GURALP SYSTEMS

CMG-5T

Triaxial Accelerometer

Operator's guide

Part No. MAN-050-0001

Designed and manufactured by
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1 Introduction

The CMG-5T accelerometer is a three-axis strong-motion force-feedback accelerometer in a sealed case. The sensor system is self-contained except for its 10 – 36V power supply, which can be provided through the same cable as the analogue data. An internal DC–DC converter ensures that the sensor is completely isolated.

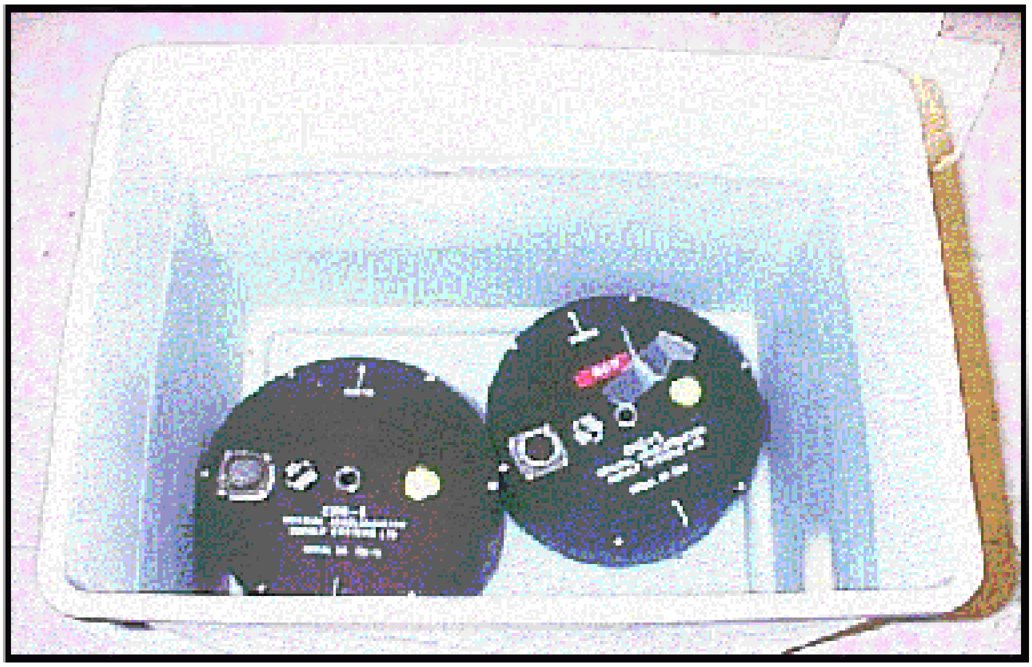
The 5T system combines low-noise components with high feedback loop gain to provide a linear, precision transducer with a very large dynamic range. In order to exploit the whole dynamic range two separate outputs are provided, one with high gain and one with low gain. Nominally, the high gain outputs are set to output a signal 10 times stronger than that from the low gain outputs.

The 5T sensor outputs are all differential with an output impedance of 47 Ω. A single signal ground line is provided as a return line for all the sensor outputs.

Full-scale low-gain sensitivity is available from 4.0*g* down to 0.1*g*. The most common configuration is for the 5T unit to output 5 V single-ended output for 1 *g* ($\approx$ 9.81 ms^{-2}) input acceleration. The standard frequency pass band is flat to acceleration from DC to 100 Hz (although other low pass corners from 50 Hz to 100 Hz can be ordered.) A high frequency option provides flat response from DC to 200 Hz.

Each seismometer is delivered with a detailed calibration sheet showing its serial number, measured frequency response in both the long period and the short period sections of the seismic spectrum, sensor DC calibration levels, and the transfer function in poles/zeros notation. Installation is simple, using a single fixing bolt to fix the sensor onto any surface. No sensor levelling is required.

Optionally, you can use a Güralp Control Unit (CU) and Breakout Box (BB) to distribute power and calibration signals to the sensor and to receive the signals it produces. The CU can also trim DC offsets during installation, if required. It is available in both rack-mounted and water-resistant portable formats. The accelerometer housing itself is completely waterproof, with a hard anodised aluminium body and "O"-ring seals throughout. The photograph below shows two instruments under test by long-period total immersion in a tank of water.



2 Installation

2.1 Unpacking and packing

The CMG-5T accelerometer is delivered in a single cardboard box with foam rubber lining. The packaging is specifically designed for the 5T and should be reused whenever you need to transport the sensor. Please note any damage to the packaging when you receive the equipment, and unpack on a clean surface. The package should contain:

- the accelerometer;
- a signal connection cable (if ordered); and
- a connector, of type 06F-14-19S.

Place the accelerometer on a clean surface, and identify:

- The signal cable connector on the top of the unit;
- The N/S orientation line, engraved on the lid;
- The N/S orientation pointers (studs);
- The bubble level;
- The screw-on cover for the output offset adjuster (see below);

- The central hole for the main fixing bolt; and
- The serial number. If you need to request the sensor production history, you will need to quote either the serial number of the sensor or the works order number, which is also provided on the calibration sheet.

