LAMPIRAN
Gambar alat Pendeteksi Keseimbangan Kanal Pada Audio

dengan Indikator LED
Gambar sinyal input/output dengan frekuensi 1KHz

Gambar sinyal input/output dengan frekuensi 2KHz
Gambar sinyal input/output dengan frekuensi 3KHz.
The Maxim ICL7106 and ICL7107 are monolithic analog-to-digital converters. They have very high input impedances and require no external display drive circuitry. On-board active components include polarity and digit drivers, segment decoders, voltage reference, and a clock circuit. The ICL7106 will directly drive a non-multiplexed liquid crystal display (LCD) whereas the ICL7107 will directly drive a common anode light emitting diode (LED) display.

Versatility and accuracy are inherent features of these converters. The dual-slope conversion technique automatically rejects interference signals common in industrial environments. The true differential input and reference are particularly useful when making radiometric measurements (ohms or bridge transducers). Maxim has added a true-polarity indication for the ICL7106 and ICL7107, eliminating overrange hangover and hysteresis effects. Finally, these devices offer high accuracy by lowering rollover error to less than one count and zero reading drift to less than 1µV/°C.

Applications

These devices can be used in a wide range of digital panel meter applications. Most applications, however, involve the measurement and display of analog data:

- Pressure
- Conductance
- Current
- Resistance
- Voltage
- Temperature
- Material Thickness

Typical Operating Circuit

3½ Digit A/D Converter

Features

- Improved 2nd Source! (See 3rd page for "Maxim Advantage")
- Guaranteed first reading recovery from overrange
- On-board Display Drive Capability—no external circuitry required
- LCD-ICL7106
- LED-ICL7107
- High impedance CMOS Differential Inputs
- Low Noise (< 15µV p-p) without hysteresis or overrange hangover
- Clock and Reference On-Chip
- True Differential Reference and input
- True Polarity Indication for Precision Null Applications
- Monolithic CMOS design

Ordering Information

<table>
<thead>
<tr>
<th>PART</th>
<th>TEMP. RANGE</th>
<th>PACKAGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>ICL7106CP</td>
<td>0°C to 70°C</td>
<td>40 Lead Plastic DIP</td>
</tr>
<tr>
<td>ICL7106CA</td>
<td>0°C to 70°C</td>
<td>40 Lead PLCC-20</td>
</tr>
<tr>
<td>ICL7106CDH</td>
<td>0°C to 70°C</td>
<td>44 Lead Plastic Chip Carrier</td>
</tr>
<tr>
<td>ICL7106CCE</td>
<td>0°C to 70°C</td>
<td>44 Lead Ceramic DIP</td>
</tr>
<tr>
<td>ICL7107CP</td>
<td>0°C to 70°C</td>
<td>40 Lead Plastic DIP</td>
</tr>
<tr>
<td>ICL7107CCE</td>
<td>0°C to 70°C</td>
<td>44 Lead Ceramic DIP</td>
</tr>
</tbody>
</table>

Pin Configuration
# 3½ Digit A/D Converter

## ABSOLUTE MAXIMUM RATINGS

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Conditions</th>
<th>Min</th>
<th>Typ</th>
<th>Max</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supply Voltage</td>
<td></td>
<td>10V</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ICL7106, V~ to GND</td>
<td></td>
<td>16V</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ICL7107, V~ to GND</td>
<td></td>
<td>16V</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ICL7107 V~ to GND</td>
<td></td>
<td>-5V</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Analog Input Voltage (either input)</td>
<td>V~ to V~</td>
<td>10V</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reference input voltage (either input)</td>
<td>V~ to V~</td>
<td>10V</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Clock Input</td>
<td>ICL7106, TEST to V~</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>ICL7107, GND to V~</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Power Dissipation (Note 2)

- ICL7106, T~ = 25°C: 1000 mW
- ICL7107, T~ = 25°C: 1000 mW

### Operating Temperature

- 0°C to +70°C
- Storage Temperature: -65°C to +125°C
- Operating Temperature (Soldering, 60 sec): -300°C

### Lead Temperature

- 10 sec: 300°C

### Package

- 100mW

### Note 2: Dissipation rating assumes device is mounted with all Essex supplied to power input leads.

Stresses above those listed under "Absolute Maximum Ratings" may cause permanent damage to the device. These are stress ratings only and functional operation of the device at these or any other conditions beyond those indicated in the operational sections of the specification is not implied. Exposure to absolute maximum ratings conditions for extended periods may affect device reliability.

