Description

The FE-376-IPF is a dual channel AC coupled amplifier with constant current source for transducers with built in electronics commonly known as ICP®. The unit is presented as a printed circuit card with amplifier fine gain controls brought to the front edge of the card. Internal jumpers set gain, filter bypass and ICP current on/off.
8 pole (-48dB/octave) filter setting is by plug-in resistor network.
This amplifier features a unique active current termination option which allows the differential amplifier to reject the interference which may be generated when a transducer has a remote earth connection.
The amplifier may be used with ICP current disabled for general AC voltage amplification and additionally in filtering applications for example for alias protection in sampling systems.

Specification

Current source	2 sources per card.
Level	Setting 4 mA.
Compliance Voltage	22V typical.
Noise	<0.1μA RMS (DC - 20 kHz).
Activation	Jumper select current on/off
Indication	2 green LEDs indicate current flow.
Active Current Termination	Plug-in sub-module option is able to reject earth line interference for remotely earthed transducers. Typical rejection >40dB.
Amplifier section	Two identical amplifiers and filters, each individually configurable.

Gain	Selection	Internal jumpers for x1 to x300 0.5% (1, 3, steps).
	Alternative	0 to 50dB (via solder link).
	Vernier	Front card edge control for additional x1 to >x3.2 (0 to +10dB).
Input	Configuration	Balanced differential.
	Coupling	1μF and 1 MΩ (0.16Hz -3dB, 1.04 Hz -0.1 dB). (Note that this is not the dominant HP response. See HP Filter)
	Noise	15nV√ Hz @ 1-10 kHz.
Common Mode	Rejection	> 80dB (x10 up) 50 - 500Hz.
Frequency Range	<1Hz - 50kHz (-3dB).	
Output	Voltage Capability	±10V into 2kΩ, 5000pF max.
	Offset	<±25 mV.
LP Filter	Type	Butterworth 8 pole, preset by plug-in resistor network (50Hz to 50kHz).
	Bypass	Filter may be bypassed by jumper link.
	Gain	Unity.
	Roll Off	48dB/ octave, 160dB/decade.
HP Filter	Type	Butterworth 2 pole, preset by plug-in resistor network (2.5Hz to 1kHz -3dB).
	Bypass	Filter may be bypassed by resistor network removal (When bypassed response is single pole <700 mHz -3dB).
	Gain	Unity.
	Roll Off	12dB/ octave, 40dB/decade.

Physical

Environment	Temp. Range	0°C to 50°C operating.
Physical	Card size	7” x 2.65” (180mm x 67mm). Fylde MicroAnalog2 format.

FE-376-IPF Specification

Table of Contents **Page 1**

1 FE-376-IPF Amplifier Card Description

The FE-376-IPF is a dual channel combined power supply, filter, and amplifier for use with accelerometers and other dynamic signal sources. The FE-376-IPF is typically used to measure dynamic quantities such as acceleration.

Accelerometers are generally either ICP® type which have integrated electronics and are suitable for direct connection to the FE-376-IPF or Piezoelectric types which generate a charge output and can be connected to the FE-376-IPF via a head amplifier.

In the following text, the lower case letters a & b are used to differentiate between the two channels of the amplifier card.

The module may be most easily appreciated by consideration of its constituent parts :-

1. Constant Current Transducer Power Supply
2. Differential High Pass Input Stage
3. Low Pass Filter
4. High Pass Filter
5. Output Buffer Amplifier

1.1 Constant Current Transducer Supply

The FE-376-IPF is designed to be used with a class of transducers (or head amplifiers) which are powered by a constant current of nominally 4 mA. With the current held constant, the transducer is able to vary the voltage which is seen as a signal by the FE-376-IPF amplifier. This allows a two wire system which is most often a coaxial cable to be used as the connection between the FE-376-IPF amplifier and the remote transducer or head amplifier. The supply is inherently protected against short circuits, and an LED indicates the presence of current in the loop .

The current passing through the transducer may be returned to the FE-376-IPF, or may be terminated by the electrical earth connection of the transducer itself. See 3.3 “Remote Earthing of Transducers”.

The FE-376-IPF has a jumper link which removes the constant current if a channel is to be used only as an amplifier and filter.

1.2 Differential High Pass Input Stage

The FE-376-IPF amplifies dynamic properties signalled by the transducer (e.g. change of acceleration). For this reason the input stage preamplifiers are arranged to pass only signals which are changing at more than a certain rate. (As a guide, signals changing at less than approximately 1 cycle per second are more strongly rejected). The user may configure the input stages to provide gain of unity, x 10 or x 100 to contribute to the overall amplifier gain, and provide protection from high voltage transients and RF interference. See 2.1 “Setting the Desired Output Range” for tables of gain in both dB and Volts / mV.

