Description

The FE-316-DYN is a dual channel dynamic strain gauge amplifier which energises a gauge or bridge using a unique low noise balanced dynamic constant current. The unit is presented as a printed circuit card with jumpers which select constant current, gain and filter bypass. The 8 pole (-48 dB / octave) LP and 2 pole (-12 dB / Octave) HP filter settings are by plug-in resistor network.

The constant current supply is very low noise and is balanced so that the load resistance develops approximately equal positive and negative voltages at its terminals.

Specification

Amplifier section 2 identical amplifiers.

Input	Impedance	2MΩ differential (1MΩ to ground on each input).
	Coupling	0.16 Hz -3 dB (AC).
	Protection	± 30V peak input volts.
Gain	Selection	Internal jumpers for x 100 to x 3000 (1, 3, steps).
	TempCo	< 25 ppm / °C
	Accuracy	Better than 0.25 %.
	CMRR	> 80 dB 50- 500 Hz
Frequency Range	Bandwidth	0.16 Hz to 100 kHz (-3 dB)
Noise	Amplifier Noise	25 μV pk-pk (referred to input) 1 Hz to 100 kHz Measurement Bandwidth.
Output	Capability	±10V into 2kΩ, 5000pF max.
	Offset	< ± 5 mV
LP Filter	Type	Butterworth 8 pole, preset by plug-in resistor network (50 Hz to 50 kHz)
	Bypass	Filter may be bypassed by jumper link.
	Gain	Unity
	Roll Off	48 dB/ octave, 160 dB/decade
HP Filter	Type	Butterworth 2 pole, preset by plug-in resistor network (0.35 Hz to 350 Hz -3 dB).
	Bypass	Filter may be bypassed by resistor network removal.
	Gain	Unity
	Roll Off	12 dB/ octave, 40 dB/decade

Constant Current supply 2 identical CC supplies.

Current Source	Level	Jumper Selectable 10 mA or 20 mA
	Compliance	> 20V.
	Impedance	> 250 kΩ
	Stability	0.01% / °C
	Noise	<10 nA RMS (equivalent to 1 μStrain pk to pk in 350Ω)

Physical

Environment	Temperature Range	0°C to 50°C operating
Card Size		180 mm x 67 mm.FYLDE MicroAnalog2 format.

FE-316-DYN Specification

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1 FE-316-DYN Amplifier Card Description

The FE-316-DYN is a dual channel combined constant current power supply, filter, and amplifier for use with strain gauges in AC coupled measurement systems. The FE-316-DYN provides a unique constant current which is dynamic, low noise and balanced, allowing the amplifier's high CMR to reject noise and pickup sources.

The constant current method of energisation provides an excellent signal to noise ratio, which combines with the simplicity of a 2 wire connection (to a single gauge) to develop a precise AC coupled measurement technique over a large dynamic range and from below 1Hz to 10's of kHz. No bridge completion is required and the technique removes the need to balance as with a normal strain gauge bridge.

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 Strain Gauge Supply
2. Differential AC Coupled Low Noise Preamplifier
3. Low Pass Filter
4. High Pass Filter
5. Output Buffer Amplifier

1.1 Constant Current Strain Gauge Supply

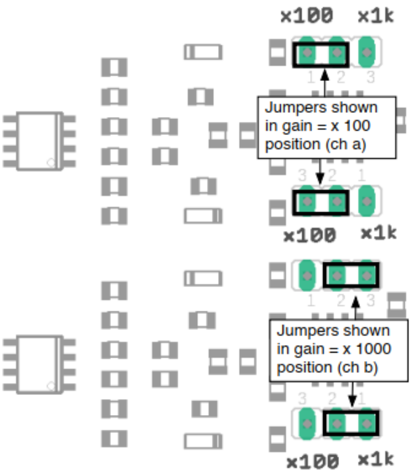
The Constant Current supply is selected by a jumper (see user drawing in the appendix to this handbook.) Selection of 5mA, 10 mA or 20 mA are available. The high compliance voltage (> 20 V) allows all gauge types to be used including the series resistance of Zener barriers. Take care not to select the 20 mA setting if this current exceeds the specified rating of the gauge. There is no minimum resistance and the supply is inherently protected against short circuit. Because the current is constant, the connections to the gauge may be long. The gauge current flows through a constant or slowly varying resistance without detriment to the calibration: ie, the voltage developed across the gauge is dependent only on the current supplied and the resistance of the gauge itself. When current is not flowing the red indicator illuminates for that channel. This normally indicates that the connection to the gauge is faulty (open circuit).

