Plessey PS25003 EPIC Demonstration Kit.



Demonstration Kit Standard Components

PS25003

- Control and interface box (CIB).
- Control and interface box software (download from website).
- USB cable.
- 2xPS25013 connector cables.
- Flying lead (2m long), 4mm plug to crocodile clip.
- Conductive sheet.
- User guide.

Demonstration Kit Sensor Options

The PS250003 is supplied with a choice of one of the following options:

- 2x PS25101 sensors, or
- 2x PS25102 sensors, or
- 2x Single channel demonstration boards with EPIC sensors*, or
- 1x Dual channel demonstration board with two EPIC sensors*

* *Various EPIC sensors are available on these demonstrator boards.*

User Guide Contents

1.0	Introduction.	Page	2
2.0	The EPIC sensors.		2
3.0	The Control and Interface Box.		5
4.0	The Control and Interface Box Software.		7
	4.1 System Requirements		7
	4.2 Software Installation		7
	4.3 Software Use		7
	4.4 Software Shutdown		14
5.0	Example applications.		15
	5.1 Obtaining an electrocardiogram (ECG) signal		15
	5.2 Obtaining other physiological signals		16
	5.3 Non-contact ECG		17
TERMS and CONDITIONS			20

1.0 Introduction

The EPIC technology provides active electric potential sensors that may be used in a range of applications.

This demonstration unit comprises a pair of EPIC active sensors and a Control and Interface box (CIB). It is a flexible system that may be used to explore a range of applications from electrophysiological signal detection such as ECG (EKG) and EEG through to local electric field detection for applications such as motion sensing.

2.0 The EPIC sensors

The demonstration sets are supplied with either:

- 2x PS25101 sensors, or
- 2x PS25102 sensors, or
- 2x Single channel demonstration boards with EPIC sensors*, or
- 1x Dual channel demonstration board with two EPIC sensors*

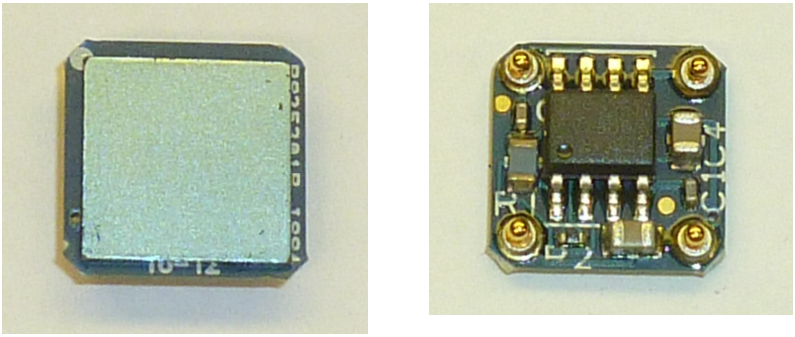
  * *Various EPIC sensors are available on these demonstrator boards*

PS25101 and PS25102: These are metal body sensors. Each is terminated by a 1.5m cable and a four pin DIN plug. The DIN plug attaches directly to the inputs of the PS25003 Control/Interface box. This sensor style is depicted below:



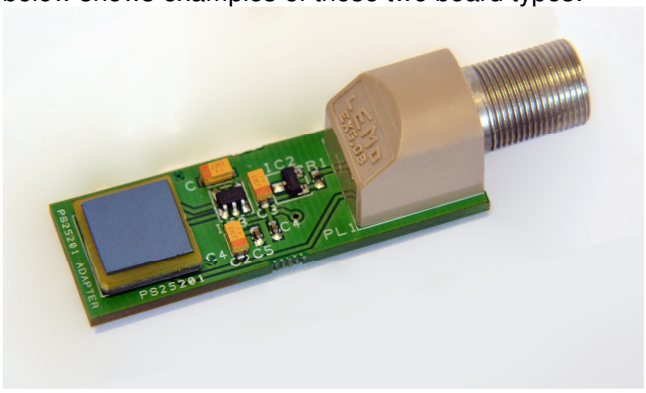
PS25101 or PS25102 Metal Body Sensor Showing Front and Back, Cable and Plug

The alternative sensor type to the metal body sensor is the so called 'Compact Sensor'. An example is shown in the images below:

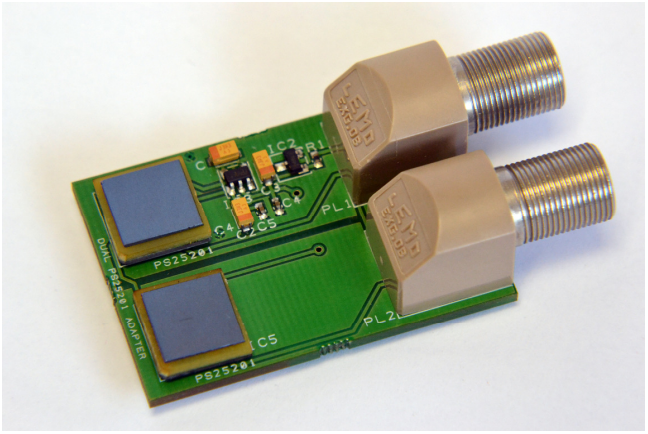


PS25201B Compact Sensor Showing Front and Back

These compact sensors are intended for surface mount in a finished system. This style of sensor is not directly suitable for connection to the Control/Interface Box and so these sensors are supplied on small demonstration boards that are terminated by a robust socket. Single channel and dual channel boards are available. The image below shows examples of these two board types:



Single Channel Demonstration Board Carrying a Compact Sensor



Dual Channel Demonstration Board Carrying Two Compact Sensors

The demonstration boards are connected to the Control/Interface Box by two PS25013 cables (supplied). These are terminated by a four pin DIN plug that attaches directly to the inputs of the PS25003 Control/Interface box.