The differential nature of the input stage preamplifiers allows the FE-376-IPF to solve certain problems which can arise with transducers with electrical connections to earth. See 3.3 “Remote Earthing of Transducers”.

1.3 Low Pass Filter

The preamplifiers are followed by low pass filters. The filters have 8th order Butterworth response with frequency programmed by plug in resistor networks RP1 and RP2 (a & b). The filters may be used for noise reduction, or as alias protection where the signal is to be A-D converted. See 2.2 .1 “Low Pass Response” for details of the frequency response for different filter settings. A jumper position is provided to bypass the low pass filter if maximum signal bandwidth is required.

1.4 High Pass Filter

A 2nd order response high pass filter follows the low pass filter. The high pass frequency setting is programmed by plug in resistor networks RP3 and RP4 (a & b) , arranged so that when no resistor pack is fitted the high pass response is a single pole with cut off at 800 mHz (-3 dB). Fitting a resistor pack makes the high pass filter effective. See 2.2.2 “High Pass Response” for details of the frequency response for different filter settings.

® *ICP is a trademark of Piezotronics Inc.*

1.5 Output Buffer Amplifiers

The output buffer amplifiers provide additional gain using either the x 3 jumper positions or using the vernier gain potentiometers. These multi-turn controls give an additional x 2.5 maximum. For users who find it more convenient to work with gain expressed as dB, a link can be fitted which changes the operation of the x 3 jumper to x 10 dB.

2 Configuring the Module

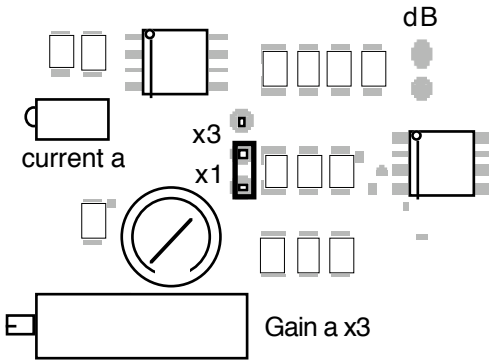
Refer to 'FE-376-IPF user drawing' 1079PC in the appendix for additional configuration information. Note that the circuit board is silk screen idented to aid component location.

2.1 Setting the Desired Output Range

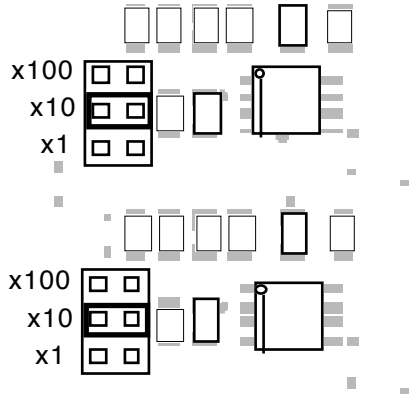
The factors which affect the choice of gain are the maximum expected amplitude of the signal input from the transducer, and the operating range of the signal output to the following data acquisition equipment.

The FE-376-IPF module output has a maximum ±10 V output range, and a calibrated gain of between x 1 and x 300 in steps of 1, 3, 10 etc. The output range depends upon the chosen gain and the input signal range. It is necessary to ensure that the expected measurements produce outputs within both the ±10 V range of the FE-376-IP and within the range of the following data acquisition or recording equipment.

Ensure that the front panel potentiometers are wound fully anticlockwise and set gain using on board jumpers shown below :



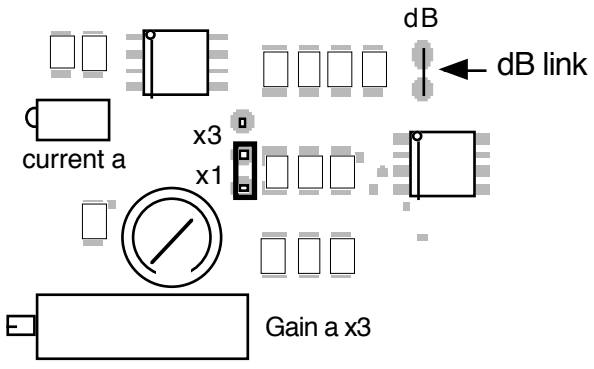
Output stage components are near the front of the module
Output Stage Gain (x1 or x3 with additional x3 potentiometer)
Shown above set for x 1.
Channel a is shown.



Input stage at rear of module
Input stage Gain
Shown above set for x 10
Channels a and b are shown.

The input signal range is expressed in millivolts (mV) and is derived from the transducer sensitivity (mV / g) and the expected range of acceleration to be measured. Hence for a transducer of sensitivity 50 mV / g and an expected measurement range of ±10 g, the input signal range is ±500 mV. Selecting a gain of 10 will provide an output range of ±5 V corresponding to ±10 g. Provided that the following equipment can accept inputs over this range, this will be a good choice for the gain.

