

## Circuit Applications of the AD2S81A and AD2S80A Resolver-to-Digital Converters

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This application note discusses some useful circuit applications of the AD2S80A and the AD2S81A monolithic resolver-to-digital converters.

It does not discuss the basic operation or specifications of either of the two converters; this information may be found in the data sheets. The following applications are discussed:

1. Interfacing to High Voltage Synchros and Resolvers
2. Connecting the Converter to a 15V Supply
3. Using the AD2S80A as a Control Transformer
4. Using the Converters with External Pitch or Revolution Counters
5. Simulating an Incremental Encoder Using the AD2S80A or AD2S81A
6. Connecting Inductosyns\* to the Converters
7. Using the AD2S81A/AD2S80A to Build a Two Speed Coarse/Fine System.

The AD2S81A is a 12-bit tracking R/D converter packaged in a 28-pin ceramic DIP. The converter can track signals at rates up to 260 revolutions per second. Users can set the dynamic performance of the converter with external components, providing greater flexibility in tailoring the AD2S81A to suit system requirements.

The AD2S80A is a monolithic variable resolution, 10-, 12-, 14- or 16-bit tracking R/D converter packaged in a 40-pin DIP. The AD2S80A offers accuracy up to 2 arc mins  $\pm 1$ LSB and velocity linearity output of 1% at 25°C. The resolution and the dynamic performance of the AD2S80A can be set by the users to suit their own system requirements.

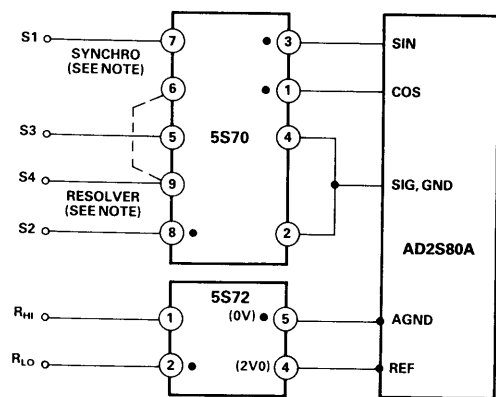
### 1. INTERFACING TO HIGH VOLTAGE SYNCHROS AND RESOLVERS

#### a. Interfacing with External Transformers

Transformers are often used to step down a higher voltage signal to a lower voltage signal. An additional advantage provided by using a transformer in this mode, is that it provides true isolation for the electronics from the resolver and other systems that may be attached to the resolver.

The 5S70 series of signal input transformers are ideal for use with the AD2S80A/AD2S81A converters. They accept all the standard synchro and resolver signal voltages and give the 2V rms signal output required by the monolithic converters.

Similarly the 5S72 transformer enables the reference input of the AD2S80A/AD2S81A to be isolated and accept higher voltages than the standard 2V rms. Figure 1 shows the circuit connections required when the 5S70 and the 5S72 transformers are used with the AD2S80A or AD2S81A.



NOTE  
FOR SYNCHRO OPTIONS, CONNECT PIN 9 TO PIN 6.  
FOR RESOLVER OPTIONS, CONNECT PIN 9 TO S4 TERMINAL OF RESOLVER.  
• DENOTES START OF WINDING.

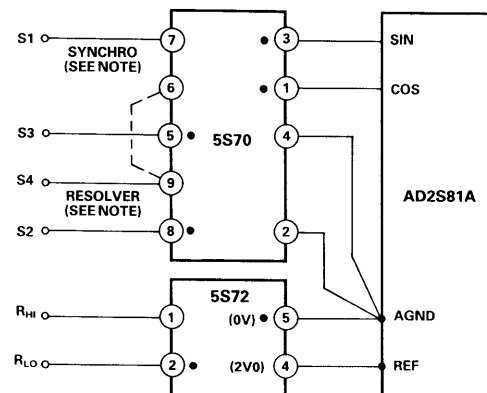


Figure 1. Connecting 5S70 and 5S72 to Either AD2S80A or AD2S81A

### b. Using External Resistors for Scaling Inputs

Sometimes a requirement arises to interface a resolver with nonstandard output voltages to a resolver-to-digital converter. This requirement can either be met by designing a special transformer made to convert the nonstandard outputs of the resolver to the required input voltage on the converter or by using external resistors to scale the input voltages.