The details of the sensors and demonstration boards is summarised in the table below:

plessey semiconductors

Sensor Options

Supplied Sensor	Supplied Quantity	Channels	Body Style	Mounted sensor	Sensor Type	Freq. Range (-3dB)		Voltage Gain	Termination	Supplementary Component
						Lower	Upper			
PS25101	2	Single	Metal	N/A	Contact / non-contact	200mHz	10kHz	50	Cable + DIN	
PS25102	2	Single	Metal	N/A	Contact / non-contact	200mHz	20kHz	10	Cable +DIN	
PS25012A1	2	Single	Demo board	PS25201B	Contact / non-contact	200mHz	10kHz	50	Socket	PS25013 cables *(supplied)*
PS25012B1	1	Dual	Demo board	PS25201B	Contact / non-contact	200mHz	10kHz	50	Socket	2x PS25013 cables*(supplied)*
PS25012A3	2	Single	Demo board	PS25203B	Contact / non-contact	200mHz	20kHz	10	Socket	PS25013 cables *(supplied)*
PS25012B3	1	Dual	Demo board	PS25203B	Contact / non-contact	200mHz	20kHz	10	Socket	2x PS25013 cables*(supplied)*
PS25014A1	2	Single	Demo board	PS25401B	Non-contact	200mHz	20kHz	50	Socket	PS25013 cables *(supplied)*
PS25014B1	1	Dual	Demo board	PS25401B	Non-contact	200mHz	20kHz	50	Socket	2x PS25013 cables*(supplied)*

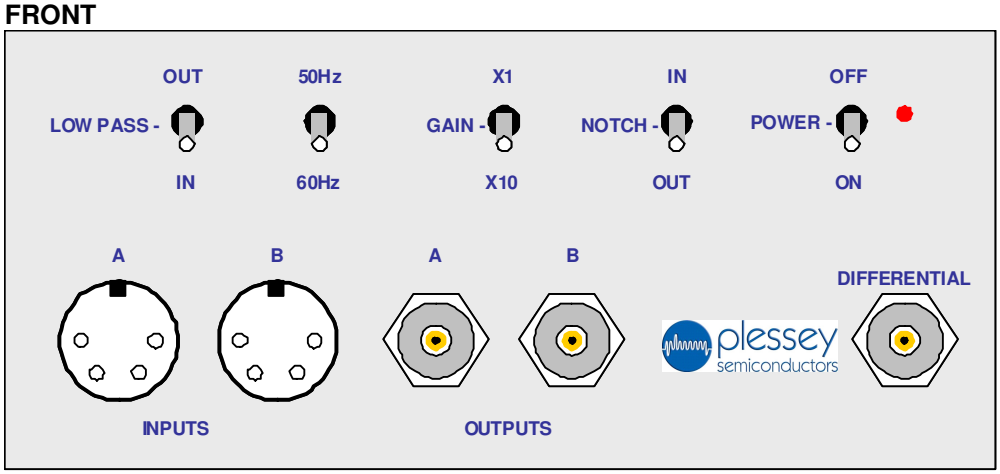
3.0 The Control and Interface Box (CIB)



Control and Interface box

The Control and Interface box (CIB) provides an easy interface for the evaluation of EPIC sensors with both analog outputs and also digitised output (USB) using the internal data acquisition (DAQ) card. The front and back panels are detailed below:

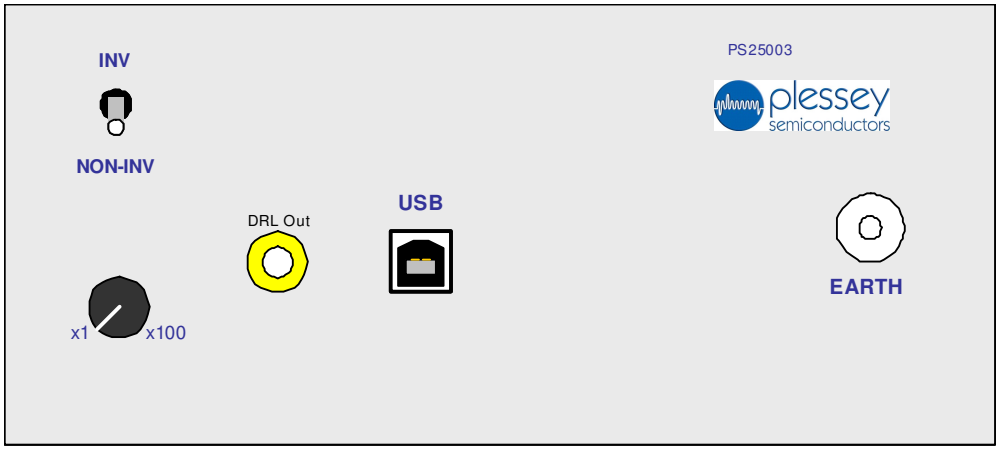
FRONT



Control and Interface box front panel

- Power and signal socket for two sensors (channel A and B).
- Switchable gain of x1 and x10.
- Switchable low pass filtering
- Switchable notch filtering, used in conjunction with,
  - Notch filter frequency selector, 50 or 60Hz
- Analogue outputs for each sensor (channel A and B)
- Analogue difference output for the two sensors (channel A - channel B)

REAR



Control and Interface box rear panel

- Earth terminal
- Driven Right Leg (DRL) circuit
  - Phase selector
  - Gain control, x1 to x100
  - 4mm output socket
- A USB 2.0 interface

A short specification of the control and interface box is:

Parameter		min	typ	max	Units	Notes
Supply voltage – USB 2.0			5.0		V	
Low pass filter			30		Hz	
Notch filter	frequency		50/60		Hz	
	attenuation		30		dB	
	Q		4			
Analogue output impedance			10		Ω	
Data acq'n	resolution		12		bit	
	Sampling rate			10	kS/s	
	Output rate			150	Hz	

The power for the internal electronics of the box is provided by the data acquisition card. This is a National Instruments card, USB-6008. The internal electronics can only be powered by connection of the USB port to a computer with the driver for the DAQ installed.

