this therefore makes continuity testing to earth with a Multimeter inaccurate. as the coil primary circuit is only complete during the dwell period and this is the time that the voltage drop should be monitored.

Ensure that the 'voltage ramp' does not exceed 0.5 volts. The 'flatter' the resultant waveform the better. A waveform with virtually no rise shows that the amplifier/module has a adequate earth.

FORD EDIS PIP / SAW WAVEFORMS

Menu



Reference Waveform Notes - Ford EDIS PIP / SAW

PIP and SAW are two Ford terms and are abbreviations for:-

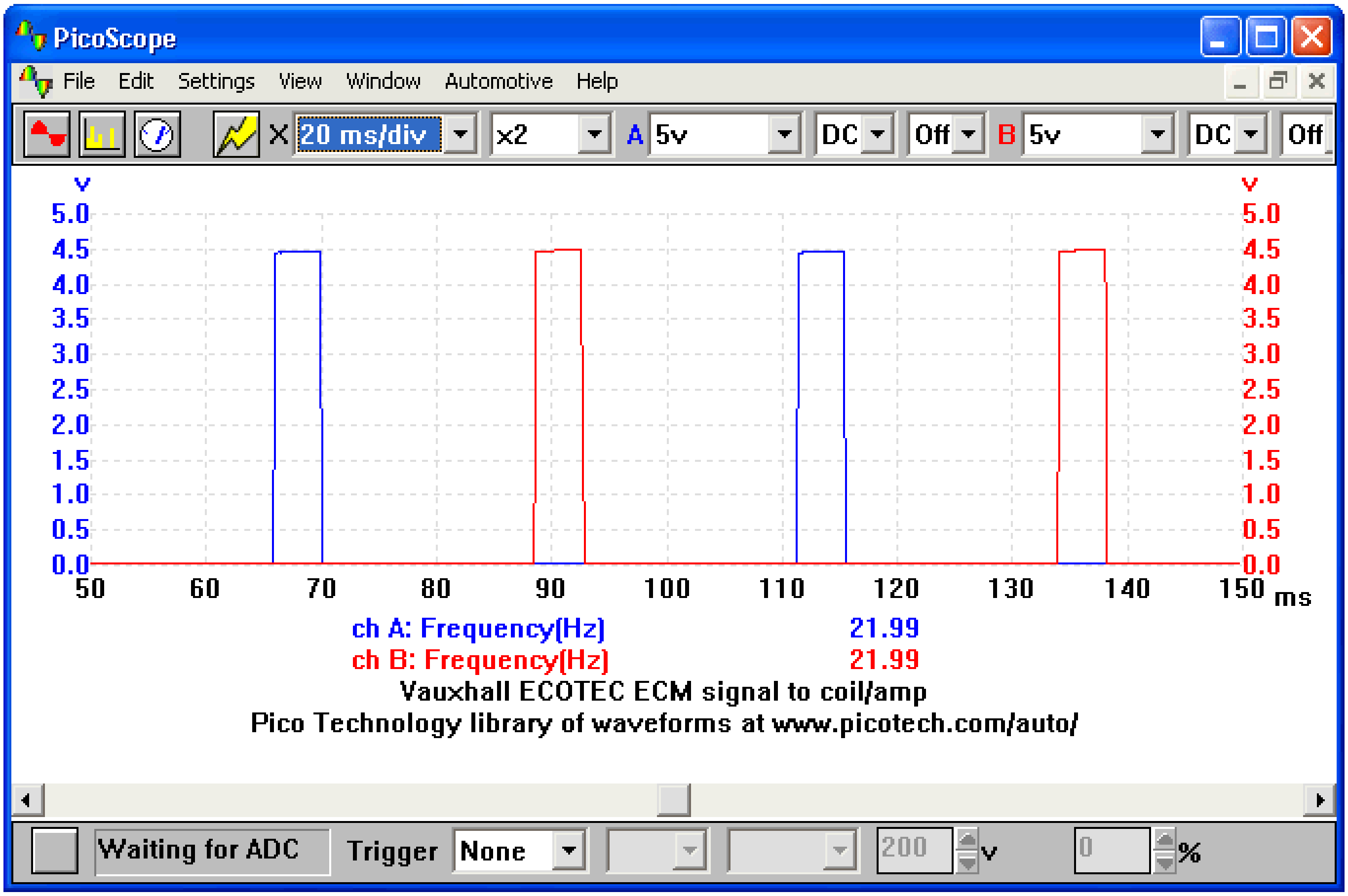
- Profile Ignition Pick-up and
- Spark Advance Word

Profile Ignition Pick-up is the term used for the signal sent from the Electronic Distributorless Ignition System (EDIS) to the Electronic Control Module (ECM). This signal is the digitally modified signal that originated from the Crank Angle Sensor (CAS) in an Alternating Current (AC) format. The PIP signal into the ECM is a square wave switched at 12 volts and is the ECM reference for the engines speed and position. The PIP signal when received by the ECM can then be modified to take into account the ignition timing advance. This returning signal to the EDIS unit is called the SAW signal as is in the form of a 5 volt square wave.

Both signals can be seen in the example waveform with the PIP signal in blue and the SAW signal in red.

VAUXHALL ECOTEC ECM to COIL WAVEFORM

Menu



Reference Waveform Notes - Vauxhall ECOTEC to ECM

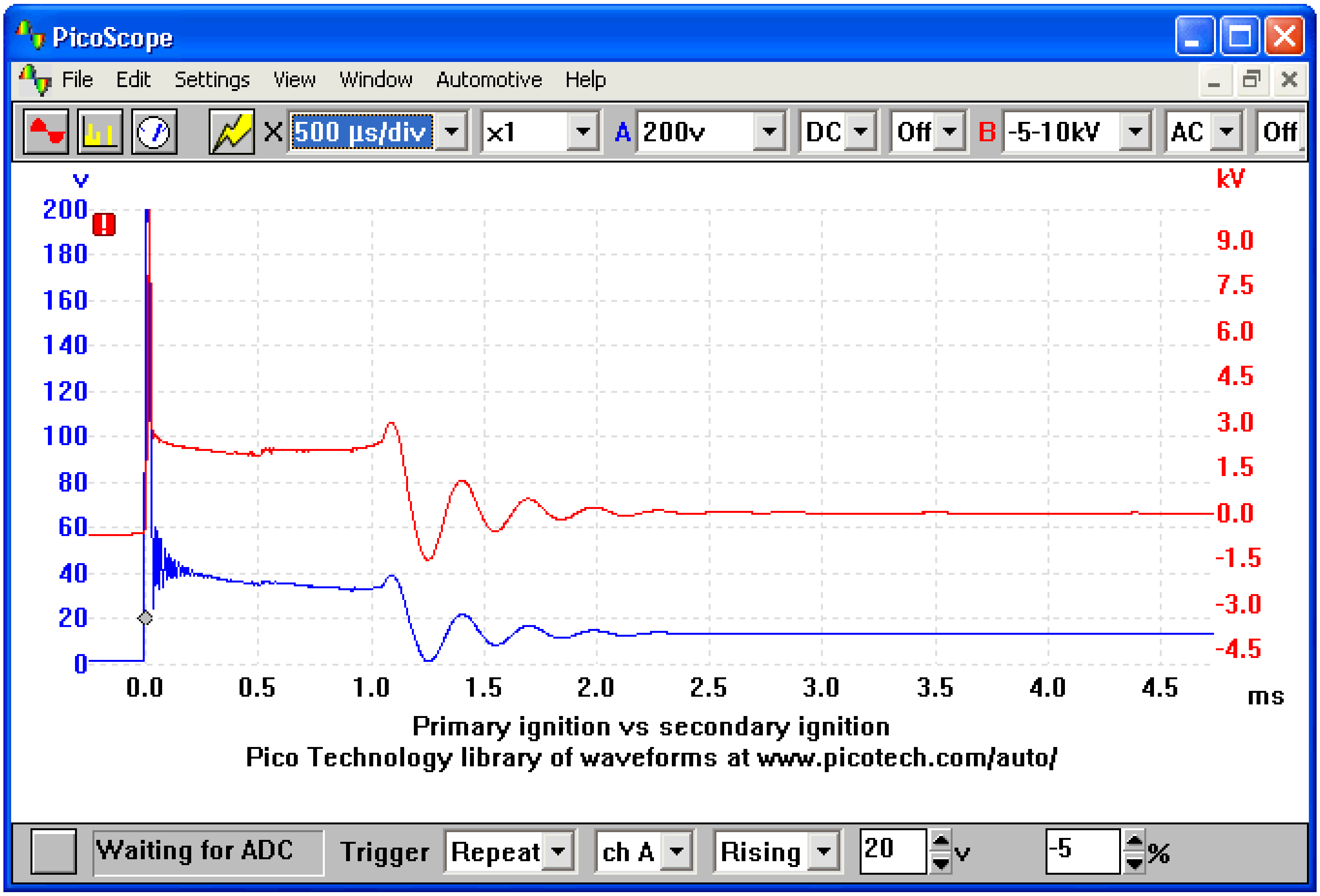
The double ended coil in this particular case differs from many other systems as it has the ignition amplifier built into the coil pack. The coil/amplifier pack will have 4 electrical connections. The pack receives a 12 volt supply from the ignition switch, has an independent earth return and the remaining two connections are in the form of a 5 volt 'square wave' digital signal from the Electronic Control Module (ECM).

The ECM will receive information from the engines sensors and calculates the point of ignition by the ECM from its internal pre-set parameter. At the designated point, the 5 volt supply drops to zero volts, signaling the amplifier to remove the earth path on the coil primary, firing the coil.

The coil/amplifier pack has two separate sides (one for cylinders 1 + 4 and the other for cylinders 2 + 3). Using an oscilloscope with dual trace both circuits can be monitored and it can be seen that the coils are fired alternately, as the example shows.

PRIMARY IGNITION vs SECONDARY IGNITION

Menu



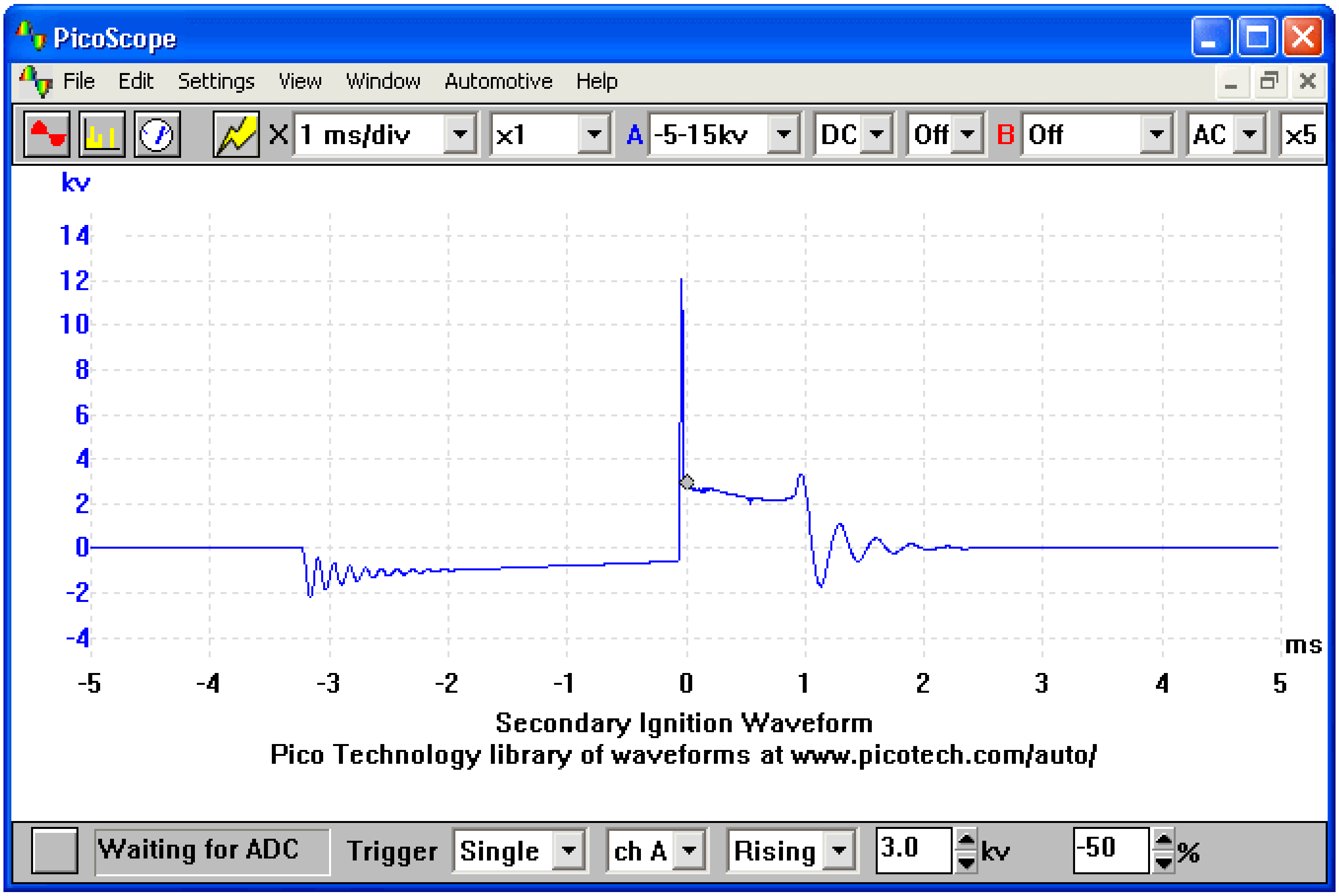
Reference Waveform Notes - Primary Ignition vs Secondary Ignition

The example waveform shows the exact relationship between the ignition's primary circuit and the secondary output. The primary circuit transfers its characteristics into the secondary through 'mutual inductance' and will mirror the primary exactly.

The blue trace shown in the example is the Low Tension (LT) signal, measured from the coil's negative terminal (marked number 1). The red trace is the High Tension (HT) output voltage measured at the coil HT secondary lead. In the example shown both waveforms show exactly the same burn time of 1.1 milli seconds (ms).

SECONDARY IGNITION WAVEFORM

Menu



Reference Waveform Notes - Secondary Ignition

The ignition secondary picture shown in the example waveform is a typical picture from an engine fitted with electronic ignition.

The waveform is an individual secondary High Tension (HT) picture that can be observed one cylinder at a time. This secondary waveform shows the initial voltage to jump the plug gap, know as the 'Plug Kv' then shows the length of time that the HT is flowing across the spark plugs electrode plug gap. This time is referred to as either the 'Burn Time’ or the 'Spark Duration'.

In the example waveform it can be seen that the horizontal voltage line (Spark line) in the centre of the screen is at a fairly constant voltage of approximately 3 Kilo volts (Kv), which then drops sharply into what is referred to as the 'Coil Oscillations'.

The Coil Oscillation should display a minimum number of peaks (both upper and lower) and a minimum of 4 - 5 should be seen. A loss of peaks on this oscillation shows that the coil needs substituting.

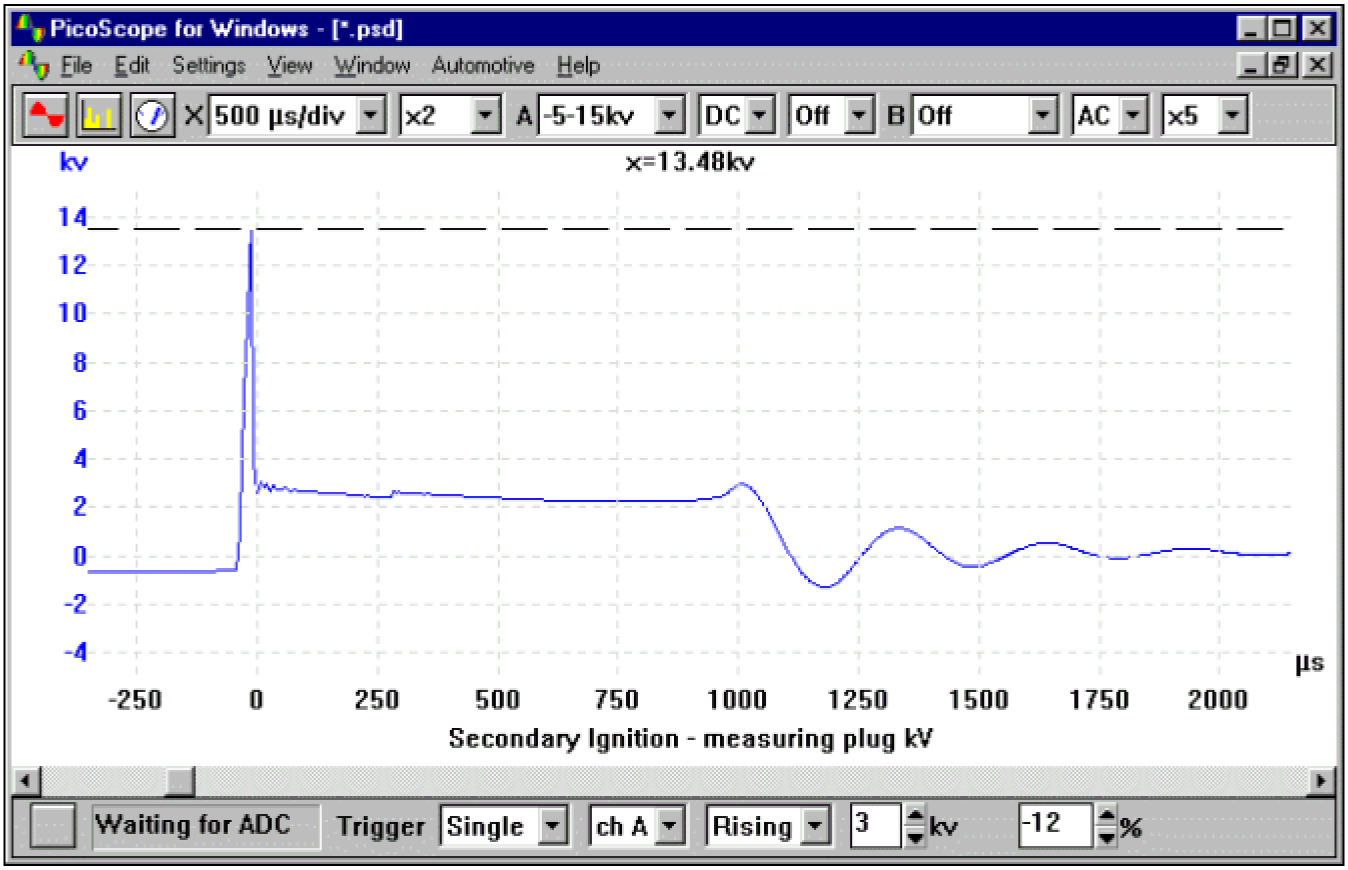
The period between the coil oscillation and the next 'drop down' is when the coil is at rest and there is no voltage in the coils secondary.

The 'drop down' is referred to as the 'Polarity Peak' and produces a small oscillation in the opposite direction to the plug firing voltage. This is due to the initial switching on of the coil's primary current.

The voltage within the coil is only released at the correct point of ignition and the HT spark ignites the Air/Fuel mixture.

SECONDARY IGNITION – PLUG Kv

Menu



Reference Waveform Notes - Secondary Ignition (Plug Kv)

The plug firing voltage is the voltage required to jump and bridge the gap at the plug's electrode. Commonly known as the 'Plug Kv' (Kilo Volts).

The plug Kv's will be increased by :

- Large plug gaps
- A large rotor air gap
- A break in a plug lead
- A break in the coil HT lead
- Worn spark plugs
- A lean mixture
- Rotor to reluctor misalignment

The plug Kv's will be decreased by :

- Small plug gaps
- Low compression
- Rich mixture
- Incorrect ignition timing

- Tracking to earth
- Fouled plugs

A high resistance in the High Tension (HT) leads or the coil lead will not alter the plug Kv (however an increase in spark line Kv will be evident). An open circuit lead will increase both the plug Kv and the spark line Kv.

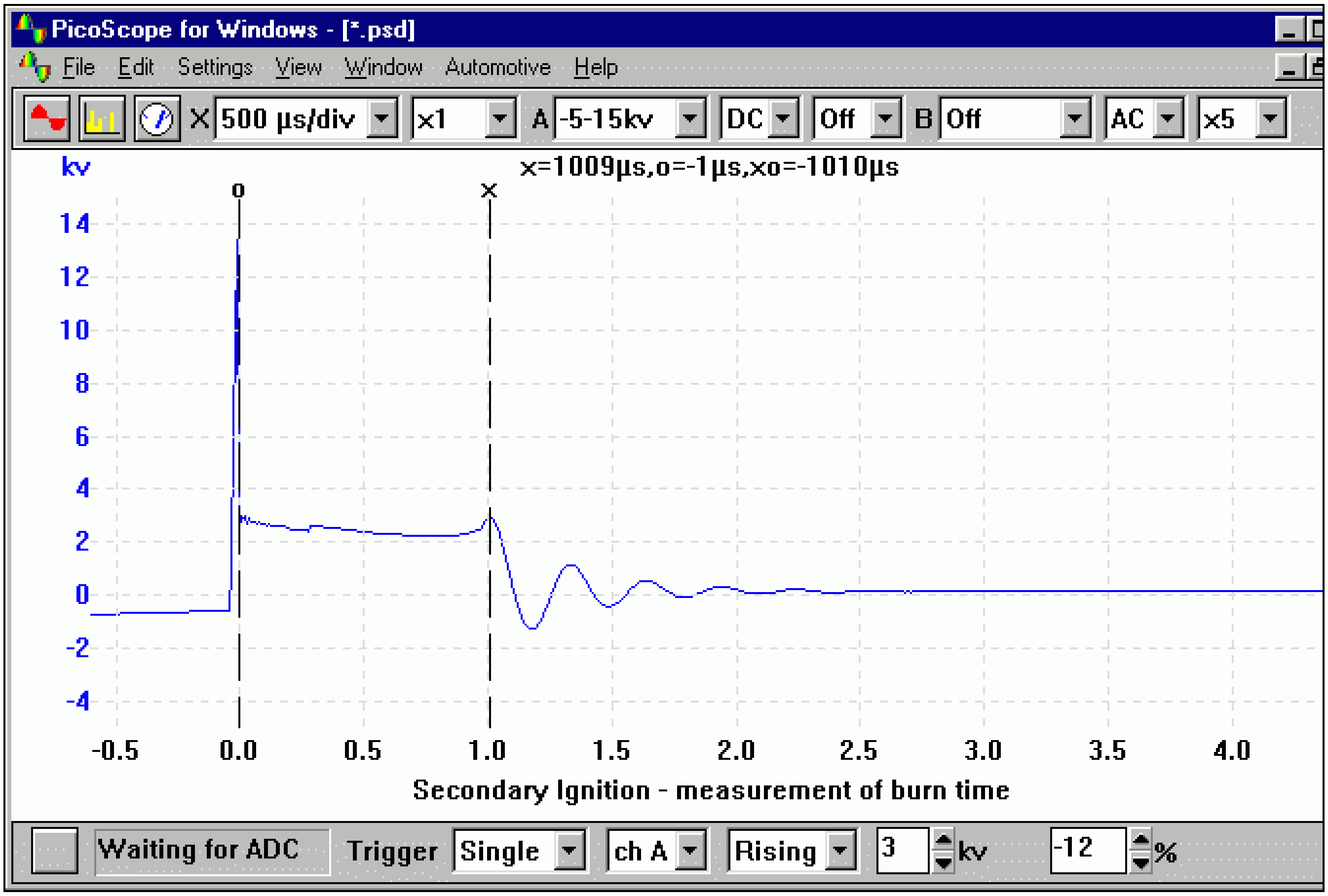
Use different voltage ranges for different tests:-

- 0 to 25 Kv for plug firing voltages and HT insulation testing
- 0 to 50 Kv for plug firing voltages on Distributorless Ignition System (DIS) and coil output testing.

PICO SCOPE

SECONDARY IGNITION – BURN TIME

Menu

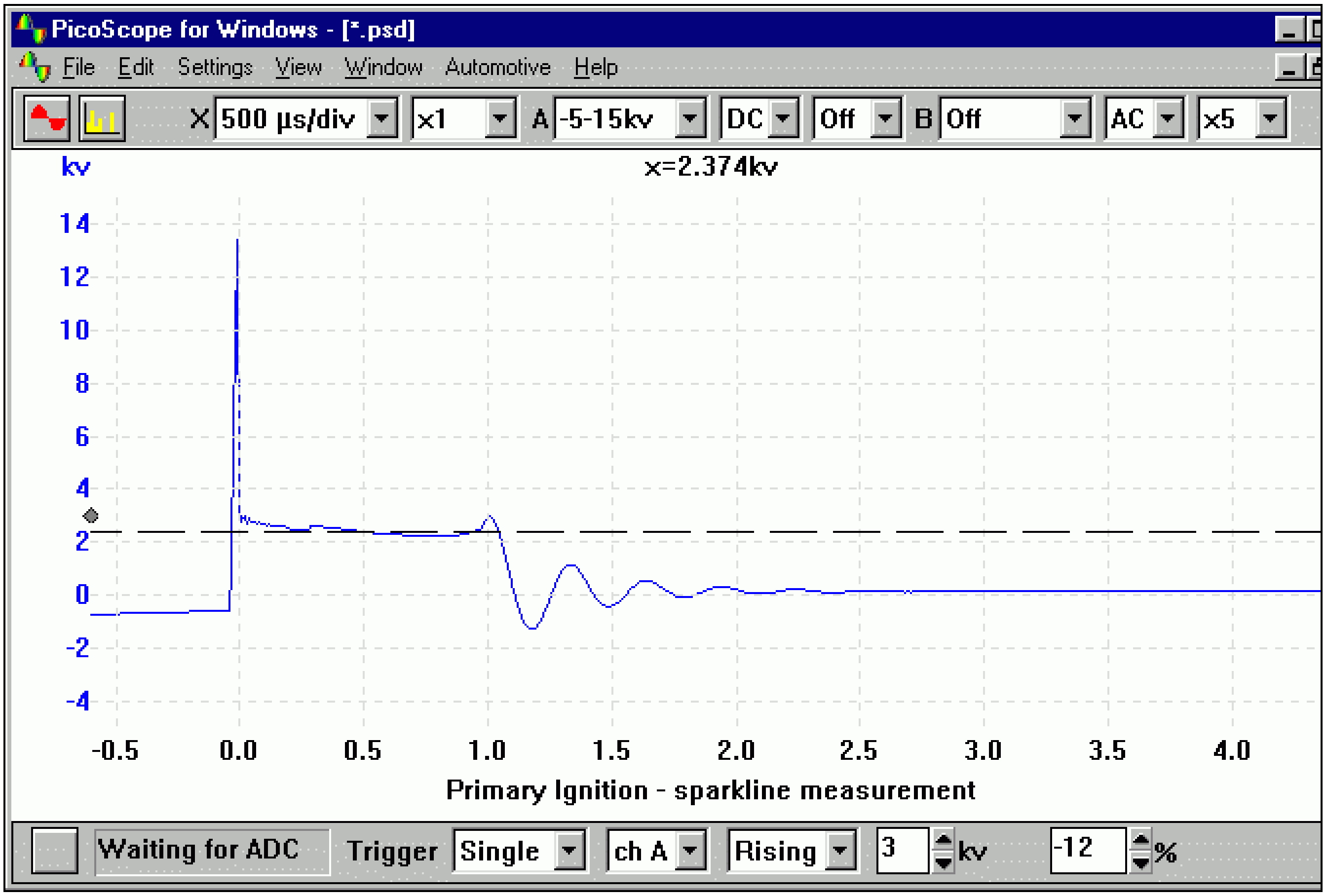


Secondary Ignition (Measurement of Burn Time) Reference Waveform

PICO SCOPE

SECONDARY IGNITION – SPARK LINE

Menu

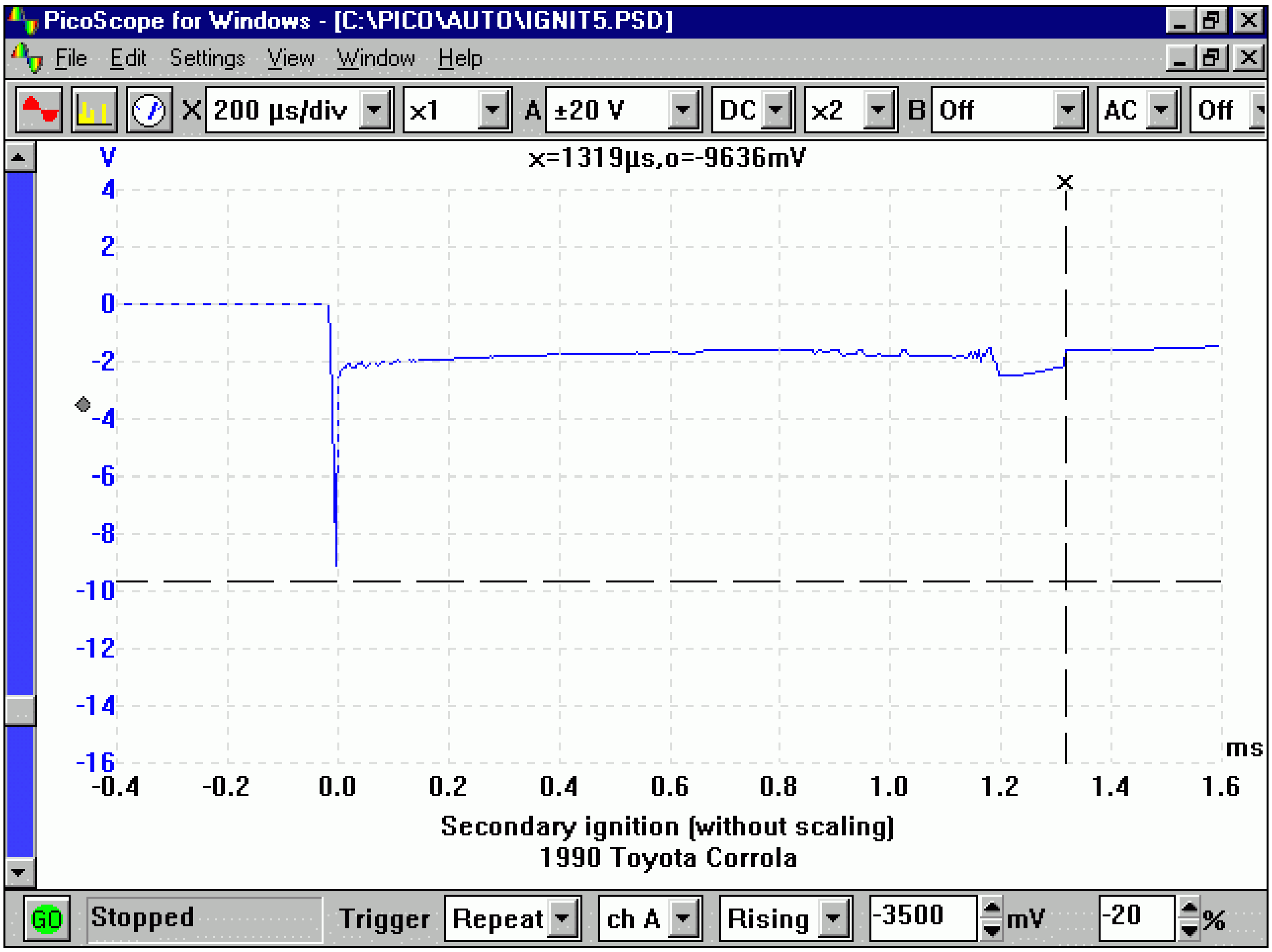


Secondary Ignition (Measurement of Spark Line) Reference Waveform

PICO SCOPE

SECONDARY IGNITION – (No Pico Scope Scaling)

