catoolRT 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.

Configure DAQ				
Channel	Device	Channel Name	Туре	Add
沅 CYLPR1	IFile IFile IFile IFile IFile	/Simulated/CYLPR1 /Simulated/CYLPR2 /Simulated/CYLPR3 /Simulated/CYLPR4 /Simulated/SPARK1	Cylinder Pressure Cylinder Pressure Cylinder Pressure Cylinder Pressure Ignition Angle Meter	Edit Delete
武SPARK2 듔SPARK3 듔SPARK4 즀Clock 듔Trigger	IFile IFile IFile IFile IFile	/Simulated/SPARK2 /Simulated/SPARK3 /Simulated/SPARK4 ExtClock ExtTrigger	Ignition Angle Meter Ignition Angle Meter Ignition Angle Meter External Clock: 1800 pulses/rev Trigger: 90.0 deg BTDC	Engine
				Export OK

Firstly we need to add a new channel for the knock sensor. Select "Acquisition" -> "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".

Add Channel: "KNKB1"	
Device [IFile: "Simulated" Channel Simulated/KNKA1	Units gl Slope 1.0 /V
Input Configuration Range Differential Description Engine Block Acceleration for Cylinder 1 Channel Type	Offset 0.0
Engine Block Acceleration	_
TDC Offset 0.0 degrees	Cylinder
Rename Properties OK	Cancel

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.

$$slope = \frac{1000}{35 \text{ (mV/g)}} = 28.57 \text{ (}g/V\text{)}$$

KNKB1 Propertie	s						
Name	Name KNKB1 Units g						
Description	Engine	Block Accele	eration for Cyl	inder 1			
TDC Offset	0.0	Туре	Engine Block	Acceleration	٦	Cylind	er 1
Offset Correct	tion St	art of Combu	istion Filterii	1g Valve Events			
	Туре	FIR Band Pa	ss		•		
Lower Fre	quency	5000	Hz				
Upper Fre	equency	25000	Hz				
						ОК	Cancel

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.

Configure DAQ				
Channel	Device	Channel Name	Туре	Add
₩ CYLPR1	IFile	/Simulated/CYLPR1	Cylinder Pressure	Edit
तित CYLPR2	IFile	/Simulated/CYLPR2	Cylinder Pressure	
TTT CYLPR3	IFile	/Simulated/CYLPR3	Cylinder Pressure	Delete
5 Tri CYLPR4	IFile	/Simulated/CYLPR4	Cylinder Pressure	
5 SPARK1	IFile	/Simulated/SPARK1	Ignition Angle Meter	Abasias
5 SPARK2	IFile	/Simulated/SPARK2	Ignition Angle Meter	Abscissa
5 SPARK3	IFile	/Simulated/SPARK3	Ignition Angle Meter	Engine
₩ SPARK4	TEile	/Simulated/SP ARK4	Ignition Angle Motor	
TIT KNKB1	IFile	/Simulated/KNKA1	Engine Block Acceleration	
ní Clock	100	EvtClock	External Clock 1880 pulses/rev	Reset
, Trigger	IFile	ExtTrigger	Trigger: 90.0 deg BTDC	Export
				OK

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...".

Edit Absciss	a (KNKB)	
From	То	Resolution (dog)
-180.0	180.0	0.2 deg (1800 PPR)
		-
		OK Cancel
		Cancel

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.

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.

Compression Finish Angle	-30	Deg	-
Expansion Start Angle	60	Deg	
Expansion Finish Angle	100	Deg	
E Knock			
Knock Integral Type	Rectified		
PKP Start Angle	0	Deg	
PKP Finish Angle	40	Deg	:
PKP Smoothing Range	2	Deg	
PKP Smoothing Resolution	0.2	Deg	_
Smoothed Pressure Method	Moving Average		
Checkel & Dale Start Angle	0	Deg	
Checkel & Dale Finish Angle	40	Deg	
FFT Start Angle	20	Deg	
FFT Finish Angle	60	Deg	
Reference FFT Start Angle	-60	Deg	
Reference FFT Finish Angle	-20	Deg	
Cycle Classification			

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.

	gram 🔘 3D D	hagram		
My Data My Data CA - Crank Ang CYLPR1 CYLPR2 CYLPR2 CYLPR3 CYLPR3 CYLPR3 CYLPR4 SPARK4 SPARK4 CY-Cycle Bark4 CYL-Cycle Bark4 CY-Cycle Cyclere CYCUR4 CY	Cha le cased Triff	annel Description FFI Fourier Analysis for Cylinder 1 FFIRI Fourier Analysis (Reference Window) for Cyli	Units - nder1 -	OK Canc
X-Axis Frequency				
Source	Channel	Description	Cycle	
Data Acquisition	EET1	Fourier Analysis for Cylinder 1	All	
	FFTR1	Fourier Analysis (Reference Window) for Cylinder 1	All	
近 Data Acquisition				

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".



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.



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.

Select Channels				
💿 Data List 🛛 💿 2D Diag	ram 💿 3D Dia	igram		
🛄 My Data	Char	nel Description	Units	ОК
Data Acquisition		BF1 Knock Boss Factor for Cylinder 1	-	Cancel
C - Crank Angle CYUPR1 CYUPR3 CYUPR3 CYUPR3 CYUPR3 CYUPR3 CYUPR3 SPARK1 SPARK1 SPARK4 O CY - Cycle Based O CY - Cycle Based O CYCDUR O CYCERR		NKBUYTI Knock Boo Integral for Cylinder 1 1 Engine Speed for Cylinder 1	g deg RPM	Cancer
X-Axis				_
KBF			•	J
Y-Axis				
Source	Channel	Description	Cycle	
🖒 Data Acquisition	KNKMAX1	Peak Knocking Pressure for Cylinder 1	All	
				Add
·				nemove

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".



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.