## ELECTRICAL CHARACTERISTICS (Note 3)

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Conditions</th>
<th>Min</th>
<th>Typ</th>
<th>Max</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Zero input reading</td>
<td></td>
<td>-10000</td>
<td>0000</td>
<td>10000</td>
<td>Digital Reading</td>
</tr>
<tr>
<td>Hysteresis reading</td>
<td></td>
<td>5599</td>
<td>9999</td>
<td>10000</td>
<td>Digital Reading</td>
</tr>
<tr>
<td>Rollover Error (difference in reading for equal positive and negative reading near full scale)</td>
<td>V~ - V~</td>
<td>200 mV</td>
<td>1000 mV</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Linearity (Max deviation from best straight line)</td>
<td>Full scale</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>Counts</td>
</tr>
<tr>
<td>Common mode rejection ratio (Note 4)</td>
<td></td>
<td>50</td>
<td></td>
<td></td>
<td>( \mu )V</td>
</tr>
<tr>
<td>Noise (P1-P2) value not exceeded 50% of time</td>
<td>V~</td>
<td>0</td>
<td></td>
<td></td>
<td>( \mu )V</td>
</tr>
<tr>
<td>Input Leakage Current</td>
<td></td>
<td>10</td>
<td></td>
<td></td>
<td>pA</td>
</tr>
<tr>
<td>Zero Reading Drift</td>
<td></td>
<td>0.1</td>
<td></td>
<td></td>
<td>( \mu )V</td>
</tr>
<tr>
<td>Scale Factor Temperature Coefficients</td>
<td></td>
<td>1</td>
<td>5</td>
<td></td>
<td>ppm °C</td>
</tr>
<tr>
<td>V Supply Current</td>
<td>V~</td>
<td>0</td>
<td></td>
<td>1.8</td>
<td>mA</td>
</tr>
<tr>
<td>V supply current 7107 only</td>
<td></td>
<td>0.6</td>
<td></td>
<td>1.8</td>
<td>mA</td>
</tr>
<tr>
<td>Analog Common voltage with respect to pos supply</td>
<td>2.5kΩ between Common &amp; Pos Supply</td>
<td>2.4</td>
<td>28</td>
<td>32</td>
<td>V</td>
</tr>
<tr>
<td>Temp. Coef. of Analog Common with respect to Pos Supply</td>
<td>25kΩ between Common &amp; Pos Supply</td>
<td>80</td>
<td></td>
<td>ppm °C</td>
<td></td>
</tr>
<tr>
<td>Pin 19 only</td>
<td></td>
<td>5</td>
<td>6</td>
<td></td>
<td>V</td>
</tr>
<tr>
<td>Pin 19 only</td>
<td></td>
<td>5</td>
<td>10</td>
<td></td>
<td>mA</td>
</tr>
<tr>
<td>Segment sinking current</td>
<td></td>
<td>5</td>
<td>80</td>
<td></td>
<td>mA</td>
</tr>
</tbody>
</table>

### Note 3: Unless otherwise noted, specifications apply to both the ICL7106 and ICL7107 at T~ = 25°C, T~ = -25°C. ICL7107 is tested in the circuit of Figure 1. ICL7106 is tested in the circuit of Figure 2.

### Note 4: Differential input ground

- The electrical characteristics shown are a reproduction of a portion of Maxim's copyrighted (1985/1984) data book. The information does not constitute any representation of the current, but rather products will perform in accordance with these specifications. The Electrical Characteristics table, along with the Advance Prototype data sheet, have been included in this data sheet entry for comparative purposes.

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*MAXIM*
# MAXIM

## 3 1/2 Digit A/D Converter

- Guaranteed Overload Recovery Time
- Significantly Improved ESD Protection (Note 7)
- Key Parameters Guaranteed over Temperature
- Negligible Hysteresis
- Low Noise
- Maxim Quality and Reliability
- Increased Maximum Rating for Input Current (Note 8)

### ABSOLUTE MAXIMUM RATINGS:

This device contains the Absolute Maximum Ratings on adjacent page.