4.0 The Control and Interface Box (CIB) Software

The CIB requires a connection to a laptop with the associated CIB software installed. The protocols provided by the software enable the internal data acquisition card within the CIB and this, in turn, provides power to the other electronics within the box.

The enabled USB connection is also required if the analogue output signals from the box are to be sent to an oscilloscope since the acquisition card is the only method of applying power to the CIB electronics.

The CIB software provides a rolling oscillogram and a chart recorder capability.

4.1 System Requirements

The system requirements for a Windows/PC system are:

Processor	Pentium III/Celeron 866 MHz or equivalent
RAM	256 MB
Screen Resolution	1024 x 768 pixels
Operating System	Windows 7/Vista/XP/Windows Server 2003 R2 (32-bit)/Windows Server 2008 R2 (64-bit)

4.2 Software Installation

The software can be downloaded from the customer portal found on the internet at:

http://www.plesseysemiconductors.com/

Download and install the software before connection of the CIB to the computer.

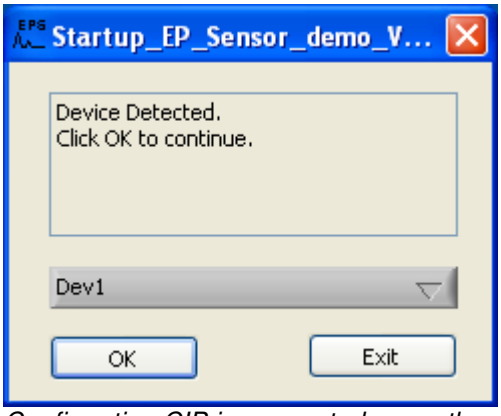
Follow the on-screen installation instructions.

After installation has been performed a reboot of the system is required to complete the installation process.

4.3 Software Use

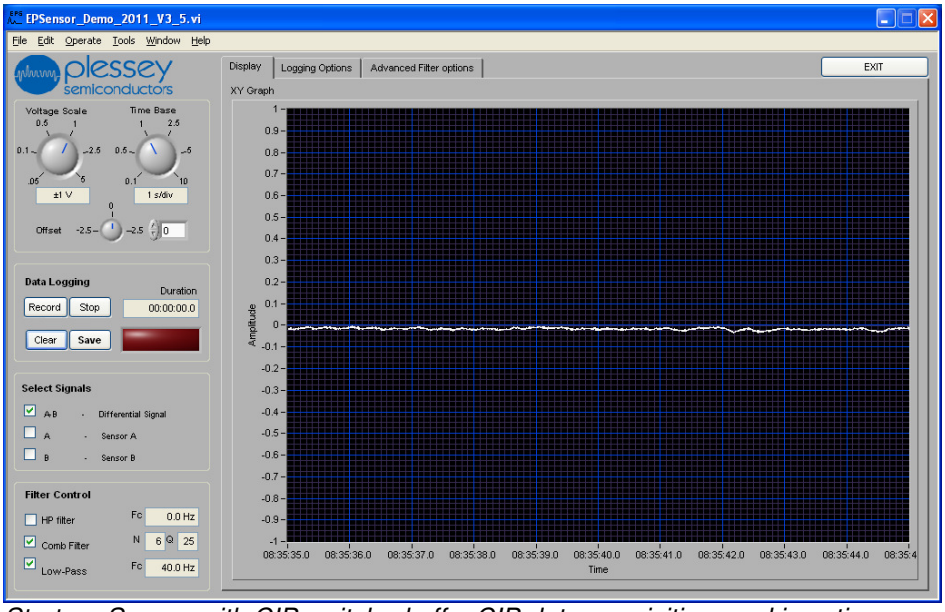
Once the software is installed the CIB may be connected to a USB socket. The CIB will be automatically detected and the driver loaded.

The software may now be started. Provided the CIB is connected and the drivers loaded then the software will display the box:



Confirmation CIB is connected correctly - Click "OK".

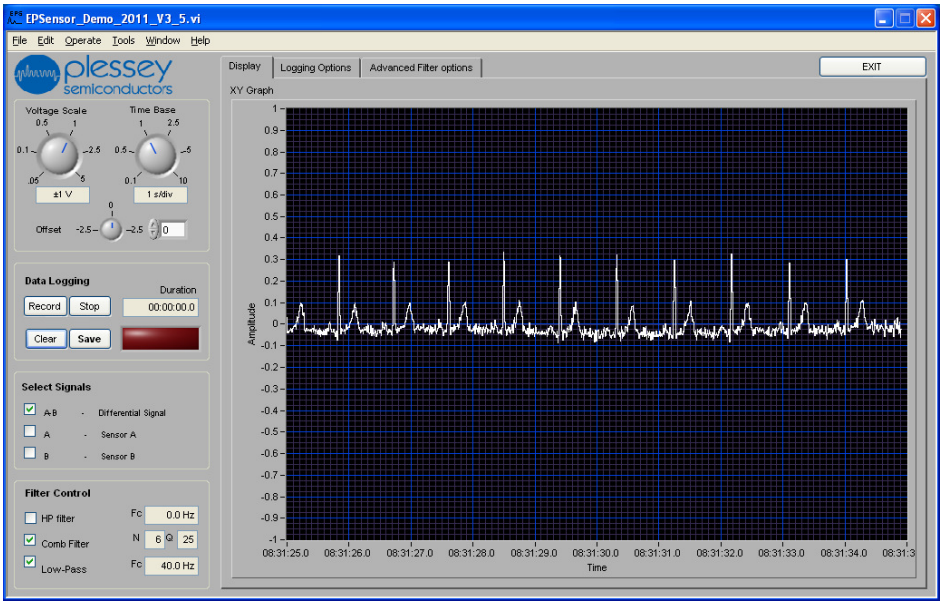
The soft oscilloscope and data logger will now be displayed:



Start-up Screen with CIB switched off – CIB data acquisition card is active.

