Description

The FE-346-CA is a dual channel carrier amplifier for use with inductive LVDT type transducers. Designed for data acquisition and processing applications, the unit is presented as a printed circuit card with amplifier fine gain and balance controls brought to the front edge of the card. Internal jumpers set gain, filter and transducer configuration.

Specification

Oscillator section	Common Oscillator supply	
Frequency	5kHz ±1% Sinewave	
Amplitude	1V, 2V or 3V RMS ±1%, Link Selectable	
Output Drive	1V rms into 20Ω	
	3V rms into 60Ω	
Stability	0.01%/°C.	
Distortion	<0.2%	

Bridge Section

Balance	Front edge control by screwdriver operated potentiometer, jumper selectable shunt or voltage injection balance. Balance resistor mounted on turret lugs	
Completion	Turret lug positions for 1/2 bridge completion resistors. Internal jumpers select full or 1/2 bridge transducers.	

Amplifier section	Two identical amplifiers and filters, each individually configurable	
Gain	Selection	Internal jumper links to give gains from 1 to 50 in 1, 2, 5 steps.
	Vernier	Front card edge control x1 to x2.5.
	Accuracy	Step accuracy ±0.5%. T.C.<50ppm/°C.
	Linearity	Better than 0.01%.
Input	Impedance	>100KΩ single ended (>200kΩ differntial.)
	Offset Voltage	<50μV.
Noise	Input	<20μV pk-pk dc-500Hz
	Output	<1mV rms dc - 500Hz.
Bandwidth		dc - 1000Hz (-3dB)
Output	Voltage	Capability ±10V into 2kΩ, 5000pF max. Offset <±25 mV
Filter	Type	3 pole, preset by plug-in resistor network (5Hz - 1kHz)
	Gain	Unity
	Roll Off	18dB/ Octave, 60dB/decade
	Offset	±5mV
	Characteristic	Butterworth standard, Bessel or Tchebychev to order.
Environment	Temp. Range	0°C to 50°C operating
Physical	Card size	7” x 2.65”. 2u high format (180mm x 67mm).

Specification

Table of Contents Page 1

1 FE-346-CA Amplifier Card Description

The FE-346-CA is a dual channel carrier amplifier and oscillator, complete with filter, for data acquisition and processing. The card has been specially developed to provide high performance at low cost in multichannel applications, and may be applied with Linear Variable Differential Transformers (LVDTs), Electrolevels and other transducers requiring AC energisation.

The FE-346-CA is presented as a printed circuit card with amplifier fine gain and balance controls brought to the front edge. Internal jumpers set gain, filter, oscillator level and transducer configuration.
In the following text, the lower case letters a & b are used to differentiate between the two channels of the amplifier card.

Breakdown of amplifier:-

1. Transducer Oscillator Power Supply
2. Completion system for 1/2 bridge style transducers
3. Pre-Amplifiers
4. Low Pass Filters
5. Output Buffer Amplifiers
6. Synchronisation.

1.1 Transducer Oscillator Power Supply

A high performance oscillator, generates a 5 kHz sine wave with a choice of voltages for transducer energisation. The oscillator draws its current from the system bridge power supply, which must be configured for ±5V.

FE-MM4 System :	±5V Supply set by FE-813-BPSDC
FE-MM4-USB System	±5V Supply set by FE-813-USB
FE-MM8 System	±5V Supply set by FE-810-BPSDC
FE-MM16 System	±5V Supply set by FE-810-BPSDC
FE-MM40 System	±5V Supply set by 2 x FE-810-BPSDC

1.2 Completion for 1/2 Bridge Transducers & Balance System

For half bridge form LVDTs, a pair of internal 1/2 bridge completion networks formed with precise resistors are used to complete external 1/2 bridges using plug links **Half** (one per channel).

Note: Many LVDT transducers will be of the 4 wire form and will require no completion.

For each channel , manual balance is provided by front panel multi turn **balance** potentiometers and associated series resistors. Plug link **VBal** causes the front panel **balance** potentiometer to operate as a voltage offset control. Pug links **Sbal1** and **Sbal2** are not fitted for this mode.

Plug links **Sbal1** and **Sbal2** offer the option of shunt balance as an alternative to voltage offset. The front panel **balance** potentiometer is directly connected to the bridge through a balancing resistor. For each channel, plug links **Sbal1** and **Sbal2** provide a choice of 100kΩ or 20kΩ resistors; i.e. **Sbal1** provides a finer shunt balance control than **Sbal2**. Plug link **VBal** is not fitted for this mode.

1.3 Pre-Amplifiers

The preamplifiers are differential input type featuring low drift and low noise coupled with high accuracy and good common mode rejection. They have in built protection against over voltage and are provided with an input filter to limit high frequency interference. The preamplifier has gain steps of x1 or x10 selectable via jumper links.

1.4 Low Pass Filters

The preamplifiers are followed by low pass filters. The filters are 3rd order Butterworth Sallen-Key designs whose frequency setting is programmed by plug in resistor networks. The filters may be used for noise reduction, or as simple alias protection where the signal is to be A-D converted.

1.5 Output Buffer Amplifiers

The output buffer amplifiers provide additional gain settings x1, x2 and x5. Coupled with the preamplifier gain settings previously described, they enable calibrated gains x1, x2, x5, x10, x20, and x 50 to be set. Vernier gain potentiometers are included. These multi-turn controls give an additional x2.5 maximum and enable coverage between the calibrated gain steps. Note that for reasons of EMC, 'T' form output filters are included; these raise the output impedance to 100Ω.

1.6 Synchronisation

When several FE-346-CA modules are used in the same system, there is the possibility that the unsynchronised sine wave transducer supplies could mutually interfere. This phenomenon is known as 'beating' and can be avoided by locking all the sine waves to a single 'master'. Modules transmit a synchronisation signal optically from their component (top) side, and receive the synchronisation signal at their connector (bottom) side.

