How Far the transducer could reach?

One of the most frequently asked questions is “How far the transducer could reach?”. This question can be answered by a simple calculation that is based on the published specifications in the Ultrasonic Ceramic Transducer Data Sheets.
The basic procedure is to first determine the minimum sound pressure level developed at the front end of the receiver for a specific transmitter driving voltage and distance between the transmitter and receiver (transceiver has double distance between reflect target). This SPL must then be converted “Pa” (Pascal) or “µbar” (microbar) units.
The sensitivity of the receiver must then be converted from a dB reference to an absolute mV/Pa or µbar level present to obtain the final output.
Assume a 400ST160 transmitter is driven at a level of 20Vrms and a 400SR160 receiver is located 5 meters from the transmitter and loaded with a 3.9K Ohm resistor (loaded resistor value varies receiver sensitivity, please see “Acoustic Performance” of transducer data sheet).

Data sheet of 400ST/R160 shows:

Transmitting Sound Pressure Level at 40.0Khz; 120dB min.
0dB re 0.0002µbar per 10Vrms at 30cm

Receiving Sensitivity at 40.0Khz 0dB = 1 volt/µbar -65dB min.

Determining SPL at the front end of Receiver

SPL Gain for 20Vrms driving voltage	=	20 * log (20V / 10V) = 6 dB
SPL Reduction at 5 meters	=	20 * log (30 cm / 500 cm) = -24.4 dB
Wave absorption (refer to Figure 2)	=	0.1886 dB/m * 5 = 0.94 dB
The SPL at 5 meters becomes	=	120 + 6 – 24.4 – 0.94 = 100.6 dB

Converting SPL to µbar:

$$100.6 \text{ dB} = 20 * \log (X / 0.0002 \ \mu\text{bar})$$
$$X = 21.4 \ \mu\text{bar}$$

Determining Receiver Sensitivity in Volts/µbar

Converting Sensitivity to Volt/µbar:

$$-65 \text{ dB} = 20 * \log (X / 1 \text{ Volt}/\mu\text{bar})$$
$$X = 0.56 \text{ mV}/\mu\text{bar}$$

Voltage generated under 21.4 µbar = 0.56 * 21.4 = 11.98 mV

This is the calculated voltage developed under the assumed conditions. The actual voltage output will be varied depending on the environmental conditions and absorption or reflection characteristics of target materials in or near the emanating beam. Users, then, have to judge whether this receiving voltage level is large enough for electronic processing.

The analysis is necessary to the fundamental understanding of the principals of sound wave propagation and detection but it is tedious. The figure 10 below is a graphical representation of previous analysis which may be used once in the SPL at the receiver is determined. Enter the graph from the SPL axis and proceed upward to an intersection with –dB sensitivity level of the receiver using the 1V/μbar referenced data.   Follow a horizontal line to the "Y" axis to obtain the receiver output in μV.

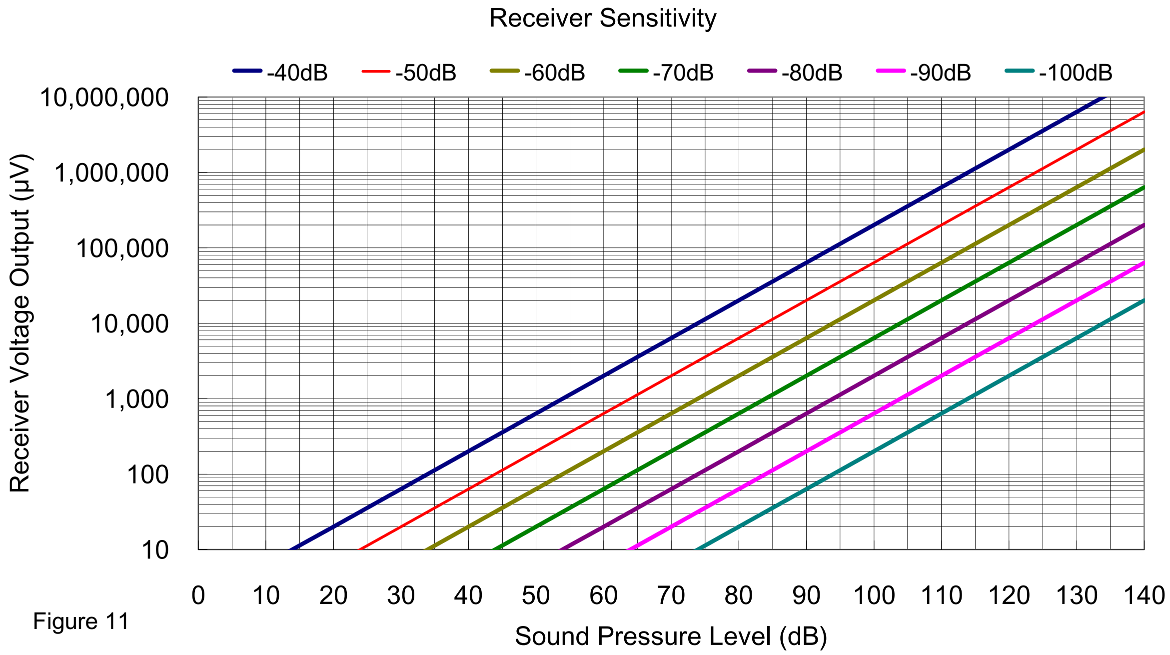

Figure 11

Ultrasonic Echo Ranging

Ultrasonic ranging systems are used to determine the distance to an object by measuring the time required for an ultrasonic wave to travel to the object and return to the source. This technique is frequently referred to as "echo ranging".
The distance to the object may be related to the time it will take for an ultrasonic pulse to propagate the distance to the object and return to the source by dividing the total distance by the speed of sound which is 344 meters/second or 13.54 inches/millisecond.

Below is a block diagram that illustrates the basic design concept and functional elements in a typical ranging system.