

# DOCTOR

## *Doctor DK Series Operating Manual*

*Revision 2.8  
October 2006*



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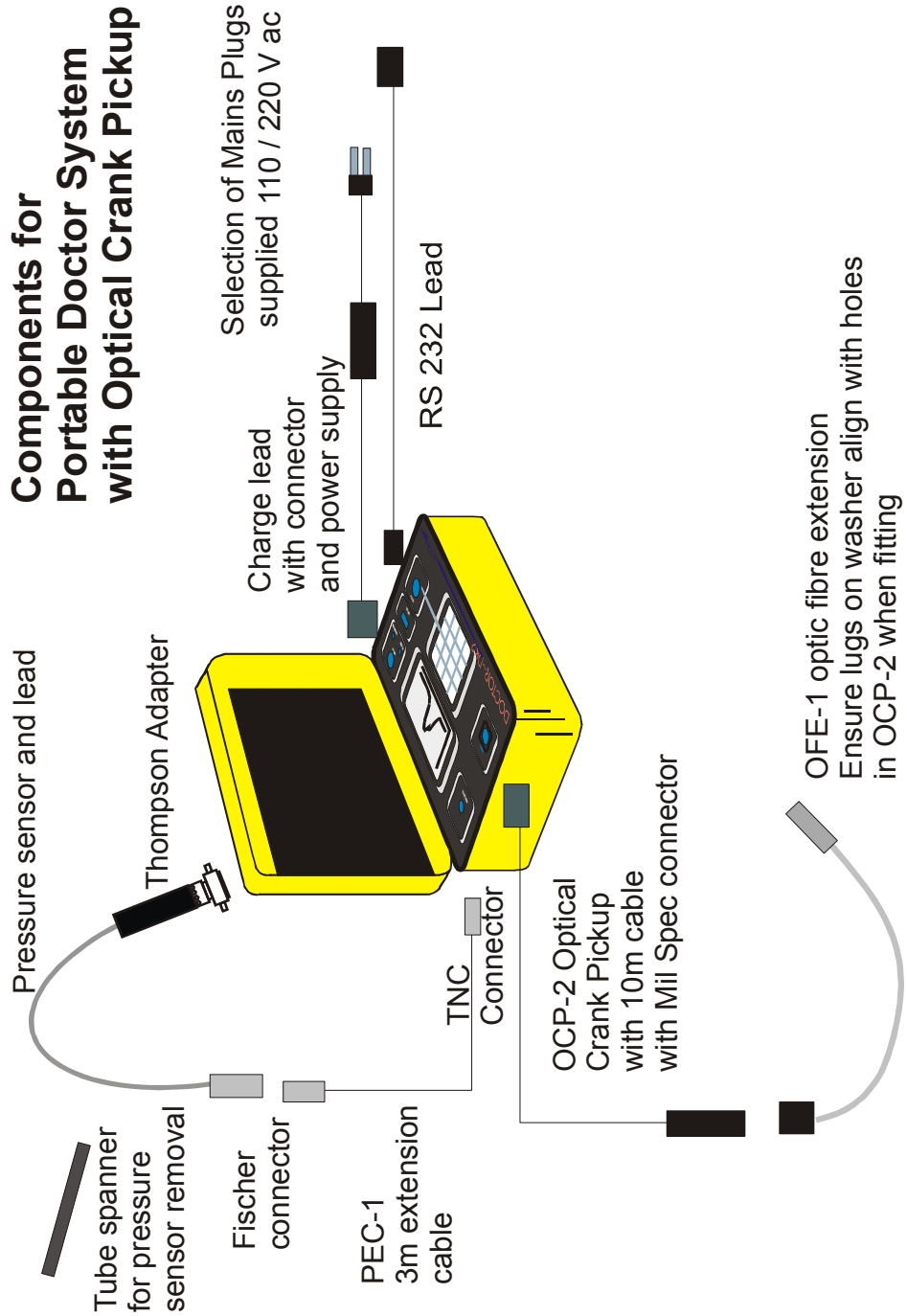
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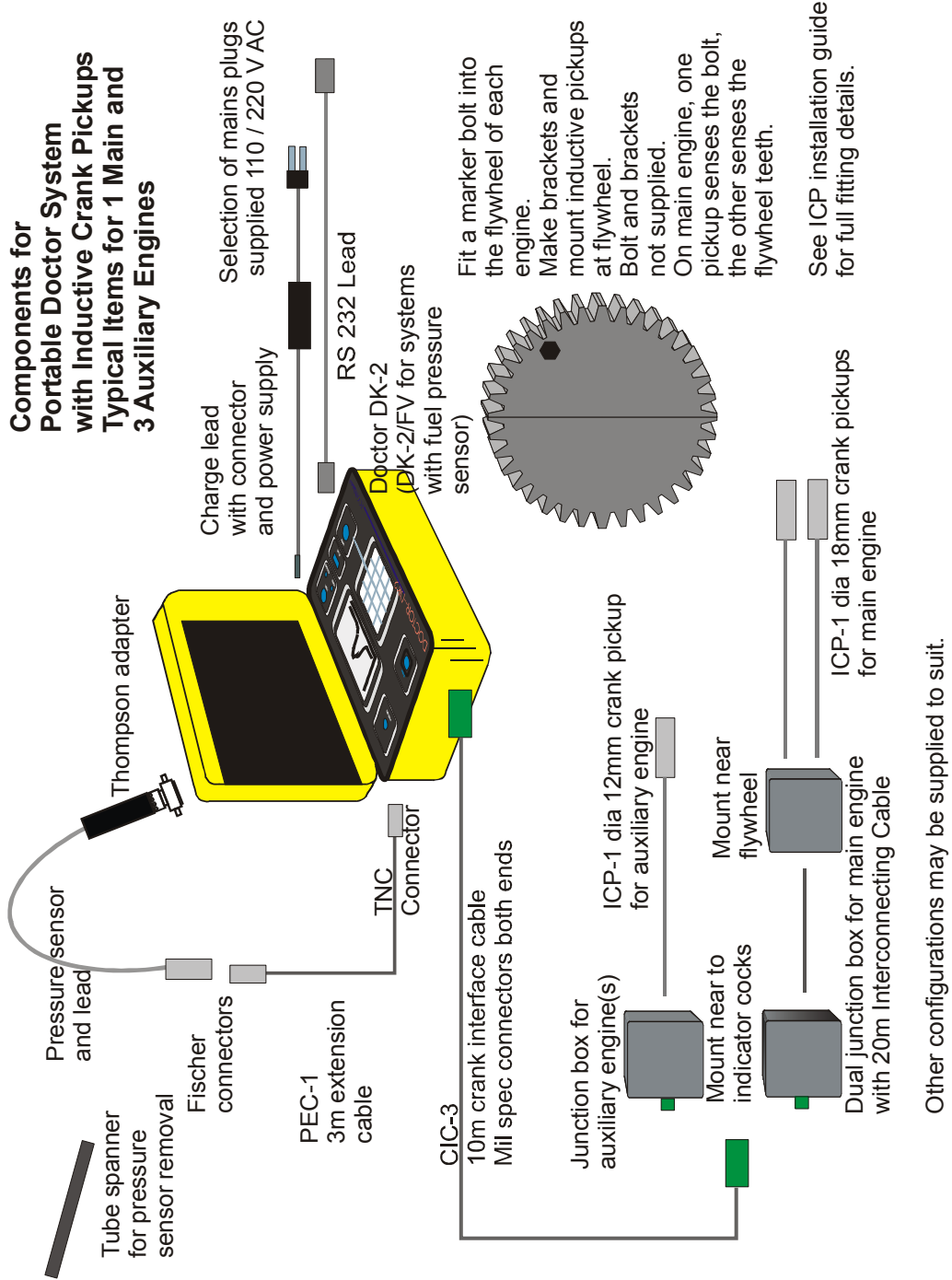


## CHAPTER 1 - Getting Started

### 1.1 System Components – Systems with Optical Crank Pickup



## 1.2 System Components – Systems with Inductive Crank Pickup



### 1.3 Equipment Check

If this is the first time you have used the Doctor system, first check that you have all of the items shown in one of the diagrams on the previous pages.

Your Doctor instrument will have been delivered with the battery in a discharged condition. Before any readings are taken, the battery should be charged up. Connect the power supply to the mains using the appropriate plug, and charge the unit until the CHARGE lamp goes out. This should take around 2.5 hours.

You will first need to ensure that the crank pickups are correctly installed. There are two types of crank pickup:

**Optical Pickup:** Ensure there is a clean piece of optical reflective tape on the flywheel. The optical pickup should be at least 25mm away from the flywheel. There is adjustment available on the rear of the main optical unit – if the LED on the unit does not flash regularly when the engine is turning, adjust the unit until it does.

**Inductive Pickup:** The TDC pickup must have a metal marker on the flywheel of a larger diameter than the pickup. If dual pickups are used, the second one senses the flywheel teeth. The teeth must be larger than the pickup diameter. The correct gap settings are 2mm for 12mm diameter pickups and 3mm for 18mm diameter pickups.

### 1.4 Initial Doctor Set-up

- Switch on the Doctor instrument.
- Wait till the memory and stores check finishes.
- Press **[UTIL]** to select the UTILITIES SCREEN.
- Use the ↑ and ↓ cursor keys to select the following:
- MEASUREMENT MODE AVERAGED
- OPERATING MODE NORMAL

The operations required on the keyboard for these settings is described at the bottom of the screen.

- Press **[SET]** to select the SETUP SCREEN.
- Use the ← and → cursor keys to select following:
- SETUP NO 1 ENGINE 1
- AVERAGES enter 20 for 2-strokes and 40 for 4-strokes.
- ANG RES 1° is good for most applications.
- PICKUP MODE DUAL or TDC depending on your system
- MEASURE CMP ONLY is best for the initial reading (FV only)
- SENSITIVITY See the pressure sensor calibration sheet
- ENGINE TYPE 4 STROKE or 2 STROKE

Your Doctor instrument is now set up ready for initial readings.

### 1.5 Checking the Crank Pickups

Before taking a reading, you should check that the crank pickup(s) are giving the right signals. If they are not, your measurements may be corrupted.

- Connect the crank pickup lead.
- Press **[UTIL]** to enter the UTILITIES screen.
- Use the ↑ and ↓ cursor keys to select CRANK SETUP.
- Press **[ENT]** twice.
- Check for correct RPM and stable readings on the screen.
- Select CLEAR MEMORY.
- Press **[ENT]** twice to clear all the memories.

### 1.6 Taking the First Reading

- You are now ready to take a reading.
- Start at cylinder 1 (on A bank if it is a V engine).
- Connect the Pressure Sensor to the Doctor using the extension lead (PEC-1).
- Open the indicator cock briefly to clear it.
- Attach the Pressure Sensor to the indicator cock.
- Open the cock fully.
- Make sure the instrument is switched on and ENGINE 1 selected in the MAIN screen.
- Enter the scavenge pressure using the ← and → cursor keys to adjust the value.
- PRESS **[GO]**.

