Vi-PEC

versatile intelligent performance engine control

Knock Amplifier and Digital Interface

Installation and Configuration Manual

vi-pec.com

Made in NZ

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1 Introduction

Vi-PEC's ViPEC Knock Amplifier has been designed as a knock tuning tool as well as a knock control interface. This flexibility allows the ViPEC Knock Amplifier to be used as a tuning tool for every day workshop and dyno use, as well as a permanently installed knock controller.

Knock Control Interface

The ViPEC Knock Amplifier can act as knock detection interface for Vi-PEC VX ECUs. The ViPEC Knock Amplifier connects directly with the knock sensor and provides the ECU with an accurate measurement of engine knock. The VX ECU can then be configured for closed loop knock control, allowing the ignition timing to be advanced and retarded to maintain output power while protecting the engine.

Additionally, the supplied knock light can be mounted on the dash to provide the driver with a visible warning in the event of engine knock.

Knock Tuning Tool

The ViPEC Knock Amplifier can be used as a knock tuning tool. Connected to a correctly positioned knock sensor the ViPEC Knock Amplifier will provide a clear audio output with a crisp distinction between normal engine sounds and knock. This will allow the tuner to safely optimise ignition timing and mixtures when tuning an engine.

Key Features

- Two knock sensor inputs.
- High power, low distortion audio output.
- ANC (active noise cancellation) detection mode.
- 40MHz digital signal micro-processor.
- Analogue 0V to 5V output for interfacing to a dyno, gauge or engine management system.
- Digital window input/output for interfacing to Vi-PEC VX ECUs.
- External knock indication LED.
- Fifteen user selectable digital filters.
- Selectable digital detection gain from 1 to 64.
- Internal 9V battery compartment for quick setup.
- Low power mode for extended battery life (audio only).

Specifications

- 120mm x 80mm x 25mm.
- 8V to 18V supply input range.
- 160g with 9V Battery.

2 Installation

The ViPEC Knock Amplifier can be installed as a knock control interface, a knock indicator or a knock tuning tool. Example installation topologies are provided.

Vi-PEC VX Interface

This topology interfaces to the VX range of ECUs. The ECU must have one available Auxiliary channel and one Digital Input. This topology offers the best performance in terms of knock control because of the window interface allowing detection of knock per cylinder. With this topology an after market knock gauge, data logger or dyno can be connected to the 0-5V output and the supplied Knock Light can be connected to the LED output. The headphones can be optionally connected when tuning. One or two knock sensors can be connected.

Notes

- The pull-up resistor on the DI channel used must be DISABLED.
- The auxiliary channel providing the window must be set to active LOW.

