catoolRT User Guide

Issue 1 (29 April 2017)

Contents

catoolRT comes ready configured to acquire data from a four-cylinder, four-stroke engine from a simulated engine. You can modify this configuration to suit your exact needs and actual hardware.

If you want to investigate catoolRT's features before your hardware is setup leave the configuration alone for the time being and skip to the section on going online.

To configure the data acquisition firstly ensure your National Instruments hardware is connected and turned on if necessary, then select "Configure DAQ" from the "Acquisition" menu.
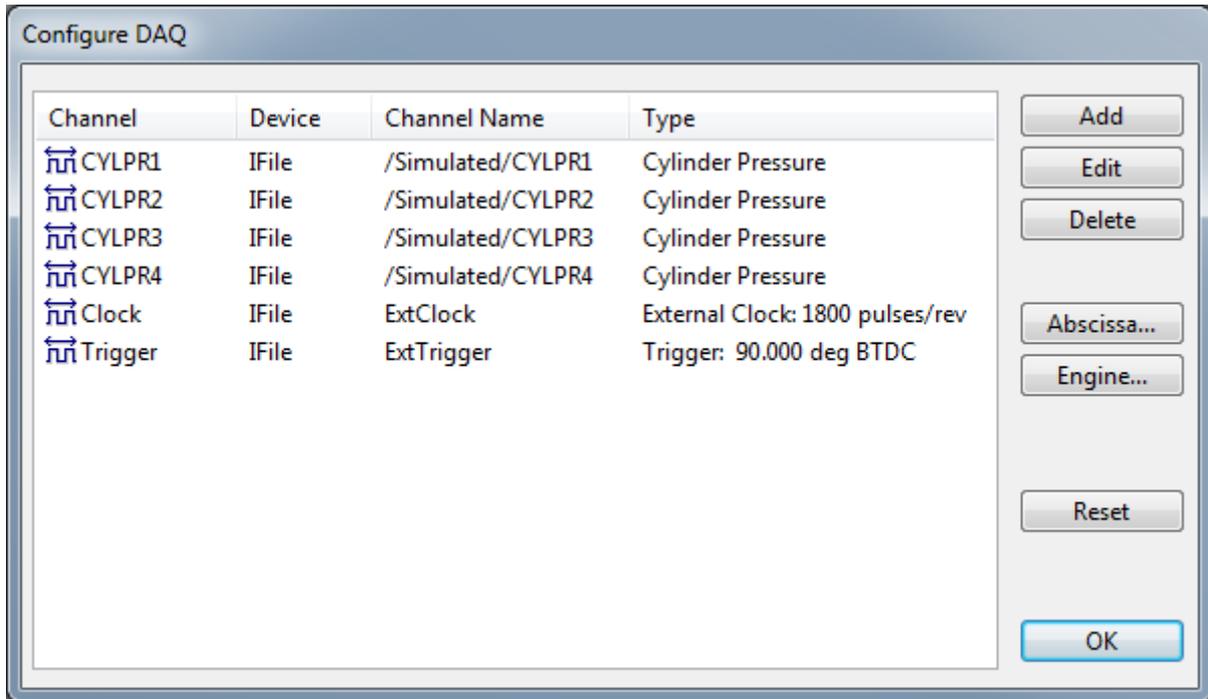

Figure 1.1: Configure DAQ

Firstly, configure engine geometry by clicking the "Engine…" button.

Configure Engine

| Engine		
Name	Engine	
Number Of Cylinders	4	
Bore	87.5	mm
Stroke	83.099998	mm
Conrod Length	146.25	mm
Pin Offset		
Cylinder 1	0	mm
Cylinder 2	0	mm
Cylinder 3	0	mm
Cylinder 4	0	mm
Firing Order	1-3-4-2	
Compression Ratio	10.8	
Type	Spark Ignition	
Number Of Strokes	4-Stroke	
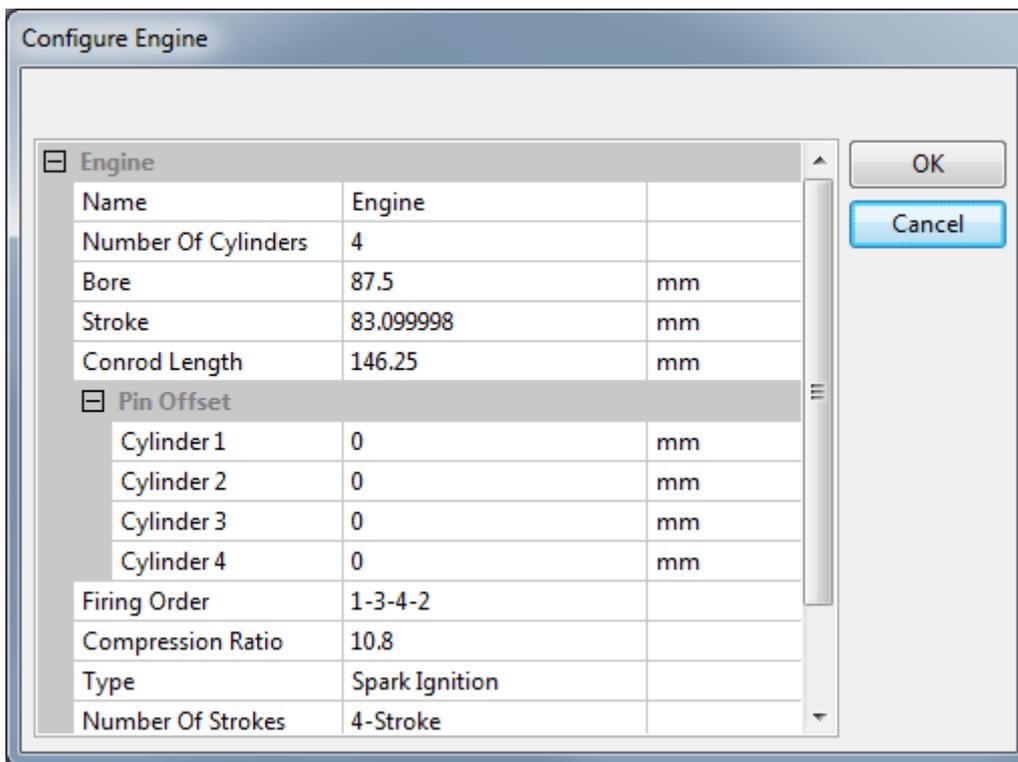
Figure 1.2: Configure Engine

This should be edited to suit the geometry of the engine you are testing. If you do not have such information available the effect will be to compromise the absolute values of such parameters as IMEP. And estimated value will still allow comparisons between different engine hardware, calibrations or speed-load points.

Set the number of cylinders first so that you can then select the correct firing order. If the firing order of your engine is not listed then select "Custom". This will allow you to manually enter the TDC offset of each channel individually.

Change the number of strokes to 2 or 4 as necessary. Intake Valve Opening (IVO) and Exhaust Valve Opening (EVO) angles are not critical.

Next, add or remove channels to suit your hardware. To delete channels highlight them in the list and click "Delete" or press the "Delete" key. To add channels click the "Add" button.

Editing existing channels

To edit an existing channel either double-click the channel in the list or highlight it and press the "Edit" button.
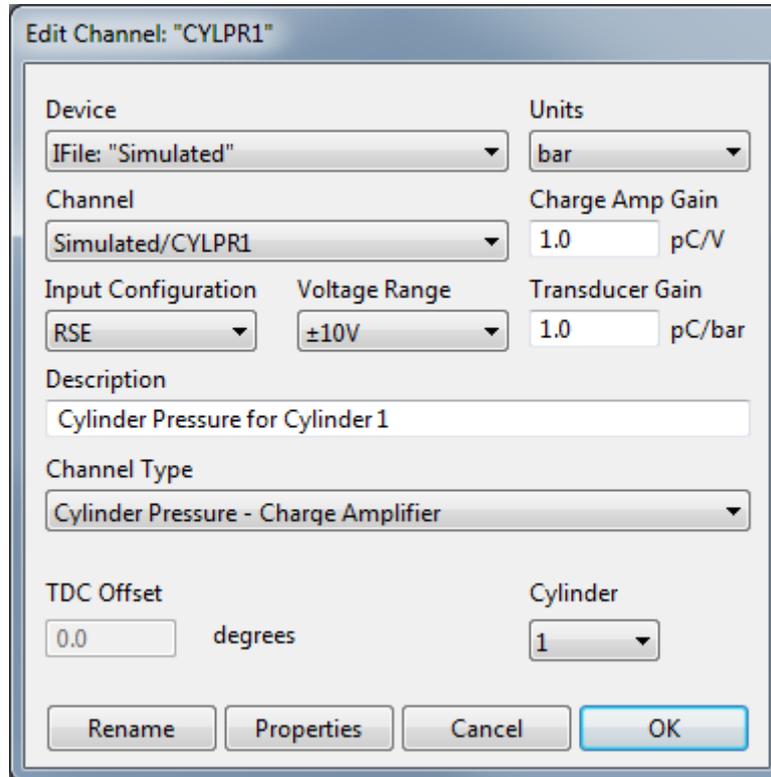

Figure 1.3: Edit Channel

Firstly select the data acquisition device from the Device drop down menu. This will only display hardware that is suitable for use with catoolRT. If a device does not appear that you think is suitable then check it appears in NI-MAX and if so contact Xarin support for assistance.

Next select the channel, input configuration and voltage range for the channel. Be sure to understand the different types of input configuration that your National Instruments hardware allows and how to use them for the most reliable, noise free measurements. A good document is available here http://www.ni.com/white-paper/3344/en/.

For cylinder pressure channels there are three channel types available. These simplify the transducer calibration depending on the hardware you are using. For normal piezo transducers such as those from Kistler use "Cylinder Pressure – Charge Amplifier". This simplifies the input of the transducer calibration and charge amplifier gain. For Optrand sensors use "Cylinder Pressure – Optrand". This simplifies the input of the transducer calibration by using the calibration values directly without conversion. Finally for a conventional slope and offset sensor such as a Beru PSG use "Cylinder Pressure – Other".

If you have selected the correct firing order in the engine configuration then you can select the cylinder from the drop down and the TDC offset will be calculated automatically. If you selected "Custom" in the engine configuration then the cylinder number and TDC offset must be specified manually. Contact support to add any missing firing orders to the next version of the software.