The instrument will automatically check the Crank Pickups and measure engine speed. After this it will take readings on each cycle of the engine until the selected amount of averages are acquired. When finished, the screen will show a graph. From the shape of this you will know if the reading is OK. The most common fault is forgetting to open the cock.

### 1.7 To Take the Next Reading

- Close the cock on the cylinder just read.
- Remove the pressure sensor.
- Open the next indicator cock briefly to clear it.
- Attach the Pressure Sensor to the indicator cock.
- Open the cock fully.
- PRESS **[GO]**.

Repeat this until all the cylinders on the engine have been read.

Each cylinder's reading should now be stored in the Doctor in consecutive stores.



### 1.8 Downloading

- To download, the engine must first be set up in the Doctor PC software. See the Doctor Step-by-Step Guide for details.
- If you purchased the database set-up service, you will use the database that has been provided with your instrument.
- Connect the Doctor instrument to the PC with the RS232 cable supplied.
- In the software, select the correct engine and highlight the engine name.
- Click on the button with a “yellow Doctor box” in it.
- On newly installed software, you will need to enter the serial number at this time. The serial number is on a label on the CD pocket.
- Select Memory 1 and Cylinder 1.
- Click on Auto Connect.
- Click on Transfer.
- Enter the Scavenge pressure.
- Click OK and everything will be transferred.

### 1.9 TDC Correction Service

Once you have initial readings from your engines, Icon provides a TDC correction service that is included in your purchase of a Doctor system.

To make use of this service, make an archive of your initial results and Email the resulting file to: [doctor@iconresearch.co.uk](mailto:doctor@iconresearch.co.uk) for correction. We also keep a copy of your initial database in case you have any PC problems in the future and lose your database.

## Chapter 1 – Getting Started

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## CHAPTER 2 - Description

The Doctor system combines ease of use with extremely high accuracy and hidden sophistication.

### 2.1 General

The main elements in the system are as follows:

- The Doctor Instrument
- Pressure Sensor
- Crank Pickup
- PC Doctor Software

There are two types of portable instrument available.

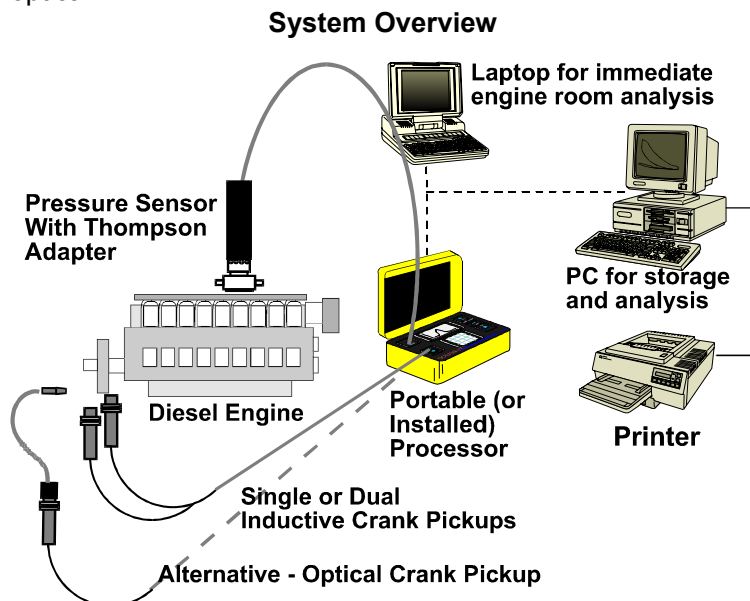
- DK-2 - Single channel for cylinder pressure.
- DK-2/FV - Dual simultaneous channels for taking fuel pressure (or vibration) readings in addition to cylinder pressure.

There is also an On-Line version available.

Earlier versions included an installed system that is now discontinued, but for which operating instructions are included in this manual. These were:

- DK-2/M - Single channel installed unit with direct PC connection.
- DK-2/M/FV - Dual simultaneous channel installed unit with direct PC connection.

All units can accept either dual or single crank pickups and these can be either inductive or optical.

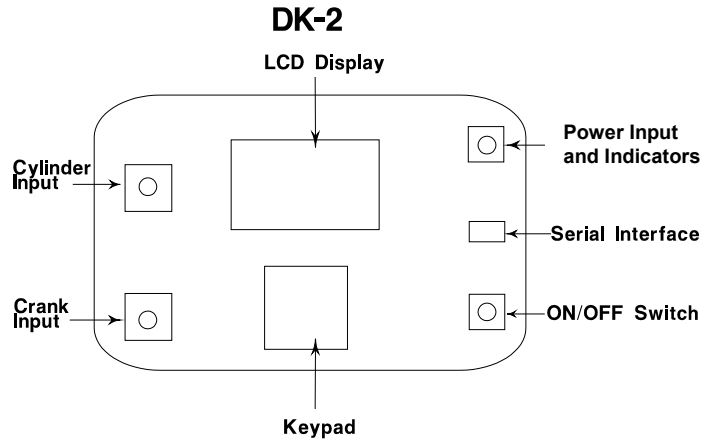


### 2.2 Mechanical Layout

Each of the DK series instruments, which are called Engine Processor Units or EPU's, is housed in a highly ruggedised waterproof ABS plastic enclosure. The enclosure is "lunchbox" style for ease of carrying and transportation. The unit is sealed to IP67 with the lid closed and to IP65 with the lid open. This means that water, oil and dust can be sprayed onto the unit while it is operating without danger of leaking into the internal circuitry.

The figure below shows the internal configuration of the instrument. On the left side are the pressure inputs (one for the DK-2, two for the DK-2/FV) together with the connector for the crank interface pick-ups. In the centre is a high-contrast graphic LCD display, below which is a fully-sealed rubber keypad. The keypad incorporates large keys with tactile feedback for operation with gloved hands. On the right are the power input, serial computer interface, ON/OFF switch and indicator lights (LED's) for power and battery charging.

**Internal Layout**



### 2.3 Powering the Instrument

The EPU can be powered from its internal rechargeable battery pack or from mains power using the charger supplied. The charger can take any input voltage in the range 100V to 240Vac. Three different types of power cord are supplied, namely UK, US and Euro. These cover virtually any mains source encountered in the world.

The DC output of the charger is rated at 9V, 3A. The connection is shown in the diagram below.



If the charger supplied is lost, it is possible to use a supply as per the above rating and connection to charge the instrument. The dc plug is a standard type, the outer cylinder diameter being 5.5mm and the inner diameter being 2.5mm.

When mains power is connected via the charger, the POWER LED will be illuminated. Battery charging is shown by the CHARGING LED being illuminated. When the internal battery is fully charged, charging will stop automatically and the CHARGING LED will be extinguished. Battery charging will still take place when the ON/OFF switch is in the OFF position.

The internal battery takes approximately 2.5 hours to recharge. With one transducer, the unit will last approximately 12 hours on one charge.

The batteries used are high quality Ni-Cad batteries. A warning is given at the top right of the screen when the battery voltage becomes low. The level for this is normally set at 5.9V but this can be changed if desired. Ni-Cad batteries last longest if they are charged fully after a full discharge. For this reason it is advisable to wait till the battery warning appears on the screen before charging fully.

The unit contains a battery back-up system so that stored data is not lost when the instrument is turned OFF, even if the battery is discharged.

### 2.4 EPU Functionality

The data acquisition section receives analogue data from the pressure sensor and converts this to a series of digital numbers using an analogue-to-digital converter. The EPU automatically adjusts to the amplitude of the incoming signal to maximise the dynamic range (and thus reduce unwanted noise) in the system. The data acquisition process is synchronised to the flywheel multiplier.

The crank interface comprises a digital multiplier circuit which multiplies the synchronisation pulses from the crank pick-ups with high accuracy and no phase shift. For example, when dual pickups are used, pulses from a flywheel (perhaps 60 per rev) can be multiplied up to 3600 per rev (or one every 0.1°) and maintain constant phase with the once-per-rev signal. This means that the angle for the pressure readings is corrected 60 times per revolution which leads to greatly increased accuracy especially on low speed engines where speed can vary during a revolution. This feature enables the DOCTOR to achieve significantly better analysis results than conventional systems based on a once-per-rev input only.

### **2.5 Modes of Operation**

Doctor instruments have two modes of operation – Normal and Advanced. In the Normal Mode, the EPU takes readings which are transferred to the PC Software for analysis. In the Advanced Mode, the EPU is programmed with engine details and calculates many of the parameters immediately and displays the results in a table on the instrument screen. Results are still normally transferred to a PC for more detailed analysis.

# CHAPTER 3 - Operation of the Instrument

## 3.1 Overview

The EPU contains 105 memory stores into which measurements are written. There are 20 stores available for different engine set-ups. In the Advanced Mode, one set-up is used per engine.

The procedure is to select a particular engine in the MAIN screen, enter the current scavenge pressure and take measurements by simply pressing the **[GO]** key. To take the next measurement, move the pressure sensor to the next cylinder and open the cock. Then just press the **[GO]** key.

Measurements are stored sequentially in the memory stores, and increment automatically between readings. It is possible to go back through the stores and overwrite results if mistakes are made.

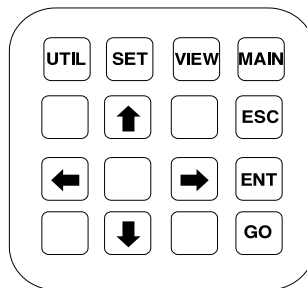
Two types of measurement are possible. The first is an AVERAGED measurement from a cylinder (and from a second sensor on FV units) where a number of cycles can be averaged.

The second is a NON-AVERAGED X10 set of readings whereby ten single cycles are taken in succession on a cylinder (and from a second sensor on FV units) - this is sometimes called a Firing Analysis and is useful in detecting intermittent problems.

## 3.2 Keypad Functions

Operation of the instrument is carried out entirely via the keypad. This is a sealed rubber type with tactile feedback. The layout of the keypad is shown below.

**Keypad Layout**



The top row of buttons is used to access the four main screens.

**[←], [→], [↑], [↓]** are the cursor keys which select set-up parameters and displays for review.

**[ENT]** provides the ENTER function for parameter selection as prompted on the display.

**[ESC]** escapes from a particular mode of operation, including data acquisition.

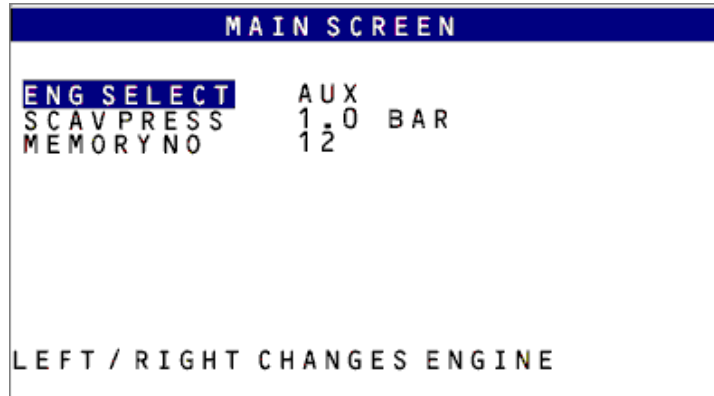
**[GO]** initiates data acquisition.