1.2 Differential High Pass Input Stage

The FE-316-DYN amplifies dynamic properties signalled by the transducer (e.g. change of gauge resistance). 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 input stage handles the rejection of RF frequency signals and common mode signals.

There are two settings for the gain of the input stage. These are x100 and x 1000 set by a pair of jumpers.

Figure 1.



Jumper positions for setting x 100 and x 1000 input gain

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

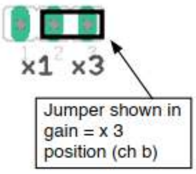
A 2nd order response high pass filter follows the low pass filter. The high pass frequency setting is programmed by plug in resistor networks RP3 and RP4 (a & b) , arranged so that when no resistor pack is fitted the high pass response is a single pole with cut off at 160 mHz (-3 dB). Fitting a resistor pack makes the high pass filter effective. See 2.2.2 “High Pass Response” for details of the frequency response for different filter settings.

1.5 Output Buffer Amplifiers

The output buffer amplifiers are responsible for driving the signal on any cables and to any following recording or data acquisition equipment. The output impedance of the amplifier is 100 Ω. This means that equipment with input impedance of 100 kΩ will reduce the signal by 0.1%. Ideally the following equipment should have an input impedance > 100 kΩ.

The output buffer amplifiers provide additional gain of x1 or x3. This gain is set for each channel using a single jumper.

Figure 2.



Jumper positions for output gain of x 1 and x 3

2 Configuring the Module

Refer to 'FE-316-DYN user drawing 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 gauge, and the operating range of the signal output to the following data acquisition equipment.

The input signal range depends on the current flowing in the gauge, so the minimum signal occurs when 5 mA is flowing in the gauge, and the module gain is set to x 100. The maximum signal occurs when 20 mA is flowing in the gauge and the module gain is set to x 3000.

if you want to reduce the output signal, it is better to decrease the module gain rather than decrease the gauge current. This is because reducing the gauge current reduces the signal to noise ratio. If the signal range is too large and the gain is x 100, then you must reduce the current flowing in the gauge.

The FE-316-DYN module output has a ±10 V output range, and a calibrated gain of between x 100 and x 3000 in steps of 100, 300, 1000 etc. The output range depends upon the chosen gain and the input signal range (which depends on the gauge current).

2.2 Setting the Frequency Response

2.2.1 Low Pass Response.

The FE-316-DYN 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 48 dB 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 300 have approximately 110 kHz bandwidth, and gains of x 1000 and above have approximately 90 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 M	50 Hz
100 k	500 Hz
47 k	1 kHz
22 k	2 kHz
10 k	5 kHz
4700 *	**10 kHz ***
2200	20 kHz
1 k	50 kHz

** Denotes factory fitted resistor pack value*

2.2.2 High Pass Response.

A resistor pack position is provided for a High pass filter. When the resistor pack is not fitted, the high pass -3dB frequency is 160 mHz.

Fitting an 8 pin resistor pack with 4 equal value resistors introduces a 2nd 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.

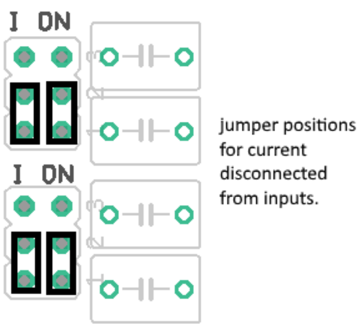
Resistor Pack	-3 dB Bandwidth (Fc)
1 M	0.35 Hz
470 k *	**0.75 Hz ***
220 k	1.6 Hz
100 k	3.5 Hz
47 k	7.5 Hz
10 k	35 Hz

** Denotes factory fitted resistor pack value*

2.3 Operation as an AC Differential Amplifier

The module is suitable for use as a differential AC amplifier. Either channel may be configured as an AC amplifier by setting the jumpers controlling the current sources to ‘out’ .