### ELECTRICAL CHARACTERISTICS:

Specifications below satisfy or exceed all "guaranteed" parameters on adjacent page.

### Parameters

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Conditions</th>
<th>Min</th>
<th>Typ</th>
<th>Max</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Zero Input Reading</td>
<td>V_{IN} = 0 V, Full Scale = 200.0mV</td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
<td>Digital</td>
</tr>
<tr>
<td></td>
<td>0°C &lt; TA &lt; 70°C (Note 10)</td>
<td>-0.000</td>
<td>+0.000</td>
<td>+0.000</td>
<td>Heating</td>
</tr>
<tr>
<td>Ratiometric Reading</td>
<td>V_{IN} = V_{REF}, V_{IN} = 100mV</td>
<td>1.000</td>
<td>0.000</td>
<td>0.000</td>
<td>Digital</td>
</tr>
<tr>
<td></td>
<td>0°C &lt; TA &lt; 70°C (Note 6)</td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
<td>Heating</td>
</tr>
<tr>
<td></td>
<td>Differential Error (Difference)</td>
<td>+ V_{IN} = + V_{IN} = 200.0mV</td>
<td>1.000</td>
<td>1.000</td>
<td>1.000</td>
</tr>
<tr>
<td></td>
<td>Delta differential reading near Full Scale</td>
<td>1.000</td>
<td>1.000</td>
<td>1.000</td>
<td>Counts</td>
</tr>
<tr>
<td></td>
<td>Input Voltage (Max deviation from</td>
<td>Full Scale = 200.0mV</td>
<td>1.000</td>
<td>1.000</td>
<td>1.000</td>
</tr>
<tr>
<td></td>
<td>Best Straight Line (fit)</td>
<td>V_{IN} = ±1V, V_{IN} = 0V</td>
<td>50.000</td>
<td>50.000</td>
<td>50.000</td>
</tr>
<tr>
<td></td>
<td>Common Mode Rejection Ratio</td>
<td>V_{CM} = ±1V, V_{CM} = 0V</td>
<td>15.000</td>
<td>15.000</td>
<td>15.000</td>
</tr>
<tr>
<td></td>
<td>Noise (Pk-Pk) value not exceeded</td>
<td>V_{IN} = 0V</td>
<td>1.000</td>
<td>1.000</td>
<td>1.000</td>
</tr>
<tr>
<td></td>
<td>2% or smaller</td>
<td>Full Scale = 200.0mV</td>
<td>10.000</td>
<td>10.000</td>
<td>10.000</td>
</tr>
<tr>
<td>Input Leakage Current</td>
<td>V_{IN} = 0</td>
<td>0°C &lt; TA &lt; 25°C (Note 6)</td>
<td>1.000</td>
<td>10.000</td>
<td>100.000</td>
</tr>
<tr>
<td></td>
<td>2°C &lt; TA &lt; 70°C</td>
<td>20.000</td>
<td>200.000</td>
<td>200.000</td>
<td>pA</td>
</tr>
<tr>
<td></td>
<td>Zero Reading Shift</td>
<td>V_{IN} = 0</td>
<td>0°C &lt; TA &lt; 25°C (Note 6)</td>
<td>0.000</td>
<td>0.000</td>
</tr>
<tr>
<td></td>
<td>2°C &lt; TA &lt; 70°C</td>
<td>0.200</td>
<td>1.000</td>
<td>1.000</td>
<td>µV/°C</td>
</tr>
<tr>
<td></td>
<td>Scale Factor Temperature</td>
<td>V_{IN} = ±199.0mV</td>
<td>1.000</td>
<td>1.000</td>
<td>1.000</td>
</tr>
<tr>
<td></td>
<td>Reference (Except TYP)</td>
<td>0°C &lt; TA &lt; 70°C (Note 6)</td>
<td>5.000</td>
<td>5.000</td>
<td>5.000</td>
</tr>
<tr>
<td></td>
<td>Analog Common Voltage (with</td>
<td>V_{IN} = 0</td>
<td>0°C &lt; TA &lt; 25°C</td>
<td>1.000</td>
<td>1.8</td>
</tr>
<tr>
<td></td>
<td>respect to Pos. Supply)</td>
<td>25°C to Common &amp;</td>
<td>0°C &lt; TA &lt; 70°C</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>7107 only (Note 9)</td>
<td>0.25</td>
<td>0.6</td>
<td>1.8</td>
<td>mA</td>
</tr>
<tr>
<td></td>
<td>Supply Current (7107 only)</td>
<td>V_{IN} = 0</td>
<td>0°C &lt; TA &lt; 25°C</td>
<td>1.000</td>
<td>1.8</td>
</tr>
<tr>
<td></td>
<td>0°C &lt; TA &lt; 70°C</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>25kHz between Common &amp;</td>
<td>2.5</td>
<td>2.5</td>
<td>2.5</td>
<td>V</td>
</tr>
<tr>
<td></td>
<td>Temp. Coef. of Analog Common</td>
<td>25kHz between Common &amp;</td>
<td>75.000</td>
<td>75.000</td>
<td>75.000</td>
</tr>
<tr>
<td></td>
<td>with respect to Pos. Supply)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>7106 Only (Note 9)</td>
<td>75.000</td>
<td>75.000</td>
<td>75.000</td>
<td>V</td>
</tr>
<tr>
<td></td>
<td>Power Supply Drive Voltage</td>
<td>V = 10 V</td>
<td>V = 9V</td>
<td>4.5</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td>7106 Only - Segment Drive Voltage</td>
<td>V = 5 V</td>
<td>V = 3V</td>
<td>6</td>
<td>8.0</td>
</tr>
<tr>
<td></td>
<td>(Except Pin 19)</td>
<td>Segment Voltage = 3V</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>7107 Only - Segment Sinking Current</td>
<td>V = 5 V</td>
<td>V = 3V</td>
<td>6</td>
<td>8.0</td>
</tr>
<tr>
<td></td>
<td>7106 Only - Test Pin Voltage</td>
<td>With Respect to</td>
<td>V</td>
<td>4</td>
<td>4.5</td>
</tr>
<tr>
<td></td>
<td>Overload Recovery Time</td>
<td>V_{IN} changing from ±10 V</td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
</tr>
<tr>
<td></td>
<td>(Note 9)</td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
<td></td>
</tr>
</tbody>
</table>

