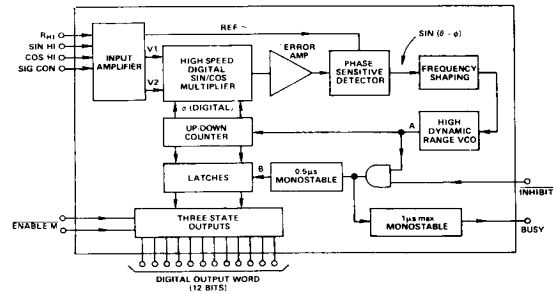
Hybrid, Tracking Inductosyn™/ Resolver-to-Digital Converter

IRDC1732

FEATURES
Low Cost
High Tracking Rate
Reference Frequency 400Hz to 10kHz
Hybrid Construction
Tri-State Digital Output
No External Adjustment

APPLICATION
Industrial Controls
Machine Tool and Robots

IRDC1732 FUNCTIONAL BLOCK DIAGRAM



GENERAL DESCRIPTION

The IRDC1732 converts resolver format (sine and cosine) signals into a 12-bit parallel digital word. A resolver input is converted into a 12-bit natural binary digital word that represents the shaft angle. An Inductosyn input is similarly converted. The 12-bit word now represents the distance moved through an Inductosyn pitch.

The converter is of the continuous tracking loop type employing a type 2 servo loop and operates at input rates in excess of 100 revolutions or pitches per second.

Operation of the converter is possible over the reference frequency range of 400Hz to 10kHz; the signal and reference voltages are nominally 2.5V rms. The signal and reference inputs are nonisolated resistive.

As the IRDC1732 uses only the ratio of sine to cosine value for the conversion of the angle it is insensitive to reference voltage, frequency and waveform variations. The ratiometric amplitude measurement technique also ensures a high degree of input noise immunity. The inclusion of a phase sensitive demodulator within the tracking loop means that the converter is insensitive to signals which are not phase and frequency coherent with the reference input.

The IRDC1732 is of hybrid manufacturing technique using only three integrated circuit chips, including 1 LSI custom chip, for the realization of the converter function. Hybrid construction and the small number of chips ensures high realiability. The IRDC1732 is housed in a triple DIP 32-pin enclosure. The industrial temperature range (0 to +70°C) version IRDC1732/560 is housed in a ceramic case and the extended temperature range (−55°C to +125°C) version IRDC1732/460 and 410 are housed in a hermetically sealed metal case.

MODELS AVAILABLE

Three versions of the IRDC1732 are available: the industrial temperature range and the extended temperature range. Details of how to specify the exact part number are listed under "Ordering Information".

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SPECIFICATIONS (typical @ +25°C, unless otherwise noted)

Models	IRDC1732/560	IRDC1732/460	IRDC1732/410
RESOLUTION	12 Bits (Natural Binary)	*	*
ACCURACY[1]	± 21 arc mins	*	*
DIGITAL OUTPUT	Parallel 1LS TTL Load MSB = 180°or Halfpitch	*	*
SIGNAL & REFERENCE FREQUENCY	1kHz to 10kHz	*	400Hz
SIGNAL VOLTAGE	2.5V rms	*	
SIGNAL INPUT IMPEDANCE	50kΩ ± 2%	*	*
REFERENCE VOLTAGE	2.5V to 10V rms	*	*
ALLOWABLE PHASE SHIFT (SIGNAL TO REFERENCE)	± 20° Will Give No Additional Static Error	*	*
TRACKING RATE	100 Revolution or Pitches Per Second Minimum	*	50 Revolution or Pitches Per Second Minimum
SETTLING TIME (179° Step)	20ms max	*	40ms max
ACCELERATION CONSTANT (K_a)	650,000/sec/sec	*	159,878
BUSY OUTPUT	Logic "Hi" When BUSY 1μs max 1LS TTL Load	*	*
INHIBIT INPUT	Logic "Lo" to INHIBIT 1LS TTL Load	*	*
POWER SUPPLIES	$+V_S$ +12V to +15V @ 10mA	*	*
	$-V_S$ −12V to −15V @ 10mA	*	*
	+5V @ 3mA	*	*
POWER DISSIPATION	0.320 Watts	*	*
TEMPERATURE RANGE	0 to +70°C Operating	−55°C to +125°C Operating	*
	−60°C to +150°C Storage	*	*
PACKAGE TYPE[2]	HY32J	HY32B	*
WEIGHT	1 oz (28 grams)	*	*