The reference and signal inputs to either the AD2S80A or AD2S81A may be scaled using external resistors to accept higher voltages than 2V rms. Let us assume that the signal and reference inputs are at A V rms, where A > 2 V rms. Figure 2a shows how two external resistors can be used as

a potential divider to scale the reference input.

The value of R1 and R2 should be chosen such that:

$$\frac{R1}{R2} = \frac{(A-2)}{2}$$

Absolute resistor values are not critical and should be chosen in the kΩ range.

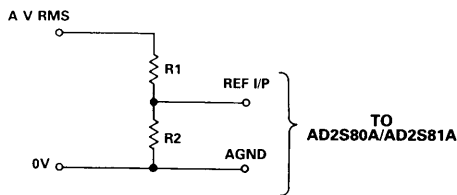
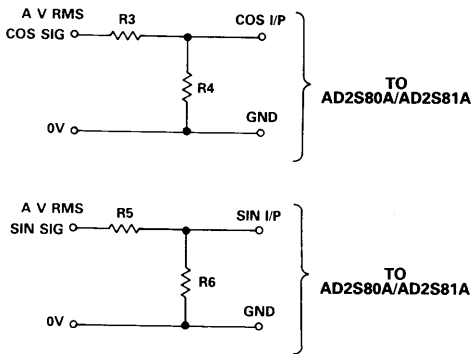


Figure 2a. Scaling Reference Input with External Resistors

It is not important that the absolute value resistors calculated for the reference input is used. The nearest value resistors available to the calculated values can be used.



NOTE: GND FOR 2S81A IS "AGND" PIN AND GND FOR 2S80A "SIG GND" PIN

Figure 2b. Scaling Signal Inputs with External Resistors

Figure 2b shows how the signal inputs can be scaled using external resistors.

In the above external resistor network, R3 and R4 should be chosen such that:

$$\frac{R3}{R4} = \frac{(A-2)}{2} \text{ where } R3 \text{ and } R4 \text{ are in the } k\Omega \text{ range.}$$

$$\frac{R3}{R4} = \frac{R5}{R6} \text{ It is important that this RATIO IS EQUAL. } R5 \text{ and } R6 \text{ should also be in the } k\Omega \text{ range.}$$

The absolute value of the resistors R3, R4, R5 and R6 is not important but the ratio of R3/R4 = R5/R6 should be maintained otherwise the converter accuracy will be affected.

The additional error due to mismatch of the ratio R3/R4 = R5/R6 can be calculated using the formula given below:

$$\frac{\text{Gain Error of Resistors in ppm}}{10} = \text{Error in arc sec}$$

i.e., 1% gain error results in 16.7 arc min.

It is also advisable that the converter outputs be checked for input angle of 45 degrees and the resistor values adjusted accordingly if required.

### 2. USING THE CONVERTER WITH 15V SUPPLY

The AD2S80A/AD2S81A operates from a ±12V supply. In order to operate it from a ±15V supply requires stepping down from ±15V to ±12V. This may be done using the circuit shown in Figure 3a.

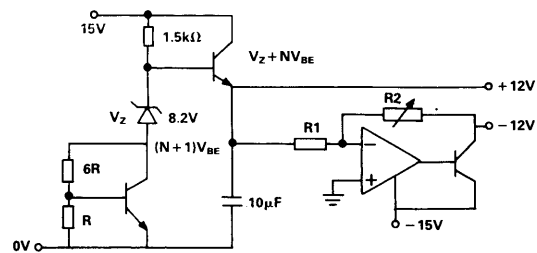


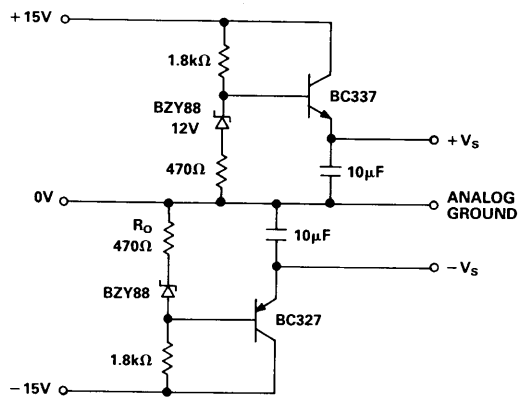
Figure 3a. Circuit for Connecting the Converter to ±15V Supply Requiring Velocity Reversion Error Trimming

The transistors and the Zener diode's combined temperature coefficient compensates for VCO rate temperature coefficient and will ensure a sufficiently accurate 12V supply to the converter over the full operating temperature range.