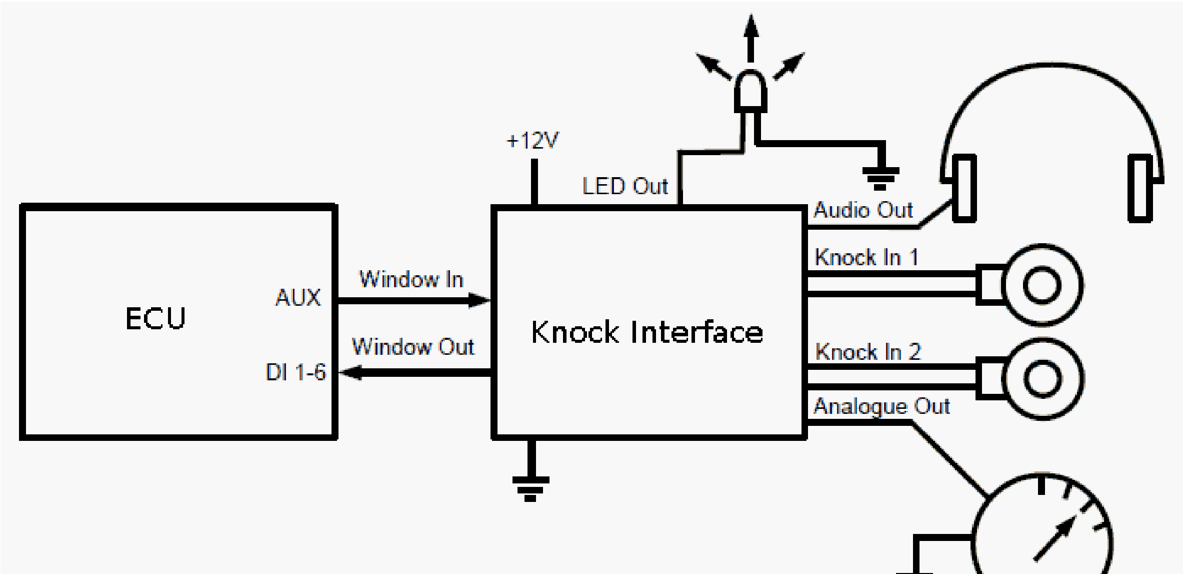


Figure 1 - Full Installation

Standalone Installation

The standalone installation is used for detection and driver feedback. There is no ECU interface for knock control. The headphones can be optionally connected when tuning. Optionally one or two knock sensors can be connected.

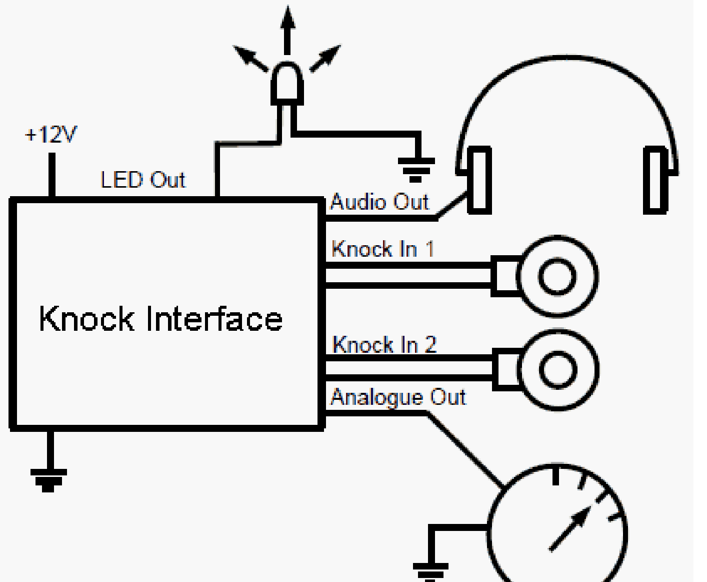


Figure 3 – Standalone

Quick Install

The quick installation topology has been designed to reduce setup times in a workshop environment. The quick installation topology uses an internal 9V battery to reduce the time in connecting up a power and ground. The quick installation is for audio only, it is recommended that the device is configured to run in low power mode to conserve battery life. Optionally one or two knock sensors can be connected.

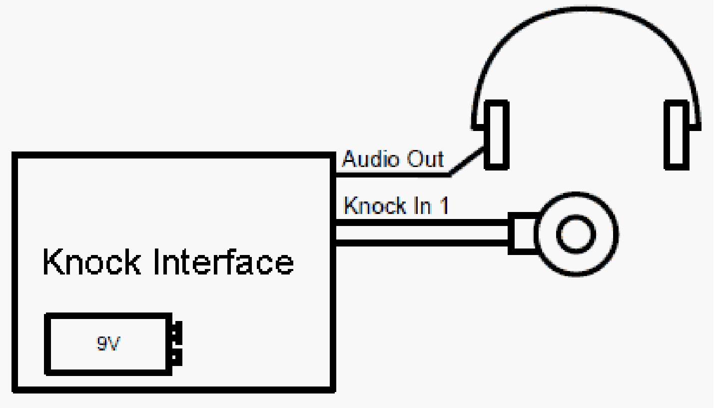
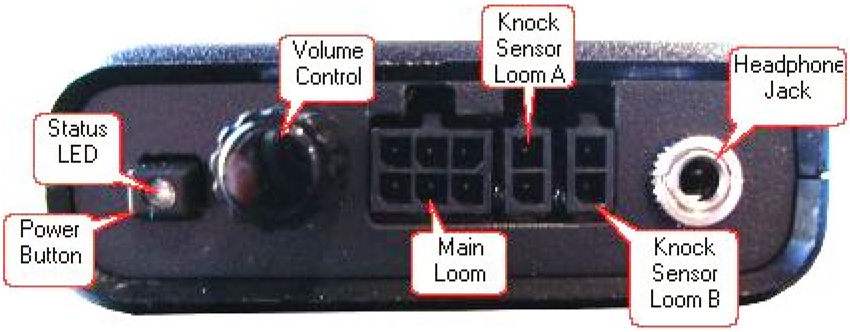


