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TUTORIAL 2102

Delta-Sigma ADCs Replace Integrating ADCs for Panel Meters

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Abstract: This article compares the merits of integrating ADC and delta-sigma ADC architectures for panel-meter applications. It includes a description of two families of panel-meter-specific ICs, the MAX1491–MAX1499 and the MAX1365–MAX1368.

Introduction

This application note compares the merits of integrating ADC and delta-sigma ADC architectures for panel-meter applications. It includes a description of two families of panel-meter-specific ICs, the MAX1491–MAX1499 and the MAX1365–MAX1368.

Integrating ADC Architecture

Panel-meter designers often choose integrating ADCs because they are familiar and widely available. An integrating converter architecture combines high resolution and excellent noise rejection, making it ideal for converting low-bandwidth analog signals. Integrating analog-to-digital converters (ADCs) reject both high-frequency and 50Hz/60Hz noise.

If the integrate cycle time = T, then all frequencies of N(1/T) are, in theory, completely rejected. T can be chosen to reject 50Hz/60Hz noise. Since an analog integrator is effectively a lowpass filter, all input signals with periods significantly shorter than T average out to zero. For digital panel-meter applications, a wide selection of integrating ADCs with built-in light-emitting diode (LED) and liquid-crystal display (LCD) drivers provide a stand-alone solution. The ICL71 series of industry-standard integrating ADCs is showing its age, but improved parts are available (**Table 1**).

The performance of integrating ADCs relies on precision integration and deintegration cycles, which require external precision components. The most critical components are autozeroing and integrating capacitors. Both of these capacitors require exceptional dielectric-absorption characteristics to reduce the memory effect, which ultimately limits accuracy. These high-performance capacitors are costly and are susceptible to leakage currents, so careful PCB layout and cleaning are required.

Other disadvantages of these ADCs include the fact that some require dual supplies, which increases cost. Also, the integrating ADCs currently available often have a relatively large form factor. An external zener diode created the ADC's reference voltage. Moreover, nonlinear input signals need specialized signal conditioning to convert the signal to ±2V or ±200mV for displaying on the LED or LCD panel.

Delta-Sigma Converters

Delta-sigma converters are also well suited for low-bandwidth, high-resolution acquisition. They combine a simple analog modulator with a more complex digital filter. Accuracy depends on the noise and linearity performance of the modulator, which uses high-performance amplifiers. These amplifiers are not dependent on highly accurate external components. Smaller-process geometries have allowed IC manufacturers to integrate references, clock sources, charge pumps, and display drivers, while saving both cost and space. For these many reasons, designers now prefer delta-sigma ADCs for panel-meter applications.

The digital filter converts the analog modulator output to the digital output word and also provides lowpass filtering. In panel-meter applications, a $Sinc^3$ filter response with notches at 50Hz and 60Hz provides excellent (> 100dB) 50Hz/60Hz rejection. However, one disadvantage inherent in the delta-sigma architecture is that the filter does not provide attenuation at integer multiples of the modulator sampling frequency. The modulator frequency is based on the oversampling ratio (OSR) × data output rate. In practice, large oversampling ratios result in the modulator sampling frequency well above the bandwidth of the input signal. An anti-aliasing filter can be omitted without degrading system performance, if the magnitude of the input signal at the modulator sampling frequencies is small.

The MAX1491–MAX1499 utilize a delta-sigma architecture and are excellent choices for panel-meter applications. They feature an integrated oscillator, an internal 2.048V bandgap reference (20ppm/°C typ) and an on-chip charge pump that internally generates a negative supply for the bipolar, high-impedance input buffers (> 1GΩ typ). These 20-bit delta-sigma-based ADCs also include low-battery-warning, peak-detector, and hold functions. For the ±2V input range, the oversampling ratio is 128; for the ±200mV input range, the oversampling ratio is 1024. The MAX1365–MAX1368 delta-sigma ADC-based, digital panel-meter solutions feature an SPI™/QSPI™/MICROWIRE®-compatible serial interface, which increases design flexibility. The MAX1365–MAX1368 also include a 0–16mA (4–20mA) current output that allows driving a remote display and a digital-to-analog converter (DAC) that is directly accessible through the SPI interface. In addition to replacing DIP switches and jumpers needed to configure the panel meter, a microcontroller (µC) interface allows for linearization or table lookup of the conversion result. You can use a low-cost µC before displaying the output. Nonlinear calculations such as thermocouple measurements, thermistor measurements, and pH no longer require complex analog linearization. Use Table 1 to select the suggested functional equivalent of the integrating panel-meter ICs.