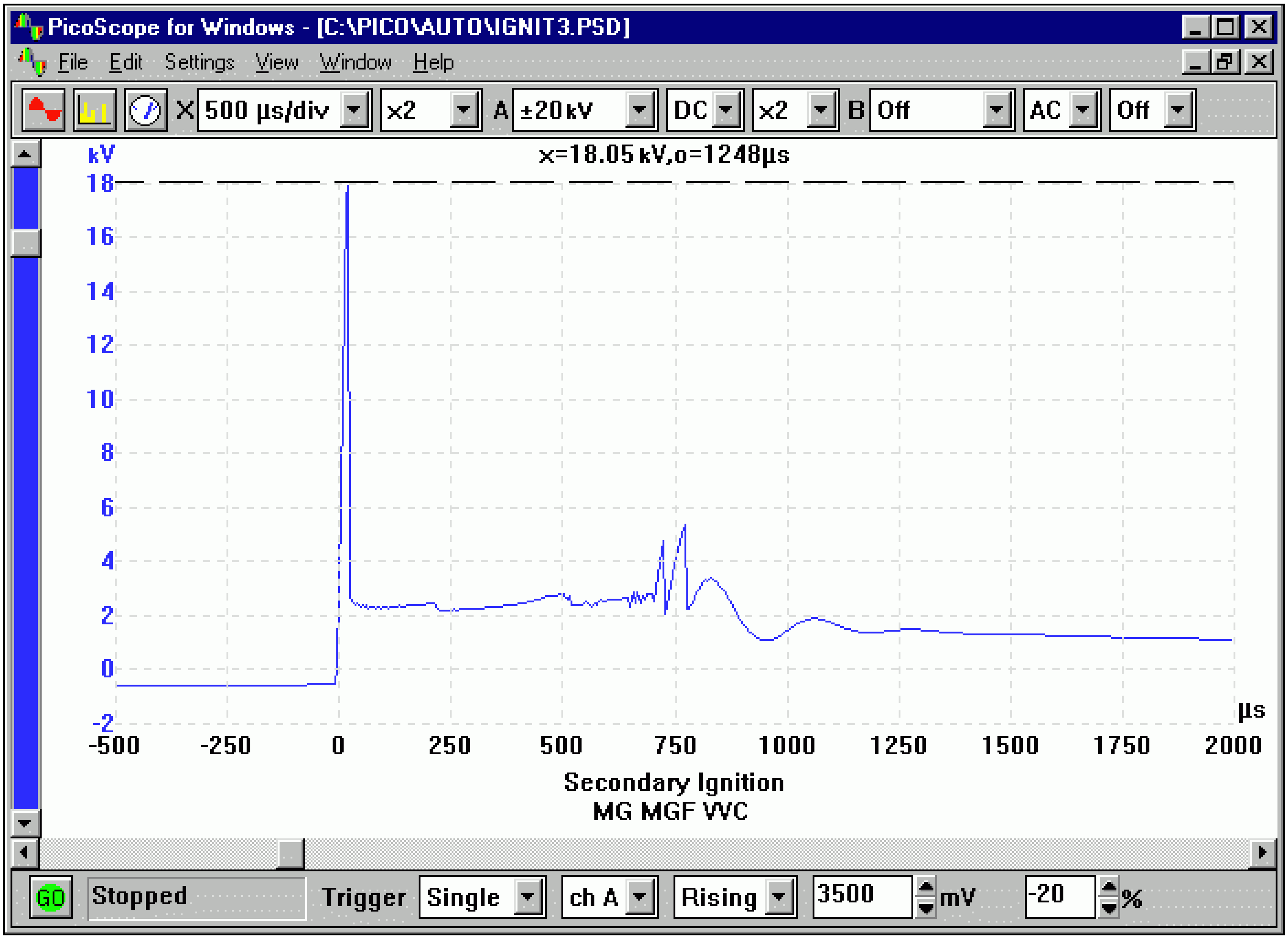
Menu



Secondary Ignition (Toyota Corolla 1.4L 1990 – No Pico Scope Scaling) Waveform Capture

PICO SCOPE

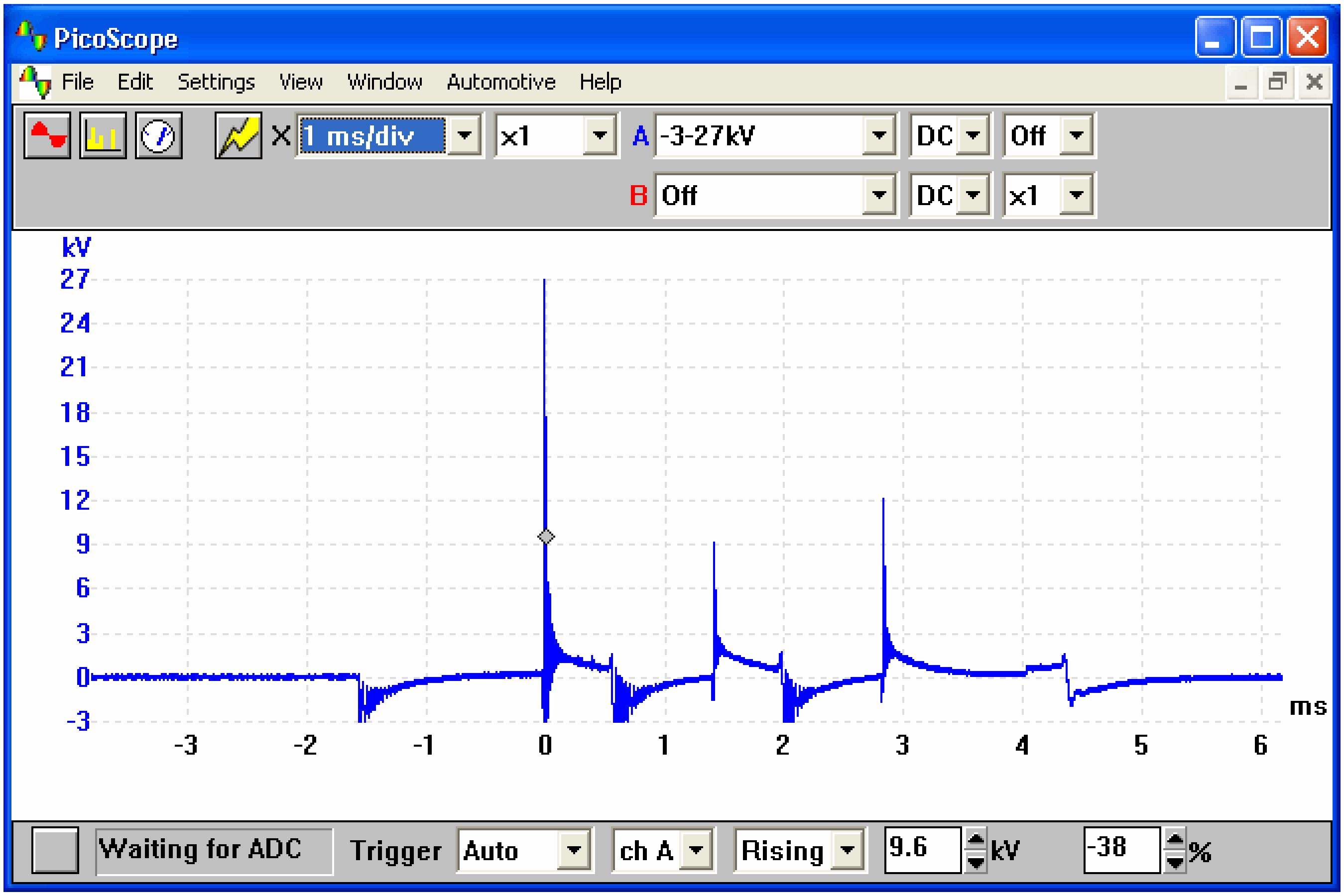
SECONDARY IGNITION – (With Pico Scope Scaling) **Menu**



Secondary Ignition (MG MGF VVC – With Pico Scope Scaling) Reference Waveform

SECONDARY IGNITION - MULTI SPARK

Menu



Reference Waveform Notes - Secondary Ignition (Aston Martin V8 - Multi Spark)

The multi spark replaces the usual single spark found on most systems. The system uses 3 sparks in quick succession to improve combustion with lower idle speeds and decreases low rpm emissions. The multi spark switches to single spark once a preset rpm is reached — usually in the region of 2500 rpm. Multi spark is used mainly on large CID V8 engines.

This waveform was captured on V8 engine at idle with COP (Coil on Plug) Ignition. Each coil is individually controlled by the PCM. The waveform was captured using a 2-channel Pico Scope automotive oscilloscope in conjunction with a COP ignition HT probe.

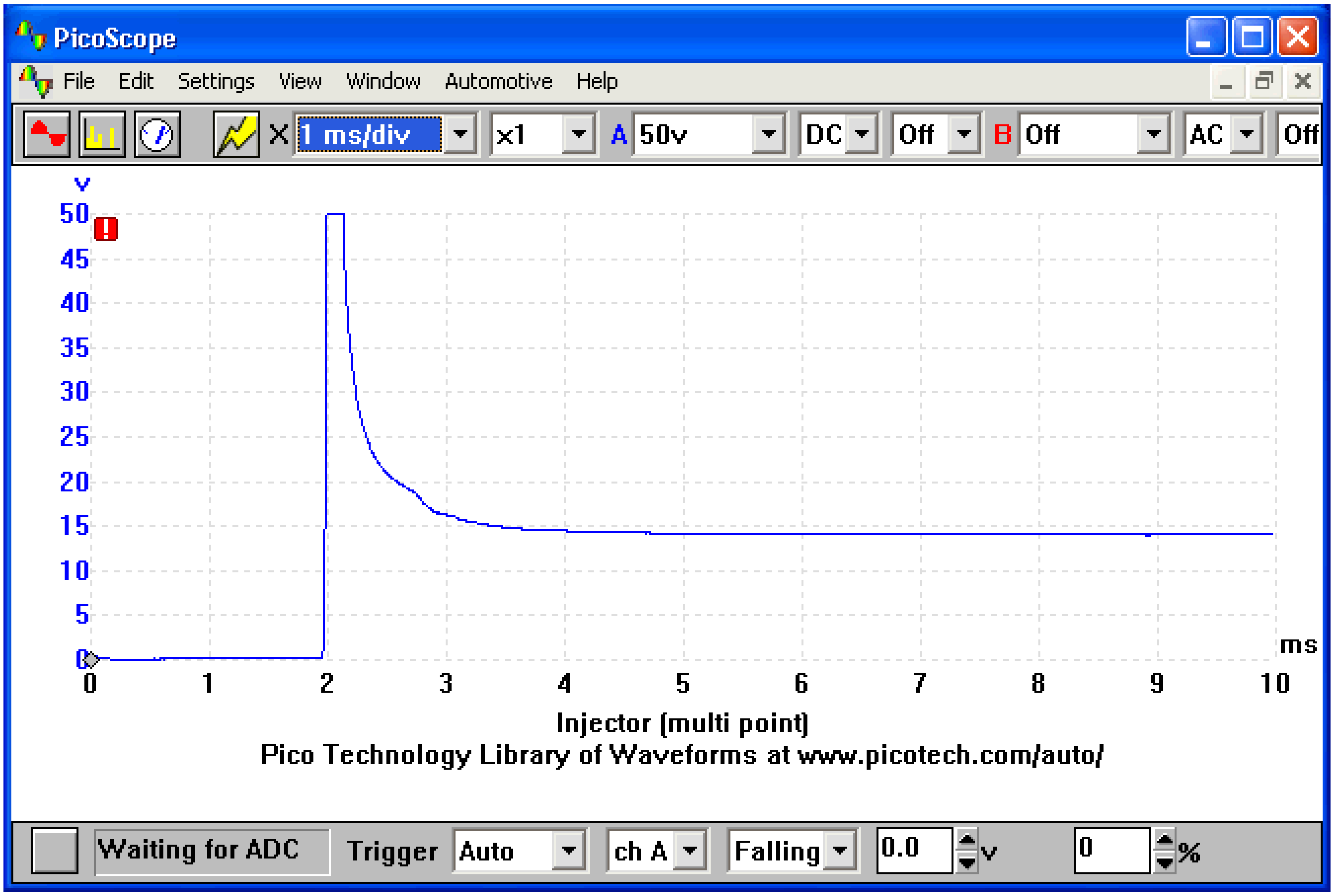
So what can we see in the waveform? Well, notice that the first 2 sparks are of a shorter than usual duration, the coil re-energises after less than 1 ms of burn time to top-up the charge in the coil, then switches off the current again to produce another spark at the plug.

On the last spark, the fully stored energy in the coil is used, finishing up with the usual coil oscillations caused by the last amount of energy left in the coil when the spark dies ringing away into the coil internal impedance.

Testing the system is done coil-by-coil, using the COP probe. Check the pattern in the usual way, but raise engine rpm and confirm that the system switches over to single spark at the same rpm at each coil, and that the pattern is stable and consistent through the rpm range of the motor with no misfiring.

FUEL INJECTOR – MULT POINT

Menu



Reference Waveform Notes - Fuel Injector (Multi Point)

The injector is an electromechanical device which is powered by a 12 volt supply. The voltage will only be present when the engine is cranking or running, due to the voltage supply being controlled by a tachometric relay.

The length of time the injector is held open will depend on the input signals seen by the Electronic Control Module (ECM) from the systems various engine sensors.

The held open time or 'injector duration' will vary to compensate for cold engine starting and warm-up periods. The duration time will also expand under acceleration.

The injector will have a constant voltage supply while the engine is running and the earth path will be switched via the ECM, the result can be seen in the example waveform.

When the earth is removed a voltage is induced into the injector and a spike approaching 50 volts is recorded.

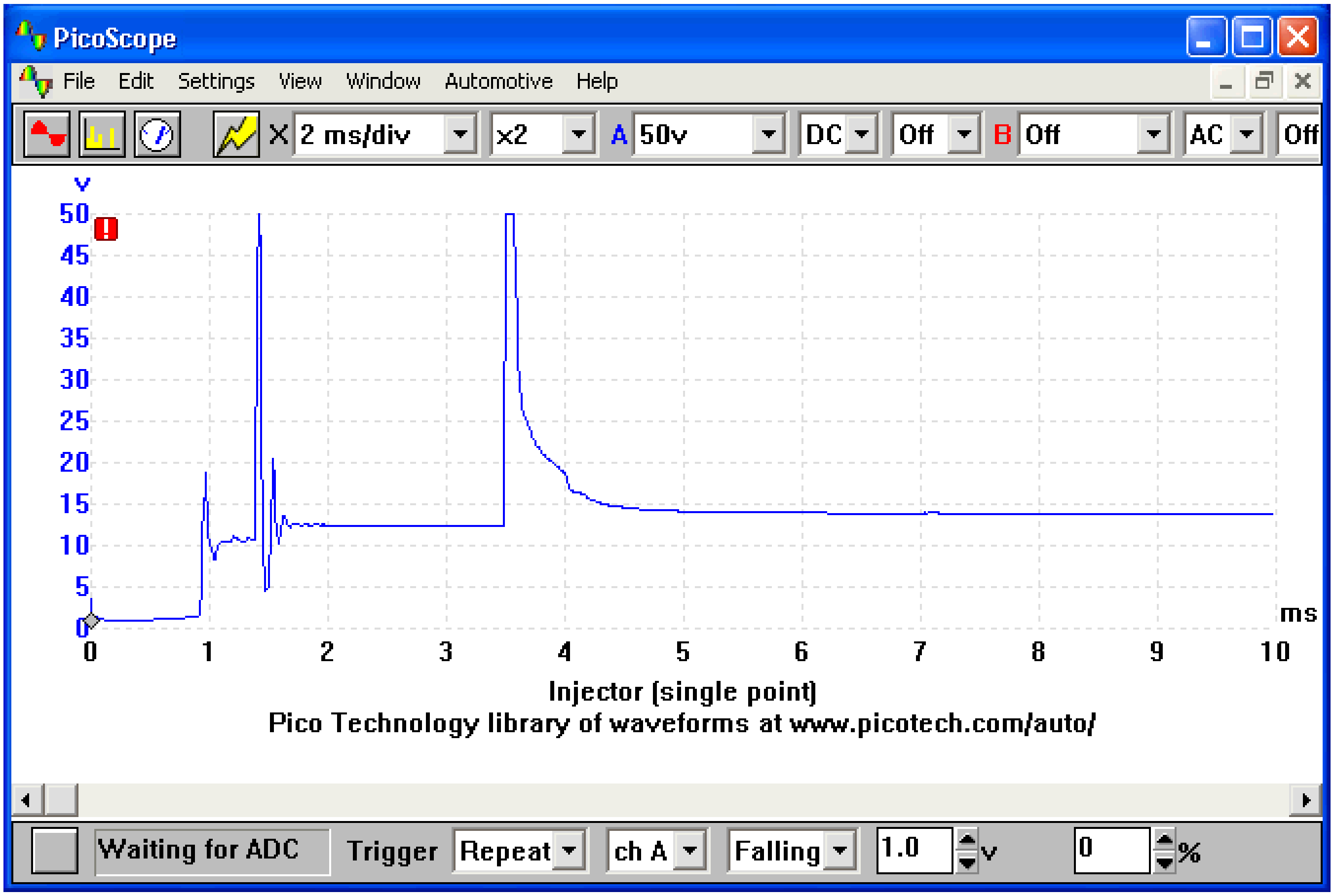
Multi Point injection may be either Sequential or Simultaneous. A Simultaneous system will fire all 4 injectors at the same time with each cylinder receiving 2 injection pulses per cycle (720° crankshaft rotation).

A Sequential system will receive just 1 injection pulse per cycle and this is timed to coincide with the opening of the inlet valve.

As an approximate guide the injector duration for an engine at normal operating temperature, at idle speed are:-

- 2.5 ms - Simultaneous
- 3.5 ms - Sequential

FUEL INJECTOR – SINGLE POINT (Example 1) [Menu]

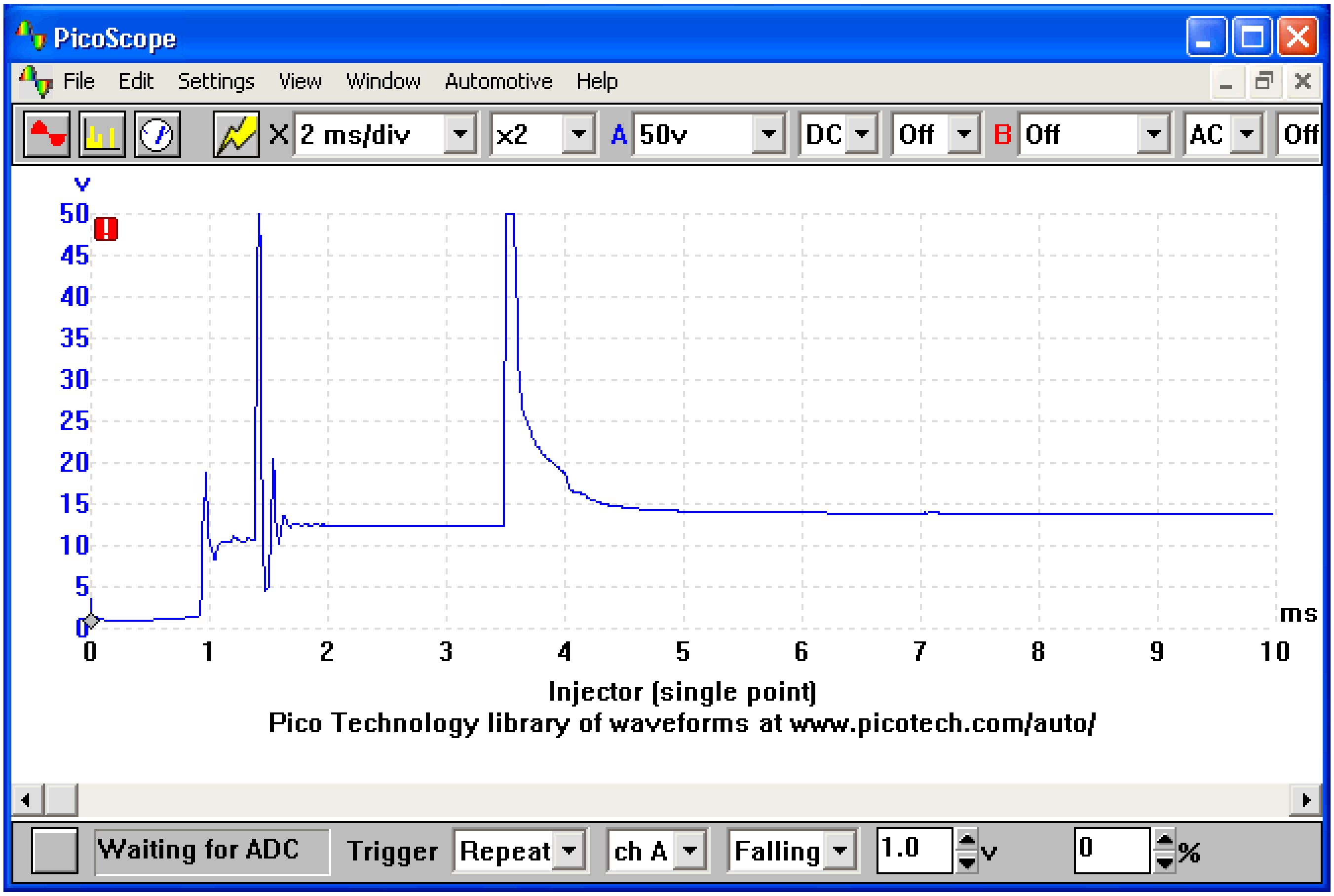


Reference Waveform Notes - Fuel Injector (Single Point – Example 1)

Single Point Injector (SPI) is also sometimes refereed to as Throttle Body Injection (TBI).
A single injector is used (on larger engines two injectors can be used) in what may have the outward appearance to be a carburettor housing.

The resultant waveform from the SPI system will show an initial injection period followed by multi-pulsing of the injector in the remainder of the trace. This section of the waveform is called the supplementary duration and is the only part of the injection trace to expand.

FUEL INJECTOR – SINGLE POINT (Example 2) Menu



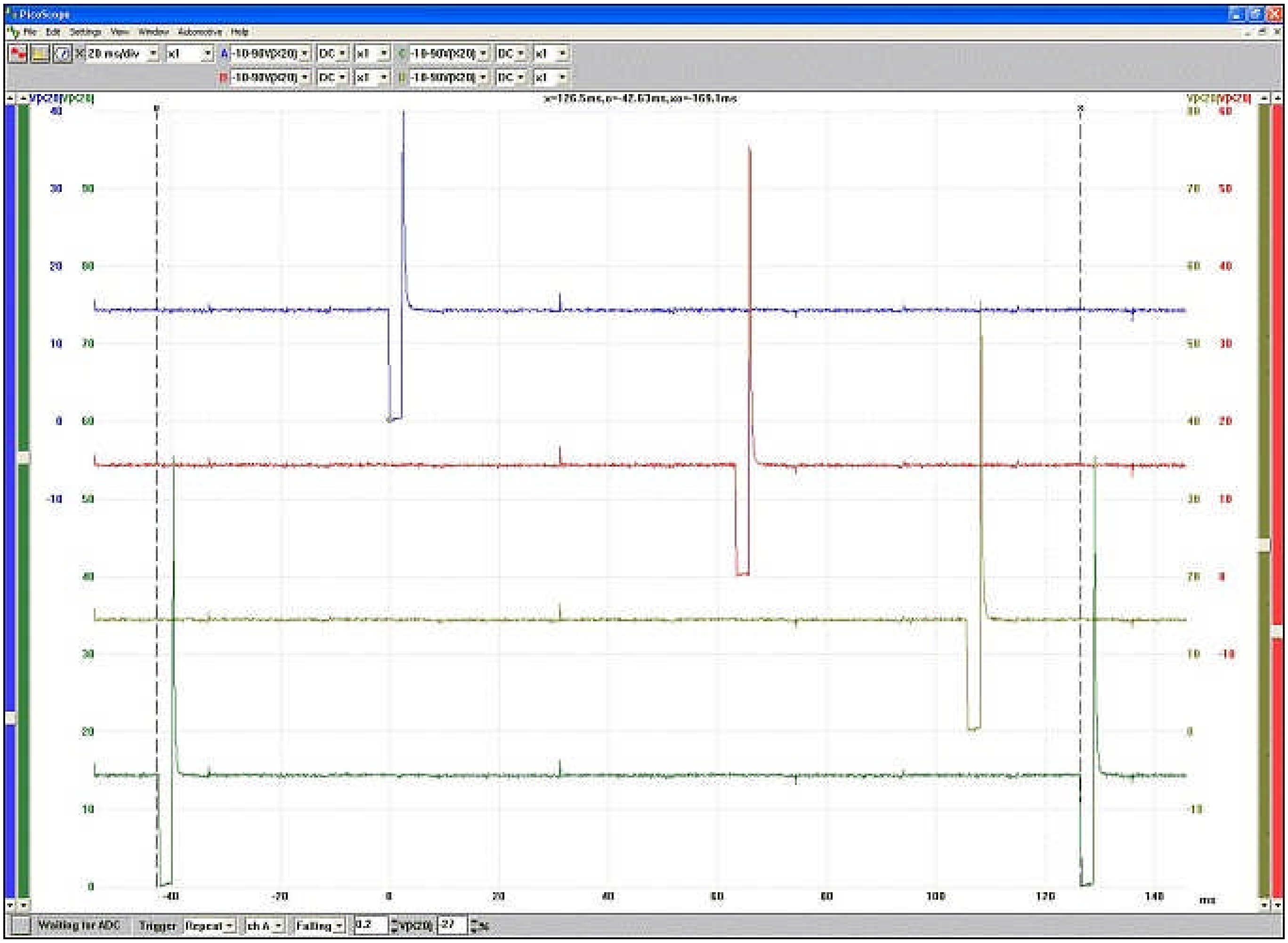
Reference Waveform Notes - Fuel Injector (Single Point – Example 2)

Single Point Injector (SPI) is also sometimes referred to as Throttle Body Injection (TBI).
A single injector is used (on larger engines two injectors can be used) in what may have the outward appearance to be a carburettor housing.

The resultant waveform from the SPI system will show an initial injection period followed by multi-pulsing of the injector in the remainder of the trace. This section of the waveform is called the supplementary duration and is the only part of the injection trace to expand.

FUEL INJECTOR – (4 CHANNEL PICO SCOPE CAPTURE)

Menu



Reference Waveform Notes - Fuel Injector (4 Channel Pico Scope Capture)

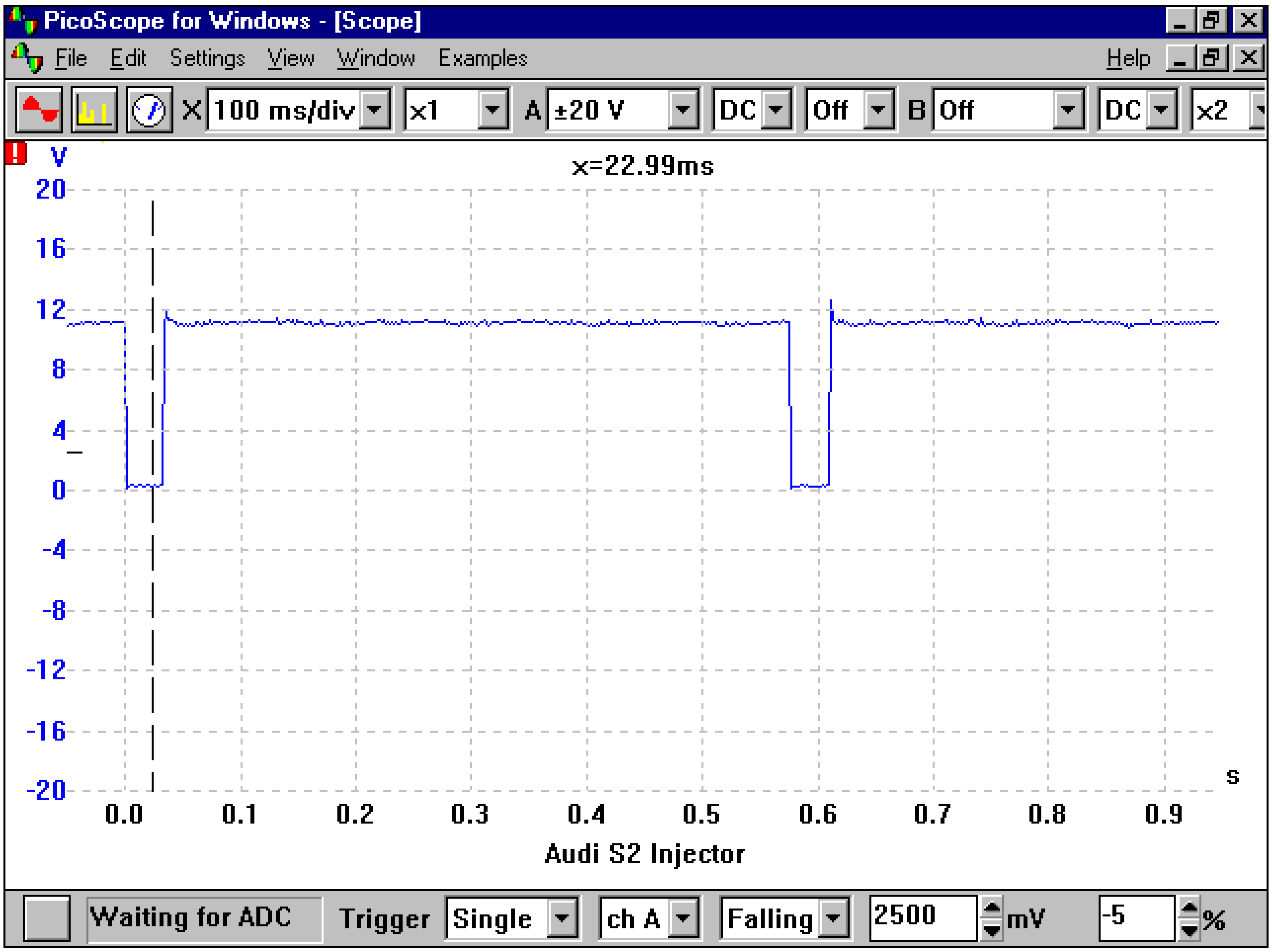
This waveform shows Injector Voltage signals from all 4 injectors from Bank 1 of a V8 cylinder engine. This clearly shows the timing of the injector events and the correct operation of the injector driver in the ECU.

This waveform was captured using a 4-channel Pico Scope 3423 Automotive Oscilloscope.