Gain can also be expressed in terms of decibels (dB), and with the dB solder link made, the x1 to x300 gain range becomes 0 to 50 dB in 10 dB steps. (See table overleaf).



Channel 'a' shown above.

Additional gain is available using the front panel potentiometer, and this can be used when it is necessary to scale the overall gain so that a particular output range is covered. See 3.2 Setting an Arbitrary Full Scale Output.

A summary of the module gain settings is given below:-

Gain (Vout/Vin) dB link removed	Gain (dB) dB link fitted	Pre-Amp gain jumper position	O/P Amp gain jumper position
x 1 (Unity)	0	x 1	x 1
x 3	10	x 1	x 3
x 10	20	x 10	x 1
x 30	30	x 10	x 3
x 100	40	x 100	x 1
x 300	50	x 100	x 3

Note that the above settings hold only when the channel's front panel potentiometer is wound fully anticlockwise.

2.2 Setting the Frequency Response

2.2.1 Low Pass Response.

The FE-376-IPF preamplifier is followed by a low pass filter. This filter has an 8 pole (-48 dB / octave) Butterworth response which means that it will pass frequencies below its cut off frequency with minimal effect on amplitude, but above the cut off frequency the amplitude is attenuated by a factor of 250 for each doubling of the frequency.

A resistor pack mounted in a socket allows a range of cut off frequencies to be simply selected. The resistor pack comprises 8 equal value resistors in a 16 pin package, and it can be plugged into its socket without regard for orientation.

The lower limit to the frequency response is dictated by the performance of the filter with high resistor pack values. 1 M Ω is the highest practical value, giving a bandwidth (-3 dB) of 50 Hz.

With the low pass filter 'in', the upper limit to the frequency response is 50 kHz. When the low pass filter is selected 'out', the upper limit of the frequency response depends upon the selected gain. Gains up to x 30 have approximately 100 kHz bandwidth, and gains of 100 and above have approximately 75 kHz bandwidth

The following table shows the resistor pack value which must be fitted to provide a particular measurement bandwidth.

Resistor Pack	-3 dB Bandwidth (Fc)
1 MΩ	50 Hz
100 kΩ	500 Hz
47 kΩ	1 kHz
22 kΩ	2 kHz
10 kΩ	5 kHz
4700 Ω	10 kHz
2200 Ω *	**20 kHz ***
1 kΩ	50 kHz

** Denotes factory fitted resistor pack value*

Section 3 (Operation) provides further details of the effect of the filter setting on the measurement.

2.2.2 High Pass Response.

A resistor pack position is provided for a High pass filter . When the resistor pack is not fitted, frequencies above approximately 1 Hz are passed without attenuation. This is the factory configuration.

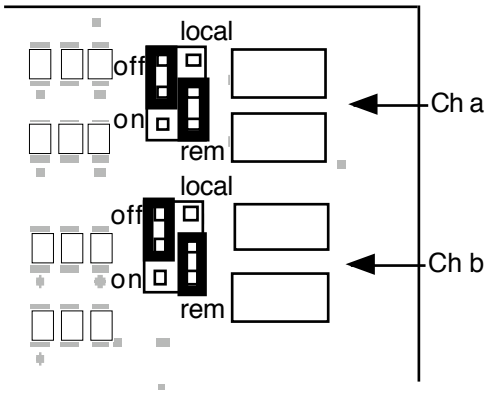
Fitting an 8 pin resistor pack with 4 equal value resistors introduces a 2 nd order high pass (Butterworth response) filter to the output stage. The following table shows the high pass cut off frequency for available resistor pack values.

Resistor Pack	-3 dB Bandwidth (Fc)
1 MΩ	2.5 Hz
470 kΩ	5 Hz
220 kΩ	10 Hz
100 kΩ	25 Hz
47 kΩ	50 Hz
10 kΩ	250 Hz

Section 3 (Operation) provides further details of the effect of the filter setting on the measurement.

2.3 Operation as an AC Differential Amplifier

The module is suitable for use as a differential AC amplifier because its input stage has very good common mode rejection (>100 dB). Either channel may be configured as an AC amplifier by setting the jumper controlling the current source to 'off' and the jumper controlling the current return to 'rem'. The Active Termination option must not be fitted.



Channels a and b configured for AC amplifier operation

2.4 Operation with Isolated or Local Transducers

In most applications with current powered transducers, the return path for the current is either to the amplifier (Transducer return isolated from earth), or is to an earth which is electrically identical to the earth at the amplifier (Local Earth Transducer). The factory set configuration is for current 'on' and 'local 'earth, and need not be changed.

