INTERSIL

ICM7216A/B/C/D 10 MHz Universal/ Frequency Counters

FEATURES

ALL VERSIONS:

- **Functions as a frequency counter. Measures frequencies from DC to 10 MHz**
- **Four internal gate times: 0.01 sec, 0.1 sec, 1 sec, 10 sec in frequency counter mode**
- **Output directly drives digits and segments of large multiplexed LED displays. Common anode and common cathode versions**
- **Single nominal 5V supply required**
- **Stable high frequency oscillator, uses either 1 MHz or 10 MHz crystal**
- **Internally generated decimal points, interdigit blanking, leading zero blanking and overflow indication**
- **Display Off mode turns off display and puts chip into low power mode**
- **Hold and $\overline{\text{Reset}}$ inputs for additional flexibility**

ICM7216A AND B

- **Functions also as a period counter, unit counter, frequency ratio counter or time interval counter**
- **1 cycle, 10 cycles, 100 cycles, 1000 cycles in period, frequency ratio and time interval modes**
- **Measures period from 0.5μs to 10s**

ICM7216C AND D

- **Decimal point and leading zero blanking may be externally selected**

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GENERAL DESCRIPTION

The ICM7216A and B are fully integrated Universal Counters with LED display drivers. They combine a high frequency oscillator, a decade timebase counter, an 8-decade data counter and latches, a 7-segment decoder, digit multiplexers and 8 segment and 8 digit drivers which directly drive large multiplexed LED displays. The counter inputs have a maximum frequency of 10 MHz in frequency and unit counter modes and 2 MHz in the other modes. Both inputs are digital inputs. In many applications, amplification and level shifting will be required to obtain proper digital signals for these inputs.

The ICM7216A and B can function as a frequency counter, period counter, frequency ratio (f_A/f_B) counter, time interval counter or as a totalizing counter. The counter uses either a 10 MHz or 1 MHz quartz crystal timebase. For period and time interval, the 10MHz timebase gives a 0.1 μsec resolution. In period average and time interval average, the resolution can be in the nanosecond range. In the frequency mode, the user can select accumulation times of 0.01 sec, 0.1 sec, 1 sec and 10 sec. With a 10 sec accumulation time, the frequency can be displayed to a resolution of 0.1 Hz in the least significant digit. There is 0.2 seconds between measurements in all ranges.

The ICM7216C and D function as frequency counters only, as described above.

All versions of the ICM7216 incorporate leading zero blanking. Frequency is displayed in kHz. In the ICM7216A and B, time is displayed in μsec. The display is multiplexed at 500Hz with a 12.2% duty cycle for each digit. The ICM7216A and C are designed for common anode display with typical peak segment currents of 25mA. The ICM7216B and D are designed for common cathode displays with typical peak segment currents of 12mA. In the display off mode, both digit and segment drivers are turned off, enabling the display to be used for other functions.

ORDERING INFORMATION

Universal Counter; Common Anode LED	**ICM 7216 A**	**IJI**
Universal Counter; Common Cathode LED	**ICM 7216 B**	**IPI**
Frequency Counter; Common Anode LED	**ICM 7216 C**	**IJI**
Frequency Counter; Common Cathode LED	**ICM 7216 D**	**IPI**

Type

Package — JI — 28 pin CERDIP; PI — 28 pin PLASTIC DIP

Temperature Range -20° C to +85° C

Evaluation Kit:

ICM7226 EV/Kit

PIN CONFIGURATIONS (OUTLINE DRAWINGS JI, PI)

ICM7216A

CONTROL INPUT	1	28	INPUT A
INPUT B	2	27	HOLD INPUT
FUNCTION INPUT	3	26	OSC OUTPUT
DECIMAL POINT OUTPUT	4	25	OSC INPUT
SEG E OUTPUT	5	24	EXT OSC INPUT
SEG G OUTPUT	6	23	DIGIT 0 OUTPUT
SEG A OUTPUT	7	22	DIGIT 1 OUTPUT
GND	8	21	DIGIT 2 OUTPUT
SEG D OUTPUT	9	20	DIGIT 3 OUTPUT
SEG B OUTPUT	10	19	DIGIT 4 OUTPUT
SEG C OUTPUT	11	18	V^+
SEG F OUTPUT	12	17	DIGIT 5 OUTPUT
$\overline{\text{RESET}}$ INPUT	13	16	DIGIT 6 OUTPUT
RANGE INPUT	14	15	DIGIT 7 OUTPUT