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### 3.3 MAIN Screen (Normal Mode)

The MAIN screen is shown below. The up and down cursor keys are used to select a menu item and the left/right keys change the parameter.

#### MAIN Screen



#### ENG SELECT Selection

The ENG SELECT menu item selects the engine to be measured, with parameters as defined in the SETUP screen. Change the engine selection using the ← and → cursor keys. Up to 20 different engines can be defined, and each engine can be given a name with up to 10 characters. Engine names may be edited in the UTILITIES screen.

#### SCAV PRESS Selection

SCAV PRESS (Scavenge Pressure or Boost Pressure) can be entered in the range 0.1 to 10.0 bar. This value is used to calculate the Pmax value displayed after each reading and is usually read from a dial on the engine. Change the SCAV PRESS value using the ← and → cursor keys. Note that it is not necessary to enter this value if Pmax values on the EPU are not required. The value of scavenge pressure is entered independently in the analysis software.

#### MEMORY NO Selection

MEMORY NO is the number of the memory store (up to 105) in which the next measurement will be stored. It is automatically incremented after each measurement. If desired, this memory "pointer" can be changed at any time by using the ← and → cursor keys. This is useful for overwriting data if an error has been made.

Once the desired engine is selected and the scavenge pressure value entered, just press **[GO]** to take a reading. The reading will be entered into the memory number which was shown prior to the reading. After the reading, the memory number automatically increments by one, however there is no need to return to the MAIN SCREEN to initiate another reading, just move the pressure sensor to the next cylinder cock, open the cock and press **[GO]** again.



### 3.4 MAIN Screen (Advanced Mode)

#### CYL SELECT Selection

In the advanced mode of operation, there is an additional selection possible where the number of the cylinder being measured is displayed. After clearing the memories, this will always start at CYL1 and it is recommended that readings are always taken starting at cylinder No 1 on the engine and that readings are kept in order after that to simplify downloading. If a reading needs to be repeated or several readings are required on a cylinder, the number in CYL SELECT must match the number of the cylinder in order to calculate results correctly. The cylinder number can be altered by using the ← and → cursor keys.

From the MAIN Screen, pressing the **[GO]** button will initiate a reading.

### 3.5 After Pressing GO

After pressing **[GO]**, the instrument will display 3 screens in sequence, and then display the result of the measurement.

```
MEASURING ENGINE SPEED
CHECKING TRANSDUCERS
```

```
MEASURING ENGINE SPEED
ALLOWING SETTLING TIME
```

```
MEASURING ENGINE SPEED
CALCULATING TDC PERIOD
READING PRESSURE DATA
SAMPLES/CYCLE = 1440
MULT VALUE = 072
FLYWHEEL TEETH = 010
SAMPLE RATE = 06025 Hz
MEASURED 011 CYCLES OF 020
SPEED: 502.1 RPM
```

First the TDC and flywheel periods are measured to calculate the initial RPM and sampling rate. Sampling rate varies during acquisition as the DOCTOR tracks engine speed. Data is then read and stored. At the foot of the screen, there is a counter of the current cycle being measured. Once the counter reaches the selected number of averages, acquisition is complete and the result will be presented immediately after. Pressing **[ESC]** at any point stops the acquisition process.

---

### 3.6 SETUP Screen (Normal Mode)

The SETUP screen is selected by pressing the **[SET]** key. This screen enables engine parameters and measurement parameters for a particular engine to be set up. The ↑ and ↓ cursor keys select the menu item to be changed, and this is highlighted in inverse video. The ← and → cursor keys change the parameter itself. The screen format is shown below.

SETUP Screen (FV version shown)

| SETUP SCREEN    |              |    |
|-----------------|--------------|----|
| SETUP NO 1      | ENGINE 1     | ON |
| <b>AVERAGES</b> | 20           |    |
| ANGRES          | 1 DEG        |    |
| PICKUP MODE     | TDC ONLY     |    |
| MEASURE         | CMP ONLY     |    |
| SENSITIVITY CMP | 20 mV / BAR  |    |
| POLARITY CMP    | NON-INVERTED |    |
| SENSITIVITY F/V | N/A          |    |
| POLARITY F/V    | N/A          |    |
| ENGINE TYPE     | 4 STROKE     |    |

< · -> TO SELECT NUM AVERAGES

#### SETUP Selection

The SETUP NO 1 to SETUP NO 20 selection is used to set the conditions for measurement for a particular engine type. Change the SETUP selection using the ← and → cursor keys.

The screen above shows a typical setting for a 4-stroke engine. On non FV EPU's, the selections for MEASURE, F/V SENSITIVITY and POLARITY are not available.

Up to 20 individual engine set-ups can be defined and the name of the engine can be edited in the UTILITIES screen. An engine set-up can be set to ON or OFF. When selected to ON, it will appear as one of the selectable engines in the MAIN screen. When selected to OFF, it is not selectable in the MAIN screen. ON and OFF are toggled using the **[ENT]** key when the SETUP section is highlighted.

The name of an engine may be changed using the UTIL screen – see the section on EDIT ENGINE NAMES.

#### AVERAGES Selection

The number of cycles over which a measurement is taken is defined in the AVERAGES selection. The range is 1 to 100. One cycle of a 2-stroke engine is one revolution whereas one cycle of a 4-stroke engine is two revolutions. A selection of 1 for the AVERAGES value will take a reading without any averaging. The number of cycles is modified by pressing the ← and → cursor keys while AVERAGES is selected. Holding a key down accelerates the update rate.

Averaging helps to remove noise from the signals and provides the mean performance for a particular cylinder. AVERAGES values between 20 and 50 are typical.

## Chapter 3 – Operation of Instrument

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### **ANG RES Selection**

In the ANG RES menu selection, the angular resolution of the measurement (in degrees) is selected. For example, if value 0.5 is selected, then 720 data samples per revolution of the shaft will be taken and the resulting graphs will have a point every  $\frac{1}{2}^\circ$ . If the resolution is too high for the particular engine speed, a warning message is given to select a lower resolution. A resolution of  $0.1^\circ$  will be available for engine speeds of up to 600 RPM or a little higher. Change the ANG RES selection using the ← and → cursor keys.

The available selections are 0.1, 0.2, 0.5, 1 and 2. As a guide,  $0.5^\circ$  is normally used for 2-stroke main engines and  $1^\circ$  for 4-stroke auxiliary engines. This gives the resolutions required for analysis and keeps the database size within reasonable limits. Higher resolutions may be required for special applications but the rate of change of pressure plots in the PC software may become noisy and database size will increase.

When dual pickups are used, the resolution is defined partly by the number of teeth on the flywheel. For example, a flywheel with 84 teeth has  $4.285^\circ$  between each tooth so the nearest resolution for a requested  $1^\circ$  resolution would be 4 samples for each tooth or a resolution of  $1.07^\circ$  per sample. The PC software and the advanced mode in the EPU can handle fractional resolutions so results stay accurate.

### **PICKUP MODE Selection**

PICKUP MODE can be set to TDC ONLY or DUAL depending on whether a single (once-per-rev) pickup is being used or whether two have been installed (i.e. a once-per-rev and flywheel teeth pickup). The mode should be selected to match the installation. Change the PICKUP MODE selection using the ← and → cursor keys.

### **MEASURE Selection (FV units only)**

On dual channel units it is possible to take simultaneous readings of cylinder pressure and another parameter. The standard selections are for Fuel Pressure or Vibration as the second parameter but in practice, any other compatible pickup can be used and a signal, synchronised to the engine cycle will be stored. The available selections on the screen are CMP ONLY, CMP + FUEL and CMP + VIB. Change the MEASURE selection using the ← and → cursor keys.

## Chapter 3 – Operation of Instrument

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### **SENSITIVITY CMP Selection**

SENSITIVITY enables the sensitivity of the pressure sensor to be entered in order that the Pmax value displayed after each reading can be calculated. The value required will be found on the calibration certificate of your pressure sensor and for standard sensors will be around 20mV/bar. Choose the value at the higher temperature and pressure if there is a choice. The default value is 20mV/bar so that if a value is not entered, the readings should be close to correct. Change the SENSITIVITY value using the ← and → cursor keys.

### **POLARITY CMP Selection**

POLARITY is a means by which the incoming signal from the pressure sensor can be inverted if desired. This is to cope with different types of pressure sensor and charge amplifier. In general, when using a pressure sensor, the NORMAL selection should be used. When using a charge amplifier, INVERTED should be selected. If the signal from a particular pressure sensor appears upside down, use the other selection. Change the POLARITY CMP selection using the ← and → cursor keys.

### **SENSITIVITY F/V (FV units only)**

This item is only active if either CMP + FUEL or CMP + VIB has been selected in the MEASURE Selection (see above). The default sensitivities are 2.5mV/bar for fuel pressure readings and 50mV/g for vibration readings. Change the SENSITIVITY F/V value using the ← and → cursor keys.

### **POLARITY F/V (FV units only)**

This item is only active if either CMP + FUEL or CMP + VIB has been selected in the MEASURE Selection (see above). POLARITY is a means by which the incoming signal from the Fuel Pressure sensor or Vibration sensor can be inverted if desired. This is to cope with different types of sensors and charge amplifiers. In general, when using a pressure sensor, the NORMAL selection should be used. When using a charge amplifier, INVERTED should be selected. If the signal from a particular pressure sensor appears upside down, use the other selection. Change the POLARITY CMP selection using the ← and → cursor keys. For Vibration signals, either selection can be used.

### **ENGINE TYPE Selection**

ENGINE TYPE selects whether the engine is a 2-STROKE or 4-STROKE. Change the ENGINE TYPE selection using the ← and → cursor keys.

### 3.7 SETUP Screen (Advanced Mode)

The EPU can be operated in Advanced Mode by selection through the UTILITIES screen.

The Advanced Mode allows cylinder results to be calculated directly in the instrument and provides a table showing results as well as still having graphs available. The SETUP SCREEN changes once the advanced mode is selected.

There are now two screens for setting measurement parameters as shown below.

To move between the screens, you can press the **[SET]** key or alternatively, scrolling to the “next” or “previous” selections will jump to the next screen.

#### SETUP Screen 1 Advanced Mode (FV version shown)

| SETUP SCREEN 1               |              |    |
|------------------------------|--------------|----|
| SETUPNO 1                    | ENGINE 1     | ON |
| <b>AVERAGES</b>              | 20           |    |
| ANGRES                       | 1 DEG        |    |
| PICKUP MODE                  | TDC ONLY     |    |
| MEASURE                      | COMP ONLY    |    |
| SENSITIVITY CMP              | 20mV/BAR     |    |
| POLARITY CMP                 | NON-INVERTED |    |
| SENSITIVITY F/V              | N/A          |    |
| POLARITY F/V                 | N/A          |    |
| SPRING VALUE                 | N/A          |    |
| ENGINE TYPE                  | 2-STROKE     |    |
| next                         |              |    |
| <- -> TO SELECT NUM AVERAGES |              |    |

In the FV version of the EPU, one additional item appears in the SETUP SCREEN 1. This is SPRING.