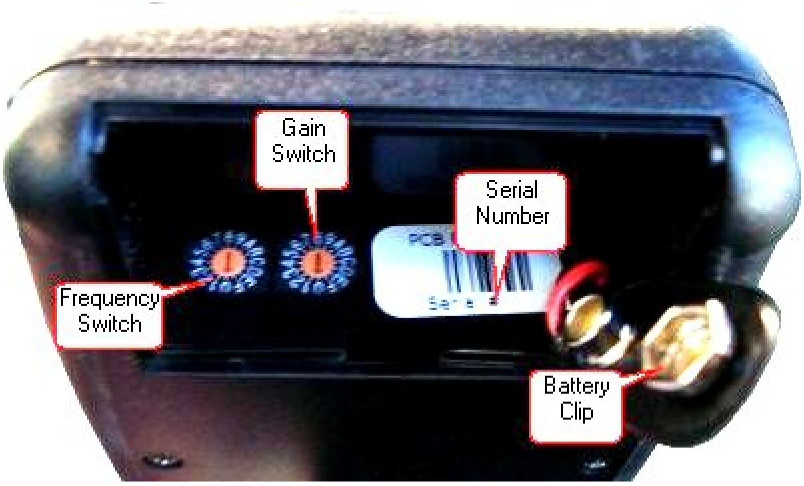
Figure 4 – Quick Install Tuning Setup

2.1 Overview

The following images show the ViPEC Knock Amplifier's key connections and settings.

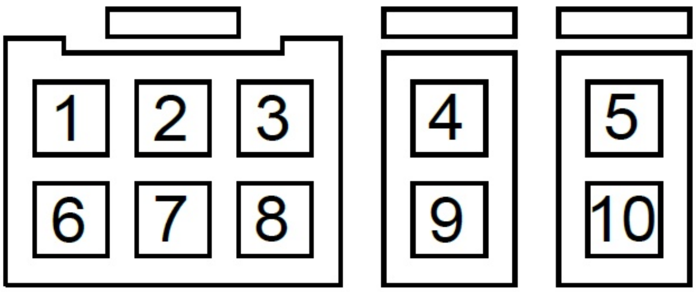


Front View



Under Battery Cover View

2.2 Pinouts



(Looking into ViPEC Knock Amplifier)

Pin Number	Wire Colour	Pin Description	Typical Connection
1	Red	+14V	Main Relay +14V
2	Orange	Window In	VX ECU Auxiliary Channel
3	White	0V-5V Out	ECU Analogue Channel or Gauge Input
4	White (Shielded)	Knock Signal 1	Knock Sensor Signal Terminal
5	White (Shielded)	Knock Signal 2	Knock Sensor Signal Terminal
6	Black	Ground	Ground
7	Grey	Window Out	VX ECU Digital Input
8	Blue	External LED	Red wire on supplied LED
9	Black (Shielded)	Knock Ground 1	Knock Sensor Ground Terminal
10	Black (Shielded)	Knock Ground 2	Knock Sensor Ground Terminal

2.3 Knock Light Mounting

The ViPEC Knock Amplifier is provided with a plastic clip used for mounting the device. Peal the adhesive protector off the bottom of the clip to mount it to any clean dry surface. For extra support a mounting screw can be used.

Once the clip has been mounted, clip the Knock Light into it by squeezing the loop into the base. The Knock Light will fit firmly in the mount.

