

Circuits from the Lab Reference Designs

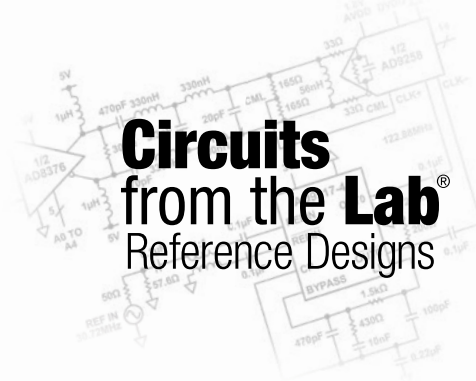
Linear and Angular Position and Velocity

About Circuits from the Lab Reference Designs

Circuit from the Lab® Reference Designs are built and tested for function and performance by Analog Devices applications experts, and are commonly used in analog signal chain design as standalone solutions or to build more complex circuits and subsystems. These proven reference designs support quick and easy evaluation, prototyping, and design integration, and offer:

- Comprehensive documentation
- Complete design and integration files
- Factory tested evaluation hardware

ADI's Circuits from the Lab library has over 200 built and tested reference designs, supporting a wide range of industry segments and applications.



Linear and Angular Position and Velocity

Application Introduction

Sensing and measurement of linear and angular position and velocity is required in a variety of industrial, motor control, medical, avionics, and other applications. For instance, in motor control, the rotor angle (measured in degrees) and velocity (measured in revolutions per second) is converted into digital format, where processing algorithms generate PWM outputs that accurately and efficiently control the motor operation. In avionics, accurate angular and linear position measurements are required to control the ailerons, flaps, tail, and other critical flight mechanisms. The same concepts apply to the field of robotics, where angular and linear position measurements are needed to control the movement of levers, arms, motor drives, and steering mechanisms. In healthcare, angular and linear position sensing is used in laparoscopic surgery, and motion sensors find wide application in vital signs monitoring devices.



Accuracy requires an appropriate sensor and signal conditioning circuitry. The most popular sensor types used to perform these functions are electronic and electromechanical such as MR (magnetoresistive), resolvers, MEMS (microelectromechanical systems) accelerometers, LVDTs (linear variable differential transformers), and ultrasonic. Signal conditioning circuitry (typically a combination of ADC, voltage reference, input drive amplifier, instrumentation amplifier, multiplexer, and/or power supply) converts sensor output into a digital format that can be interpreted and processed.

Design Considerations—Choosing the Appropriate Sensor and Signal Conditioning Circuitry

Magnetoresistive (MR) noncontact sensors are popular because of their low cost and high sensitivity compared to Hall effect sensors. They consist of two Thermalloy bridges oriented 45° from each other that are subjected to a magnetic field. The bridge resistors change value with respect to the orientation of the magnetic field, thereby producing a proportional output voltage. The sensors can be optimized to measure either angular position or linear position. Instrumentation amplifiers are generally used to convert the differential signal from the bridge into a signal compatible with the input range of the ADC. SAR ADCs are easy to use and are widely available in many different resolutions, package types, and power dissipations suitable for most any MR sensor application. They are also easy to interface with analog multiplexers for use in multichannel applications, and there is no pipeline delay as with Σ - Δ ADCs.

Electromechanical resolvers convert rotational position and velocity into sine and cosine outputs when the excitation winding is driven with a sinusoidal signal. The outputs are processed with a special type of ADC called a resolver-to-digital converter (RDC). An RDC is a tracking converter that is optimized to process the outputs of the resolver and convert the angular position and velocity information from the resolver into digital format.

MEMS-based accelerometers produce outputs proportional to acceleration. Dual-axis low *g* accelerometers are useful in angular measurements where operation over a full 360° is required. MEMS accelerometers also measure vibration or motion. Precision op amps are used to provide the required gain and level shifting. SAR ADCs, popular for the same reasons previously stated, then provide the analog-to-digital conversion.

The linear variable differential transformer (LVDT) is also a highly reliable position measurement sensor because the magnetic core can move without friction and does not touch the inside of the tube. Therefore, LVDTs are suitable for flight control feedback systems, position feedback in servomechanisms, automated measurement in machine tools, and many other industrial and scientific electromechanical applications where long-term reliability is important. LVDTs are driven with sine waves, and their outputs are often processed with ICs that are optimized to extract the position information from the LVDT signals. SAR ADCs are then used to provide the digital output as in the case of MR and MEMS applications.

Ultrasonic techniques are popular in making distance measurements, such as in level sensing applications. The time between the transmitted and reflected ultrasonic signal is measured using the timer in a microprocessor and then converted into distance based on the speed of sound at the temperature of the measurement environment. The transmitter is controlled using the PWM output of a microprocessor, and the receiver is composed of several op amp stages to provide the required gain, followed by a window comparator to detect the presence of the reflected signal.