For cylinder pressure channels click the "Properties" button to configure additional settings.
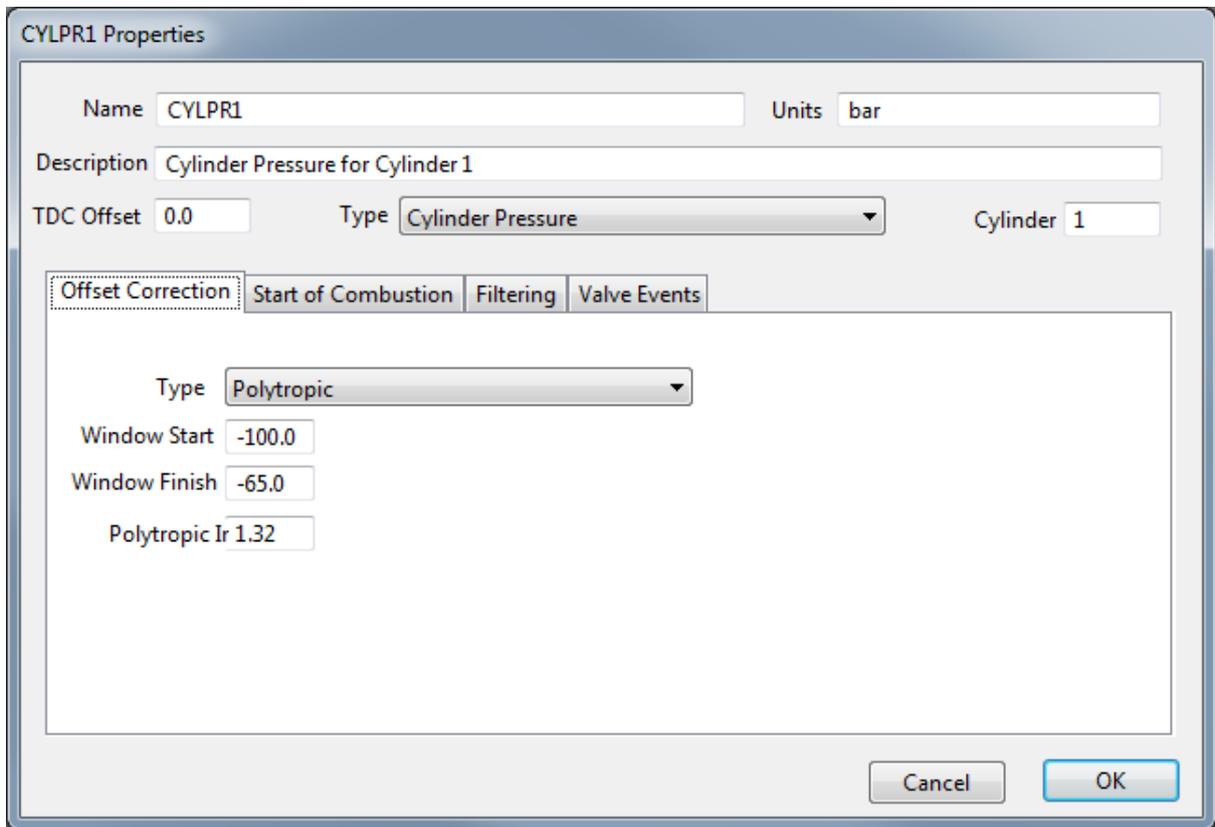
Figure 1.4: Channel Properties

Firstly offset correction needs to be set. The normal methods are polytropic correction or intake manifold pressure pegging.

For a gasoline engine a polytropic index of 1.32 is sufficient and for a Diesel 1.37.

For intake manifold pressure pegging (Reference Channel) you will first need to configure a channel of type "Intake Manifold Pressure". It will then appear as an available channel.

Secondly the start of combustion should be measured. This can be from either a spark signal for a gasoline engine or injector for a Diesel. Generally this will use the "Channel Rising Edge" or "Channel Falling Edge" type. If no such signal is available then a fixed value can be specified.

Filtering can be turned on if a pressure signal is noisy. A 4 kHz low pass filter should suffice. Please note that digital filtering is no substitute for good quality wiring, shielded and routed away from sources of noise such as mains wiring or high current coils or injectors.

Editing the clock
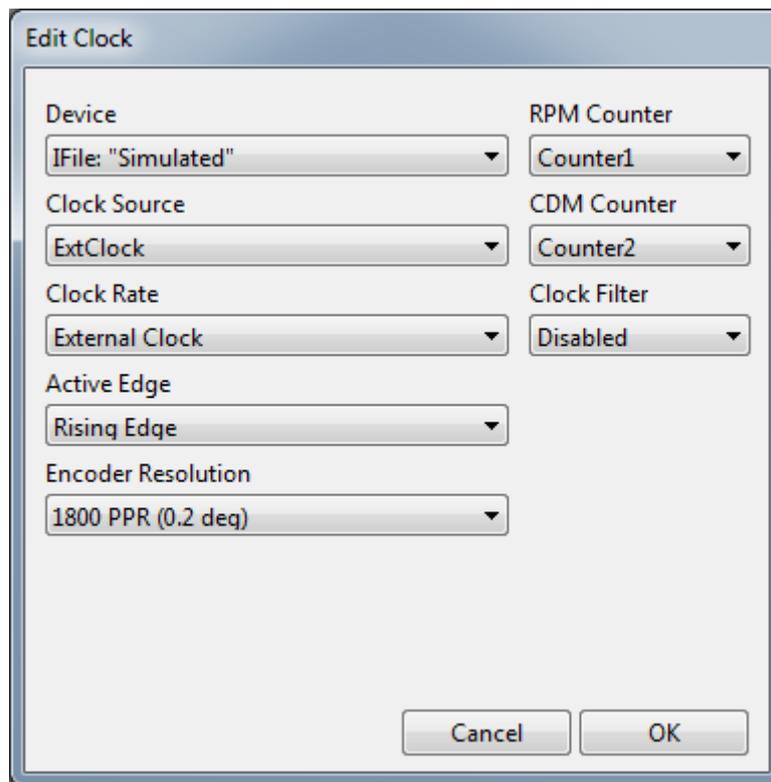
Figure 1.5: Edit Clock

The clock is the timing source for the combustion data acquisition. This comes from the crank angle encoder or crank angle convertor if using an OE crank angle sensor. Your encoder probably refers to the clock input signal as CDM, A or B.

Once the device and clock source are configured to match your wiring check the "Encoder Resolution" matches the raw resolution of your encoder. The actual rate at which data is stored can be down sampled elsewhere. If you are measuring directly from the engine crank angle sensor the encoder resolution should include any missing teeth. For a 36-1 encoder it should be 36, for a 60-2 it should be 60, etc.

You need to specify a counter to be used for reliable data acquisition. The very least required is one counter for the "RPM Counter". This will allow the engine speed to be calculated at all times. Some National Instruments hardware only has two counters so you will then need to choose whether you have the "CDM Counter" or "Clock Filter" active.

The "CDM Counter" will check that for every revolution the data acquisition receives exactly the right number of clock pulses. This aids with measurement robustness as you will immediately know if noise issues are causing the acquisition position to drift. This should be the normal choice for the second counter.

The "Clock Filter" can be used to remove noise from the clock signal. Again, there is no substitute for eliminating noise sources at source. Use the +5V power supply feed from the National Instruments card to power the encoder and use good quality shielded cabling, routed away from sources of noise. If you have a third counter on your hardware then use the third counter for this.

Edit the trigger
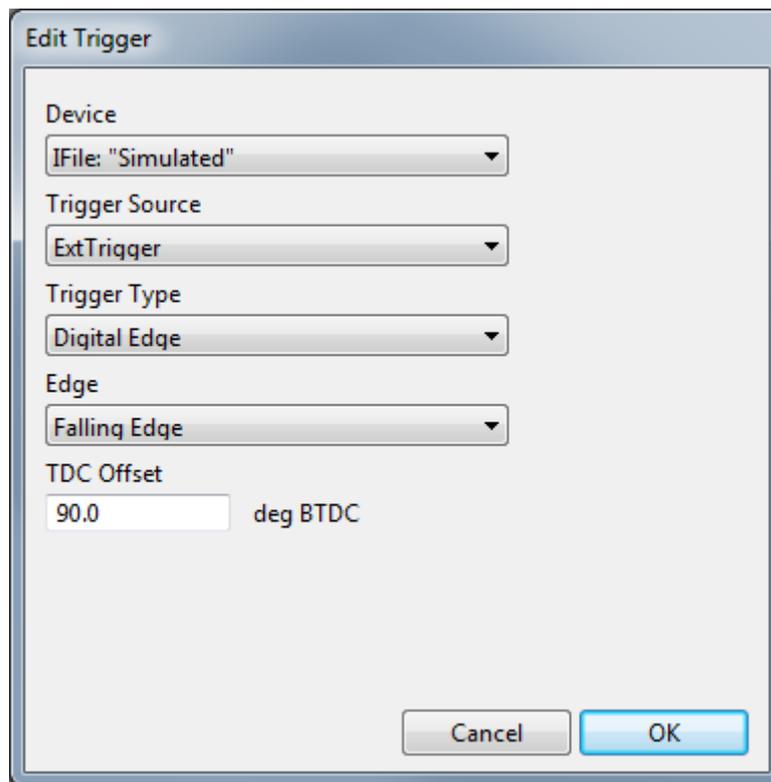
Figure 1.6: Edit Trigger

The trigger is used to start the data acquisition at a known angular position within the engine's rotation. For acquisitions with missing teeth change the trigger type to "Clock Signal with X Missing Teeth".

Make as good as possible estimation of the TDC offset of the encoder trigger. Once online you will be able to refine this.

Edit the abscissas
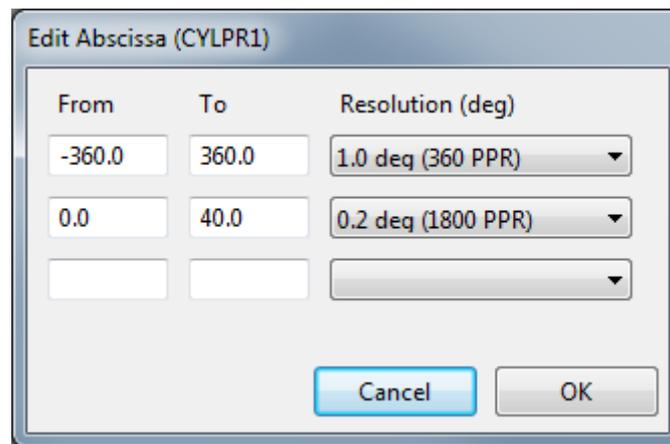
Figure 1.7: Edit Abscissa

The resolution at which crank angle data is stored can be down sampled from the native encoder resolution. This reduces the storage and calculation overhead required for online analysis.

To edit the abscissa select one or more channels in "Configure DAQ" and press the "Abscissa…" button.

Up to three measurement ranges can be specified. They can have different measurement resolutions and can overlap. If they do then the highest resolution is stored.

To delete a measurement range select the blank option from the resolution drop down.

The measurement range does not have to cover the entire engine cycle, so for example injector or coil signals need only be measured around the combustion region -180 to +180 degrees.

Acquiring Data

Firstly, in the "Hardware Type" submenu in the "Acquisition" menu select either "National Instruments" if you have configured for real acquisition or "Simulated" if you want to test out catoolRT's capabilities away from a running engine.

To go online press F4, select "Online" in the "Acquisition" menu or press the green play icon on the toolbar.

Acquiring Data	1501 RPM	1800 CDM	Statistics: 0.0 ms

Figure 1.8: Online status information

The acquisition should begin and you can look at the status bar at the bottom of the catoolRT window to see the acquisition status:

- Acquisition status (Acquiring Data)
- Engine Speed (1501 RPM)
- Crankangle Degree Marks (if "CDM Counter" configured) (1800 CDM)
- Rolling information:
    - Time to calculate statistics (0.0ms)
    - Average and maximum time to calculate analysis
    - DAQ buffer size
    - Total cycles acquired

If the status does not transition through to "Acquiring Data" then check the trigger signal is present.

Once acquiring data check the engine speed matches an independent measurement from the ECU, engine dyno, vehicle instrument cluster, etc.

The CDM measurement should match the expected number of encoder pulses from the encoder or crank angle calculator.

If the number of buffer cycles is constantly increasing then the data acquisition hardware or PC is unable to transfer the raw data quickly enough to catoolRT. At some point the DAQ hardware buffers will overflow and data will be lost.

catoolRT will acquire data at a fixed number of times per engine cycle. This can be configured in "Advanced Config" in the "Acquisition" menu under the "Analysis Rate" setting. This value should match the number of engine cylinders to ensure that calculations are made available as soon as a combustion cycle finishes.

Chapter 2: Encoderless Operation

Analogue crank position sensor (VRS)

Input voltage must be externally conditioned to ensure within the range of the NI hardware

Configure the analogue input

Add a new DAQ channel configured as "Crank Position Sensor"

Figure 2.1: Add CPS channel

For a VRS sensor a good starting point for the zero crossing detection is +0.1 and -0.1 volts.