2.2 Initial testing

To test the 5T before installation, you will need a power source which can deliver 100 mA at 10 to 36 V and a digital voltmeter (DVM) with 1 and 10 V ranges. Also ensure that the supplied cable is connected with the correct polarity (see the Appendices).

To make it easier to measure the output from the sensor, you can use a hand-held Control Unit or a custom interface box, which can be manufactured from a screw clamp connector block. This will simplify the connections to the appropriate connector pin outputs.

1. Place the 5T sensor on a flat, horizontal surface.
2. Connect the power supply, observing the correct polarity for the cable supplied, and switch on.
3. Connect the voltmeter to pins L and M of the output connector (corresponding to the low gain vertical component.) Measure the output of the low gain vertical component. The steady output voltage should be about zero (± 10 mV).
4. Repeat the measurement for the N/S and E/W low-gain component outputs (pins C/D and K/U respectively).
5. Now gently turn the sensor onto its side, propping it carefully to prevent rolling.
6. The low gain vertical component should now read about –5 V, corresponding to –1*g*.
7. Roll the instrument until the N/S line is vertical, with N at the top.
8. The low gain N/S component should now read +5 V, corresponding to +1*g*.
9. Roll the instrument until the N/S line is horizontal.
10. The low gain E/W component should now read +5 V.

If the performance so far has been as expected, the instrument may be assumed to be in working order and you may proceed to install the unit for trial recording tests. Most likely, however, you will need to adjust the mass deflection offset (see Section 2.4, page 8.)

2.3 Installing the sensor

You will need a solid surface such as a concrete floor to install the 5T.

If you are in any doubt about how to install the sensor, you should contact Güralp Systems.

1. Prepare the surface by scribing a N/S orientation line, and installing a grouted-in fixing bolt around the middle of the line. A 6 mm (0.25 in) threaded stud is suitable, or an expanding-nut rock bolt or anchor terminating in a threaded stud. The bolt should be about 120 mm (5 in) long.

2. Place the accelerometer over the stud, on the scribed base-line, and rotate to bring the orientation line and studs accurately in alignment with it. The accelerometer has no levelling feet, but can use an internal simulated level adjustment to compensate as long as it is fixed to a hard, clean surface within 1 ° of the horizontal.

3. Fix the accelerometer in place using a fixing nut with spring washer. Do not over-tighten.

4. If required, make a screening box for the sensor, to shield it from draughts and sharp changes of temperature. A suitable box can be constructed from expanded polystyrene slabs (*e.g.* 5 cm building insulation slabs) with sealed joints between them and a hole drilled for the connector. You can then use high-grade glass fibre sealing tape to fix the leads in position and fasten the box to the mounting surface. Commercial duct sealing tape is ideal.

5. Connect the sensor to your digitizing equipment or Control Unit to start receiving signals.

Temporary installations

5T sensors are ideal for monitoring vibrations at field sites, owing to their ruggedness, high sensitivity and ease of deployment. Temporary installations will usually be in hand-dug pits or machine-augered holes. Once a level base is made in the floor, the accelerometer can be sited there and covered with a box or bucket. One way to produce a level base is to use a hard-setting liquid:

1. Prepare a quick-setting cement/sand mixture, and pour it into the hole.

2. “Puddle” the cement by vibrating it until it is fully liquefied, allowing its surface to level out.

3. Depending on the temperature and type of cement used, the mixture will set over the next 2 to 12 hours.

4. Install the sensor as above, cover, and back-fill the emplacement with soil, sand, or polystyrene beads.

5. Cover the hole with a turf-capped board to exclude wind noise and provide a stable thermal environment.

If you prefer, you can use quicker-setting plaster or polyester mixtures to provide a mounting surface. However, you must take care to prevent the liquid leaking away by “proofing” the hole beforehand. Dental plaster, or similar mixtures, may need reinforcing with sacking or muslin.

Installation in Hazardous environments

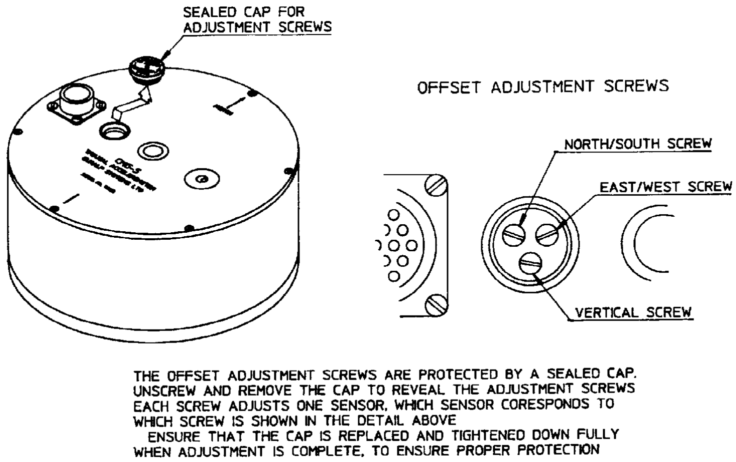
The fully enclosed aluminium case design of the 5T instrument makes it suitable for use in hazardous environments where electrical discharges due to the build up of static charge could lead to the ignition of flammable gasses. To ensure safe operation in these conditions, the metal case of the instrument must be electrically bonded ('earthed') to the structure on which it is mounted, forming a path to safely discharge static charge.