#### SPRING VALUE Selection

This value is useful when fuel pressure readings are being taken and will identify the angle at which the spring pressure is reached. The value to enter is the snap pressure of the injectors and with this value set, the instrument will be able to identify the delivery angle for fuel entering the cylinder. Change the SPRING value by using the ← and → cursor keys.

### SETUP Screen 2 Advanced Mode

| SETUP SCREEN 2  |         |
|-----------------|---------|
| previous        |         |
| <b>BORE</b>     | 840mm   |
| STROKE          | 2400mm  |
| CONROD LEN      | 3450mm  |
| TRIG REL TO TDC | 2.0DEG  |
| CYL CONFIG      | IN-LINE |
| CYL PER BANK    | 9       |
| ENG ROTATION    | N/A     |
| BANK ANGLE      | N/A     |
| FIRING ORDER    |         |

<- -> TO SELECT BORE DIA

In this screen, the engine parameters that are needed for calculation of results are set.

#### **BORE Selection**

The bore diameter is entered in mm. Use the ← and → cursor keys to increase or decrease the value.

#### **STROKE Selection**

The stroke length is entered in mm. Use the ← and → cursor keys to increase or decrease the value.

#### **CON ROD LEN Selection**

The con rod length is entered in mm. Use the ← and → cursor keys to increase or decrease the value. The correct dimension to use is the distance between centres.

#### **TRIG REL TO TDC Selection**

This value is determined after initial readings have been taken and requires the PC software to ensure it is correct. The procedures for determining the correct TDC offset are described fully in the Step-by-Step software guide. The value is entered in degrees and can be adjusted in steps of 0.1°. Use the ← and → cursor keys to increase or decrease the value. The same value is used for all cylinders in an engine.

#### **CYL CONFIG Selection**

The engine configuration will either be IN-LINE or V-ENGINE. Use the ← and → cursor keys to make your selection.

#### **CYL PER BANK Selection**

This is used to input the number of cylinders the engine has. On an IN-LINE engine, there is only one bank so just enter the number of cylinders. On a V-ENGINE, there are two banks but just enter the number per bank. Use the ← and → cursor keys to increase or decrease the value shown.

## Chapter 3 – Operation of Instrument

---

### ENGINE ROTATION Selection

On V-ENGINES, it is necessary to let the system know which way the engine is rotating. This selection is not active for IN-LINE engines. The rotation is defined as the way the top of the flywheel rotates relative to the A bank and B bank of the engine. Use the ← and → cursor keys to select either A→B or B→A.

### BANK ANGLE Selection

Again this is only for V-ENGINES and is the angle between the cylinder banks. Normal values are 45° to 60° although there are other angles used. Use the ← and → cursor keys to increase or decrease the number until the required value is reached.

### FIRING ORDER Selection

With FIRING ORDER highlighted, press the [ENT] key and a screen will appear as shown below.

#### EDIT FIRING ORDER

```
EDIT FIRING ORDER

1 2 3 4 5 6 7 8 9

LEFT/RIGHT CHANGES POSITION
UP/DOWN CHANGES CYLINDER NO.
ENTER STORES NEW FIRING ORDER
ESCAPE CANCELS CHANGES
```

To get the cylinder numbers in the correct order, move to the cylinder position using the ← and → cursor keys and increase or decrease the number using the ↑ and ↓ cursor keys.

If the engine is a V engine with two banks of cylinders, enter the firing order for the A bank. The system is able to calculate the B bank results correctly without further information.



### 3.8 UTILITIES Screen (Normal Mode)

The UTILITIES screen is selected by pressing [UTIL]. Options are selected by using the four cursor keys as in the SETUP screen. The format of the screen is shown below.

#### UTILITIES Screen (Normal Mode)

```
UTILITIES SCREEN
MEASUREMENT MODE      AVERAGED
READ PMAX
CRANK SETUP
CLEAR MEMORY
EDIT ENGINE NAMES
SYSTEM REST
BATTERY LEVEL
DISPLAY MODE
SERIAL TRANSFER
OPERATING MODE

PRESS LEFT/RIGHT TO SELECT
MEASUREMENT MODE
```

#### MEASUREMENT MODE Selection

There are two measurement modes. The normal one for most users is AVERAGED and readings under this setting are taken as an average over the number of averages chosen in the set-up. The other option is NON AV X 10 and this selection forces the instrument to take 10 readings on individual firing strokes. This uses 10 memories per cylinder per test (20 if a second sensor for Fuel Pressure etc. is used). This can be used to help to find intermittent problems. Use the ← and → cursor keys to make the selection.

#### READ PMAX Selection

This is a utility where the EPU can be used as a peak pressure gauge. To use this option it is not necessary to have a crank pickup connected. Ensure the pressure sensor is connected to an indicator cock and the cock fully opened and press [ENT] to start the reading. The value for Pmax will update on the screen several times per second. Note that for correct peak values to be recorded, the current scavenge pressure must be entered in the MAIN screen.

```
UTILITIES SCREEN
MEASUREMENT MODE      AVERAGED
READ PMAX
CRANK SETUP
CLEAR MEMORY
EDT ENGINE NAMES
SYSTEM RESET
BATTERY LEVEL          5.95V
DISPLAY MODE           NORMAL
SERIAL TRANSFER        NORMAL
OPERATING MODE         NORMAL

          PMAX= 125bar
PRESS+HOLD ESC TO CANCEL
```

## Chapter 3 – Operation of Instrument

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### CRANK SETUP Selection

This is used to check that the crank pickups are providing the correct signals to the EPU. If the signals are not correct, the instrument will not be able to take a reliable reading and may not take any reading at all. To initiate a check, first ensure the pickups are in place and connected to the EPU. Press **[ENT]** and a screen will be displayed describing the test to be carried out. This will either be for DUAL Pickups or for TDC ONLY Pickup. To ensure the correct test is being made, the correct engine set-up for the engine being tested must first be selected (see SETUP Selection). Press **[ENT]** again to start the test. A screen as shown below will appear.

#### CRANK SETUP Screen

```
CRANK SETUP
DUAL PICKUP TEST MODE

TDC PERIOD      = 23928 US
FLYWHEEL PERIOD = 2392 US
FLYWHEEL TEETH  = 10
TOOTH PK-PK     = 0.3 %
ENGINE SPEED    = 501.5 RPM

PRESS ESCAPE TO STOP TEST
```

On TDC ONLY operation it is only necessary to ensure that the reported RPM is correct and steady. On DUAL Pickup installations, the number of teeth reported should be constant and although counted automatically, if the number is known it must be correct. The engine speed must also be correct and steady.

TOOTH PK-PK is an indication of how much variation between teeth the pickup is seeing. This should not exceed 10% (which on a flywheel with 60 teeth would be a variation of  $0.6^\circ$  between successive teeth). Variation can be caused by speed changes during each engine rev or by physical defects on the flywheel. The DOCTOR is capable of handling large variations in speed and will track these very well. If the variation exceeds the resolution being used, the DOCTOR will still compensate but a lower resolution should be selected. As a guide, under 2% variation will allow  $0.1^\circ$  resolution on a 60 to 80 tooth flywheel. If the variation exceeds 10%, it is likely that the flywheel teeth are irregular and it is recommended to change to a TDC ONLY configuration.

### CLEAR MEMORY Selection

CLEAR MEMORY erases all data from the channel stores. Pressing **[ENT]** activates the operation. A message: "ARE YOU SURE?" appears after which **[ENT]** has to be pressed again. This is to avoid inadvertent erasing of data. Memories do not have to be cleared of old data before new data is acquired - old data is simply overwritten.

## Chapter 3 – Operation of Instrument

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### EDIT ENGINE NAMES Selection

EDIT ENGINE NAMES enables the names of engines to be defined and edited. An engine name can be up to 10 characters long. By selecting EDIT ENGINE NAMES and pressing the **[ENT]** key, the screen below is displayed.

#### EDIT ENGINE NAMES Screen

```
EDIT ENGINE NAMES
OLD NAME : ENGINE - 1
NEW NAME : _____

SYMBOL ORDER IS AS BELOW :
A to Z 0 to 9 / - . SPACE

LEFT / RIGHT CHANGES POSITION
UP / DOWN CHANGES CHARACTER
ENTER ADVANCES SETUP CHOICE
ESCAPE RETURNS TO UTILITIES
```

Editing the name from a previous (or default) name is carried out by following the instructions on the screen. The cursor keys enable characters to be changed according to which character is being pointed to. The new name will appear on the MAIN and SETUP screens for that SETUP NO. **[ENT]** moves on to a subsequent engine, and **[ESC]** escapes back to the main UTILITIES screen. The facility to define names enables the user to associate his own engine with the set-up parameters he wishes to use.

### SYSTEM RESET Selection

SYSTEM RESET is a master reset of the instrument and is normally only required if the programme chips in the instrument have been changed (for example with updated software). Pressing **[ENT]** will bring up an "ARE YOU SURE?" message, pressing **[ENT]** again will start a large 10 second counter. At any time during the count, the operation can be stopped by pressing any key. After following the on-screen messages, all set-ups you may have made will be erased and set-up data will be reset to default values. They can then be modified as desired. This operation does not delete cylinder results, only the settings made in the SETUP and UTILITIES screens are changed back to factory settings.

### BATTERY LEVEL Selection

BATTERY LEVEL sets the voltage threshold on the main battery at which the BAT low battery warning will be displayed. The message BAT appears on the top right hand side of the screen if the battery is in a low discharge state (i.e. about 1-2 hours remaining depending on the number of transducers connected). The threshold can be varied to allow for ageing of the battery pack. The recommended level for setting this is 5.9V. This selection can also be used to measure the battery voltage by selecting higher numbers until the BAT warning appears. The threshold monitoring can also be DISABLED so that no warning is given. Use the ← and → cursor keys to make the selection.

## Chapter 3 – Operation of Instrument

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### **DISPLAY MODE Selection**

The screen can display in normal video or inverse video modes. Use the ← and → cursor keys to make the selection.

### **SERIAL TRANSFER Selection**

Serial transfer can either be SLOW or NORMAL. In some cases, a timing conflict arises with certain computers and SLOW mode will normally overcome this. For the vast majority of situations, use NORMAL for the fastest transfer possible. Use the ← and → cursor keys to make the selection.

### **OPERATING MODE Selection**

The two modes available are NORMAL and ADVANCED. Use the ← and → cursor keys to make the selection. The advanced mode allows results to be calculated directly in the EPU.

### 3.9 UTILITIES Screen (Advanced Mode)

With the ADVANCED mode selected, an additional menu item appears on the UTILITIES screen. This allows the table of results which is presented after a reading in advanced mode to be configured.

#### EDIT TABLE LAYOUT Selection

To edit the table, press the [ENT] key and the following edit table layout screen will be shown.

