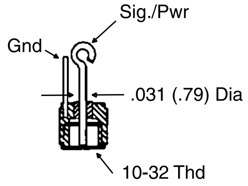
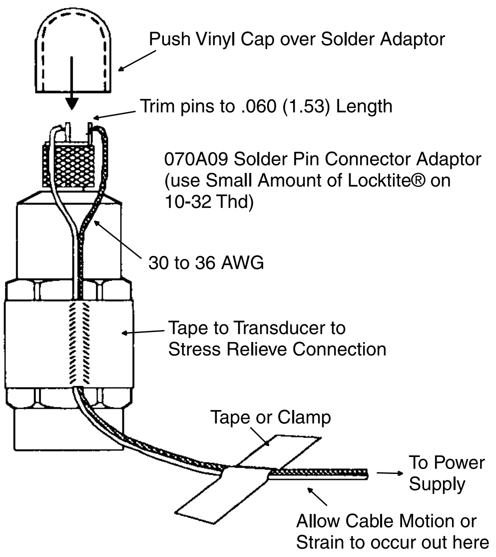
contamination, use RTV sealant or heat-shrinkable tubing on cable connections. O-rings with heat shrink tubing have proven to be an effective seal for protecting electrical connections for short-term underwater use. The use of only RTV sealant is generally only used to protect the electrical connection against chemical splash or mist.

Under high shock conditions or when cables must undergo large amounts of motion, as with package drop testing applications, the use of a solder connector adaptor and lightweight ribbon cables are generally recommended. These solder connector adaptors provide a more durable connection and can be installed onto the accelerometer with a thread locking compound to prevent loosening. Use of lightweight cables helps to minimize induced strain at the connector, which can create an erroneous output signal. Electrical connection fatigue is also minimized, reducing the possibility of intermittent or open connections and loss of data. Solder connector adaptors are installed onto the cable with solder. This easy connection makes this type of connector user- or field-repairable in times of crisis. Normally, a flexible plastic plug is placed over the electrical connections for protection, as well as to provide cable strain relief.

The solder connector adaptor provides an affordable and simplistic method for making cables in the field. Only solder and a soldering iron are required. No special tools or equipment are necessary for installation on a cable end. Because of the reliability and strength of this connection, these connectors are recommended for use in shock applications.



Solder Connector Adaptor



CABLE DRIVING CONSIDERATIONS AND CONSTANT CURRENT LEVEL

Operation over long cables may effect frequency response and introduce noise and distortion when an insufficient current is available to drive cable capacitance.

Unlike charge mode systems, where the system noise is a function of cable length, ICP sensors provide a high voltage, low impedance output well-suited for driving long cables through harsh environments. While there is virtually no increase in noise with ICP sensors, the capacitive loading of the cable may distort or filter higher frequency signals depending on the supply current and the output impedance of the sensor.

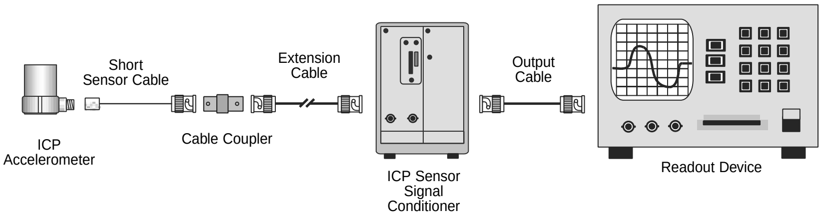
Generally, this signal distortion is not a problem with lower frequency testing within a range up to 10 000 Hz. However, for higher frequency vibration, shock, or transient testing over cables longer than 100 ft. (30 m.), the possibility of signal distortion exists.