Where electrical bonding ('earthing') is required during the installation of a 5T instrument, the central mounting hole that extends through the instrument should be used as the connection point. This is electrically connected to all other parts of the sensor case. Connection can be made by either a cable from a local earthing point terminated in a 8mm ring tag or via the mounting bolt itself.

2.4 Centring the 5T

Once it is installed, you should centre the instrument ready for use. The offset can be as much as the entire output range of the accelerometer, which corresponds to around 1 ° from the horizontal or vertical. You can check that the 5T is within this range by using the bubble level on the top of the casing: as long as the bubble lies completely within the scribed ring, the remaining adjustments can be made internally.

1. Remove the screwed cover protecting the level adjusters. The cavity contains three adjustment screws, which are arranged as shown in the diagram below:



2. Power up the sensor, and connect a digital multimeter to its low-gain vertical outputs (pins L and M). Alternatively, use a Güralp Systems CMG-5T hand-held control unit to monitor the outputs more easily.

3. Adjust the vertical screw until the output voltage reads zero.

4. Repeat steps 2 and 3 for the N/S and E/W channels, (pins C/D and K/U respectively).

5. If necessary, continue to adjust each channel in turn until consistent results are obtained on all three channels.

6. Repeat steps 2 to 5 using the high-gain outputs, if available, and refine the settings as far as possible.

7. Replace the protective cover firmly, to keep the instrument's electronics protected from water and dust.

After the cover is installed, the accelerometer outputs may drift until the system establishes temperature equilibrium with its environment and the sensor settles down in its position. If required, the offset adjustment can be repeated to achieve a better output offset. With experience, it should be possible to reduce the output level to less than ± 1 mV.

2.5 Electrical connections

Each channel inside the 5T sensor has four output lines: a pair of differential outputs with low gain and another pair with high (around × 10) gain.

Optionally, the second gain block can be configured at the factory to act as a high-pass filter to remove the DC offset at the output terminal. If this is the case, the gain at these outputs will be set to × 1 (unity), with a separate circuit board providing a filter with a corner frequency of 0.05 Hz (20 s) or 0.025 Hz (40 s). The output offsets of a high-pass output cannot be zeroed using the DC offset adjustment screws; in any case, this offset should not be more than ± 1 mV. The high-pass output is likely to take around five times the time constant of the high-pass circuit to settle down. This time constant is provided on the calibration sheet, together with accurately-measured frequency values.

The two pairs of output lines are balanced about signal ground so that either differential drive or single-ended drives of opposite polarity (phase) are available. For a single-ended drive, the signal ground must be used as the signal return path. You must *not* ground any of the active output lines, as this would allow damaging currents to flow through the output circuits. Also, if single-ended outputs are used, the positive acceleration outputs must be interfaced to the recorder.

For distances up to 10 metres, you can connect the sensor outputs using balanced, screened twin lines terminated with a high-impedance differential input amplifier. The sensor outputs have a nominal impedance of 47 Ω.

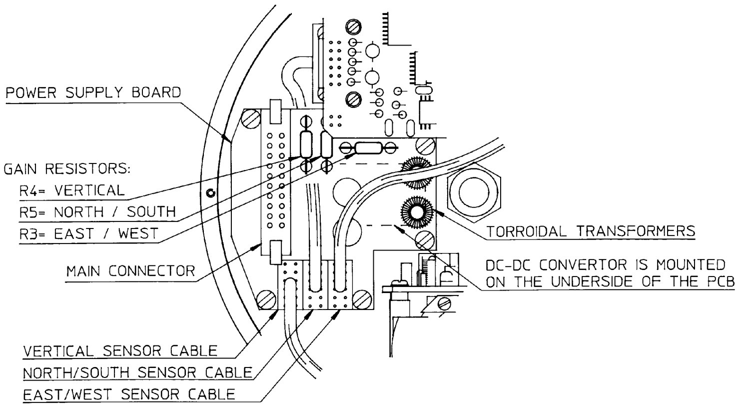
The 5T is normally powered directly from a connected Güralp digitizer through the 10-way connector, although you can use a separate 10 – 36 V DC power supply if you wish. The current consumption from a 12 V supply is about 53 mA. An isolated DC–DC converter installed inside the sensor housing forms the main part of the 5T unit's power supply; its filtered outputs provide the ±12 V required to operate the sensor electronics. The DC–DC converter is protected against polarity reversal.

The calibration signal and calibration enable inputs are referenced to the signal ground. If you are using a Güralp digitizer, these lines can be connected directly to its calibration lines. Otherwise, you will need to provide a 5 V logic level on the calibration enable input in order to calibrate the instrument. The signal ground line is used as the return for both calibration enable and calibration signal lines. See Chapter 3 for more details.

Modifying the sensitivity

This section applies to instruments *before* serial number T5225 only.

The primary gain block of the 5T is normally set at × 1 (unity). If higher sensitivity is required, the gain of the instrument can be altered by inserting gain-setting resistors onto the power supply board of the unit:



If G is the gain change you require, then the value of the resistors to insert is given by the formula

$$R = 10000 / (G - 1)$$

Care must be taken when soldering these resistors to the circuit board, as overheating the terminal could easily damage surrounding circuit elements.