NOTES
[1]Accuracy applies over the operating range and for ± 10% signal and reference voltage and frequency variation. ± 5% power supply variation.
[2]See Section 19 for package outline information.
*Specifications same as IRDC1732/560.
Specfications subject to change without notice.

OPERATION OF THE CONVERTER

The IRDC1732 is a tracking converter. This means that the output automatically follows the input for speeds up to and including 100 rps. There is no requirement for a convert command as the conversion is initiated by each LSB increment of the input. Each LSB increment of the converter is indicated by a BUSY pulse.

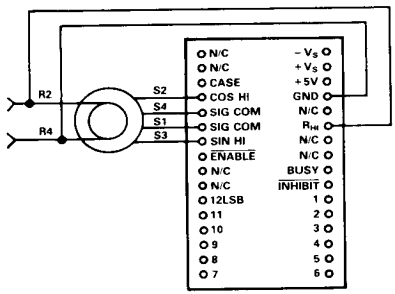

Figure 1.

CONNECTING THE CONVERTER

The electrical connection of the converter is straightforward. The power supply voltages connected to $+V_S$ and $-V_S$ pins can be $\pm 12V$ to $\pm 15V$ but must not be reversed. The $+5V$ supply connects to the $+5V$ pin and should not be allowed to become negative with respect to the GND pin potential.

The resolver connection S1 through S4 are made to the sine and cosine inputs as shown in the IRDC1732 electrical connection diagram, Figure 1.

It is suggested that decoupling capacitors of $0.1\mu F$ and $6.8\mu F$ are connected in parallel between the power supply lines ($+V_S$, $-V_S$ and $+5V$) and GND adjacent to the converter. When more than one converter is used on a card, then separate decoupling capacitors should be used for each converter.

THEORY OF OPERATION

The sine and cosine signals are applied to the signal input.

$$V_1 = K\ E_O \sin \omega t \sin \theta$$
$$V_2 = K\ E_O \sin \omega t \cos \theta$$

Where θ is the angle of the resolver shaft or the distance through a particular pitch of the Inductosyn.

To understand the conversion process, then assume that the current word state of the up-down counter is ϕ.

The V_1 is multiplied by Cos ϕ and V_2 is multiplied by Sin ϕ to give:

$$K\ E_O \sin \omega t \sin \theta \cos \phi$$
and $$K\ E_O \sin \omega t \cos \theta \sin \phi$$

These signals are subtracted by the error amplifier to give:

$$K\ E_O \sin \omega t (\sin \theta \cos \phi - \cos \theta \sin \phi)$$
or $$K\ E_O \sin \omega t \sin (\theta - \phi)$$

A phase sensitive detector, integrator and Voltage Controlled Oscillator (VCO) form a closed loop system which seeks to null Sin $(\theta - \phi)$.

When this is accomplished, the word state of the up-down counter (ϕ), equals within the rated accuracy of the converter, the resolver shaft angle θ.

Bit Number	Weight in Degrees
1 (MSB)	180.0000
2	90.0000
3	45.0000
4	22.5000
5	11.2500
6	5.6250
7	2.8125
8	1.4063
9	0.7031
10	0.3516
11	0.1758
12 (LSB)	0.0879