Figure 3.



Channels a and b configured for AC amplifier operation

2.4 Connecting the Input

Typically only 2 wires will be required for the connection of a single gauge to the amplifiers and current sources; the current for the gauge being supplied via the same wires as the signal which is picked off by the AC coupled preamplifier. It is recommended to use a screened lead having a twisted pair as this will reduce both electrostatic and electromagnetic interferences which may otherwise be gathered in the wiring. The twisted nature of the connection ensures that interference signals are presented equally to both inputs where the common mode rejection is able to reduce the effects. Additionally, the use of a screen benefits electrostatic pickup by providing a shield for the wiring from capacitively induced interference and from RF.

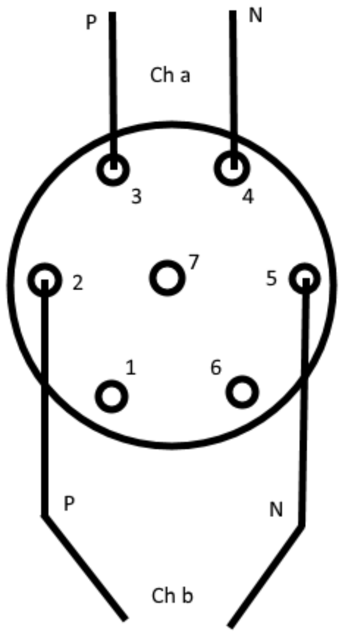
It may be helpful in multichannel applications to minimise wiring complication by using cable having individual twisted pairs with an overall screen, cross talk is controlled by the twisted nature of the connection.

For correct phase (i.e. P more positive than N) connect as shown below. Figure 4 shows the rear view of the input connectors.

Pins 1 and 6 are not connected to the FE-316-DYN module.

When power is ON and current is connected to the input pins, Pin 3 and Pin 2 are at approximately +12V relative to pin 7 (0V). Pins 4 and 5 are at approximately -12 V. It is better to use the cable shell as the screen connection, but pin 7 can also be used.

Figure 4.



Input Connection

2.5 Connecting the Output

The amplifier outputs are ±10 V full scale with a capability of ±5 mA. A connection list is given in the 'System Chassis' section of the enclosure manual. (FE-MM4, FE-MM8, FE-MM16, FE-MM40) It is important to be aware that the amplifier output impedance is 100 Ω.

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 System Configuration

Each Fylde Micro-Analog2 system contains a power supply module (FE-810-BPSDC). The Fylde FE-MM40 contains two power supply modules.

The FE-810-BPSDC is not suitable for more than four FE-316-DYN modules. In any system where more than 4 FE-316-DYN modules operate from a single power supply, the power supply must be replaced by a special configuration of the FE-810-BPSDC. This special configuration is marked "FE-316-DYN Modules Only".

The power supply configuration for "FE-316-DYN only" is not suitable to power other Micro-Analog2 modules.

Of course systems are delivered from Fylde properly configured. However users may wish to move modules between systems.

If it is necessary to mix FE-366-TA modules and FE-316-DYN modules in a FE-MM40 system, the left hand power supply is for channels 1 to 20 and the right hand power supply is for channels 21 to 40. One of these power supplies can be a normal FE-810-BPSDC and can power FE-366-TA modules. The other power supply can be a special "FE-316-DYN only" configuration and can power FE-316-DYN modules.

3.2 Switching On

Refer to the separate handbook for your system enclosure for general information before switching on for the first time..

With power on, the outputs of the FE-316-DYN modules will be at approximately zero. The signals move dynamically positive or negative in response to changing signals at the input.

3.3 Calculation of required Gain

The theoretical signal from the gauge is dependent upon the gauge factor (GF), the voltage across the gauge is 3.5 V (at 10 mA) for a 350Ω gauge (1.2 V for 120Ω gauge) and the output is as follows:-

The change in voltage at the direct output of the amplifier (∂V) is related to the strain by the gauge factor (GF).

i) $\partial R/R = GF \times \text{Mechanical Strain}$

ii) $\partial V = I \times \partial R \times \text{Gain}$

Hence (using Ohm's law)

iii) $\partial V = (V \times GF) \times \text{Strain} \times \text{Gain}$

Expressions ii and iii lead to two methods for calculating the gain required for the measurement.