3 Calibration

The 5T is supplied with a comprehensive calibration document, and it should not normally be necessary to calibrate it yourself. However, you may need to check that the response and output signal levels of the sensor are consistent with the values given in the calibration document.

3.1 Absolute calibration

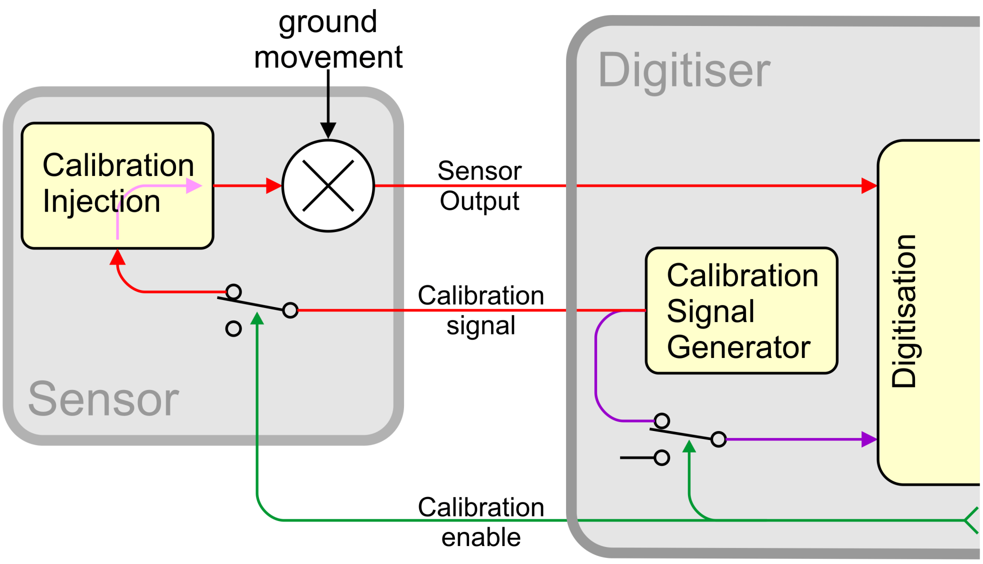
The sensor's response (in V/ms^{-2}) is measured at the production stage by tilting the sensor through 90 ° and measuring the acceleration due to gravity. Local *g* at the Güralp Systems production facility is known to an accuracy of 5 digits. In addition, sensors are subjected to the "wagon wheel" test, where they are slowly rotated about a vertical axis.

The response of the sensor traces out a sinusoid over time, which is calibrated at the factory to range smoothly from 1*g* to –1*g* without clipping.

3.2 Relative calibration

The response of the sensor, together with several other variables, is measured at the factory. The values obtained are documented on the sensor's calibration sheet. Using these, you can convert directly from voltage (or counts as measured in Scream!) to acceleration values and back. You can check any of these values by performing calibration experiments.

Güralp sensors and digitizers are calibrated as described below.



In this diagram a Güralp digitizer is being used to inject a calibration signal into the sensor. This can be either a sine wave, a step function or broad-band noise, depending on your requirements. As well as going to the sensor, the calibration signal is returned to the digitizer on a full rate channel (older digitizers used one of the 4 Hz auxiliary (Mux) channels). The calibration signals and sensor output all travel down the same cable from the sensor to an analogue input port on the digitizer.

The signal injected into the sensor gives rise to an *equivalent acceleration* (EA on the above diagram) which is added to the measured acceleration to provide the sensor output. Because the injection circuitry can be a source of noise, a *Calibration enable* line from the digitizer is provided which disconnects the calibration circuit when it is not required. Depending on the factory settings, the *Calibration enable* line must be either allowed to float high (+5 to +10 V) or held low (0V, signal ground) during calibration: this is specified on the sensor's calibration sheet.

The equivalent acceleration corresponding to 1 V of signal at the calibration input is measured at the factory, and can be found on the sensor calibration sheet. The calibration sheet for the digitizer documents the number of counts corresponding to 1 V of signal at each input port.

The sensor transmits the signal differentially, over two separate lines, and the digitizer subtracts one from the other to improve the signal-to-noise ratio by increasing common mode rejection. As a result of this, the sensor output should be halved to give the true acceleration.

CMG-5T instruments are tuned at the factory to produce 1 V of output for 1 V input on the calibration channel. For example, a sensor with an acceleration response of 0.25 V/ms^{-2} should produce 1 V output given a 1 V calibration signal, corresponding to 1/0.25 = 4 ms^{-2} = 0.408 *g* of equivalent acceleration.

3.3 Calibrating accelerometers

Both the DM24 digitizer and Scream! software allow direct configuration and control of any attached Güralp instruments. For full information on how to use a DM24 series digitizer, please see its own documentation. If you are using a third-party digitizer, you can still calibrate the instrument as long as you activate the *Calibration enable* line correctly and supply the correct voltages.