Configure the Clock

Clock Source is the analogue channel configured as the crank position sensor

Clock Rate should be "Interpolate External Clock"

Encoder Resolution should be set including the missing teeth, i.e. 60 for a 60-2 or 36 for a 36-1

Active Edge is normally falling edge

Clock Filter should be enabled
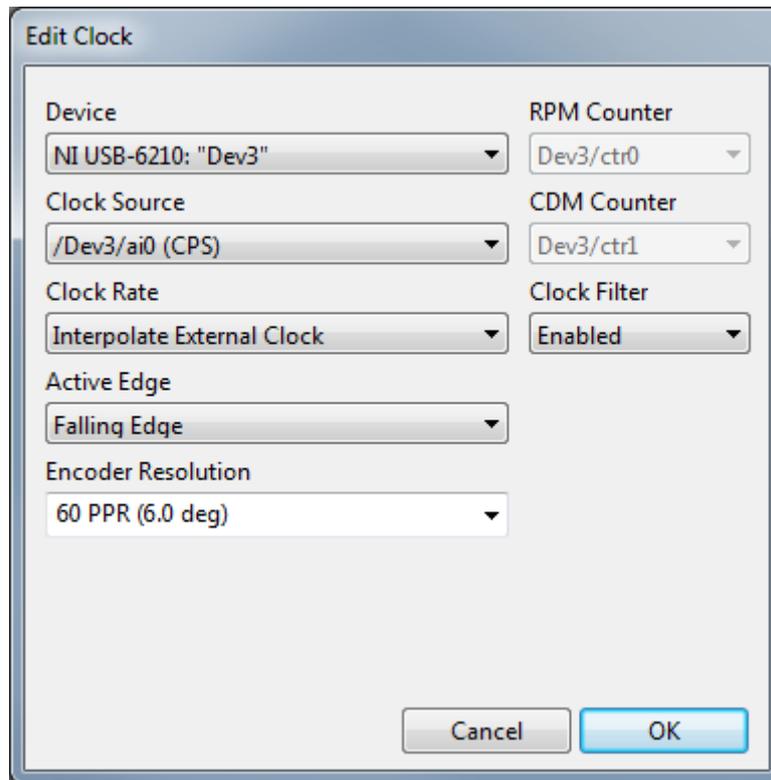
Figure 2.2: Edit Clock

Configure the Trigger

Trigger type should reflect the number of missing teeth (1 or 2)

TDC Offset is measured in the Bosch convention as the angle of the first downedge after the missing tooth has passed.

Figure 2.3: Edit Trigger

Digital Crank Position Sensor

(Hall or externally conditioned CPS)

Optical isolation is recommended to prevent interference with PCM engine position management

Configure the Clock

Clock Source is the digital channel the sensor is connected to. Note that not all NI hardware allows correlated digital/analogue IO. In this case connect the input to an analogue channel and follow the instructions above for analogue VRS. As a starting point set "Latch High" to 2.0V and "Latch Low" to 0.8V to match a TTL signal.

Clock Rate should be "Interpolate External Clock"

Encoder Resolution should be set including the missing teeth, i.e. 60 for a 60-2 or 36 for a 36-1

Active Edge is normally falling edge

Clock filter should be enabled
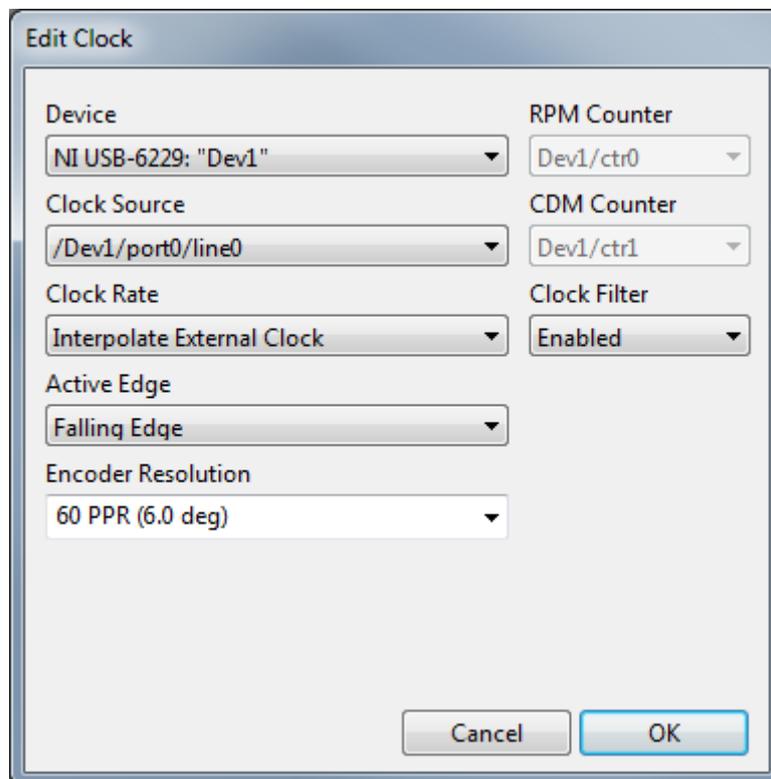
Figure 2.4: Edit Clock

Configure the Trigger

Trigger type should reflect the number of missing teeth (1 or 2)

TDC Offset is measured in the Bosch convention as the angle of the first downedge after the missing tooth has passed.

Figure 2.5: Edit Trigger

Figure 3.1: Channel Properties

Note that the start of combustion is specified in degrees after TDC. Most engine control systems work in reference to degrees before TDC. Depending on where you obtain the start of combustion value from you may need to invert the sign.

None

No start of combustion method is specified. This is equivalent of a fixed SOC value of zero degrees.

Fixed Value

Start of combustion is at a fixed value.

Channel Rising/Falling Edge

The start of combustion is determined by the first rising or falling edge found within a window of a specified reference channel.

If the channel includes information about many cylinders, i.e. a current clamps for each cylinders injector or coil wired in parallel, then you can use the "Align with cylinder TDC offset" option. This ensured the window is in reference to the configured channel.

Channel Average

This takes the start of combustion as the average value of another channel during the window specified. This can be used if the voltage output from an ignition angle meter is proportional to spark advance. The signal can be inverted if necessary and aligned to the current TDC offset.

Channel Value

This takes a value from another results channel. This may also include channels that have been acquired using ATI VISION. The value may also be inverted.

Align with cylinder TDC offset

When this option is selected the specified window is adjusted such that the channel and reference channel values are coincident at the same time.

Consider these usage scenarios for a four cylinder engine:

Four cylinder pressures and cylinder one injector (or coil) signal

	TDC Offset	Channel	Align
CYLPR1	0	INJ1	Y*
CYLPR2	540	INJ1	N
CYLPR3	180	INJ1	N
CYLPR4	360	INJ1	N
INJ1	0	-	-

*actually doesn't matter as CYLPR1 and INJ1 have the same TDC offset

Obviously in this scenario all cylinders are assuming the same start of combustion as cylinder one. You could achieve the same result by setting the start of combustion type to "Channel Value" for CYLPR2-4 and selecting channel "INJ1.INJTM1".

Four cylinder pressures and four individual injector (or coil) signals

	TDC Offset	Channel	Align
CYLPR1	0	INJ1	Y*
CYLPR2	540	INJ2	Y*
CYLPR3	180	INJ3	Y*
CYLPR4	360	INJ4	Y*
INJ1	0	-	-
INJ2	540	-	-
INJ3	180	-	-
INJ4	360	-	-

*actually doesn't matter as cylinder pressure and referenced injector channels have the same TDC offset

Four cylinder pressures and four injector (or coil) signals superimposed on single channel

|	TDC Offset	Channel	Align
CYLPR1	0	INJ1	Y*
CYLPR2	540	INJ1	Y
CYLPR3	180	INJ1	Y
CYLPR4	360	INJ1	Y
INJ	0	-	-

*actually doesn't matter as CYLPR1 and INJ have the same TDC offset

Chapter 4: Offset Correction

Most cylinder pressure transducers are piezoelectric which means in practical terms that they measure rate of change of cylinder pressure rather than absolute pressure. In order to turn the signal into something useful an offset must be calculated and applied to each combustion cycle.

There are two main methods, firstly pegging the cylinder pressure and intake manifold pressures equal to each other at some point during the intake valve event and secondly fitting the initial compression process to a polytropic compression with known index.

To configure the offset correction select "Acquisition" then "Configure DAQ". Select the required channel either by double-clicking on the channel in the list or by highlighting the channel and clicking "Edit". In the "Edit Channel" dialogue select "Properties".

Figure 4.1: Channel Properties

None

No offset correction is applied. Use this method if the pressure transducer signal requires no offset other than the voltage slope and offset.

Fixed Value

A fixed offset correction in bar is applied. This is the same as applying the offset in the voltage slope and offset configuration.

Polytropic

The initial compression phase, between the intake valve closing and the start of combustion is fitted to a polytropic compression with a specified index.

For a gasoline engine an index value of 1.32 is suggested. For a Diesel engine a value of 1.37 is used.

This offset correction is calculated for every combustion cycle. It has the benefit that no additional parameters need to be recorded. A window between -100 and -65 degrees is recommended.

Reference Channel

This sets the mean pressure of the channel during a window to be that of a reference channel during the same window. Normally the reference channel would be that of the intake manifold pressure. The window would be during the intake valve opening period at a point where the pressure in the cylinder has equalised with that of the intake manifold. An approximate window would be around -300 to -240 degrees.

Mean

This sets the mean pressure of the channel during a window to be that of a fixed reference pressure. Normally this would be a point during the intake valve opening period where the intake manifold pressure could be estimated. An approximate window would be around -300 to -240 degrees.

Reference Channel (Absolute CA)

This works in a similar manner to the "Reference Channel" method except the reference channel window is not moved to account for the TDC offset between the channels. This is useful if you want to peg cylinder pressure signals to each other, where the first cylinder is pegged using one method and the other cylinders assume the same reference pressure. You would do this by using a reference window similar to the polytropic method, -100 to -65 degrees.

