

# MAXIM

## 4½ Digit Counter/Decoder/Driver

ICM7224/7225

### General Description

The Maxim ICM7224(LCD) and ICM7225(LED) are high speed 4½ digit counters, featuring segment decoders, leading zero blanking, store and reset inputs, and a carry output that allows cascading of 8 or more digits. The ICM7224 directly drives a non-multiplexed liquid crystal display(LCD). The ICM7225 has 29 constant current outputs for driving a non-multiplexed common anode LED display.

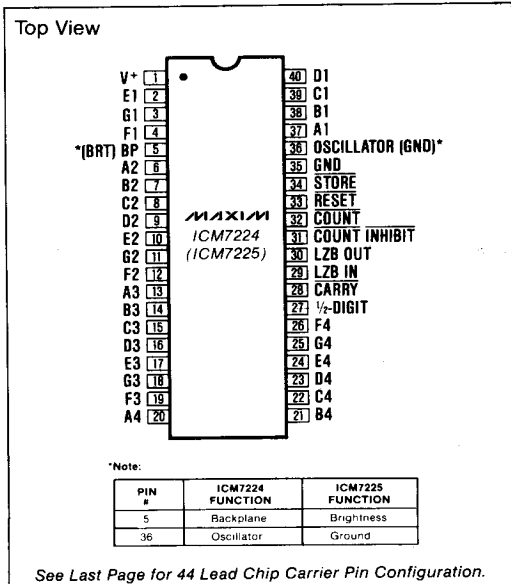
These counters operate with inputs from DC to 25MHz while using only 10µA of supply current. A Schmitt trigger on the count input ensures reliable operation in noisy environments and in applications with slowly varying inputs.

The ICM7224 and ICM7225 are available in a 44 lead plastic chip carrier package in addition to the standard 40 lead plastic DIP.

### Applications

Unit Counter  
Frequency Counter  
Tachometer  
Hour Meter  
Totalizer

### Pin Configuration



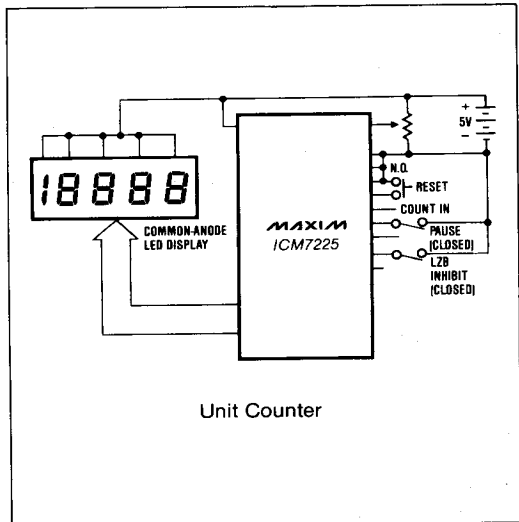
### Features

- ◆ Improved 2nd Source! (See 3rd page for "Maxim Advantage™").
- ◆ High Speed Up Counter: 25MHz Typ.
- ◆ Leading Zero Blanking
- ◆ Can Be Cascaded for 8 or More Digits
- ◆ STORE and RESET Inputs for Frequency Counter Applications
- ◆ On-Board Oscillator to Provide Backplane Frequency (ICM7224)
- ◆ Brightness Control Input (ICM7225)
- ◆ Low Power CMOS

### Ordering Information

| PART       | TEMP. RANGE    | PACKAGE                      |
|------------|----------------|------------------------------|
| ICM7224IPL | -20°C to +85°C | 40 Lead Plastic DIP          |
| ICM7224CQ  | 0°C to +70°C   | 44 Lead Plastic Chip Carrier |
| ICM7224C/D | 0°C to +70°C   | Dice                         |
| ICM7225IPL | -20°C to +85°C | 40 Lead Plastic DIP          |
| ICM7225CQ  | 0°C to +70°C   | 44 Lead Plastic Chip Carrier |
| ICM7225C/D | 0°C to +70°C   | Dice                         |

### Typical Operating Circuit



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The "Maxim Advantage™" signifies an upgraded quality level. At no additional cost we offer a second-source device that is subject to the following: guaranteed performance over temperature along with tighter test specifications on many key parameters; and device enhancements, when needed, that result in improved performance without changing the functionality.