The -12V supply is derived using the +12V, an amplifier, transistor and resistors. The amplifier is used in negative feedback mode with resistor, R1, and a variable potentiometer, R2. One of the benefits of deriving the -12V in such a way is that it allows trimming of the reversion error on the velocity signal using the potentiometer.

The reversion error, or side-to-side nonlinearity, of the velocity output is a result of differences in the up and down rates of the VCO in the converter. The sensitivity of the VCO rate to -12V depends on the direction of the rotation; therefore, the reversion error can be reduced by varying the magnitude of -12V. By trimming, it is possible to achieve a reversion error of less than 1%.

An alternative to the above circuit which does not require the amplifier is shown in Figure 3b. This circuit may be used if the effect of reversion error on the velocity signal can be tolerated. The reversion error trim can still be included by replacing R<sub>O</sub> with a 1kΩ potentiometer, but it will be more sensitive to supply and temperature variations.



NOTE  
IF  $R_0$  IS REPLACED BY A 1kΩ POTENTIOMETER, IT CAN BE USED TO TRIM THE REVERSION ERROR OF THE VELOCITY SIGNAL.

Figure 3b. Connecting the Converter to  $\pm 15V$  Supply

### 3. USING THE AD2S80A AS A CONTROL TRANSFORMER

The ratio multiplier section of the AD2S80A can be used independently to the rest of the converter to perform the function of Control Transformer. In this mode the signal from the resolver inputs,  $\theta$ , is compared to a digital angle,  $\phi$ , loaded into the counters. Any difference between these two angles results in an analog voltage at the AC ERROR OUTPUT. To use the device in this manner the DATA LOAD pin is used.

Applying a logic "low" to the DATA LOAD pin will allow data to be loaded into the counters of the converter from the data lines. It is important that the data lines are placed in the high impedance state before pulling the DATA LOAD pin "low". A logic "high" on the enable input maintains the output data pins in the high impedance condition and a logic "low" presents the data in the latches to the output pins.

A switch or an open collector logic gate should be used to apply a logic "low" to the DATA LOAD pin because when it is in the "high" state the pin is internally pulled

up to 12V. Figure 4 shows the circuit connections required to operate the AD2S80A as a control transformer.

To operate the AD2S80A as a tracking resolver-to-digital converter the DATA LOAD pin should be left unconnected as it is pulled high internally.

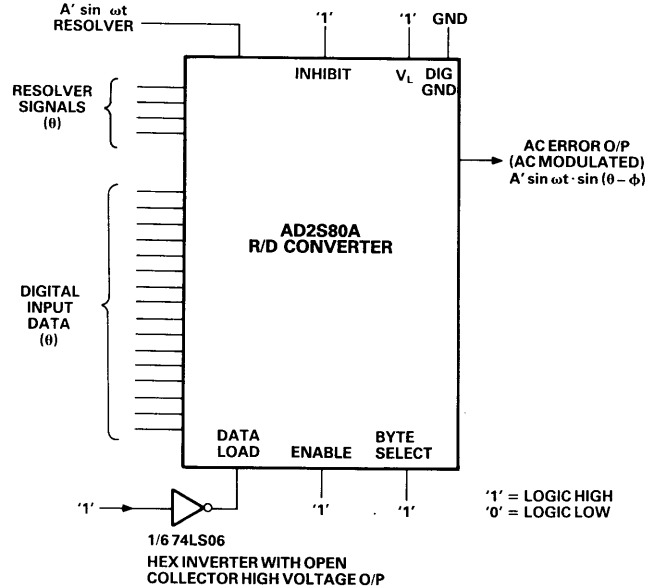


Figure 4. Using the AD2S80A as a Control Transformer

### 4. USING THE CONVERTERS WITH EXTERNAL PITCH OR REVOLUTION COUNTERS

Applications requiring pitch or revolution counts of the resolver can be easily done using external counters and gates. The input revolutions can be counted by using the RIPPLE CLOCK (RC) and DIRECTION (DIR) logic outputs provided on the AD2S80A/AD2S81A. Figure 5 shows the application circuit that can be used to perform this counting function.