The maximum frequency that can be transmitted over a given cable length is a function of both the cable capacitance and the ratio of the peak signal voltage to the current available from the signal conditioner according to:

$$f_{max} = \frac{10^9}{2\pi CV / (I_c\text{-}1)}$$

where, f_{max} = maximum frequency (hertz)
C = cable capacitance (picofarads)
V = maximum peak output from sensor (volts)
I_c = constant current from signal conditioner (mA)
10^9 = scaling factor to equate units

Driving Long Cable Lengths



Note that in the equation, 1 mA is subtracted from the total current supplied to the sensor (1c). This is done to compensate for powering the internal electronics. Some specialty sensor electronics may consume more or less current. Contact the manufacturer to determine the correct supply current. When driving long cables, the equation above shows that as the length of cable, peak voltage output or maximum frequency of interest increases, a greater constant current will be required to drive the signal.

The nomograph on the next page provides a simple, graphical method for obtaining the expected maximum frequency capability of an ICP® measurement system. The maximum peak signal voltage amplitude, cable capacitance, and supplied constant current must be known or presumed.

For example, when running a 100 ft. cable with a capacitance of 30 pF/ft, the total capacitance is 3000 pF. This value can be found along the diagonal cable capacitance lines. Assuming the sensor operates at a maximum output range of 5 volts and the constant current signal conditioner is set at 2 mA, the ratio on the vertical axis can be calculated to equal 5. The intersection of the total cable capacitance and this ratio result in a maximum frequency of approximately 10.2 kHz.

The nomograph does not indicate whether the frequency amplitude response at a point is flat, rising, or falling. For precautionary reasons, it is good general practice to increase the constant current (if possible) to the sensor (within its maximum limit) so that the frequency determined from the nomograph is approximately 1.5 to 2 times greater than the maximum frequency of interest.

Note that higher current levels will deplete battery-powered signal conditioners at a faster rate. Also, any current not used by the cable goes directly to power the internal electronics and will create heat. This may cause the sensor to exceed its maximum temperature specification. For this reason, do not supply excessive current over short cable runs or when testing at elevated temperatures.

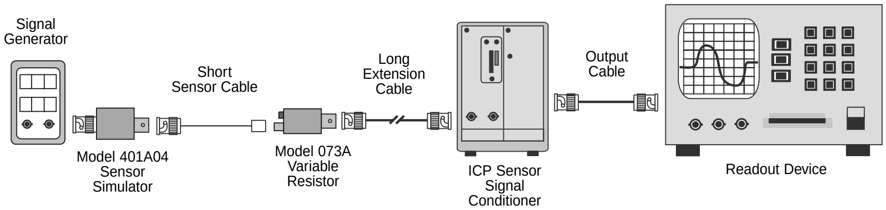
Experimentally Testing Long Cables

To more accurately determine the effect of long cables, it is recommended to experimentally determine the high frequency electrical characteristics.