3.3.1 Method 1

For small changes in resistance, V and GF are both constant, and for a 350Ω gauge V is 3.5 Volts at 10 mA. Thus the calculation is performed as for constant voltage.

e.g. Using a Gauge Factor of 2.0 and assuming a maximum measurement of 1000 μstrains:-.

$\partial V = (3.5 \times 2.0) \times 1000 \times 10^{-6} \times \text{Gain}$

$\partial V = 7000 \times 10^{-6} \times \text{Gain}$

Choose the highest gain which makes $\partial V < 10$ V. In this case choose a gain of 1000.

For 1000 μstrains the gauge signal would be 7 millivolts peak, and an amplifier gain of x1000 raises the 1000 μstrain signal to 7 volts at the direct output of the amplifier.

The voltage developed across a 120Ω gauge for the current of 10 mA is 1.2 V, so for 120Ω gauges simply substitute the lower figure in the above calculation. Note that of course 120Ω gauges will result in lower output signals and often a requirement for higher gains to be set.

e.g. For 100 μstrains with GF = 2.75 and 120Ω gauge @10mA.

$\partial V = (1.2 \times 2.75) \times 100 \times 10\text{ E-6} \times \text{Gain}$

$\partial V = 0.33 \text{ mV} \times \text{Gain}$

To obtain 1V at the output :-

Choose the highest gain which makes $\partial V < 10$ V . In this case choose a gain of 3000.

3.3.2 Method 2

Using expression ii :- $\partial V = I \times \partial R \times \text{Gain}$

Multiply the applied current by the Gauge Factor and the change in gauge resistance :-

Reworking the previous example 2 :-

$\partial V = 10 \times 10\text{ E-3} \times 2.75 \times 120 \times 100 \times 10\text{ E-6} \times \text{Gain}$

$\partial V = 0.33 \text{ mV} \times \text{Gain}$

The user will appreciate that the result will be the same and that the calculation method is a matter of preference.

4 Measurement Accuracy

4.1 Gain Accuracy

The cascaded gain accuracy of the preamplifier and output buffer amplifier is 0.25% with a temperature coefficient of approximately 50ppm/°C

4.2 Current Source Accuracy

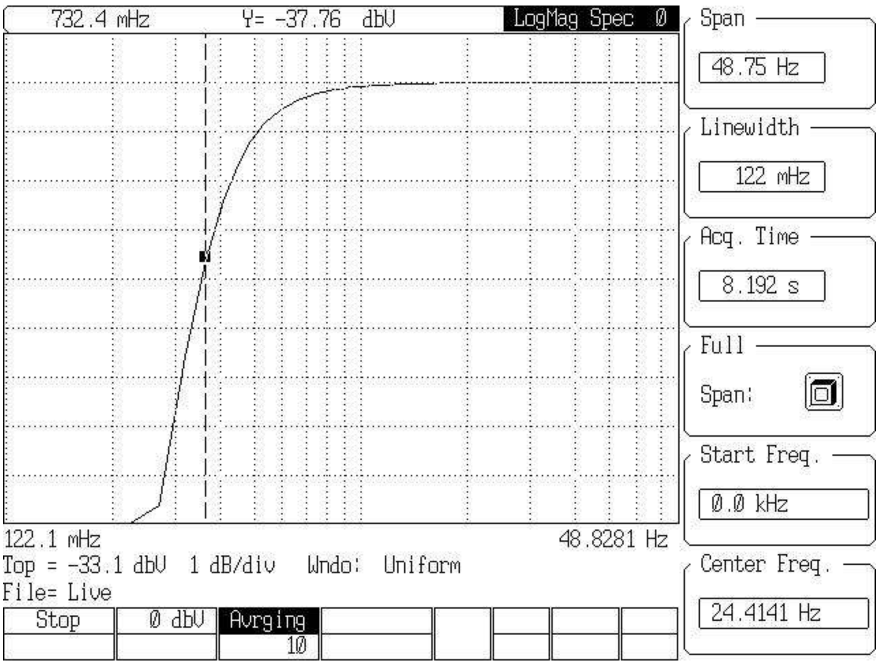
The accuracy of the current sources is ±0.25% when used with resistances in the range 120Ω to 1000 Ω, with a temperature coefficient of approximately 0.03%/°C.