The CIB can now be switched on using the power switch on the CIB front panel. The red power LED should light.

After settling an oscillogram should be generated. The example below shows a typical difference trace (A-B) that will be obtained from a sensor held in each hand:



Initial Signal (ECG type) generated by two EPIC sensors, left and right hand.

The software has the following controls:

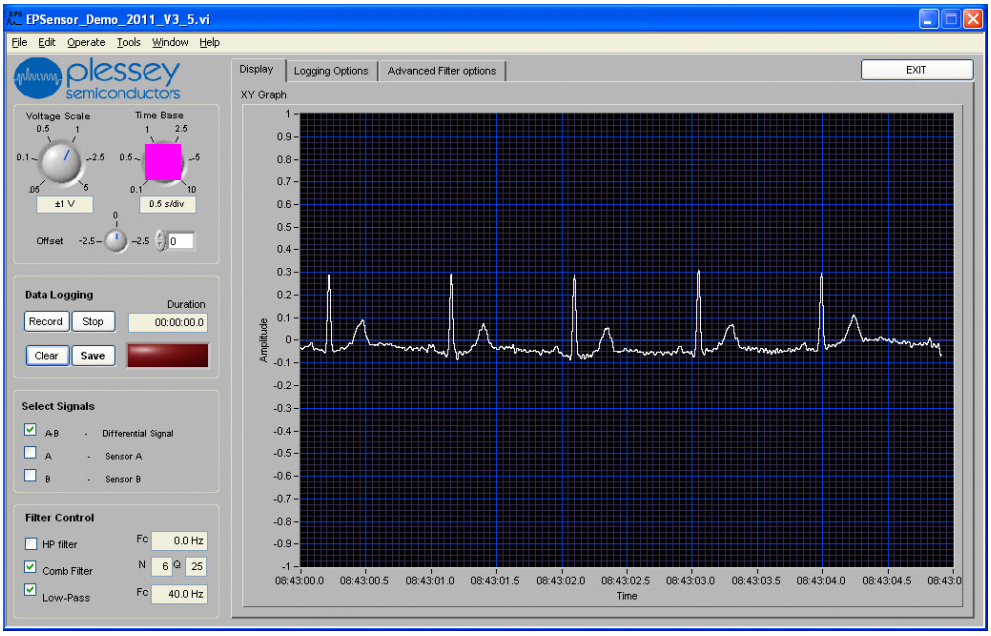
- Voltage Scale
- Time Base
- Offset

and the following features:

- Data Logging
- Select Signal
- Filter Control

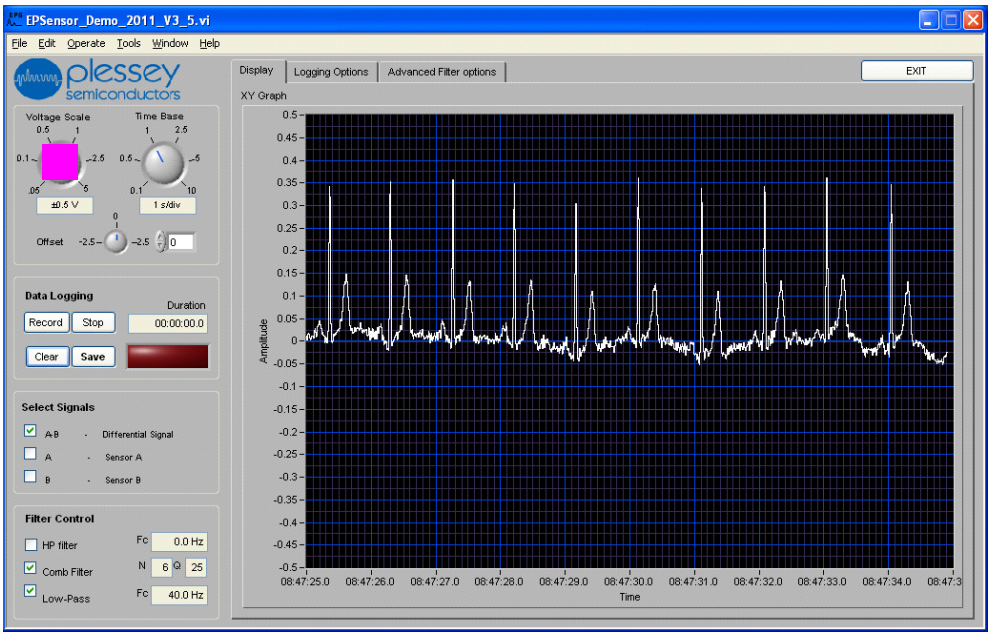
Time Base

This may be adjusted to increase or decrease the time (x) axis of the oscillogram:



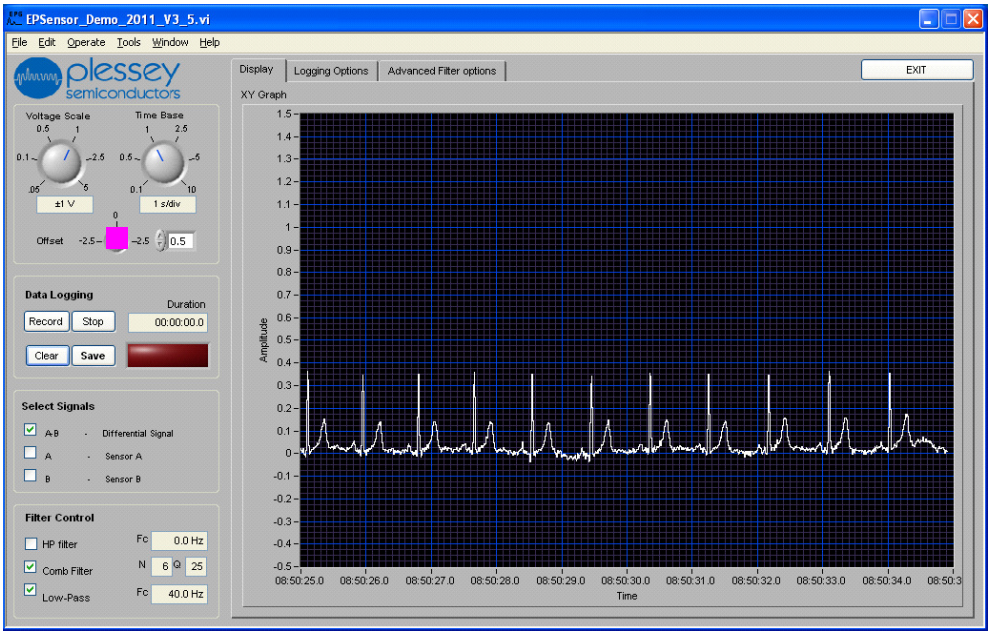
Voltage Scale

This may be adjusted to increase or decrease the voltage (y) axis of the oscillogram:



Offset

This may be adjusted to apply an offset to the voltage (y) axis of the oscillogram:



Select Signals

The Select Signals check boxes allow the displayed signals to be selected. The signal options are:

- A-B This is a difference signal between the two sensors, A and B.
- A This is sensor A signal.
- B This is sensor B signal.

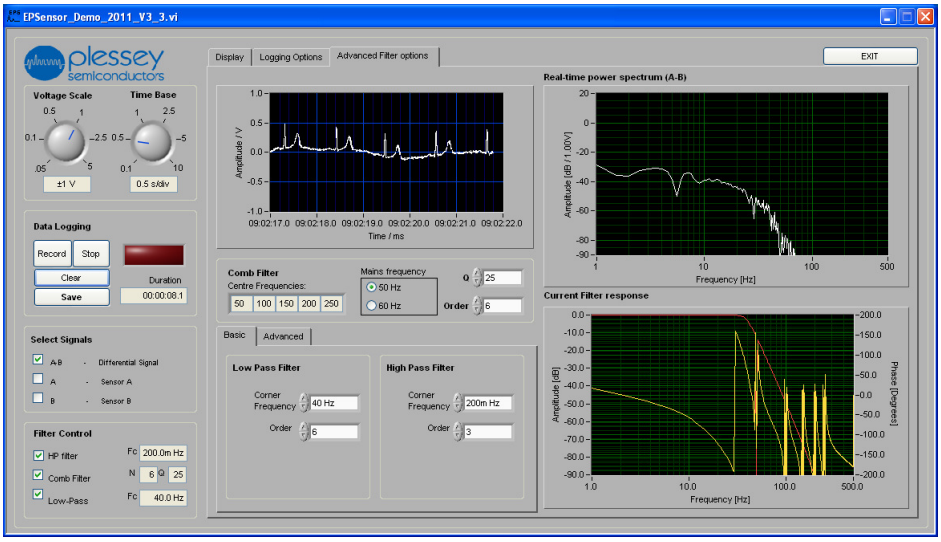
None, one, two or all may be selected.

Filter Control

The Filter Control check boxes allow the following digital filters to be applied and modified:

- High Pass (HP) filter
- Comb filter
- Low Pass filter

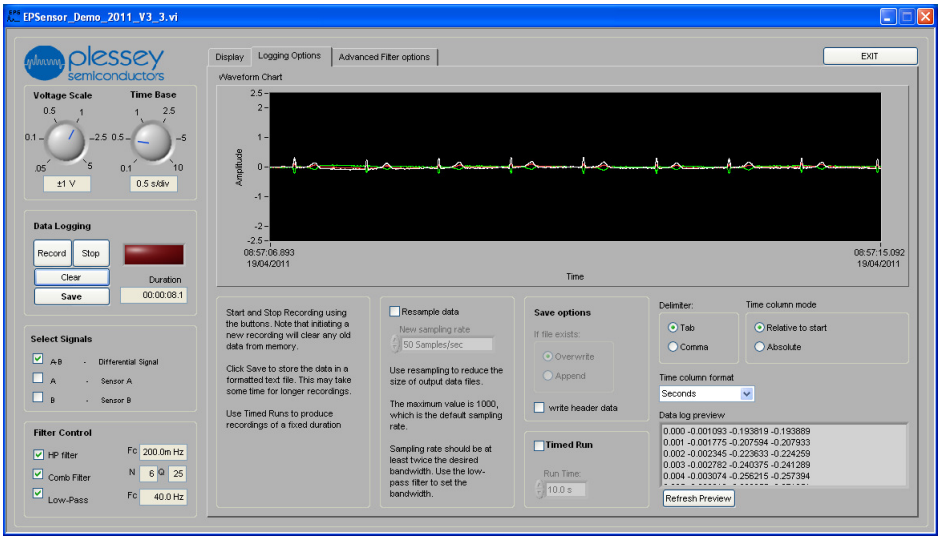
The effect of these filters may be further modified or adjusted using the Advanced Filter options tab at the top of the screen:



These filters are applied to the digitised signal by the local processing of the signals in the PC. These controls do not adjust or override the internal filtering options of the CIB.

Data Logging

The data logging controls on the soft front panel of the oscilloscope allow the start, stop, save and clear functions of the data recorder. Further, the Logging Options tab at the top of the screen provides additional control over the data logging function.