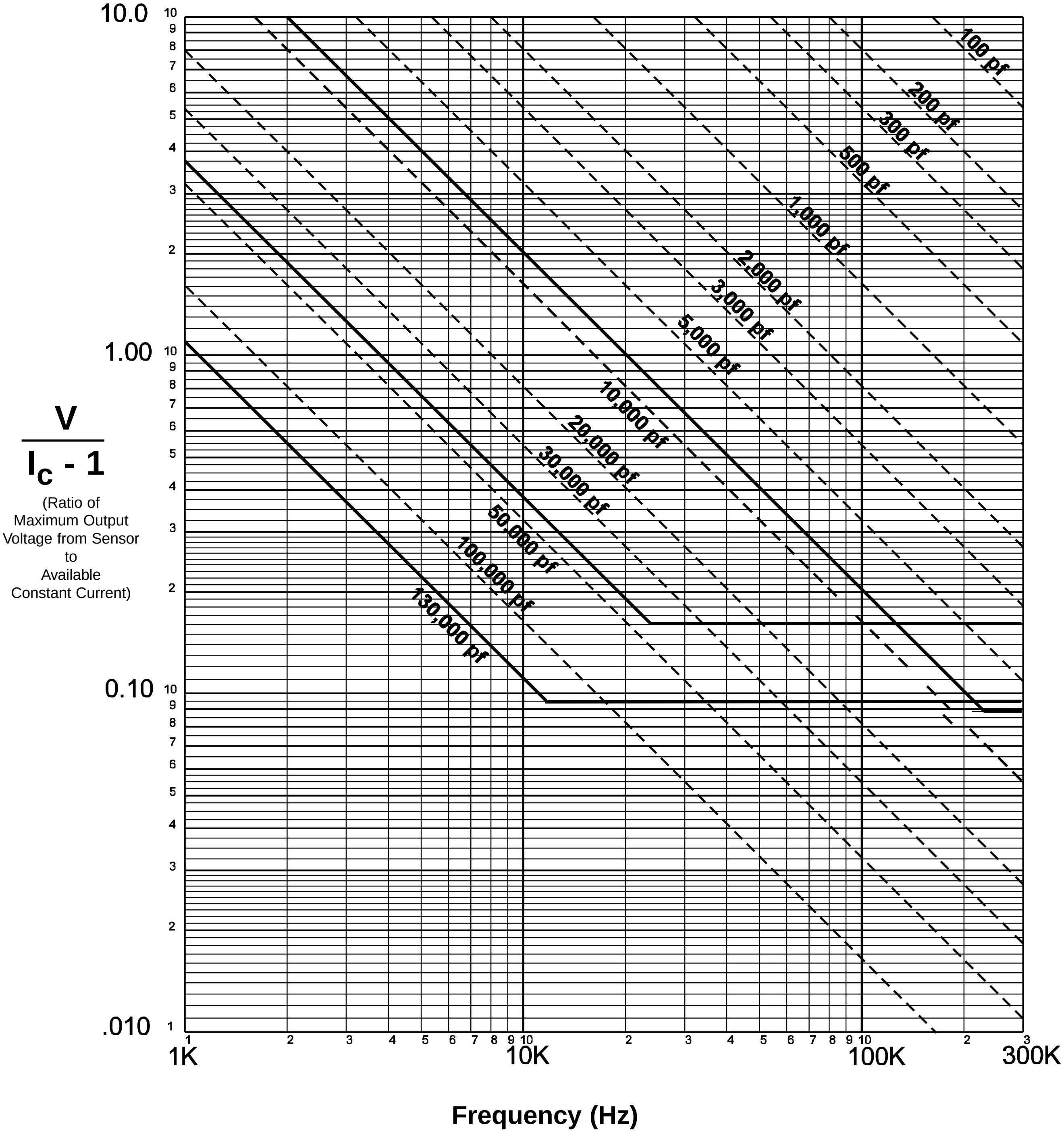
The method illustrated below involves connecting the output from a standard signal generator into a unity gain, low-output impedance (<5 ohm) instrumentation amplifier in series with the ICP sensor. The extremely low output impedance is required to minimize the resistance change when the signal generator/amplifier is removed from the system.

In order to check the frequency/amplitude response of this system, set the signal generator to supply the maximum amplitude of the expected measurement signal. Observe the ratio of the amplitude from the generator to that shown on the scope. If the ratio is 1:1, the system is adequate for your test. (If necessary, be certain to factor in any gain in the signal conditioner or scope.) If the output signal is rising (1:1.3 for example), add series resistance to attenuate the signal. Use of a variable 100 ohm resistor will help set the correct resistance more conveniently. Note that this is the only condition that requires the addition of resistance. If the signal is falling (1:0.75 for example), the constant current level must be increased or the cable capacitance reduced.

It may be necessary to physically install the cable during cable testing to reflect the actual conditions encountered during data acquisition. This will compensate for potential inductive cable effects that are partially a function of the geometry of the cable route.



Driving Long Cable Lengths



f_{max} = Maximum frequency given the following characteristics

C= Cable capacitance (pF)

V= Maximum output voltage from sensor (volts)

I_c= Constant current level from power unit (mA)

10^9= Scale factor to equate units