# Digital Resolver Integration

## By Dennis Shi-hsiung Fu

Resolver (Synchro) technology has been used in the industrial environment for many years. This technology still provides the best angular position transducer available in terms of ruggedness, reliability and resolution. The resolver operates on the same principle as a rotating transformer which has one primary winding (usually on the rotor for modern brushless resolvers) and two secondary windings (usually on the stator). Figure 1 shows the trigonometrical relationship between resolver rotors and stator windings:
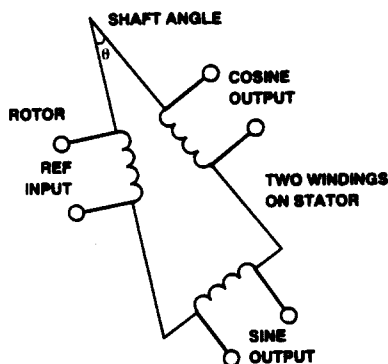
Figure 1. Trigonometrical Relationship Between Resolver Windings

If there is a sinusoidal signal applied across the rotor input, i.e.,

$$V = A \, Sin\omega t$$

then two stator windings will have a certain induced voltage output which has the form:

$$A \, Sin\theta Sin\omega t$$
$$A \, Cos\theta Sin\omega t$$

Here, $\theta$ is the resolver shaft angle, assuming that the primary/secondary ratio is 1:1.

Obviously the output signals are quite similar to those amplitude modulated signals with carrier angular frequency ($\omega$). Figure 2 shows the waveform from rotor and stators.
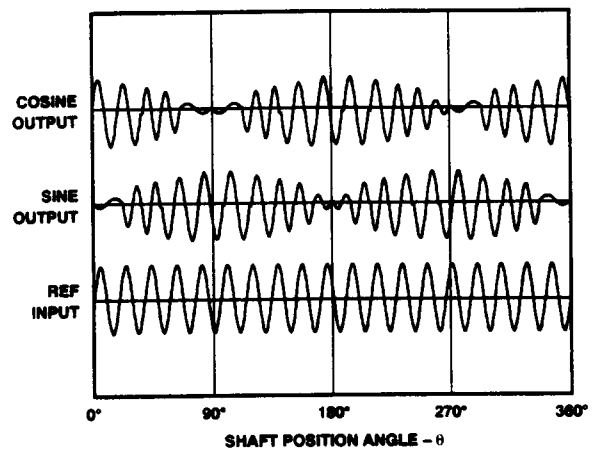
Figure 2. Resolver Signal Waveform

To get position angle $\theta$ in digital format, both sine and cosine channel signals must be sent to a resolver-to-digital converter for decoding. Because of the size, output digital format, cost and the complexity of the peripheral circuitry of the resolver-to-digital converter in the past, it is neither easy nor economical to integrate the converter into the resolver, (especially smaller ones like the size 11 or size 15). Now, with the advent of the AD2S90 (with a 20-pin, PLCC package), comes the real solution for industrial applications—a very rugged, low cost angular position transducer—with digital position output. This digital resolver integration consists of a sine wave oscillator and a AD2S90 R/D converter. Figure 3 shows the block diagram. There are two sets of signals coming out from the digital resolver, serial absolute position data and A Quad B incremental encoder outputs. All the input/output signals are TTL logic compatible.
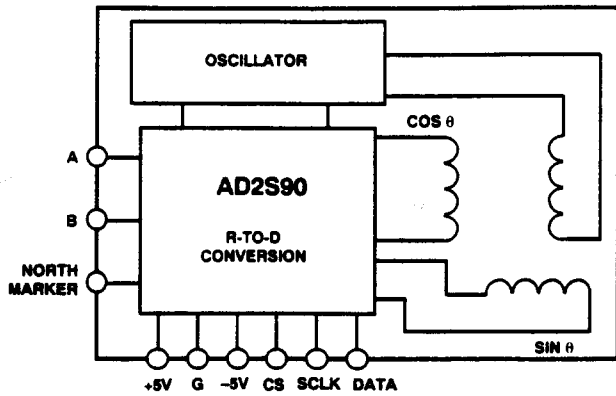
Figure 3. Block Diagram of Digital Resolver

The next section details the implementation of the concept outlined above.