In a synchronised system, the master module has jumper links set to **solo** and **master**, and other modules have links set to **slave** and **master**. The master module is located at one end of the set of synchronised modules with the other modules adjacent to one another at the component (top) side of the master module.

In a system with a single FE-346-CA module, jumper links are set to **solo** and **solo**.

2 Configuration of the Module

Refer to 'User Drawing' 949PC for a complete drawing of the printed circuit card and additional configuration information. Note that the circuit board is silk screen idented to aid component location.

Note that throughout this handbook, the 2 channels on the card are referred to as channels "a" and "b".

Important Note: In any system verify that the power supply module is configured for ±5V. The system power supply module may be FE-810-BPSDC or FE-813-BPSDC. Each has a jumper link shown below.

FE-813-BPSDC jumper setting

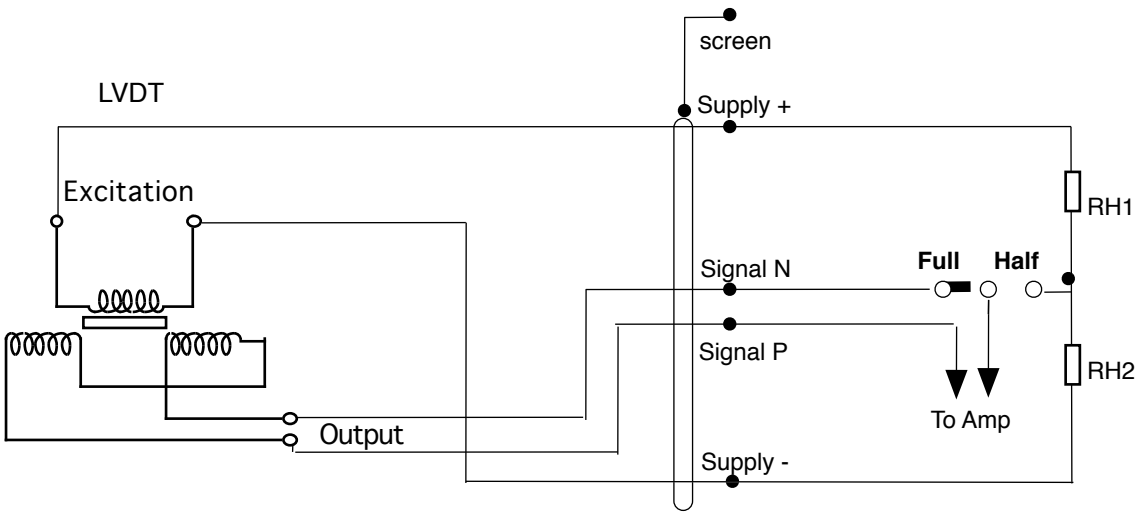
FE-810-BPSDC jumper setting

2.1 LVDT Transducer Configuration

The module will operate with transducers which are either 3 or 4 wire style. 4 wire transducers will usually have two connections for the power supply, sometimes labelled "Input" or "Excitation" . These should be connected to supply + and supply - (AC energisation levels derived from the oscillator). The two signal connections may be identified as "Output" and these should be taken to Signal P and N inputs of the amplifier (see section 2.1.2 for connections to the 7 pin input connector).

2.1.1 Four Wire LVDT Connection

Fit Jumper Links **'Full'** (1 per channel). Connections shown apply to either channel. The full bridge connection requires no completion resistors either internal or external to the amplifier. Ensure that balance jumper links **VBal** are fitted (1 per channel).

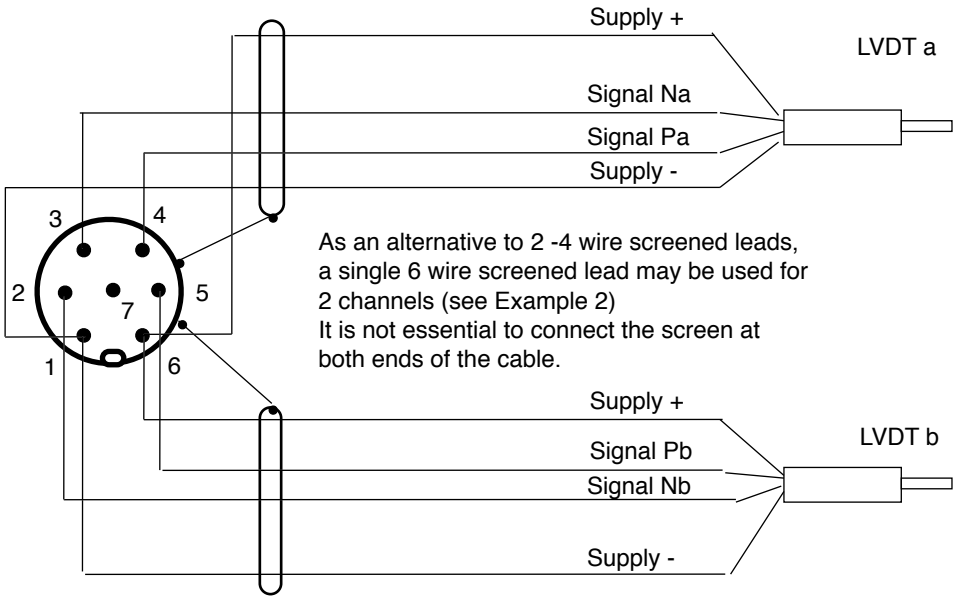


2.1.2 Recommended Connection for Four Wire Transducers

Example 1

7 pin Tuchel connector
(view into chassis mounted plug)

Pin 1	Supply -
2	Signal Nb
3	Signal Na
4	Signal Pa
5	Signal Pb
6	Supply +
7	Screen