#### Edit Table Layout Screen

```
EDIT TABLE LAYOUT
SELECTED COLUMNS:
MEM  CYL  PMAX  PKW  MPR  RPM
MIP
AVAILABLE PARAMETERS:
CYL  MIP  ADEL  clear
PMAX MPR  ASPR
APMX AMPR FMX
PKW  PTDC VMAX
PHP  REM  AVMX

ARROW KEYS TO SELECT PARAMETER
ENTER TO SELECT/DESELECT PARAM
ESC TO SAVE CHANGES
```

Use the ← and → cursor keys to select the parameter you wish to enter in the next column. Press [ENT] to select that parameter. Note that selecting clear first and then pressing [ENT] will clear all columns. Pressing [ESC] saves the changes and takes you back to the UTILITIES SCREEN.

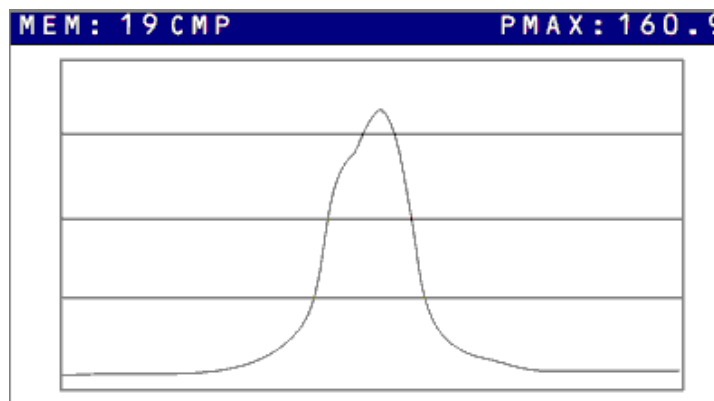
### 3.10 VIEW Screen (Normal Mode)

The view screen appears after each reading or can be accessed at any time by pressing the **[VIEW]** key. If there is no data in the memory selected in the main screen, the message NO DATA FOR THIS MEMORY will be displayed.

A different memory may be selected from the MAIN screen by using the ← and → cursor keys. Alternatively, from the VIEW screen repeatedly press the VIEW key to select the fourth VIEW screen then use the ↑ and ↓ cursor keys to scroll through the available results.

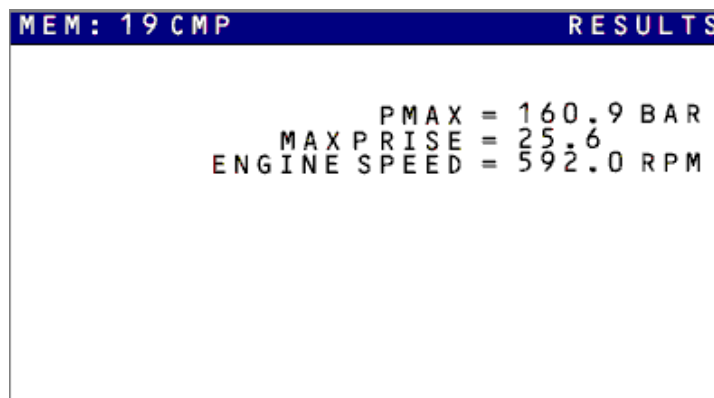
After data acquisition is complete, a graphic display of pressure versus angle is shown. When a NON-AV X 10 reading has been taken, the display shows the first measurement. Note that the value of Pmax is shown on the display screen. For correct values of Pmax, the appropriate values of channel sensitivity and scavenge pressure must have been entered in the SETUP and MAIN screens respectively. The graphic display can be magnified up to a maximum of five steps by pressing the ↑ cursor key and reduced by pressing the ↓ cursor key.

#### VIEW Screen (Normal Mode)



When a graphic display is on the screen, pressing the **[VIEW]** key will display the results of the measurement in numeric form.

#### Second VIEW Screen (Normal Mode)



## Chapter 3 – Operation of Instrument

Pressing the **[VIEW]** key a third time will provide the measurement conditions.

### Third VIEW Screen (Normal Mode)

| MEM: 19 CMP              | CONDITIONS |
|--------------------------|------------|
| ANG RESOLUTION = 0.5 DEG |            |
| ENGINE TYPE = 4 STROKE   |            |
| AVERAGING CYCLES = 001   |            |
| FLYWHEEL TEETH = 010     |            |
| MULTIPLIER VALUE = 072   |            |
| SAMPLES = 01440          |            |

Pressing the **[VIEW]** key again will show a table of the available results with brief details of the measurements. You can scroll through the results using the ↑ and ↓ cursor keys.

### Fourth VIEW Screen (Normal Mode)

| MEM | P MAX   | MPR | RPM |
|-----|---------|-----|-----|
| 001 | 127     | 4.5 | 720 |
| 002 | 130     | 4.7 | 720 |
| 003 | 128     | 4.6 | 719 |
| 004 | 132     | 4.8 | 720 |
| 005 | 130     | 4.5 | 720 |
| 006 | 129     | 4.3 | 721 |
| 007 | (EMPTY) |     |     |
| 008 | (EMPTY) |     |     |

### 3.11 VIEW Screen (Advanced Mode)

In the advanced mode, the initiation of readings is the same – from the MAIN screen just press the [GO] button. The same screen as in the normal mode is shown during the measurement but the results are presented slightly differently. As with the NORMAL mode, the view screens can be called up at any time by pressing the [VIEW] key. Press the [VIEW] key again to move to the next VIEW SCREEN. There are four screens showing the results as follows:

- A table of the results – the table as defined using the UTILITIES menu selection for EDIT TABLE LAYOUT. You can scroll through the results using the ↑ and ↓ cursor keys.

#### First VIEW Screen (Advanced Mode)

| MEM | CYL     | P MAX | PKW  | MPR | RPM |
|-----|---------|-------|------|-----|-----|
| 019 | 001     | 132   | 2852 | 4.5 | 98  |
| 020 | 002     | 132   | 2854 | 4.7 | 98  |
| 021 | 003     | 132   | 2855 | 4.6 | 98  |
| 022 | 004     | 132   | 2859 | 4.8 | 98  |
| 023 | 005     | 132   | 2853 | 4.5 | 98  |
| 024 | 006     | 132   | 2855 | 4.3 | 98  |
| 025 | 007     | 132   | 2856 | 4.4 | 98  |
| 026 | 008     | 132   | 2854 | 4.5 | 98  |
| 027 | 009     | 132   | 2859 | 4.9 | 98  |
| 028 | 010     | 132   | 2853 | 4.8 | 98  |
| 029 | 011     | 132   | 2854 | 4.7 | 98  |
| 030 | (EMPTY) |       |      |     |     |
|     | (EMPTY) |       |      |     |     |

- Results for the memory selected in the first screen. This screen shows all the available results for the memory – not just the ones selected for the table.

#### Second VIEW Screen (Advanced Mode)

| MEM : 28 CMP | RESULTS                 |
|--------------|-------------------------|
|              | P MAX = 130.2 BAR       |
|              | ANG OF P MAX = 10.7 DEG |
|              | POWER = 29802 KW        |
|              | POWER = 3995 HP         |
|              | MIP = 13.7              |
|              | MAX PRISE = 4.5         |
|              | ANG OF MAX PRISE = 4.3  |
|              | PTDC = 101.0 BAR        |
|              | ENGINE SPEED = 98.1 RPM |

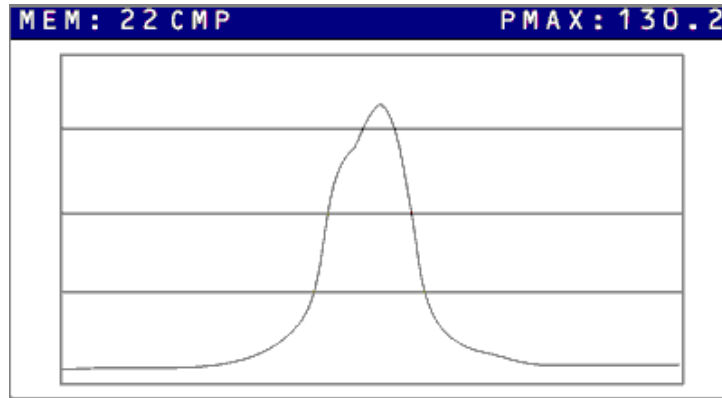


## Chapter 3 – Operation of Instrument

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- A graph of the result selected in the first screen. This presentation is the same as the first screen in Normal Mode. The graphic display can be magnified up to a maximum of five steps by pressing the ↑ cursor key and reduced by pressing the ↓ cursor key.

### Third VIEW Screen (Advanced Mode)



- The conditions under which the measurement was taken. This screen is the same as the third screen in Normal Mode.

### Fourth VIEW Screen (Advanced Mode)

The figure shows a screen with a dark blue header bar containing the text "MEM: 28" on the left and "CONDITIONS" on the right. Below the header is a white rectangular area containing a list of measurement conditions in a monospaced font:

```
ANG RESOLUTION = 1.071 DEG
ENGINE TYPE = 2 STROKE
CYLINDER NUMBER = 009
AVERAGING CYCLES = 026
FLYWHEEL TEETH = 084
MULTIPLIER VALUE = 004
SAMPLES = 00336
```

## Chapter 3 – Operation of Instrument

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### Reviewing Data

Data can be reviewed any time except when a reading is in progress or downloading is in progress. Press **[VIEW]** and the first VIEW screen will be displayed. The screen you get will depend on whether you are operating in Normal or Advanced Mode. If a memory contains no data, the message NO DATA FOR THIS MEMORY appears in Normal Mode or <EMPTY> next to the memory numbers in the first screen in Advanced Mode.

The graphic display can be magnified up to a maximum of five steps by pressing the ↑ cursor key and reduced by pressing the ↓ cursor key.

### Downloading Data

Measurements are downloaded to the PC by connecting an RS232 cable between the EPU and the PC and using the PC analysis software program to carry out the transfer. It is not necessary to press any keys on the EPU - just ensure that it is switched on.

Note that the EPU always assumes that the PC serial interface is set to 9600 baud, and that the PC serial port set-up is the standard 9600,N,8,1. Flow control should be set to *None*.

In the UTILITIES SCREEN, there is a selection for SERIAL TRANSFER and the options are either NORMAL or SLOW. If you experience any problems with transfer (as sometimes occur with older computers), try the SLOW selection.

## CHAPTER 4 - Operation of Installed Doctor Instruments

### 4.1 General

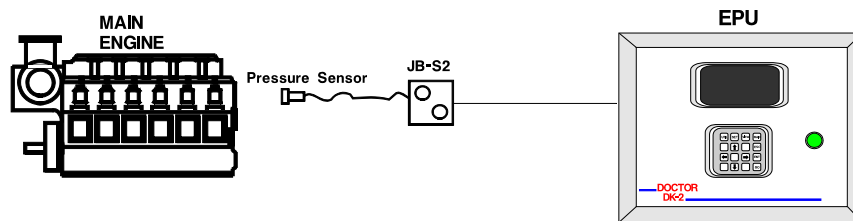
Although the Installed Doctor instrument is no longer in production, this section is included for those who own and operate such units.