Table 1. Functional Equivalents of Integrated Panel-Meter ICs

Part	Resolution (Digits)	Display Type	
ICL7106	3.5	LCD	MAX1491
ICL7107	3.5	LED	MAX1496
ICL7116	3.5	µP	MAX1492, MAX1497
ICL7117	3.5	LED	MAX1496
ICL7126	3.5	LCD	MAX1491
ICL7129A	4.5	Multiplexed LCD	MAX1493
ICL7136	3.5	LCD	MAX1491
ICL7137	3.5	LED	MAX1496
MAX130	3.5	LCD	MAX1491
MAX131	3.5	LCD	MAX1491

MAX136	3.5	LCD	MAX1491
MAX138	3.5	LCD	MAX1491
MAX139	3.5	LED	MAX1498
MAX140	3.5	LED	MAX1496

Additional Information

For more information on the theory and operation of integrating and delta-sigma ADCs, refer to the following application notes:

- Application note 1041, "Understanding Integrating ADCs"
- Application note 1870, "Demystifying Sigma Delta"

Related Parts		
ICL7106	3 1/2 Digit A/D Converter	Free Samples
ICL7107	3 1/2 Digit A/D Converter	Free Samples
ICL7109	12-Bit A/D Converter with 3-State Binary Outputs	Free Samples
ICL7116	3 1/2 Digit ADC with Direct LCD Display/Hold	Free Samples
ICL7117	3 1/2 Digit ADC with Direct LCD Display/Hold	Free Samples
ICL7126	Low-Power, 3 1/2 Digit A/D Converter	Free Samples
ICL7129A	Low-Noise, 4 1/2 Digit, Single-Chip ADC with Multiplexed LCD Drivers	Free Samples
ICL7135	4 1/2 Digit ADC with Multiplexed BCD Outputs	Free Samples
ICL7136	Low-Power, 3 1/2 Digit A/D Converter	Free Samples
ICL7136	Low-Power, 3 1/2 Digit A/D Converter	Free Samples
ICL7137	Low-Power, 3 1/2 Digit A/D Converter	Free Samples
MAX130	3 1/2 Digit ADC with Bandgap Reference	Free Samples
MAX131	3 1/2 Digit ADC with Bandgap Reference	Free Samples
MAX136	Low-Power, 3 1/2 Digit ADC with Display/Hold and Direct LCD Drivers	Free Samples
MAX1365	Stand-Alone, 4.5-/3.5-Digit Panel Meters with 4–20mA Output	Free Samples
MAX1366	Microcontroller-Interface, 4.5-/3.5-Digit Panel Meters with 4-20mA Output	Free Samples

MAX1367	Stand-Alone, 4.5-/3.5-Digit Panel Meters with 4–20mA Output	Free Samples
MAX1368	Microcontroller-Interface, 4.5-/3.5-Digit Panel Meters with 4-20mA Output	Free Samples
MAX138	3 1/2 Digit ADC with Reference, Charge Pump, and Direct LED Drivers	Free Samples
MAX139	3 1/2 Digit ADC with Reference, Charge Pump, and Direct LED Drivers	Free Samples
MAX140	3 1/2 Digit ADC with Reference, Charge Pump, and Direct LED Drivers	Free Samples
MAX1491	3.5- and 4.5-Digit, Single-Chip ADCs with LCD Drivers	Free Samples
MAX1491	3.5- and 4.5-Digit, Single-Chip ADCs with LCD Drivers	Free Samples
MAX1492	3.5- and 4.5-Digit, Single-Chip ADCs with LCD Drivers	Free Samples
MAX1493	3.5- and 4.5-Digit, Single-Chip ADCs with LCD Drivers	Free Samples
MAX1494	3.5- and 4.5-Digit, Single-Chip ADCs with LCD Drivers	Free Samples
MAX1496	3.5- and 4.5-Digit, Single-Chip ADCs with LED Drivers	Free Samples
MAX1497	3.5- and 4.5-Digit, Single-Chip ADCs with LED Drivers and µC Interface	Free Samples
MAX1498	3.5- and 4.5-Digit, Single-Chip ADCs with LED Drivers	Free Samples
MAX1499	3.5- and 4.5-Digit, Single-Chip ADCs with LED Drivers and µC Interface	Free Samples

More Information
For Technical Support: http://www.maximintegrated.com/support
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Application Note 2102: http://www.maximintegrated.com/an2102
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