1. In Scream!'s main window, right-click on the digitizer's icon and select **Control...**. Open the *Calibration* pane.

2. Select the calibration channel corresponding to the instrument, make any other choices you require, and click **Inject now**. A new data stream, ending `Cn` (*n* = 0 – 7) or `MB`, should appear in Scream!'s main window containing the returned calibration signal.

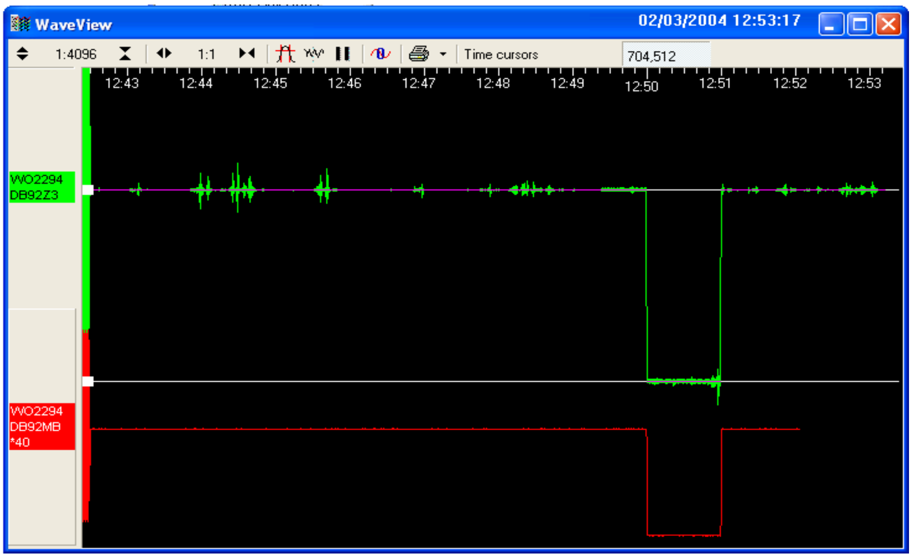
3. Open a Waveview window on the calibration signal and the returned streams by selecting them and double-clicking. The streams should display the calibration signal combined with the sensors' own measurements. If you cannot see the calibration signal, zoom into the Waveview using the scaling icons at the top left of the window or the cursor keys.

4. If you need to scale one, but not another, of the traces, right-click on the trace and select **Scale…**. You can then type in a suitable scale factor for that trace.

5. Click on **Ampl Cursors** in the top right hand corner of the window. A white square will appear inside the Waveview at the top left. This is in fact two superimposed cursors.

6. Drag one cursor down to be level with the lowest point of the signal trace.

7. Drag the other down to be level with the highest point. In the following example, a step function of 1 minute duration has been applied to the `Z3` stream. Note that ground movements continue to be observed, superimposed on the returning calibration signal.



The **Ampl Cursors** button will now be displaying a value, which is the strength of the returning signal in counts (doubled, if using a sine wave). Measure the other two signal strengths in this manner.

Note that if you have used the **Scale...** option described above, you will need to take the scale factor into account to produce the correct number of counts. In the example, the `MB` (calibration input) signal has been scaled by a factor of 40, so the signal strength as measured by the **Ampl Cursors** must be *divided* by 40 to yield the correct value.

8. Convert to volts using the *μV/Bit* values given on the digitizer's calibration sheet for the various input ports, and compare the returned signal with the input calibration signal (`MB`).

9. In the example, the following data are now known:

Input calibration signal strength (`MB`)	697,221 counts
Returning signal strength (`Z3`)	701,512 counts

The calibration sheets provide us with the remaining values needed to calibrate the sensor:

Sensor acceleration response	0.254 V/ms^{-2}
Equivalent accel. from 1V calibration	1.968 ms^{-2}
Digitizer input port sensitivity	3.507212 μV/Bit
Calibration channel sensitivity	3.491621 μV/Bit

From these we calculate that the calibration signal is producing 697,221 × 3.491621 = 2,434,431 μV (2.434 V). This corresponds to an equivalent input acceleration of 2.434 × 1.968 = 4.791 ms^{-2}.

The sensor's acceleration response is given as 0.254 V/ms^{-2}, so that an acceleration of 4.791 ms^{-2} will produce an output of 0.254 × 4.791 = 1.217 V (1,216,904 μV), which corresponds to a count number at the digitizer's input port of 1,216,904 / 3. 507212 = 346,972 counts.

Because this calibration is being carried out with a differential-output sensor, the count number observed at the digitizer should be double this: 693,944 counts. All Güralp Systems sensors use balanced differential outputs.

The actual signal at the digitizer of 701,512 counts is within 1.5% of this value, indicating that the sensor is adequately calibrated.

10. If you know the local value of *g*, you can also perform absolute calibration by tilting the sensor by 90 ° and varying the calibration signal until it precisely compensates for the signal generated due to gravity.

11. Calibrate any other sensors connected to the digitizer in the same way. You must wait for the previous calibration to finish before doing this: clicking **Inject now** has no effect whilst the *Calibration enable* relay is open.

If you prefer, you can inject your own signals into the system at any point (together with a *Calibration enable* signal, if required) to provide independent measurements, and to check that the voltages around the calibration loop are consistent. For reference, a DM24-series digitizer will generate a calibration signal of around 16000 counts / 4 V when set to 100% (sine-wave or step), and around 10000 counts / 2.5 V when set to 50%.