ICM7216B

CONTROL INPUT	1	28	INPUT A
INPUT B	2	27	HOLD INPUT
FUNCTION INPUT	3	26	OSC OUTPUT
DIGIT 0 OUTPUT	4	25	OSC INPUT
DIGIT 2 OUTPUT	5	24	EXT OSC INPUT
DIGIT 1 OUTPUT	6	23	DECIMAL POINT OUTPUT
DIGIT 3 OUTPUT	7	22	SEG G OUTPUT
GND	8	21	SEG E OUTPUT
DIGIT 4 OUTPUT	9	20	SEG A OUTPUT
DIGIT 5 OUTPUT	10	19	SEG D OUTPUT
DIGIT 6 OUTPUT	11	18	V^+
DIGIT 7 OUTPUT	12	17	SEG B OUTPUT
$\overline{\text{RESET}}$ INPUT	13	16	SEG C OUTPUT
RANGE INPUT	14	15	SEG F OUTPUT

ICM7216C

CONTROL INPUT	1	28	INPUT A
$\overline{\text{MEASUREMENT IN PROGRESS}}$	2	27	HOLD INPUT
DECIMAL POINT OUTPUT	3	26	OSC OUTPUT
SEG E OUTPUT	4	25	OSC INPUT
SEG G OUTPUT	5	24	EXT OSC INPUT
SEG A OUTPUT	6	23	DIGIT 0 OUTPUT
GND	7	22	DIGIT 1 OUTPUT
SEG D OUTPUT	8	21	DIGIT 2 OUTPUT
SEG B OUTPUT	9	20	DIGIT 3 OUTPUT
SEG C OUTPUT	10	19	DIGIT 4 OUTPUT
SEG F OUTPUT	11	18	V^+
$\overline{\text{RESET}}$ INPUT	12	17	DIGIT 5 OUTPUT
EX. D.P. INPUT	13	16	DIGIT 6 OUTPUT
RANGE INPUT	14	15	DIGIT 7 OUTPUT

ICM7216D

CONTROL INPUT	1	28	INPUT A
$\overline{\text{MEASUREMENT IN PROGRESS}}$	2	27	HOLD INPUT
DIGIT 0 OUTPUT	3	26	OSC OUTPUT
DIGIT 2 OUTPUT	4	25	OSC INPUT
DIGIT 1 OUTPUT	5	24	EXT OSC INPUT
DIGIT 3 OUTPUT	6	23	DECIMAL POINT OUTPUT
GND	7	22	SEG G OUTPUT
DIGIT 4 OUTPUT	8	21	SEG E OUTPUT
DIGIT 5 OUTPUT	9	20	SEG A OUTPUT
DIGIT 6 OUTPUT	10	19	SEG D OUTPUT
DIGIT 7 OUTPUT	11	18	V^+
$\overline{\text{RESET}}$ INPUT	12	17	SEG B OUTPUT
EX. D.P. INPUT	13	16	SEG C OUTPUT
RANGE INPUT	14	15	SEG F OUTPUT

EVALUATION KIT

The ICM7226 Universal Counter System has all of the features of the ICM7216 plus a number of additional features. The ICM7226 Evaluation Kit consists of the ICM7226AIDL (Common Anode LED Display), a 10 MHz quartz crystal, 8 each 7 segment .3" LED's, P.C. board, resistors, capacitors, diodes, switches, socket: everything needed to quickly assemble a functioning ICM7226 Universal Counter System.

ABSOLUTE MAXIMUM RATINGS

Maximum Supply Voltage .... 6.5 Volts
Maximum Digit Output Current 400mA
Maximum Segment Output Current 60mA
Voltage On Any Input or
Output Terminal(1) .... V^+ + .3V to V^- − .3V
Maximum Power Dissipation at
70°C .... 1.0 W (ICM7216A & C)
0.5 W (ICM7216B & D)
Lead Temperature (Soldering, 10 sec) .... 300°C
Maximum Operating Temperature
Range .... -20°C to +85°C
Maximum Storage Temperature
Range .... −55°C to +125°C

NOTE: 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.