**Notes:**
- Test condition is V_{IN} applied between pins 1 and 2 (pin 4) through a 10 kΩ series resistor as shown in Figure 1 and 6.
- All pins are designed to withstand maximum short-circuit (ESS) currents in excess of 200mA, with no heat dissipation (Note 9).
- Overload Recovery Time is limited to 4 ms (Note 1).
- Each device is tested under Note 9 on adjacent page.
- Number of measurement cycles for display to gain accurate reading.
3½ Digit A/D Converter

Analog Section

Figure 3 shows the Block Diagram of the Analog Section for the ICL7106. Each measurement cycle is divided into four phases:

1. Auto-Zero (A-Z)
2. Signal Integrate (INT)
3. Reference De-Integrate (DI)
4. Zero Integrator (ZI)

Auto-Zero Phase

Three events occur during auto-zero. The inputs, IN-HI and IN-LO, are disconnected from the pins and internally shorted to analog common. The reference capacitor is charged to the reference voltage. And lastly, a feedback loop is closed around the system to charge the auto-zero capacitor C_AZ to compensate for offset voltages in the comparator, buffer amplifier and integrator. The inherent noise of the system determines the A-Z accuracy.

Signal Integrate Phase

The internal input high (IN-HI) and input low (IN-LO) are connected to the external pins, the internal short is removed and the auto-zero loop is opened. The converter then integrates the differential voltage between IN-HI and IN-LO for a fixed time. This differential voltage can be within a wide common-mode range (within one volt of either supply). If, however, the input signal has no return with respect to the converter power supply, IN-LO can be used to analog common to establish the correct common-mode voltage. The polarity of the integrated signal is determined at the end of this phase.