Plot cylinder pressure against crank angle

You can create a new diagram three ways:

Select "Diagram", "New Diagram"

Press F5

Click the "New Diagram" icon on the toolbar


Figure 5.1: Add new diagram
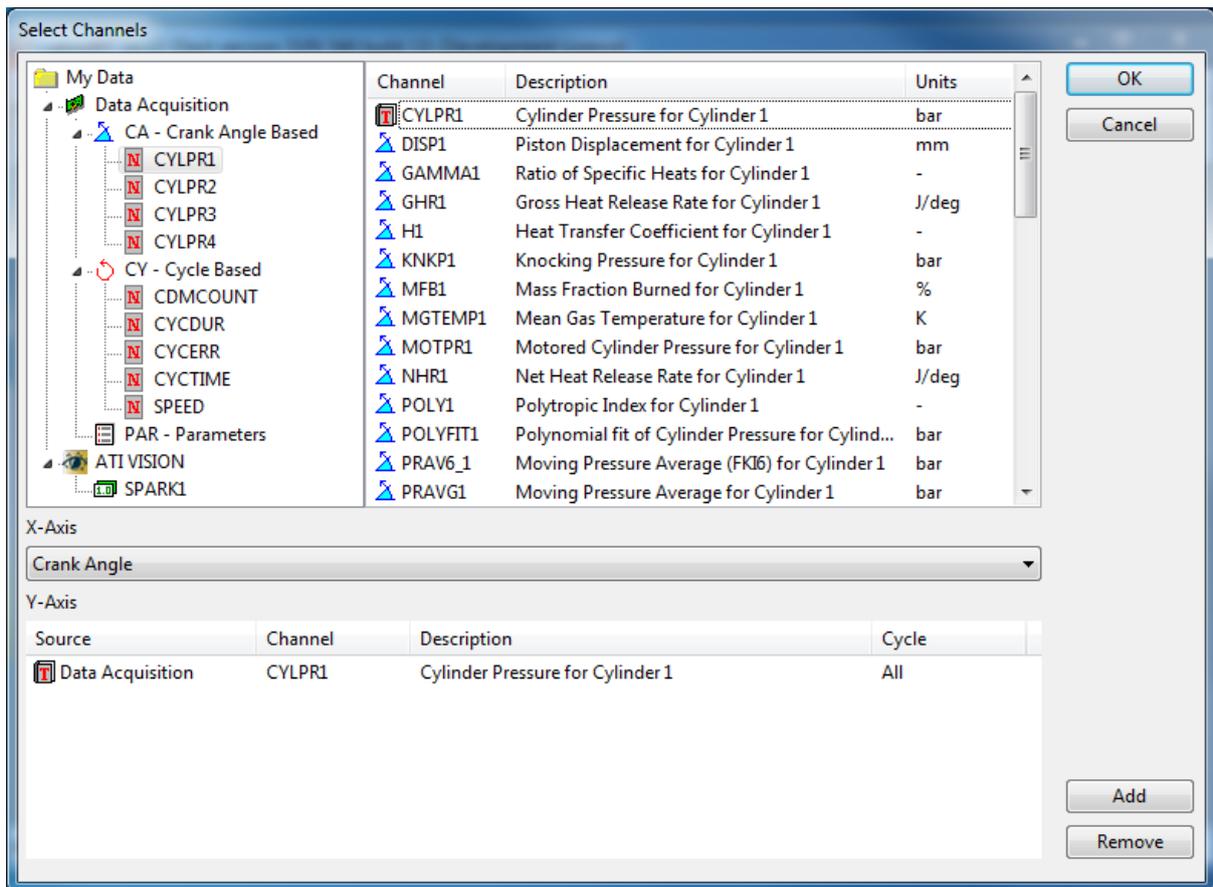
Figure 5.2: Select Channels

This will open the "Select Channels" dialogue. Select the raw pressure channel, such as CYLPR1, in the left hand tree. A list of channels will appear in the right hand list that can be plotted with the current x-axis type. For a crank angle plot the first channel listed is the raw channel, the channels underneath are calculations.

Double-click a channel, or press the "Add" button, to add it to the list of channels to be plotted. These will appear in the list at the bottom of the window. Channels can be removed from the list by selecting them and pressing the "Remove" button.

Raw channels can be added to the diagram either by double-clicking them either in the left hand tree or list of channels on the right.

To add a channel for all cylinders right click on a channel in the right hand list and select "Add for All Cylinders".

Press OK to create the diagram.

Plot cylinder pressure against volume

Select the cylinder pressure channel as before, i.e. by double clicking on CYLPR1.

Now right click on the channel you want as the X-axis such as volume (VOL1) and select "Plot Channel As X-Axis".
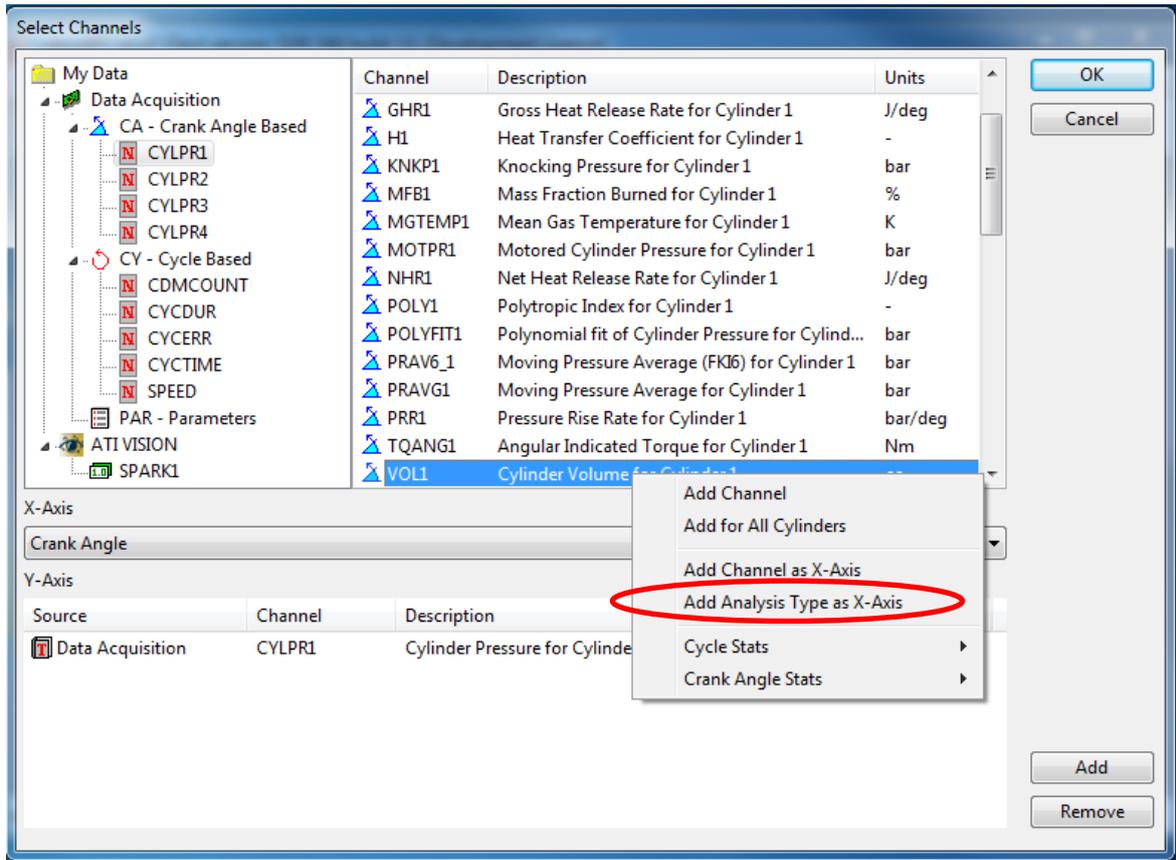

Figure 5.3: Select Channels

Press OK to create the diagram.
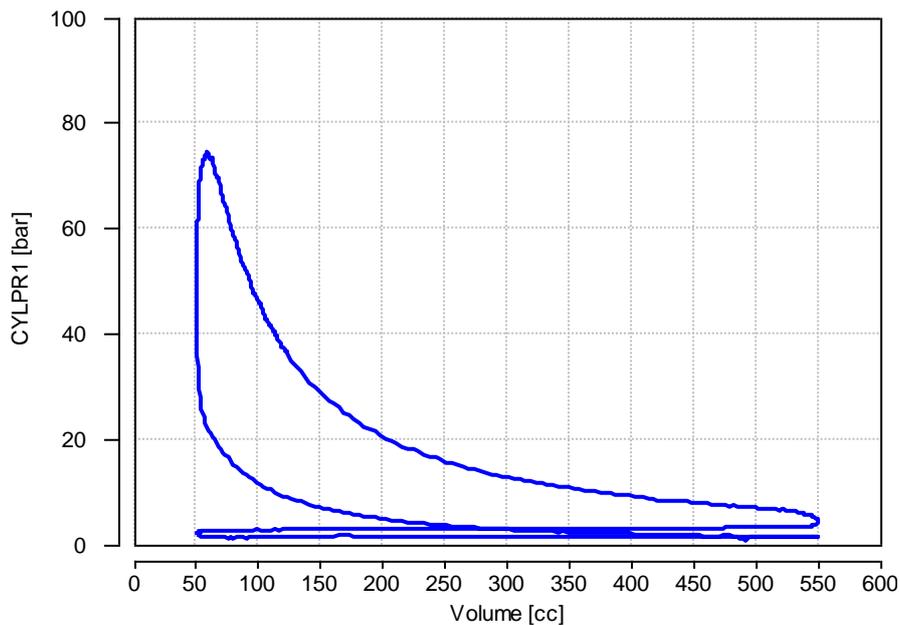
Figure 5.4: pV Diagram

To create a log pV diagram right click in the diagram and check "X-Axis Log" and "Y-Axis Log"
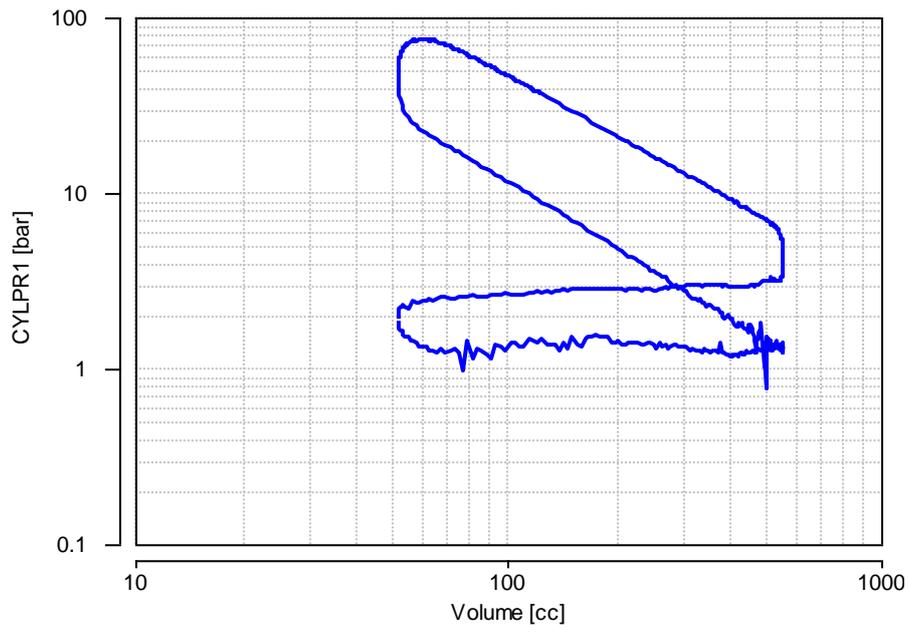
Figure 5.5: log pV Diagram

Plot cycle calculations on crank angle data

Some calculations can be plotted with the crank angle data such as start of combustion, MFB fractions, etc. These appear in the list of available calculations in the right hand pane of the "Select Channels" dialogue beneath the crank angle based calculations.
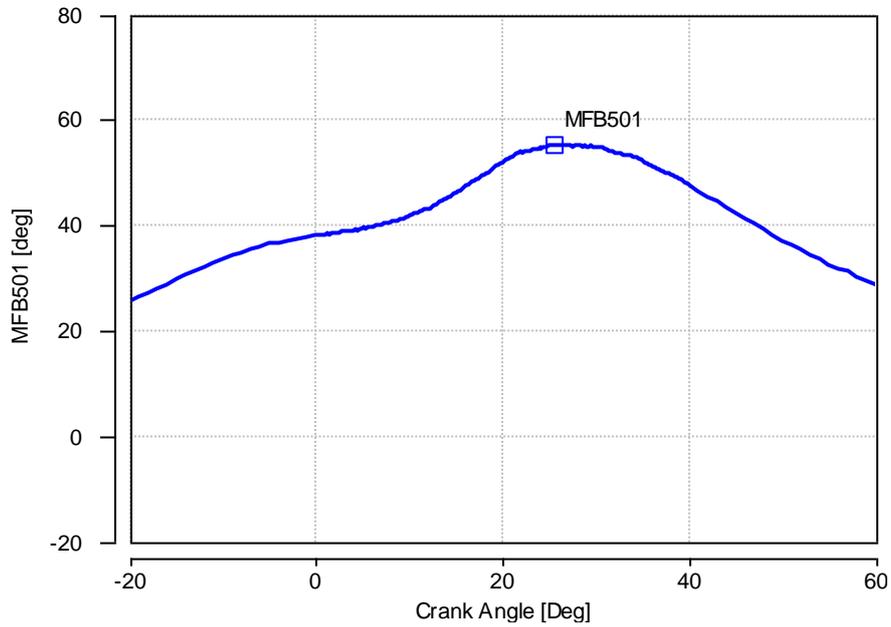