Notes:
1. The ICM7216 may be triggered into a destructive latchup mode if either input signals are applied before the power supply is applied or if input or outputs are forced to voltages exceeding V^+ to V^- by more than 0.3 volts.

ELECTRICAL CHARACTERISTICS

TEST CONDITIONS: $V^+ = 5.0V$, Test Circuit, $T_A = 25°C$, unless otherwise specified.

PARAMETER	SYMBOL	CONDITION	MIN.	TYP.	MAX.	UNITS
ICM7216A/B						
Operating Supply Current	I^+	Display Off, Unused Inputs to GND		2	5	mA
Supply Voltage Range	V^+	-20°C < T_A < +85°C, Input A, Input B Frequency at F_{MAX}	4.75		6.0	V
Maximum Frequency Input A, Pin 28	$f_{A(max)}$	-20°C < T_A < +85°C 4.75 < V^+ ≤ 6.0V, Figure 1, Function = Frequency, Ratio, Unit Counter Function = Period, Time Interval	10 2.5			MHz MHz
Maximum Frequency Input B, Pin 2	$f_{B(max)}$	-20°C < T_A < +85°C 4.75 < V^+ ≤ 6.0V, Figure 2	2.5			MHz
Minimum Separation Input A to Input B Time Interval Function		-20°C < T_A < +85°C 4.75 < V^+ ≤ 6.0V, Figure 3	250			n
Maximum Osc. Freq. and Ext. Osc. Frequency	f_{osc}	-20°C < T_A < +85°C 4.75 < V^+ ≤ 6.0V	10			MHz
Minimum Ext. Osc. Freq.	f_{osc}				100	kHz
Oscillator Transconductance	g_m	$V^+ - V^- = 4.75V$, $T_A = +85°C$	2000			μmhos
Multiplex Frequency	f_{mux}	f_{osc} = 10MHz		500		Hz
Time Between Measurements		f_{osc} = 10MHz		200		ms
Input Voltages: Pins 2,13,25,27,28 Input Low Voltage Input High Voltage	 V_{INL} V_{INH}	-20°C < T_A < +85°C	 3.5		 1.0	 V V
Input Resistance to V^+ Pins 13,24	R_{IN}	$V_{IN} = V^+ - 1.0V$	100K	400K		Ω
Input Leakage Pin 27,28,2	I_{ILK}				20	μA
Minimum Input Rate of Change	dV_{IN}/dt	Supplies Well Bypassed	25	15		mV/μs
ICM7216A						
Digit Driver: Pins 15,16,17,19,20,21,22,23 High Output Current Low Output Current	 I_{OH} I_{OL}	 $V_{OUT} = V^+ - 2.0V$ $V_{OUT} = +1.0V$	 -140	 -180 +0.3		 mA mA
Segment Driver: Pins 4,5,6,7,9,10,11,12 Low Output Current High Output Current	 I_{OL} I_{OH}	 $V_{OUT} = +1.5V$ $V_{OUT} = V^+ - 2.5V$	 20	 35 -100		 mA μA
Multiplex Inputs: Pins 1,3,14 Input Low Voltage Input High Voltage Input Resistance to GROUND	 V_{INL} V_{INH} R_{IN}	 V_{IN} = +1.0V	 2.0 50	 100	 0.8	 V V kΩ
ICM7216B						
Digit Driver: Pins 4,5,6,7,9,10,11,12 Low Output Current High Output Current	 I_{OL} I_{OH}	 $V_{OUT} = +1.3V$ $V_{OUT} = V^+ - 2.5V$	 50	 75 -100		 mA μA
Segment Driver: Pins 15,16,17,19,20,21,22,23 High Output Current Leakage Current	 I_{OH} I_{SLK}	 $V_{OUT} = V^+ - 2.0V$ $V_{OUT} = V^+ - 2.5V$	 -10		 10	 mA μA
Multiplex Inputs: Pins 1,3,14 Input Low Voltage Input High Voltage Input Resistance to V^+	 V_{INL} V_{INH} R_{IN}	 $V_{IN} = V^+ - 1.0V$	 $V^+ - 0.8$ 200	 360	 $V^+ - 2.0$	 V V kΩ

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ELECTRICAL CHARACTERISTICS

TEST CONDITIONS: $V^+ = 5.0V$, Test Circuit, $T_A = 25°C$, unless otherwise specified.