Reference De-Integrate

IN-HI is connected across the previously charged reference capacitor and IN-LO is internally connected to analog common. Circuitry within the chip ensures that the capacitor will be connected with the correct polarity to cause the integrator output to return to zero. The input signal determines the time required for the output to return to zero. The digital reading displayed is:

1000 × \( \frac{V_{IN}}{V_{REF}} \)

Zero Integrator Phase

Input low is shorted to analog COMMON and the reference capacitor is charged to the reference voltage. A feedback loop is closed around the system to input high, causing the integrator output to return to zero. This phase normally lasts between 11 and 140 clock pulses but is extended to 740 clock pulses after a "heavy" overrange conversion.

Differential Reference

The reference voltage can be generated anywhere within the power supply voltage of the converter. The main source of common-mode error is a rollover voltage. This is caused by the reference capacitor losing or gaining charge to stray capacitance on its nodes. The reference capacitor can gain charge (increase voltage) if there is a large common-mode voltage. This happens during de-integration of a positive signal. In contrast, the reference capacitor will lose charge (decrease voltage) when de-integrating a negative input signal. Rollover error is caused by this difference in reference for positive or negative input voltages. This error can be held to less than half a count for the worst-case condition by selecting a reference capacitor that is large enough in comparison to the stray capacitance. (See component value selection.)

Differential Input

Differential voltages anywhere within the common-mode range of the input amplifier can be accepted by the input (specifically from 1V below the positive supply to 1.5V above the negative supply). The system has a CMRR of 86dB (typ) in this range. Care must be exercised, however, to ensure that the integrator output does not saturate, since the integrator follows the common-mode voltage. A large positive common-mode voltage with a near full-scale negative differential input voltage is a worst-case condition. When most of the integrator output swing has been used up by the positive common-mode voltage, the negative input signal drives the integrator more positive. The integrator swing can be reduced to less than the recommended 2V full-scale swing with no loss of accuracy in these cases.

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The primary purpose of this pin is to set the common-mode voltage for battery operation. This is useful when using the ICL7106, or for any system where the input signals are floating with respect to the power supply. A voltage of approximately 2.8V less than the positive supply is set by this pin. The analog common has some of the attributes of a reference voltage. If the total supply voltage is large enough to cause the IC to regulate (20V), the common voltage will have a low output impedance (approximately 15Ω), a temperature coefficient of typically 0ppm/°C, and a low voltage coefficient (0.01%).

The internal heating of the ICL7107 by the LED display drivers degrades the stability of Analog Common. The power dissipated by the LED display drivers changes with the displayed count, thereby changing the temperature of the die, which in turn results in a small change in the Analog Common voltage. This combination of variable power dissipation, thermal resistance, and temperature coefficient causes a 25-50μV increase in noise power. Another effect of LED display driver power dissipation can be seen at the transition between a full scale reading and an overload condition. Overload is a low power dissipation condition since the least significant digits are blanked in overload. On the other hand, a near full scale reading such as 1999 has many segments turned on and is a high power dissipation condition. The difference in power dissipation between overload and full scale may cause a ICL7107 with a negative temperature coefficient reference to cycle between overload and near full scale display as the die alternately heats and cools. An ICL7107 with a positive TC reference will exhibit hysteresis under these conditions, once put into overload by a voltage just barely more than full scale, the voltage must be reduced by several counts before the ICL7107 will come out of overload.

None of the above problems are encountered when using an external reference. The ICL7106, with its low power dissipation, has none of these problems with either an external reference or when using Analog Common as a reference.

During auto-zero and reference integrate the internal input low is connected to Analog Common. If IN-LO is different from analog-common, a common-mode voltage exists in the system and is taken care of by the excellent CMRR of the converter. Some applications, however, IN-LO will be set at a fixed known voltage (e.g., power supply common). Whenever possible analog common should be tied to the same point, thus removing the common-mode voltage from the converter. The same holds true for the reference voltage. If convenient, REF-LO should be connected to analog common. This will remove the common-mode voltage from the reference system.

Analog Common is internally tied to an N-channel FET that can sink 50mA or more of current. This will hold the Analog Common voltage 2.8V below the positive supply (when a source is trying to pull the common line positive).

There is only 10kΩ of source current, however, so COMMON may easily be tied to a more negative voltage, thus overriding the internal reference.