Alternatively the tube can be threaded off the bezel and discarded. The bezel can then be dash mounted by drilling a hole and threading in the bezel into the dashboard.

Wiring Notes

- Connect the red wire on the knock light to the blue wire on the ViPEC Knock Amplifier.
- Connect the black wire on the knock light the the black wire on the ViPEC Knock Amplifier.

NOTICE

The knock light is provided as a visual warning of medium to heavy detonation only.

- The knock light's detection ability is based on correct gain and frequency settings.
- The knock light will not definitively show every knock event. See Chapter 4 – External LED Operation

WARNING

The knock light can only be used the with ViPEC Knock Amplifier.

The knock light will be permanently damaged if wired to any other device.

2.4 Test Mode

A special test mode has been provided, this allows you to check that the ViPEC Knock Amplifier is receiving the knock window signal from the ECU. To put the device into test mode set both switches to '**F**'. The knock LED will flash in time with the received window signal.

- If you are not seeing the knock LED flashing:

  - Check the connections between the ViPEC Knock Amplifier and the ECU.

  - Check the connections between the ViPEC Knock Amplifier and the knock LED.

3 Configuration

The performance of the devices relies heavily on correct configuration. There are two key parameters that need to be configured; gain and filter response.

3.1 Gain Configuration

It is recommended that the gain is set with the filtering disabled (position 0). Noise cancellation must be disabled during this process. Free rev the engine to approximately 3500rpm. Using a multimeter, measure the voltage on the Analogue Output wire. Adjust the switch position (noise cancelling disabled only) until approximately 1-2V is present on the output.

Switch Position	Gain	Noise Cancellation
0	Gain = 0 Low Power Mode *	No
1	Gain = 1	No
2	Gain = 2	No
3	Gain = 4	No
4	Gain = 8	No
5	Gain = 16	No
6	Gain = 32	No
7	Gain = 64	No
8	Gain = 1	Yes
9	Gain = 2	Yes
A	Gain = 4	Yes
B	Gain = 8	Yes
C	Gain = 16	Yes
D	Gain = 32	Yes
E	Gain = 64	Yes
F	Reserved	No

* Processing is halted to save power

Active Noise Cancellation

Active noise cancellation is a special algorithm that calculates the current ambient engine noise. The N/A then removes the engine noise from the output signal.

- Active noise cancellation is only applied to the Analogue voltage output.
- Active noise cancellation can be applied after correctly setting the gain. To do this, find

the switch position that gives the same gain but with noise cancellation enabled. E.g., If your gain was configured as switch position '3', to turn noise cancellation on you would set the switch position to 'A'

3.2 Frequency Configuration

The ViPEC Knock Amplifier provides several filters to assist in the accurate detection of engine knock. Selecting the correct filter can prove difficult.

There are three methods of determining the correct knock filter setting:

Calculation Technique

This method provides an estimated frequency based on piston diameter, ideally this method should be used in conjunction with either of the following two.

Measurement Technique

This method provides the most accurate measurement of frequency and can be used independently of any other technique.

Practical Technique

This method uses existing information on engine knock frequency, and adjusting the knock filter to achieve best performance.

Once the knock frequency is determined, the correct filter must be selected. Select the narrow band filter with the closest FC to the knock frequency. The knock frequency must be above FL and below FU. Figure 4 provides a graphical representation of the definitions of FL, FC and FU.

Wide band filters are provided for situations where the frequency is unknown. The narrow band filters always provide superior detection performance, but in somes applications wide band filters may be adequate. The 4kHz to 10kHz wide band filter can be used with all after market knock sensors. The 10kHz to 16kHz wide band filter is provided for 2nd harmonic detection, this is only recommended for advanced users where it has been confirmed that the sensor is of the tuned 2nd harmonic type .

The following table shows the switch position required for each filter.