PARAMETER	SYMBOL	CONDITION	MIN.	TYP	MAX.	UNITS
ICM7216C/D						
Operating Supply Current	I^+	Display Off, Unused Inputs to GND		2	5	mA
Supply Voltage Range		$-20°C < T_A < +85°C$, Input A Frequency at f_{max}	4.75		6.0	V
Maximum Frequency Input A, Pin 28	$f_{A(max)}$	$-20°C < T_A < +85°C$ $4.75 < V^+ < 6.0V$, Figure 1	10			MHz
Maximum Osc. Freq and Ext Osc. Frequency	f_{osc}	$-20°C < T_A < +85°C$ $4.75 < V^+ < 6.0V$	10			MHz
Minimum Ext. Osc. Freq.	f_{osc}				100	kHz
Oscillator Transconductance	g_m	$V^+ = 4.75V$, $T_A = +85°C$	2000			µmhos
Multiplex Frequency	f_{mux}	f_{osc} = 10MHz		500		Hz
Time Between Measurements		f_{osc} = 10MHz		200		ms
Input Voltages: Pins 12,27,28						
Input Low Voltage	V_{INL}	$-20°C < T_A < +85°C$			1.0	V
Input High Voltage	V_{INH}		3.5			V
Input Resistance to V^+ Pins 12,24	R_{IN}	$V_{IN} = V^+ - 1.0V$	100	400		kΩ
Input Leakage Pin 27, Pin 28	I_{ILK}				20	µA
Output Current Pin 2	I_{OL}	$V_{OL} = +.4V$	0.36			mA
	I_{OH}	$V_{OH} = V^+ - .8V$	265			µA
Minimum Input Rate of Change	dV_{IN}/dt	Supplies Well Bypassed	25	15		mV/µs
ICM7216C						
Digit Driver: Pins 15,16,17,19,20,21,22,23						
High Output Current	I_{OH}	$V_{OUT} = V^+ - 2.0V$	-140	-180		mA
Low Output Current	I_{OL}	$V_{OUT} = 1.0V$		0.3		mA
Segment Driver: Pins 3,4,5,6,8,9,10,11						
Low Output Current	I_{OL}	$V_{OUT} = +1.5V$	20	30		mA
High Output Current	I_{OH}	$V_{OUT} = V^+ - 2.5V$		-100		µA
Multiplex Inputs: Pins 1,13,14						
Input Low Voltage	V_{INL}				0.8	V
Input High Voltage	V_{INH}		2.0			V
Input Resistance to GROUND	R_{IN}	$V_{IN} = +1.0V$	50	100		kΩ
ICM7216D						
Digit Driver: Pins 3,4,5,6,8,9,10,11						
Low Output Current	I_{OL}	$V_{OUT} = +1.3V$	50	75		mA
High Output Current	I_{OH}	$V_{OUT} = V^+ - 2.5V$		100		µA
Segment Driver: Pins 15,16,17,19,20,21,22,23						
High Output Current	I_{OH}	$V_{OUT} = V^+ - 2.0V$	10	15		mA
Leakage Current	I_{SLK}	$V_{OUT} = V^+ - 2.5V$			10	µA
Multiplex Inputs: Pins 1,13,14						
Input Low Voltage	V_{INL}				$V^+ - 2.0$	V
Input High Voltage	V_{INH}		$V^+ - 0.8$			V
Input Resistance to V^+	R_{IN}	$V_{IN} = V^+ - 1.0V$	200	360		kΩ

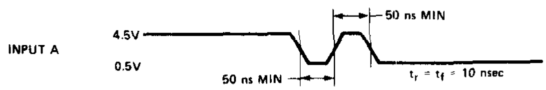

FIGURE 1. Waveform for Guaranteed Minimum $f_{A(max)}$ Function = Frequency, Frequency Ratio, Unit Counter.

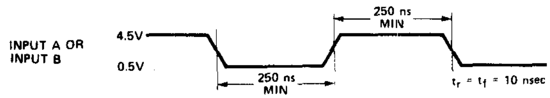

FIGURE 2. Waveform for Guaranteed Minimum $f_{B(max)}$ and $f_{A(max)}$ for Function = Period and Time Interval.