MAXIM

Maxim Integrated Products 7-53

# 4½ Digit Counter/Decoder/Driver

## ABSOLUTE MAXIMUM RATINGS

|                                      |                                    |
|--------------------------------------|------------------------------------|
| Supply Voltage                       | 6.5V                               |
| Input Voltage (any terminal, Note 1) | -0.3V to V <sup>+</sup> +0.3V      |
| Power Dissipation                    |                                    |
| 40 Lead Plastic Dip                  | 1W<br>(derate 10mW/°C above 25°C.) |
| 44 Lead Plastic Chip Carrier         | 1W<br>(derate 10mW/°C above 25°C.) |

|   |                 |
|---|-----------------|
| Operating Temperature Range             |                 |
| Plastic Package (IPL)                   | -20°C to +85°C  |
| Plastic Chip Carrier (Quad) Package (Q) | 0°C to +70°C    |
| Storage Temperature Range               | -65°C to +160°C |
| Lead Temperature (Soldering, 10 sec.)   | +300°C          |

**Note 1:** The input voltage may exceed this rating if the input current is limited to 1mA. Connecting any terminal to a voltage greater than V<sup>+</sup> or less than Ground and exceeding 1mA input current may activate the parasitic SCR inherent in the junction isolated CMOS process, causing destructive device latchup. For this reason, it is recommended that no inputs from sources operating on a different power supply be applied to the device before its supply is established, and that in multiple supply systems, the supply to the ICM7224/25 be turned on first.

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 above those indicated in the operational sections of the specifications is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

## ELECTRICAL CHARACTERISTICS

(All parameters measured with V<sup>+</sup> = 5V, unless otherwise indicated)

### ICM7224 CHARACTERISTICS

| PARAMETER                      | SYMBOL            | CONDITIONS                  | MIN | TYP | MAX | UNITS |
|--------------------------------|-------------------|-----------------------------|-----|-----|-----|-------|
| Operating current              | I <sub>OP</sub>   | Test circuit, Display blank |     | 10  | 50  | μA    |
| Operating supply voltage range | V <sup>+</sup>    |                             | 3   | 5   | 6   | V     |
| OSCILLATOR input current       | I <sub>OSCI</sub> | Pin 36                      |     | ±2  | ±10 | μA    |
| Segment rise/fall time         | t <sub>rf</sub>   | C <sub>load</sub> = 200pF   |     | 0.5 |     | μs    |
| Backplane rise/fall time       | t <sub>rb</sub>   | C <sub>load</sub> = 5000pF  |     | 1.5 |     |       |
| Oscillator frequency           | f <sub>osc</sub>  | Pin 36 Floating             |     | 19  |     | kHz   |
| Backplane frequency            | f <sub>bp</sub>   | Pin 36 Floating             |     | 150 |     | Hz    |

### ICM7225 CHARACTERISTICS

| PARAMETER                      | SYMBOL           | CONDITIONS  | MIN | TYP   | MAX | UNITS |
|--------------------------------|------------------|---|-----|-------|-----|-------|
| Operating current display off  | I <sub>OPQ</sub> | Pin 5 (BRightness) at GROUND<br>Pin 29, 31-34 at V <sup>+</sup> |     | 10    | 50  | μA    |
| Operating supply voltage range | V <sup>+</sup>   |   | 4   | 5     | 6   | V     |
| Operating current              | I <sub>OP</sub>  | Pin 5 at V <sup>+</sup> , Display 18888                         |     | 200   |     | mA    |
| Segment leakage current        | I <sub>SLK</sub> | Segment Off   |     | ±0.01 | ±1  | μA    |
| Segment on current             | I <sub>SEG</sub> | Segment On, V <sub>out</sub> = +3V                              | 5   | 8     |     | mA    |
| Half-digit on current          | I <sub>H</sub>   | Half-digit On, V <sub>out</sub> = +3V                           | 10  | 16    |     |       |