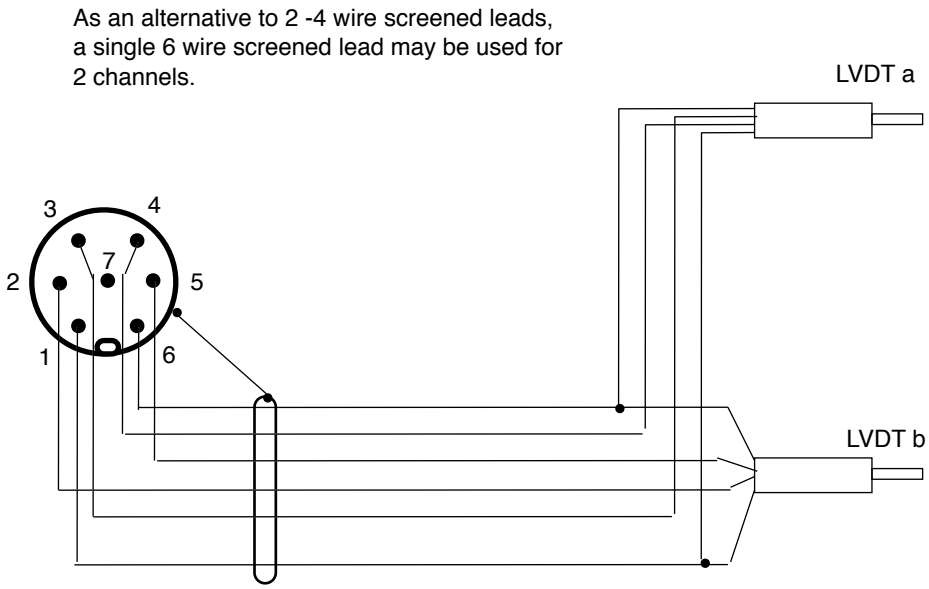
The transducers may be wired with 4 wire screened lead with one cable per channel. This will necessitate the fitting of two screened leads within the one input connector; this is feasible providing that the cable overall diameter is small enough (less than 3.5 mm overall diameter per cable) - the rubber connector outlet boot may need to be trimmed marginally to allow passage for the two cables.

2.1.3 Recommended Connection for Four Wire Transducers

Example 2

7 pin Tuchel connector
(view into chassis mounted plug)

Pin 1	Supply -
2	Signal Nb
3	Signal Na
4	Signal Pa
5	Signal Pb
6	Supply +
7	Screen

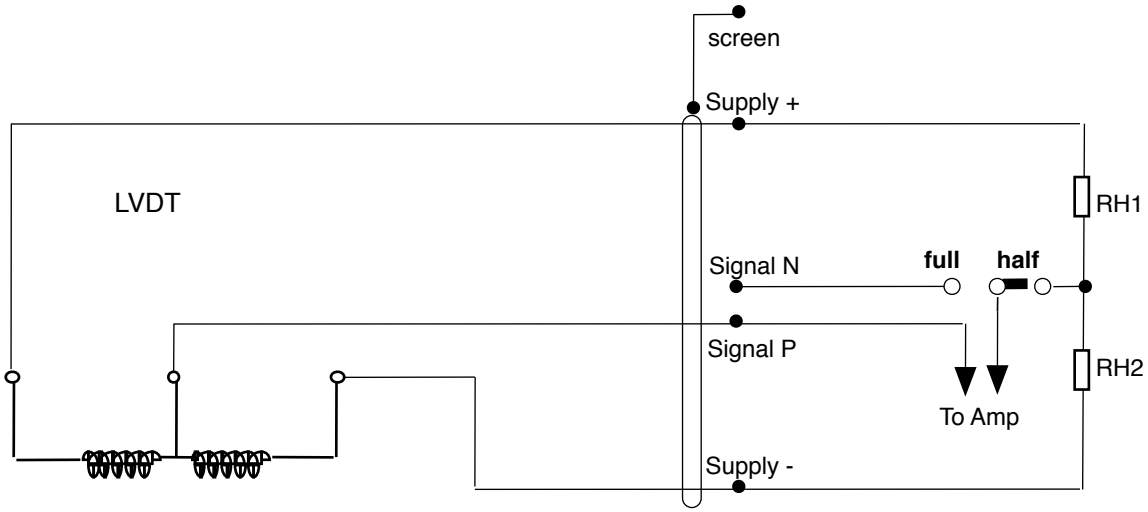


2.1.4 Balance Jumper Links

Normally, balance jumper links **VBal** should be used for LVDT applications. The balance resistors associated with these links, will allow wide range and sufficient resolution to allow zeroing or back off of the transducer in most instances.

Alternative positions **Sbal1** and **Sbal2** exist for the balance links and these will enable shunt balancing of suitable transducers such as Electrolevels or strain gauge bridges.

2.1.5 Three Wire LVDT Connection



The amplifier has built in 1/2 bridges for each channel; these are selected by jumper links **half** (1 per channel). No additional resistors are needed to complete a half bridge.

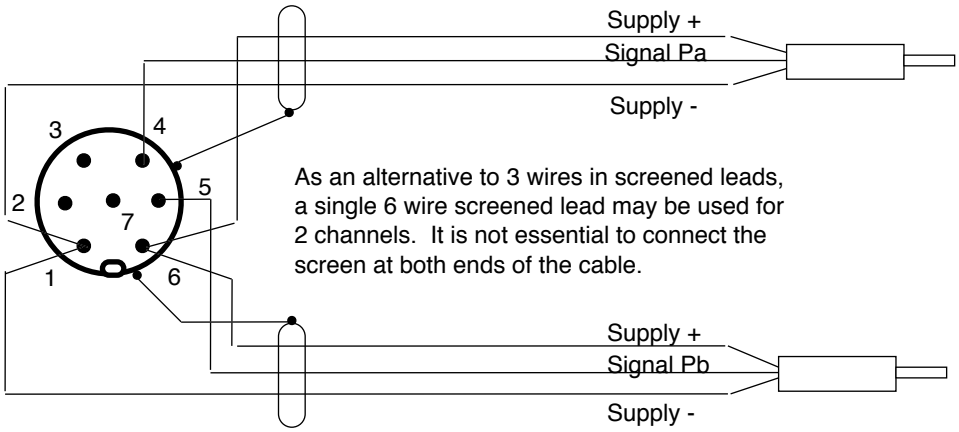
3 wires in a screen lead are required for each channel (Example 1). A 6 wire screened lead may be used for 2 channels in most applications. If the two channels for a particular card are located close together, a 4 wire screen lead may be used as shown in Example 2.