TIME INTERVAL MEASUREMENT

The ICM7216 can be used to accurately measure the time interval between two events. With a 10 MHz timebase crystal, the time between the two events can be as long as ten seconds. Accurate resolution in time interval measurement is 100ns.

The feature operates with Channel A going low at the start of the event to be measured, followed by Channel B going low at the end of the event.

When in the time interval mode and measuring a single event, the ICM7216 must first be "primed" prior to measuring the event of interest. This is done by first generating a negative going edge on channel A followed by a negative going edge on channel B to start the "measurement interval." The inputs are then primed ready for the measurement. Positive going edges on A and B, before or after the priming, will be needed to restore the original condition.

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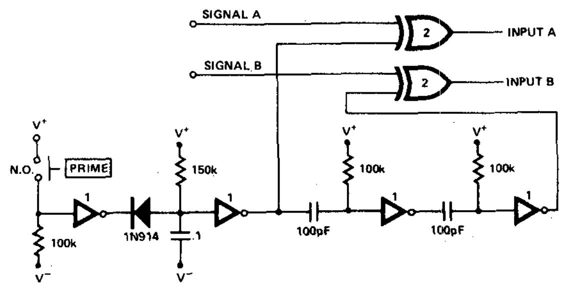
This can be easily accomplished with the following circuit: (Figure 3b).



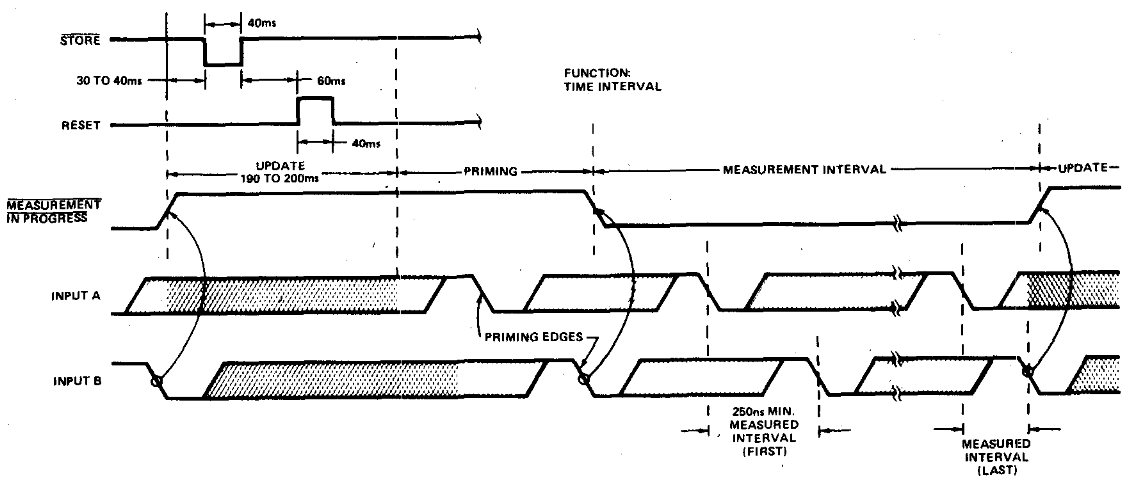
Device	Type
1	CD4049B Inverting Buffer
2	CD4070B Exclusive-OR

FIGURE 3b. Priming Circuit, Signal A&B High or Low.

Following the priming procedure (when in single event or 1 cycle range input) the device is ready to measure one (only) event.