### FAMILY CHARACTERISTICS

| PARAMETER                        | SYMBOL                          | CONDITIONS   | MIN | TYP   | MAX | UNITS |
|----------------------------------|---------------------------------|--|-----|-------|-----|-------|
| Input Pull-up Currents           | I <sub>P</sub>                  | Pins 29, 31, 33, 34<br>V <sub>out</sub> = V <sup>+</sup> - 3V                              |     | 10    |     | μA    |
| Input High Voltage               | V <sub>IH</sub>                 | Pin 29, 31, 33, 34   | 3   |       |     | V     |
| Input Low Voltage                | V <sub>IL</sub>                 | Pin 29, 31, 33,  |     |       | 1   |       |
| COUNT Input Threshold            | V <sub>CT</sub>                 |  |     | 2     |     |       |
| COUNT Input Hysteresis           | V <sub>CH</sub>                 |  |     | 0.5   |     |       |
| Output High Current              | I <sub>OH</sub>                 | CARRY Pin 28<br>Leading Zero Blanking OUT Pin 30<br>V <sub>out</sub> = V <sup>+</sup> - 3V | 350 | 500   |     | μA    |
| Output Low Current               | I <sub>OL</sub>                 | CARRY Pin 28<br>Leading Zero Blanking OUT Pin 30<br>V <sub>out</sub> = +3V                 | 350 | 500   |     |       |
| Count Frequency                  | f <sub>count</sub>              | 4.5V < V <sup>+</sup> < 6V   | 0   | DC-25 | 15  | MHz   |
| STORE, RESET Minimum Pulse Width | t <sub>S</sub> , t <sub>R</sub> |  | 3   |       |     | μs    |

The electrical characteristics above are a reproduction of a portion of Intersil's copyrighted (1983/1984) data book. This information does not constitute any representation by Maxim that Intersil's products will perform in accordance with these specifications. The "Electrical Characteristics Table" along with descriptive excerpts from the original manufacturer's data sheet have been included in this data sheet solely for comparative purposes.

## 4 1/2 Digit Counter/Decoder/Driver

ICM7224/7225

- ◆ Key Parameters Guaranteed Over Temperature
- ◆ Low Power (Typically 25μW)
- ◆ Increased Segment-On Current
- ◆ Maxim Quality and Reliability
- ◆ Significantly Improved ESD Protection (Note 1)

**ABSOLUTE MAXIMUM RATINGS:** This device conforms to the Absolute Maximum Ratings on adjacent page.

**ELECTRICAL CHARACTERISTICS:** Specifications below satisfy or exceed all "tested" parameters on adjacent page.

(V<sup>+</sup> = 5V, T<sub>A</sub> = 25°C unless otherwise noted)

### ICM7224 ELECTRICAL CHARACTERISTICS

| PARAMETER                      | SYMBOL            | CONDITIONS                     | MIN | TYP | MAX | UNITS |
|--------------------------------|-------------------|--------------------------------|-----|-----|-----|-------|
| Operating current              | I <sub>op</sub>   | Display blank                  |     | 5   | 25  | μA    |
| Operating supply voltage range | V <sup>+</sup>    | -20°C ≤ T <sub>A</sub> ≤ +85°C | 3   | 5   | 6   | V     |
| OSCILLATOR input current       | I <sub>OSCI</sub> | Pin 36                         |     | ±2  | ±10 | μA    |
| Segment rise/fall time         | t <sub>rfs</sub>  | C <sub>load</sub> = 200pF      |     | 0.5 |     | μs    |
| Backplane rise/fall time       | t <sub>rfb</sub>  | C <sub>load</sub> = 5000pF     |     | 1.5 |     |       |
| Oscillator frequency           | f <sub>osc</sub>  | Pin 36 Floating                |     | 19  |     | kHz   |
| Backplane frequency            | f <sub>bp</sub>   | Pin 36 Floating                |     | 150 |     | Hz    |