2.1.6 Recommended Connection for Three Wire Transducers

Example 1

7 pin Tuchel connector
(view into chassis mounted plug)

Pin 1	Supply -
2	Signal Nb
3	Signal Na
4	Signal Pa
5	Signal Pb
6	Supply +
7	Screen

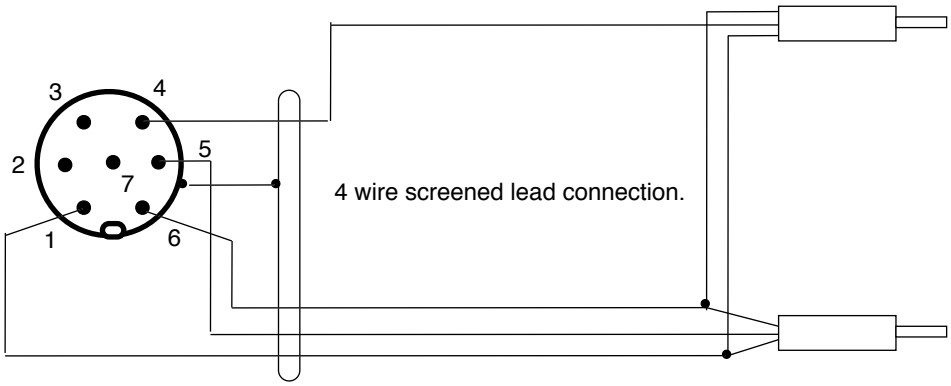


2.1.7 Recommended Connection for Three Wire Transducers

Example 2

7 pin Tuchel connector
(view into chassis mounted plug)

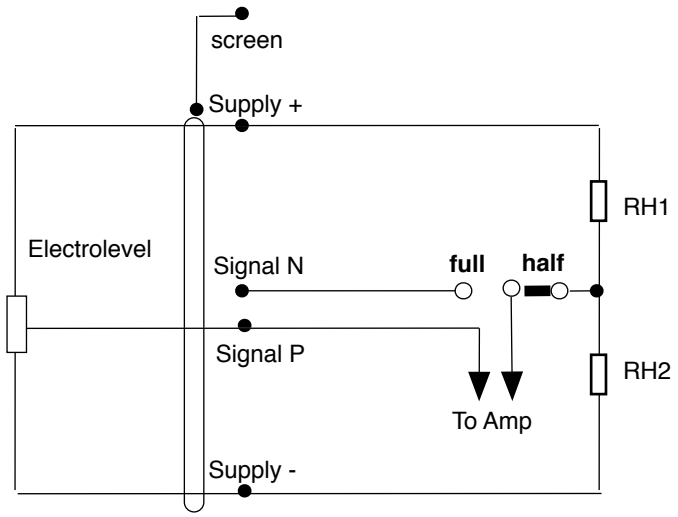
Pin 1	Supply -
2	Signal Nb
3	Signal Na
4	Signal Pa
5	Signal Pb
6	Supply +
7	Screen



2.1.8 Electrolevel Connection

Electrolevels are electronic transducers able to measure tilt. They comprise a glass phial filled with a special electrolyte and are able to resolve tilt down to seconds of arc. A typical Electrolevel has 3 electrodes and forms a 1/2 bridge circuit. They must be energised by an AC sine wave voltage.

The FE-346-CA is able to complete the bridge by virtue of its built in completion resistors for 1/2 bridge. Refer to Figure 1 for location of jumper link positions for internal 1/2 bridge selection.

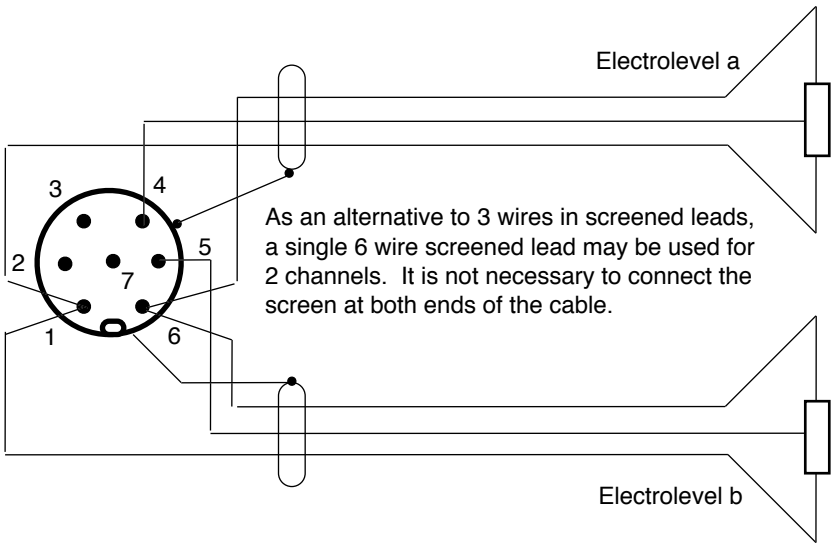


Fit Jumper Links **Half** (1 per channel) to invoke internal 1/2 bridge completion.

Connections shown apply to either channel.