PICO SCOPE

FUEL INJECTOR

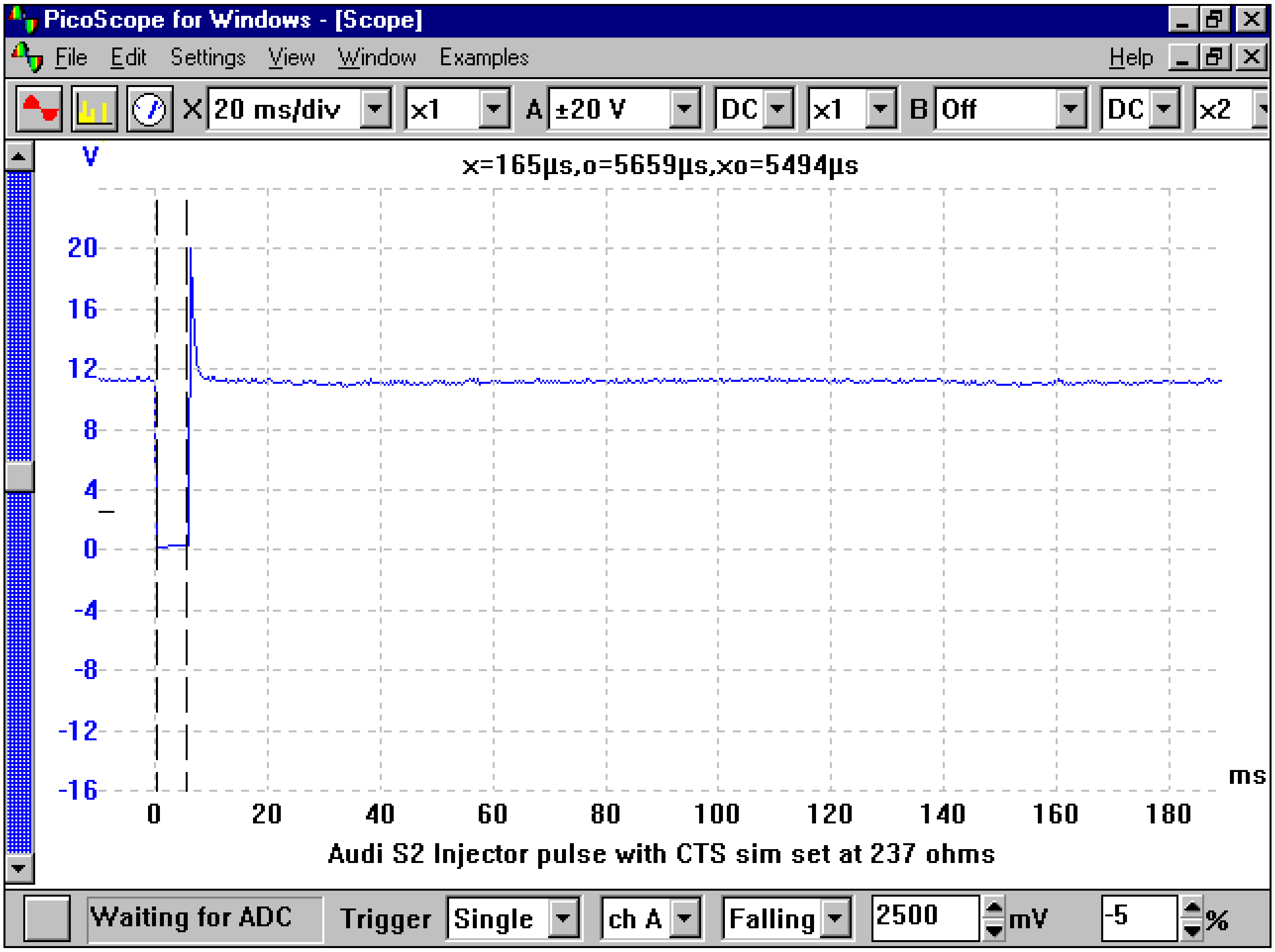
Menu



Fuel Injector (Audi S2) Reference Waveform

PICO SCOPE

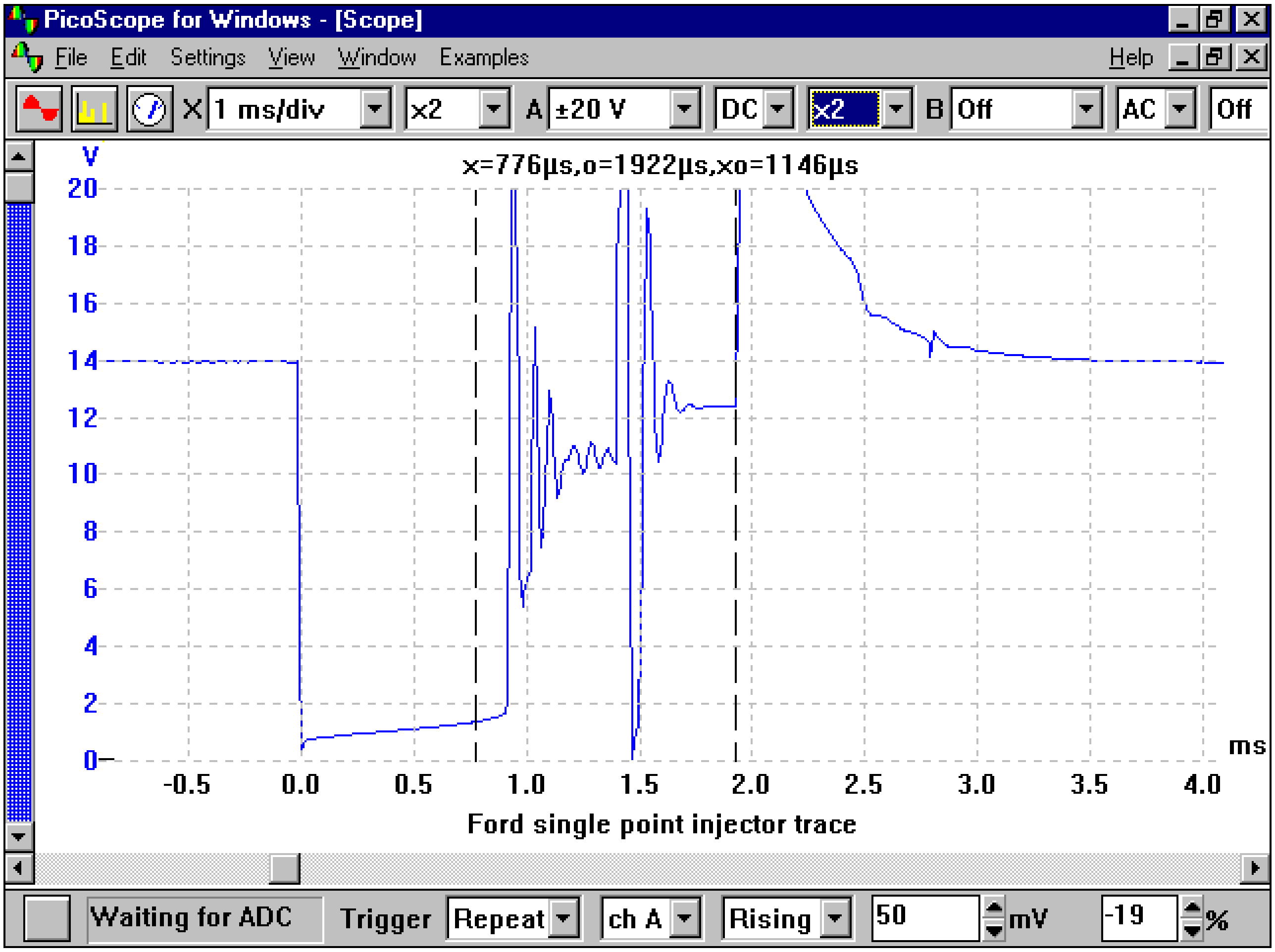
FUEL INJECTOR **Menu**



Fuel Injector (Audi S2 – with simulated Coolant Temp. Sensor set at 237 Ohms) Reference Waveform

PICO SCOPE

FUEL INJECTOR Menu

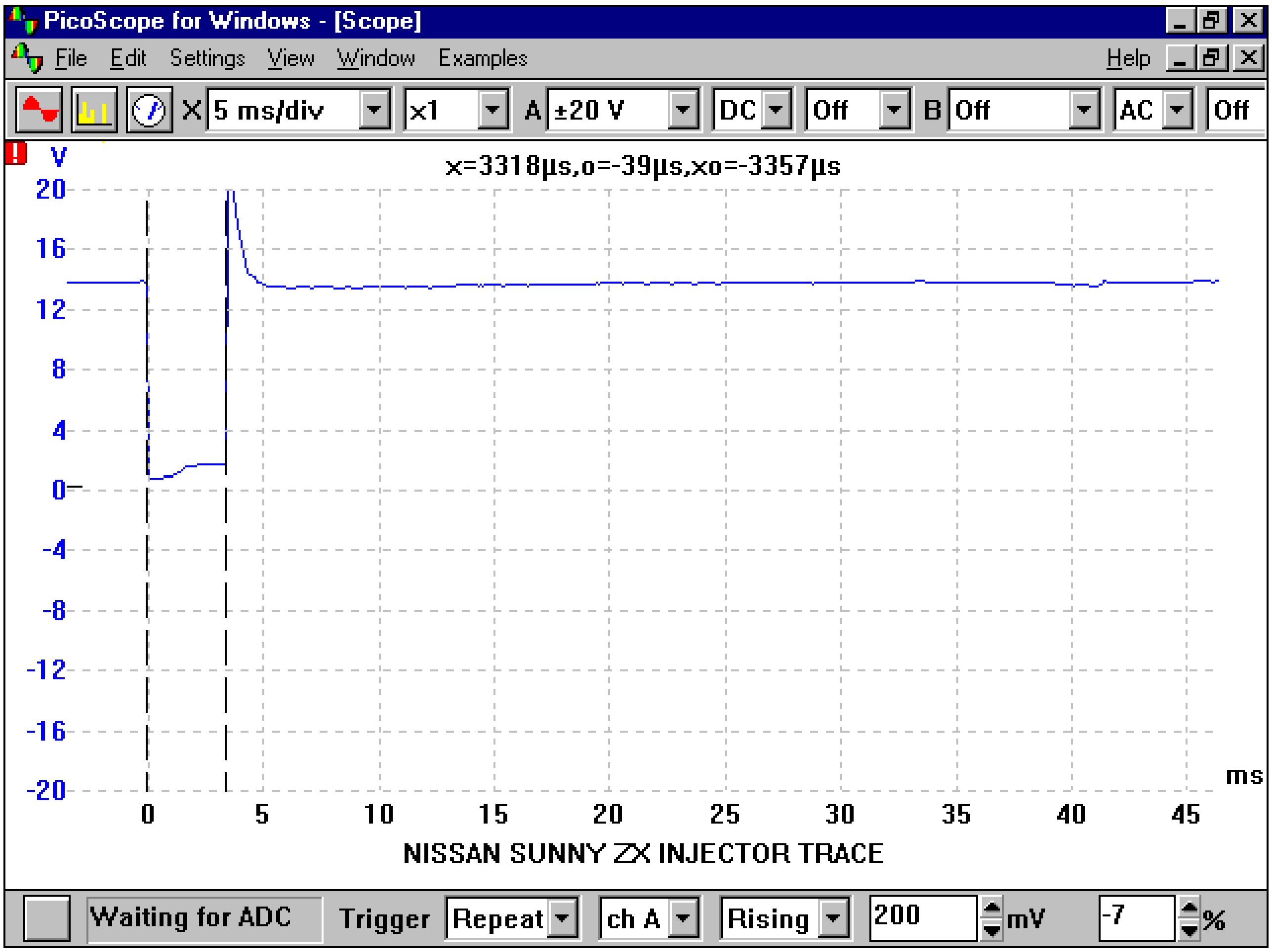


Fuel Injector (Ford Single Point) Reference Waveform

PICO SCOPE

FUEL INJECTOR

Menu

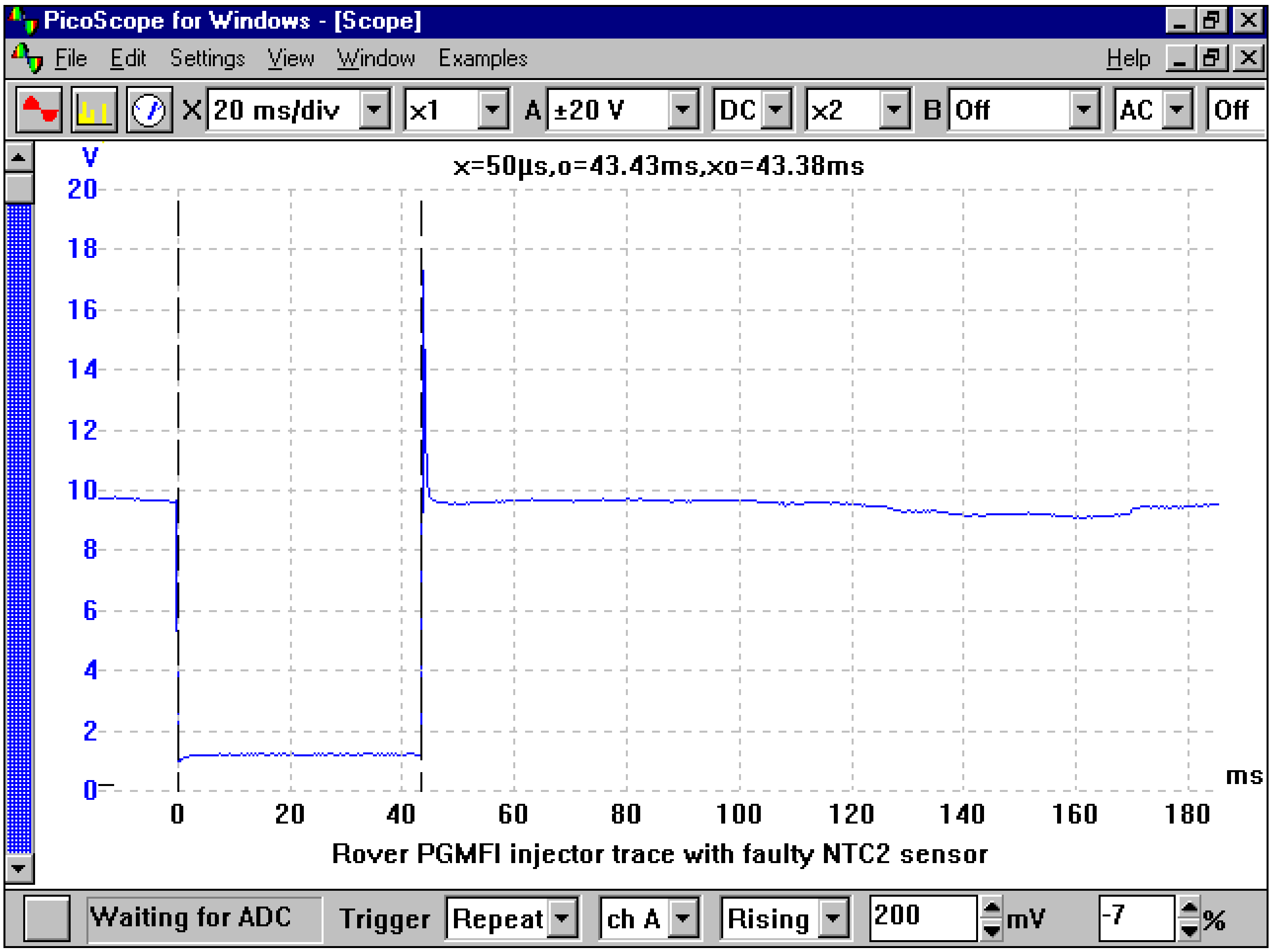


Fuel Injector (Nissan Sunny ZX) Reference Waveform

PICO SCOPE

FUEL INJECTOR

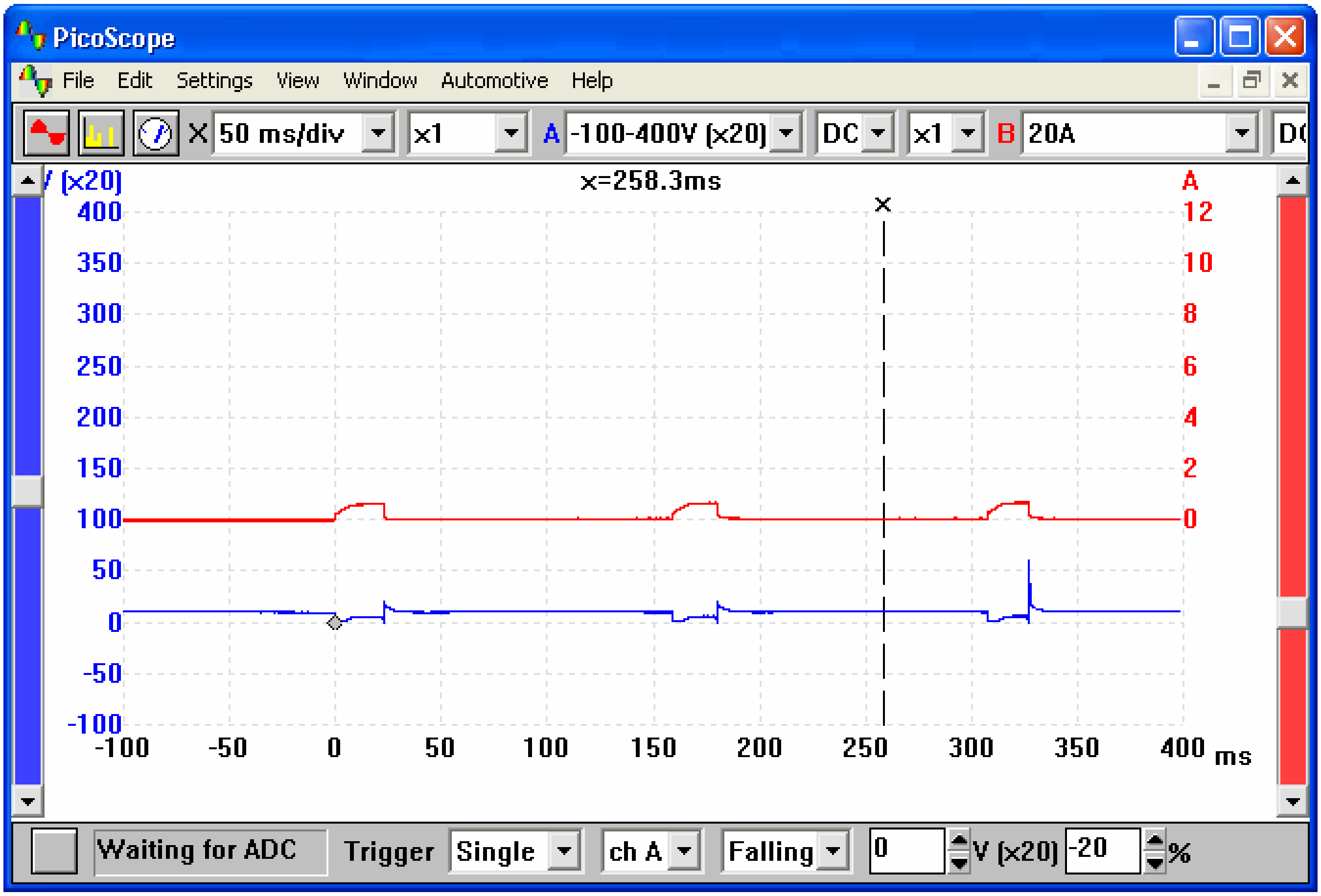
Menu



Fuel Injector (Rover PGMFI with faulty CTS2Sensor) Reference Waveform

PICO SCOPE

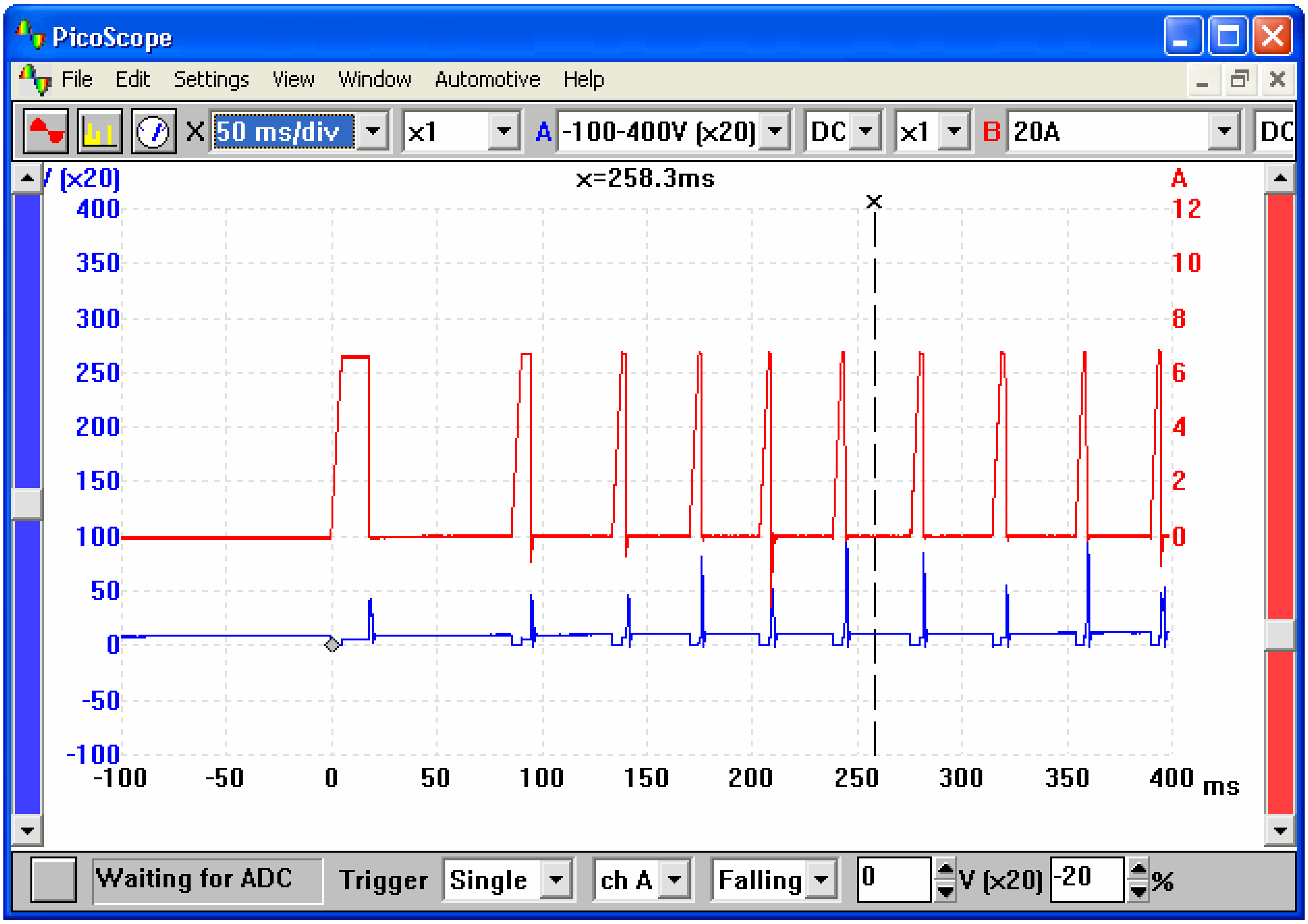
FUEL INJECTOR **Menu**



Fuel Injector (Toyota Tercel – Injector / Coil Current, Engine fails to start) Reference Waveform

PICO SCOPE

FUEL INJECTOR **Menu**

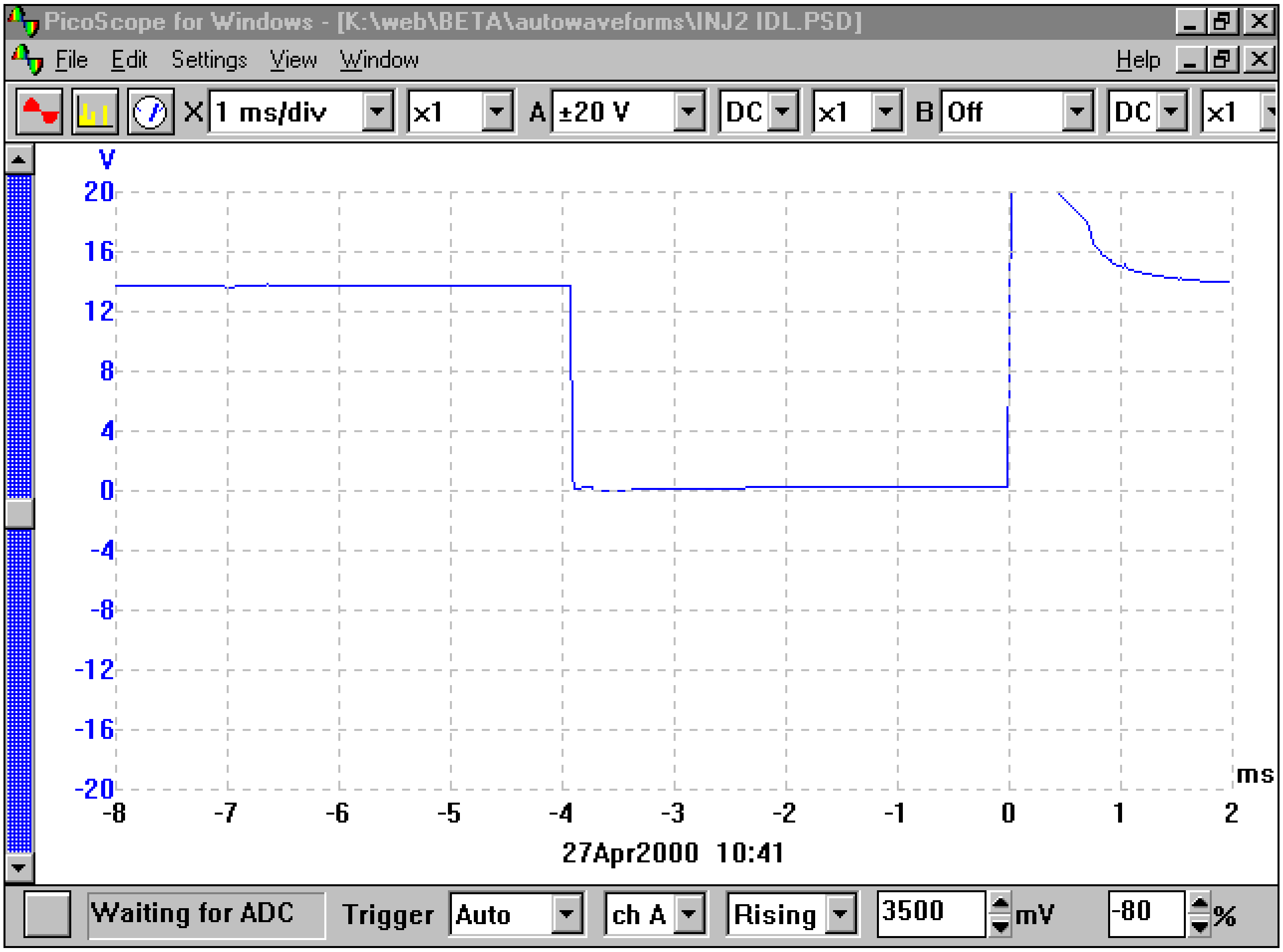


Fuel Injector (Toyota Tercel – Injector / Coil Current, After coil replacement) Reference Waveform