Figure 5.6: Crank angle plot with cycle calculation displayed on plot (MFB50)

Plot cycle calculations against cycle number
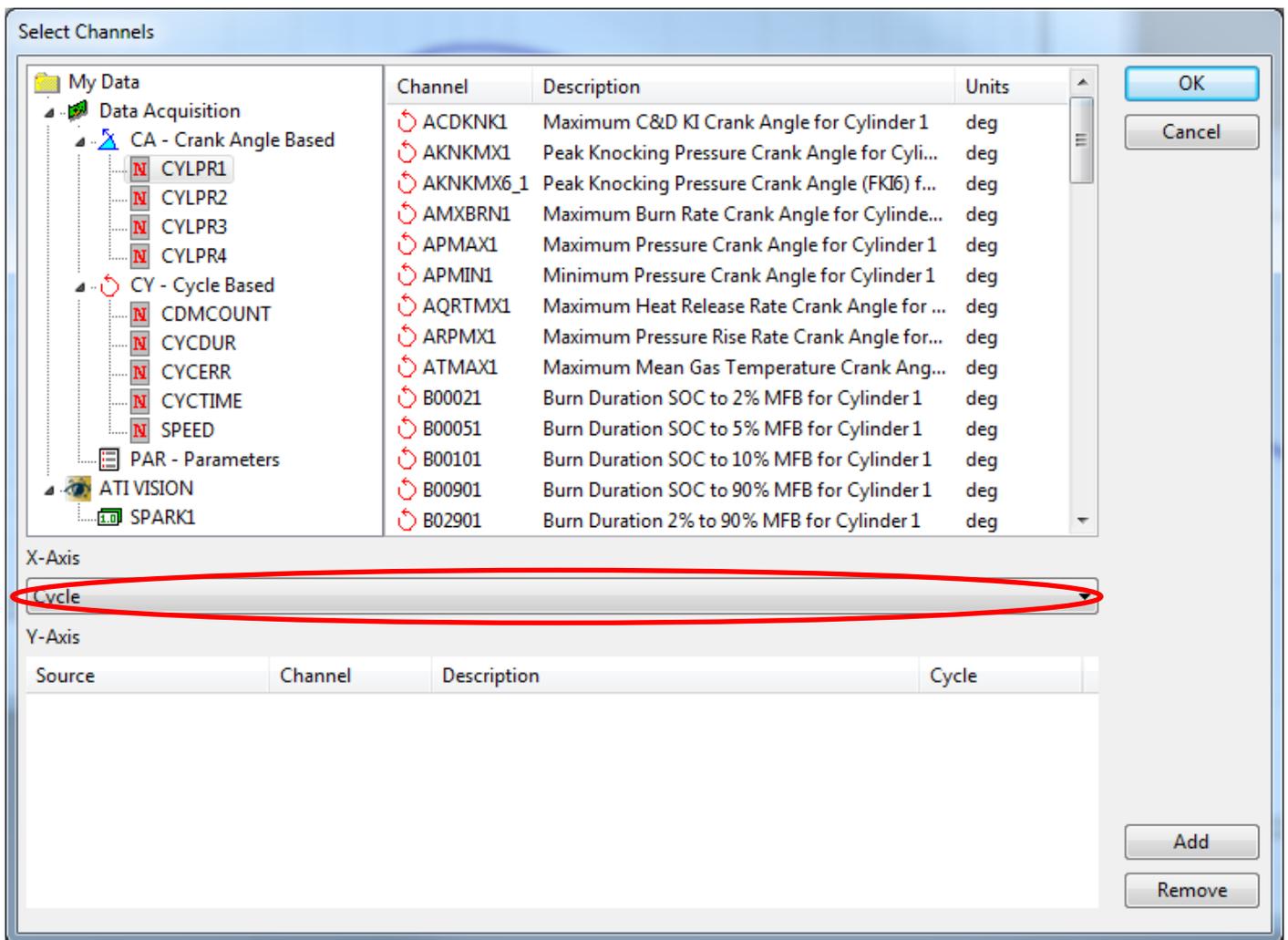
Figure 5.7: Select Channels

Change the X-Axis pull down menu to "Cycle". The list of available channels will be updated to the cycle based calculations for that channel.
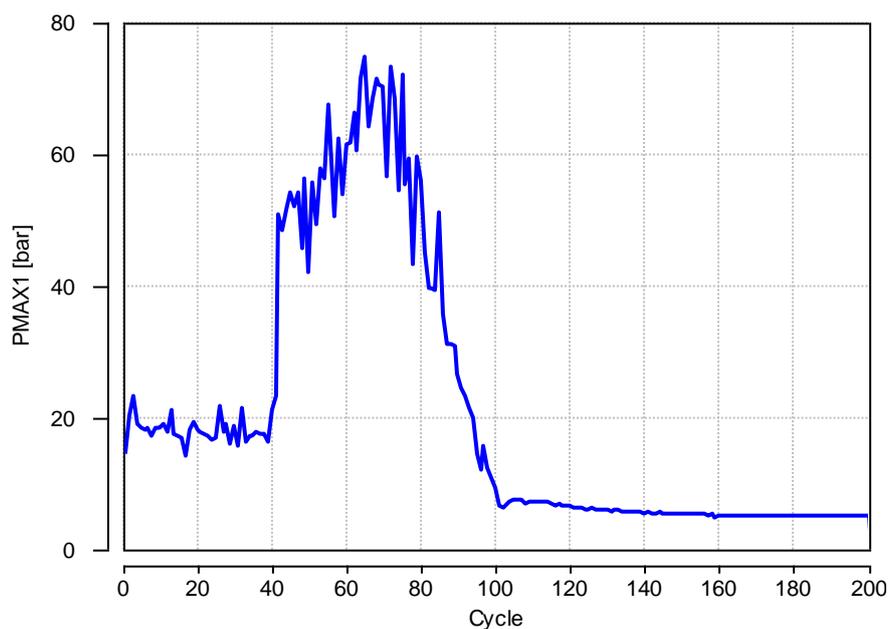
Figure 5.8: Cycle based calculation (PMAX) against cycle number

Plot cycle calculations against each other

As with the crank angle calculation you can right click on a calculation and select "Add Channel As X-Axis".
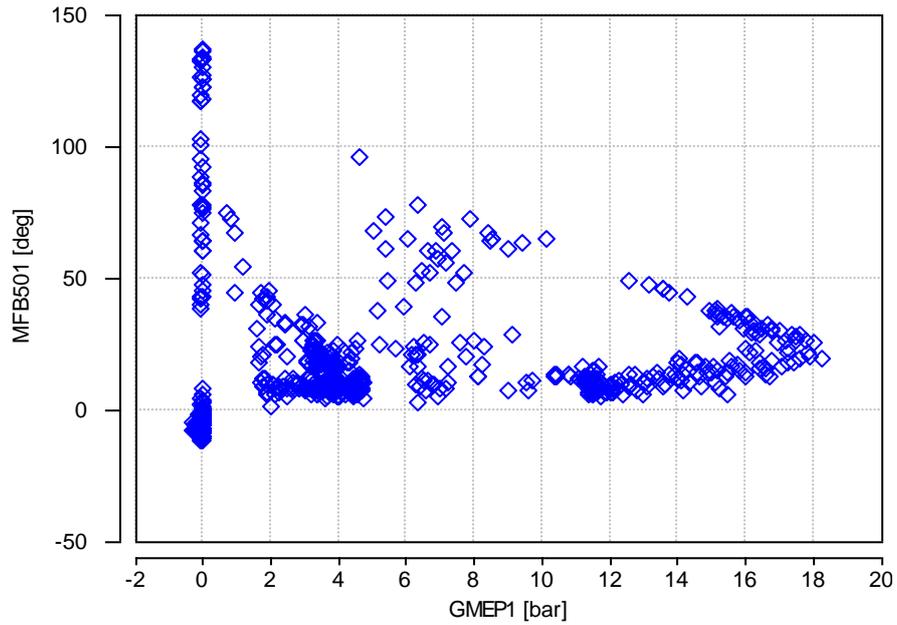
Figure 5.9: MFB50 plotted against GMEP

When plotting data from multiple cylinder you will want to select "Add Analysis Type As X-Axis". This ensures that the X-Axis data set used is from the same cylinder as the Y-Axis data set.
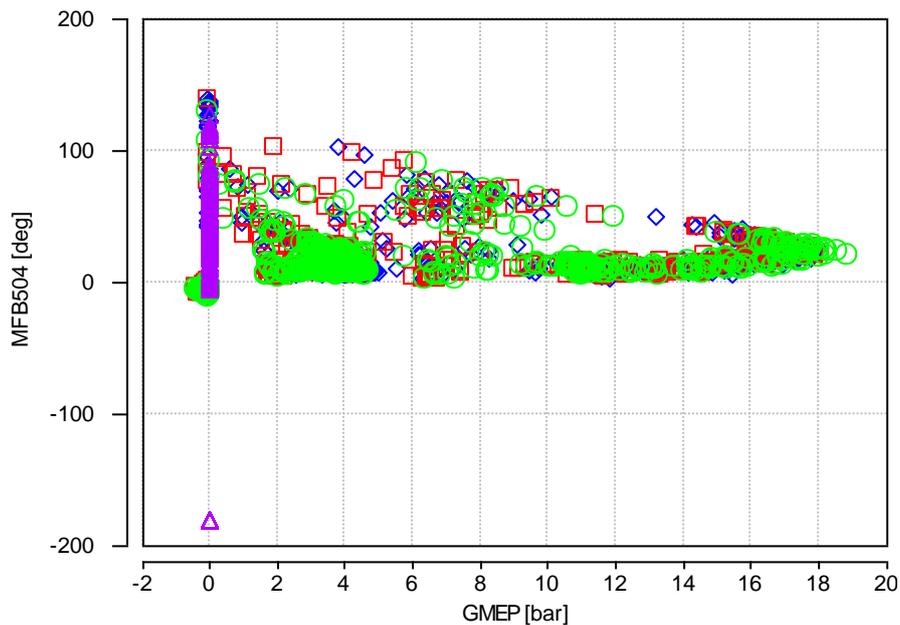
Figure 5.10: MFB50 plotted against GMEP for four cylinders

Navigating diagrams

Double click on diagram - rescales X and Y axis to include all available data

Click and drag on diagram – scrolls diagram whilst mouse button held down (Hand tool mode)

Click and drag on diagram – draws "zoom box" on diagram (Marquee zoom mode)

Click and drag on axis – zooms between start and end click points

Right click on diagram – opens the Diagram menu

In offline mode holding the cursor near a cycle data point will display the cycle number in the bottom status bar of the main catoolRT window. Clicking a data point will change the current selected channel to that cycle.

Diagram menu

Edit Diagram – returns to the "Select Channels" dialogue and allows channels to be added or removed.

Save Diagram – Export diagram as a bitmap or vector graphic

Print Diagram – Print diagram to printer

Copy Figure – Copies the diagram to clipboard as a graphic to paste into Word, etc.

Copy Data – Copies the numeric data of the diagram to the clipboard to paste into Excel, etc.