2.5 Connecting the Input

A connector adaptor (Part Number CA-376-IP) converts the standard screw lock (Tuchel) connector on the rear panel of the chassis into a pair of coaxial (BNC) connectors identified as 'a' and 'b' which can then be connected via coaxial cable to the accelerometer or head amplifier.

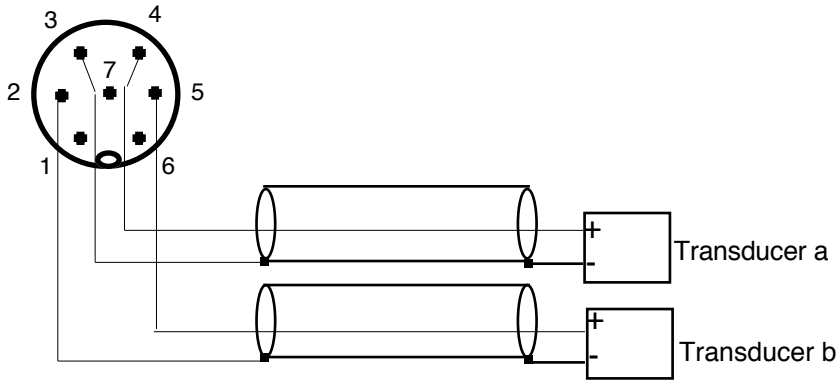
Some accelerometers may have micro-dot type coaxial connectors, and lengths of BNC to micro-dot cable may be obtained from FYLDE if required.

The length of cable to the transducer may be run over long distances, but note that the length of cable from the head amplifier to the Piezoelectric transducer should always be as short as possible. Refer to Section 6 (Compatible Head Amplifiers) for further details on cable types and the effect of cable length.

The following diagram shows the connections made by the CA-376-IP connector adaptor from the standard 7 pin rear panel connector of a Micro Analog 2 chassis.

7 pin Tuchel connector
(view into chassis mounted plug)

Pin 1	Supply - (Not Used)
2	Signal Nb
3	Signal Na
4	Signal Pa
5	Signal Pb
6	Supply + (Not Used)
7	Screen



2.6 Connecting the Output

The amplifier outputs are ±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 built into standard Micro Analog 2 enclosures in series with the voltage outputs; these components have the effect of raising the output impedance to 50Ω.

For FE-MA32/40 and FE-MM40, the output connector is a 50 way ribbon contact connector, popularly known as a 'Centronics' style.

For FE-MM4 , FE-MM8, and FE-MM16, 15 way 'D' sockets are used , 2 are fitted on the 16 channel system.
Mating leads to wire ends are provided.

A connection list is given in the "System Chassis" section of this manual.

2.7 BNC Expander Boxes

FYLDE offer BNC expander boxes to fit the output connectors. For the FE-MA32/40 this is known as the FE-MAC-40C. The FE-MM4, FE-MM8 and FE-MM16 all connect to the FE-MAC8C ; note that 2 are required for the FEMM16. These boxes bring out all outputs onto BNC sockets and provide connectors for control lines.

Connectors for ribbon cables and a version with flying leads are available. Output harnesses may also be obtained to suit various Data Acquisition systems - please contact the factory for advice.

3 Operation

Before operating the system, it is advisable to study the previous pages referring to setting up the module and making the input and output connections.

3.1 Switching On

The system power switch is located on the rear panel.

For FE-MA32 chassis, two mains voltage settings are available; be sure to select the most suitable setting for your available supply :-

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

The fuse rating is marked on the rear panel.

For FE-MM4, FE-MM8, FE-MM16 and FE-MM40, power is 10-36VDC and fusing is internal. Refer to the appropriate handbook section for connection information. Note that an inline mains power supply is available for these systems.

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

Note: The FE-376-IPF does not connect to the power overload circuits, hence a flashing supply LED is most probably due to incorrect input wiring on a different module type such as FE-366-TA.

With power on and inputs connected, the outputs of the FE-376-IPF modules will be at approximately zero (for static transducers), and their LEDs will be illuminated indicating that the corresponding transducers are powered up.

3.2 Setting an Arbitrary Full Scale Output

Any arbitrary gain may be set using the front panel gain potentiometer. This potentiometer provides an additional x 3 gain when set fully clockwise, although this is a minimum figure, and the clockwise end position is not calibrated.

Use a sine wave signal generator at a frequency of approximately 20 Hz and measure both the input and output amplitude using an AC DVM. Set the potentiometer to provide the required multiplication factor. Note: The ICP current will not cause damage to a signal generator applied in this way, since the low output impedance of such generators (typically 50Ω) will absorb the ICP current safely.