**Test**

Two functions are performed by the test pin. The first is using this pin as the negative supply for externally generated segment drivers or any other annunciators the user may want to include on the LCD. This pin is coupled to the internally generated digital supply through a 500Ω resistor. This application is illustrated in Figures 5 & 6.

A lamp test is the second function. All segments will be turned on and the display should read — 0008 when TEST is pulled high (V+).

Caution: In the lamp test mode, the segments have a constant dc voltage (no square wave). This can burn the LCD if left in this mode for several minutes.
**3½ Digit A/D Converter**

The ICL7107 is identical to the ICL7106 except that the backplane and drivers have been replaced by N-channel segment drivers. The ICL7107 is designed to drive common anode LED's with a typical segment current of 8mA.

Pin 19 (thousands digit output) sinks current from two LED segments, and has a 16mA drive capability.

The polarity indication is "on" for negative analog inputs, for both the ICL7106 and ICL7107. If desired IN-HI and IN-LO can be reversed giving a "off" for positive analog inputs.

**System Timing**

The clocking circuitry for the ICL7106 and ICL7107 is illustrated in Figure 7. Three approaches can be used:

1. A crystal between pins 39 and 40.
2. An external oscillator connected to pin 40.
3. An RC oscillator using all three pins.

The decade counters are driven by the clock frequency divided by four. This frequency is then further divided to form the four convert-cycle phases, namely, signal integrate (1000 counts), reference de-integrate (0 to 2000 counts), auto-zero (260 to 2989 counts) and zero integrator (11 to 740).

The signal integration should be a multiple of 60Hz to achieve a minimum rejection of 60Hz pickup. Oscillator frequencies of 30kHz, 40kHz, 60kHz, 50kHz, 120kHz, 240kHz, etc., should be selected. Similarly, for 50Hz rejection, oscillator frequencies of 200kHz, 100kHz, 65kHz, 50kHz, 40kHz, etc., are appropriate. Note that 40kHz (2.5 readings/second) will reject both 50 and 60Hz (also 400 and 440Hz).

Auto-zero receives the unused portion of reference deintegrate for signals less than full-scale. A complete measurement cycle is 4,000 counts (16,000 clock pulses), independent of input voltage. As an example, an oscillator frequency of 48kHz would be used to obtain three readings per second.

**Digital Section**

The digital section for the ICL7106 and ICL7107 is illustrated in Figures 8 and 9. In Figure 8, an internal digital ground is generated from a 6V zener diode and a large P-channel source follower. This supply is made stiff to absorb the large capacitive currents when the back plane (BP) voltage is switched. The BP frequency is calculated by dividing the clock frequency by 800. For example, with a clock frequency of 48kHz (3 readings per second), the backplane will be a 60Hz square wave with a nominal amplitude of 5V. The segments are driven at the same frequency and amplitude. Note that these are out-of-phase when the segment is ON and in-phase when OFF. Negligible dc voltage exists across the segments in either case.

**Figure 5A: Digit Encoder/Point Drivers**

**Figure 5B: Point Decimal/Point Drivers**

**Figure 7: Clock Circuit**
3½ Digit A/D Converter

Figure 8: ICL7106/7107 Digital Section

Figure 9: ICL7106/7107 Digital Section

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Component Value Selection

Auto-Zero Capacitor

The noise of the system is influenced by the auto-zero capacitor. For the 2V scale, a 0.01μF capacitor is adequate. A capacitor size of 0.47μF is recommended for 200mV full scale where low noise operation is very important. Due to the Z1 phase of Maxim’s ICL7106/7, noise can be reduced by using a larger auto-zero capacitor without causing hysteresis or overrange hangover problems seen in other manufacturers’ ICL7106/7 which do not have the Z1 phase.

Reference Capacitor

For most applications, a 0.1μF capacitor is acceptable. However, a large value is needed to prevent rollover errors where a large common-mode voltage exists (i.e., the HEF-1C pin is not at analog common) and a 200mV scale is used. Generally, the rollover error will be held half a count by using a 1.0μF capacitor.