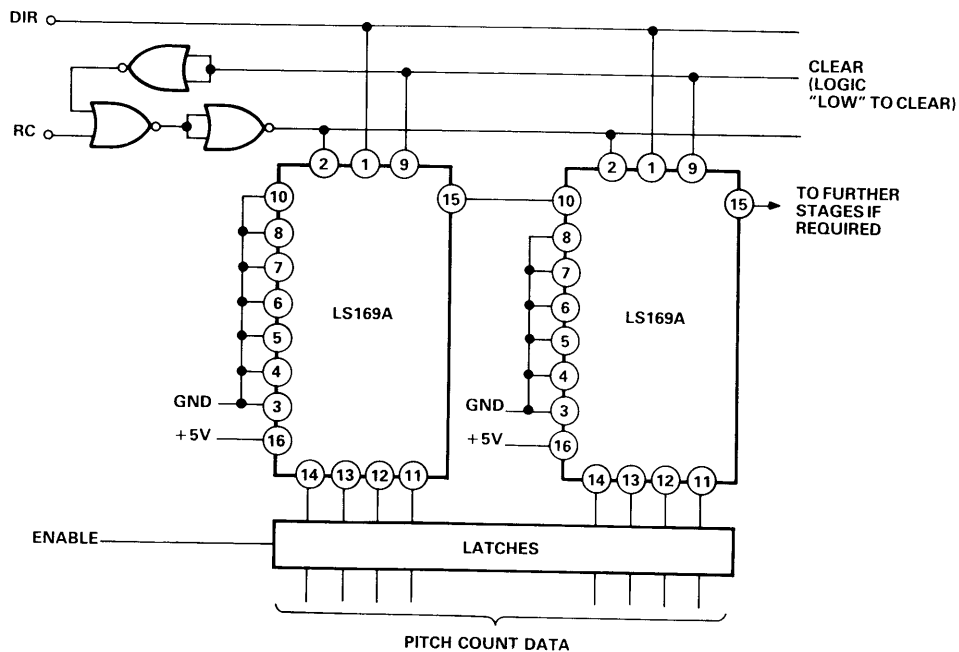


Figure 5. Circuit for Counting Pitches or Revolutions

To transfer the data into output latches on the converter, it is recommended in the data sheet that the INHIBIT input should be used. The data is valid  $1\mu\text{s}$  after the application of a logic "low" to the INHIBIT. Hence the output latches used in Figure 5 should be enabled  $1\mu\text{s}$  after the application of a logic "low" to the INHIBIT input. This will ensure that if an active BUSY pulse is present when the INHIBIT is applied it is given time to clear.

### 5. SIMULATING AN INCREMENTAL ENCODER USING AD2S80A OR AD2S81A

Incremental shaft encoders usually have two outputs similar to the A and B format, shown in Figure 6. These two outputs are normally used to either increment or decrement an up-down counter and hence show the current shaft angle position. They are often called A quad B outputs.

Where there is a requirement for interfacing to circuitry requiring incremental outputs, the monolithic converters can be easily configured to provide this type of output. Figure 6 shows a circuit which can be used to convert the resolver-to-digital converter parallel digital output into the A quad B outputs.

The "once per revolution" encoder marker pulse is supplied by the converter. An additional advantage of the resolver method is that the "Direction" signal is automat-

ically provided. In the case of the encoder it would require extra circuitry to derive it from the A and B waveforms. N.B. Any of the digital outputs need to be buffered if they are to drive capacitive loads greater than  $5\text{pF}$ .

### 6. CONNECTING INDUCTOSYN TO AS2S80A/AD2S81A

The AD2S80A and AD2S81A R/D converter with a preamplifier can be used as an Inductosyn-to-digital converter.