Bit Weight Table

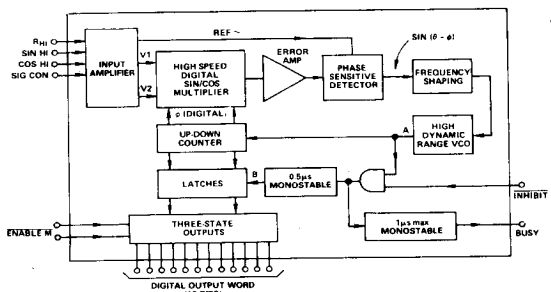

Figure 2. Functional Diagram

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DATA TRANSFER

The readiness of the converter for data transfer is given by the state of the BUSY output. The signal appearing on the BUSY output pin is a series of pulses of TTL levels when the angular input of the converter is changing. A BUSY pulse is initiated each time the input moves by an LSB and the internal counter is incremented or decremented. With the $\overline{\text{INHIBIT}}$ input pin in the "Hi" TTL state, data will be transferred automatically to the output latches.

The $\overline{\text{ENABLE}}$ input pin state determines the state of the output data. A TTL logic "Hi" maintains the output data pins in a high impedance condition, the application of a logic "Lo" presents the data in the latches to the output pins.

From the above it can be seen that there are two methods available for transferring data.

The first is to detect the state of the BUSY which is "Hi" for 1μs max and transfer the data when BUSY is "Lo". Both $\overline{\text{INHIBIT}}$ and $\overline{\text{ENABLE}}$ must be in their correct state of "Hi" and "Lo" respectively to present data to the output.

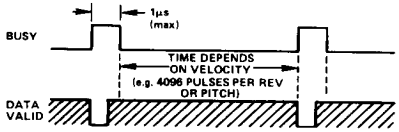


Figure 3.

The alternative method is to use the $\overline{\text{INHIBIT}}$ input. As can be seen from the functional diagram, application of the $\overline{\text{INHIBIT}}$ prevents the two internal monostable circuits being triggered and consequently the latches being updated. Data will always be valid 1μs after the application of a logic "Lo" to the $\overline{\text{INHIBIT}}$. This is true regardless of the time when $\overline{\text{INHIBIT}}$ is applied.

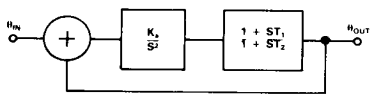
The three state $\overline{\text{ENABLE}}$ can be used at any time to present the data in the latches to the output pins.

The internal operation of the converter cannot be affected by the logic state present on either the $\overline{\text{ENABLE}}$ or $\overline{\text{INHIBIT}}$ input pins.

Use of the BUSY pulses output as an incremental counter input is not recommended as the BUSY output signals a change of output irrespective of direction.

DYNAMIC PERFORMANCE

The transfer function of the converter is given below.



Open loop gain:

$$\frac{\theta_{OUT}}{\theta_{IN}} = \frac{K_a}{S^2} \cdot \frac{1 + ST_1}{1 + ST_2}$$

Closed loop gain:

$$\frac{\theta_{OUT}}{\theta_{IN}} = \frac{1 + ST_1}{1 + ST_1 + \frac{S^2}{K_a} + \frac{S^3 T_2}{K_a}}$$

IRDC1732/560 and IRDC1732/460

$k_a = 650{,}000$
$T_1 = 2.3\text{ms}$
$T_2 = 0.4\text{ms}$

IRDC1732/410

$k_a = 159{,}878$
$T_1 = 3.7\text{ms}$
$T_2 = 0.7\text{ms}$

ACCELERATION ERROR

A tracking converter like the IRDC1732 employing a type 2 servo loop does not suffer any velocity lag, however, there is an additional error due to acceleration. This additional error can be defined using the acceleration constant K_a of the converter.

$$k_a = \frac{\text{Input acceleration}}{\text{Error in output angle}}$$

The numerator and denominator have the same units. K_a does not define maximum acceleration only the error due to acceleration, maximum acceleration is in the region of 5 times the K_a figure (deg/sec^2).

An example using the K_a of the IRDC1732/500.