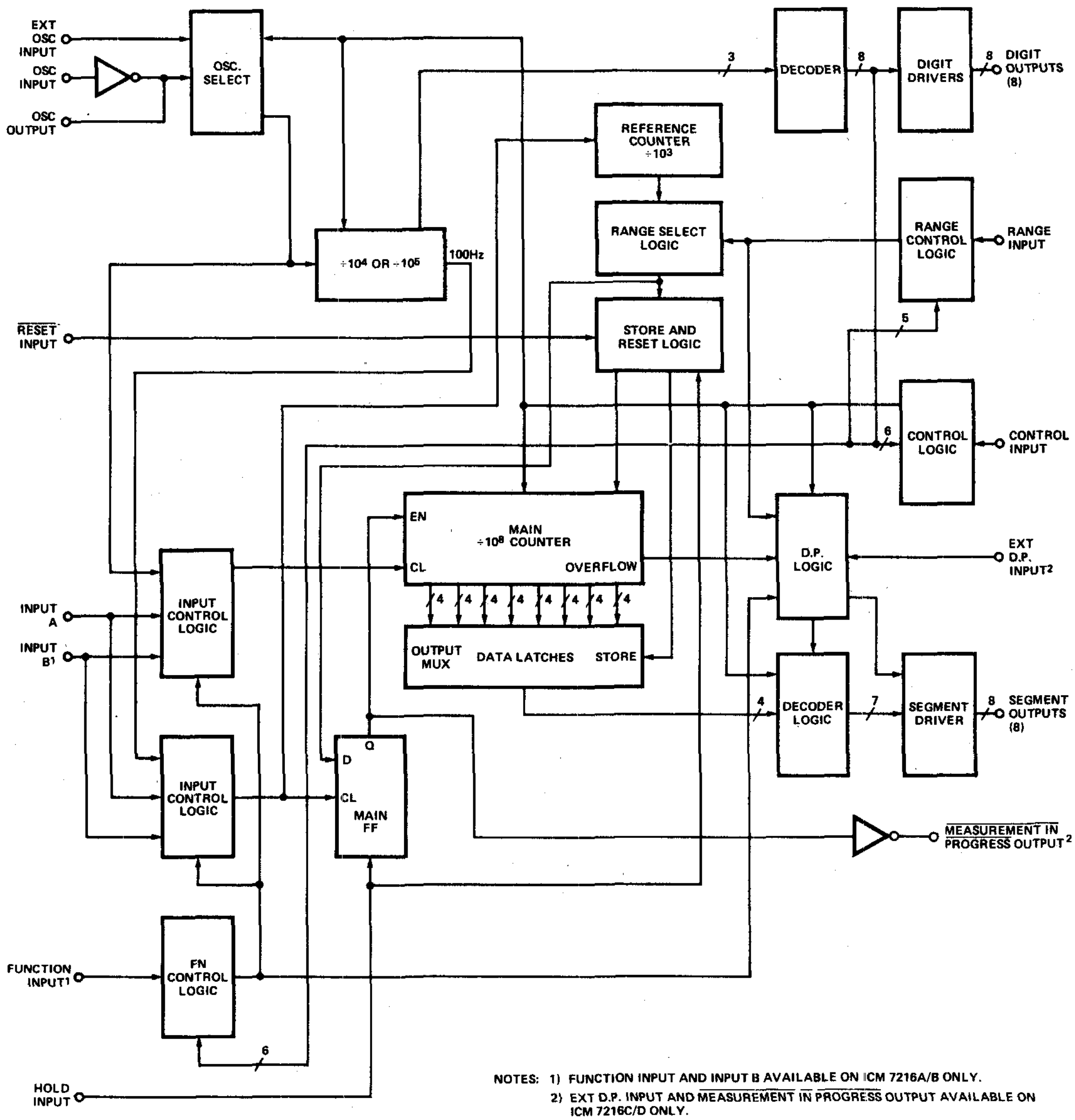
When timing repetitive signals, it is not necessary to "prime" the ICM7216 as the first alternating signal states automatically prime the device. See Figure 3b.

During any time interval measurement cycle, the ICM7216 requires 200ms following B going low to update all internal logic. A new measurement cycle will not take place until completion of this internal update time.



NOTE: IF RANGE IS SET TO 1 EVENT, FIRST AND LAST MEASURED INTERVAL WILL COINCIDE.

FIGURE 3a. Waveforms for Time Interval Measurement.



NOTES: 1) FUNCTION INPUT AND INPUT B AVAILABLE ON ICM 7216A/B ONLY.
2) EXT D.P. INPUT AND MEASUREMENT IN PROGRESS OUTPUT AVAILABLE ON ICM 7216C/D ONLY.