PICO SCOPE

FUEL INJECTOR

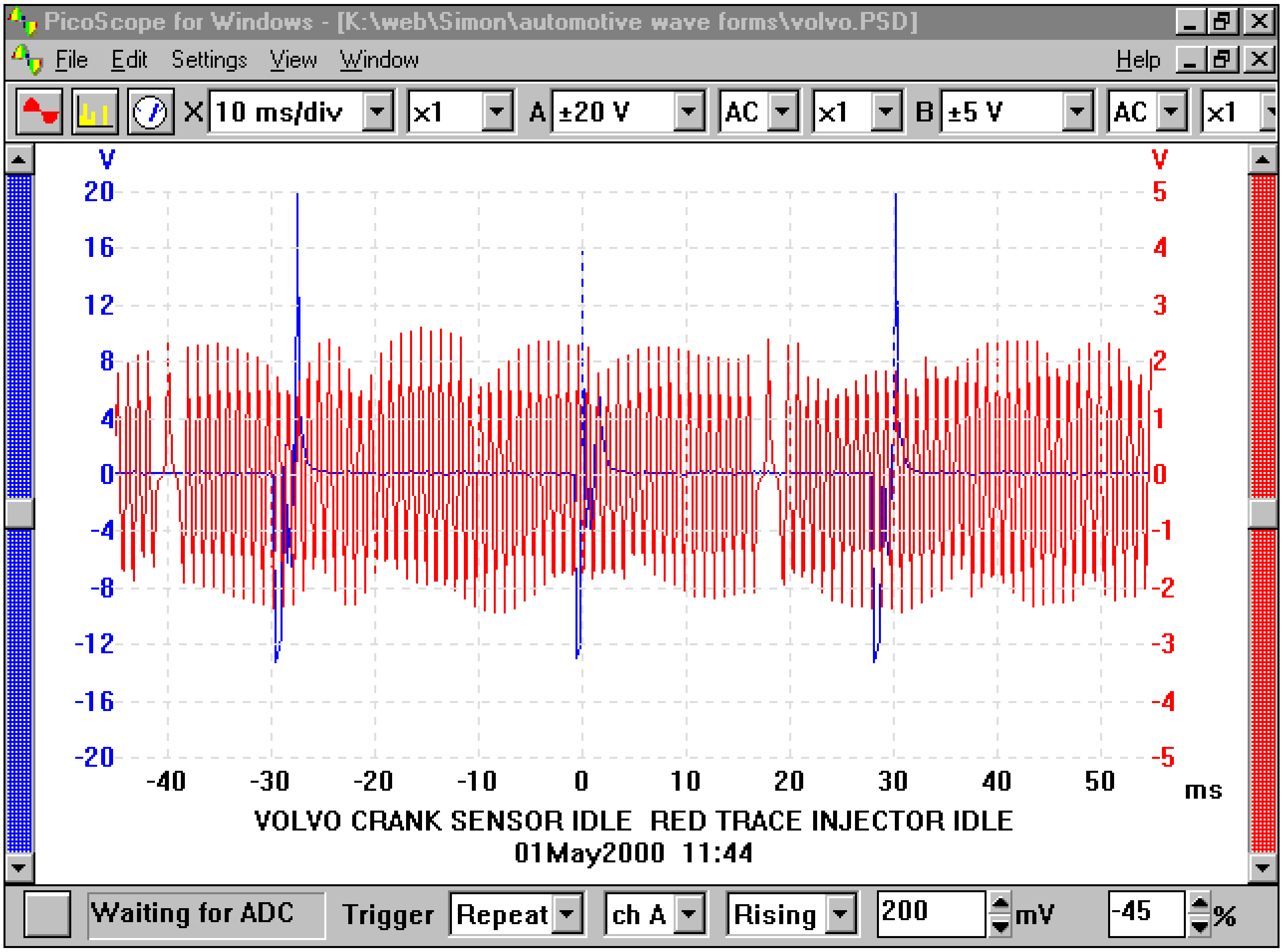
Menu



Fuel Injector (Volvo 940 Turbo) Reference Waveform

PICO SCOPE

FUEL INJECTOR **Menu**

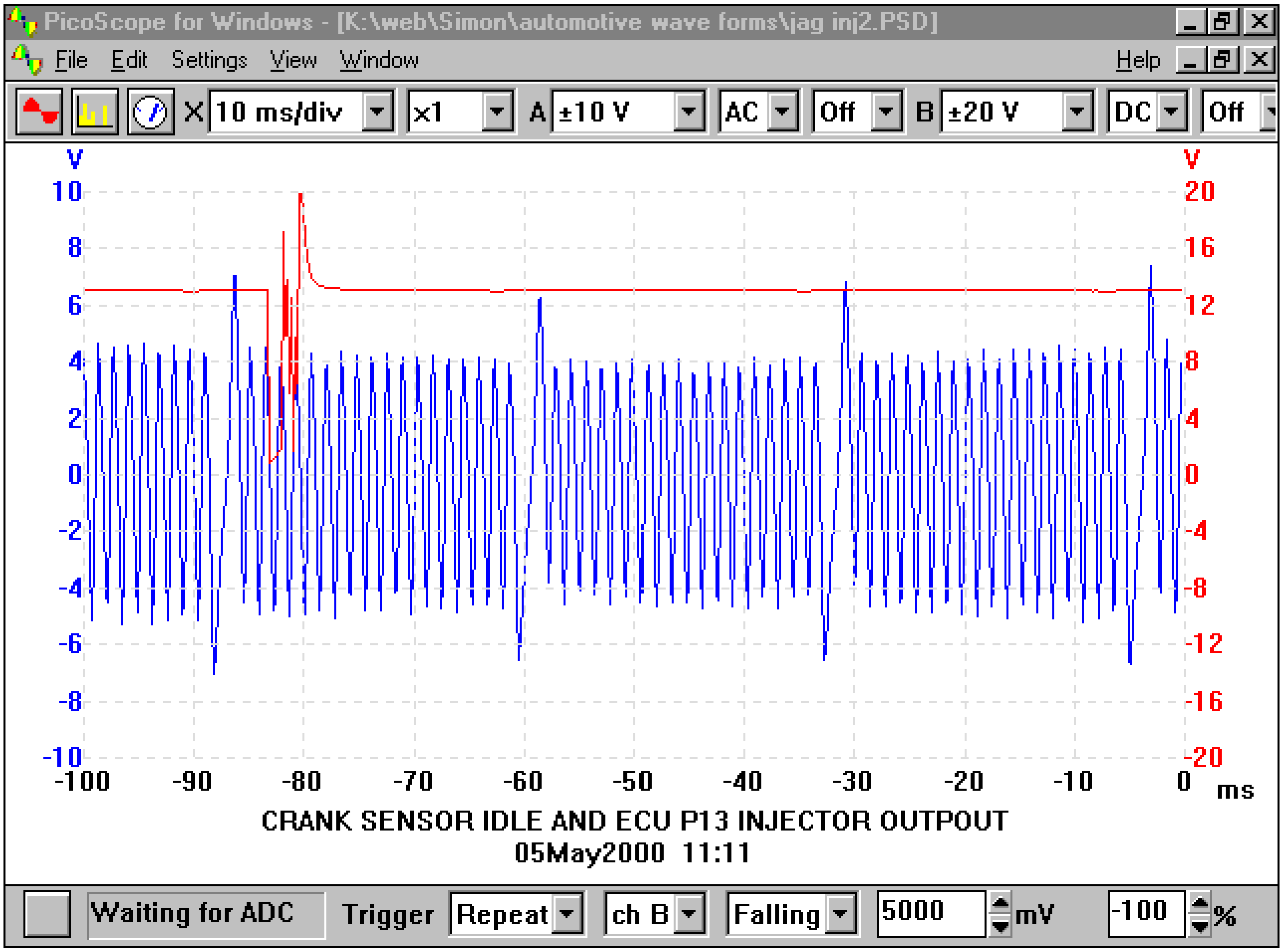


Fuel Injector (Volvo – Injector / Crank Signal at idle) Reference Waveform

PICO SCOPE

FUEL INJECTOR

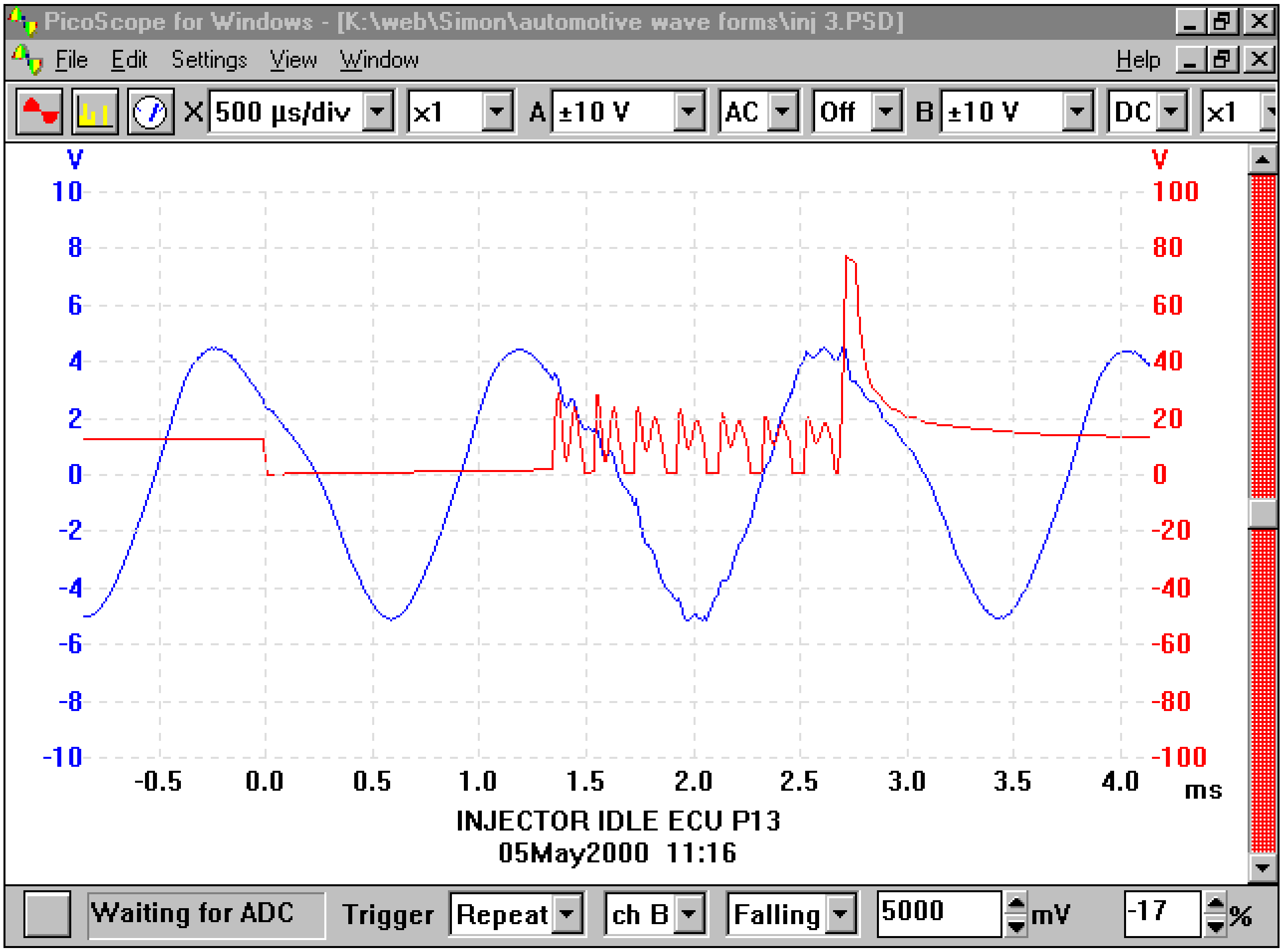
Menu



Fuel Injector (Jaguar 3.6L – Injector / Crank Signal at idle) Reference Waveform

PICO SCOPE

FUEL INJECTOR **Menu**

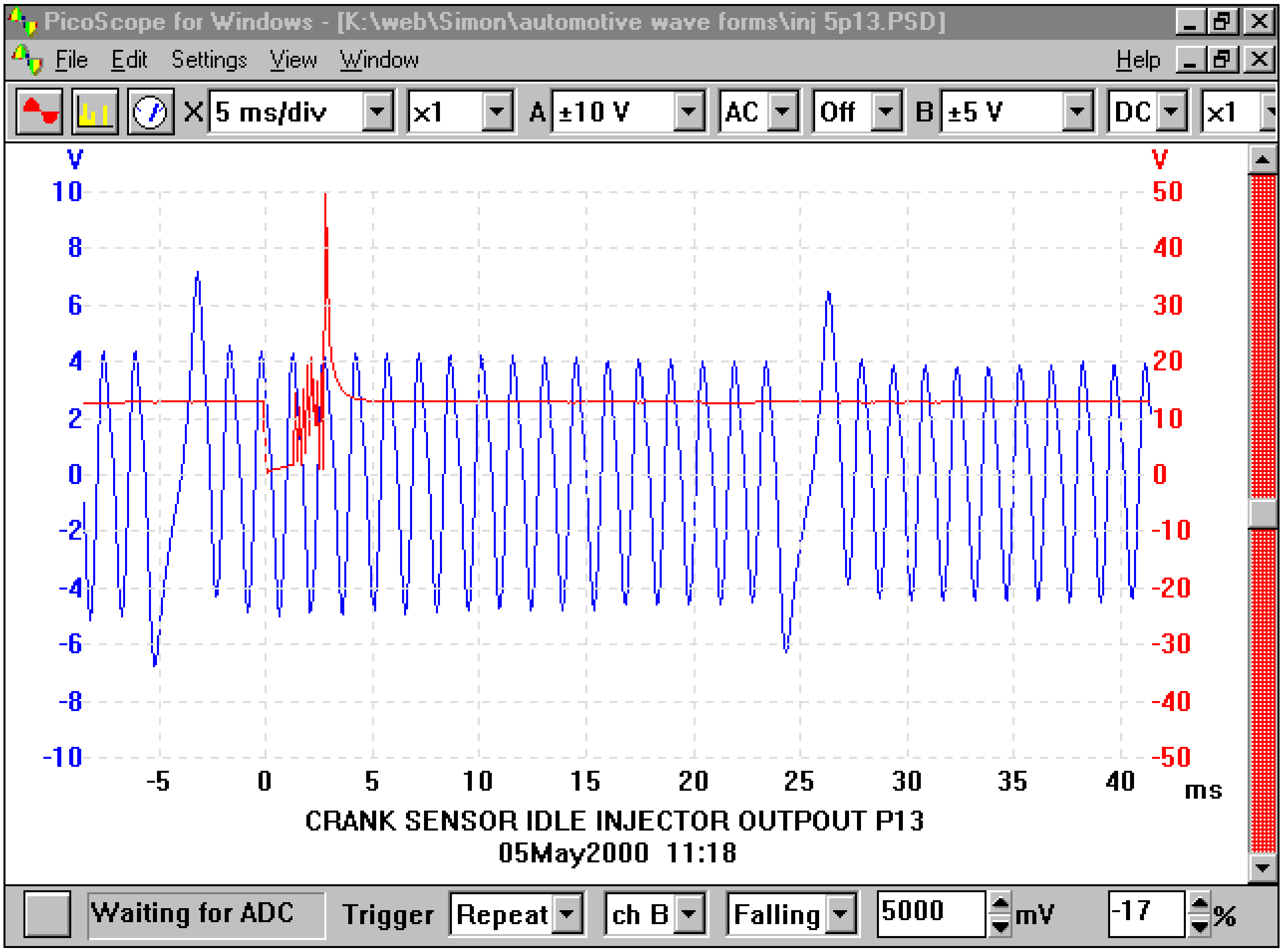


Fuel Injector (Jaguar 3.6L – Injector / Crank Signal at idle, 500 us/div) Reference Waveform

PICO SCOPE

FUEL INJECTOR

Menu

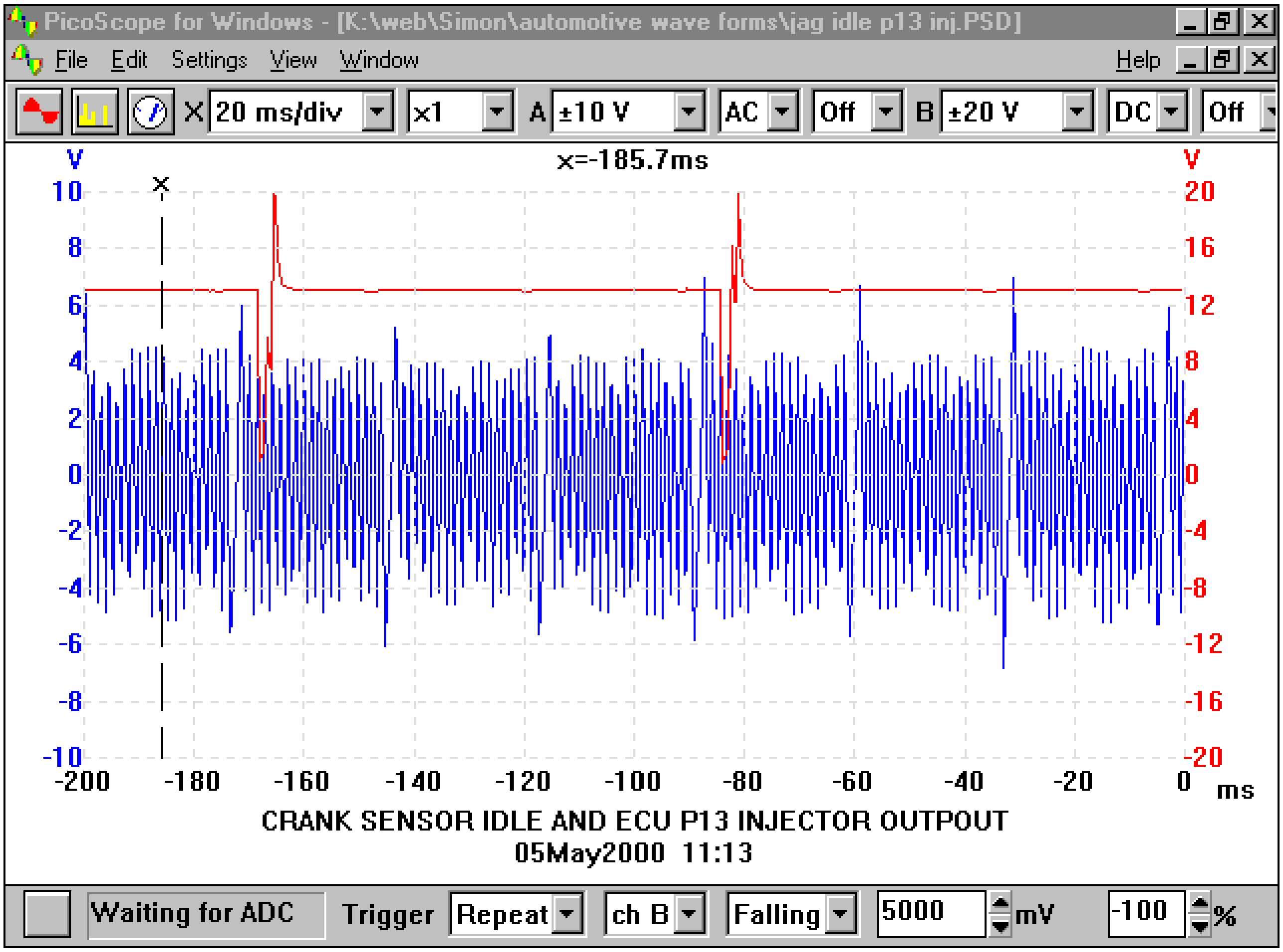


Fuel Injector (Jaguar 3.6L – Injector / Crank Signal at idle, 5ms/div) Reference Waveform

PICO SCOPE

FUEL INJECTOR

Menu

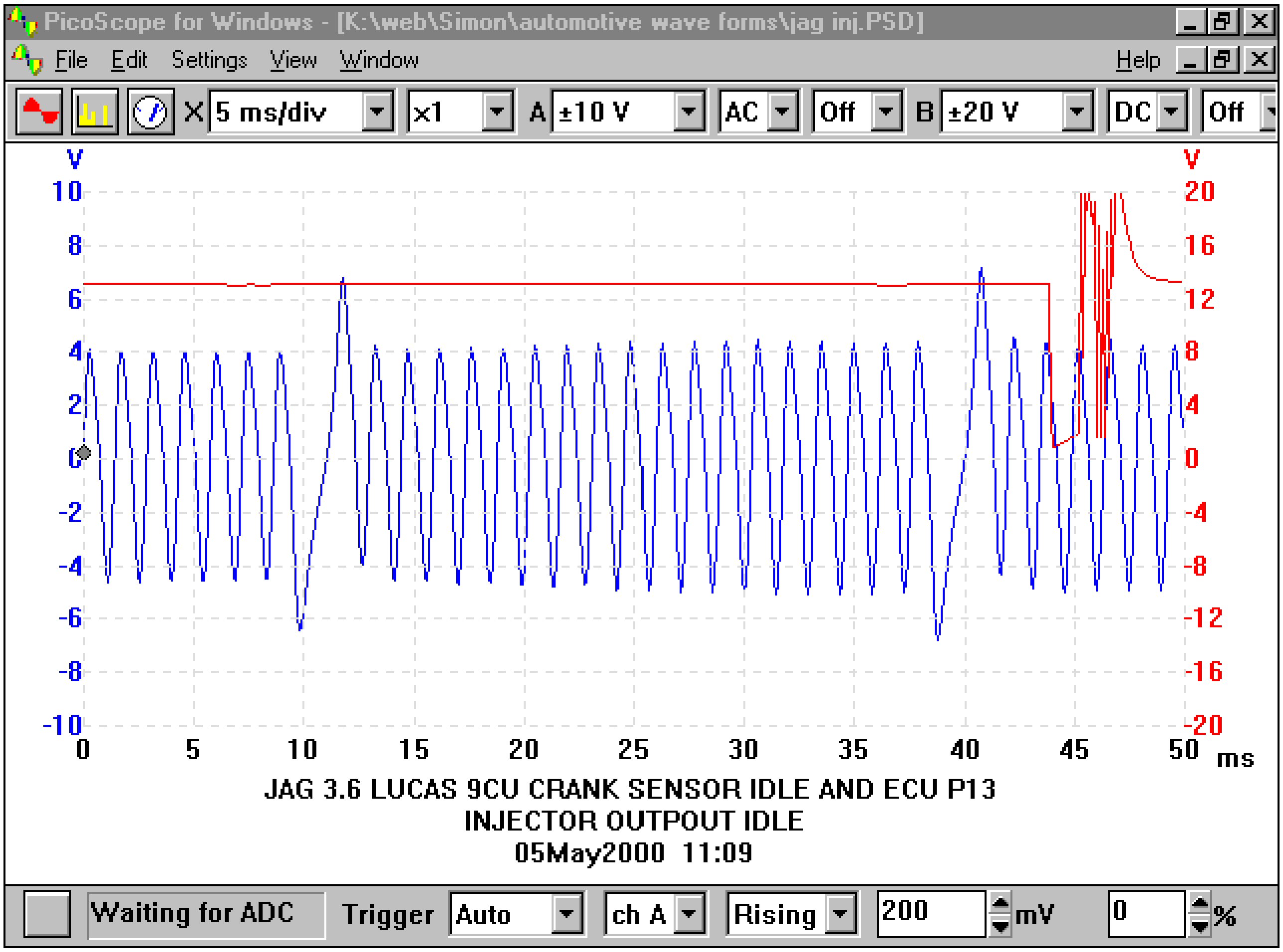


Fuel Injector (Jaguar 3.6L – Injector / Crank Signal at idle, 20ms/div) Waveform Capture

PICO SCOPE

FUEL INJECTOR

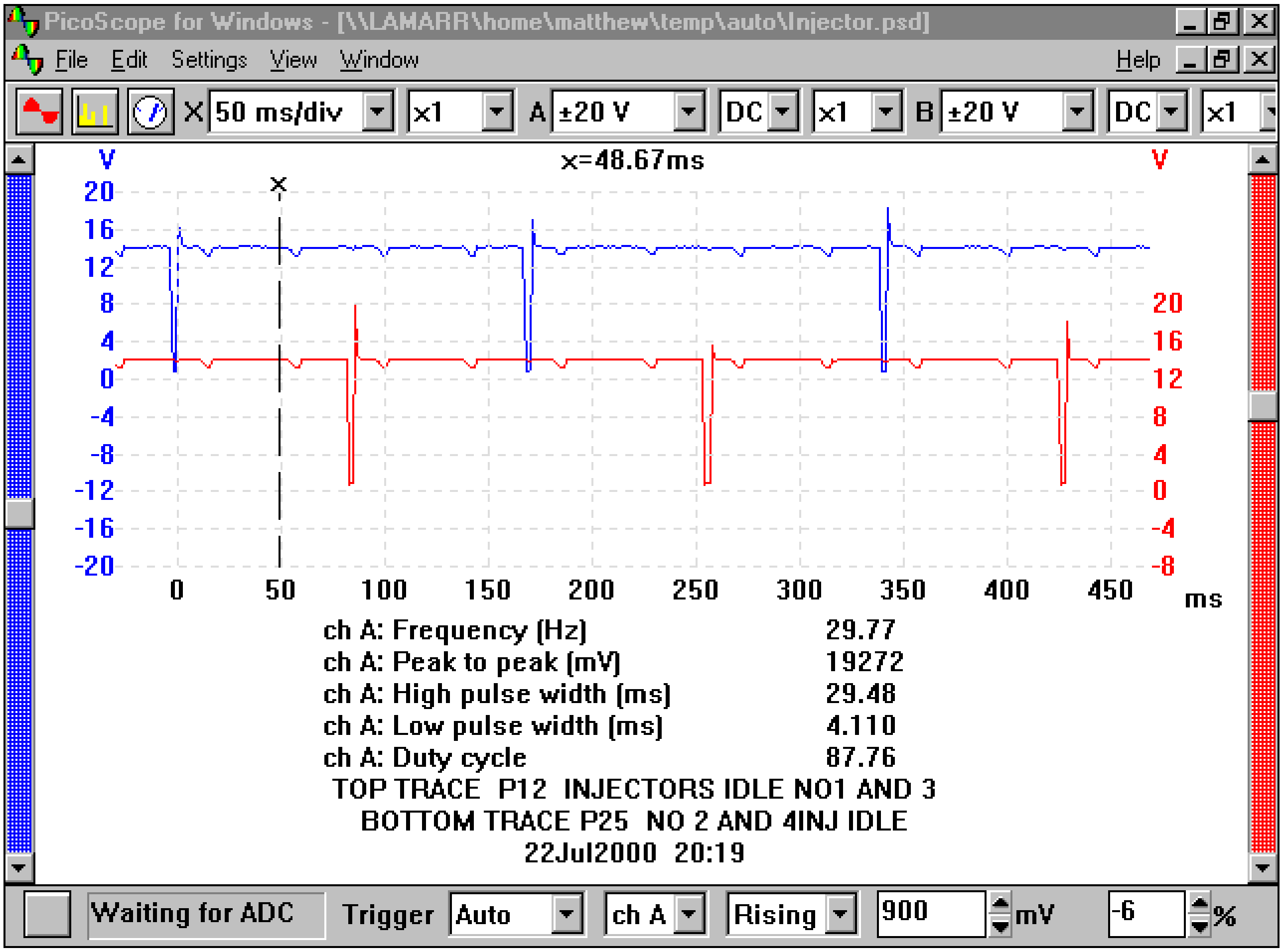
Menu



Fuel Injector (Jaguar 3.6L Lucas 9CU – Injector / Crank Signal at idle) Reference Waveform

PICO SCOPE

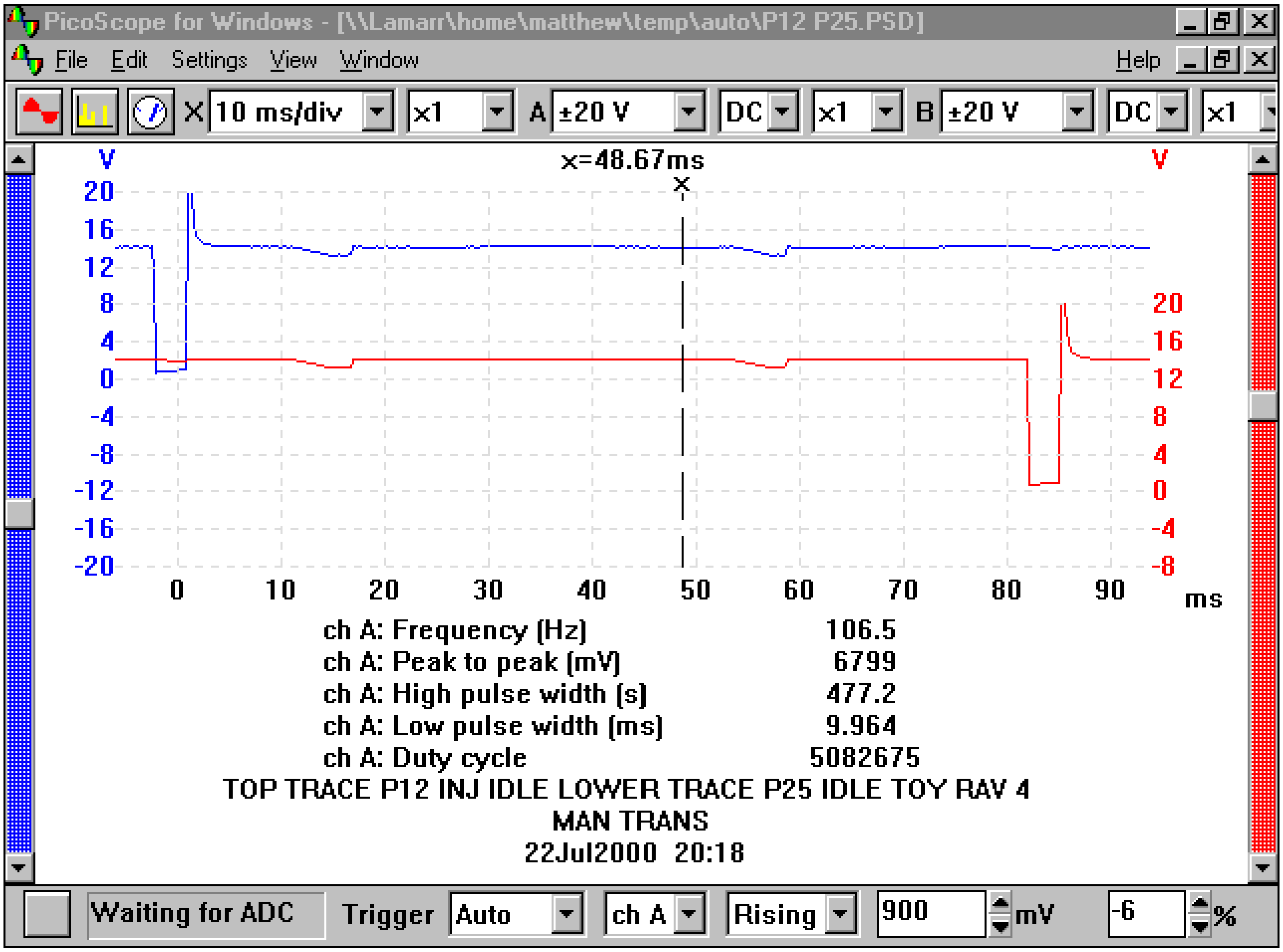
FUEL INJECTOR **Menu**



Toyota RAV 4 2.0L (CHA Injectors 1 & 3, CHB Injectors 2 & 4 at idle) Reference Waveform

PICO SCOPE

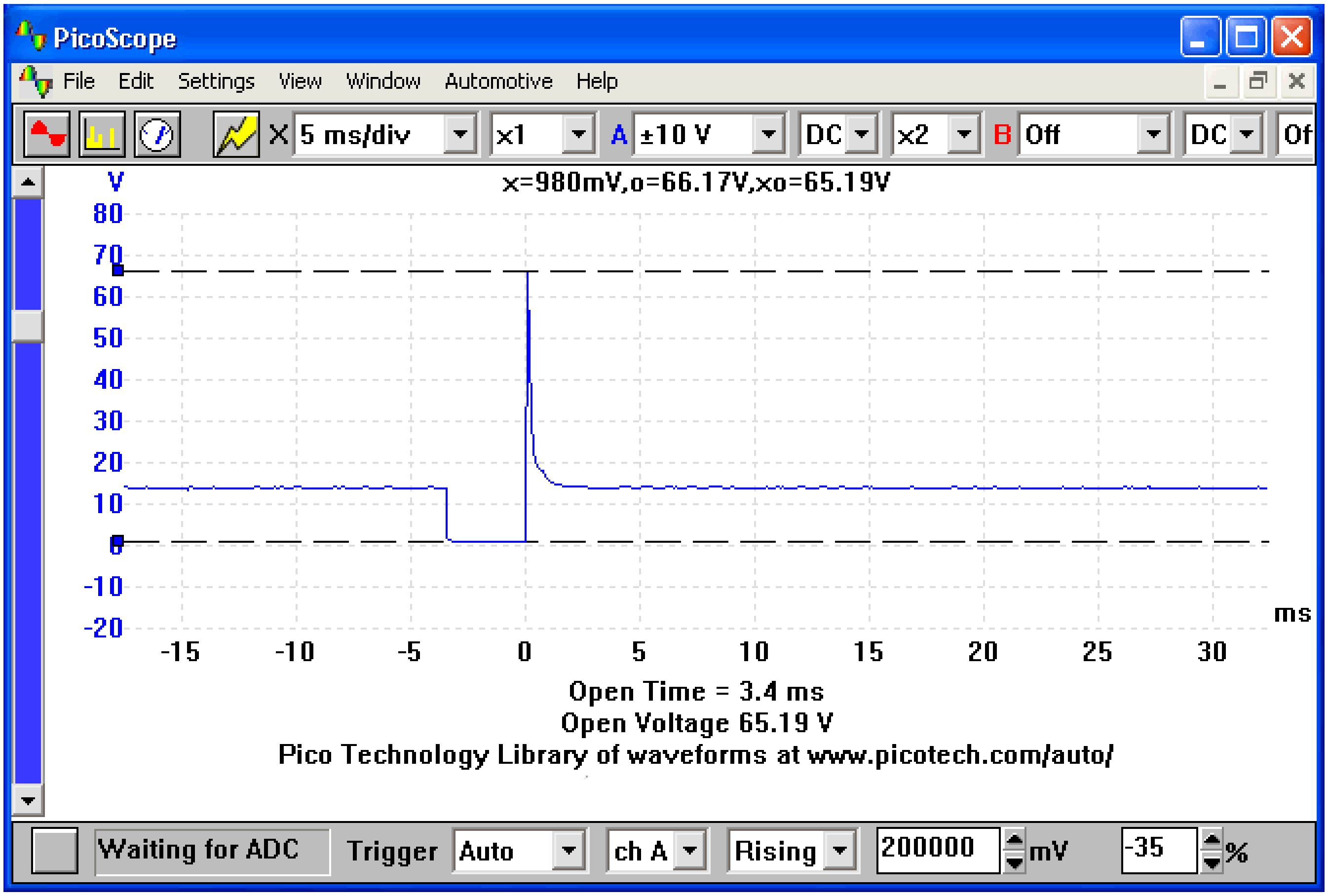
FUEL INJECTOR **Menu**



Fuel Injector (Toyota RAV 4 2.0L – CHA P12, CHB P25 at idle) Reference Waveform

FUEL INJECTOR

Menu

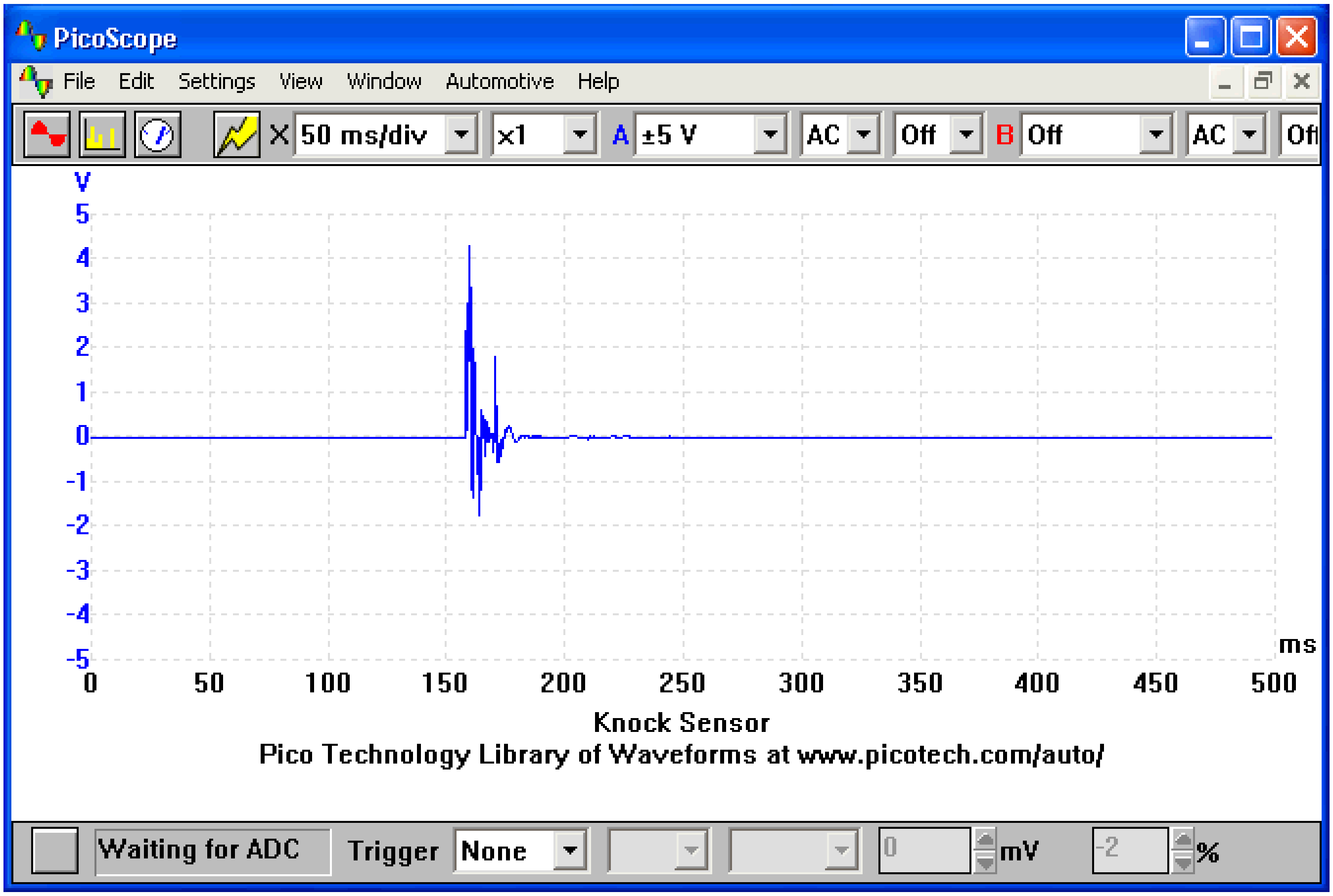


Reference Waveform Notes - Fuel Injector (Dodge Colt 200 GT 1992)

This waveform was captured from a Dodge Colt 200 GT 1992 (Mitsubishi engine 1.5 L).
It shows a good injector signal at idle.