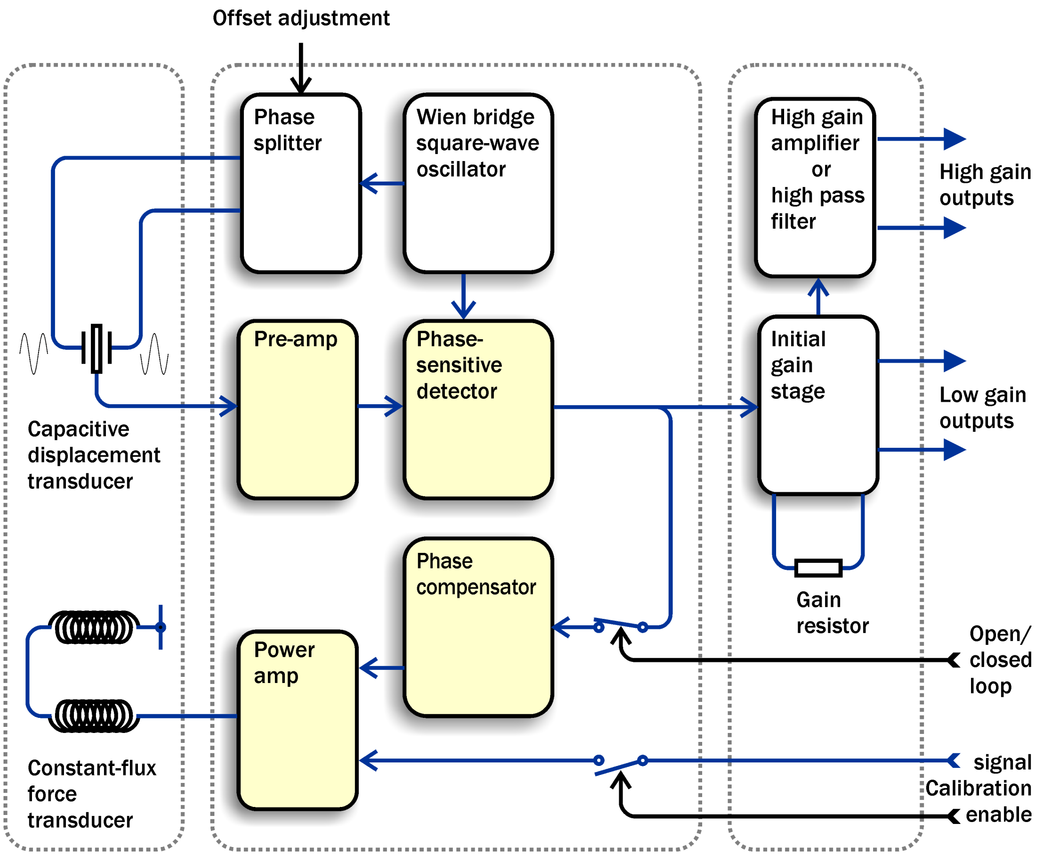
4 Inside the 5T

The 5T unit is constructed of hard-anodised aluminium with “O” rings throughout, ensuring a completely waterproof housing.

Inside, the mass of the vertical and horizontal components is attached to the rigid frame with parallel leaf springs. The geometry of the spring spacing, together with the symmetrical design, ensures large cross-axis rejection. The sensor mass is centred between two capacitor plates, and moves in a true straight line, with no swinging motion. Feedback coils are attached either side of the sensor mass, forming a constant-flux force feedback transducer.

The vertical and horizontal sensors are identical in mechanical construction; the vertical sensor's mass spring system is adjusted to compensate for gravity. They are mounted directly onto the base, with the sensor electronics fixed onto the rigid sensor frame. A single-row, 12-way surface mount R/A Molex connector joins each sensor to the main power supply circuit board.

The signal and feedback circuits inside the 5T accelerometer are arranged according to the following diagram:



The mass and the capacitor plates are energised by a two-phase transformer driver, forming a differential capacitor. This acts as a capacitive transducer, whose signal is then demodulated with a phase-sensitive detector. The accelerometer feedback loop is completed with a feedback loop compensator and a feedback force transducer power amp.

The differential output amplifier scales the output sensor sensitivity and a second stage amplifier can be configured (at the factory) either as a further cascaded gain stage or as a high-pass filter with unity gain.

4.1 The force transducer

The CMG-5T is a force feedback strong-motion accelerometer which uses a coil and magnet system to generate the restoring feedback force. Such accelerometers inherently depend on the production of a constant-strength field in the magnet gap. Although the high quality magnets used in the 5T accelerometer are exceedingly stable under normal conditions, if the sensor is sited in an area where the background seismic noise is much higher than that of vaults built in seismically stable locations, the flux density may be affected by the external magnetic field generated by the feedback transducer coil.

