Specification of Signal Cable for Downhole Seismic Testing when using ICP® Accelerometers

The length of the cable used in Downhole Seismic Testing (DST) adversely affects the bandwidth of the recorded signals for Integrated Circuit Piezoelectric (ICP®) accelerometers. BCE recommends the use of high precision and high bandwidth (1 Hz to 10 KHz) piezoelectric accelerometers which have an operational amplifier integrated within the sensor. The ICP® accelerometers have highly desirable rise and decay times of approximately 5 µs. These fast rise and decay times result in recorded traces where the input of acoustic waves and ambient noise are recorded with minimal or no sensor distortion as opposed to a damped low bandwidth geophone.

The relationship between ICP® accelerometers bandwith reduction and cable capacitance, shown in a Nomograph chart on the next page, can be defined as follows:

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

with: f_{max} = Maximum frequency [Hz]
I_C = Constant current level from power [mA]
C = Cable capacitance [pF]
V = Maximum output voltage [volts]

The BCE signal conditioning board has a V value of ±3.5 V and an I_C value of 2.25 mA. The cable capacitance depends obviously on the type of cable used. For example, the PCB Piezotronics Inc. coaxial cable has a C value of 95pF/m and diameter of 0.305mm.

For a PCB coaxial cable with a total length of say 150 m the maximum frequency can then be calculated as:

$$f_{max} = \frac{10^9}{2\pi(95x110)(3.5)/(2.25-1)} = 4\ kHz$$

In order to properly characterize the source wave and the background noise, minimal signal distortion, and allow for fast response times and corresponding accurate first break detection BCE suggests a minimum bandwidth of approx. 4 kHz (even though the recommended accelerometers have a bandwidth of 10 kHz). This means that a cable length of 150 m is really the upper limit when using the PCB coaxial cables and that for longer lengths cables with a lower capacitance must be used. For example, twisted pair cables with a C value of 23pF/m (30 AWG) can be obtained resulting in a f_{max} value of 16 kHz.

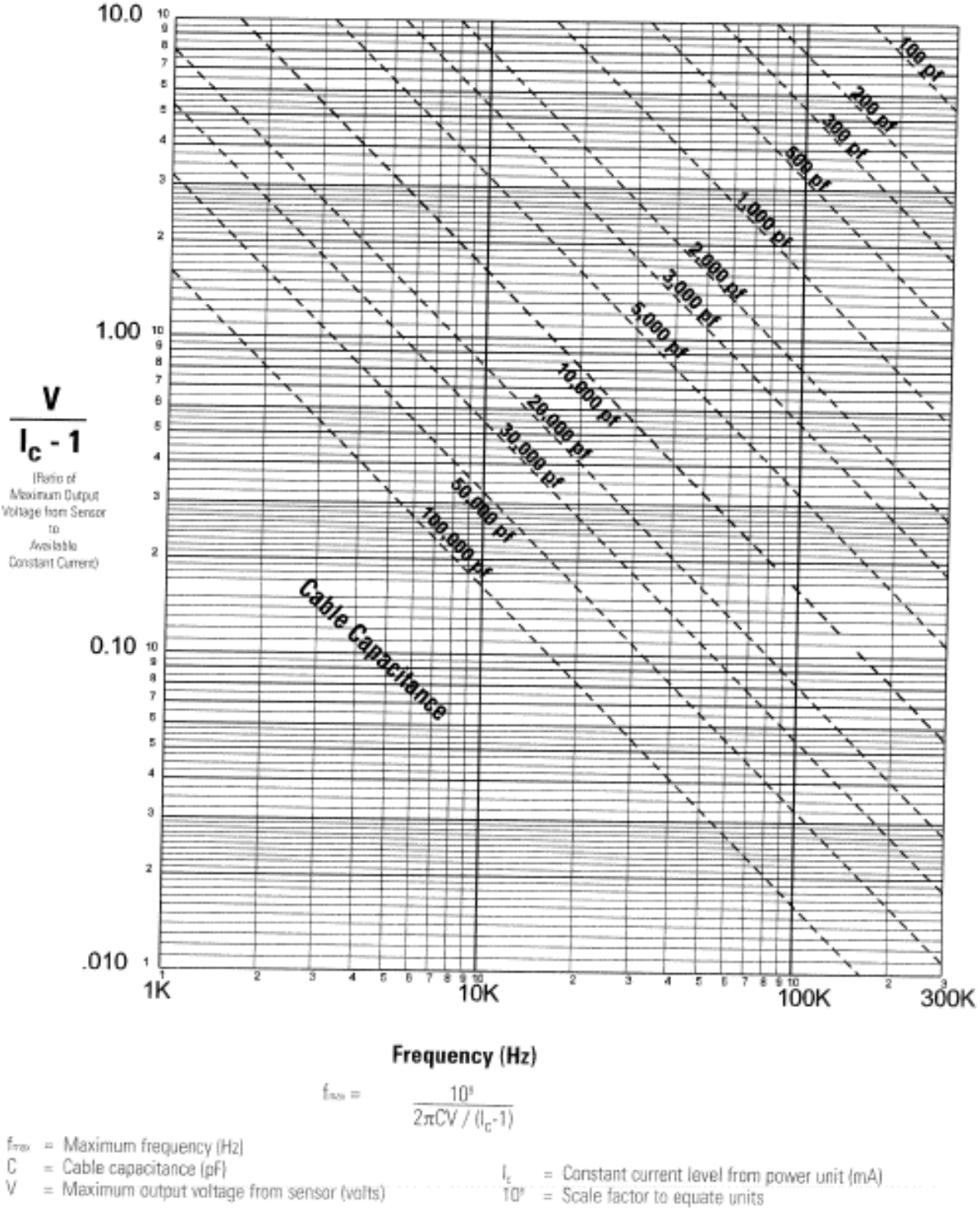

Figure 1. Nomograph chart.

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