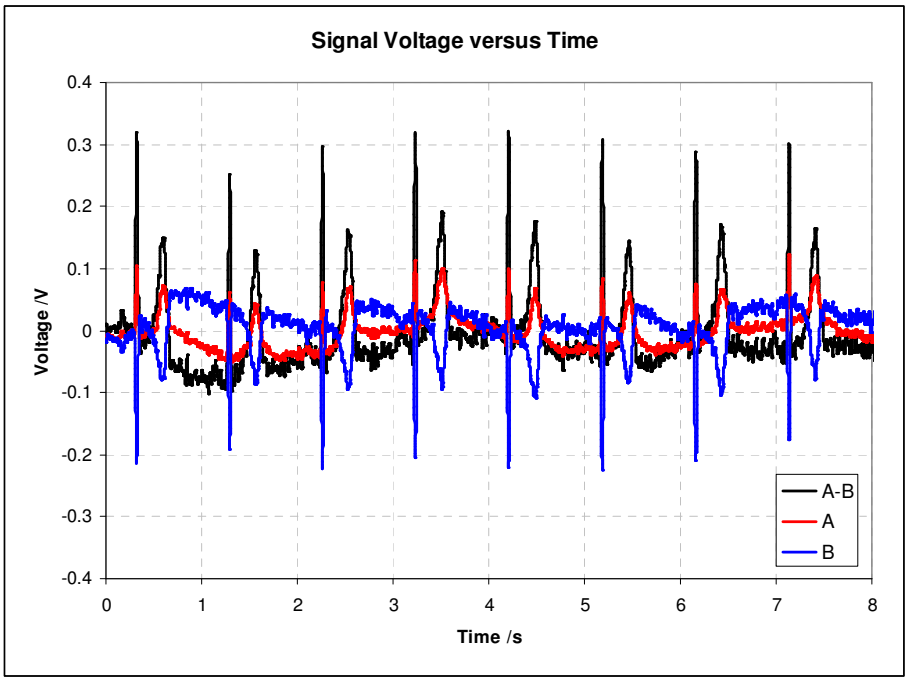
The data can be saved as a text file that is either comma or tab delimited. The data is tabulated in the form:

```
0.000    0.008346      -0.008809      -0.018999
0.001    0.009432      -0.008183      -0.019048
0.002    0.010199      -0.007738      -0.018926
0.003    0.010598      -0.007477      -0.018621
0.004    0.010596      -0.007394      -0.018130
```

The columns represent for following:

Time (s) A-B (V) A (V) B(V)

The data may be opened with a text editor and may be readily processed in a spread sheet. Below are example graphs made in a spread sheet.



4.4 Software Shutdown

The CIB software is closed by use of the EXIT button. Once the software is closed the CIB may be switched off and then the USB connection may be broken.

It is inadvisable to disconnect the USB connection while the CIB software is running.

5.0 Example Applications

5.1 Obtaining an electrocardiogram (ECG) signal:

Start by setting:

- Gain to "x10"
- Low pass "IN"
- Notch filter "IN"

Oscilloscope:

If using an oscilloscope connect the control and interface box differential output to an oscilloscope using a standard BNC cable, set the time base to 0.5secs/cm and Y gain to 0.5Volts/cm dc coupled.

Virtual instrument:

If using the soft virtual instrument then drag the voltage setting to about 1.5, select "Differential A-B" from the channel selection and click on the "Start" button, the time axis should start to scroll.

Switch on the module power and hold one sensor in each hand (hands should be clean and dry) with the tips of the thumbs resting lightly (do not squeeze) on the contact surface of the sensor. It is important that both the violet coloured electrode face and outer metal case of the sensor contact the skin. After a few seconds settling time your ECG should be displayed by the oscilloscope/PC centred on 0 volts. Everyone's ECG is different so you may need to adjust the scope setting/voltage scale for an optimal display; if the ECG appears inverted swap the sensors over to opposite hands. If you now squeeze the sensor between your thumb and forefinger you should still see your ECG but the level of baseline noise will increase noticeably; this is an electromyogram (EMG) signal caused by nerve impulses to the muscles in the forearm. The EMG signal can also be seen more clearly by placing both sensors next to each other on one forearm and then clenching the fist; no ECG signal should be present and the EMG signal level should increase the harder you clench your fist.

It is also possible to detect the ECG signal through clothing if the subject is wearing a shirt that is predominantly made of a natural fibre such as cotton. An ECG can be obtained by holding one sensor over the mid sternum and the other on the left hand side of the chest. The shape of the signal may be different to the finger tip ECG and will change depending on the relative positions of the sensors.

It is possible but not recommended to connect the sensors directly to your own equipment.

5.2 Obtaining other physiological signals:

Start by setting:

- Gain to “x10”
- Low pass “IN”
- Notch filter “IN”

Oscilloscope:

If using an oscilloscope connect the module’s differential output to an oscilloscope using a standard BNC cable, set the timebase to 0.5secs/cm and Y gain to 0.5Volts/cm dc coupled.

Virtual instrument:

If using the soft virtual instrument then drag the voltage setting to about 1.5 select “Differential A-B” from the channel selection and click on the “Start” button, the time axis should start to scroll.

Switch on the module power:

An electrooculogram (EOG) signal can be seen by placing a sensor on each temple, look straight ahead and wait for the output to stabilise then by looking left then right you should see a step response as the eyeball moves. Placing the sensors above and below one eye should enable you to see up and down movement of the eye and also blinking.

It is also possible to detect electroencephalogram (EEG) signals from the head. As these signals are very small, additional amplification and filtering may be needed. By using spectrum analysis in conjunction with the EPS system it has been possible to detect alpha waves within the EEG signal.

It is possible but not recommended to connect the sensors directly to your own equipment.