Inductosyns are similar in operation to resolvers. They consist of two magnetically coupled parts, a scale and a slider. The slider moves along the scale in association with the device to be positioned. There are two types of Inductosyns available: linear and rotary Inductosyns. Inductosyns are not inherently absolute, but it is often sufficient to start from a datum and keep track of pitches with an external counter.

The output signals from an Inductosyn slider are at a low level of the order of millivolts. These signals can be amplified with the hybrid Inductosyn preamplifier, IPA1764, to provide the necessary input signal amplitude required by the monolithic converters. The hybrid power oscillator, OSC1758, can be used to provide the drive for energization of the Inductosyn track.

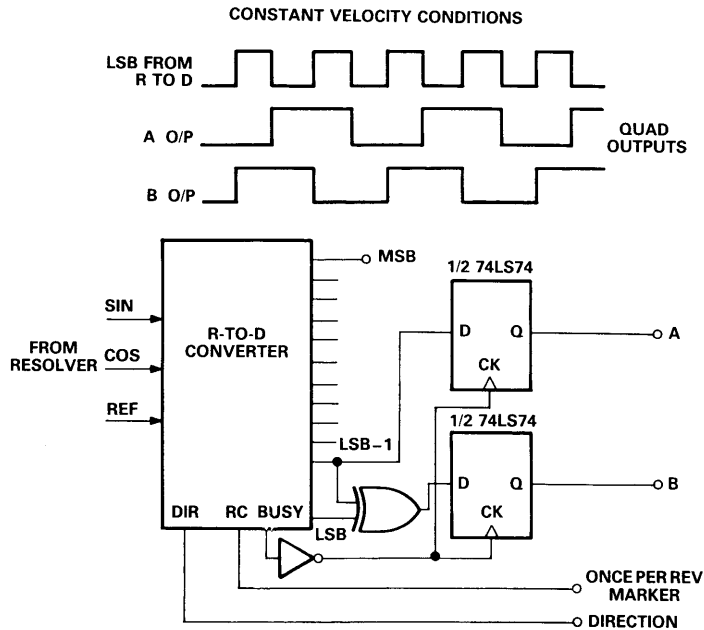


Figure 6. Simulating an Incremental Encoder Using a R/D Converter

## 7. USING AD2S80A/AD2S81A IN A TWO-SPEED COARSE/FINE SYSTEM

Often it is required to digitize the output of a coarse/fine mechanically geared synchro or resolver system or of an electrically geared or multiple resolver. Both requirements involve identical techniques.

Take for example a two-speed mechanical coarse/fine system with a gear ratio of 32:1. The AD2S80A and AD2S81A can be used in this system where the AD2S80A is used as a fine converter and the AD2S81A is used as the coarse converter. The combined digital output will be 17, 19 or 21 bits, depending on whether the AD2S80A is used as a 12-, 14- or 16-bit converter. The combinational logic required to combine the coarse and fine converter out-

puts is relatively easy to design. Figure 8 shows a circuit which may be used for this application. The data should be read using software if possible as this will remove the need for sophisticated timing electronics.

For detailed explanation on designing the combinational logic required for two-speed coarse/fine resolver systems, refer to pages 66 to 71 of the "Synchro and Resolver Conversion" book published by Memory Devices (Division of Analog Devices Inc.).

Alternatively, the TSL1612 (available from Analog Devices) which is a two-speed processor for coarse/fine synchro/resolver systems can be used to provide the combinational logic. The standard TSL1612 module is available for two-speed systems with gear ratio of 36:1, 18:1 or 9:1.