### ICM7225 ELECTRICAL CHARACTERISTICS

| PARAMETER                      | SYMBOL           | CONDITIONS  | MIN | TYP   | MAX | UNITS |
|--------------------------------|------------------|---|-----|-------|-----|-------|
| Operating current display off  | I <sub>OPD</sub> | Pin 5 (BRIGHTNESS) at GROUND<br>Pin 29, 31-34 at V <sup>+</sup> |     | 10    | 25  | μA    |
| Operating supply voltage range | V <sup>+</sup>   | -20°C ≤ T <sub>A</sub> ≤ +85°C                                  | 4   | 5     | 6   | V     |
| Operating current              | I <sub>OP</sub>  | Pin 5 at V <sup>+</sup> , Display 18888                         |     | 275   |     | mA    |
| Segment leakage current        | I <sub>SLK</sub> | Segment Off   |     | ±0.01 | ±1  | μA    |
| Segment on current             | I <sub>SEG</sub> | Segment On, V <sub>out</sub> = +3V                              | 6   | 9     |     | mA    |
| Half-digit on current          | I <sub>H</sub>   | Half-digit On, V <sub>out</sub> = +3V                           | 12  | 18    |     |       |

### FAMILY DC ELECTRICAL CHARACTERISTICS

| PARAMETER              | SYMBOL          | CONDITIONS   | MIN | TYP | MAX  | UNITS |
|------------------------|-----------------|--|-----|-----|------|-------|
| Input Pull-up Currents | I <sub>P</sub>  | Pins 29, 31, 33, 34<br>V <sub>out</sub> = V <sup>+</sup> - 3V                              | 2   | 10  | 25   | μA    |
| Input High Voltage     | V <sub>IH</sub> | Pin 29, 31, 33, 34, -20°C ≤ T <sub>A</sub> ≤ +85°C   | 3   |     |      | V     |
| Input Low Voltage      | V <sub>IL</sub> | Pin 29, 31, 33, 34, -20°C ≤ T <sub>A</sub> ≤ +85°C   |     |     | 1    |       |
| COUNT Input Threshold  | V <sub>CT</sub> |  | 1.5 | 2   | 3.25 |       |
| COUNT Input Hysteresis | V <sub>CH</sub> |  | 0.1 | 0.5 | 1.75 |       |
| Output High Current    | I <sub>OH</sub> | CARRY Pin 28<br>Leading Zero Blanking OUT Pin 30<br>V <sub>out</sub> = V <sup>+</sup> - 3V | 350 | 500 |      | μA    |
| Output Low Current     | I <sub>OL</sub> | CARRY Pin 28<br>Leading Zero Blanking OUT Pin 30<br>V <sub>out</sub> = +3V                 | 350 | 500 |      |       |

**Note 1:** All pins are designed to withstand electrostatic discharge (ESD) levels in excess of 2000V (Mil STD 883C Method 3015.2 Test Circuit).