Switch Position	Filter Description	FL	FC	FU
0	Filtering Disabled	N/A	N/A	N/A
1	4kHz to 10kHz wide band filter	4kHz	7kHz	10kHz
2	10kHz to 16kHz wide band filter	10kHz	13kHz	16kHz
3	4kHz narrow band filter	3kHz	4kHz	5kHz
4	5kHz narrow band filter	4kHz	5kHz	6kHz
5	6kHz narrow band filter	5kHz	6kHz	7kHz
6	7kHz narrow band filter	6kHz	7kHz	8kHz
7	8kHz narrow band filter	7kHz	8kHz	9kHz
8	9kHz narrow band filter	8kHz	9kHz	10kHz
9	10kHz narrow band filter	9kHz	10kHz	11kHz
A	11kHz narrow band filter	10kHz	11kHz	12kHz
B	12kHz narrow band filter	11kHz	12kHz	13kHz
C	13kHz narrow band filter	12kHz	13kHz	14kHz
D	14kHz narrow band filter	13kHz	14kHz	15kHz
E	15kHz narrow band filter	14kHz	15kHz	16kHz
F	16kHz narrow band filter	15kHz	16kHz	17kHz

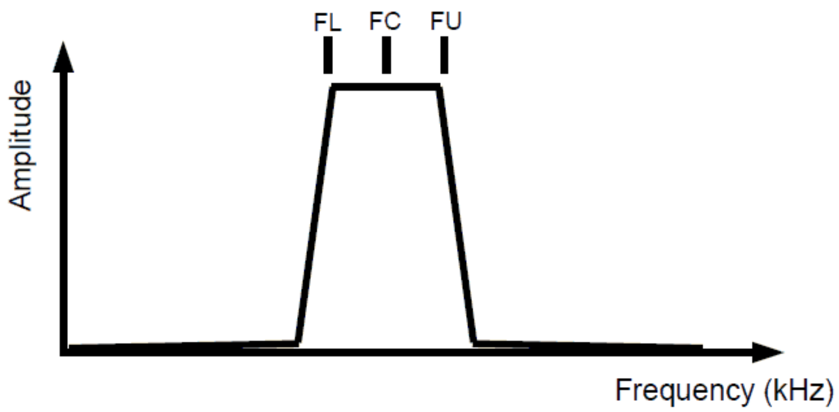


Figure 4 – Frequency Response

3.2.1 Calculation Technique

The knock frequency can be estimated by calculation. There are other factors affecting the knock frequency but this equation provides a general guide:

Knock Resonant Frequency *kHz* = 1800 / (3.14 * piston diameter *mm*)

Avoid using this equation on late model cars, as they often have 2nd harmonic tuned knock sensors. To find the 2nd harmonic, use the following equation:

2nd Harmonic Knock Resonant Frequency *kHz* = 3600 / (3.14 * piston diameter *mm*)

It is recommended that the calculated frequency is checked using the measurement technique.

3.2.2 Measurement Technique

The MOST accurate method of determining the correct knock frequency is to measure it. This can be done by using a doubled ended 3.5mm stereo audio cable connected from the audio output of the ViPEC Knock Amplifier to the microphone input of the PC. Vi-PEC recommends the use of WavePad Sound Editor by NCH Software for the frequency measurement, this can be downloaded from their website at http://www.nch.com.au/wavepad .

Note: It is recommended that a high quality sound card is used. Results may not be as obvious with a low end sound card.

It is important to note that with this method, knock must occur for accurate measurement.