7 pin Tuchel connector
(view into chassis mounted plug)

Pin 1	Supply -
2	Signal Nb
3	Signal Na
4	Signal Pa
5	Signal Pb
6	Supply +
7	Screen



As an alternative to 3 wires in screened leads, a single 6 wire screened lead may be used for 2 channels. It is not necessary to connect the screen at both ends of the cable.

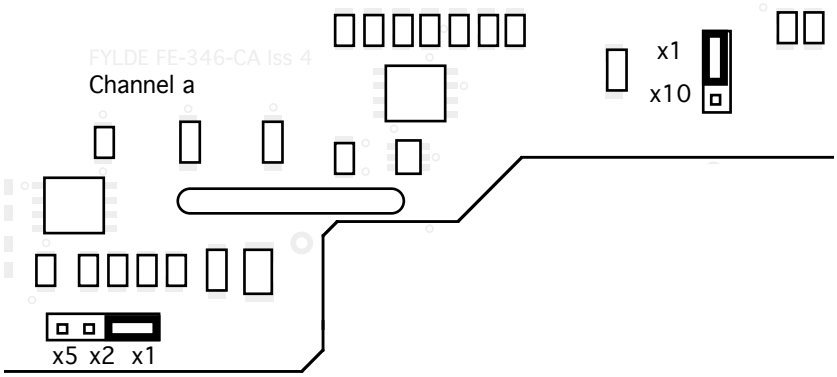
2.1.9 Screen Connection

It is recommended that the body of the Tuchel connector be used for the screen connection of the input cable in order to obtain best noise immunity. Note that a solder tag inside the connector body facilitates this connection.
In situations where the transducer end of the screened lead is unavoidably earthed (such as with transducers with integral screened lead which have metal bodies electrically connected to earth), it may be acceptable to leave the screen unconnected or to connect to Tuchel Pin 7 “Screen”.

2.2 Setting the Gain

The preamplifier has Input Gain settings of x1 or x10, selected via a jumper link for each channel as shown below right. The arrangement is identical for channels ‘a’ and ‘b’.

The output buffer amplifiers provide additional Output Gain settings; these are chosen to be x1, x2 and x5. Coupled with the Input Gain settings, they enable any gain from x1 to x 50 in a 1, 2, 5 sequence to be set. Vernier gain potentiometers are included on the front card edge. These multi-turn controls give an additional x2.5 minimum and enable coverage between the calibrated gain steps, and a maximum gain of > x100 overall. For calibrated gain steps of x1 to x50, be certain to set these controls in the fully anticlockwise position.



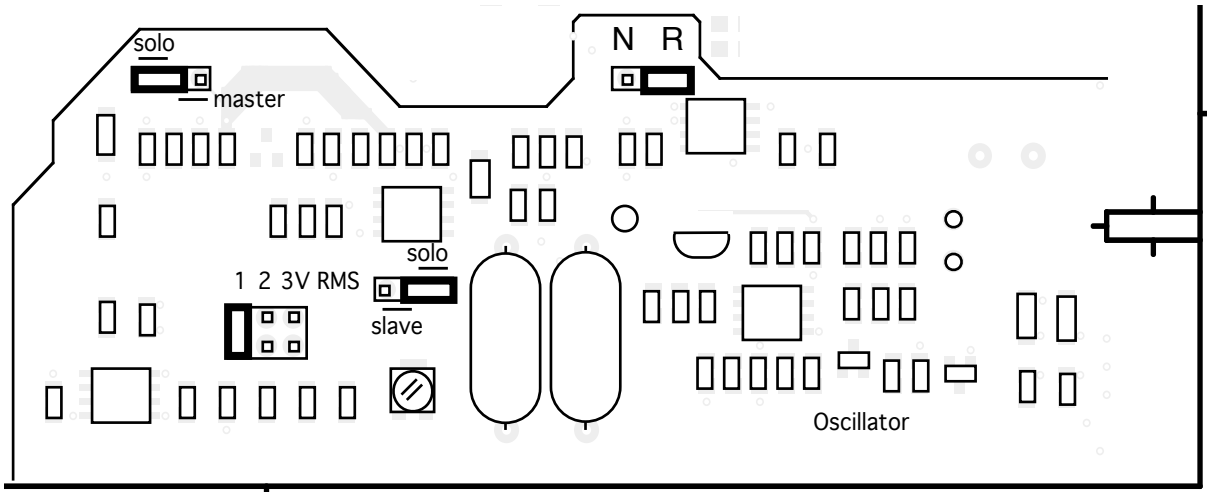
Similar jumpers (not drawn), exist for channel b. Refer to ‘User Drawing’ 949PC for a complete drawing of the printed circuit card and additional configuration information.

2.3 Setting the Oscillator Voltage

The oscillator voltage may be set to either 1V, 2V or 3V RMS by choice of the appropriate jumper link. 1VRMS is recommended for LVDTs as these devices have high sensitivity and often constitute a higher burden for the oscillator to drive.

For electrolevels and other lower output devices, select 2V or 3V RMS for maximum sensitivity.

Note that there is only one oscillator per card and thus the same oscillator voltage is applied to both channel a and channel b transducers.