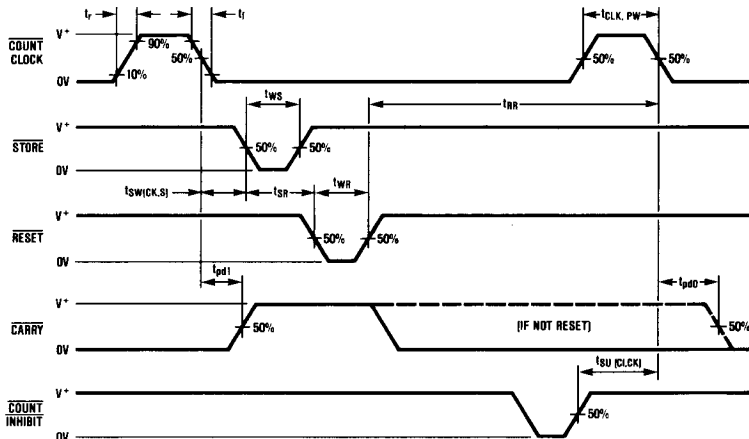
# 4½ Digit Counter/Decoder/Driver

**FAMILY AC ELECTRICAL CHARACTERISTICS** (CL = 50pF unless noted)

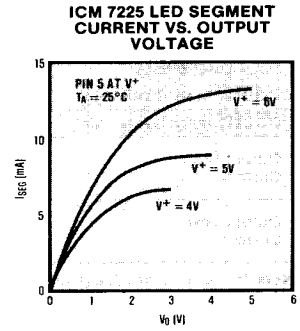
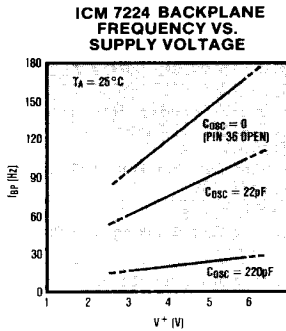
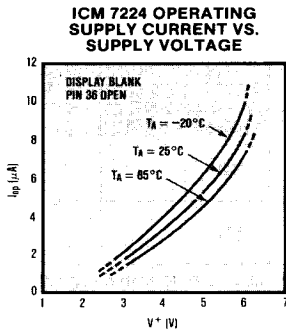
| PARAMETER                        | SYMBOL             | CONDITIONS            | MIN | TYP   | MAX      | UNITS   |
|----------------------------------|--------------------|-----------------------|-----|-------|----------|---------|
| Propagation Delay Clock to Carry | $t_{pd0}, t_{pd1}$ |                       |     | 0.6   |          | $\mu$ s |
| Maximum Clock Frequency          | $f_{CLK}$          |                       | 0   | DC-25 | 15       | MHz     |
| Minimum Clock Pulse Width        | $t_{CLK,PW}$       |                       |     | 25    |          | ns      |
| Clock Input Rise or Fall Time    | $t_r, t_f$         |                       |     |       | No Limit |         |
| Reset Pulse Width                | $t_{WR}$           |                       |     | 125   |          | ns      |
| Store Pulse Width                | $t_{WS}$           |                       |     | 1     |          | $\mu$ s |
| Clock to Store Set-Up Time       | $t_{SU(CLK,S)}$    |                       |     | 0.4   |          | $\mu$ s |
| Store to Reset Wait Time         | $t_{SR}$           |                       |     | 1.3   |          | $\mu$ s |
| Inhibit to Clock Set-Up Time     | $t_{SU(CLK)}$      |                       |     | 0     |          | ns      |
| Reset Removal                    | $t_{RR}$           |                       |     | 20    |          | ns      |
| Input Capacitance                | $C_{IN}$           | Logic Inputs (Note 1) |     | 5     |          | pF      |

**Note 1:** Does not apply to backplane and oscillator pins.

## Timing Diagram



## Typical Operating Characteristics



# 4½ Digit Counter/Decoder/Driver

ICM7224/7225

TABLE 1. PIN DESCRIPTIONS

| PIN                    | FUNCTION        | DESCRIPTION   |
|------------------------|-----------------|---|
| 1                      | V <sup>+</sup>  | Positive power supply input.  |
| 2-4,<br>6-26,<br>37-40 | Segment Outputs | These 28 pins directly drive LCD segments (ICM7224) or common anode LED segments (ICM7225). Segments A1-G1 drive the least significant digit, segments A4-G4 drive the 1000s digit.   |
| 27                     | ½ Digit         | This segment output drives both segments of the most significant half digit. This segment output turns on when the count reaches 10,000 and is reset only by a low level on the Reset input.  |
| 5<br>(ICM7224)         | BP              | The backplane pin is both an input and an output. As an output it drives the LCD backplane with an internally generated backplane signal. The backplane pin is an input when the slave mode is selected by grounding pin 36 (Oscillator).   |
| 5<br>(ICM7225)         | BRT             | An analog input voltage applied to the brightness (BRT) pin controls the output current of the LED segment drivers. Connecting this pin to ground shuts off the display. Connecting this pin to V <sup>+</sup> drives the display with the maximum available output current. Intermediate voltage levels will adjust the brightness to any level between full off and full brightness.                              |
| 28                     | CARRY           | Connect this logic output to the Count input of another ICM7224/5 to make an 8 digit counter/display driver. The Carry output goes high at count 6000 and goes low on the transition between count 9999 and count 10,000. The Carry output repeats this cycle every 10,000 counts.  |
| 29                     | LZB IN          | The ICM7224 displays leading zeroes when this pin is grounded. Connecting this pin to V <sup>+</sup> or leaving it floating enables leading zero blanking. The entire display will be blanked if this pin is high or floating, the count is 0000, and the half digit is reset. This pin has an internal 10µA pullup.  |
| 30                     | LZB OUT         | This output allows the proper blanking of cascaded counters. The Leading Zero Blanking (LZB) output goes high when all digits are blanked.  |
| 31                     | COUNT INHIBIT   | A low level on this input pin disables the counter. Connecting this pin to V <sup>+</sup> or floating this pin enables the counter. This pin has an internal 10µA pullup.   |
| 32                     | COUNT           | Every negative-going transition at the Count input clocks the counter. This input has 500 mV of hysteresis to prevent multiple clocking with slow rate-of-fall inputs.  |
| 33                     | RESET           | A low level on Reset will reset the counter. Reset also clears the half-digit flip-flop and turns off the half-digit output. This input has an internal 10µA pullup and is inactive when either connected to V <sup>+</sup> or left floating.   |
| 34                     | STORE           | When the Store input is low, the latches are transparent and the counter contents are displayed. When Store is taken high or floated, the counter contents are latched and this latched data is displayed.  |
| 35                     | GND             | The negative power supply input.  |
| 36<br>(ICM7225)        | GND             | An additional ground pin for the ICM7225. The ICM7225 has two ground pins to handle the high LED drive currents.  |
| 36<br>(ICM7224)        | Oscillator      | When this pin is left floating, the ICM7224 oscillates at approximately 19kHz. Connecting an external capacitor between this pin and either V <sup>+</sup> or GND lowers the oscillator frequency as shown in the Typical Characteristics graphs. The Oscillator can be externally driven using the circuit of Figure 4. Grounding this pin puts the ICM7224 into the slave mode, turning pin 5, BP, into an input. |