**Practical Implementation**

The digital resolver designed, prototyped and tested is based on a size 11 brushless resolver and has the original profile of a size 11 resolver with an increase in the overall length. Figure 4 shows the outline dimensions of this prototyping model.
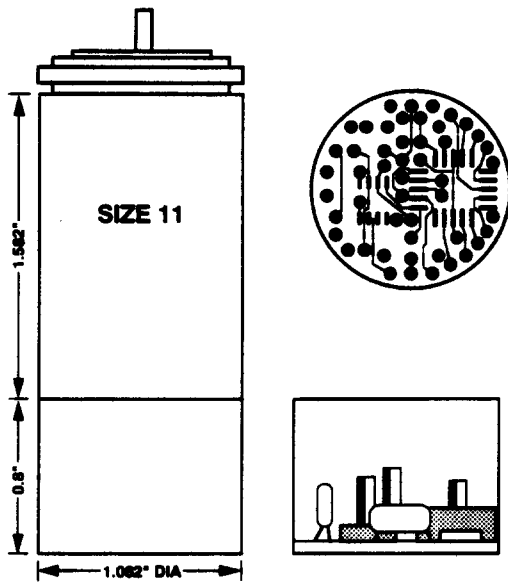


Figure 4. Outline Drawings of the Prototype Digital Resolver (Actual Size)

## FEATURES

Size 11, Heavy Duty Resolver
Totally Digital I/O
Absolute Position Data Output
12-Bit Resolution
Very High Readout Rate
Low Cost
Incremental Encoder, A Quad B and NM O/P

There are five inputs (+5 V, –5 V, GND, Serial Clock, Chip Select) and four outputs (Absolute Serial Data, Incremental A Quad B, and North Marker). For high ambient noise and long distance data transmission applications, this digital resolver can be easily upgraded to a configuration which has differential line driver/receivers built in. For more information on this, please refer to application note "Circuit Applications of AD2S90 Resolver-to-Digital Converter."

## SYSTEM SPECIFICATIONS

| | |
|---|---|
| Resolution | 12 Bit |
| Accuracy | 15 arc min |
| Max Read Rate | 137 Kbyte/s |
| | (1 Byte = 12 Bits Digital Word) |
| Max Rotating Speed | 22,500 rpm |
| Settling Time | 1° Step – 5 ms |
| | 179° Step – 20 ms |
| Logic I/O | Standard TTL |
| Power Supply | ±5 V |
| Operating Temperature Range | –40°C to +85°C |
| Outline Dimensions | See the Left Figure (Actual Size) |
| Weight | ≈ 19 oz |

For more detailed information on digital timing, specifications and application circuits, please refer to the AD2S90 data sheet and other AD2S90 application notes.

The circuit diagram of this design is shown in Figure 5. A Wienbridge oscillator is used here as an excitation source for the resolver. This particular circuit provides an oscillating frequency at about 3000 Hz, which is determined by R and C.