2.4 Normal / Reverse Oscillator Phase

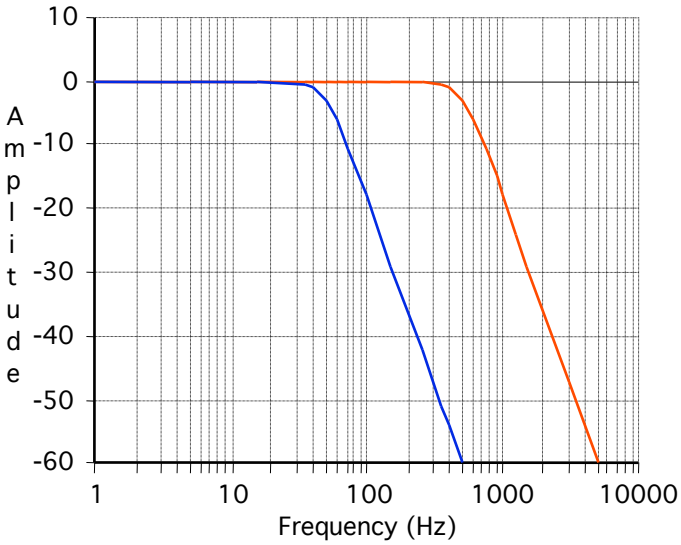
The Normal and Reverse jumper enables the polarity of the oscillator phase to be changed and gives an easy way of reversing the output polarity of the amplifier without rewiring the transducer connections. Thus an amplifier developing +5V to -5V for a specified transducer movement when in Normal, will develop -5V to +5V when jumpered in Reverse.

2.5 The Low Pass Filter

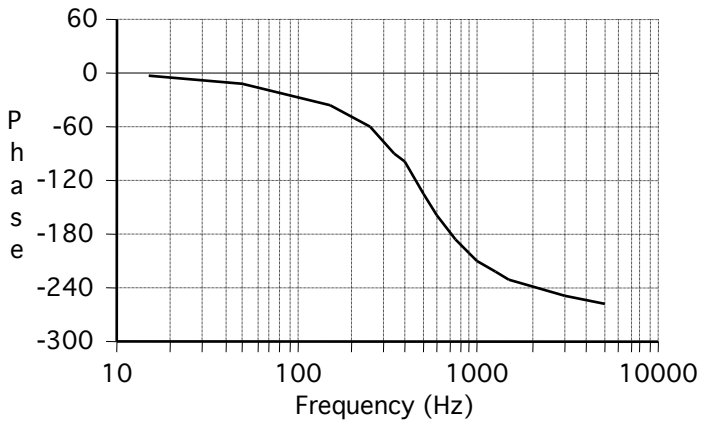
The low pass filter is a 3 pole (-18 dB / octave) Sallen Key design with Butterworth response. The cut off frequency may be chosen to be from 4.7 Hz (-3 dB) to 4.7 kHz (-3 dB). Resistor packs RP1a and b program the filters over this range.

Cut-off (Fc)	RP1 value
4.7Hz	1MΩ
10Hz	470kΩ
20Hz	220kΩ
47Hz	100kΩ
100Hz	47kΩ
200Hz	22kΩ
470Hz	10kΩ
1kHz	4.7kΩ

FE-346-CA
The factory fitted value for RP1 is 10kΩ (470Hz -3dB). Alternative filter resistor packs are available from FYLDE for a nominal charge. Note that generally lower bandwidths will improve noise performance.



Frequency response plots for Fc 470Hz and Fc 47Hz.



Phase response plot for Fc 470Hz Butterworth response.
Channel to channel Phase match is within ±1° @ 0.5Fc and ±2° @ 0.75Fc.

2.6 Connecting the Output

The amplifier outputs are capable of generating up to ±10 V full scale with a capability of ±2 mA. Please note that due to EMC qualification of this equipment, 'T' form passive filters are included in series with the voltage outputs; these components have the effect of raising the output impedance to 100Ω.

Refer to the "System Chassis" section of this handbook for details of the output connectors.

2.7 Setting Master/Slave Operation.

When several FE-346-CA modules are used in the same system, there is the possibility that the unsynchronised sine wave transducer supplies could mutually interfere. This phenomenon is known as 'beating' and can be avoided by locking all the sine waves to a single 'master'. Modules transmit a synchronisation signal optically from their component (top) side, and receive the synchronisation signal at their connector (bottom) side.

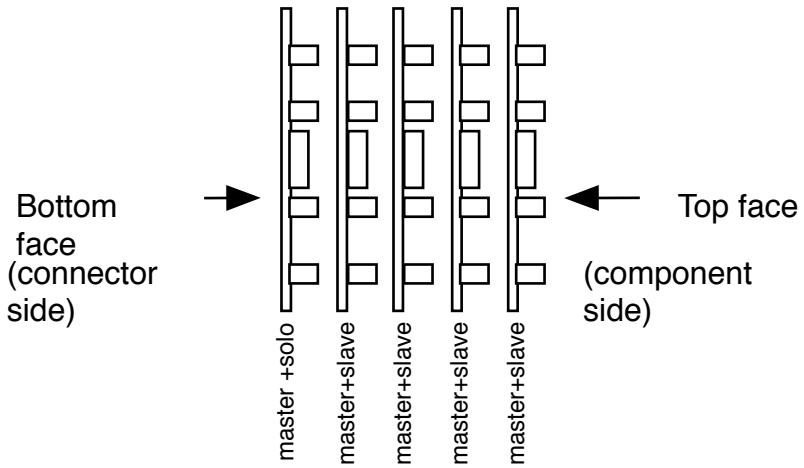
There are two jumper links which are concerned with synchronisation. These are marked **solo/master** and **solo/slave** on the PCB.

When only one FE-346-CA module is used, set both jumper links to **solo**.

When several FE-346-CA modules are used, ensure that all the FE-346-CA modules are positioned in adjacent slots within the system enclosure. Set each module's **master/slave** link to **master** so that it transmits a synchronisation signal to the FE-346-CA module next to its top face.

If a module's bottom face is next to another FE-346-CA, then it is a 'slave' and its **solo/slave** link must be set to **slave**.

The module which does not have another FE-346-CA next to its bottom face has its **solo/slave** link set to **solo**.



2.8 Example Transducer Calibration Calculation

Many transducers, and particularly LVDTs, will be delivered with documentation giving the sensitivity in the form :

Vo / Vi / MU. Where Vo is the output voltage
Vi is the input oscillator voltage
MU mechanical Unit (distance for LVDTs)

Example For an LVDT 50mV/V/mm

In this instance the transducer will output 50mV, if energised by 1V, for each mm of movement in its linear range. (LVDTs have a specific linear or calibrated range, even though they may be able to travel further, this extra movement is not capable of being calibrated. Refer to LVDT specification for further information).