In addition to the choice of sensor and signal conditioning components selected for the final design, achieving required performance levels depends on giving careful attention to layout, grounding, and decoupling techniques. All Circuits from the Lab Reference Designs have a complete set of downloadable documentation including schematics, PCB layouts, Gerber files, and bill of material to help guide the design engineer during the system design phase. The “Learn More” section of each circuit note contains additional useful references including application notes, tutorials, and technical articles. Hardware is available for purchase to evaluate circuit performance, prototyping, and/or design integration. Circuits from the Lab Reference Designs provide a cost-effective tool in achieving optimum designs with minimal risk.

Linear and Angular Position and Velocity Circuits from the Lab Reference Designs

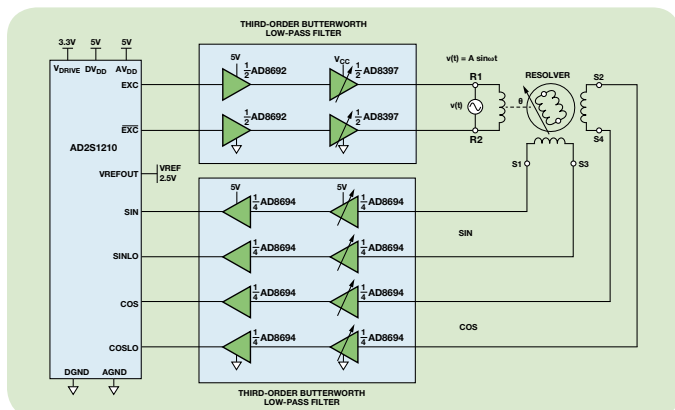
Reference Design	Sensor Type	Measurement	Input Range	Resolution	Output Data	Special Features	Evaluation Hardware	Pricing (ea)
CN0323	MR	Angular position	0° to 180°	12 bits	SPI		EVAL-CN0323-SDPZ*	\$75.00
CN0341	MR	Linear position	0" to 1"	12 bits	SPI		EVAL-CN0341-SDPZ*	\$75.00
CN0332	MR	Rotation speed	0 rps to 1M rps	N/A	Pulse		EVAL-CN0332-PMZD**	\$35.00
CN0276	Resolver	Angular position, rotation velocity	0° to 360° 0 rps to 3125 rps	10 bits to 16 bits	SPI	Integrated high voltage driver	EVAL-CN0276-SDPZ*	\$130.00
CN0192	Resolver	Angular position, rotation velocity	0° to 360° 0 rps to 3125 rps	10 bits to 16 bits	SPI		EVAL-AD2S1210EDZ*	\$99.00
CN0189	MEMS	Tilt	0° to 360°	12 bits	SPI	Dual-axis accelerometer	EVAL-CN0189-SDPZ*	\$60.00
CN0303	MEMS	Vibration	±70 g, ±250 g, ±500 g	12 bits	SPI		EVAL-CN0303-SDPZ*	\$70.00
CN0274	MEMS	Motion	±2 g, ±4 g, and ±8 g	N/A	Switch closure	Low power, standalone	EVAL-CN0274-SDPZ*	\$50.00
CN0288	LVDT	Linear position	±0.1"	12 bits	SPI		EVAL-CN0288-SDPZ***	\$110.00
CN0301	LVDT	Linear position	±0.1"	12 bits	SPI		EVAL-CN0301-SDPZ***	\$125.00
CN0343	Ultrasonic	Linear position	50 cm to 10 m	2 cm	LCD display	Standalone	EVAL-CN0343-EB1Z	\$115.00

*Requires additional evaluation control board.

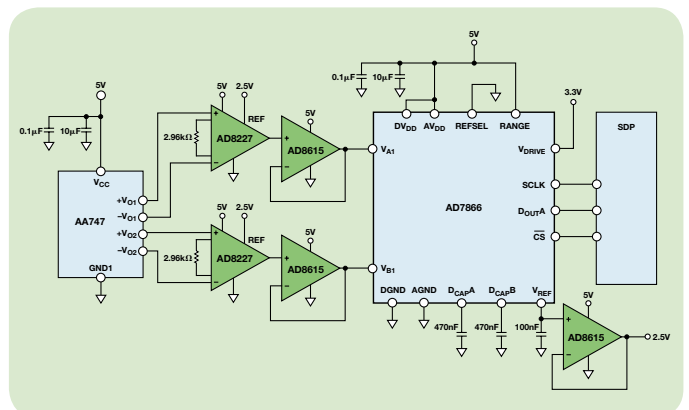
**Requires additional evaluation control board and pmod to sdp interposer board.

***Requires additional evaluation control board and measurements specialties LVDT sensor.

Highlighted Circuits from the Lab Reference Designs



CN0276: High performance, 10-bit to 16-bit resolver-to-digital converter.



CN0323: Magnetostrictive angle measurement.