Installed DOCTOR EPU units follow the same set-up and produce the same results as portable units with a few exceptions. The principle differences are as follows:

- There is no battery in the unit. It is mains powered at all times.
- The set-up requires two additional parameters to be set. These appear on Setup screen 3. The first is “ENGINE CHANNEL” and a number should be entered here matching the way the system was installed. The second is “PRESSURE VALID” and an acceptable low limit for cylinder pressure should be set here. This prevents readings being taken with a closed indicator cock for example.
- Readings are initiated from a small control box at each engine. This has a large green **GO** button and an indicator LED. Pressing the **GO** button automatically selects the correct engine on the EPU.
- The EPU is connected to the PC at all times.

### 4.2 System Layout

The following shows a typical layout for an installed DOCTOR system.



The JB-S2 has a connector for the pressure sensor, a large green “GO” button and an indicating LED. The LED can show different colours and the meaning of the colours is as follows:

- Green - The system is ready to take measurements.
- Amber - A Valid reading is being taken.
- Flashing Green - The reading currently being taken is out of range of the pre-set Valid Range
- Red - There is a problem with the reading – check the EPU screen for details.

### 4.3 Operating Sequence

Select the engine to be tested on the EPU and enter the scavenge pressure. If the previously entered scavenge pressure is still valid, this step may be omitted.

If all results have been downloaded from the EPU, the memory should be cleared from the UTILITIES menu.

Return to the MAIN screen.

Go to the engine and connect the pressure sensor to the control box.

Connect the Pressure Sensor to the first cylinder on the engine (always start at cylinder 1 to keep things simple) and open the cock. If a Fuel reading is being taken at the same time, connect that sensor to the fuel cock for No 1 cylinder.

Check that the indicator light is Green.

Press the **GO** button on the Control Box.

Watch the lights, a normal reading is indicated by the light turning to Amber and back to Green.

If the light flashes Green, check that the indicator cock has been opened.

If the Red light comes on, check on the EPU screen for an explanation of the problem. The most likely cause is incorrect pulses from the flywheel pickups.

If all is OK, move the sensor(s) to the next cylinder and press **GO** again.

Keep moving the sensor(s) and pressing **GO** till all cylinders have been read.

Go to the PC to initiate download of the readings. See the software Step-by-Step guide for details.

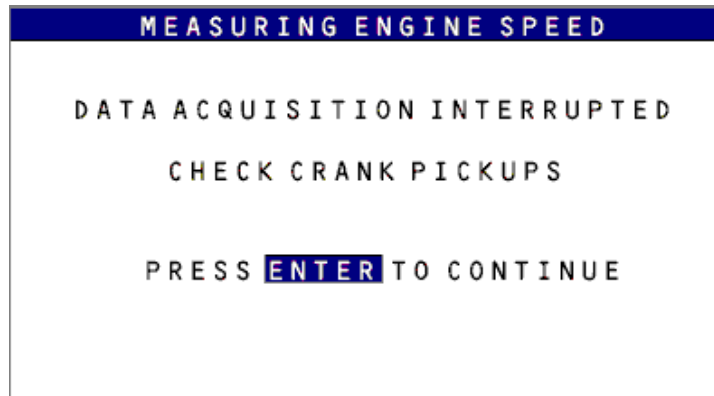
## CHAPTER 5 - Fault Messages

The Doctor instrument will give fault messages under certain conditions.

### 5.1 Crank Pickup Faults

If the crank pickup or pickups are not giving pulses when a reading is being taken, the screen will freeze. This may happen during a measurement or during CRANK SETUP.

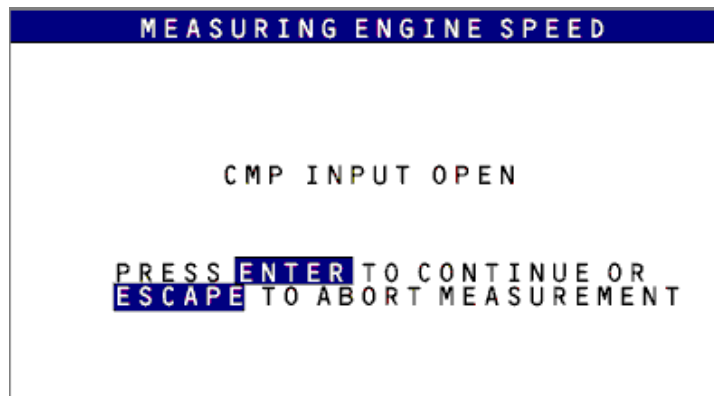
In either case, pressing **[ESC]** will abort the reading. The following screen will appear.



Press **[ENT]** to return to the MAIN screen.

### 5.2 Pressure Sensor Faults

If the instrument cannot detect a pressure sensor during normal reading, the following screen will appear.



Press **[ENT]** to return to the MAIN screen.

## Chapter 5 – Fault Messages

---

If the instrument cannot detect a pressure sensor during normal reading, the following screen will appear.

```
UTILITIES SCREEN
MEASUREMENT MODE  AVERAGED
READ P MAX
CRANK SETUP
CLEAR MEMORY
EDT ENGINE NAMES
SYSTEM RESET
BATTERY LEVEL     5.95V
DISPLAY MODE      NORMAL
SERIAL TRANSFER   NORMAL
OPERATING MODE    NORMAL

      CMP INPUT OPEN
PRESS+HOLD ESC TO CANCEL
```

## CHAPTER 6 - Installation of Flywheel Pickups

### 6.1 Introduction

For correct operation of the Doctor system, a signal from the flywheel is required to give engine speed. This signal is also used to provide instantaneous angular position.

In single flywheel pickup arrangements, each rev is divided into small equal intervals. For example, to achieve a resolution of 1°, each rev is divided by 360. This type of pickup is referred to as TDC ONLY.

For higher accuracy on 2-stroke engines where the speed can vary slightly during each rev, in addition to a TDC pickup, a second pickup senses the teeth. Each tooth provides a secondary reference and tracks the speed of the flywheel more accurately. This arrangement is referred to as DUAL.

There are two main types of pickup used. These are Optical and Inductive.

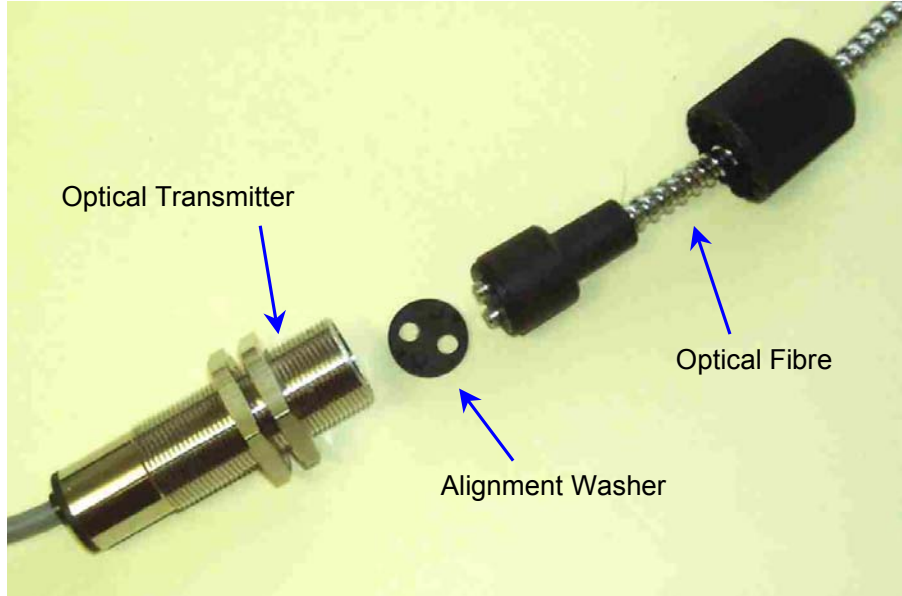
An optical pickup is used for maximum portability and is easily moved from engine to engine. These use a signal reflected back by a piece of reflective tape attached to the flywheel. With these pickups, the reference angle may need to be adjusted for each set of readings if the pickup is positioned differently or if the reflective tape needs to be replaced.

Inductive pickups are immune to oil and dirt and are used for longer term regular measurement of engines. They sense the presence of metal and a bolt is normally used as the TDC ONLY reference, while DUAL systems use a bolt for the TDC reference and the flywheel teeth as the secondary reference. The permanent fixing of these pickups ensures a consistent reference to flywheel position.

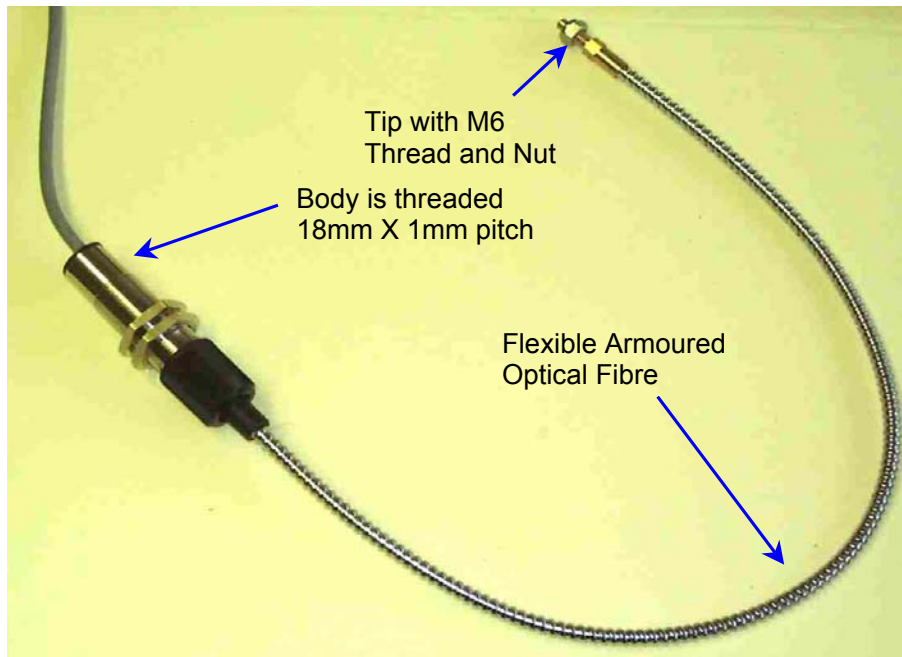
The pickups are powered by the Doctor instrument when connected and switched ON. There is a LED on the rear of each pickup that illuminates when it is ON and metal is within range.

## 6.2 Optical Pickup Installation

The optical pickup has two main parts – the optical transmitter (OCP-2) and the optical fibre (OFE-1). There is an alignment washer between the two parts; this is glued in position by Icon to prevent it being lost.



Flexible Armoured Optical Fibre



The unit is normally kept assembled.