To calibrate the FE-346-CA card to output 1V/mm:

Set Oscillator to 1V
Select input gain to x10
Select output gain to x2

Of course many other set ups are possible, the above merely illustrating a possible configuration.

3 Operation

Before operating the system, it is advisable to study the previous pages referring to configuration of connection and gain setting etc.

3.1 Switching On

3.1.1 FE-MA32 or FE-MA40

The system power switch is located on the rear panel. Two mains voltage settings are available; be sure to check that the most suitable setting for your available supply is selected :-

'120' 103 - 127 V AC 50/60Hz 50 VA max. '240' 207 - 253 V AC 50/60Hz 50 VA max.

Fusing is 0.63 A(T) located in the pull out tray which forms part of the IEC mains connector (a spare is included).

On switch on, the green power led should illuminate. If this led flashes, this is indicative of power supply overload.

Note: If this should occur, input connectors should be removed in stages in order to isolate the fault. If the rack contains a mixture of boards, remember that the FE-366-TA Transducer Amplifier routes the internal bridge supply voltage directly to the transducers in some configurations and it may be worth removing these modules first (Note, the FE-366-TA handbook carries notes regarding overloaded bridge supply problems).

3.1.2 FE-MM4, FE-MM8, FE-MM16, FE-MM40

Apply a DC voltage of between 10V and 36V via the DC socket. An internal fuse is fitted and protection is provided for reverse supply. A mains to DC supply is available. On switch on, the green power led(s) should illuminate. If an led flashes, this is indicative of power supply overload (see note above).

IMPORTANT: By default, the 2.5V/5V link(s) in the FE-810-BPSDC(s) will be set for 5V. This is necessary to give the correct ±5V to the carrier oscillators. In practice this means that any Transducer Amplifiers must operate with 5V or 10V bridge supply, this being common to both Carrier Amplifiers and Transducer Amplifiers, thus it may help to select gauges of 350Ω or higher. This may be particularly important if gauges are small or on samples having poor heat conductivity.

3.2 Zeroing the Output

3.2.1 Operation of the Balance Control

With power on and inputs connected, the outputs of the modules will assume various offsets depending on the mechanical position of the transducers. It should be possible to balance the outputs to zero or adjust them to the required voltage by use of the front card edge 'Balance' controls for each channel. Bear in mind that the maximum output voltage obtainable from the amplifier outputs is ±10V and that levels outside of these limits cannot be relied upon.

3.2.2 Problems in Balancing the Output

If a zero (or the desired datum voltage) cannot be obtained by operation of the balance control, reduce the gain in order to ensure that the output is less than ±10 V. Operating the balance control should enable the output to be moved positive and negative. If this is possible with a low gain, the gain may be gradually increased to the desired setting (please note that it necessary to switch off and remove the module for each gain change).

3.3 Termination of Unused Inputs

Generally, it is not necessary to terminate unused inputs.

3.4 Operation with LVDT Transducers

The FE-346-CA is designed to operate with most types of LVDT transducers and will energise these devices with a sine wave voltage at a frequency of 5 kHz.

Output from such transducers is usually given as mV / V / mechanical unit such as 200 mV / V /mm.

Example 200mV / V / mm

Configure for 3 wire or 4 wire transducer as appropriate.

With energising voltage of 1 V, the output of the transducer is 200 mV /mm

For a full scale of 25mm, the transducer output is 200mV x 25 = 5V.

Set the oscillator voltage to 1 V

Pre-amplifier gain to x 1

Output stage gain to x2

Zero or correct the output as desired using the 'Balance' control.

The output of the amplifier will be **10V fullscale** or **400mV /mm.**

3.4.1 Mechanical Calibration with LVDT Transducers

Because of the nature of LVDT transducers, it may be possible to mechanically set the calibration by positioning the transducer and noting the output voltage before operating the transducer through its required travel. The change in output voltage can be adjusted using the front panel potentiometer control if required in order to set an arbitrary scaling.

3.5 Operation with Electrolevel Transducers

Electrolevels are electronic transducers able to measure tilt. They comprise a glass phial filled with a special electrolyte and are able to measure and resolve tilt down to seconds of arc. A typical Electrolevel has 3 electrodes and forms a 1/2 bridge circuit. Electrolevels must be energised by a pure AC sine wave voltage, thus the FE-346-CA oscillator is eminently suitable.

Output voltages of Electrolevels vary with type. The Type 0711 generates an output voltage equivalent to 50% of the oscillator voltage for a tilt angle of 30 arc minutes.

Because of the relatively high impedance of the device, the oscillator voltage may be set to maximum (3V). Gain is likely to be suitable when set in the range x1 to x10.

4 Additional Capabilities

4.1 Operation with Bridge Type Transducers

The FE-346-CA may be applied with bridge type sources where high sensitivity is not required, particularly if the gauge resistances are 350Ω or greater (this allows the maximum oscillator level, 3V, to be used).

Set the gain of the preamplifier to x10 and output stage gain to x5 for an overall gain of x50.

Connection of a full bridge or 1/2 bridge (4 wires and 3 wires respectively) is similar to that used for 4 wire and 3 wire LVDT application, with the internal 1/2 bridge being used to complete a 1/2 bridge transducer.

Calculations for the electrical output of a Wheatstone bridges is dealt with in the next section.

4.1.1 Electrical Output of a Bridge

The electrical output of a bridge, ∂V, for a given output in microstrains, can be obtained by applying the following formula:-

$$\text{For 4 active gauges, } \partial V = \frac{\text{Output in MicroStrains} \times \text{Bridge Voltage} \times \text{Gauge Factor}}{1000} \text{ millivolts}$$

For 2 active gauges, ∂V = 1/2 of the above

Example For a full bridge with 1000 MicroStrains mechanical strain with Gauge Factor = 2.2

Configure for 4 wire connection.