Reset Axes – rescales X and Y axis to include all available data, same as double-clicking on diagram

Rescale X-Axis – only rescales the X axis to include all available data

Rescale Y-Axis – only rescales the Y axis to include all available data

Rescale Y-Axis inc Zero – rescales the Y axis to include all available data and zero

Zoom X-Axis (-20 to 60) – rescales the X axis between -20 and 60 degrees

X-Axis Log – display the x-axis in a logarithmic scale

Y-Axis Log – display the y-axis in a logarithmic scale

Hand Tool – Sets the behaviour of clicking and dragging on the diagram. In this mode you can move around the diagram like Google Maps.

Marquee Zoom – Sets the behaviour of clicking and dragging on the diagram. In this mode you draw a rectangle of the area you want to zoom into.

Single Cursor – Adds a single cursor to read off data values along the X-Axis.

Twin Cursor – Adds two cursors to read off two data values along the X-Axis.

Format Diagram – Opens a dialogue where you can modify the appearance of the diagram

Rename Diagram – Opens a dialogue where you can edit the name of the diagram

Format Diagram
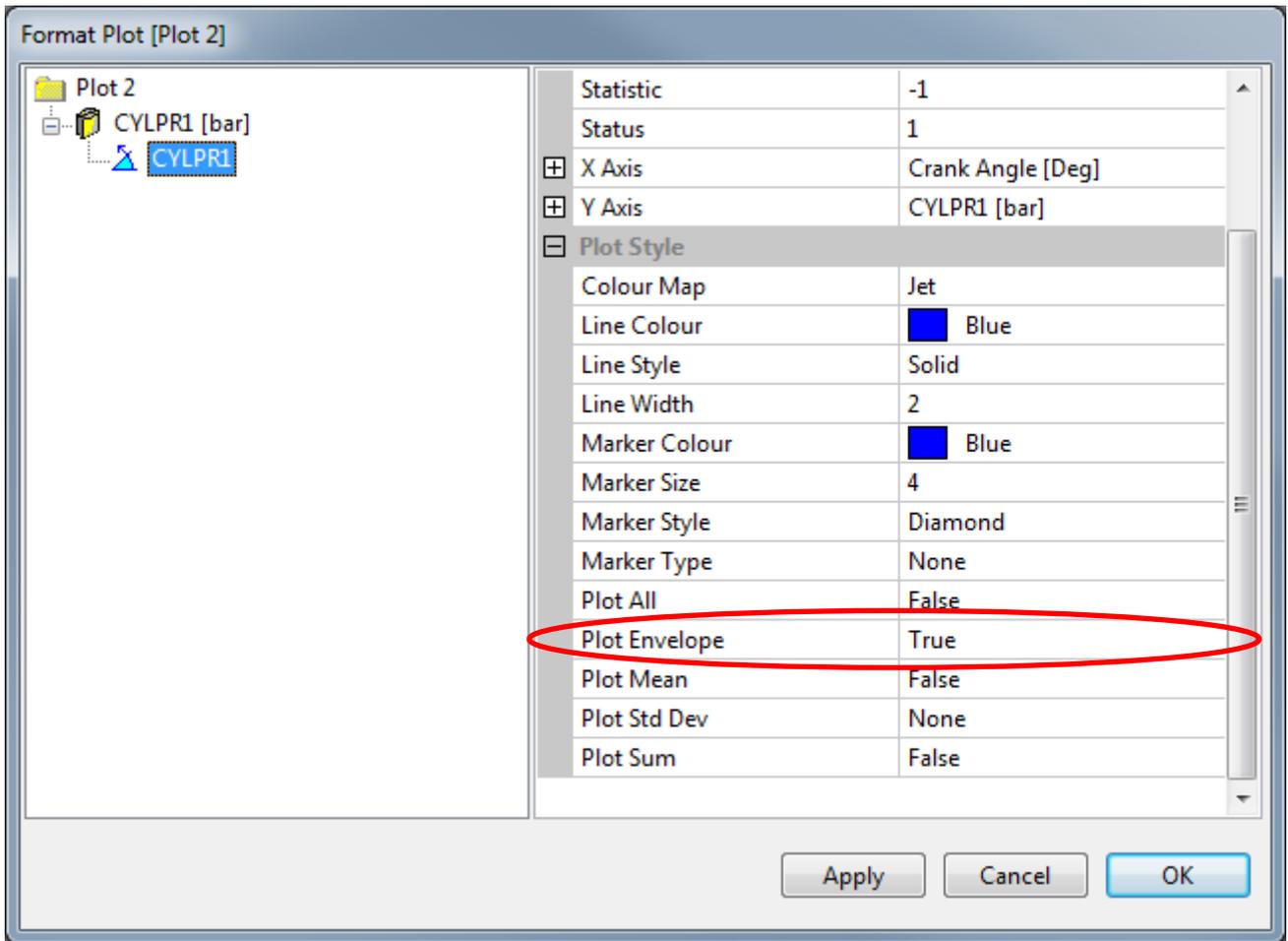
Figure 5.11: Format Diagram

In the "Format Diagram" dialogue you can change the style of how the diagram is drawn including colours and line styles.

For a crank angle based plot statistical information such as the mean, standard deviation and envelope can also be added.
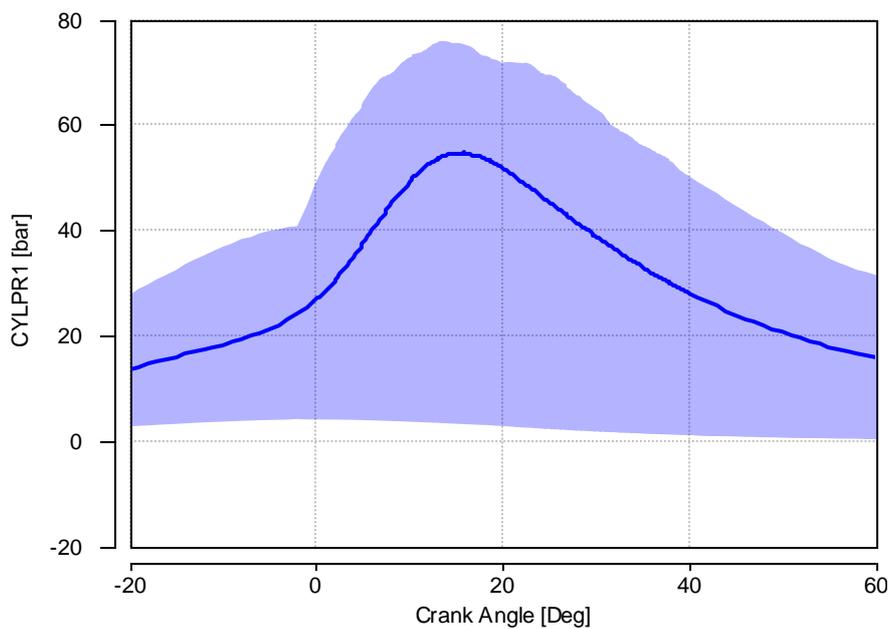

Figure 5.12: Crank angle plot with "Envelope" of all cycle data

Chapter 6: Knock Sensor Analysis

catoolRT can be used to indicate engine knock using either a cylinder pressure transducer or an engine mounted knock sensor. When fitted with both it can be used to tune the knock sensor location and to correlate to known in-cylinder knock pressure levels.

Ref: Brunt, M., Pond, C., and Biundo, J., "Gasoline Engine Knock Analysis using Cylinder Pressure Data," SAE Technical Paper 980896, 1998.
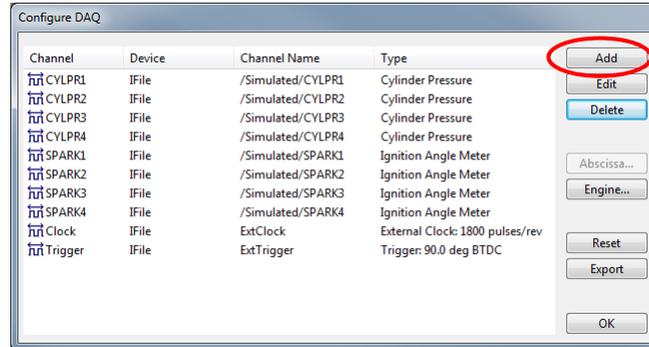
Figure 6.1: Configure DAQ

Firstly we need to add a new channel for the knock sensor. Select "Acquistion" -> "Configure DAQ". Then click on the "Add" button and select "DAQ Channel" and click "OK". Then give the new channel a name such as "KNKB1" and click "OK".
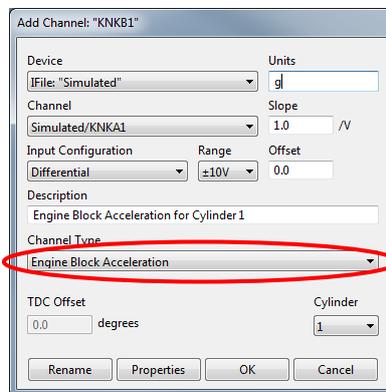
Figure 6.2: Add Channel

Change the "Channel Type" to "Engine Block Acceleration" and change the "Units" to g, "Offset" to zero and "Slope" to that appropriate for your sensor. Bosch generally publish information for their sensors with a typical value of 35 mV/g.

$$slope = \frac{1000}{35 \text{ (mV/g)}} = 28.57 \text{ } (g/V)$$
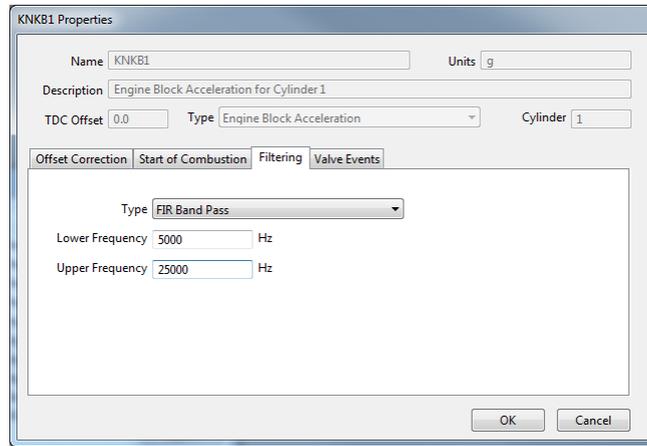
Figure 6.3: Channel Properties

Click on "Properties" and select the "Filtering" tab. Change the "Filter Type" to "FIR Band Pass" with a range of 5000 to 25000 Hz. The high pass aspect of the filter with remove any DC offset from the signal so it is centred around zero.
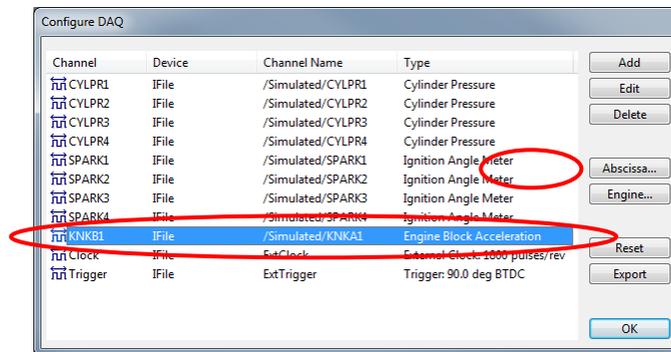
Figure 6.4: Configure DAQ

Click "OK" to return to the channel properties and "OK" to return to the "Configure DAQ" window. Select the new channel in the list and click "Abscissa…".
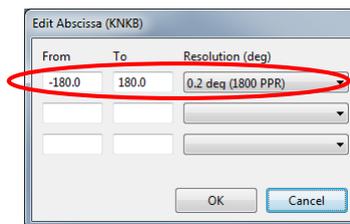
Figure 6.5: Abscissa Configuration

Change the resolution to the smallest available, i.e. 0.2 degrees and the angular range from -180 to +180 degrees.