Acceleration of 50 revolutions sec^{-2} with $K_a = 650{,}000$

$$\text{error in LSB's} = \frac{50 \times 4096}{650{,}000} = 0.3\text{LSB.}$$

PROCESSING FOR HIGH RELIABILITY

STANDARD PROCESSING

As part of the standard manufacturing procedure, all converters receive the following processing:

PROCESS	CONDITION
1. Pre-Cap Visual Inspection	In-House Criteria
2. Burn-In	70°C
3. Constant Acceleration	5000G
4. Gross Leak Test	In-House Criteria
5. Final Electrical Test	Performed at 25°C

PIN FUNCTION DESCRIPTION

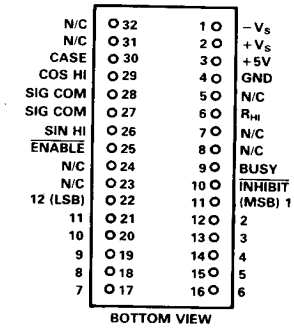
$-V_S$	Main negative power supply $-12V$ dc to $-15V$ dc.
$+V_S$	Main positive power supply $+12V$ dc to $+15V$ dc.
$+5V$	Logic voltage.
GND	Power supply ground. Digital ground. Reference voltage low.
Bit 1-12	Parallel output data bits 1MSB = 180°.
Sin Hi Cos Hi	Input analog signals.
R_{HI}	Reference voltage input HI. Reference low connects to GND.
$\overline{\text{INHIBIT}}$	Inhibit logic input. Taking this pin "lo" inhibits data transfer from counter to output latches. The conversion loop continues to track.
BUSY	Converter BUSY. A "Hi" output indicates that the the output latches are being updated. Data should not be transferred from the converter output while BUSY is "Hi".
$\overline{\text{ENABLE}}$	The output data bits are set to a low impedance state by application of a logic "lo".
CASE	This should normally be grounded. Case can be be taken to any voltage with a low impedance up $\pm 20V$.
N/C	Pins designated N/C not connected internally.
SIG COM	Internally connected to GND.

ABSOLUTE MAXIMUM INPUTS (with respect to GND)

$+V_S$[1]	0V to +17V dc
$-V_S$[1]	0V to −17V dc
$+5V$[2]	0V to +5.5V
R_{HI} to GND	±20V dc
Sin Hi/Cos Hi	±20V dc
Case to	±20V dc
Any Logical Input	−0.4V to +5.5V dc

CAUTION:
1. Correct polarity voltages must be maintained on the $+V_S$ and $-V_S$ pins.
2. The +5 volt power supply must *never* go below GND potential.

PIN CONFIGURATION



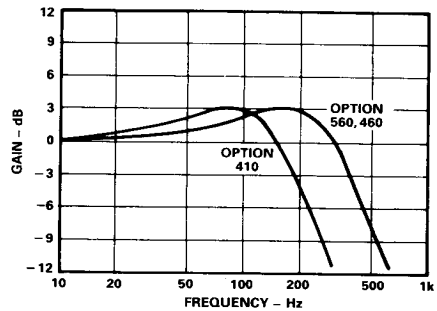


Figure 4. Magnitude of Gain vs. Frequency

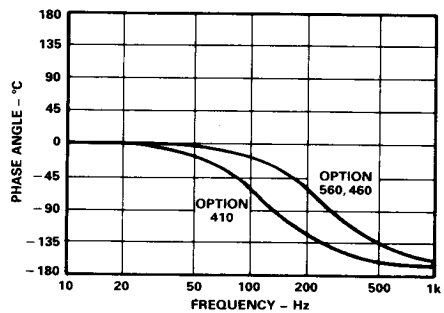


Figure 5. Output Angular Phase vs. Frequency

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MEAN TIME BETWEEN FAILURES (MTBF)

The reliability of these products is very high due to the extensive use of custom chip circuitry. For details of MTBF figures under particular conditions please consult the factory.

An example of the MTBF results: IRDC1732 at Naval Sheltered conditions 50°C = 974,000 hours or 111 years (410,460 options).

ORDERING INFORMATION

IRDC1732 X Y 0

Inductosyn/Resolver-to-Digital Converter

Y = 1 400Hz Reference Frequency

Y = 6 1kHz to 10kHz Reference Frequency

X = 4 −55°C to +125°C Operating Temperature Range

X = 5 0 to +70°C Operating Temperature Range