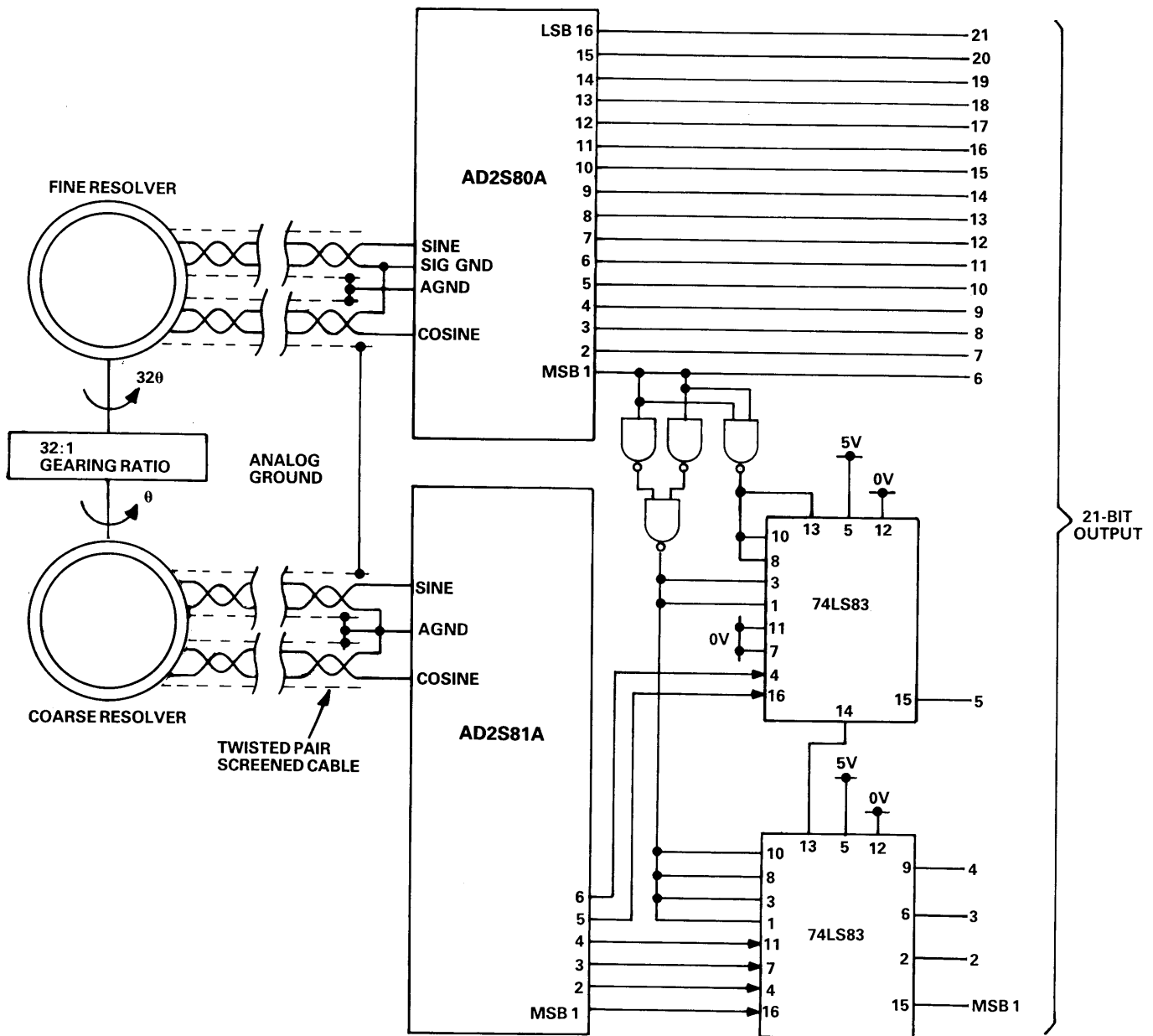


Figure 8. Two-Speed (32:1) System Using the AD2S80A and AD2S81A

Figure 7 shows the circuit configuration necessary to use the monolithic converters as Inductosyn-to-digital converters.

Precaution should be taken on the following points:

- Inductosyns have a 90 degrees phase shift built in between the reference and signal outputs. Using the OSC1758 can overcome this problem as it has two signal outputs, one 90 degrees in phase advance with respect to the other.
- The outputs of Inductosyns vary because of the mechanical tolerances involved with them. Inducto-

syns outputs must not be allowed to vary by more than  $\pm 10\%$ ; otherwise any variation greater than this will be amplified proportionally by the IPA1764, and the inputs to the AD2S80A/AD2S81A will be greater than the maximum specified.