4.3 High Pass Response

The response without a HP resistor pack is single pole and has a -3 dB cut off at 800 mHz.

Note that the response is approximately -3 dB at 0.16 Hz, and -0.1 dB at 1.6 Hz. 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. This is the standard factory fitted filter response.

Figure 5.



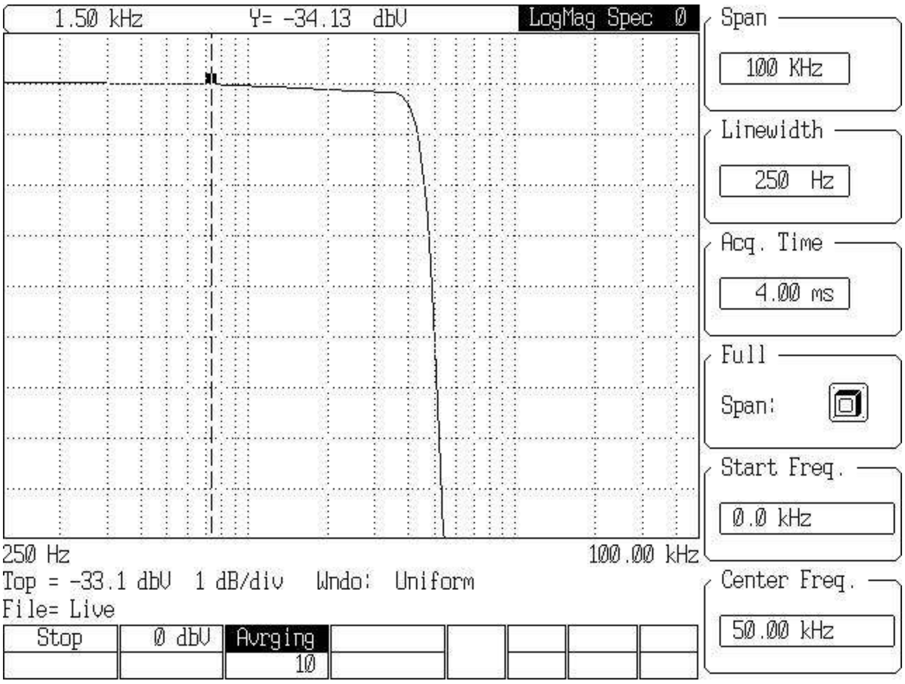
The above HP plot has a -3 dB cut off at 0.75 Hz and is for a 470 kΩ resistor pack

4.4 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 4.7 kΩ which gives a frequency at which the amplitude is 3 dB down (Fc) at 10 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.

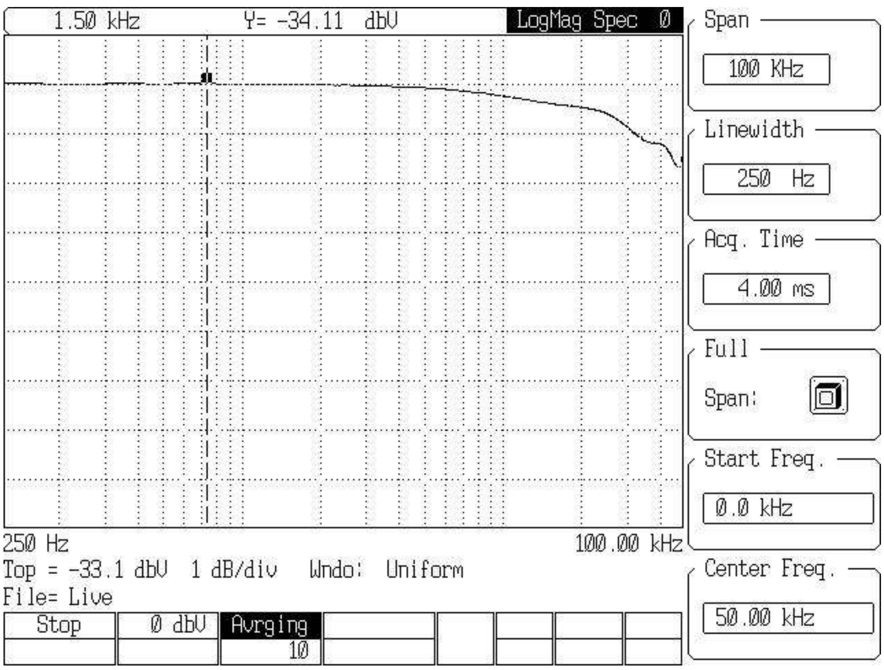
Figure 6.