5.3 Non-Contact ECG on a chair
(extract from Plessey Application Note # 291566)

Start by setting:

- Gain to "x1" (for PS25101 or PS25201/401 sensors) or
- Gain to "x10" (for PS25102 or PS25203 sensors)
- Low pass "IN"
- Notch filter "IN"
- Phase switch "INV" (for all the above sensors)

Connect the DRL output signal to the conductive fabric on the seat of the chair using the flying lead provided.

Place the two sensors on the seat back approximately to the left and right of the spine and mid back.

Virtual instrument:

If using the soft virtual instrument then:

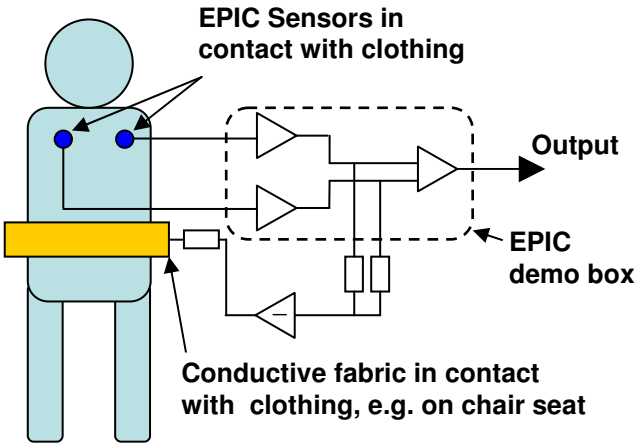
- Select "Differential A-B" from the channel selection.
- Set filters
  - High Pass "IN" 8.0 Hz
  - Comb "IN" 6 – 25 Hz
  - Low Pass "IN" 40.0 Hz
- Voltage scale: 10mV or 50mV
- Time base: 0.5s/div

Start the oscillogram. Adjust the gain of the DRL circuit using the gain control on the back plane of the Control/Interface box. If the gain is too low the ECG signal is lost in the common mode signal and no net signal can be retrieved. If the gain is too high the system becomes unstable. There will be an optimum gain when the differential ECG signal is produced. The soft oscilloscope gain may need to be increased to observe the signal. The position of the sensors may need to be adjusted to obtain the best signal.

Background

EPIC is a capacitive sensor and so does not rely on ohmic contact to the body for measuring bio-electrical signals. It therefore has the ability to measure ECG without direct skin contact. Signals measured on the human body always include a large amount of noise, the major component of this being 50 or 60 Hz power line noise capacitively coupled to the body from the mains electricity supply. Measurements such as ECG depend on being able to extract the small electrophysiological signals from the much larger noise signals.

When using EPIC in "contact mode" for ECG measurement, the subject touches both the capacitive electrode surface and some metal at the system ground directly with the skin. This ground reference allows filtering and differential amplification of signals from two sensors to be effective in removing the mains frequency noise, leaving a high quality ECG signal.



Basic configuration for non-contact ECG measurement including capacitively-coupled DRL" circuit.

In non-contact ECG measurement there is – by definition - no skin contact, and thus no direct connection can be made between the subject's body and the system ground. Some other method of reducing the power line noise is therefore required to enable the ECG signal to be extracted reliably and accurately. One such method utilises an approach very similar to the Driven Right Leg (DRL) system that is used for the same purpose in conventional ECG. In conventional ECG the DRL signal is coupled directly to the patient's skin; in non-contact ECG it is coupled capacitively to the body, through clothing, via a piece of conductive material placed – for instance – on the seat or back of a chair. Capacitive coupling of DRL signals is described by Lim et al [1] and Lee et al[2].

1. Settling time – When a subject first sits in the chair and leans against the EPIC sensors, the changes in electric potential will normally send both the sensors and the DRL circuit into saturation. Because the system contains some large impedances, and hence has some very long RC time constants, settling times of tens of seconds can be needed before a clean ECG signal is seen. During this period the signal can either appear very noisy, or be virtually flat, depending on whether one or both sensors, or the DRL circuit, are "railing". The subject should sit still during this time and wait for the circuit to settle, since continually adjusting position will only make matters worse. Settling times can sometimes be reduced by turning off the power to the demo box for a few seconds.

2. Clothing – Best results have been obtained when the material between the sensors and the skin is one or two layers of cotton material. This is therefore recommended as a starting point for system evaluation. Signals have also been measured successfully through other materials, including a wool-mix sweater and a polyester fleece in addition to two layers of cotton material. Examples are shown in figures 6 and 7. If the key parameter of interest is the "R-R" interval, adjustment of filter settings to reduce or re-centre the signal bandwidth can give significant improvement in signal quality.

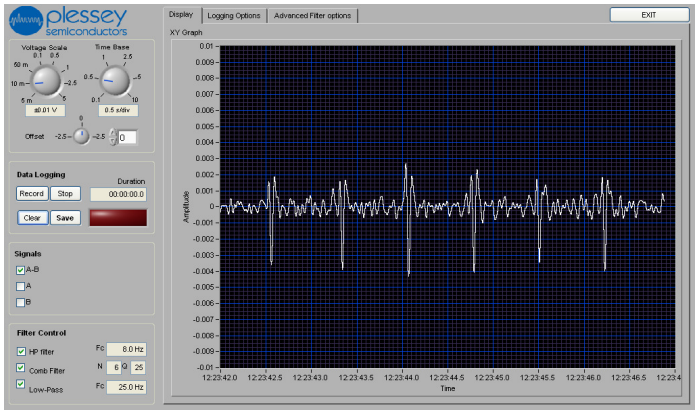
3. Static – Because there is no direct physical contact between the subject and any grounding point, there is no path for any static build up to be discharged. Under most circumstances static build up does not present a problem, but depending on factors including clothing, footwear, flooring,

humidity levels in the air and so forth, static build up can sometimes prevent the cardiac signal from being seen clearly. In this situation the subject should briefly touch something metal connected either to an external ground or to the system ground to discharge the static.