- Particular care should be taken in transferring the output signal from the slider to the amplifier because of the very low amplitude signals involved. Screened twisted pair cables should be used between the outputs of the Inductosyn slider and the amplifier and the outputs of the amplifier and the monolithic converter.

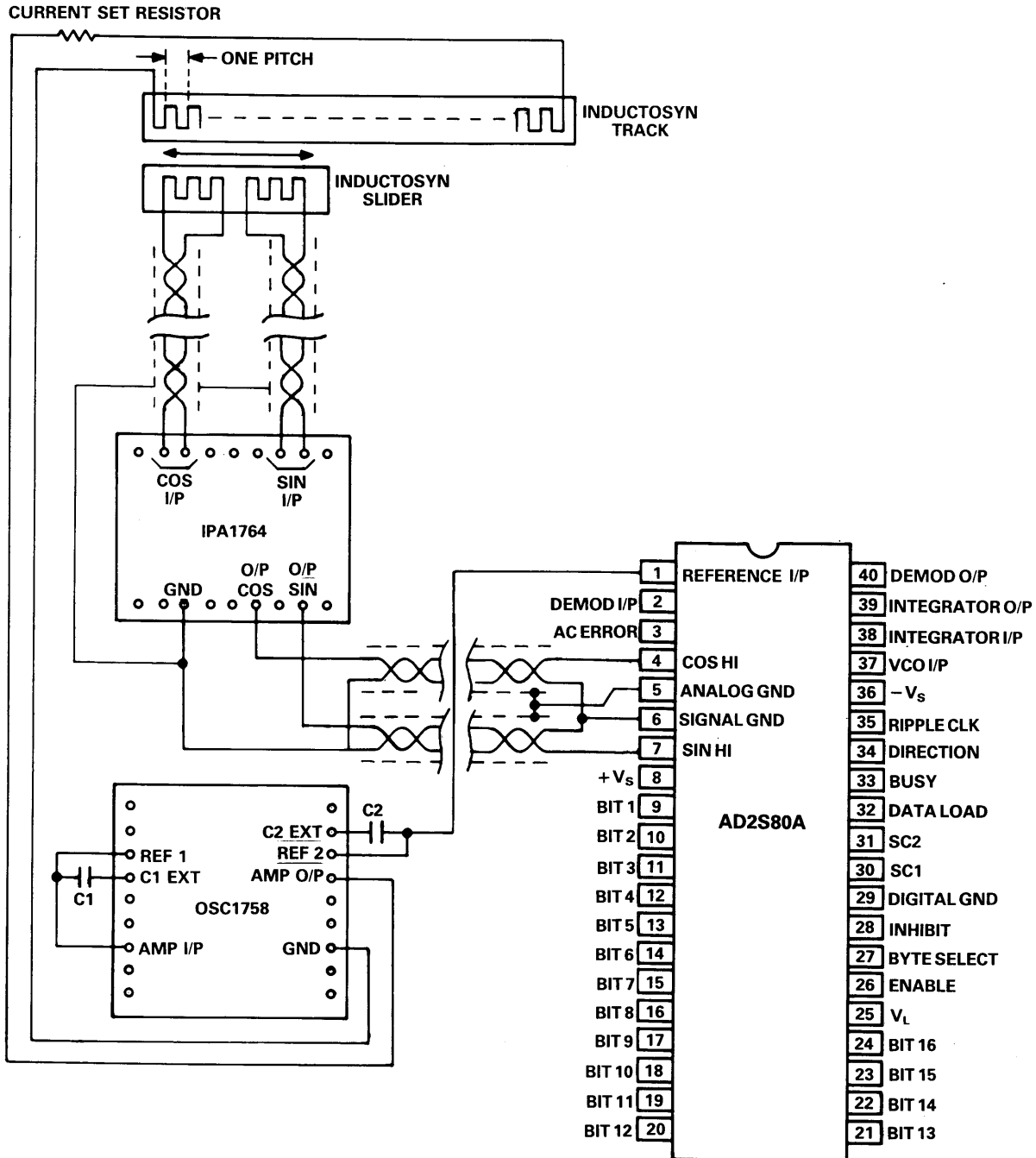


Figure 7. Use of AD2S80A/AD2S81A as an Inductosyn-to-Digital Converter