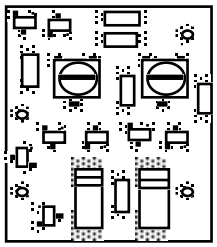
3.3 Remote Earthing of Transducers

It is generally recommended that the transducer be isolated from earth, however in some applications the transducer may be unavoidably earthed at the remote location, and connecting the receiving amplifier will introduce a second earth to the system. It is possible in such circumstances that a difference in earth potentials will cause noise to appear in series with the signal. This happens because a circuit exists for current to flow between the two earth potentials along the screen of the cable. Although the screen has a low resistance, any volt drop across the screen will appear in series with the signal generated by the transducer. The resultant noise at the amplifier output is unpredictable, and is dependent on the difference in potentials between the earths, and the length and resistance of the screened lead employed.

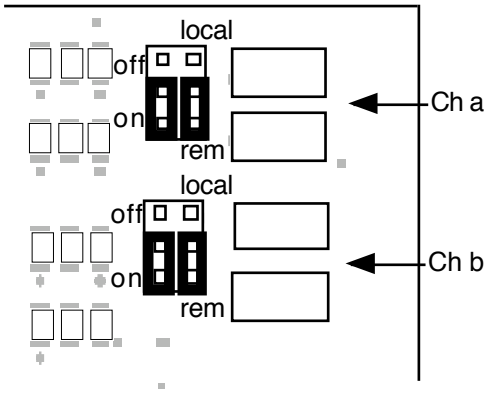
3.4 Use of the FE-376-AT Active Termination

For installations where the transducer return is earthed, and noise is experienced, the FE-376-IPF may be fitted with the FE-376-AT. This “Active Termination” consists of special circuitry (available as a plug-in option) to receive the constant current without introducing a second earth to the transducer return. The FE-376-AT will allow remote earthing of transducers where interference is not too high. A considerable improvement in signal/noise may then be obtained by selecting the Remote Earth position of the selector jumper located close to the rear edge connector. In this setting, the input amplifier functions as a differential amplifier, rejecting interference by virtue of its Common Mode Rejection. The plug-in has features which allow the screen of the cable to move with the noisy ground, and as the input impedance of the amplifier is high, the signal lead moves identically. The high common mode rejection of the FE-376-IPF differential input stage eliminates the interference to a large degree. When switched to Local, the circuitry is shorted out, and the amplifier operates in the single ended mode once more.

FE-376-IP Active Termination Plug In Option



Below : Jumper positions for Remote Earth



The receiving circuit may be damaged by static electricity, and before removing it from its antistatic packaging, the user should either make use of an antistatic workstation, or grip the metal chassis of an earthed installation.

The receiving option should be removed from its antistatic wrapping and installed by carefully pressing it home into the sockets at the rear of the FE-376-IPF module. Once installed, it is protected from static damage.

The jumper positions must be changed to “Remote” and current to “on” as shown above for the option to be effective.

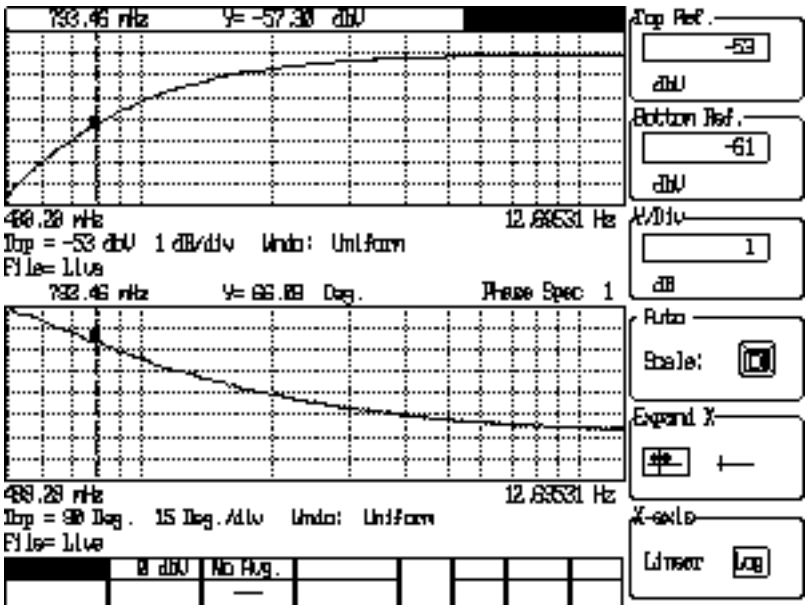
4 Measurement Accuracy

Note that the output has both an amplitude and a phase relationship to the conditions measured at the transducer.

Of course the output signal's amplitude relationship to the transducer conditions depends upon the gain, but also depends on the gain accuracy (which is ±0.5%) and the frequency response.