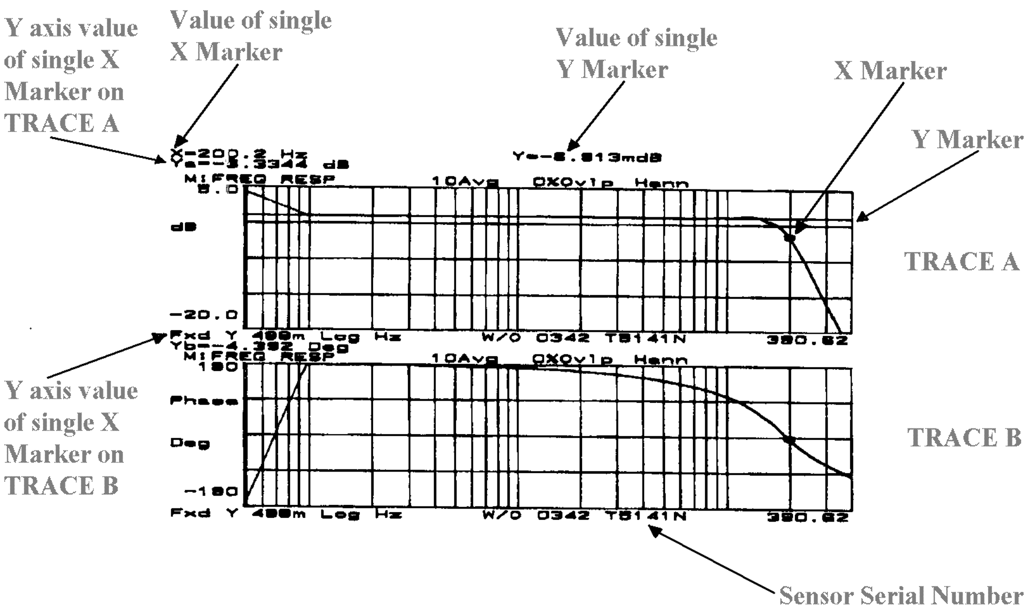
In order to minimise non-linearities in the feedback force transducer, the 5T uses a symmetrical system of two magnets and two force coils. Any increase in flux in one coil is cancelled by a corresponding decrease in flux in the other, thus eliminating any non-linearity due to lack of symmetry.

4.2 Frequency response

The frequency response of each component is provided as amplitude and phase plots.

When testing the instrument to confirm that it meets its design specification, the range of frequencies used are concentrated over about 3 decades (*i.e.* 1000 : 1) of excitation frequencies. Consequently, the frequency plots of each component are provided in normalised form. Each plot marks the frequency cut-off value (often quoted as "–3dB" or "half-power" point).

Güralp Systems performs frequency response tests on every sensor at the time of manufacture. All records are archived for future reference.



The sensor transfer function

Most users of seismometers find it convenient to consider the sensor as a "black box", which produces an output signal *V* from a measured input *x*. So long as the relationship between *V* and *x* is known, the details of the internal mechanics and electronics can be disregarded. This relationship, given in terms of the Laplace variable *s*, takes the form

$$(V/x)(s) = G \times A \times H(s)$$

In this equation

- *G* is the acceleration output sensitivity (gain constant) of the instrument. This relates the actual output to the desired input over the flat portion of the frequency response.

- *A* is a constant which is evaluated so that $A \times H(s)$ is dimensionless and has a value of 1 over the flat portion of the frequency response. In practice, it is possible to design a system transfer function with a very wide-range flat frequency response.

  The normalising constant *A* is calculated at a normalising frequency value fm = 1 Hz, with $s = j f$m, where $j = \sqrt{-1}$.

- *H* (*s*) is the transfer function of the sensor, which can be expressed in factored form:

$$H(s) = N \frac{\prod_{i=1,n} s - Z_i}{\prod_{j=1,m} s - P_j}$$

In this equation zn are the roots of the numerator polynomial, giving the zeros of the transfer function, and pm are the roots of the denominator polynomial giving the poles of the transfer function.

In the calibration pack, G is the sensitivity given for each component on the first page, whilst the roots z_n and p_m, together with the normalising factor A, are given in the *Poles and Zeros* table. The poles and zeros given are measured directly at Güralp Systems' factory using a spectrum analyser. Transfer functions for the vertical and horizontal sensors may be provided separately.

5 Calibration information

Every CMG-5T is supplied with a comprehensive calibration pack detailing the characteristics of the sensor.

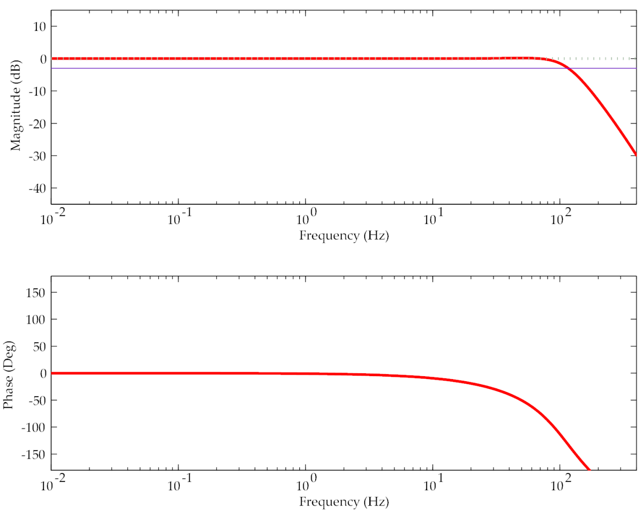
5.1 Calibration sheet

The calibration sheet provides the measured acceleration responsivities over the flat portion of the sensor frequency response, in units of volts per metre per second squared (V/ms^{-2}). Because the sensor produces outputs in differential form (also known as push-pull or balanced output), the signal received from the instrument by a recording system with a differential input will be twice the true value. For example, the calibration sheet may give the acceleration responsivity as “2 x 0.50 V/ms^{-2}”, indicating that this factor of 2 was not included in the value given.