With energising voltage of 3 V, the output of the bridge is 1000 x 3 x 2.2 /1000 = 6.6mV

Set the oscillator voltage to 3 V

Pre-amplifier gain to x 10

Output stage gain to x5

Zero or correct the output as desired using the ‘Balance’ control.

The output of the amplifier will be 6.6 x 50 = **330mV** for 1000μE.

Further uncalibrated gain of >x2.5 is available by use of the gain vernier to raise the output to almost 1V for 1000μE.

Appendix

Issue	Date	Change History
1	14/11/01	New Drawing
2	28/3/12	Redrawn for SMT version
3	18/12/12	N,R were w.w.r

Gain Potentiometer.

Clockwise rotation increases the gain by approximately x 2.5. When fully anticlockwise,the gain depends only on the two gain jumpers.

Input Stage Gain Jumper

A jumper link selects the indicated input stage gain.

Phase Reverse Jumper

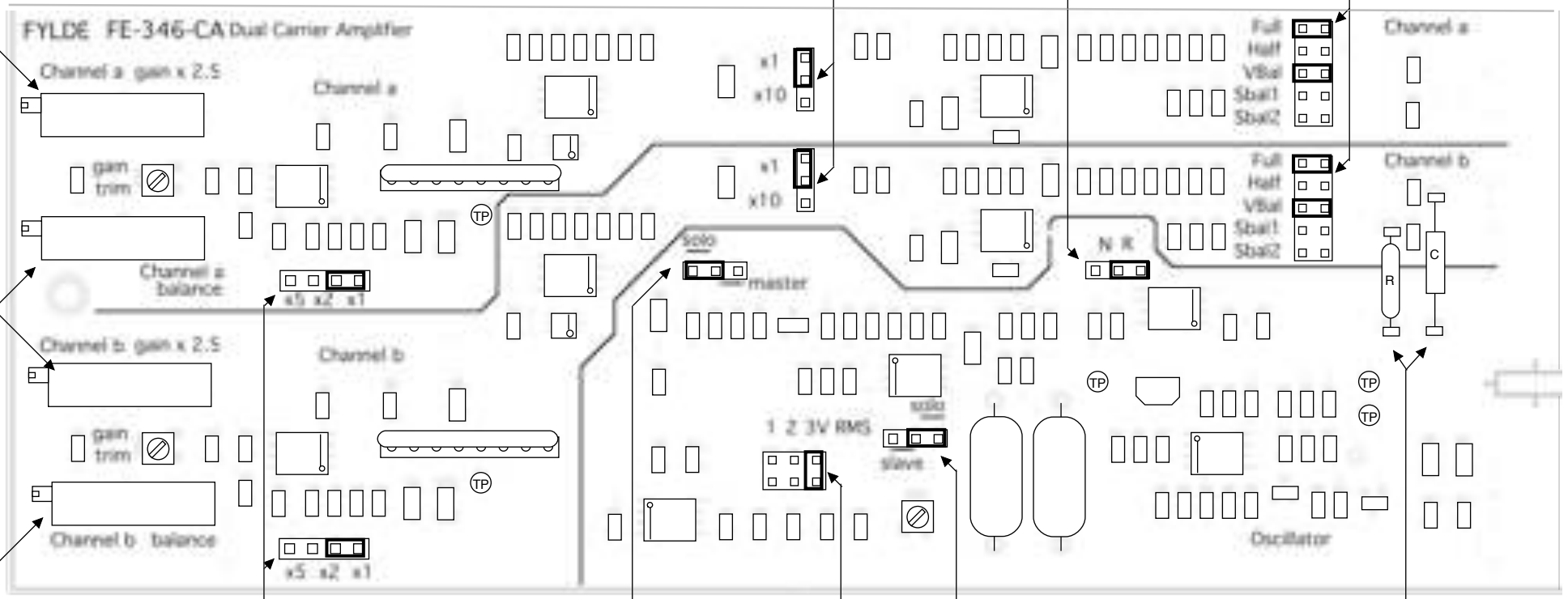
This jumper reverses the output polarity of both channels.

'N' : Normal
'R' : Reverse.

Transducer Type Configuration Jumper

'Full' : Selects the Full Bridge configuration.
'Half' : Selects the Half bridge configuration
'VBal' : The Balance Potentiomer provides a balancing voltage to offset the channel's output.
Sbal1 : The Balance Potentiometer operates as a shunt balance control.
Sbal2 : The Balance Potentiomter operates as a shunt balance control

Note that Sbal1 provides less shunt balance than Sbal2



Balance Potentiometer.

This control works together with jumper positions VBal, Sbal1, and Sbal2 to offset the output voltage. It is normally used to set the datum (zero) position.

Output Stage Gain Jumper

A jumper link selects the indicated output stage gain.

Synch Transmit Jumper

When several FE-346-CA modules are fitted to adjacent slots in the enclosure, this jumper provides a synchronisation signal to the module nearest to this module's top (component) side.

A jumper in the 'master' position provides the synchronisation signal.

A jumper in the 'solo' position disables synchronication to the next module.

Transducer Supply Jumper

A jumper selects the amplitude of the 5 kHz Transducer Supply Voltage

Synch Receive Jumper

When several FE-346-CA modules are fitted to adjacent slots in the enclosure, this jumper enables receiving a synchronisation signal fom the module next to this module's bottom (connector) side.

A jumper in the 'slave' postion receives the synchronication signal.

A jumper in the 'solo' position disables synchronisation reception.

Phase Adjust Network Components

This RC network compensates for the phase change in the transducer and input stage.

If the output is not linear in relation to the transducer action , it may be necessary to change these components.

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