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Table 2. TYPICAL LCD DISPLAYS

| Manufacturer             | PART #     | HEIGHT | # DIGITS |
|--------------------------|------------|--------|----------|
| Epson<br>(213) 534-0360  | LD-H7924   | 0.350" | 4½       |
|                          | LD-H7916   | 0.500" | 4        |
|                          | LD-K7994   | 0.700" | 4        |
| LXD<br>(216) 292-3300    | 44D3F-85   | 0.800" | 4½       |
|                          | 44D3F-45   | 0.400" | 4½       |
| Hamlin<br>(414) 648-2361 | 3909       | 0.400" | 4½       |
|                          | 3912       | 0.800" | 4½       |
| AND<br>(415) 347-9916    | FE0202W-DU | 0.500" | 4        |
|                          | FE0206W-DU | 0.400" | 4½       |

Table 3. TYPICAL LED DISPLAYS

| Manufacturer                                       | PART #    | HEIGHT | COLOR         |
|--|-----------|--------|---------------|
| Hewlett Packard<br>(Contact local<br>sales office) | 5082-7731 | 0.3"   | Red           |
|  | 5082-7611 | 0.3"   | Red (Hi Eff.) |
|  | 5082-7621 | 0.3"   | Yellow        |
|  | 5082-7631 | 0.3"   | Green         |
| General Inst.<br>(415) 493-0400                    | MAN 71A   | 0.3"   | Red           |
|  | MAN 3910A | 0.3"   | Red (Hi Eff.) |
|  | MAN 3810A | 0.3"   | Yellow        |
|  | MAN 3410A | 0.3"   | Green         |
| Siemens Opto<br>(408) 257-7910                     | HD1075R   | 0.3"   | Red           |
|  | HD1075O   | 0.3"   | Red (Hi Eff.) |
|  | HD1075Y   | 0.3"   | Yellow        |
|  | HD1075G   | 0.3"   | Green         |

MAXIM

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# 4½ Digit Counter/Decoder/Driver

## Detailed Description

The ICM7224 and ICM7225 have identical counter and control sections, but have different display driver sections. The ICM7224 is designed to drive a non-multiplexed liquid crystal display (LCD). The ICM7225 is designed to drive a non-multiplexed, common anode LED display.

### Counter and Control Logic

The counter in both the ICM7224 and ICM7225 is a 4 decade up counter with a Carry output. An overflow flip-flop, which is clocked by Carry, controls the half-digit output. This half-digit output can be used as an overflow indicator or as a half-digit to extend the count range to 19,999. Once set by Carry, the overflow flip-flop will remain set until the counter is reset by taking the Reset pin low.