4.1 High Pass Response

The high pass frequency response with the 8 pin HP resistor pack removed is the single pole response shown in the plots below :

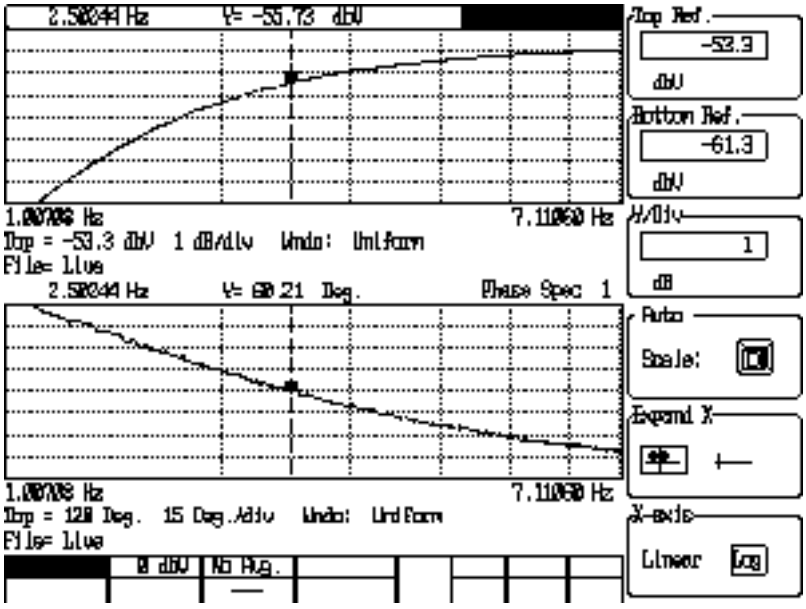


The above HP plot has a -3 dB cut off at 800 mHz and is with the 8 pin pack removed

Note that the measurement amplitude will be approximately 3 dB down at 800 mHz , and 1 % down at 8 Hz.

High pass phase match between channels is better than ±1 °at 8 Hz.

With a resistor pack fitted , the HP filter becomes active and the 2 pole response shown below is obtained.