KNOCK SENSOR

Menu



Reference Wave Form Notes - Knock Sensor

The optimal point at which the High Tension (HT) ignites the Air/Fuel mixture will be just before pinking occurs; it would appear inevitable that at certain times and under certain conditions knock (detonation) will occur.

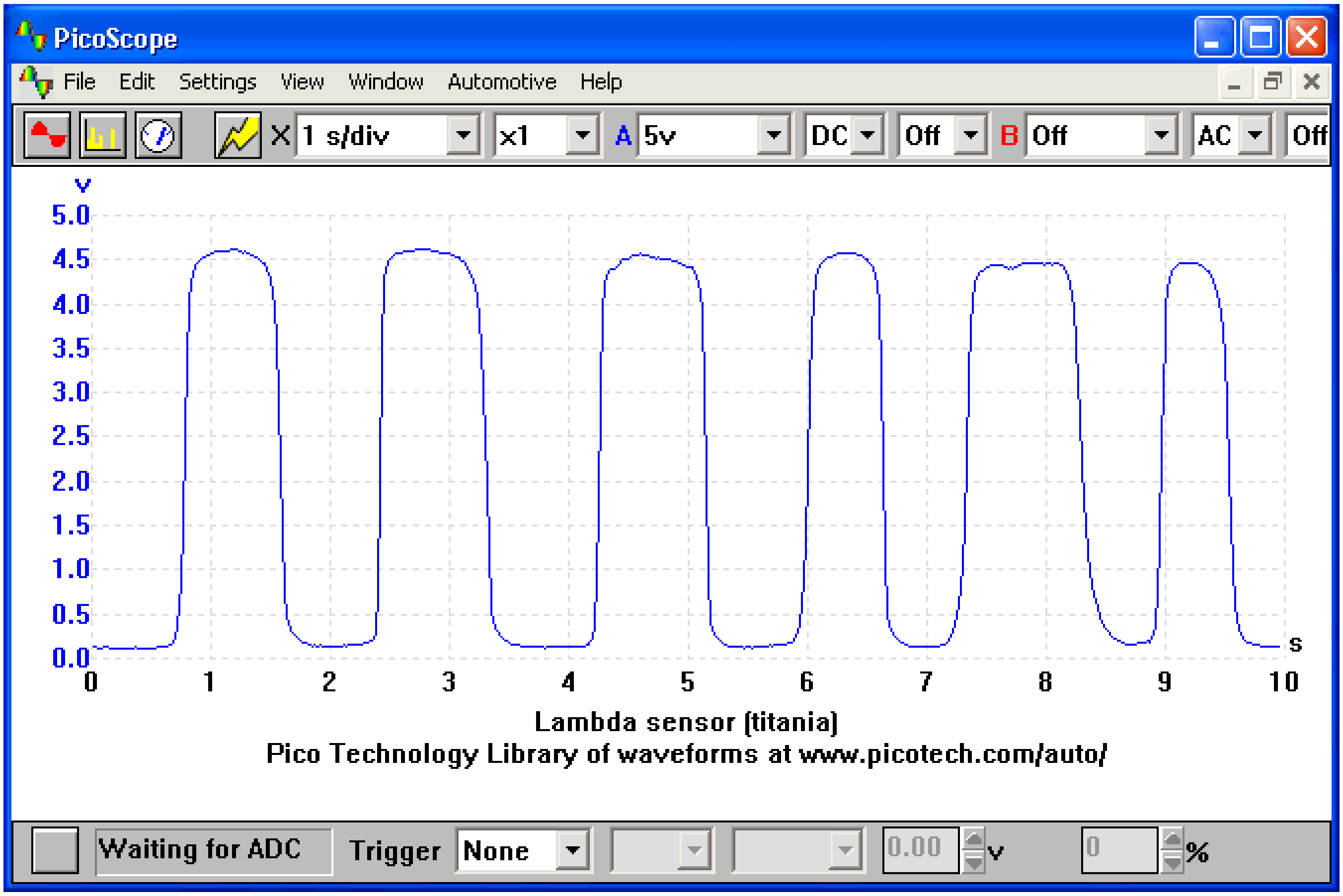
A knock sensor is fitted to some management systems, the sensor being a small piezo-electrical device that, when coupled with the Electronic Control Modules (ECM), can identify when knock occurs and retard the ignition timing accordingly.

The frequency of knocking (pinking) is approximately 15 KHz. As the response of the sensor is very fast an appropriate time scale must be set, in the case of the example waveform 0 - 500 ms and a 0 - 5 volt scale. The best way to test a knock sensor is to remove the knock sensor from the engine and to tap it with a small spanner; the resultant waveform should be similar to the example shown.

NOTE: - When refitting the sensor tighten to the correct torque setting as over tightening can damage the sensor.

OXYGEN SENSOR - TITANA

Menu



Reference Waveform Notes - Oxygen Sensor (Titania)

The lambda sensor, also referred to as the Oxygen (O2) sensor, plays a very important role in control of exhaust emissions on a catalytic equipped vehicle. The lambda sensor is fitted into the exhaust pipe before the catalytic converter.

The sensor will have 4 electrical connections and it reacts to the oxygen content in the exhaust system and will produce an oscillating voltage between 0.5 volt (lean) to 4.0 volts, or above (rich) when running correctly.

Titania sensors unlike Zirconia sensors require a voltage supply as they do not generate their own voltage.

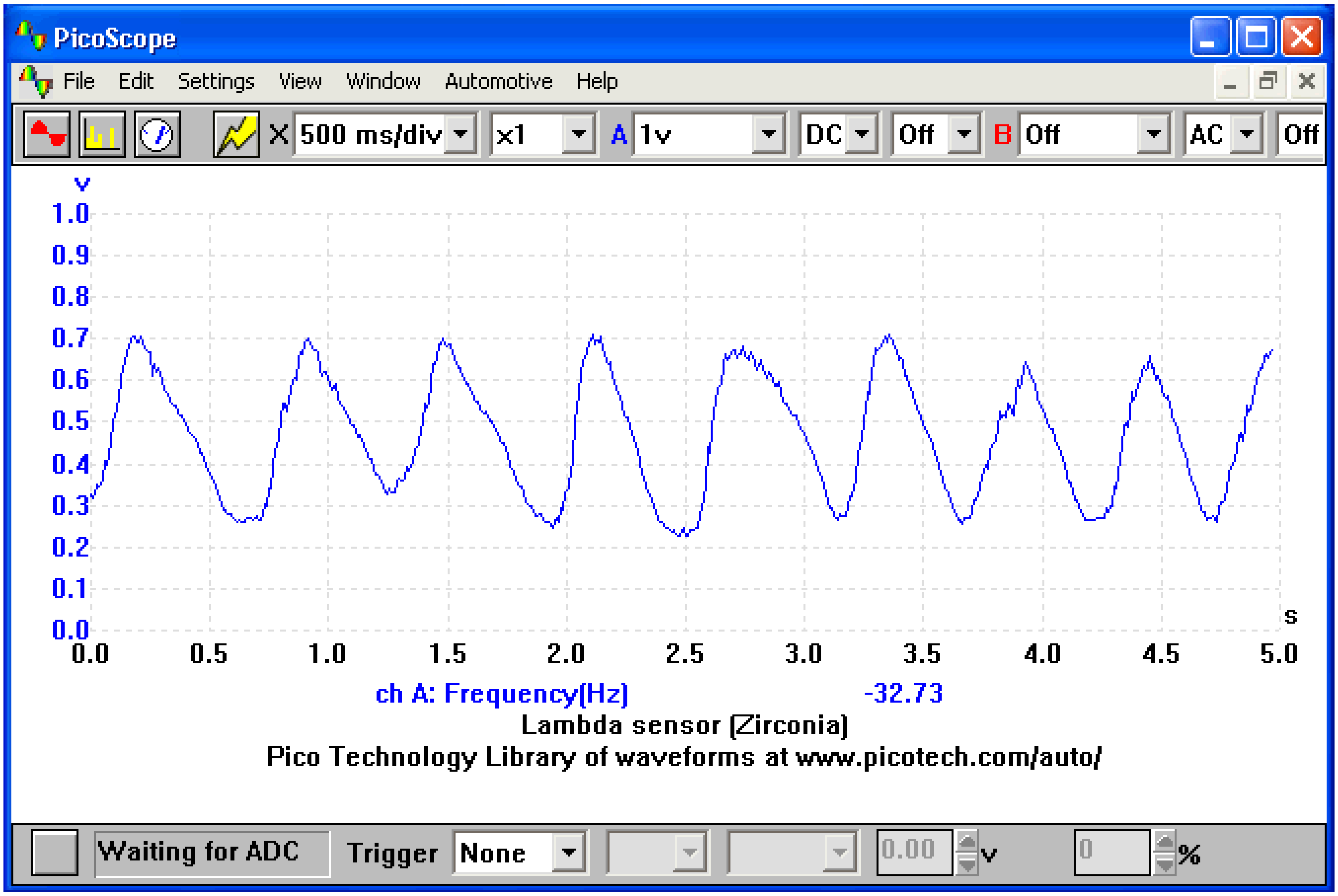
A vehicle equipped with a lambda sensor is said to have 'closed loop', this means that after the fuel has been burnt during the combustion process, the sensor will analyse the emissions and re-adjust the engine fueling accordingly.

Titania O2 sensors have a heater element to assist the sensor reaching its optimum operating temperature. The sensor when working correctly will switch approximately once per second (1 Hz) but will only start to switch when at normal operating temperature. This switching can be seen on the oscilloscope, and the waveform should look similar to the one in the example.

If the frequency of the switching is slower than anticipated, remove the sensor and clean with a solvent spray and this may improve the response time.

OXYGEN SENSOR - ZIRCONIA

Menu



Reference Waveform Notes - Oxygen Sensor (Zirconia)

The lambda sensor is also referred to as the Oxygen (O2) sensor or a Heated Exhaust Gas Oxygen (HEGO) sensor and plays a very important role in control of exhaust emissions on a catalytic equipped vehicle. The lambda sensor is fitted into the exhaust pipe before the catalytic converter.

The sensor will have varying electrical connections and may have up to four wires; it reacts to the oxygen content in the exhaust system and will produce a small voltage depending on the Air/Fuel mixture seen at the time.

The voltage range seen will, in most cases, vary between 0.2 and 0.8 volts: 0.2 volts indicates a lean mixture and a voltage of 0.8v shows a richer mixture.

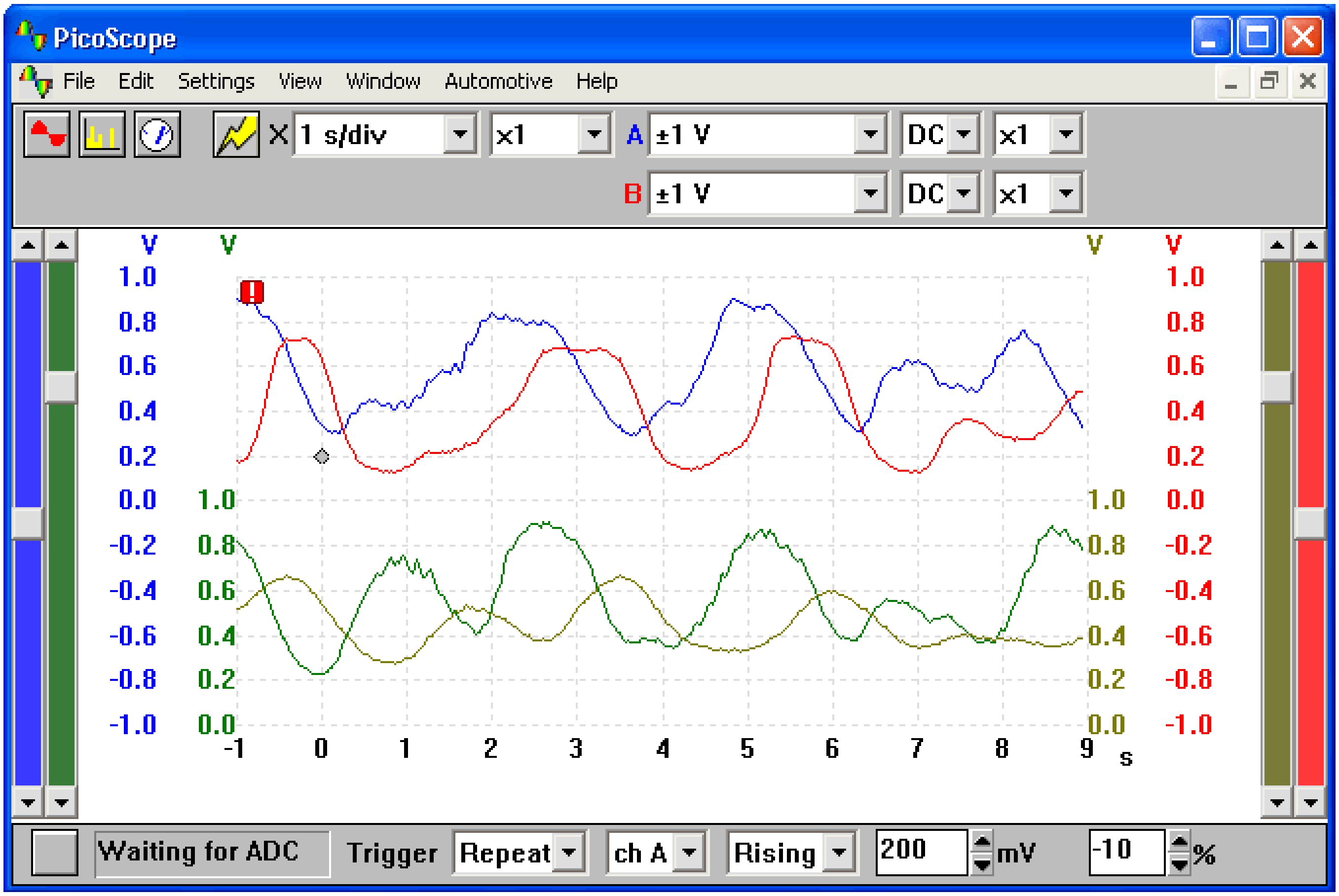
A vehicle equipped with a lambda sensor is said to have 'closed loop', this means that after the fuel has been burnt during the combustion process, the sensor will analyse the emissions and re-adjust the engine's fueling accordingly.

Lambda sensors can have a heater element to assist the sensor reaching its optimum operating temperature.

Zirconia sensors when working correctly will switch approximately once per second (1 Hz) and will only start to switch when at normal operating temperature. This switching can be seen on the oscilloscope, and the waveform should look similar to the one in the example waveform. If the frequency of the switching is slower than anticipated, remove the sensor and clean with a solvent spray and this may improve the response time.

OXYGEN SENSOR – 4 CHANNEL WAVEFORM EXAMPLE

[Menu]



Reference Waveform notes – Multiple Oxygen Sensors (Dodge Intrepid 3.5L V6)

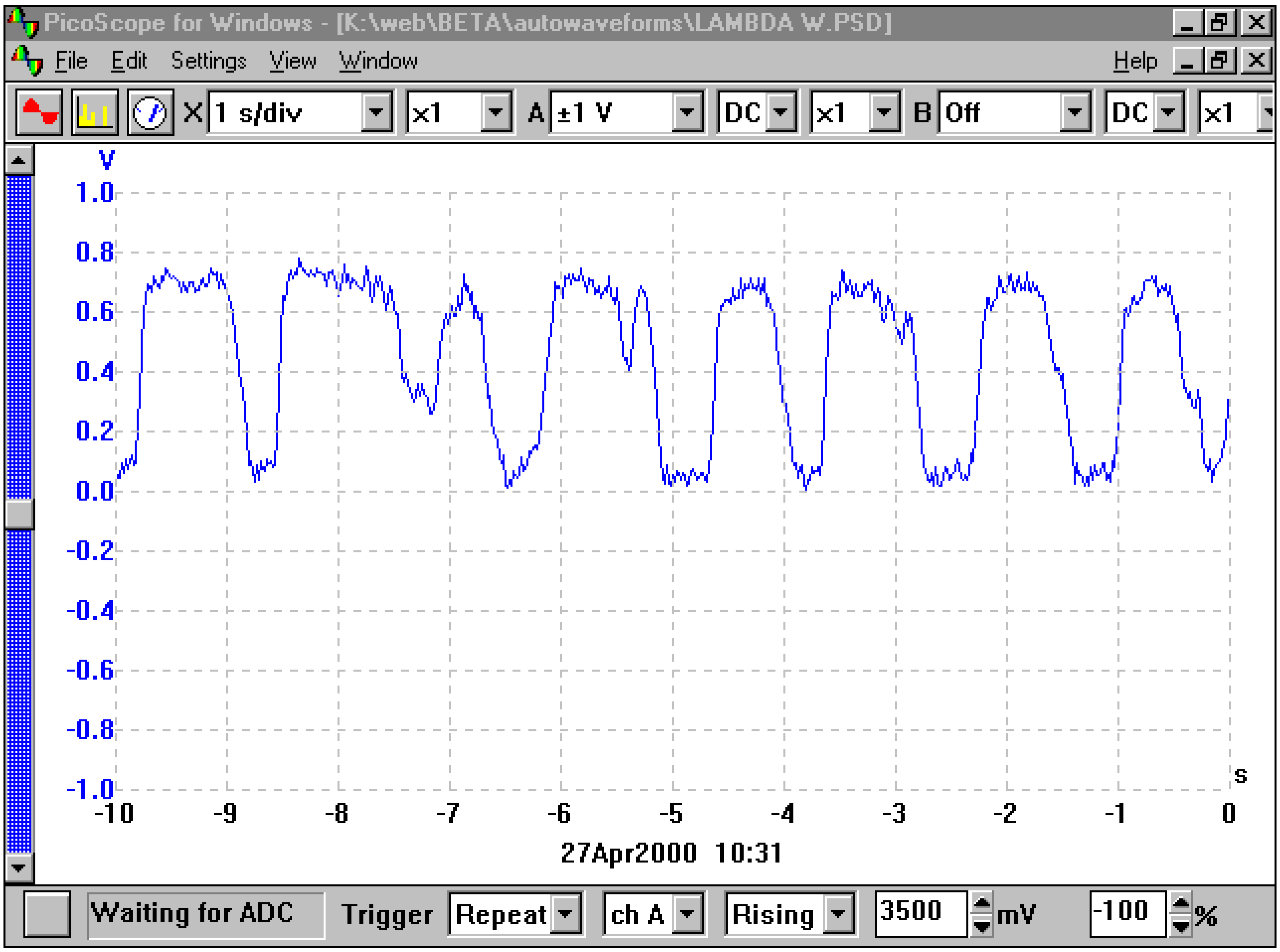
This waveform was captured from a 1997 Dodge Intrepid 3.5 V6.

Channel A is the upstream O2 sensor and **Channel B** is the down stream O2 sensor on left bank of the V6, **Channel C** is the upstream O2 sensor and **Channel D** is the downstream O2 sensor on the right bank of the V6.

PICO SCOPE

OXYGEN SENSOR

Menu

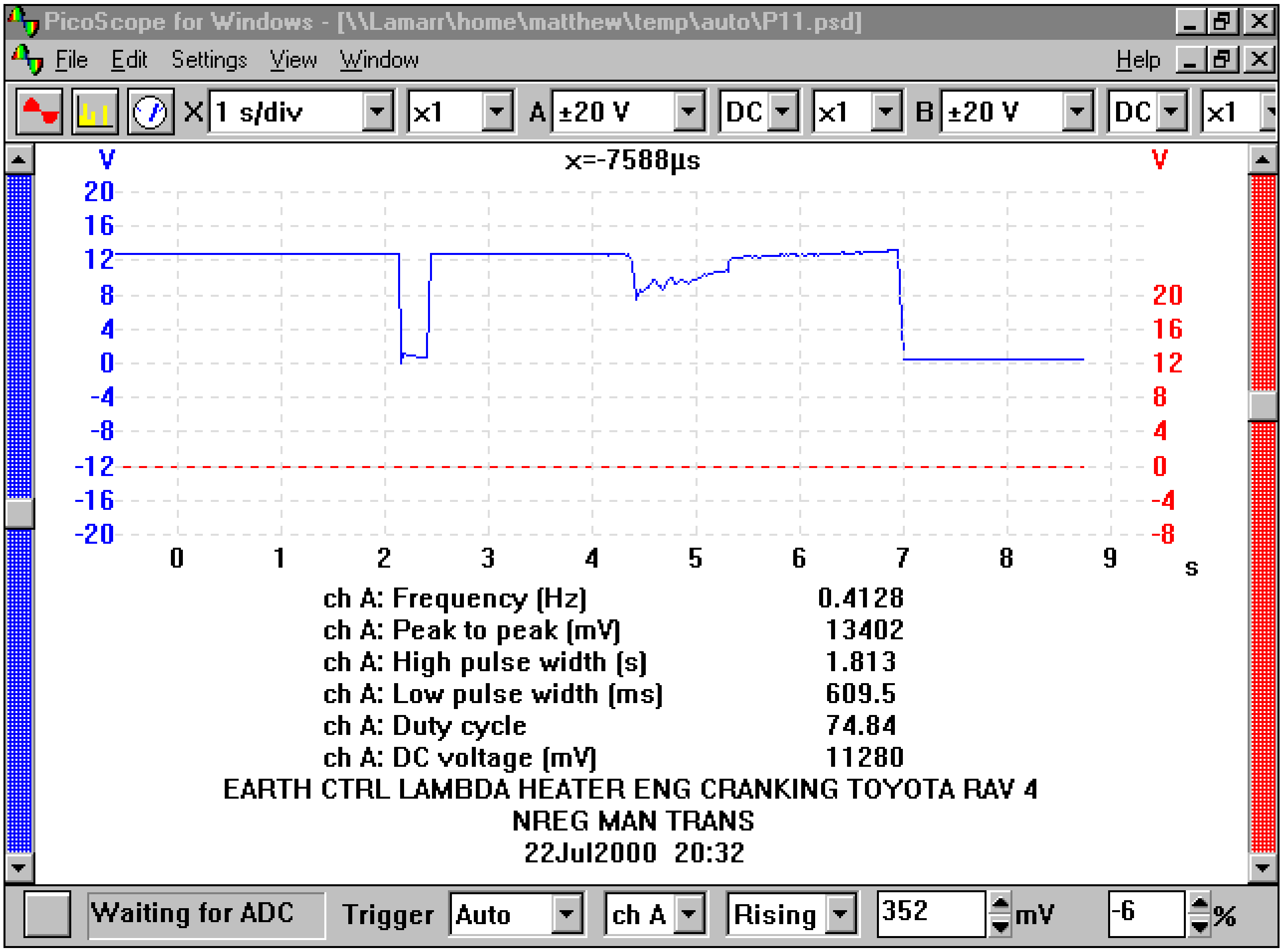


Oxygen Sensor (Volvo 940 turbo) Reference Waveform

PICO SCOPE

OXYGEN SENSOR – HEATER EARTH CONTROL

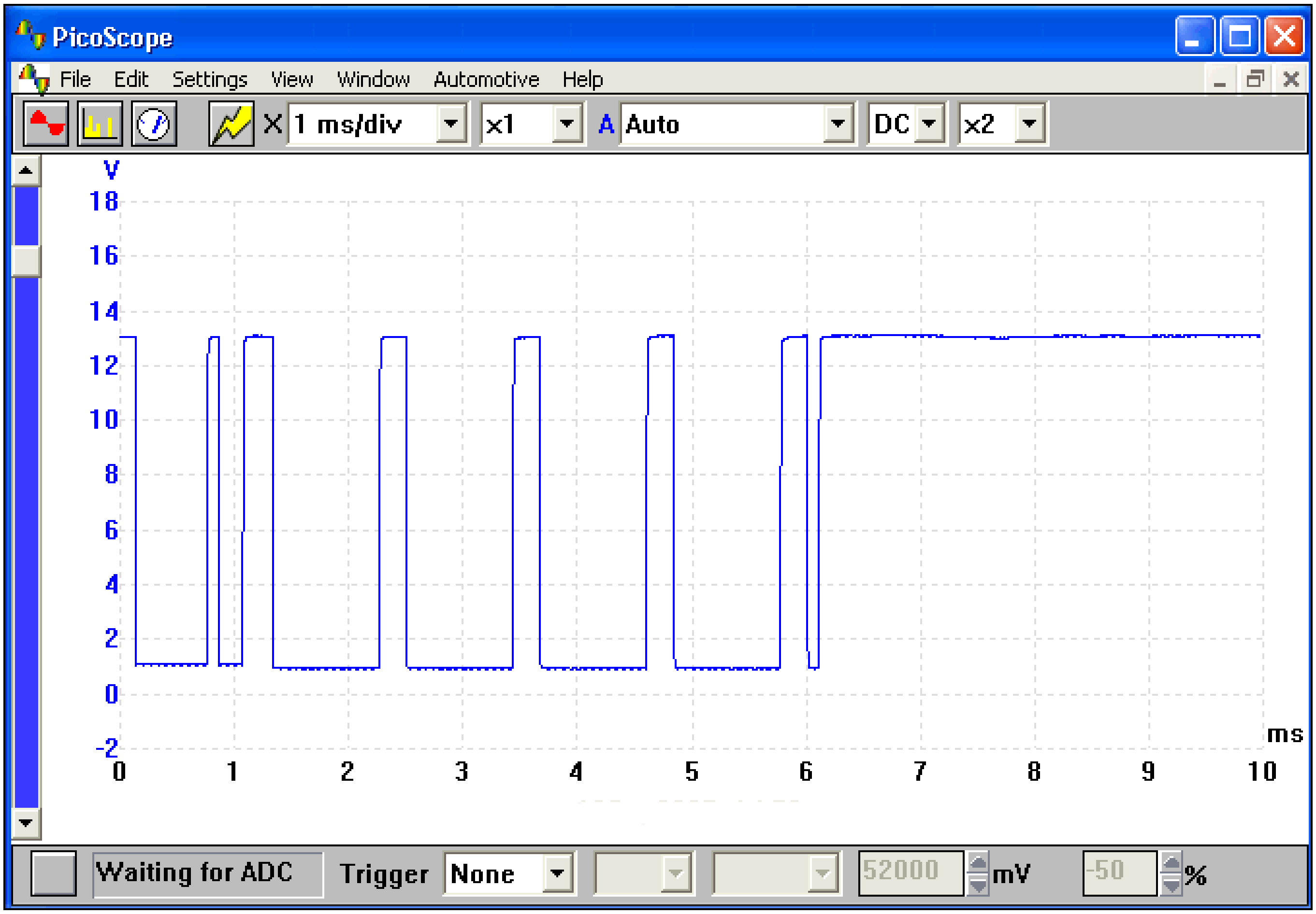
Menu



Oxygen Sensor (Toyota RAV 2.0L 1995 – Heater earth control, engine cranking) Reference Waveform

LIN BUS WAVEFORM

Menu



Reference Waveform Notes - LIN BUS

As you can see from the example waveform, the LIN bus waveform is a square wave, representing the binary states in a serial data stream. The waveform observed should be free of obvious distortion and noise spikes, and the upper and lower levels should be approximately as in the example (for a 12 V system).

The lower level voltage (logic zero) should be less than 20% of battery voltage (typically 1 V) and the upper level voltage (logic one) should be more than 80% of battery voltage. Note that the voltage levels may change slightly when the engine is started.

We cannot decode the data stream using a scope, so the purpose of this test is to verify that the signal is both present and correct, and is not interrupted by moving the wiring harness or gently tugging the connectors.

Faults may be specific to a particular function, such as a non-operating window, or general, where all the functions on the bus are not working. Before condemning a device, use the scope to check that it has power, ground, and a present and correct LIN signal.