The above LP plot has a -3 dB cut off at 500 Hz and is for a 4k7 resistor pack

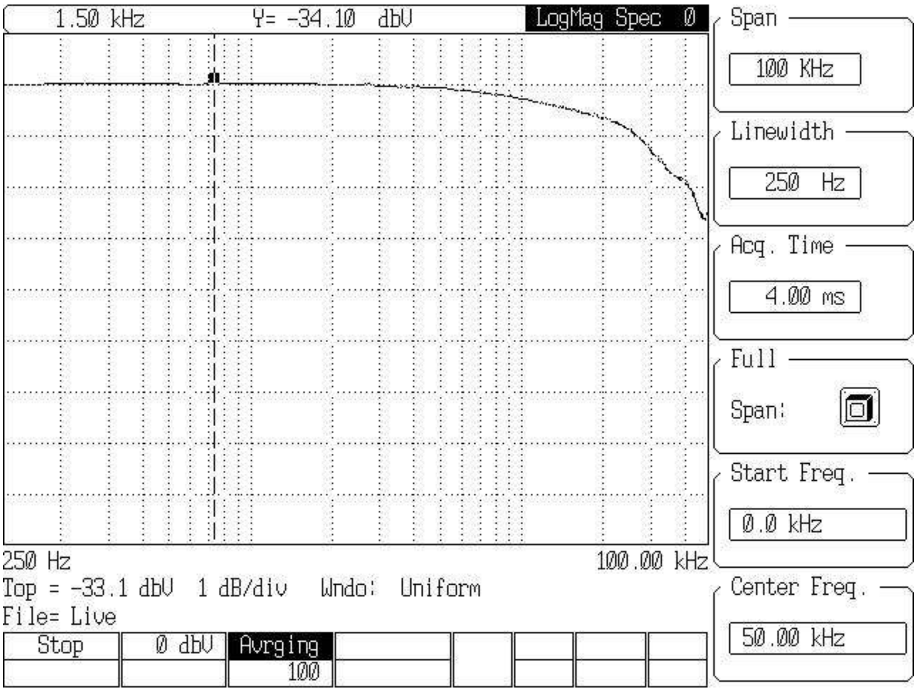
When the low pass filter is by-passed the response is very slightly different for x100 ,and x1000 gains.

Figure 7.



The above LP plot has a -3 dB cut off at > 100 kHz and is for LP filter by-passed and x100, x300 gain

Figure 8.



The above LP plot has a -3 dB cut off at > 100 kHz and is for LP filter by-passed and x1000, x3000 gain

5 Calibration

Although the FE-316-DYN will remain within its stated 0.25 % gain accuracy and current accuracy without routine adjustment, users may wish to obtain results showing the absolute values of the gains available for the different jumper positions, and the accuracy of the current sources.

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

Users should determine their calibration interval requirements based on the importance of their measurement accuracy and the operating and storage environment of the equipment.

FYLDE offer servicing for the FE-316-DYN 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

Measure the amplifier gain using a 1 kHz sine wave of known amplitude. Ensure that the current is not connected to the inputs for this measurement.

Measure Gain at x100, x300, x1000.