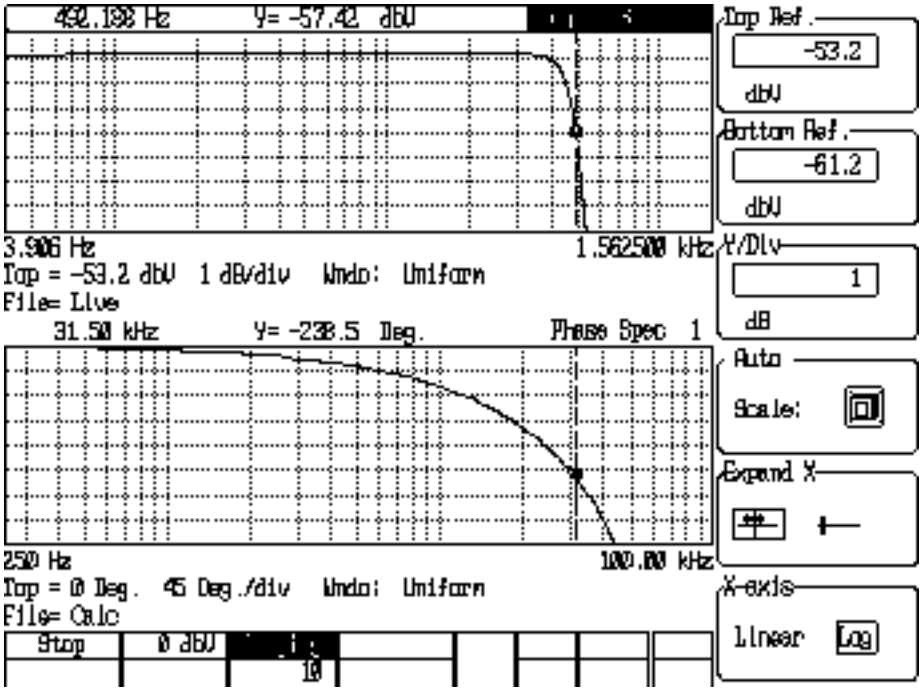


The above HP plot has a -3 dB cut off at 2.5 Hz and is for a 1 MΩ resistor pack

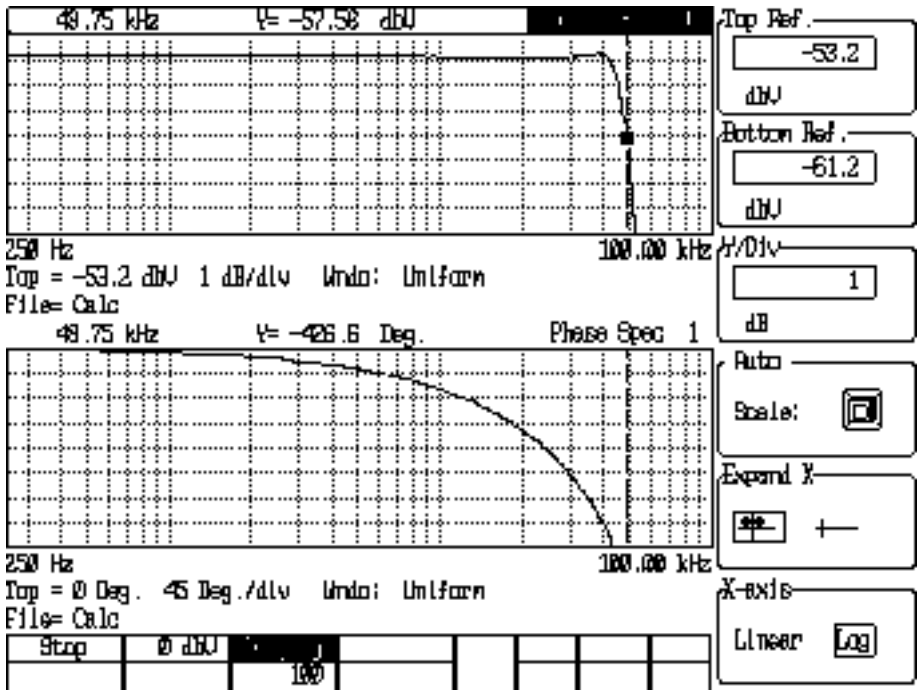
4.2 Low Pass Response

The low pass frequency response is determined by the user's choice of resistor pack (RP). Note that the factory fitted value is 2.2 kΩ which gives a frequency at which the amplitude is 3 dB down (Fc) of 20 kHz. Higher values for the resistor pack give the -3 dB frequency (Fc) listed in section 2.2. The plots below are for both Fc = 500 Hz (Rp = 100k) and Fc = 50 kHz (Rp = 1 k)

Low pass phase match between channels is ±1° at 0.75 Fc.



The above LP plot has a -3 dB cut off at 500 Hz and is for a 100k resistor pack



The above plot has a -3 dB LP cut off at 50 kHz and is for a 1 k 16 pin resistor pack

5 Calibration

Although the FE-376-IPF is will remain within its stated 0.5 % gain accuracy without routine adjustment, users may wish to obtain results showing the absolute gains available for the different jumper positions.

Alternatively through calibration of the FE-376-IPF amplifier and head amplifier/transducer combination using a vibration table or charge simulator may be required to provide results in V/g or V/pC.

This procedure can be carried out by Fylde or by the user. High stability components have been used in the construction of the amplifier, but some ageing is inevitable, and the results should only be considered valid within the calibration interval.

5.1 Calibration Interval

A calibration interval of 12 months is recommended for the FE-376-IPF.

FYLDE offer servicing for the FE-376-IPF and are able to test, repair and recalibrate the amplifiers quickly and cost effectively using instruments traceable to national standards and to ISO 9000 quality standard. Please contact the factory for advice.

5.2 User Calibration Procedure

User calibration may require specialist equipment (especially at higher gains), however at lower gains (x1, x3 , x10) calibration may be achieved by use of an external signal generator applied via the rear panel connector and a calibrated AC DVM. A sinusoidal signal of frequency 500 Hz is recommended with filters ‘out’ and the module configured as an AC amplifier (see section 2.3 of this handbook). Input amplitude must be set so that the output amplitude does not exceed 10 V pk-pk. Input and Output signal amplitudes may then be measured and absolute gain accuracy derived.

For through calibration of the FE-376-IPF in combination with head amplifiers, FYLDE offer a Charge Calibrator / Simulator available as the FE-176-CC.

A procedure for through calibration using a vibration table is outside the scope of this manual, but Fylde can carry out this procedure or can advise if required.

6 Compatible Head Amplifiers

Many acceleration transducers are not powered by a constant current source, but instead produce an output which is calibrated in units of charge (pC) per mechanical unit. The use of such transducers is often dictated by mass or space limitations, but some means of converting their output (charge) to the voltage range required by data acquisition equipment is required. One solution is the Charge Amplifier which may be directly connected to such a transducer. These instruments are often expensive, and may need to be located close to the transducer. An alternative is to use a constant current powered head amplifier in conjunction with the FE-376-IPF.

The Fylde FE-074-HA/C is a true Charge Head Amplifier with ability to operate with longer input cables and variations in transducer capacitance. It is available with a sensitivity of either 1 mV/pC or 10 mV/pC.

Microdot Coaxial connector to transducer via low noise cable

BNC connector to FE-376-IPF via CA-376-IP connector adaptor

Low noise cable connects the transducer to the head amplifier, and from the FE-376-IPF point of view, the head amplifier and transducer combination looks like any other constant current powered transducer.