Caution: You must never ground any of the differential outputs. If you are connecting to a single-input recording system, you should use the signal ground line as the return line.

5.2 Poles and zeroes

The poles and zeroes table describes the frequency response of the sensor. If required, you can use the poles and zeroes to derive the true ground motion mathematically from the signal received at the sensor. The 5T is designed to provide a flat response (to within 3dB) over its passband. For example, the following curve describes the frequency response of a 100 Hz sensor:



6 Connector pinouts

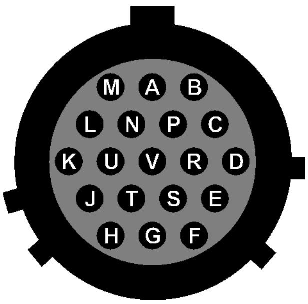
6.1 5Ts with high gain output option

The 5T sensor has a single connector for both power and signal output. The following details apply if the second amplification stage is being used to provide a high (10 ×) gain output channel.

This is a standard 19-pin "mil-spec" plug, conforming to MIL-DTL-26482 (formerly MIL-C-26482). A typical part-number is 02E-14-19P although the initial "02E" varies with manufacturer.

Suitable mating connectors have part-numbers like ***-14-19S and are available from Amphenol, ITT Cannon and other manufacturers.

Pin	Function	Pin	Function
A	High gain +ve, N/S channel	L	Low gain –ve, vertical channel
B	High gain –ve, N/S channel	M	Low gain +ve, vertical channel
C	Low gain +ve, N/S channel	N	High gain –ve, vertical channel
D	Low gain –ve, N/S channel	P	High gain +ve, vertical channel
E	Calibration signal (all channels)	R	High gain +ve, E/W channel
F	Power +12 V (all channels)	S	Calibration enable (all channels)
G	Power 0 V (all channels)	T	Signal ground (*essential* if a long power cable is used)
H	*not connected*	U	Low gain +ve, E/W channel
J	Open/closed loop (all channels)	V	High gain –ve, E/W channel
K	Low gain –ve, E/W channel		



Wiring details for the compatible socket, ***-14-19S, as seen from the cable end.

6.2 5T high pass filter output option

The following table applies if the second amplification stage is being used to provide a high-pass filter (with unity gain). The same connector is used and the connector information above (in Section 6.1) applies.

Pin	Function
A	High pass filtered acceleration +ve, N/S channel
B	High pass filtered acceleration –ve, N/S channel
C	Acceleration +ve, N/S channel
D	Acceleration –ve, N/S channel
E	Calibration signal (all channels)
F	Power +12 V (all channels)
G	Power 0 V (all channels)
H	Power –12 V (all channels)
J	Open/closed loop (all channels)
K	Acceleration –ve, E/W channel
L	Acceleration –ve, vertical channel
M	Acceleration +ve, vertical channel
N	High pass filtered acceleration –ve, vertical channel
P	High pass filtered acceleration +ve, vertical channel
R	High pass filtered acceleration +ve, E/W channel
S	Calibration enable (all channels)
T	Signal ground (*essential* if a long power cable is used)
U	Acceleration +ve, E/W channel
V	High pass filtered acceleration –ve, E/W channel

7 Specifications

Outputs and response	Low gain output options	2*g*, 1*g*, 0.5*g*, 0.1*g*
	Corresponding high gain outputs	0.2*g*, 0.1*g*, 0.05*g*, 0.01*g*
	Dynamic range at 2 g	standard
	Dynamic range, 0.005 – 0.05 Hz	< 140 dB
	Dynamic range, 3 – 30 Hz	< 127 dB
	Standard frequency band	DC – 100 Hz (–3dB point)
	Optional low-pass corner	50, 100 or 200 Hz
	Linearity	0.1 % of full scale
	Cross-axis rejection	0.001*g* / *g*
Calibration controls	Open-loop response	pin on connector
	Closed-loop response	pin on connector
	Step function response	may be added to open- and closed-loop calibrations
	External inputs	Sine-wave, step, or pseudo-random
Physical	Lowest spurious resonance	450 Hz
	Operating temperature range	–20° to +70 °C
	Pressure jacket material	hard anodised aluminium
	Power / signal connector	Mil-spec connector on sensor housing (02E-14-19P)
	Weight	2,270 g
Power	Current at 12 V DC	8 mA per axis

8 Revision history

1009-12-14	E	Revised calibration section and new “internals” diagram.
2009-10-05	D	Additional connector information and some purely cosmetic changes
2007-11-20	C	Installation in hazardous environments section added.
2006-09-22	B	Added revision history
2006-01-06	A	New document