The counter advances with each negative going transition on the Count input, provided the Count Inhibit and Reset inputs are high.

The Count Inhibit input disables the counter when it is low. The Count Inhibit input is similar to the J-K inputs of a J-K flip-flop; transitions on Count Inhibit do not increment the counter.

Reset is an active low input that resets the 4 digit counter and the overflow (½ digit) flip-flop. Reset does not clear the data in the display latches unless Store is low.

Store controls the flow of data into the display latches. When Store is low the latches are transparent and the counter data is displayed. When Store goes high the display latches go into the hold mode and the displayed count no longer follows the counter.

The LZB IN pin determines whether leading zeroes are blanked. Leading zeroes are displayed when LZB IN is low. Leading zeroes are blanked when LZB IN is high or floating. The LZB OUT allows proper leading zero blanking when cascading two ICM7224/ICM7225 devices to make an 8 digit counter/display driver (Figure 3). LZB OUT will go high only when LZB IN is high or floating, the count is 0000, and the overflow flip-flop is reset.

When the ICM7224/25 is used in electrically noisy environments (around solenoids, motor starters, etc.), do NOT rely upon the internal 10µA pullups on Reset, Count Inhibit, LZB IN and Store inputs. Stray pickup of transients may momentarily override the weak, 10µA pullup. Connect these pins directly to V<sup>+</sup>, drive them with a logic gate, or parallel the internal pullup with a 4.7kΩ resistor to V<sup>+</sup>.

### ICM7224 LCD Driver Section

The LCD driver section of the ICM7224 is similar to the Maxim ICM7211 4 digit display driver. It includes an internal 19kHz oscillator with a backplane driver, and 29 segment drivers.

The 19kHz nominal output of the onboard oscillator is divided by 128 in the 7 stage divider chain to generate a 150Hz backplane frequency. The Backplane output, pin 5, is a low impedance (200Ω typical) output that swings from ground to V<sup>+</sup> at the backplane frequency with a 50% duty cycle. The 29 segment drivers also swing from ground to V<sup>+</sup> and have an output impedance of approximately 2kΩ. The ICM7224 drives an LCD segment in phase with the backplane to turn the