$$f \approx \frac{1}{2\pi RC}$$

$$R = R_1 = R_2$$
$$C = C_1 = C_2.$$

The two resistors at the feedback loop determine waveform shape and distortion. All resistors and capacitors in this application circuit should be chosen with low temperature coefficients, e.g., better than 50 ppm/°C. High quality polycarbonate capacitors should be used to guarantee the temperature stability of the oscillating frequency and to minimize sine wave distortion.
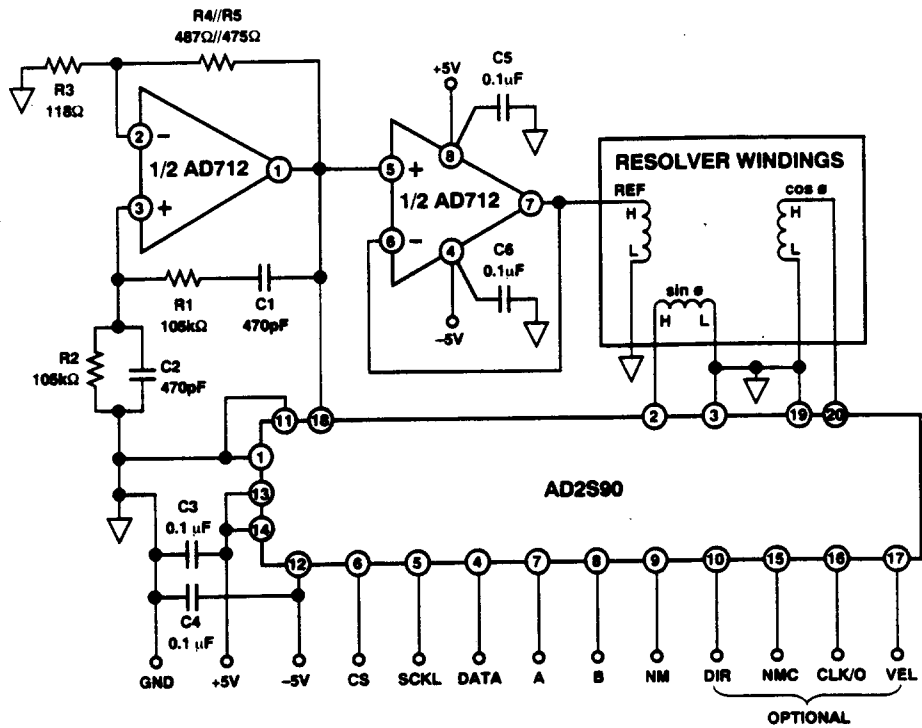
Figure 5. Digital Resolver Circuit Diagram

One application for this digital resolver is shown in Figure 6, which uses one microcontroller to select and read 16 remote location shaft position angles. When the chip select signal is logical HIGH, the corresponding serial data output bus must be in the high impedance state. This simplifies the addressing and reading process.

Another application is the direct replacement and upgrading of the incremental encoder system because of the unique A, B, NM and additional absolute position the digital resolver provides. The resolver can be used as a direct replacement for the encoder without the need to change or upgrade the interface.

**COMPONENTS PART LIST**
Size 11 Brushless Resolver (1)
AD2S90 Resolver-to-Digital Converter (1)
AD712 Dual Op Amp (1)
RN55C Metal Film Resistors (5)
Polycarbonate Caps (2)
High Quality Ceramic Caps (4)
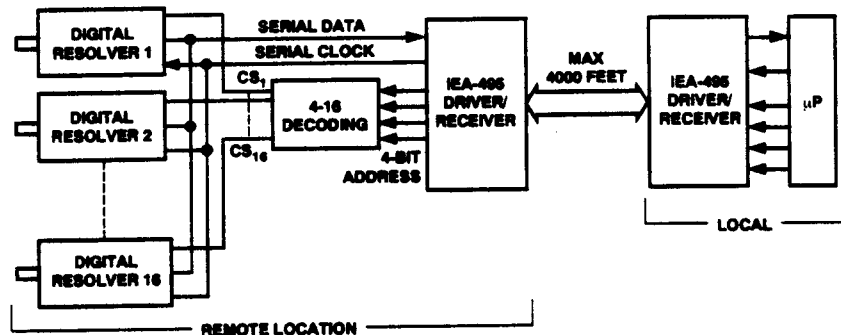PCB and 9 Pin D-Connector (1)

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Figure 6. Remote Access to 16 Shaft Angle Position Information Using One Microcontroller