## Chapter 6 – Installation of Flywheel Pickups

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Optical pickups should be firmly held in place with a bracket. The distance from the optical fibre tip to the target tape should be as in the following table.

| Optical Pickup Configuration    | Minimum Separation | Maximum Separation |
|---------------------------------|--------------------|--------------------|
| With Optical Fibre Extension    | 25mm               | 120mm              |
| Without Optical Fibre Extension | 50mm               | 250mm              |

It is recommended that the optical fibre is always used as the installation is then not sensitive to the orientation of the device. If only the main body of the optical pickup is used, the two lenses in the end of the body should always be kept in the same orientation relative to the flywheel for each set of readings.



In the installation above, the optic fibre is held in a small bracket that is clamped with a G-clamp to the flywheel housing. The gap where the engine's TDC pointer is placed has been used in this case. Axial or radial installation will work equally well. The reflective tape can be clearly seen on the flywheel, just under the end of the optical fibre.

In some installations, engines have the optic fibre mounted permanently on each engine (usually on the auxiliaries). In these cases, a bracket should be installed instead of using the clamp in the picture above. The fibre and its connection are then left in place and the main body of the optical pickup attached prior to taking a set of readings.

### 6.3 Inductive Pickup Installation

#### TDC ONLY pickup

The inductive pickups used have a threaded body and two securing nuts. The thread pitch is 1mm on the pickups irrespective of diameter. A 12mm diameter pickup is shown in the drawing below.



The pickup has a lamp on the rear of the body which will illuminate when the pickup is connected to the Doctor instrument and when metal is within the sensing range.

For TDC ONLY operation, the pickup must sense a single marker on the flywheel. This may be positioned either axially or radially.

The optimum sensing gaps and target sizes are shown in the table below.

| Pickup Size | Ideal Gap (range) | Min Target Diameter | Min Target Height |
|-------------|-------------------|---------------------|-------------------|
| 18mm        | 3mm (2-8mm)       | 20mm                | 8mm               |
| 12mm        | 2mm (1-5mm)       | 15mm                | 5mm               |
| 8mm         | 1mm (0.5- 3mm)    | 12mm                | 3mm               |

The pickup should be mounted on a sturdy bracket, ideally attached to the engine structure. In some cases it is acceptable to use the flywheel guard as a mount for the pickup. Some examples of installations are shown below.

## Chapter 6 – Installation of Flywheel Pickups

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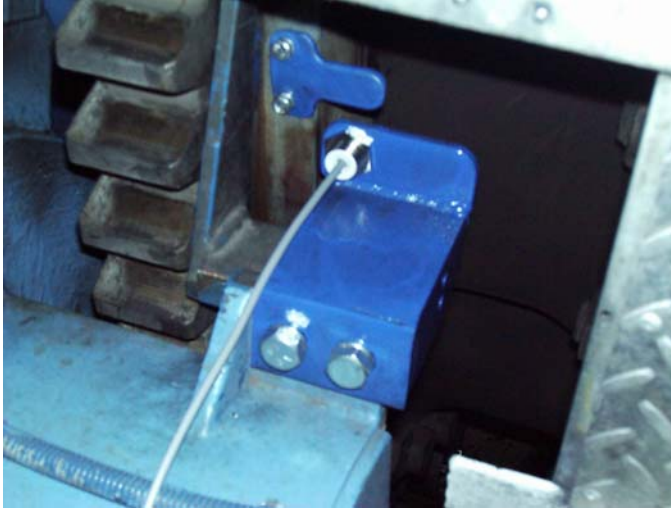
Typical installation showing a sturdy bracket attached to the engine. The marker bolt in the flywheel is not visible here.

In this example, the marker bolt in the flywheel is clearly visible next to the inductive pickup.



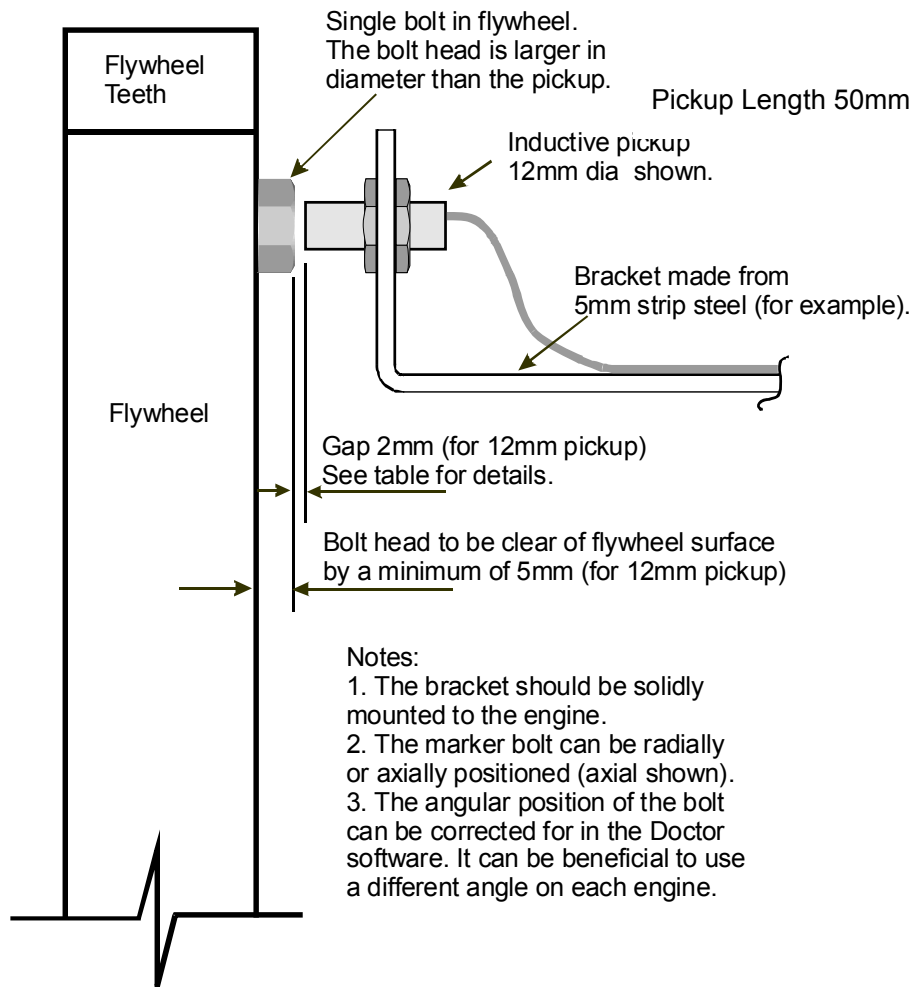
Here is an example of an inductive pickup that has been fitted directly to the flywheel guard. This method is often used on smaller engines. The guard should be of the type that is rigidly attached to the engine.

## Chapter 6 – Installation of Flywheel Pickups



In this case, it was not convenient to put a target bolt in the flywheel so a marker tab was attached instead. Any metal marker may be used; it does not necessarily have to be a bolt.

Shown below is a schematic, outlining the basic dimensions for a TDC ONLY axial pickup installation using a 12mm pickup. For 18mm pickups please refer to the table above.



## Chapter 6 – Installation of Flywheel Pickups

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### DUAL pickups

When DUAL pickups are used, one of the pickups senses the flywheel teeth, the other senses a single marker on the flywheel. This single marker is normally a bolt head of larger size than the pickup.

DUAL pickups are used to minimise the effect of small variations in speed during each rev of the engine. By sensing each tooth position, the Doctor is able to track these speed variations and compensate for the small changes in speed.

The Doctor automatically counts the flywheel teeth for you; there is no need to count them.

Normally, 18mm diameter pickups are supplied for DUAL pickup installation. This type of set-up is used mainly on 2-stroke engines.

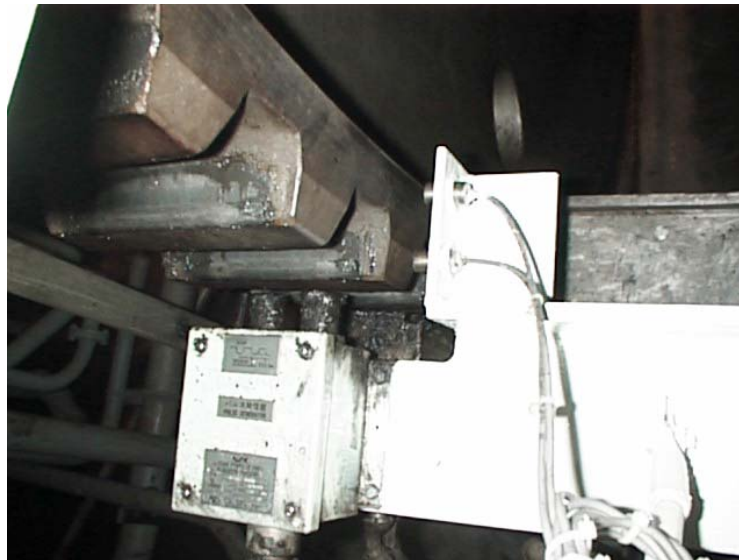
The gap settings and target sizes required for the pickups are shown below:

| Pickup Size | Ideal Gap (range) | Min Target diameter | Min Target Height |
|-------------|-------------------|---------------------|-------------------|
| 18mm        | 3mm (2-8mm)       | 20mm                | 8mm               |
| 12mm        | 2mm (1-5mm)       | 15mm                | 5mm               |

The pickups should be positioned at least 50mm apart to avoid the risk of cross talk between them.

The flywheel teeth pitch should be at least 5 times the diameter of the pickup used.

Some examples of typical installations are shown below.



Here a single bracket supports both pickups.

## Chapter 6 – Installation of Flywheel Pickups

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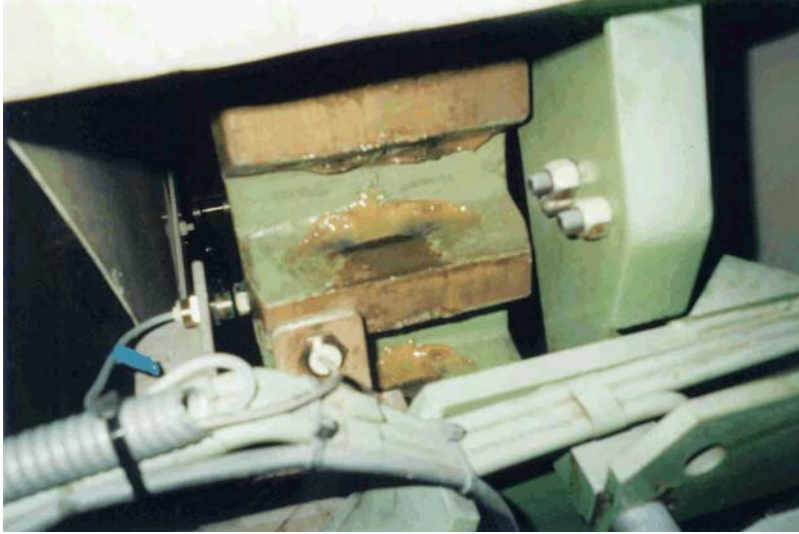


In this case, two brackets have been used, one for each pickup.