A suitable head amplifier for most “dynamic” transducers is available from FYLDE. Piezo sources or Hydrophones are examples of other transducers which cannot be connected to a conventional voltage amplifier, but will work well with a suitable head amplifier.

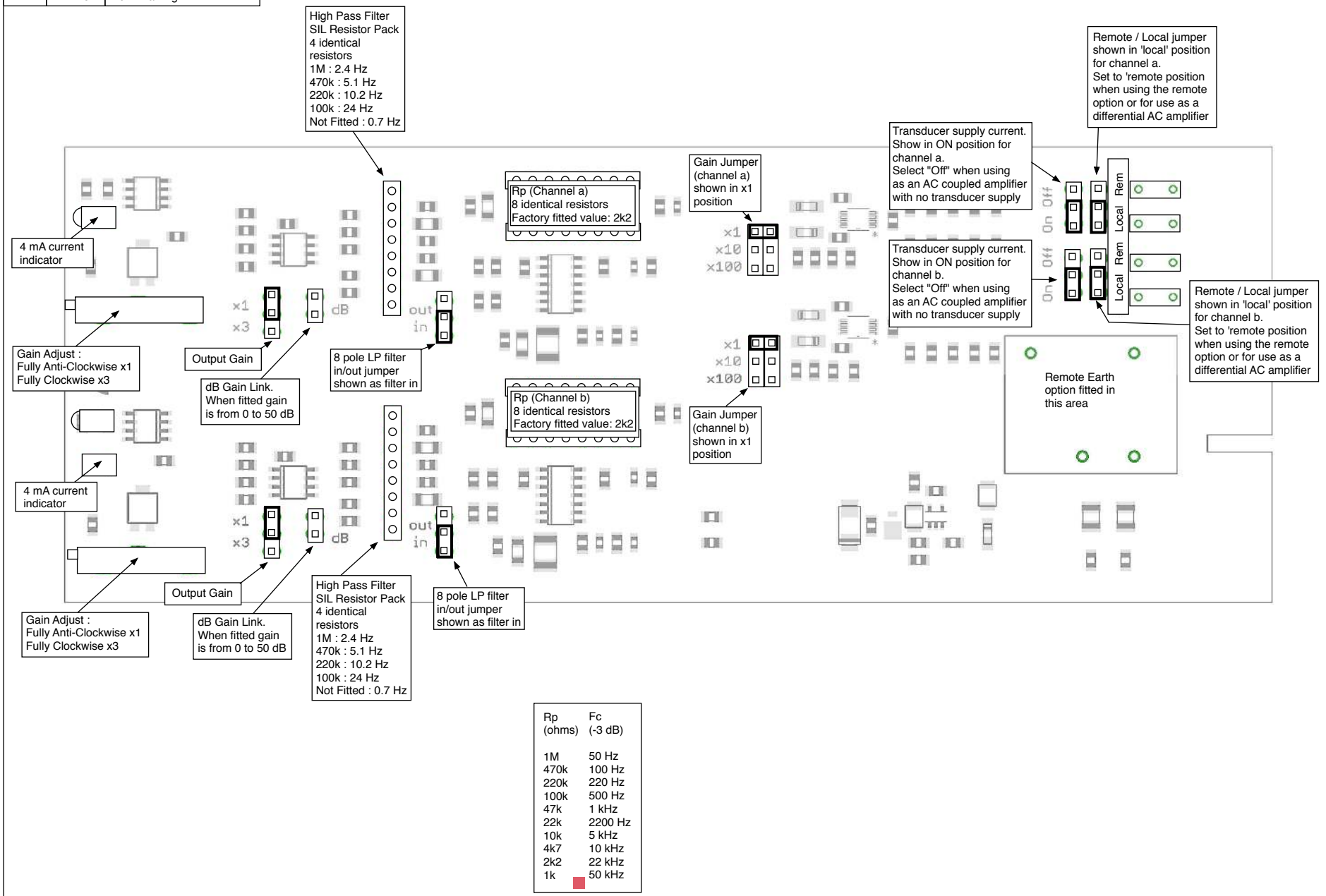
For example the FE-665-DIC head amplifier may be used with piezo-electric transducers which produce a voltage output, but have extremely high output impedance requiring special signal conditioning.

Microdot Coaxial connector to transducer via short low noise cable →

← BNC connector to FE-376-IPF via CA-376-IP connector adaptor

Appendix

Issue	Date	Change History
1	17/4/18	New Drawing



Rp (ohms)	Fc (-3 dB)
1M	50 Hz
470k	100 Hz
220k	220 Hz
100k	500 Hz
47k	1 kHz
22k	2200 Hz
10k	5 kHz
4k7	10 kHz
2k2	22 kHz
1k	50 kHz

FE-376-IPF User Drawing	REF:	DRG.No. : 1336PC	Issue : 1	Date : 18/4/2018	Checked

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