Now would be a good time to go online and check the raw accelerometer signal.
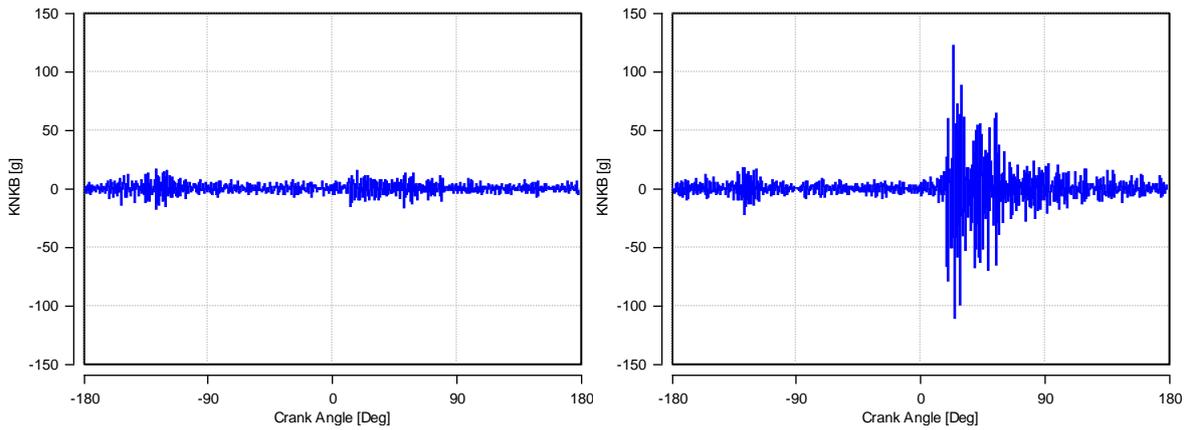
Figure 6.6: Raw Accelerometer Signals

This shows two cycles. No knock (left) and with knock (right). Examine data from a range of engine speed and load conditions to determine crank angle windows where knock does and does not occur. In this example knock occurs between 20 and 60 degrees ATDC and there is a quiet window at 20 and 60 degrees BTDC. This quiet window should be free from noise from other cylinders combustion and valvetrain closing events.
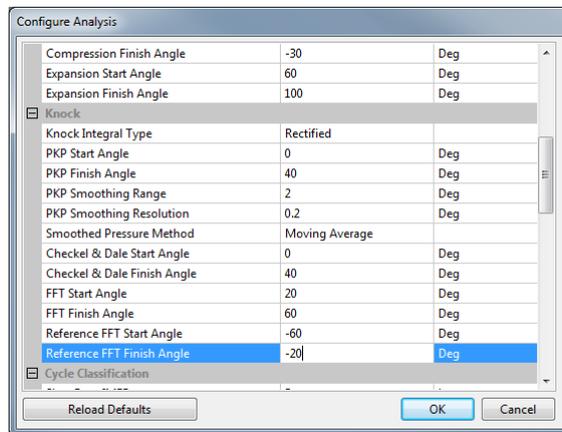
Figure 6.7: Configure Analysis

Select "Analysis" -> "Configure Analysis" and scroll to the "Knock" section. Configure the "FFT" and "Reference FFT" windows using the values determined above. These windows can also be used to calibrate your ECU knock control.
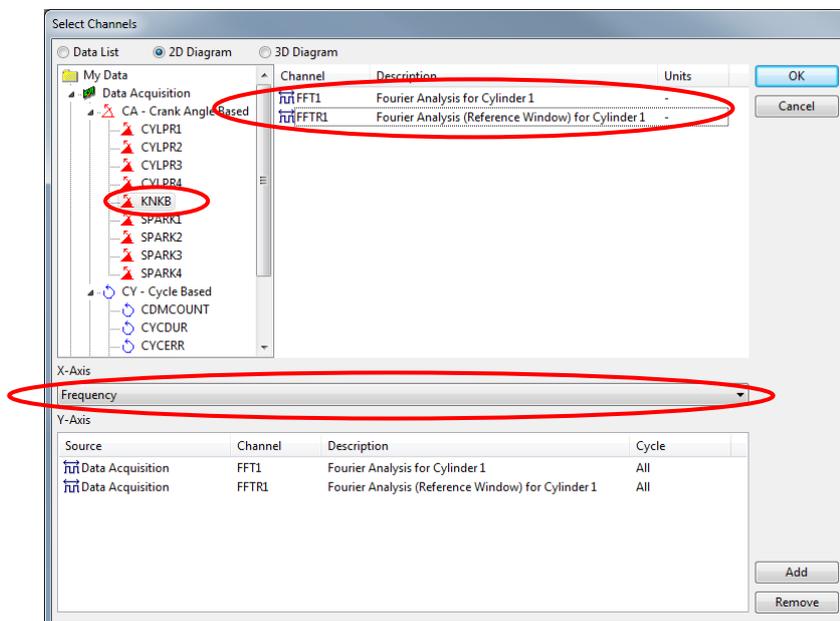
Figure 6.8: Select Channels

Now we can examine where in the frequency domain the primary knock mode occurs. The Fast Fourier Transformation (FFT) will show us which frequencies dominate the knock sensor signal. Add a new diagram (press F5), change the "X-Axis" to "Frequency" and select the knock sensor channel. Now select the FFT channel (double-click to add) and click "OK".
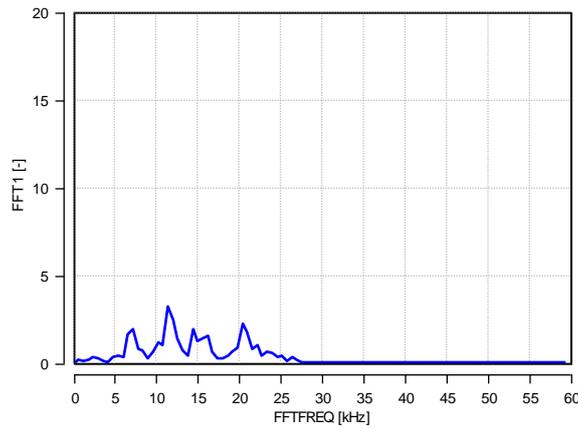
Figure 6.9: Fourier Analysis

You can see how the band pass filter is already removing frequencies below 5000 Hz and above 25000 Hz. Again, this will help you to characterise the centre frequency that your ECU knock control uses.
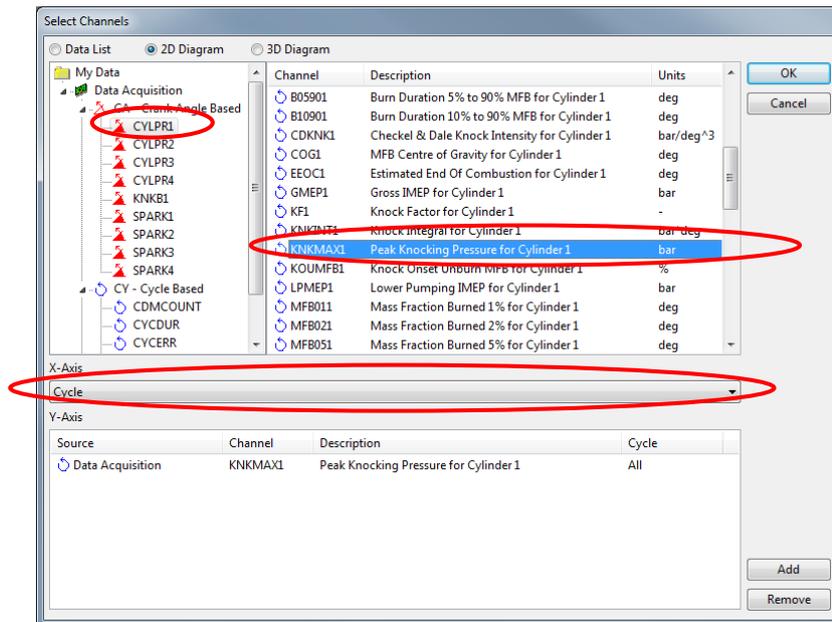
Figure 6.10: Select Channels

If you are acquiring both cylinder pressure and knock sensor channels you can use them together to verify how well the sensor and its location can detect knock. Add a new diagram and change the "X-Axis" to "Cycle". Select the cylinder pressure channel and add the KNKMAX analysis channel.
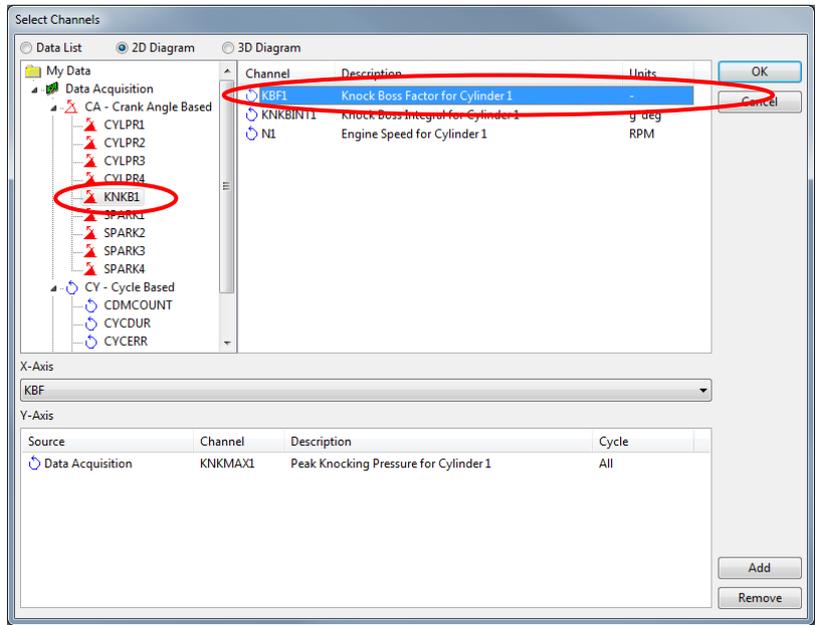
Figure 6.11: Select Channels

Now select the knock sensor channel and right-click your mouse on the KBF analysis channel. Select "Add Analysis Type as X-Axis" and click "OK".
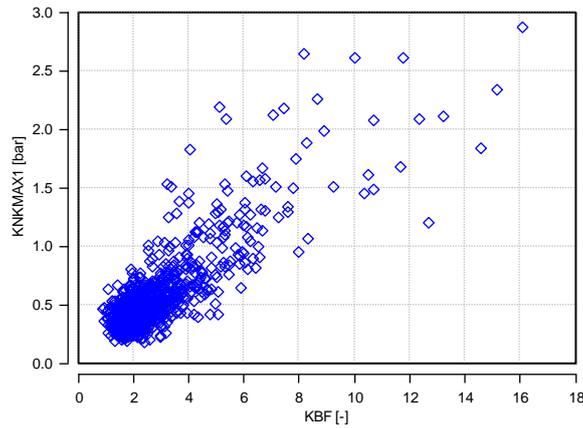
Figure 6.12: Knock sensor correlation to knocking pressure

You can now see the correlation between knock detected by the cylinder pressure transducer (KNKMAX) and knock detected by the knock sensor (KBF). This can help determine the detection threshold and gain used by the ECU knock control. It can also be used to determine if a particular location on an engine block is suitable for knock detection on a particular cylinder.

Chapter 7: TDC Determination

catoolRT includes a tool to ensure the data acquisition is synchronised to the engine timing.