Technical Information – LIN BUS

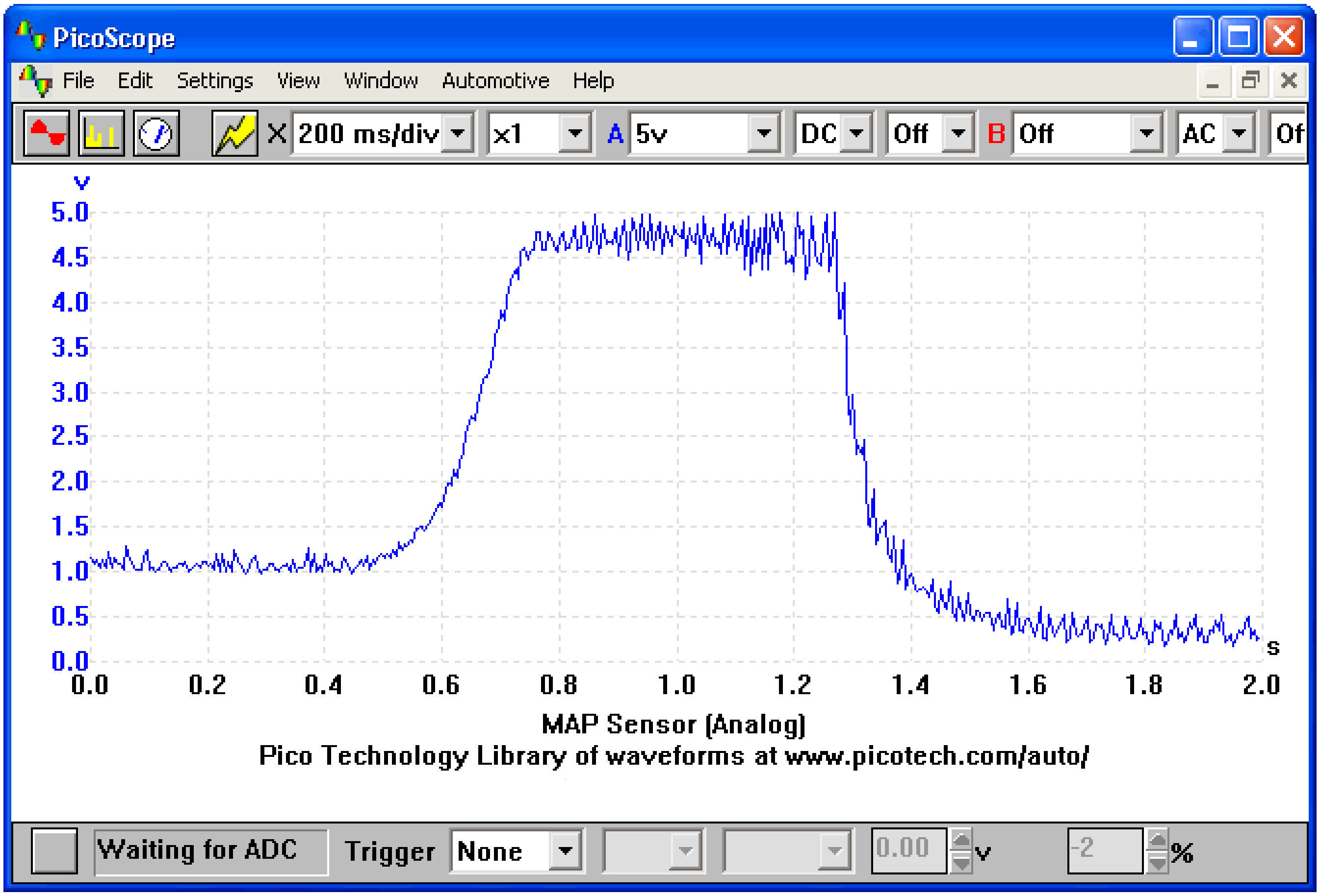
Local Interconnect Network (LIN) bus communication is becoming more common on modern CAN Bus-equipped vehicles.

It is essentially a low-speed, single-wire serial data bus (a sub-bus of the faster, more complex CAN Bus) used to control low-speed non-safety-critical “housekeeping” functions on the vehicle, especially windows, mirrors, locks, HVAC units, and electric seats.

The LIN bus is proving popular because of its low cost and also because it reduces the bus load of the supervising CAN network.

MAP SENSOR - ANALOG

Menu



Reference Waveform Notes - Map Sensor (Analog)

The Manifold Absolute Pressure (MAP) sensor is employed to measure the vacuum in the inlet manifold. It is this output that when sent back to the engine management system can determine either the fueling or the amount of vacuum (or light load) advance.

The sensor is a three wire device that will have a :-

- A 5 volt supply voltage
- An earth connection
- A varying analogue output
- A vacuum connection to the inlet manifold

This particular component can be either an integral part to the electronic control module or an individual component. The output from the external sensor will show a rise and fall voltage depending upon the vacuum seen.

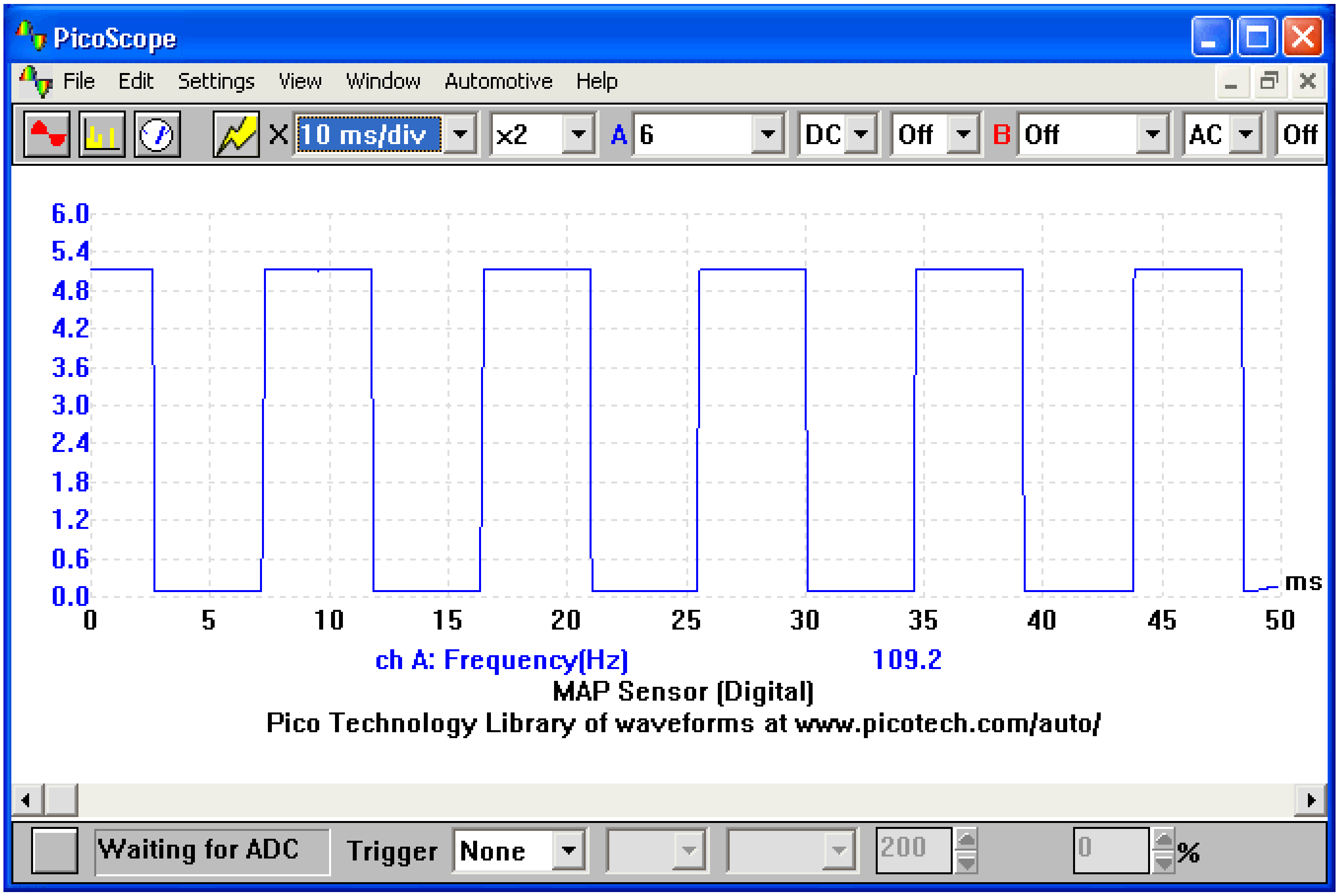
When the engine is stationary or the throttle is wide open, zero vacuum will be recorded and a voltage approaching 5 volts will be seen, as a vacuum is applied the voltage will reduce. The example waveform clearly demonstrates that at idle a voltage of around 1 volt is seen, and as the throttle is opened the vacuum in the manifold drops and a higher voltage for these conditions is seen. In this particular case the voltage is rising to almost 5 volts. The 'hash' on the waveform is due to the vacuum change from the induction pulses as the engine is running.

All voltages are similar between different manufacturers and a lower than anticipated voltage will produce a loss of power due to fuel starvation and conversely a higher voltage will cause over fueling and could eventually result in the failure of the catalytic converter if subjected to long term abuse.

This high voltage could result from any number of problems but could be as simple as a split vacuum hose or incorrectly adjusted tappet clearances. The voltage from an integral MAP sensor can only be evaluated when a Fault Code Reader (FCR) is used due to the lack of access to the output voltage.

MAP SENSOR - DIGITAL

Menu



Reference Waveform Notes - MAP Sensor (Digital)

The Manifold Absolute Pressure (MAP) sensor is employed to measure the vacuum in the inlet manifold. It is this output that when sent back to the engine management system can determine either the fueling or the amount of vacuum (or light load) advance.

The sensor is a three wire device which will have a :-

- A 5 volt supply voltage
- An earth connection
- A variable-frequency square-wave output
- A vacuum connection to the inlet manifold

This particular component can be either an integral part to the electronic control module or an individual component.

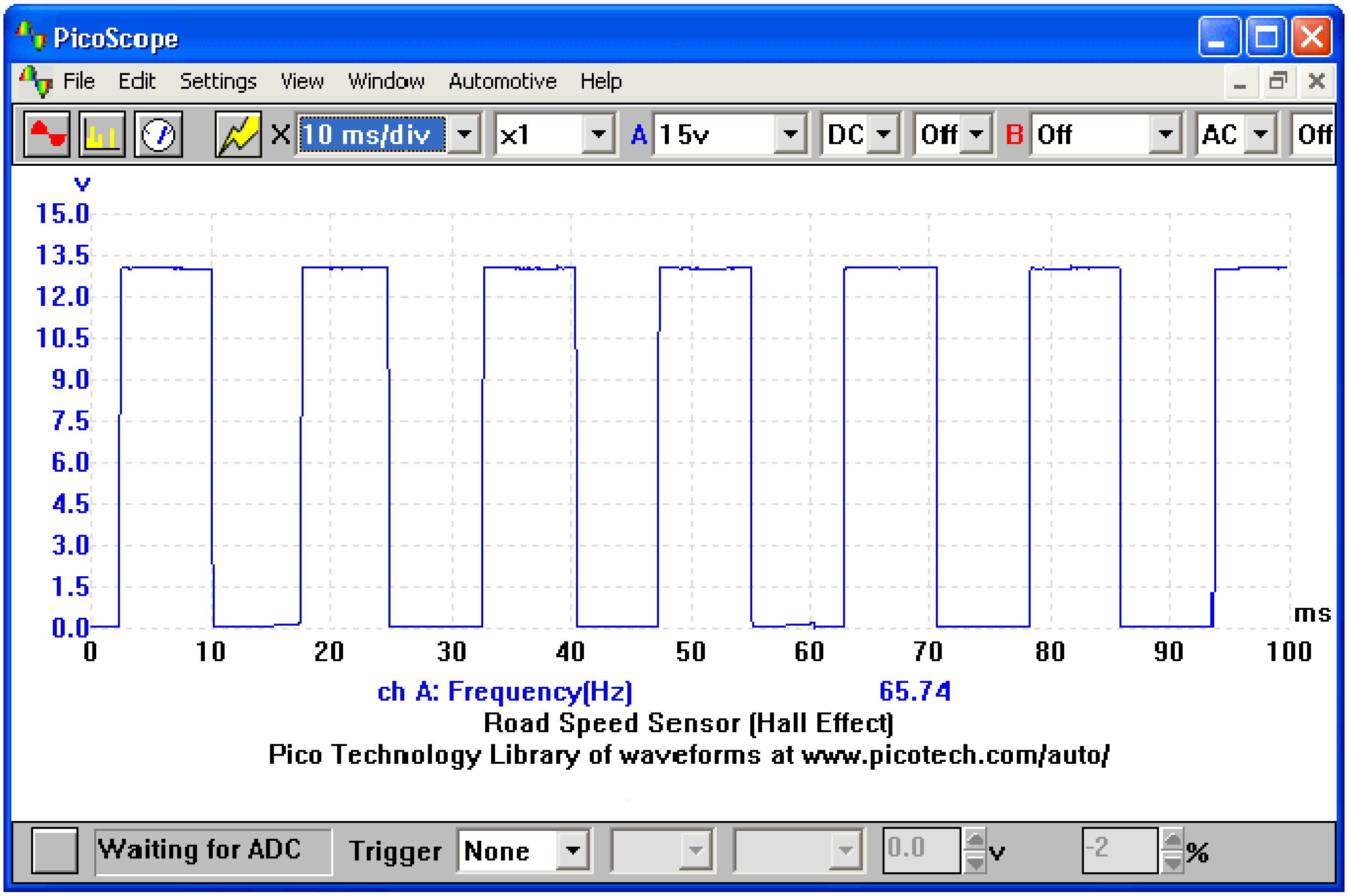
The output from the external MAP sensor will show a square wave its frequency will be lower at idle than when the throttle is opened.

The example waveform clearly demonstrates the output signal and when the frequency is also displayed can be compared against the model's specification.

A higher frequency could result from any number of problems, but could be as simple as a split vacuum hose or incorrectly adjusted tappet clearances. Prolonged exposure to this higher frequency can result in damage to the catalytic converter.

ROAD SPEED SENSOR WAVEFORM

Menu



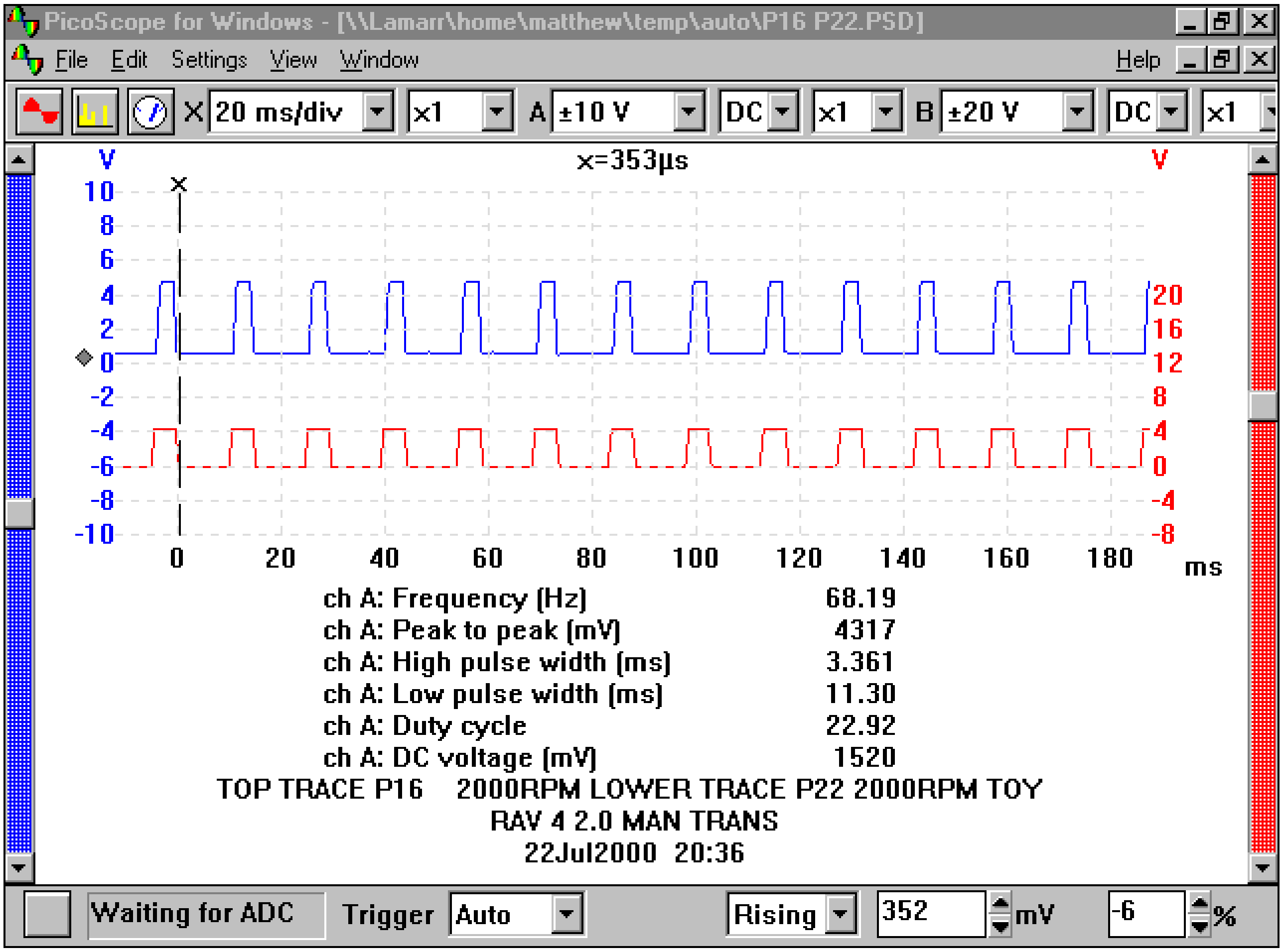
Reference Waveform Notes - Road Speed Sensor

The Electronic Control Module (ECM) has the ability to adjust the engines idle speed when the vehicle is slowing or stationary by using information from the Road Speed Sensor (RSS). The sensor is a 3 wire device and will have a supply at battery voltage, an earth and a digital square wave output also switching at 12 volts.

With the appropriate electrical connection made to the RSS output, raise one wheel with a trolley and place an axle stand under the suspension unit. Start the engine and select a gear, a waveform switching from 12 volts to zero should be seen. As the road speed is increased the frequency of the switching should be seen to increase. This change can also be measured on a Multimeter with frequency capabilities. The sensor will be located on either the speedometer drive output from the gearbox or to the rear of the speedometer head.

PICO SCOPE

RPM SENSOR WAVEFORM [Menu]

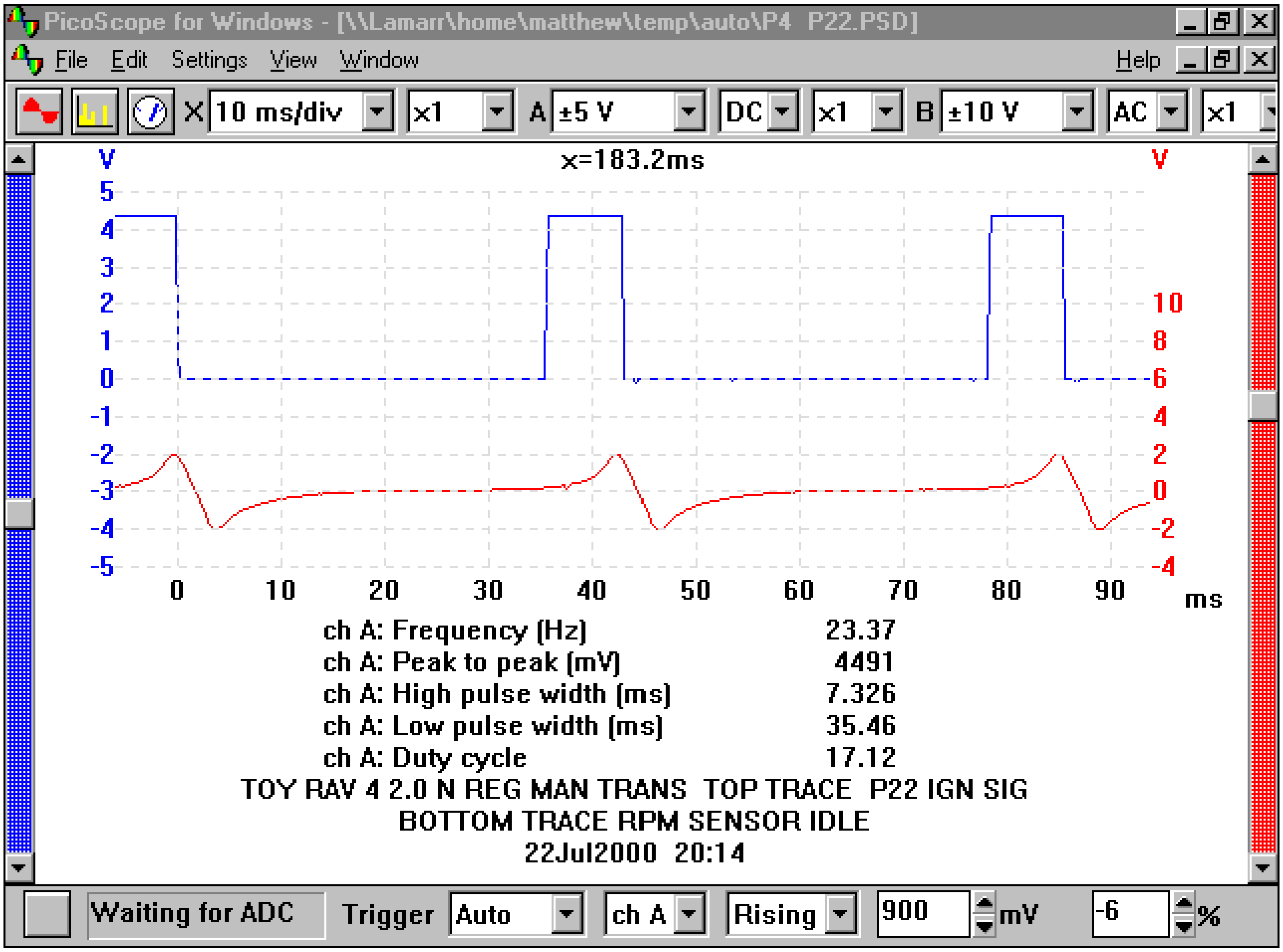


RPM Sensor (Toyota RAV 4 2.0L 1995) Reference Waveform

PICO SCOPE

RPM SENSOR

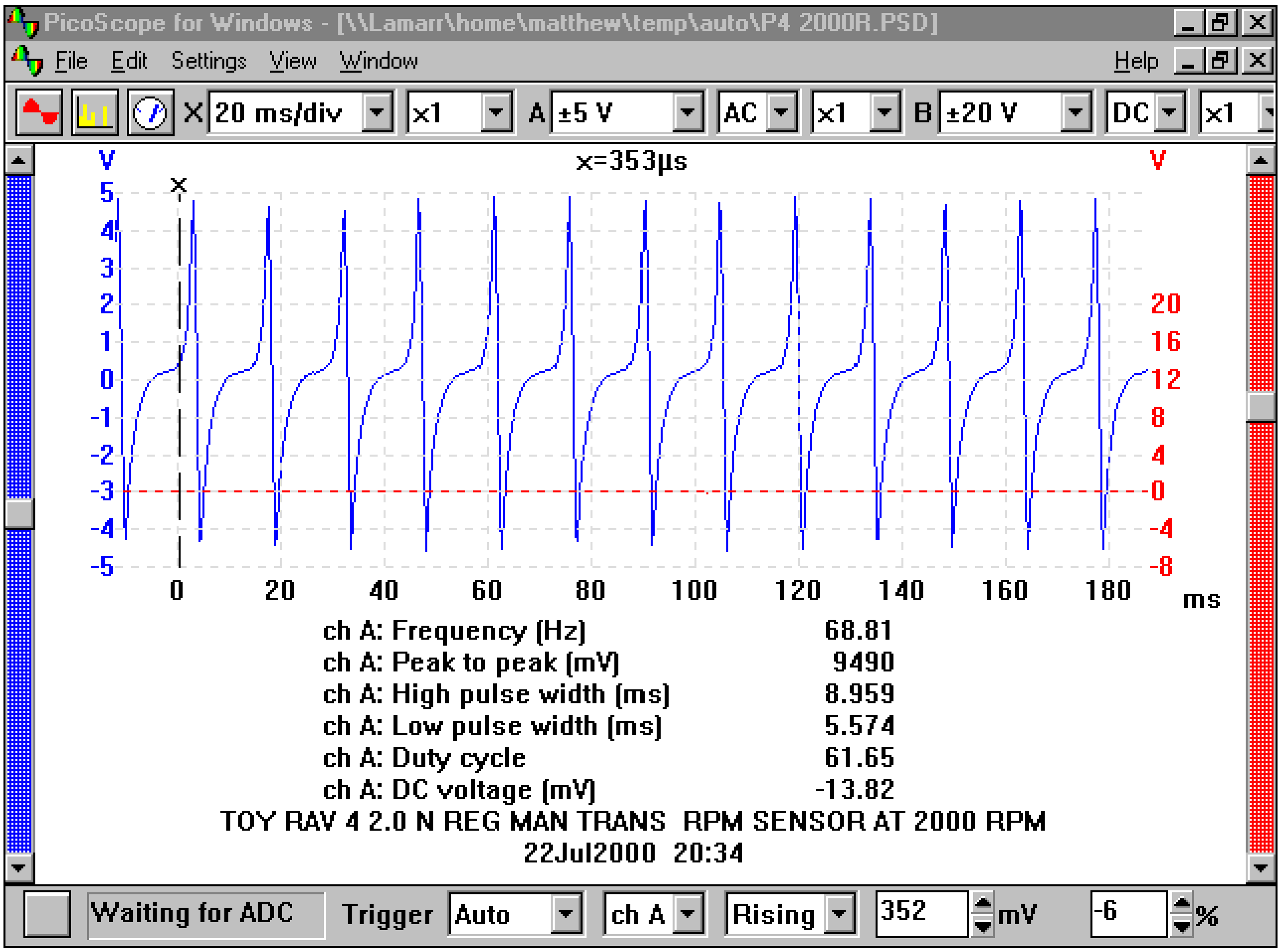
Menu



RPM Sensor (Toyota RAV 4 2.0L 1995 – RPM Sensor / Ignition Signal) Reference Waveform

PICO SCOPE

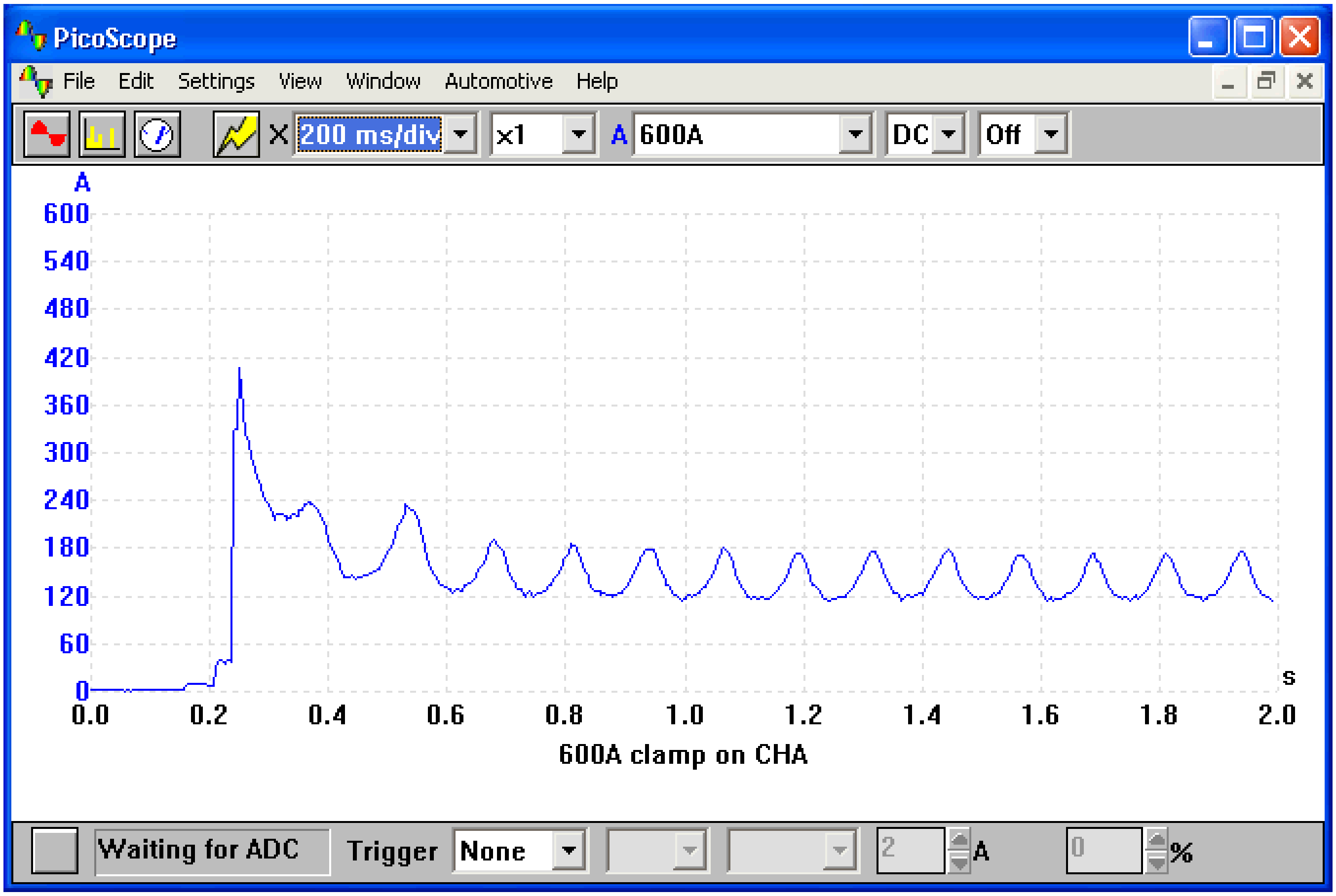
RPM SENSOR **Menu**



RPM Sensor (Toyota RAV 4 2.0L 1995 – RPM Sensor at 2000 rpm) Reference Waveform

STARTER CURRENT – TYPICAL PETROL ENGINE

Menu



Reference Waveform Notes - Starter Current (Cranking Amps – Petrol Engine)

The purpose of this particular waveform is two fold:-

- To measure the amperage required to crank the engine.
- To evaluate the relative compressions.

The amperage required to crank the engine will largely depend on many factors, these include: the capacity of the engine, the number of cylinders, the viscosity of the oil, the condition of the starter motor, the condition of the starters wiring circuit and the compressions in the cylinders.

Once the engine is rotating, the current for a typical 4 cylinder petrol engine is in the region of 80 - 200 amps.

As can be seen from the initial peak of current drawn, the current required by the starter motor to begin to rotate the engine from rest can be two or three times higher than when rotating.

