A good choice for a piezo-electric sensor interface is a charge amplifier, based on a low noise JFET input op-amp.

For battery operation a reference 0V "star point" (SP) can be generated with high value resistors plus decoupling capacitors. The electrolytic capacitors need to be quite large (47µF) as they appear in series with the sensor. The smaller (ceramic) capacitors (100nF) are best located physically close to the op-amp.

The star point should be anchored to local 0V ("earth"). To be pedantic the output signal is also referred to this point, hence the separate connection (a screened twisted pair).

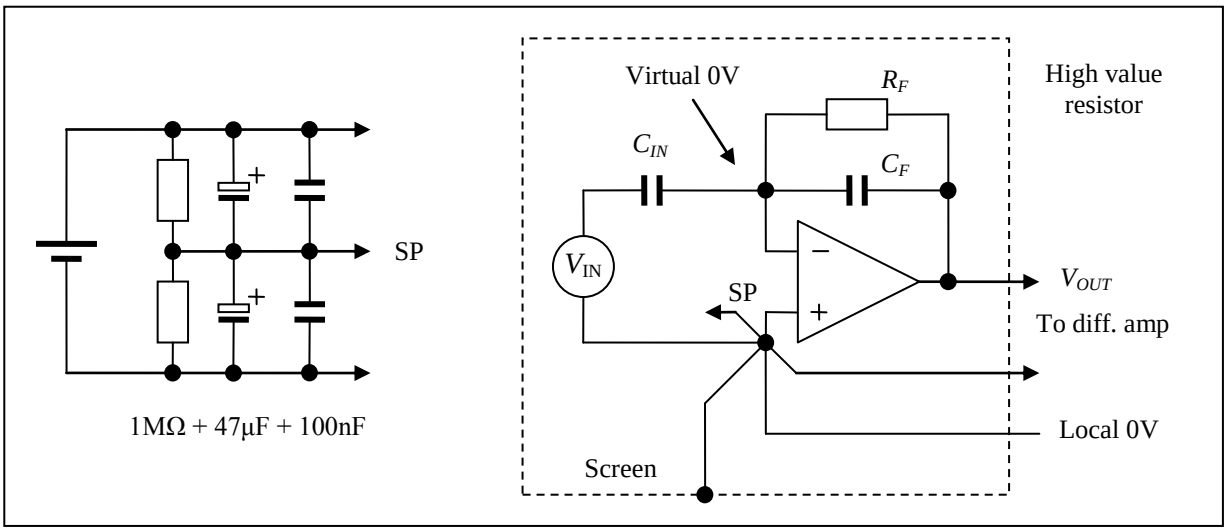

Fig. 1 Charge amplifier with screen

The action of feedback is to create a "virtual earth" at the inverting input. This can be used as a summing junction – sensors can be connected in parallel. It also means that the gain is accurately determined by the sensor and feedback capacitors. The (low frequency) transfer function is a first order high-pass filter with a lower frequency cut-off: -

$$T(s) = \frac{V_{OUT}}{V_{IN}} = \frac{C_{IN}}{C_F} \times \frac{R_F C_F s}{1 + R_F C_F s} \qquad f_L = \frac{1}{2\pi R_F C_F}$$

One can also easily measure the charge being generated: $Q = C_F V_{OUT}$

A good choice of values would be: $R_F = 100M\Omega \quad C_F = 100\,pF \quad \Rightarrow f_L = 16Hz$

The upper frequency limit is determined by the gain-bandwidth product of the op-amp in the usual way.

If you do not have a true differential amplifier you can boost the signal level with a quasi differential stage. Any current taken from the charge amplifier must return via the earth connection and to the battery via the decoupling capacitors. The capacitors thus appear in series with the input resistor, setting a lower frequency limit. An input resistor >1k should be OK: -

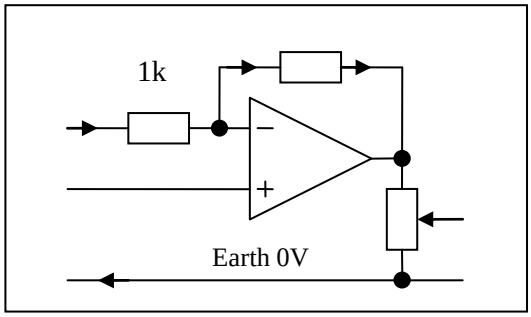

Fig. 2 Quasi diff. amp.

The screen should be 100% with only small holes for cables. The sensor and charge amp should be as physically close as possible. Any extra capacitance between the virtual earth and 0V increases noise gain (noise from the op-amp).

The screen is only for (quasi) electrostatic fields (i.e. low frequency). It can be fabricated from very thin conducting material. Copper on Mylar is ideal, else copper tape and self adhesive tape for insulation.

The output pair should also be twisted (or coax) to keep magnetic interference out.

If you must use a section of coax cable, between the sensor and charge amplifier, choose a low microphony/triboelectric type – usually with a graphite layer between the dielectric and braided layer. Both screens should overlap the coax braid.

The power supplies can also be microphonic – loose wires acting like electrets.

The high value resistor introduces a DC offset due to the leakage current of the op-amp. For example: -

$$R_F = 100M\Omega \quad \text{and} \quad I_L = 10\,pA \quad \Rightarrow \quad 1mV$$

If necessary use a 100μF (low voltage tantalum) capacitor in series with the input of the second stage amplifier.

Good luck.