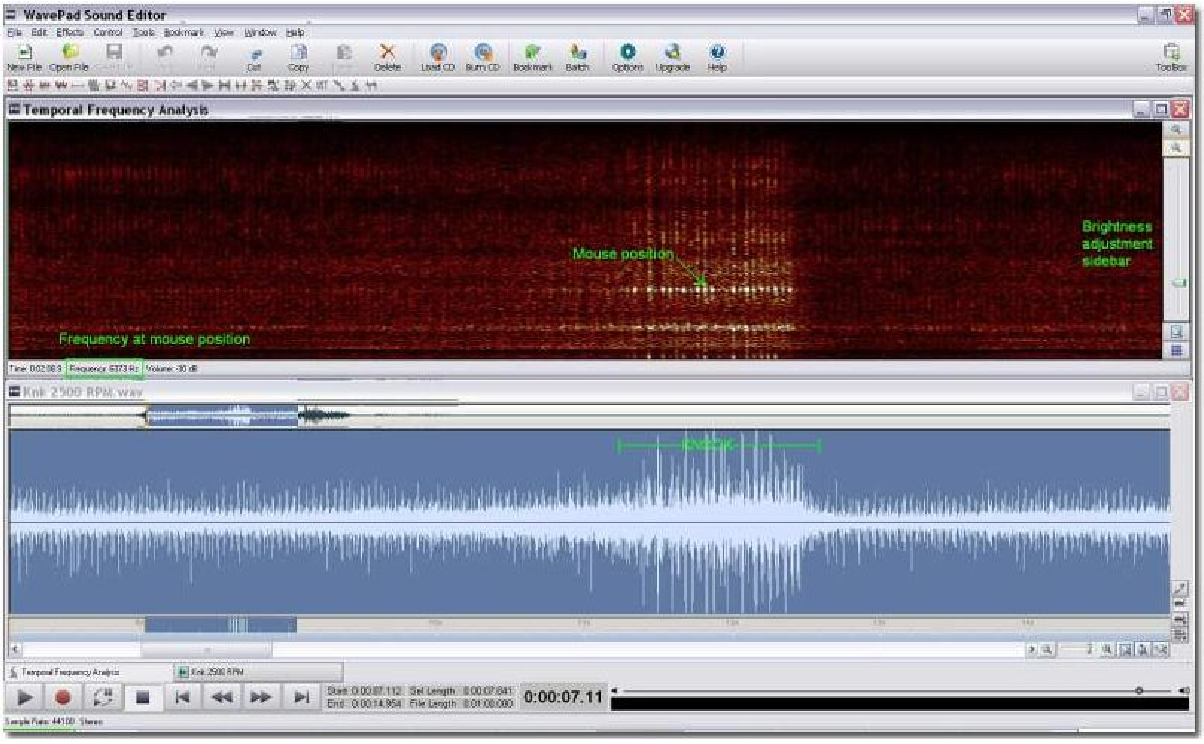
WARNING

Knock can potentially damage an engine, extreme care must be taken. Vi-PEC will take no responsibility for any damage caused to an engine when configuring this device.

Once the programme has been downloaded and installed, the following procedure is used to determine the correct knock frequency.

1. Connect the ViPEC Knock Amplifier's audio output to the PC's microphone input via a doubled ended 3.5mm audio cable.
2. Open the program and select new file.
3. Choose a sample rate of 44100 and select mono.
4. Click the red record icon down the bottom left corner of the screen, this will bring up the recording menu.
5. Click the red record icon in the Record Control window when ready to record the engine knock. It is important that the audio recording contains loaded engine noise with and without knock. Low RPM can be better as there is less ambient engine noise. Click the Stop icon to end recording. Close the Record Control window.
6. Highlight a section of the recording containing loaded engine noise and knock. You can do this by dragging the mouse from right to left while holding down the left mouse button.

7. Press CTRL+SHIFT+S to zoom on the selection.
8. From the tools menu, select Temporal Frequency Analysis. A new window will be created representing frequency in the vertical axis, time in the horizontal axis and the brightness of colour represents amplitude in decibels. The brightness of the plot can be adjusted by the 'brightness adjustment slide bar shown in the following image, this should be adjusted until only knock events become white. Hover the mouse over the white sections to measure the knock frequency



From this analysis it has been determined that the knock frequency for this motor (Toyota 1UZ-FE) is approximately 6.4kHz. The correct filter would be the 6kHz narrow band filter (switch position 5)

3.2.3 Practical Technique

The practical method involves using existing information and experience, combined with testing different filter settings to achieve the best performance. The following table shows a list of currently known knock frequencies for specific engines using specific sensors.