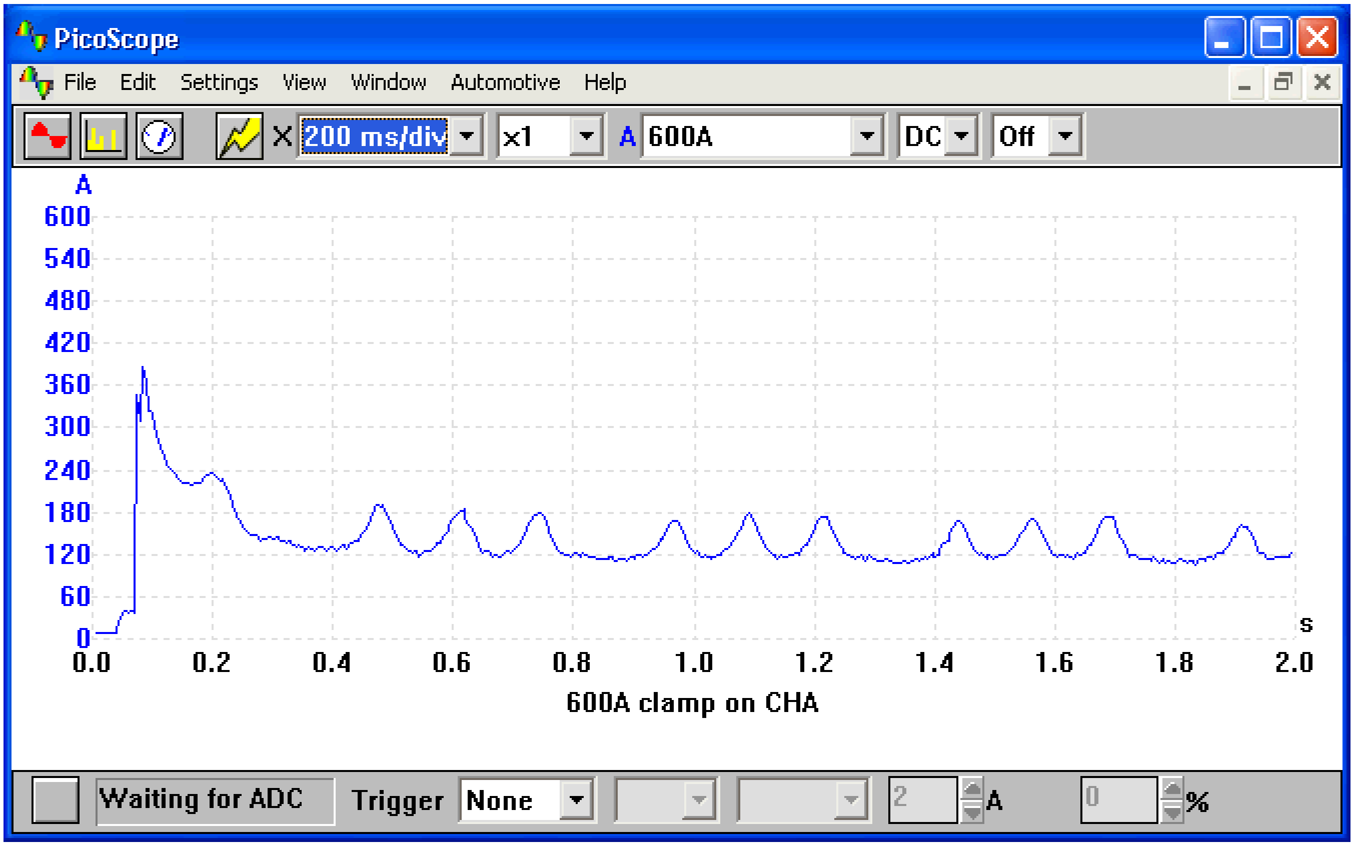
The compressions can be compared against each other by monitoring the current required to push each cylinder up on its compression stroke. The better the compression the higher the current demand and vice versa.

It is therefore important that the current draw on each cylinder is equal. This test is only a comparison against each cylinder and is not a substitute for a physical compression test with a suitable gauge.

NOTE: - when compression testing a petrol engine it is advisable to isolate the ignition primary circuit to avoid damage to the electronic circuitry.

STARTER CURRENT- RELATIVE COMPRESSION (Petrol Engine)

Menu



Starter Current (Relative Compression – Loss of compression in one cylinder) Waveform Notes

The purpose of this particular waveform is two fold:-

- To measure the amperage required to crank the engine
- To evaluate the relative compressions

The amperage required to crank the engine will largely depend on many factors, these include: the capacity of the engine, the number of cylinders, the viscosity of the oil, the condition of the starter motor, the condition of the starters wiring circuit and the compressions in the cylinders.

Once the engine is rotating, the current for a typical 4 cylinder petrol engine is in the region of 80 - 200 amps. As can be seen from the initial peak of current drawn, the current required by the starter motor to begin to rotate the engine from rest can be two or three times higher than when rotating.

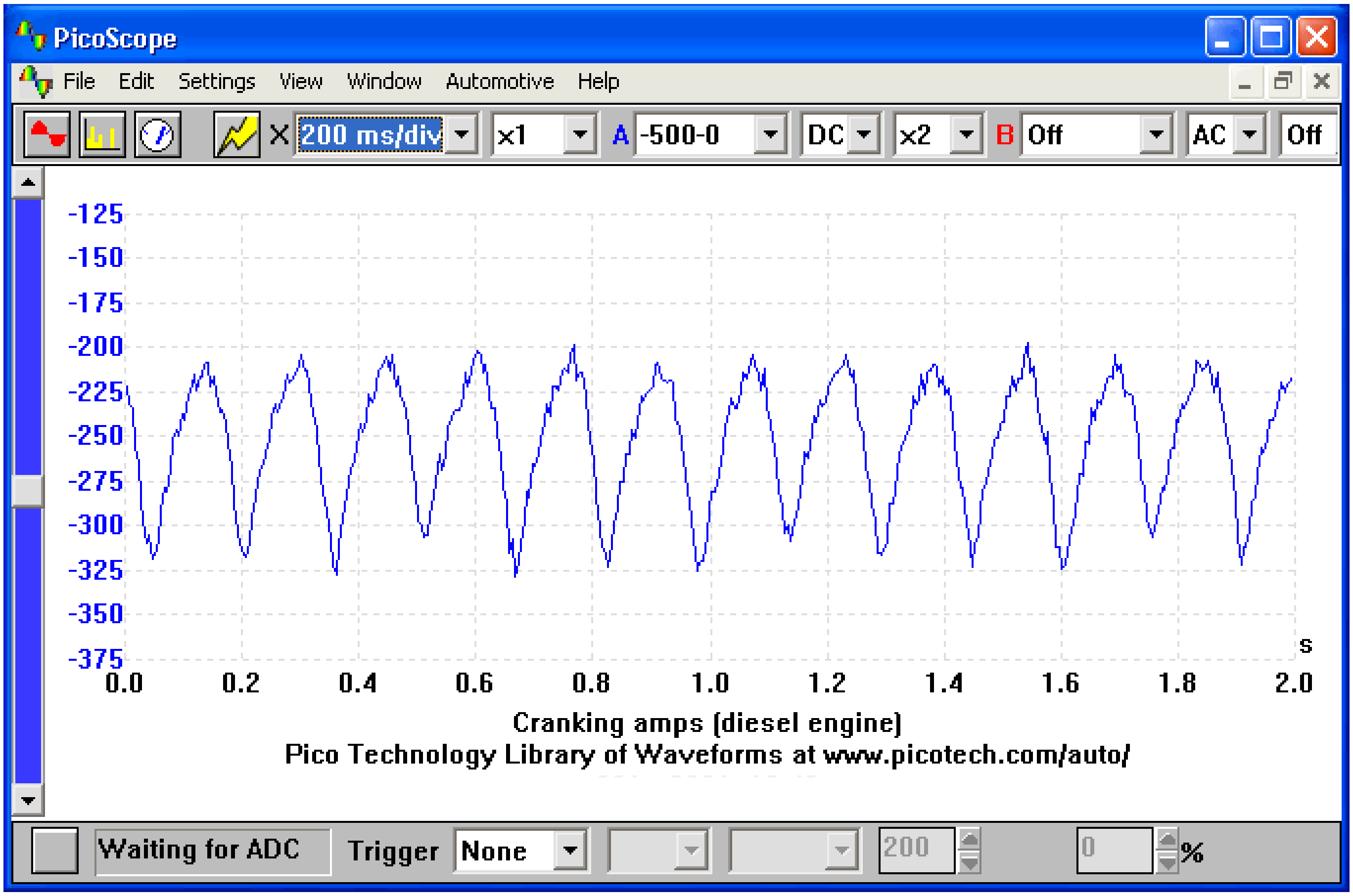
The compressions can be compared against each other by monitoring the current required to push each cylinder up on its compression stroke. The better the compression the higher the current demand and vice versa. It is therefore important that the current draw on each cylinder is equal.

As can be seen in this four cylinder example, the compression drawn on one cylinder is much lower than the others suggesting a serious mechanical failure.

NOTE: - When compression testing a petrol engine it is advisable to isolate the ignition primary circuit to avoid damage to the electronic circuitry.

STARTER CURRENT – TYPICAL DIESEL ENGINE

Menu



Reference Waveform Notes - Starter Current (Cranking Amps – Diesel Engine)

The purpose of this particular waveform is two fold:-

- To measure the amperage required to crank the engine
- To evaluate the relative compressions

The amperage required to crank the engine will largely depend on many factors, these include the capacity of the engine, the number of cylinders, the viscosity of the oil, the condition of the starter motor, the condition of the starters wiring circuit and the compressions in the cylinders.

The current for a typical 4 cylinder diesel engine is in the region of 200 to 300 amps. The compressions can be compared against each other by monitoring the current required to push each cylinder up on its compression stroke.

The better the compression the higher the current demand and vice versa. It is therefore important that the current draw on each cylinder is equal.

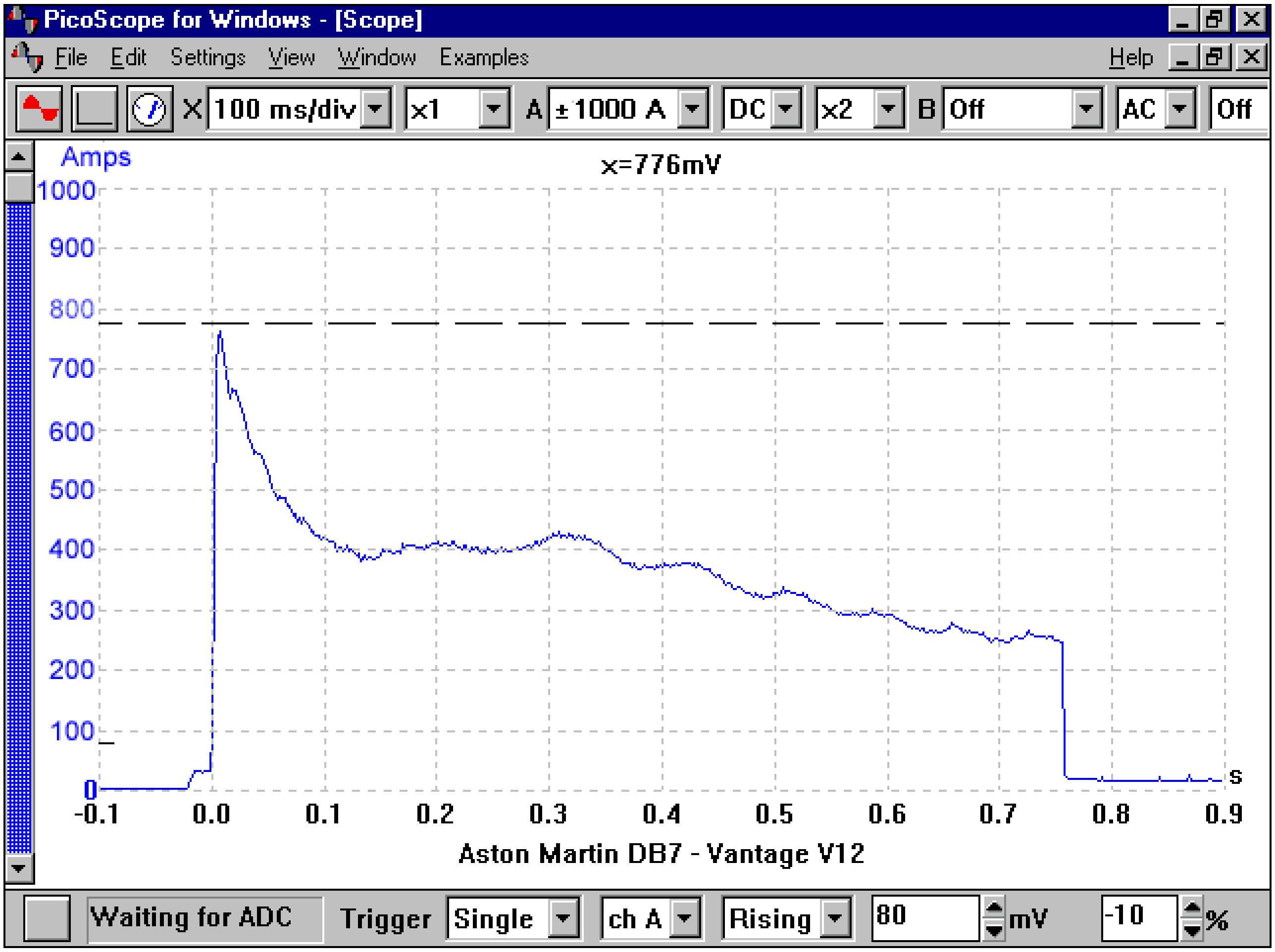
This test is only a comparison against each cylinder and is not a substitute for a physical compression test with a suitable gauge. Due to inaccessibility on a diesel engine, this test can be extremely useful when diagnosing problems on the compression/ignition diesel engine.

NOTE: - When conducting compression tests on a diesel engine ensure that the appropriate gauge is used (diesels have much higher compression than petrol engines). Also make certain that the fuel supply to the injectors is stopped by electrically isolating the fuel cut-off solenoid.