Key Products

MEMS Accelerometers

Part Number	Number of Axes	Range (g)	Sensitivity (mV/g)	Self Resonant Frequency (kHz)	Output Type	Noise Density ($\mu\text{g}/\sqrt{\text{Hz}}$)	Supply Voltage (V)	Supply Current (mA)	Package
ADXL203	2	$\pm 1.7, \pm 5, \pm 18$	1000, 312, 100	5.5	Analog	110	3 to 6	0.7	LCC
ADXL001	1	$\pm 70, \pm 250, \pm 500$	16, 4.4, 2.2	22	Analog	4000	3.135 to 6	2.5	LCC
ADXL362	3	$\pm 2, \pm 4, \pm 8$	1, 2, 4	3.5	Digital	175	1.6 to 3.5	1.8 μA	LGA

LVDT Signal Conditioners

Part Number	Excitation Frequency (Hz)	Excitation Voltage Amplitude (V rms)	Excitation Current (mA rms)	Output Signal Range (V)	Input Voltage Range (V rms)	Supply Voltage Range (V)	Package
AD598	20 to 20,000	1.2 to 20	40	± 11	0.1 to 3.5	$\pm 13; 0$ to 17.5	SOIC
AD698	20 to 20,000	1.2 to 21.2	40	± 11	0.1 to 3.5	$\pm 13; 0$ to 17.5	PLCC

Resolver-to-Digital Converter

Part Number	Resolution (Bits)	Max Tracking Rate (rps)	Accuracy (Arc Minutes)	Reference Frequency (kHz)	Velocity Output	R/D Interface	Supply Voltage (V)	Power Dissipation (mW)	Package
AD2S1210	10, 12, 14, 16	3125, 1250, 625, 156.25	± 2.5	2 to 20	Yes	Parallel or serial	5	245	LQFP

SAR Analog-to-Digital Converters

Part Number	Resolution (Bits)	Number of Channels	Full Power BW (MHz)	Throughput Rate Max (kSPS)	Package
AD7887	12	2	2.5	125	MSOP, SOIC
AD7476	12	1	13.5	1000	SOT-23
AD7992	12	2	11	121	MSOP
AD7866	12	4	12	1000	TSSOP

Instrumentation Amplifier

Part Number	Gain Min	Gain Max	Min CMRR @ 60 Hz, G = 5 (dB)	V_{SUPPLY} Span Min (V)	V_{SUPPLY} Span Max (V)	Voltage Noise RTI ($\mu\text{V p-p}$)	Supply Current (μA)	Package
AD8227	5	1000	90	2.2	36	1.5	400	MSOP, SOIC

Operational Amplifiers

Part Number	Small Signal Bandwidth (MHz)	Slew Rate (V/ μs)	Input Offset Voltage Typ (μV)	Amplifiers Per Package	V_{SUPPLY} Span Min (V)	V_{SUPPLY} Span Max (V)	Rail-to-Rail Input/Output	Supply Current per Amplifier (mA)	Package
AD8615	23	12	80	1	2.7	6	Input, output	2	SOIC, MSOP, TSOT, TSSOP
AD8027	190	100	200	1	2.7	12	Input, output	6.5	SOIC, SOT-23
ADA4897-2	230	120	28	2	3	10	Output	3	MSOP
AD8662	4	3.5	30	2	5	16	Output	1.4	SOIC, MSOP
AD8397	69	53	1000	2	3	24	Output	8.5	SOIC, SOIC-EP
AD8692	69	53	400	2	3	24	Output	0.95	SOIC, MSOP
AD8605	10	5	80	1	2.7	6	Input, output	1.2	SOT-23, WLCSP
AD8606	10	5	80	2	2.7	6	Input, output	1.2	SOIC, MSOP, WLCSP
AD8608	10	5	80	4	2.7	6	Input, output	1.2	SOIC, TSSOP

High Speed Comparator

Part Number	Comparators Per Package	Propagation Delay (ns)	Power Dissipation (mW)	Supply Voltage (V)	Input Range (V)	Input Latch	Adjustable Hysteresis	Logic Output	Package
ADCMP601	1	3	10	2.5 to 5.5	-0.2 to $V_{\text{CC}} + 0.2$	Yes	Yes	TTL/CMOS	SC70

SPST Power Switch

Part Number	V_{IN} Min (V)	V_{IN} Max (V)	Max Switch Current (A)	Switch RDS _{ON} (m Ω)	Shutdown Current (μA)	Ground Current (μA)	Enable Logic (V)	Output t_{ON} Delay (μs)	Package
ADP195	1.1	3.6	1.1	100 @ 1.2 V	0.7	1	1.2 to 3.3	5	WLCSP, LFCSP

Additional Design Resources

Technical Books and Articles

- *Linear Design Handbook*—www.analog.com/library/analogdialogue/archives/43-09/linear_circuit_design_handbook.html
- *Sensors* (Chapter 3)
- *Data Converters* (Chapter 6)
- “Which ADC Architecture Is Right for Your Application?” *Analog Dialogue*—www.analog.com/library/analogdialogue/archives/39-06/architecture.html

Tutorials

- MT-021: Successive Approximation ADCs—www.analog.com/MT-021
- MT-030: Resolver-to-Digital Converters—www.analog.com/MT-030
- MT-031: Grounding Data Converters—www.analog.com/MT-031
- MT-101: Decoupling Techniques—www.analog.com/MT-101

Design Tools and Forums

- Signal Chain Designer™ Advanced Selection and Design Environment—www.analog.com/signalchaindesigner
- EngineerZone™ Online Technical Support Community—ez.analog.com

Customer Interaction Center

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