Integrating Capacitor

To ensure that the integrator will not saturate (at approximately 0.3V from either supply), an appropriate integrating capacitor must be selected. A nominal ±5V full-scale integrator swing is acceptable for the ICL7106 or ICL7107 when the analog common is used as a reference. A nominal ±3.3 to 4 volt swing is acceptable for the ICL7107 with a ±5V supply and analog common tied to supply ground. The nominal voltage for CMINT is 0.22μF for three readings per second (45kHz clock). These values should be changed in inverse proportion to maintain the same output swing at different oscillator frequencies are used.

The integrating capacitor must have low dielectric absorption to minimize linearity errors. Polypropylene capacitors are recommended for this application.

Integrating Resistor

The integrator and the buffer amplifier both have a class A output stage with 100μA of quiescent current. 20μA of drive current can be supplied with negligible non-linearity. The resistor should be large enough to maintain the amplifiers in the linear region over the entire input voltage range. The resistor value, however, should be low enough that undue leakage requirements are not placed on the PC board for a 500mV scale. A 24KΩ resistor is recommended (2V scale/47KΩ).

Oscillator Components

A 100KΩ resistor is recommended for all ranges of frequency. By using the equation f = 0.45/RC, the capacitor value can be calculated. For 48kHz clock, 5 readings/second, the oscillator capacitor plus stray capacitance should equal 100pF.

Reference Voltage

An analog input voltage of Vin equal to 2 (VREF) is required to generate full scale output of 2000 counts. Thus, for 2V and 200mV scales, VREF should equal 1V and 100mV respectively. However, there will exist a scale factor other than unity between the input voltage and the digital reading in many applications, where the A/D is connected to a transducer.

As an example, the designer may like to have a full scale reading in a weighing system when the voltage from the transducer is 0.882V. The designer should use the input voltage directly and select Vpp at 0.341V instead of dividing the input down to 200mV. Suitable values of the capacitor and integrating resistor would be 0.22μF and 120KΩ. This provides a slightly quieter system and also avoids a divider network on the input. The ICL7107 can accept input signals up to ±5.5V with ±5V supplies. Another advantage of this system occurs when the digital reading of zero is desired for Vin ≠ 0. Examples are temperature and weighing systems with variable tare. By connecting the voltage transducer between Vin positive and common, and the variable (or fixed) offset voltage between common and Vin negative, the offset reading can be conveniently generated.

ICL7107 Power Supplies

The ICL7107 is designed to operate from ±5V supplies. However, when a negative supply is not available it can be generated from a clock output with two diodes, two capacitors, and an inexpensive IC. Refer to Figure 10. Alternatively a −5V supply can be generated using Maxim’s ICL7650 and two capacitors.

A negative supply is not required in selected applications. The conditions to use a single +5V supply are:

• An external reference is used.
• The signal is less than ±1.5V.
• The input signal can be referenced to the center of the common-mode range of the converter.

See Figure 18.
Applications Information

Heat is generated within the ICL7107 IC package due to the sinking of LED display current. Fluctuating chip temperature can cause a display to change reading if the internal voltage reference is used. By reducing the power being dissipated such variations can be reduced. The ICL7107 power dissipation is reduced by reducing the LED common anode voltage. The curve tracer illustration showing the relationship between the output current and the output voltage for typical ICL7107 is seen in Figure 11. Note that the typical ICL7107 output is 3.2V (point A), since the typical LED has 1.8V across it (8mA display current) and its common anode is connected to +5V. Maximum power dissipation is:

8.1mA x 3.2V x 24 segments = 622mW

Once the ICL7107 output voltage is above 2V, the LED current is essentially constant as output voltage increases. Point B illustrates that reducing the output voltage by 0.7V results in 7.7mA of LED current, (only 5% reduction). The maximum power dissipation is a reduction of 26% as calculated by:

7.7mA x 2.5V x 24 segments = 462mW

As illustrated in Figure 12, reduced power dissipation is easy to obtain. This can be accomplished by placing either a 5.111 resistor or a 1 amp diode in series with the display (but not in series with the ICL7107). Point C of Figure 12 illustrates that a resistor will reduce the ICL7107 output voltage when all 24 segments are "On". The output voltage will increase when segments are turned "Off". On the other hand, the diode will result in a relatively steady output voltage, around Point B. The resistor not only reduces the change in power dissipation as the display changes, but also limits the maximum power dissipation. This is due to the fact that as fewer segments are "On", each "On" output drops more voltage and current. The resistor circuit will change about 230mW when changing from the worst case of six segments, a "111" display, to worst-case of a "1888" display. If the resistor is removed, the power dissipation change will be 470mW. The resistor, therefore, will reduce the effect of display dissipation on reference voltage drift by about 50%.