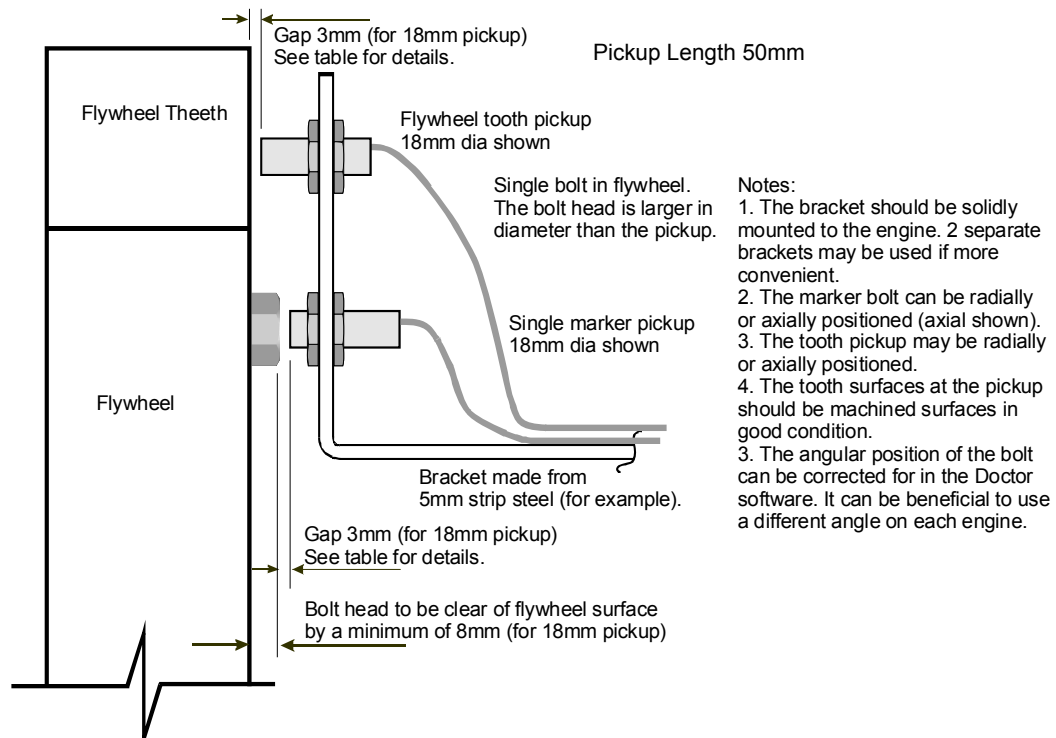
This installation used a single bracket that was split at the end to position the pickups. The marker bolt can be seen screwed into the flywheel just above the TDC (upper in picture) pickup.

## Chapter 6 – Installation of Flywheel Pickups



The tooth pickup can be either axial or radial.

The schematic below shows a typical installation of DUAL pickups using a single bracket.



## 6.4 Troubleshooting the Crank Pickups

Inductive and optical pickups are fitted with LED's which will operate when the pickup is sensing its target. With the pickup(s) connected to the EPU and the EPU switched on, the first test is with the engine stationary to ensure that the pickups are operating and their LED is illuminated.

Once this has been checked, the next test is with the engine running and using the CRANK SETUP function in the UTILITIES screen. The operation of this is described in the section on the UTILITIES screen.

The most common faults found are:

### TDC Only Operation

|                          |   |
|--------------------------|---|
| RPM is double expected.  | Two TDC markers on flywheel                       |
| RPM too low or unsteady. | Unreliable signal – check gap, pickup and marker. |
| RPM too high.            | Pickup too close to flywheel.                     |

### Dual Operation

|   |  |
|---|--|
| RPM is double expected.                                   | Two TDC markers on flywheel.   |
| RPM too low or unsteady.                                  | Unreliable signal – check gap, pickup and marker.  |
| RPM too high.   | Pickup too close to flywheel.  |
| RPM steady but number of teeth low and or unsteady.       | Pickup too far from flywheel teeth. Check that target diameter is machined and there is no run-out on the flywheel.  |
| RPM steady but number of teeth too high and /or unsteady. | Pickup too close to flywheel teeth. Check target diameter is machined and free of burrs or dents.  |
| Max tooth variation > 3% and RPM and No of teeth steady.  | Teeth probably worn or damaged – move pickup to a more uniform diameter on teeth or revert to TDC only operation.  |
| RPM correct but tooth reading fails at higher RPM's.      | The gap between the tooth readings is insufficient. Move the tooth pickup to a larger diameter where the gaps are larger or use a smaller diameter pickup with a higher response. See the section on Performance of Inductive Pickups below. |



### 6.5 Performance of Inductive Pickups

Inductive pickups have a maximum frequency at which they can trigger. This is no problem for TDC pickups but can become important on flywheel teeth.

The required frequency for an engine can be calculated by the following formula:

$$\text{Frequency (kHz)} = \text{No of teeth on flywheel} \times \text{RPM}/60000$$

The frequency capabilities of the available pickups are:

| Pickup Diameter | Max Frequency |
|-----------------|---------------|
| 18mm            | 1kHz          |
| 12mm            | 2kHz          |
| 8mm             | 5kHz          |



## CHAPTER 7 - Electrical Connections

### 7.1 Channel Inputs

The DK-2 has a single pressure input channel and the DK-2/FV has twin channels. The channel inputs are standard TNC connector styles. These are two wire connectors i.e. power/signal and ground.

Each input is a standard ICP transducer type. The signal wire carries a constant 3.6mA which powers the transducer. The transducer outputs a voltage which moves positively and negatively around a quiescent voltage. The quiescent voltage is usually around 9-11V. The transducer power is derived from a 24V supply in the EPU which means that large voltage swings can be accommodated.

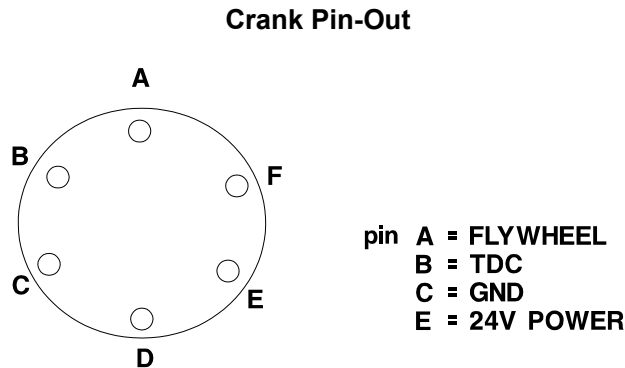
The voltage derived from the transducer swings around the quiescent voltage. This is then AC coupled to enable the signal to be referenced to ground. To avoid this AC coupling causing offset errors when a dynamic signal is applied, a very long time constant (tens of seconds) is used.

Any ICP transducer compatible with constant current power sources can be used.

#### Crank Interface

The two crank inputs accept CMOS/TTL (5V) logic inputs. The crank pickups produce these types of signal. If an alternative encoder to the standard pickups is used, then it must produce CMOS/TTL level pulses.

The pin-out of the crank connector is shown below.

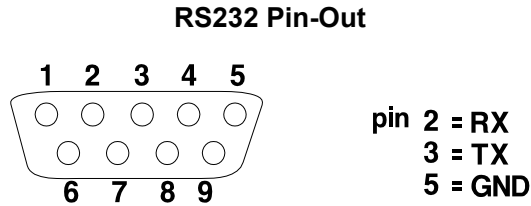


## Chapter 7 – Electrical Connections

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### RS232

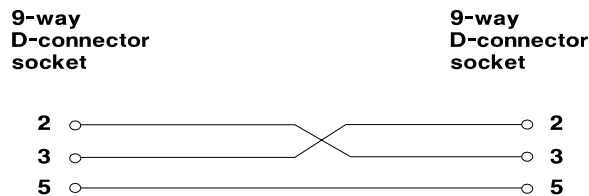
Only 3 wires are required on the RS232 cable, namely RX, TX and GND. The pin-out is shown below.



For connection to the 9-pin connector on a PC computer, a cable as shown below is recommended.

### EPU/PC RS232 Cable

#### RS232 Cable Connections



### Power

The EPU can be powered from its internal rechargeable battery pack or from mains power using the charger supplied. The charger can take any input voltage in the range 100 to 240Vac and 50 or 60Hz. Three different types of power cord are supplied, namely UK, US and Euro. These cover virtually any mains source encountered in the world.

The DC output of the charger is rated at 9V, 3A. The connection is shown in the diagram below.



If the charger supplied is lost, it is possible to use a supply as per the above rating and connection to charge the instrument. The dc plug is a standard type, the outer cylinder diameter being 5.5mm and the inner diameter being 2.5mm.

## CHAPTER 8 - Technical Specification

### Inputs

|                             |   |
|-----------------------------|---|
| No. of Channels DK-2        | 1   |
| DK-2/FV                     | 2   |
| Input Sensitivity Range     | 90dB  |
| Channel Input (per channel) | ICP 3.6mA self powered, two-wire<br>(24V nominal) |
| Input Voltage Range         | +/-5V   |
| Transducer Time Constant    | 33 seconds (auto-zero at switch on)               |
| Sampling Rate               | Variable to 8kHz                                  |

### Crank Synchronisation

|                          |  |
|--------------------------|--|
| No. of Channels          | 2  |
| Channel 1 Input          | Once-per-rev   |
| Channel 2 Input          | N-per-rev (variable) (automatic count of N per<br>rev) |
| Channel 2 Multiplication | Variable to x 255                                      |
| Multiplier Function      | Digital, constant phase                                |
| Angular Resolution       | 2°, 1°, 0.5°, 0.2°, 0.1°                               |
| Averages                 | 1-100 engine cycles per cylinder                       |

### User Interface

|                    |                                     |
|--------------------|-------------------------------------|
| Display Type       | High contrast, back-lit graphic LCD |
| Display Resolution | 240 x 128 pixels                    |
| Keypad Type        | 16-way sealed rubber mat            |
| Selections         | Menu driven, by inverse video       |

### General

|                  |  |
|------------------|--|
| Weight           | DK-2 and DK-2/FV - 4.5 kgs approx.               |
| Dimensions       | DK-2 and DK-2/FV - 35cm x 24cm x 15cm<br>approx. |
| Sealing          | IP67 lid closed, IP65 lid open                   |
| Serial Interface | RS232, to 9600 Baud                              |

### Power

|                         |   |
|-------------------------|---|
| Type                    | 9V external power supply or internal<br>rechargeable battery                |
| Battery Recharge Time   | 2.5 hours approx.   |
| Battery Charge Method   | Intelligent fast charge, reducing to trickle when<br>battery fully charged. |
| Battery Charge Duration | 15 hrs with one transducer (approx.)<br>12 hrs with 2 transducers (approx.) |
| Mains Input             | 100-240V AC<br>50-60Hz  |

Specification is subject to change without notice.

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