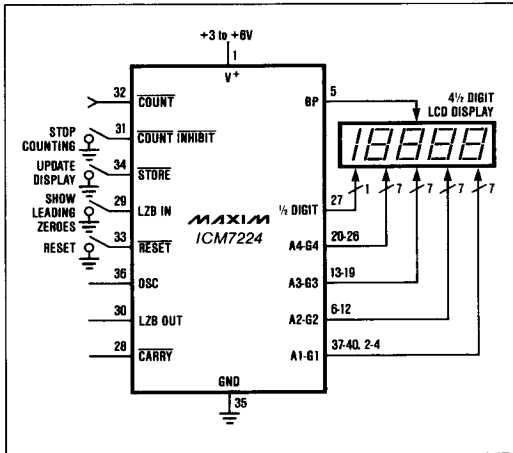


Figure 1. Simple 4½ Digit Event or Unit Counter with LCD Display

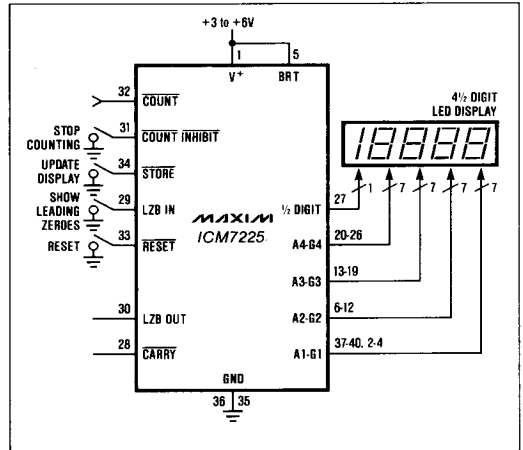


Figure 2. Simple 4½ Digit Event or Unit Counter with LED Display

# 4½ Digit Counter/Decoder/Driver

ICM7224/7225

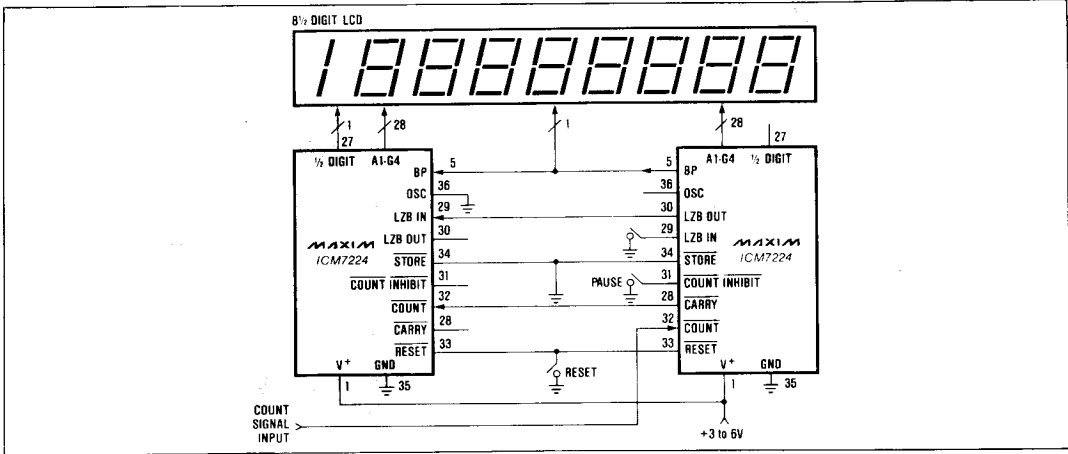


Figure 3. 8½ Digit Totalizer

segment off, and drives the LCD segment 180° out of phase with the backplane to turn the segment on.

The internal oscillator has a nominal oscillation frequency of 19kHz with no external components. This frequency can be lowered by connecting a capacitor from pin 36 (Oscillator) to either ground or V<sup>+</sup>. See Typical Characteristics graph, Backplane Frequency vs. Supply Voltage. The oscillator can also be overdriven by an external source as shown in Figure 4. The two resistors connected from the driver to pin 36 keep the voltage at pin 36 (Oscillator) above the 1.5V threshold of the backplane slaving detector which is internally connected to pin 36.

When two or more ICM7224 counter/display drivers drive one LCD with a single backplane, the backplane outputs of the ICM7224 counter/display drivers must

be synchronized. This is performed by grounding the Oscillator (pin 36) on all but one device; and connecting together the Backplanes (pin 5) of all devices. The one device with the Oscillator input not grounded will drive both its own Backplane pin and the Backplane pins of the other devices. The devices with the Oscillator input grounded disable their backplane drivers and use the Backplane pin as an input. See Figure 3.

### ICM7225 LED Display Interface

The ICM7225 has 29 open drain N channel segment drivers. These drivers are constant current sinks, whose sink current varies from 0 to 9mA as the voltage on BRT (pin 5) varies from ground to V<sup>+</sup> (0 to 18mA for pin 27, the ½ digit output). Segment current limiting resistors are not needed.

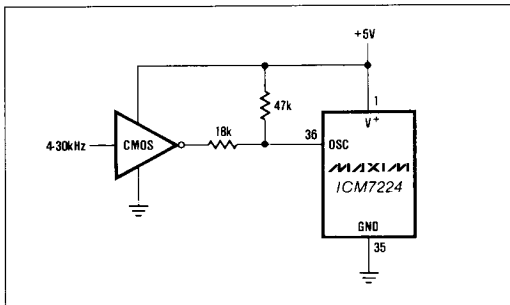


Figure 4. External Clock Drive.

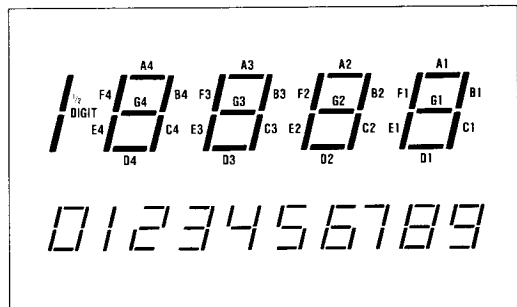


Figure 5. Segment Assignment and Display Font

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