As more segments are turned off, the change in LED brightness caused by the resistor is almost unnoticeable. A node may be used instead of the resistor if it is important to maintain a steady level of display brightness.

3½ Digit A/D Converter

![3½ Digit A/D Converter Diagram](image-url)
3½ Digit A/D Converter

Typical Applications

Figure 19. Thermocouple Thermometer. This circuit operates with an accuracy of ±50 mV reference, so the 20-kV/C output of a Type J thermocouple reads in 0.1°C.

Figure 20. Digital Thermometer

ICL7106 system setup for 2V reference

ICL7106 system setup for 200mV reference

Figure 21. Potentiometric Ohm Measurement

Figure 22. BCD Output from 7-Segment Drivers

* For ICL7107, use "INVERT" high and pull EX/NOA pins.

Figure 23. Simple End-of-Conversion Detector

* ICL7106/7 only. See data sheet for values for other parts.

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Typical Applications

ICL7106A system setup
for 2V reference
ICL7106A system setup
for 5V reference

Figure 20. Digital Thermometer

ICL7106 system setup
for 2V reference
ICL7106 system setup
for 20mA reference

Figure 21. Analog Output Amplitude Measurement

Figure 22. Simple End-of-Conversion Detector

* ICL7106A only. See data sheet for values for other parts

For ICL7106A, "INVERT" high and omit EX-HOA gates

Figure 23. 8-SSC Output from 7-Segment Drivers

For ICL7106, "INVERT" high and omit EX-HOA gates

Figure 19. Thermocouple Thermometer. This circuit operates with approximately 50 mV reference, so the 3.3 mV°C output of a Type J thermocouple results in 1 count°C.
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Typical Applications

Figure 19. Thermocouple Thermometer. The circuit operates with approximately 10mV reference, so the 50 mV/°C output of a Type J thermocouple results in 1 count/°C.

Figure 20. Digital Thermometer

Figure 21. Biased Output from 7-Segment Drivers

Figure 22. Ammeter/Dc Voltage Measurement

For ICL7107, use "INVERT" high and omit EX-NOP gates.

ICL7106 system setup for 0V reference
ICL7106 system setup for 2.5V reference

ICL7107 only. See data sheet for values for other parts.

Figure 23. Simple End-of-Conversion Detector

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Typical Applications

Figure 19. Thermocouple Thermometer. The circuit operates with approximately 50mV reference, so the 50 mV/°C output of a Type J thermocouple results in 1 count/°C.

Figure 20. Digital Thermometer

Figure 21. BCD Output from 7-Segment Drivers

Figure 22. Resistance Ohms Measurement

* For ICL7107, the "INVERT" high side only. EX-NOR gates.

Figure 23. Simple End-of-Conversion Detector

*ICL7106/7 only. See data sheet for values for other parts.
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Typical Applications

Figure 13. ICL7106 using the internal Reference 2V Full Scale 3 Readings per Second

Figure 14. ICL7107 internal Reference 200mV Full Scale, 3 Readings per Second, Vn Tied to GND for Single Ended Inputs (See discussion under Analog Common)

Figure 15. ICL7107 Measuring Parametric Values of a Load Cell. Desired Sensitivity is Determined by Resistor Values Within the Bridge

Figure 16. Circuit for Developing Under Range and Over Range Signals from ICL7108 Outputs

Figure 17. ICL7107 with ±12V external Band Gap Reference Vb+ and Vb-

Figure 18. ICL7107 Operation from Signal -8V Supply. An external Reference must be used in this application
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Chip Topographies

Pin Configuration

Maxim cannot assume responsibility for use of any circuitry other than circuitry embodied in a Maxim product. No circuit patent licenses are implied. Maxim reserves the right to change the circuitry and specifications without notice at any time.
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