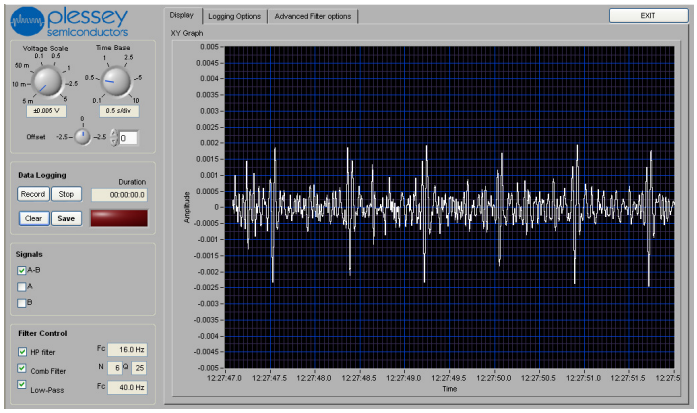
4. Cable shielding – The EPIC demo box grounds the shielding of the sensor cable via the connection between the outer casing of the sensor plugs and the metal surround of the socket on the box. Ensuring that this connection is well made will reduce unwanted noise artefacts from the signal.

[1] YG Lim, GS Chung, KS Park. "Capacitive Driven-right-leg Grounding in Indirect-contact ECG Measurement," 32nd Annual International Conference of the IEEE EMBS Buenos Aires, Argentina, August 31 - September 4, 2010 pp 1250-1253

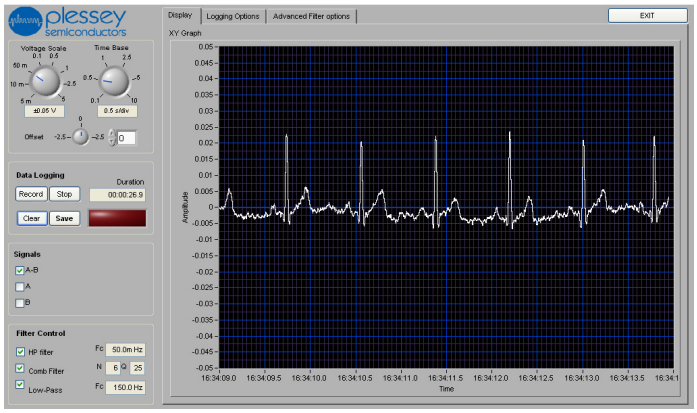
[2] KM Lee, SM Lee, KS Sim, KK Kim, KS Park "Noise Reduction for Non-Contact Electrocardiogram Measurement in Daily Life," Computers in Cardiology 2009;36: pp 493–496.



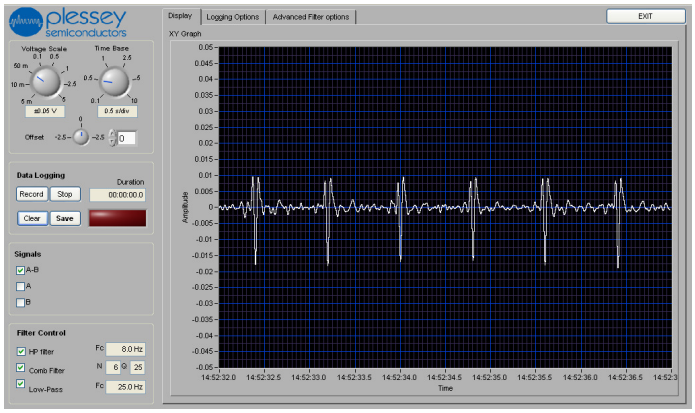
ECG signals measured from a subject wearing a wool-mix sweater over a cotton shirt. Sensors attached to the chair-back were covered with an additional layer of cotton material. Filter settings limit the bandwidth to 8-25Hz. The heart rate can be easily extracted.



ECG signals measured from a subject wearing a polyester fleece over a cotton shirt. Sensors attached to the chair-back were covered with an additional layer of cotton material. Filter settings limit the bandwidth to 16-40Hz. The heart rate can be easily extracted.



Non-contact ECG signals measured through a single layer of cotton clothing, with a capacitively coupled DRL circuit. HP filter corner frequency is 50mHz, LP filter in demo box has corner frequency of 30Hz.



Non-contact ECG signals measured through a single layer of cotton clothing, with a capacitively coupled DRL circuit. Software filters limit the bandwidth to 8-25Hz.

TERMS and CONDITIONS

Use of the EPIC Demonstration Set (“the Set”) is subject to the terms of the Evaluation Agreement (“Agreement”) entered into between the Recipient and Plessey Semiconductors Ltd . The following outlines certain key provisions;

1) DISCLAIMER

The Set is a test product and neither Plessey nor its Licensor the University of Sussex (“Sussex”) makes any representation or gives any warranty or undertaking in relation to it, and so far as permitted by law, all conditions, warranties, representations and other obligations on the part of Plessey and Sussex are excluded. Without prejudice to the generality of the above, no representation, warranty or undertaking is given;

(a) that the Set is of satisfactory quality or is fit for any particular purpose, has been developed with reasonable care and skill, or is safe to use;

(b) that the Set is suitable for monitoring or diagnosing any physiological function, condition or illness;

(c) that the Set has been manufactured or tested in accordance with applicable laws and regulations governing the manufacture and testing of medical devices;

The EPIC Demonstration Set must not, in any circumstances be used , nor data arising from its use be used to inform any decision about the health, welfare, monitoring or treatment of any human being .

2) COPYRIGHT AND CONFIDENTIALITY

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Plessey Semiconductors:

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