PICO SCOPE

STARTER CURRENT

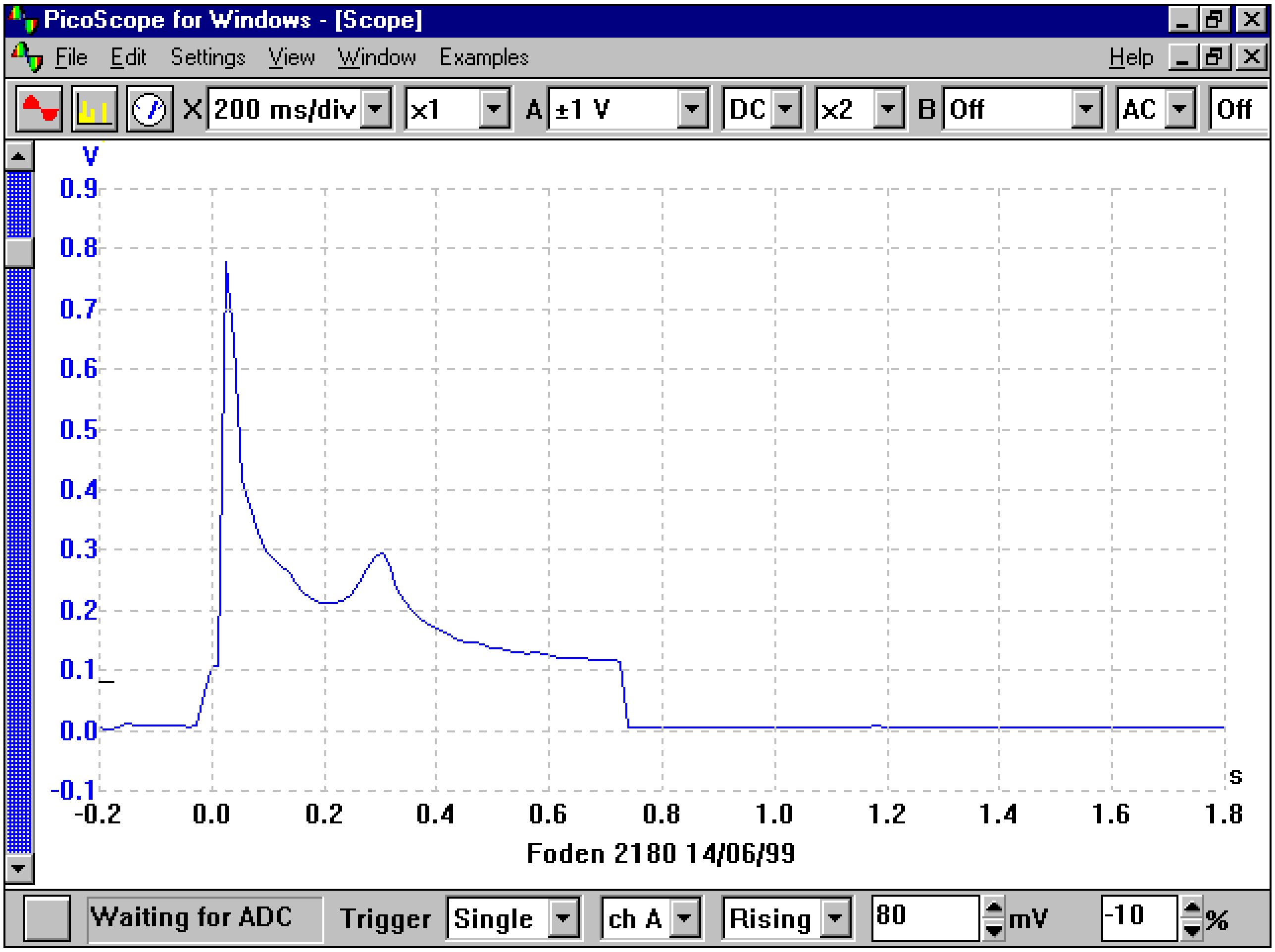
Menu



Starter Current (Aston Martin DB7 - V12 Vantage) Reference Waveform

PICO SCOPE

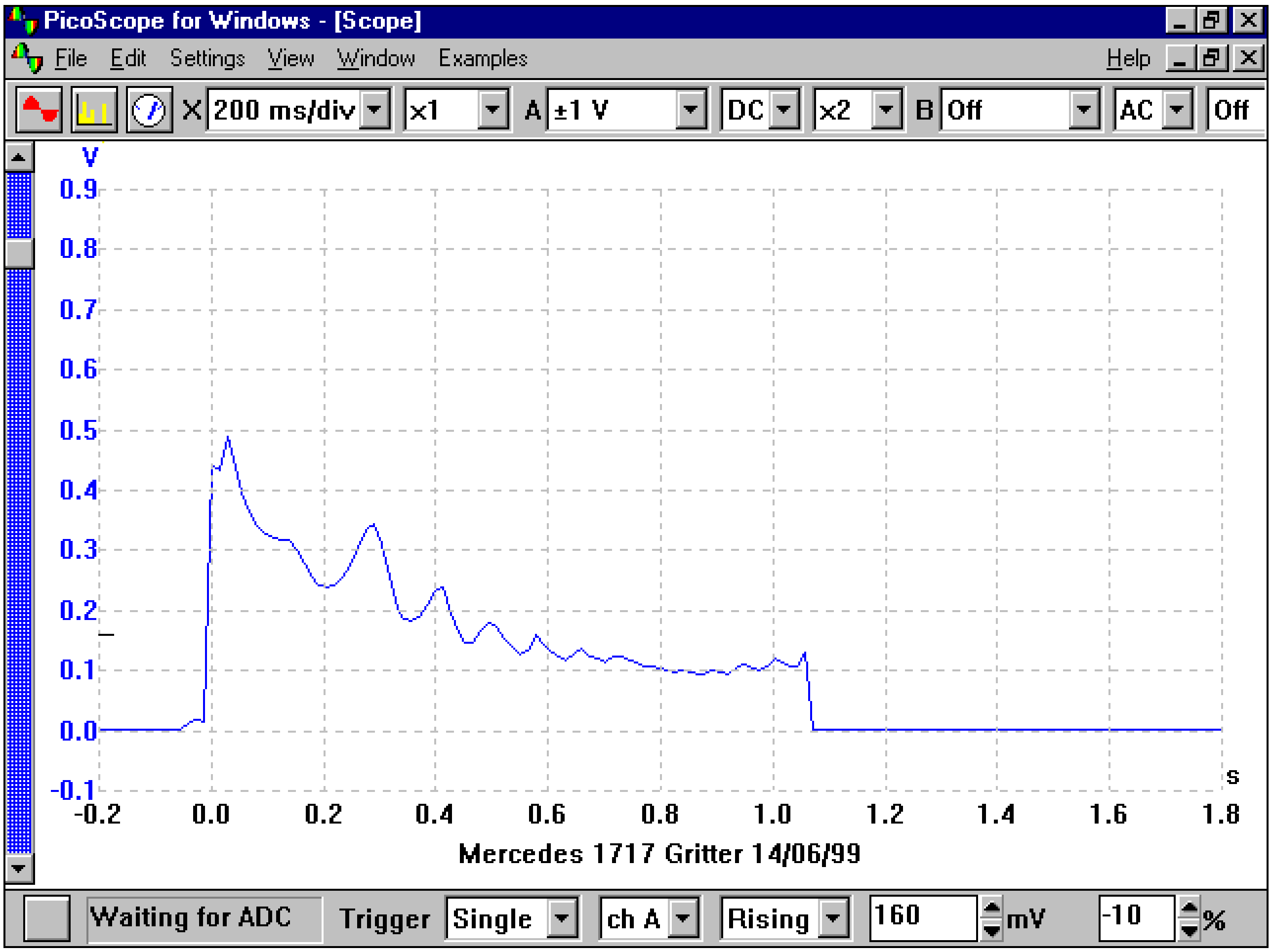
STARTER CURRENT **Menu**



Starter Current (Foden) Reference Waveform

PICO SCOPE

STARTER CURRENT **Menu**

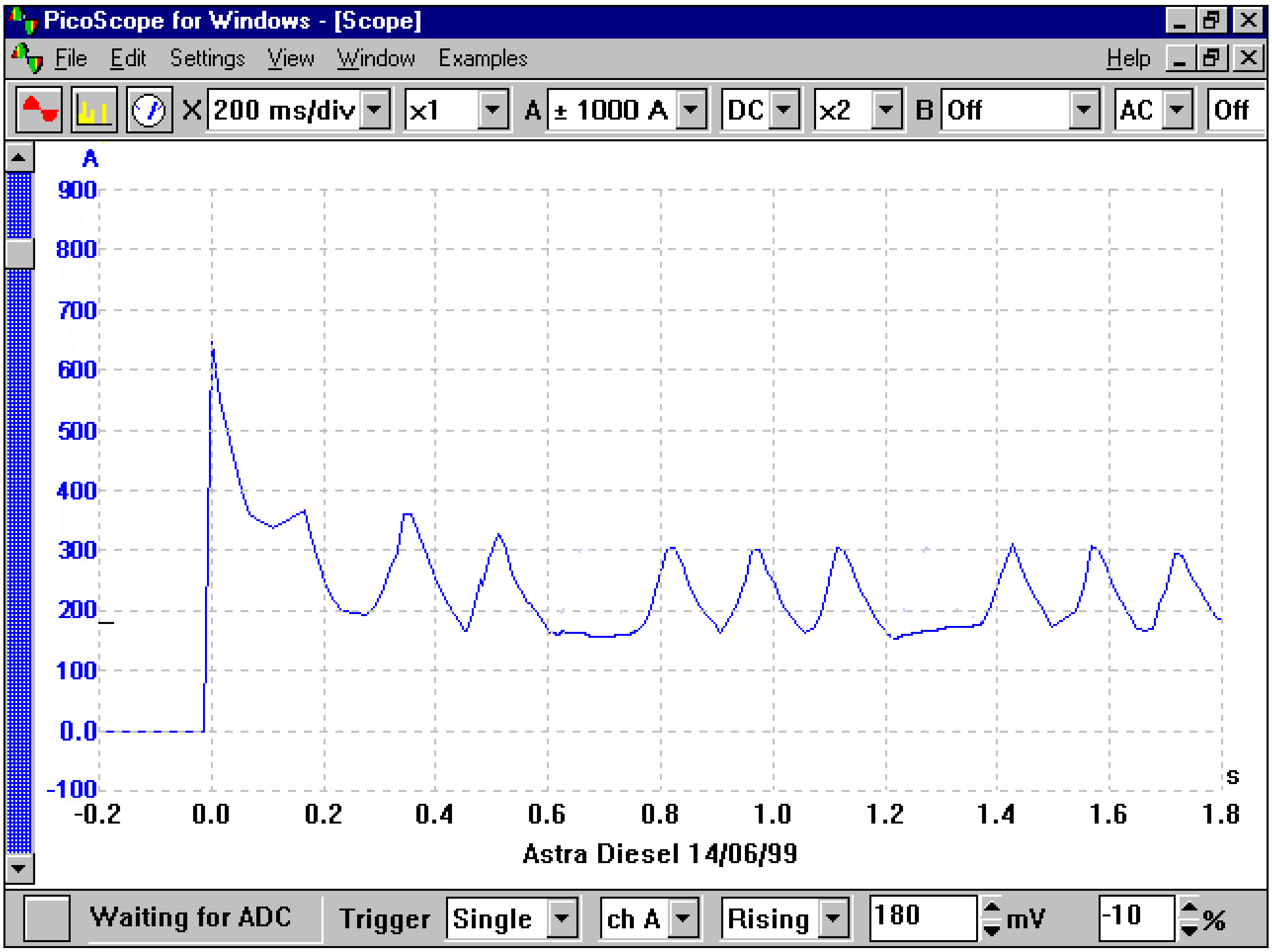


Starter Current (Mercedes 1717 Gritter) Reference Waveform

PICO SCOPE

STARTER CURRENT

Menu

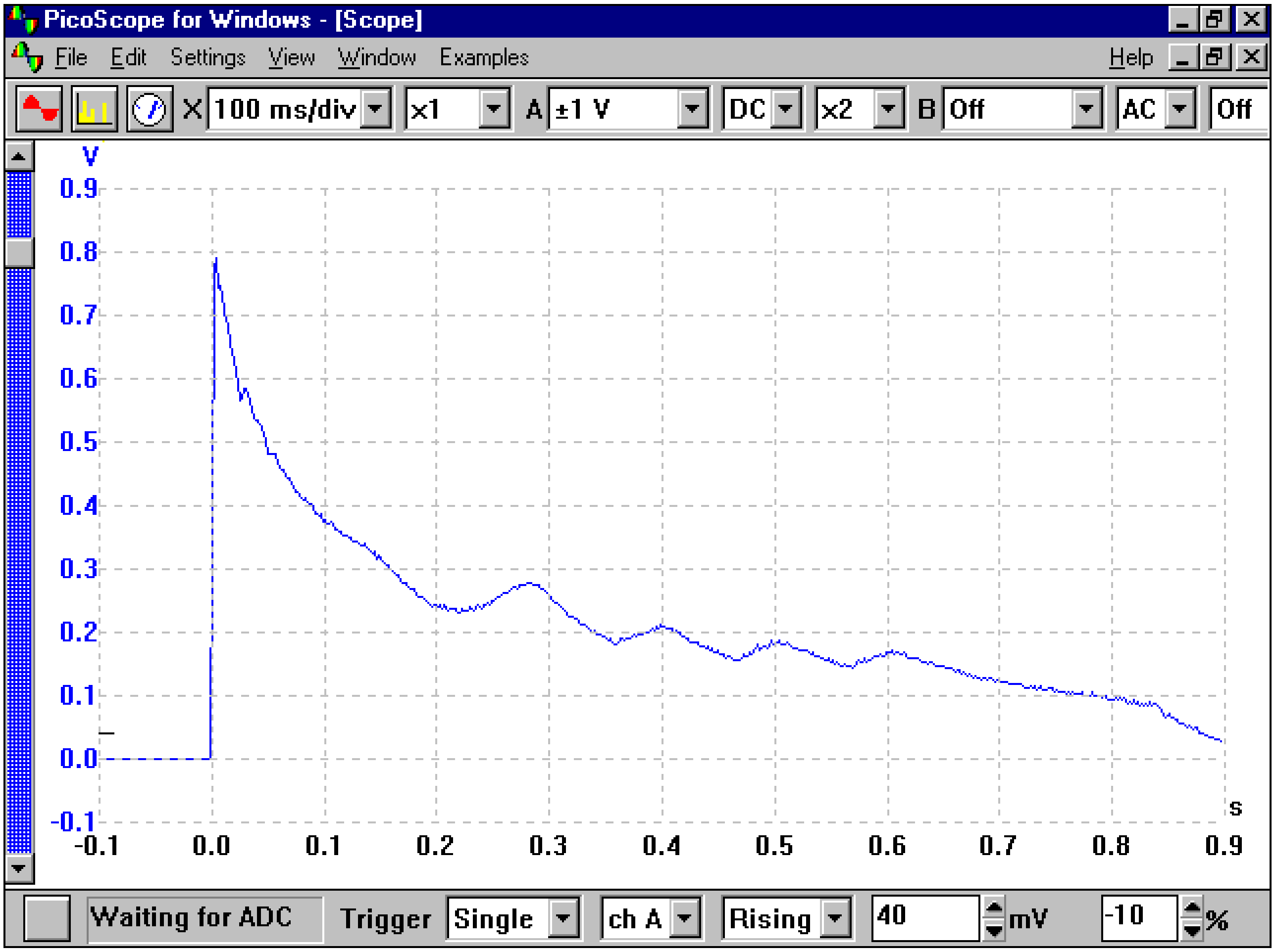


Starter Current (Vauxhall Astra Diesel) Reference Waveform

PICO SCOPE

STARTER CURRENT

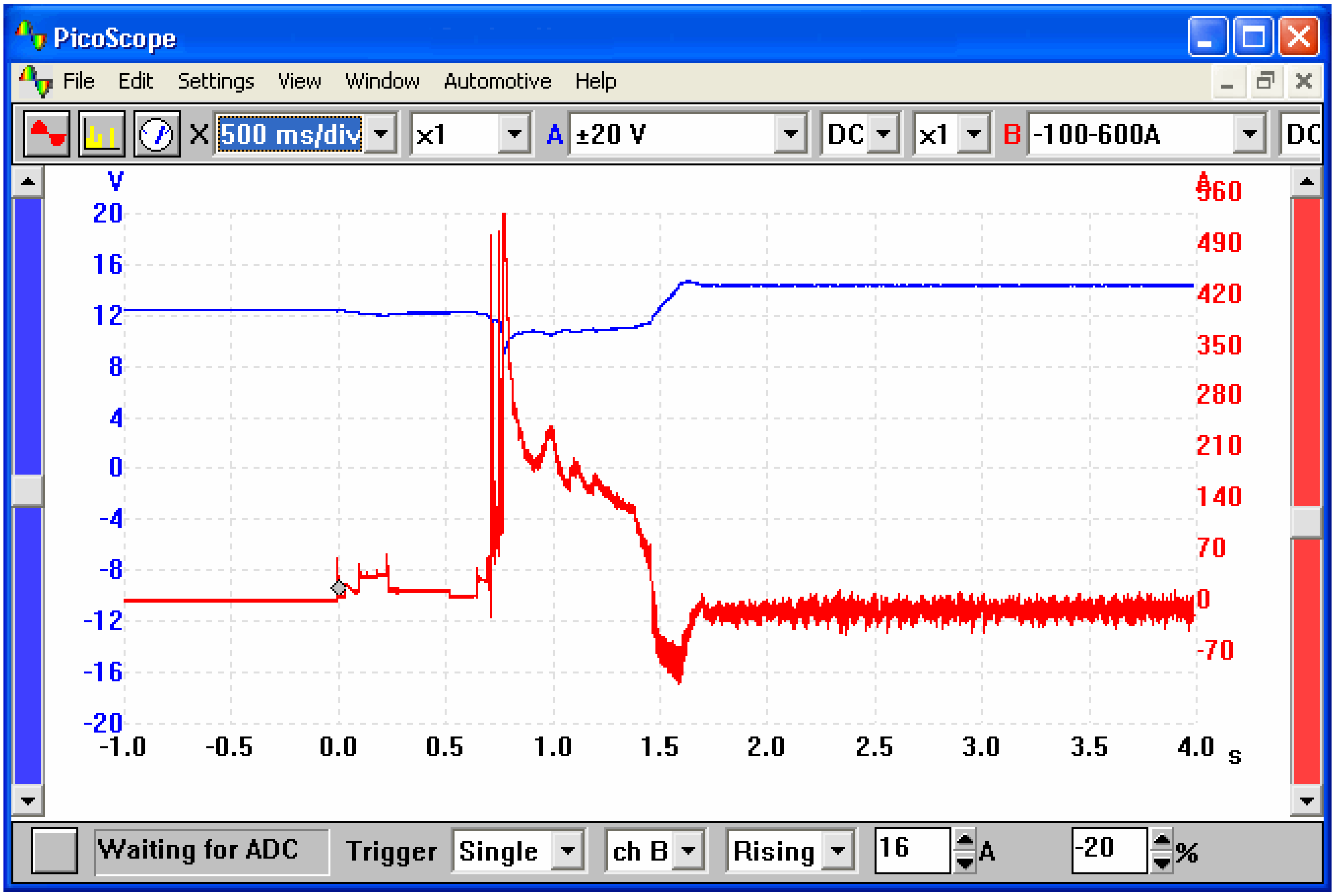
Menu



Starter Current (Vauxhall Omega) Reference Waveform

STARTER CURRENT

Menu

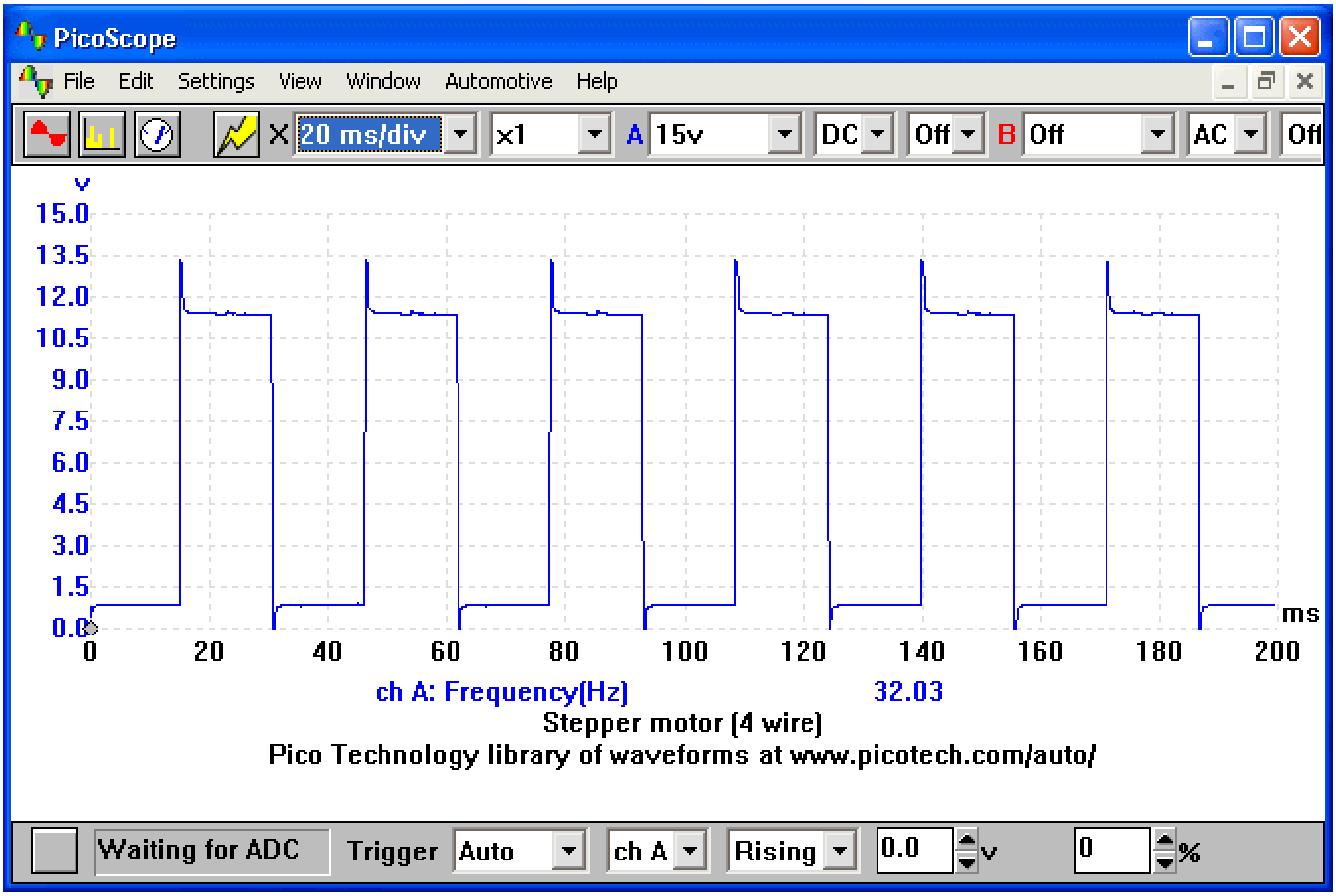


Reference Waveform Notes - Starter Current (Chevy S-10 blazer)

This waveform was captured from a 1993 Chevy S-10 Blazer. The starter on this vehicle would click and would not engage.

STEPPER MOTOR – 4 WIRE

Menu



Reference Waveform Notes - Stepper Motor (4 Wire)

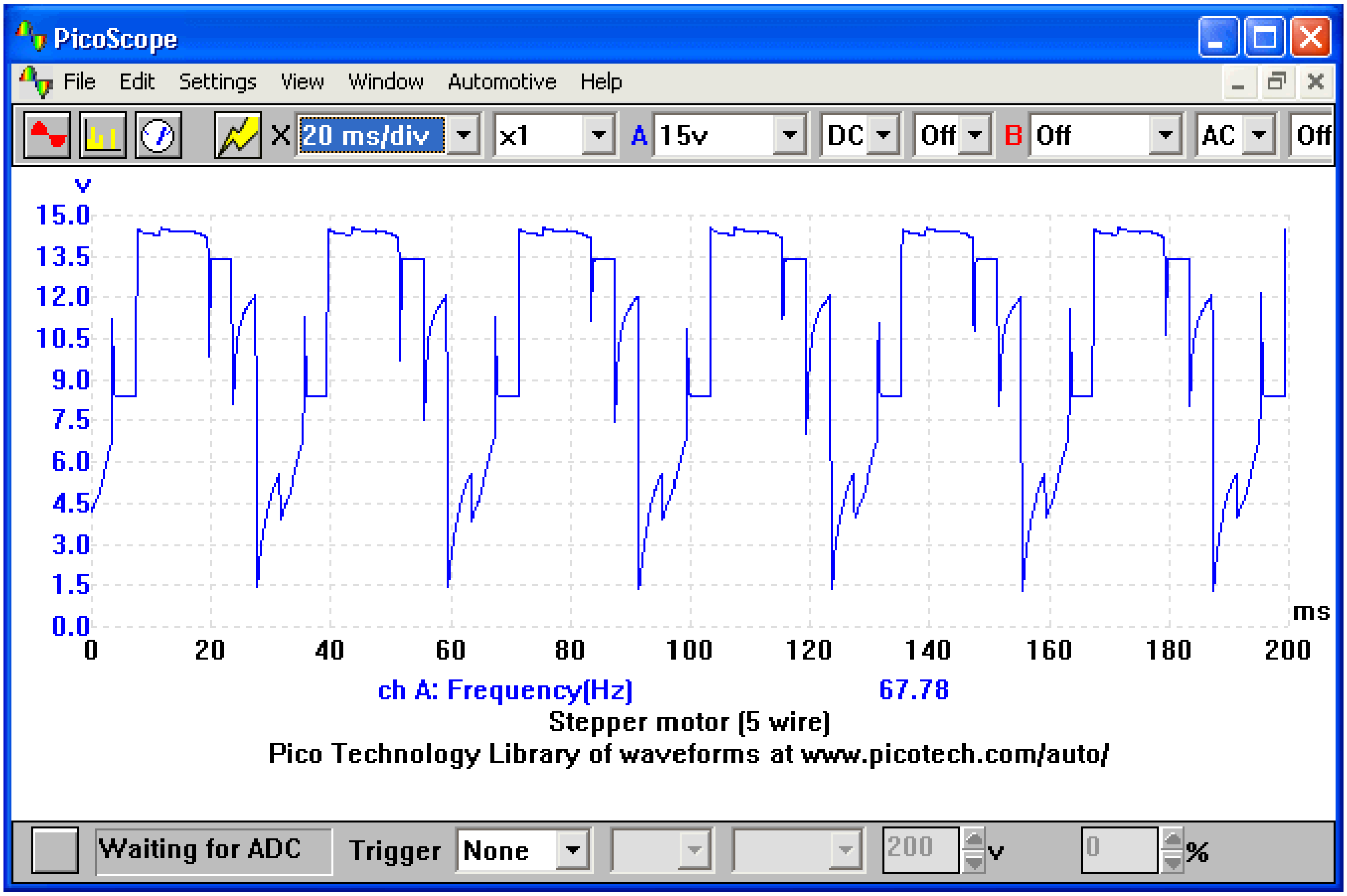
The stepper or stepper motor is a small electromechanical device that allows either an air by-pass circuit or a throttle opening to alter in position depending on the amounts that the stepper is indexed.

Invariably it will be used to control the idle speed when an idle speed control valve is not employed. The stepper may control an 'air bypass' circuit by having 4 or 5 connections back to the Electronic Control Module (ECM). The earth's enable the control unit to move the motor in a series of 'steps' and the contacts are earthed to ground via the ECM. The stepper motor may also be attached to the throttle housing, a small control rod will move onto the throttle lever and adjust the butterfly opening in very precise increments.

The individual earth paths can be checked using the oscilloscope; the waveforms should be similar on each path. Variations may be seen between different systems.

STEPPER MOTOR – 5 WIRE

Menu



Reference Waveform Notes - Stepper Motor (5 Wire)

The stepper or stepper motor is a small electromechanical device that allows either an air by-pass circuit or a throttle opening to alter in position depending on the amounts that the stepper is indexed.

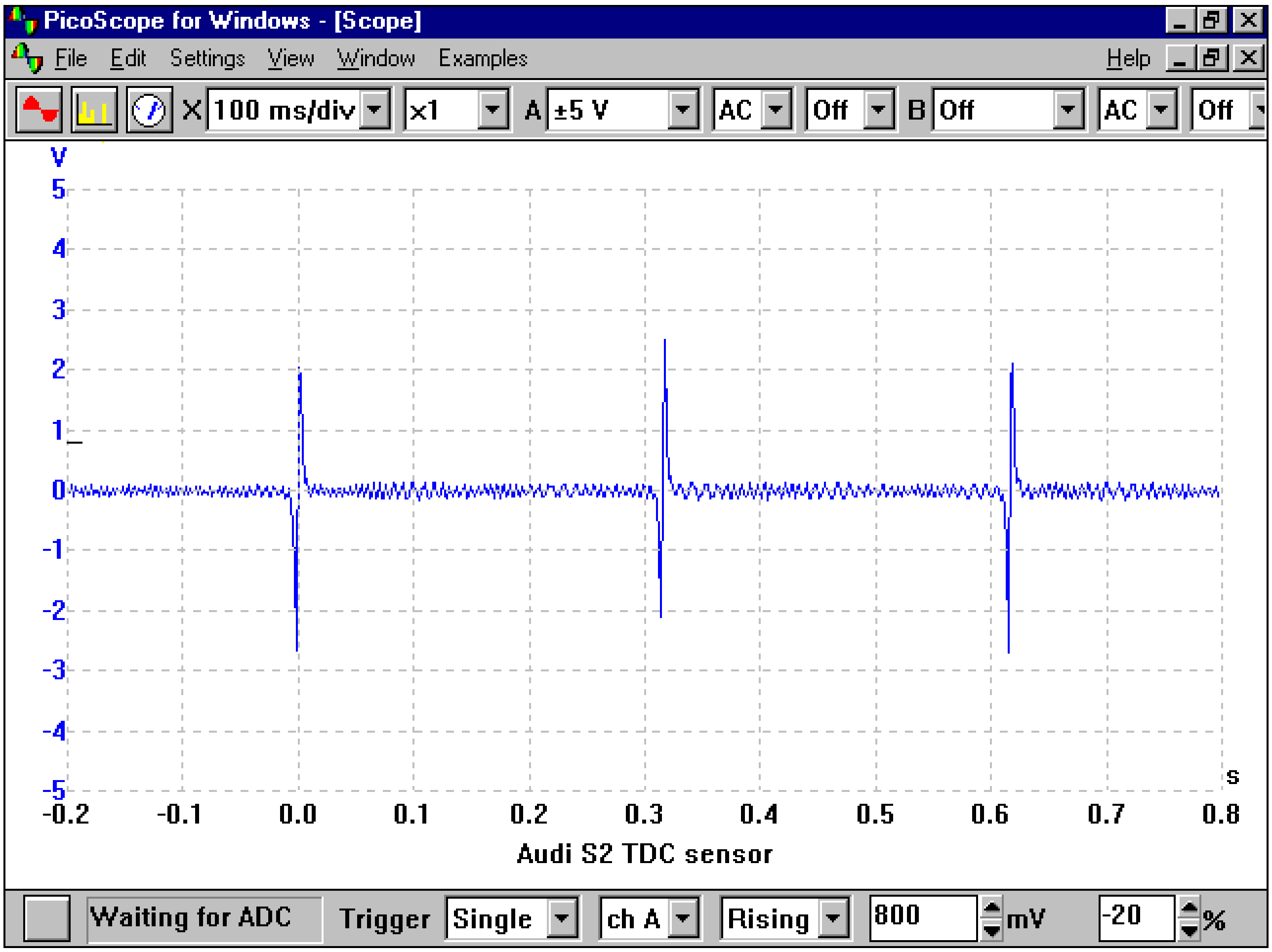
Invariably it will be used to control the idle speed when an idle speed control valve is not employed. The stepper may control an 'air bypass' circuit by having 4 or 5 connections back to the Electronic Control Module (ECM). The earth's enable the control unit to move the motor in a series of 'steps' and the contacts are earthed to ground via the ECM. The stepper motor may also be attached to the throttle housing; a small control rod will move onto the throttle lever and adjust the butterfly opening in very precise increments.

The individual earth paths can be checked using the oscilloscope; the waveforms should be similar on each path. Variations may be seen between different systems.

PICO SCOPE

TDC SENSOR

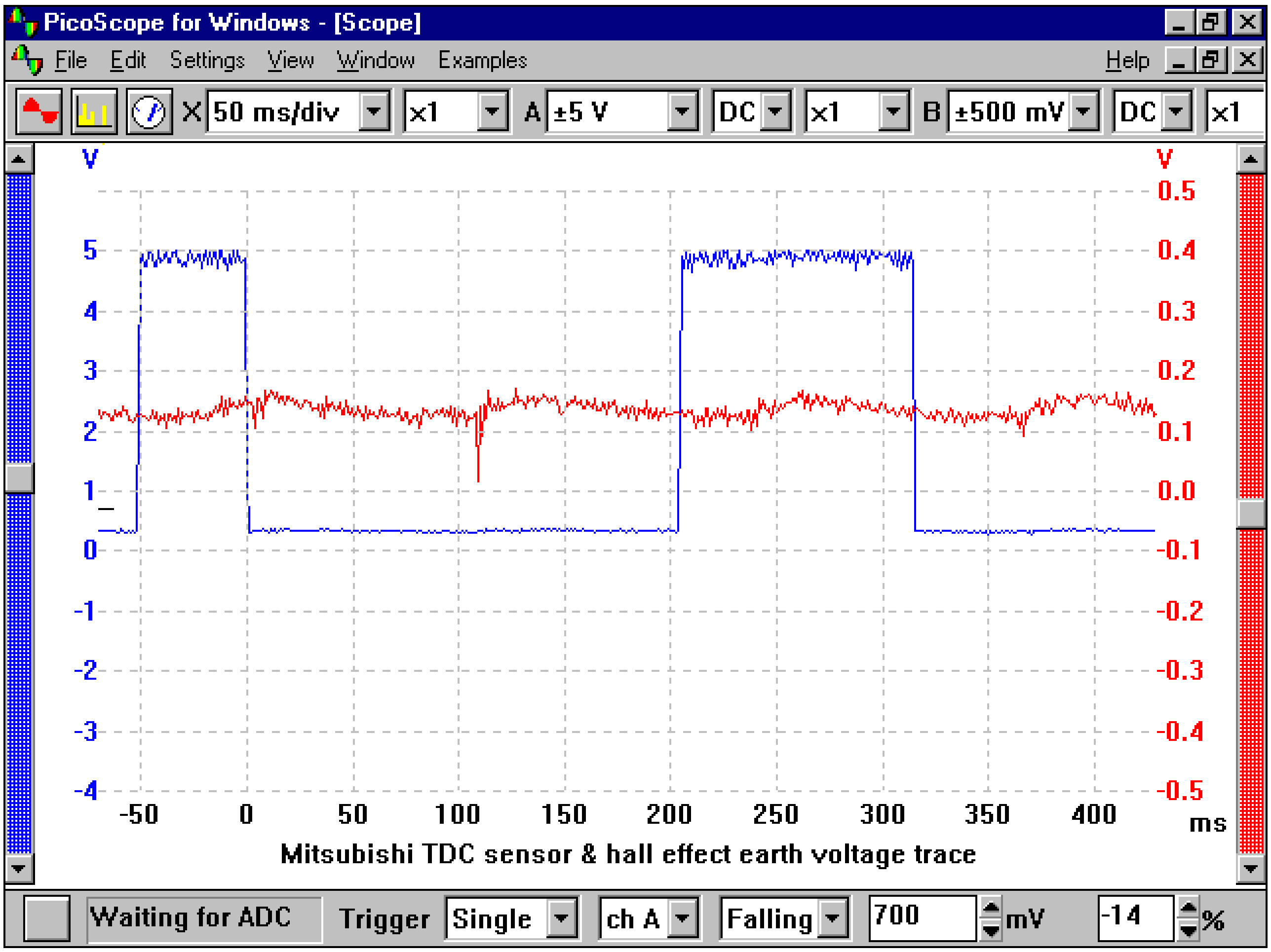
Menu



TDC Sensor (Audi S2) Reference Waveform

PICO SCOPE

TDC SENSOR **Menu**

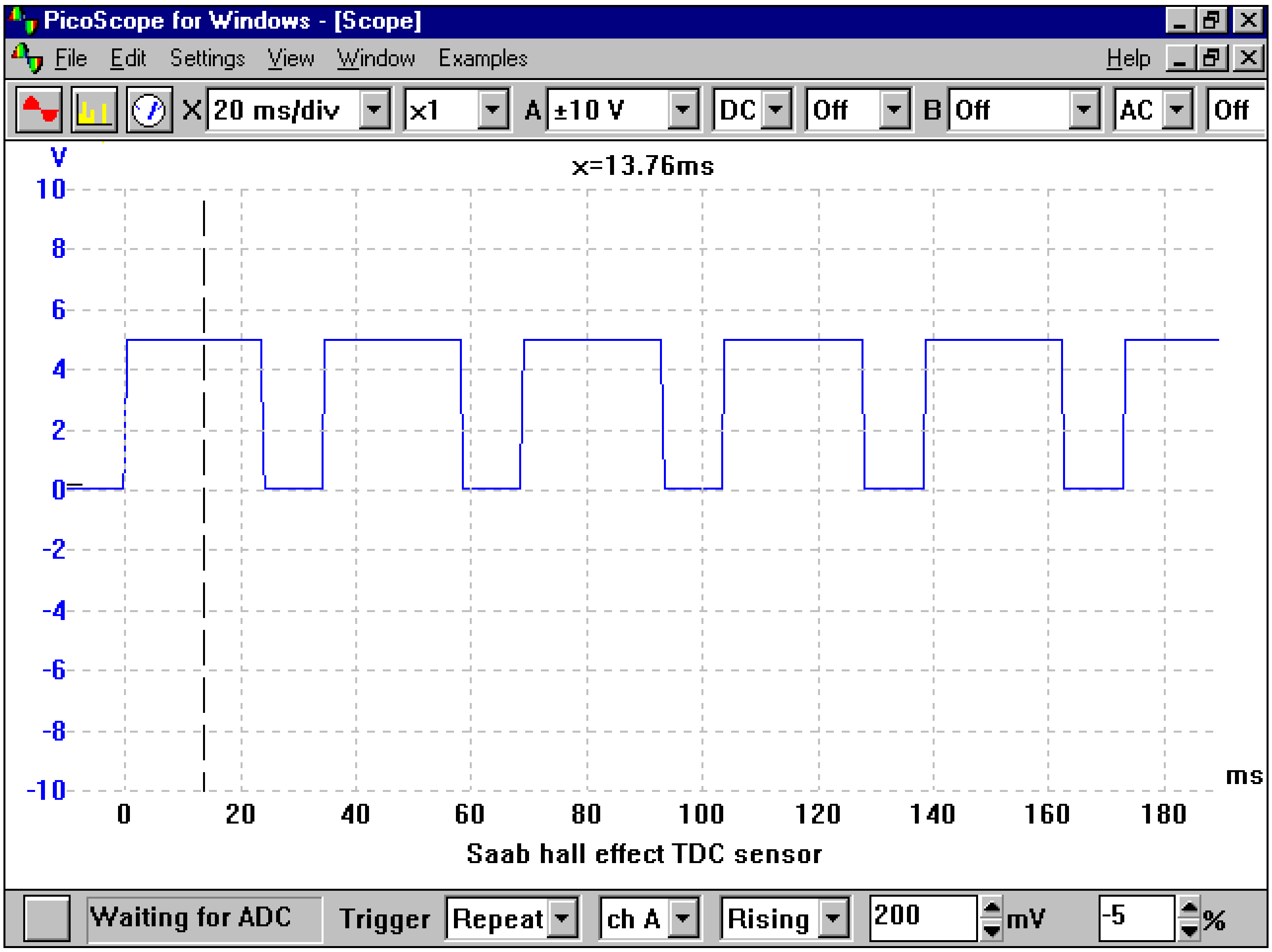


TDC SENSOR (Mitsubishi – also shows Hall Effect earth voltage noise) Reference Waveform

PICO SCOPE

TDC SENSOR

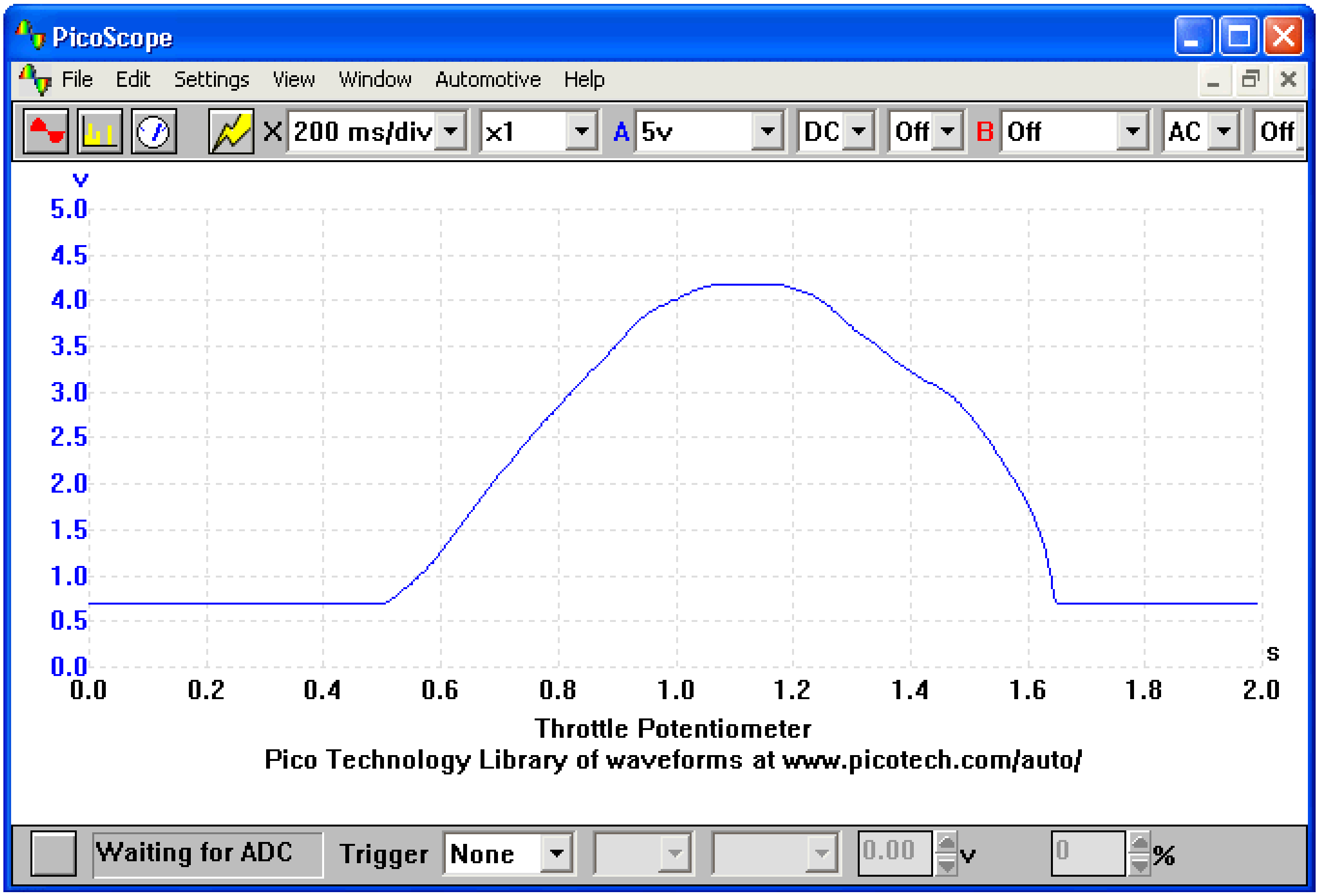
Menu



TDC SENSOR (Saab) Reference Waveform

THROTTLE POTENTIOMETER

Menu



Reference Waveform Notes - Throttle Potentiometer

This sensor or potentiometer is able to indicate to the Electronic Control Module (ECM) the exact amount of throttle opening due to its linear output. The majority of modern management systems will employ this particular sensor, and is located on the throttle butterfly spindle.

This is a 3 wire device having a 5 volt supply, an earth connection and a variable output from the centre pin. As the output is critical to the vehicle's performance, any 'blind spots' within the internal carbon track's swept area, will cause 'flat spots' and 'hesitations'.

This lack of continuity can be seen on an oscilloscope and will enable the operator to plot the output voltage over its operational range, showing any faulty areas.

A good throttle pot should show a small voltage at the throttle closed position, gradually rising in voltage as the throttle is opened and returning back to its initial voltage as the throttle is shut.

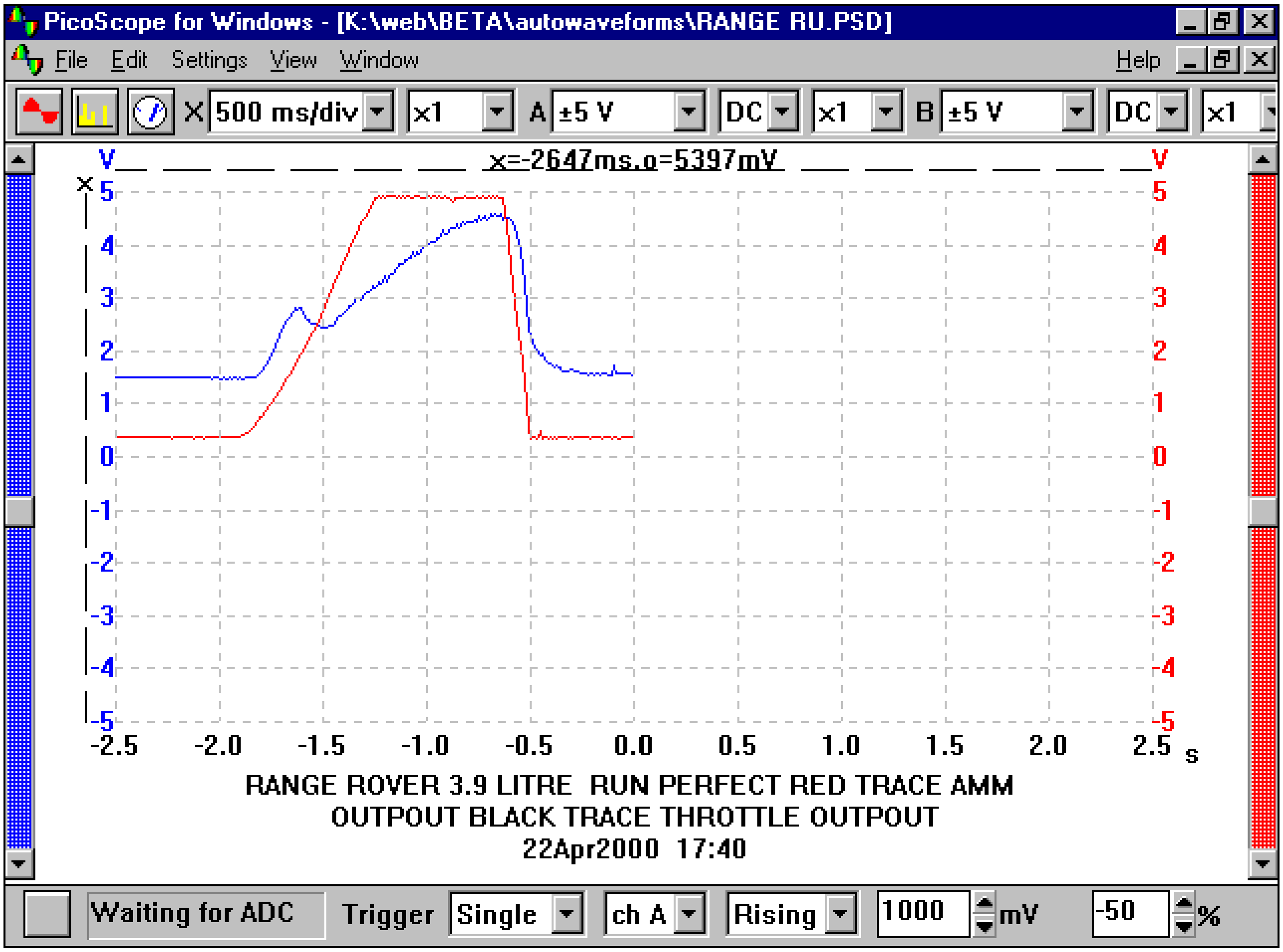
Although many throttle position sensor voltages will be manufacturer specific, many are non-adjustable and the voltage will be in the region of 0.5 to 1.0 volts at idle rising to 4.0 volts (or more) with a fully opened throttle. For the full operational range, a time scale around 2 seconds is used.

The picture should be clean with no voltage 'drop out' at any particular point, as this small discrepancy will be sufficient to cause a 'flat spot' under initial acceleration.

PICO SCOPE

THROTTLE POTENTIOMETER

Menu



Throttle Potentiometer (Ranger 3.9L – also shows Air Mass Meter signal trace) Reference Waveform