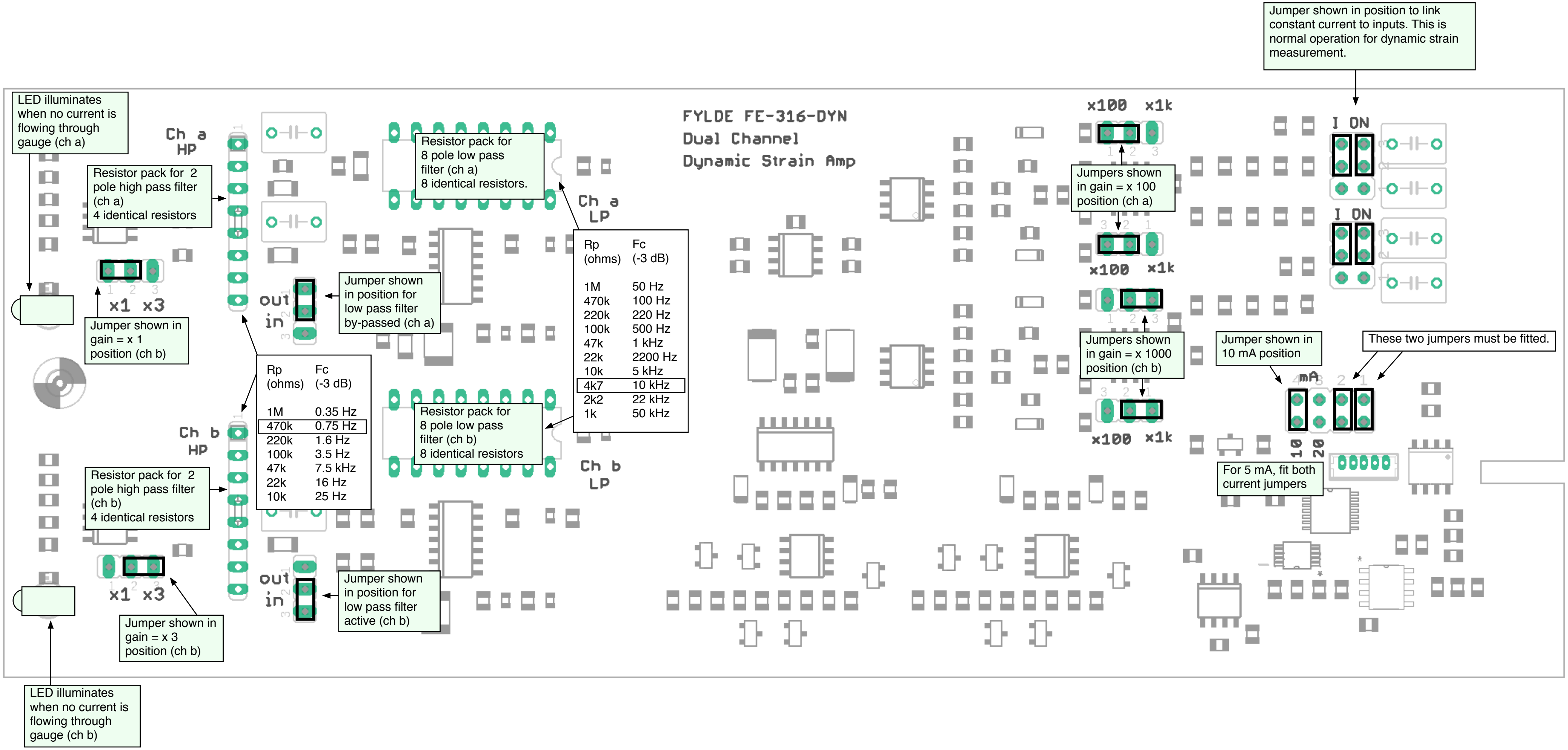
It is sufficient to measure the effect of the x 3 jumper at x300 only. (i.e. it is not necessary to take a measurement at x 3000 gain.)

Connect the current to the inputs and measure the currents at 5 mA, 10 mA, and 20 mA.

Appendix

User Drawing 1383PC

Issue	Date	Change History
1	21/8/2019	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

Rp (ohms)	Fc (-3 dB)
1M	0.35 Hz
470k	0.75 Hz
220k	1.6 Hz
100k	3.5 Hz
47k	7.5 kHz
22k	16 Hz
10k	25 Hz

FE-316-DYN Dynamic Strain Amplifier User Drawing	REF:	Dwg. No. 1383PC	Issue : 1	Date : 21/8/2019	Checked

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