Start the data acquisition and ensure the pressure trace is approximately centred around zero degrees:
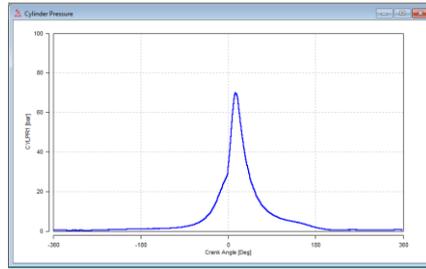
Figure 7.1: Cylinder Pressure

Open the tool by selecting "Acquisition" -> "TDC Determination" or pressing F9.

Change "Channel" to the one you are going to use for the determination.

If you are using a cylinder pressure then apparent TDC will occur slightly ahead of the actual TDC due to heat transfer and mass loss. This offset is called the Thermodynamic Loss Angle (TLA) and is approximately 0.7 degrees.

If TDC is measured using a proximity probe, i.e. AVL OT-SENSOR 428 or Kistler 2629C then set the TLA to zero degrees.
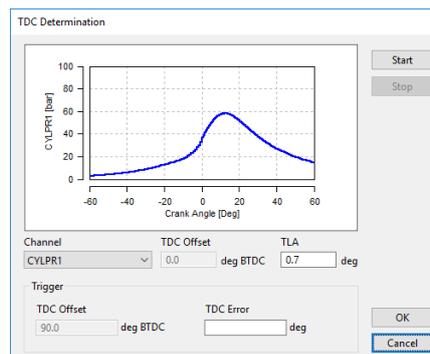
Figure 7.2: TDC Determination

Press "Start" to begin the determination.

Stop fuel injection either through a sufficient "throttle blip" to enter fuel cut or disable the cylinder's fuel injector. DO NOT DISCONNECT A DIESEL COMMON-RAIL PIEZO INJECTOR! Although Diesel engines do not cut fuel the minimum pulsewidth combustion should be sufficiently past TDC to determine the pressure curve symmetry.

Once sufficient engine cycles have passed and their standard deviation is low enough a "TDC Error" value will be determined.

Click "OK" to apply this to the TDC offset.

catoolRT can be used to acquire CAN based signals for each combustion cycle. It supports hardware from Vector, Kvaser and PEAK. It can also log from the virtual Vector or Kvaser CANbus.

To add a CAN channel select "Acquisition" -> "Configure DAQ" and click "Add".
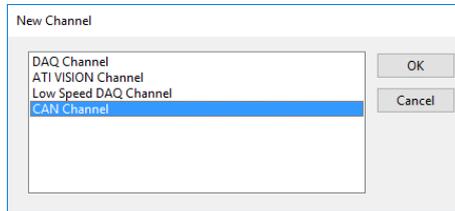
Figure 8.1: New Channel Type

Select "CAN Channel" and click "OK"
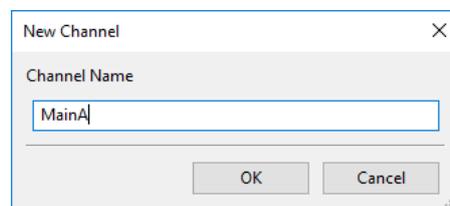
Figure 8.2: New Channel Name

Enter a unique channel name and click "OK"
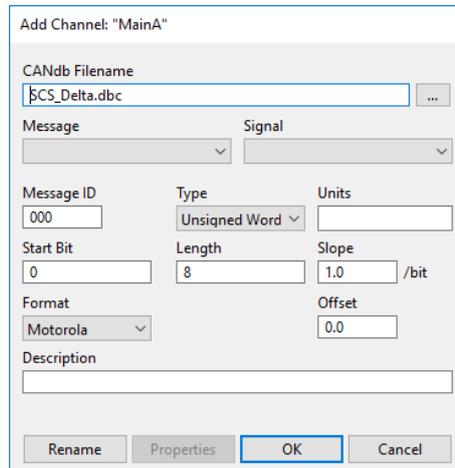
Figure 8.3: Add New Channel

CAN signals can be determined from a CANdb database file. Click the "..." button to browse for a database.

Once loaded you first select the CAN message and then CAN signal from the drop down menus. This will populate the reset of the configuration. Click "OK" to return.

If you need to create the CAN signal from scratch you can either enter the signal parameters in the window or generate a CANdb database. Kvaser make a database editor freely available at https://www.kvaser.com/downloads/.

Note that "Start Bit" numbering differs between the Vector CANdb++ tool, the Kvaser Database editor and the CANdb file format itself. catoolRT refers to the start bit in the same manner as the CANdb file format, i.e. the MSB counted from the start of the message data.

Bit Number

Data Byte Number	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Byte 0	7	6	5	4	3	2	1	0
Byte 1	15	14	13	12	11	10	9	8
Byte 2	23	22	21	20 (LSB)	19	18	17	16
Byte 3	31	30	29	28	27 (MSB)	26	25	24
Byte 4	39	38	37	36	35	34	33	32
Byte 5	47	46	45	44	43	42	41	40
Byte 6	55	54	53	52	51	50	49	48
Byte 7	63	62	61	60	59	58	57	56

Data begins at the least significant bit and starts at 20

Data is writen up to the most significant bit and ends at 27

Figure 8.4: Little Endian Bit Numbering

Bit Number

Data Byte Number	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Byte 0	7	6	5	4	3	2	1	0
Byte 1	15	14	13	12	11 (MSB)	10	9	8
Byte 2	23	22	21	20 (LSB)	19	18	17	16
Byte 3	31	30	29	28	27	26	25	24
Byte 4	39	38	37	36	35	34	33	32
Byte 5	47	46	45	44	43	42	41	40
Byte 6	55	54	53	52	51	50	49	48
Byte 7	63	62	61	60	59	58	57	56

Data is writen up to the most significant bit and ends at 11

Data begins at the least significant bit and starts at 20

Figure 8.5: Big Endian Bit Numbering

Chapter 9: Dongle Installation

Thank you for your purchase of catoolRT and a floating "dongle" licence. This will allow you to install catoolRT on a number of PCs and use one at a time with the supplied USB dongle.

In addition to the USB dongle you will also have been provided with a licence key file.

Upon loading catoolRT for the first time you will activate the "Update Licence" wizard. If you are already running a trial version you will need to select "Help" -> "Update Licence…"
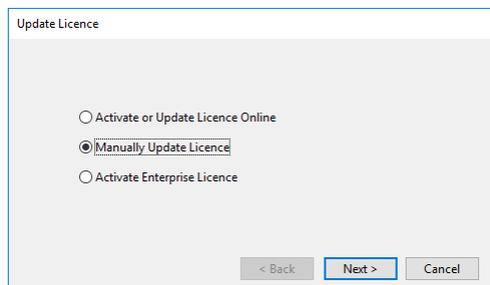
Figure 9.1: Update Licence

Change to "Manually Update Licence" and click "Next >"
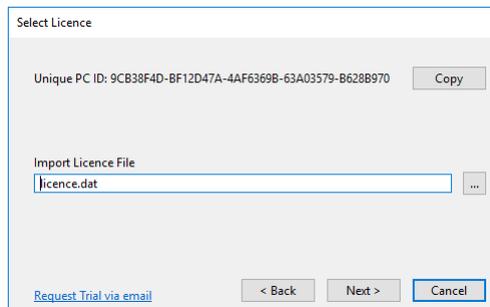
Figure 9.2: Select Licence

Use the "…" button to browse for the supplied dongle licence.dat file and click "Next >".
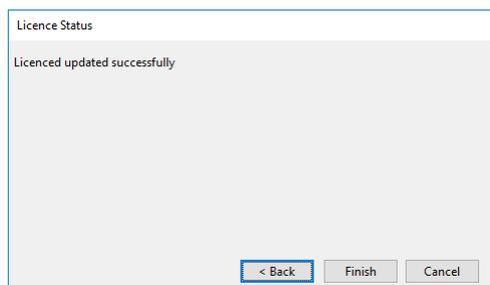
Figure 9.3: Licence Status

Insert the USB dongle into any available port. Device drivers are not required. Click "Finish".

Appendix A: catoolRT Remote Control

CAN based AK protocol support

Example control:

Send	7F0	05					Enable remote control
Receive	7F8	05	00				Remote control active
Send	7F0	07					Set acquisition online
Receive	7F8	00					Acquisition online (although not necessarily synced)
Send	7F0	08					Start recording
Receive	7F8	00					Recording started
Send	7F0	01					Get cycles recorded
Receive	7F8	01	00	64	00	00	00
							100 cycles recorded
Send	7F0	01					Get cycles recorded
Receive	7F8	01	01				Recording finished

ACYC – Number of cycles recorded

Send: 01

Receive: 01   00   AA   BB   CC   DD

Where:

      AA = Number of cycles recorded (LSB)

      BB = Number of cycles recorded

      CC = Number of cycles recorded

      DD = Number of cycles recorded (MSB)

Example: 01   00   09   01   00   00

Means 265 cycles have been recorded

Error codes:

      01   Currently not recording
      02   Offline

ASTZ – Get measurement state

Send: 02

Receive: 02   00   AA   BB

Where:

      AA = Remote State (0 = Off, 1 = On)

      BB = Run State (1 = Stopped, 3 = Recording, 4 = Online)

Example: 02   00   01   04

Means remote control is active and acquisition is online but not recording

Error codes:

      None

AVER – Actual Version Number

Send: 03

Receive: 03   00   AA   BB   CC   DD   EE   FF

Where

      AA = Major Version Number

      BB = Minor Version Number

      CC = Revision Number LSB

      DD = Revision Number MSB

      EE = Build Number LSB

      FF = Build Number MSB

Example: 03   00   0F   06   EC   02   6C   03

Means catoolRT version 15.6.748.876

Error codes:

      None

ASTF – Error Status

Send: 04

Receive: 04   AA   BB

Where:

      AA = Error count

      BB = Last Error

This resets the error count and last error to zero, so a subsequent request always returns 04 00 00.

Example: 04   02   01

Means there have been two errors the last of which was error code 01 (Data Error)

SREM – Set to remote control

Send: 05

Receive: 05 00

Sets acquisition to remote control mode.

Error codes:

    None

SMAN – Set to manual control

Send: 06

Receive: 06   00

Sets acquisition to manual mode

Error codes:

        None

SMON – Turn acquisition online

Send: 07

Receive: 07   00

Sets acquisition online

Error codes:

    01   Already online
    02   Not in remote control mode (send SREM command first)
    03   Could not go online

SMES – Start recording

Send: 08

Receive: 08   00

Start acquisition recording. If the acquisition is not online it will be set online first.

Error codes:

01   Could not go online
02   Not in remote control mode (send SREM command first) or could not go online
03   Already recording or could not start recording

STBY – Go Offline

Send: 09

Receive: 09 00

Go offline

Error codes:

      01   Could not go offline

      02   Not in remote control mode (send SREM command first)

      03   Currently recording

      04   Not online

SSTP – Stop Recording

Send: 0A

Receive: 0A   00

Stop recording

Error codes:

      02   Not in remote control mode (send SREM command first)

      03   Could not stop recording

      04   Not online or not recording

ESPC – Configure cycles to record

Send: 0B   AA   BB   CC   DD

Receive: 0B   00

Where:

AA = Number of cycles to record (LSB)

BB = Number of cycles to record

CC = Number of cycles to record

DD = Number of cycles to record (MSB)

Error codes:

02   Not in remote control mode (send SREM command first)

03   Currently recording

04   Number of cycles invalid

EDBG – Force response

Send: 0C

Receive: 0C   00

This always provides a response without risk of error or interrupting acquisition. Can be used to periodically check catoolRT is operational.

Error codes:

        None