Engine Description	Recommended Filter
Subaru EJ25 (Bosch aftermarket sensor)	6kHz Narrow Band Filter
Subaru EJ20 (Bosch aftermarket sensor)	6kHz Narrow Band Filter
Toyota 1UZ-FE (factory sensors)	6kHz Narrow Band Filter
Mitsubishi 4G63 (Bosch aftermarket sensor)	6kHz Narrow Band Filter
Nissan SR20DET (Bosch aftermarket sensor)	6kHz Narrow Band Filter
Toyota 3S-GTE (Bosch aftermarket sensor)	6kHz Narrow Band Filter
Mitsubishi Evo 6 Onwards (factory sensor)	13kHz Narrow Band Filter
Subaru WRX V7 Onwards (factory sensor)	13kHz Narrow Band Filter

NOTE

This table is provided as a guide only, do not rely solely on this information. Please confirm the frequency using other techniques.

General rules can be used to assist filter selection:

- 6kHz Narrow Band Filter works on most early 90's Japanese manufactured engines with approximately 500cc per cylinder.
- 13kHz Narrow Band Filter works on most late 90's onwards Japanese manufactured engines with approximately 500cc per cylinder.

Please help us build this database, contact your Vi-PEC distributor with any engine specific frequency information.

3.3 ECU Configuration

Correct ECU configuration is critical for an effective knock control system.

- Please consult your ECU tuning manual for instructions on setting this up.

4 Operation

Window Operation

Window operation refers to the window ECU interface. Once the ECU has been configured to work in this mode, it will issue an active low pulse to the ViPEC Knock Amplifier's window input. This low pulse will be the duration of when knock is expected to occur for a particular cylinder. During this low pulse the ViPEC Knock Amplifier actively measures engine knock. On completion the ViPEC Knock Amplifier digitally returns the knock level to the ECU via its window output. The ECU will then process this information and display and act upon the level of knock for each cylinder. Active noise cancellation has no effect on window operation.

Analogue Output Operation

The analogue output of the device provides a voltage ranging between 0 volts and 5 volts. The output voltage is normally proportional to the current level of engine noise and knock. If Active Noise Cancellation is enabled, engine noise will be removed from the output leaving a voltage proportional to knock.

External LED Operation

The external LED will be illuminated when the device detects medium to heavy detonation. The external LED will flash on power up to confirm it is working.

NOTE

In some instances, or on some engines the LED will not show detonation events. Do not rely on the LED alone for tuning, use the headphone facility.
Under some circumstances the KnockBlock will fail to illuminate the LED during detonation.

Audio Operation

The ViPEC Knock Amplifier provides an audio output. The audio is an amplified signal from the knock sensor. The volume can be adjusted using the volume control knob located on the end of the device.

Low Battery Warning

The ViPEC Knock Amplifier has a low battery warning, this is indicated by the power LED flashing rapidly.

Low Power Operation

When the ViPEC Knock Amplifier is operating in low power mode, all the outputs will be disabled apart from audio. Battery life will be extended to 5 times that of normal operation. The power LED will slowly flash to indicate the device is in Low Power Mode.

5 Knock Explained

Knock also known as detonation or pinging refers to the spontaneous combustion of an air/fuel mixture inside the combustion chamber. Knocking is induced by excessive pressure within the combustion chamber causing the air/fuel mixture to self detonate. Excessive pressures can be a resultant of excessive engine temperature, excessive turbo boost pressure, excessive charge temperature and over-advanced ignition timing.

The reason engines get near the point of detonation is tuning for performance and efficiency. To achieve maximum output and efficiency from an engine, combustion pressures must be optimised to create the maximum force on the top of the piston. This maximum combustion pressure is controlled by ignition timing.

When the air/fuel charge detonates, a large sharp pressure impulse is created which vibrates the surrounding engine structure. The effects of the vibrations range from no damage to severe engine damage. This gives the need to accurately detect engine knock.

The most common way of detecting engine knock is to bolt a piezoelectric vibration transducer (knock sensor) to the side of the engine block. The knock sensor exhibits similar characteristics to an audio microphone but converts vibrations rather than audio to an electrical signal.