BLOCK DIAGRAM

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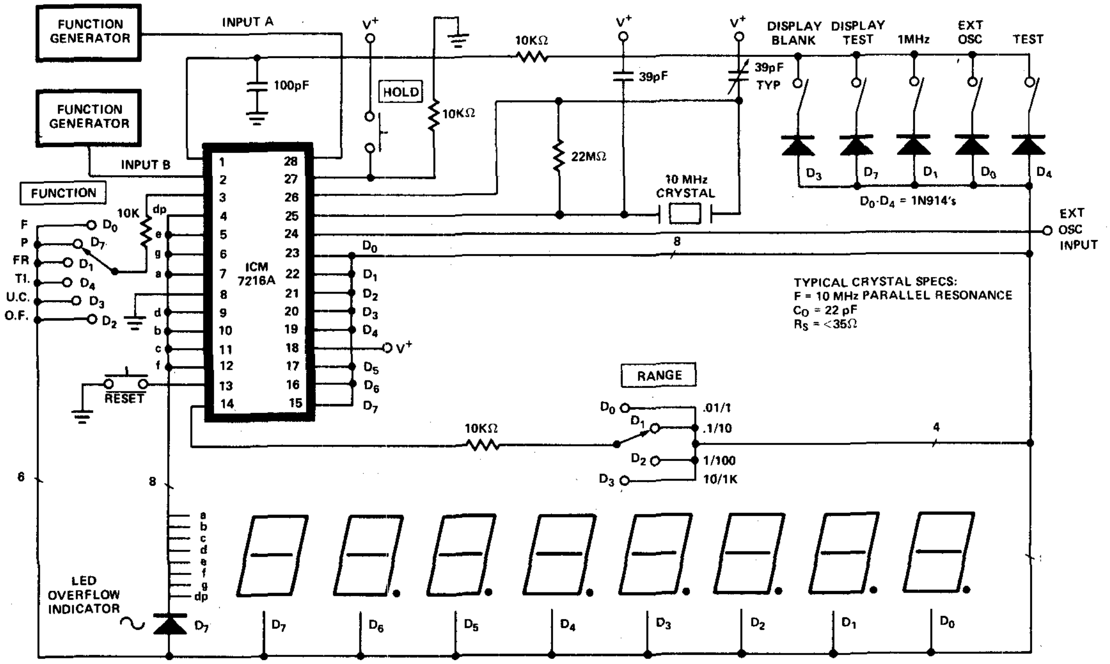
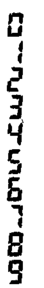


TEST CIRCUIT



OUTPUT CODES

OVERFLOW WILL BE INDICATED ON THE DECIMAL POINT OUTPUT OF DIGIT 7.

LED OVERFLOW INDICATOR CONNECTIONS

	CATHODE	ANODE
ICM 7216A	DEC. PT.	D_7
ICM 7216B	D_7	DEC. PT.
ICM 7216C	DEC. PT.	D_7
ICM 7216D	D_7	DEC. PT.

APPLICATION NOTES

GENERAL

INPUTS A and B

INPUTS A and B are digital inputs with a typical switching threshold of 2.0V at $V^+ = 5.0V$. For optimum performance the peak-to-peak input signal should be at least 50% of the supply voltage and centered about the switching voltage. When these inputs are being driven from T^2L logic, it is desirable to use a pullup resistor. The circuit counts high to low transitions at both inputs.

Note: The amplitude of the input should not exceed the supply, otherwise, the circuit may be damaged.

Multiplexed Inputs

The FUNCTION, RANGE, CONTROL and EXTERNAL DECIMAL POINT inputs are time multiplexed to select the input function desired. This is achieved by connecting the appropriate digit driver output to the inputs. The input function, range and control inputs must be stable during the last half of each digit output, (typically 125μsec). The multiplex inputs are active high for the common anode ICM7216A and C and active low for the common cathode ICM7216B and D.

Noise on the multiplex inputs can cause improper operation. This is particularly true when the unit counter mode of operation is selected, since changes in voltage on the digit drivers can be capacitively coupled through the LED diodes to the multiplex inputs. For maximum noise immunity, a 10K resistor should be placed in series with the multiplex inputs as shown in the application circuits.

Table 1 shows the functions selected by each digit for these inputs.

TABLE 1

	FUNCTION	DIGIT
FUNCTION INPUT Pin 3 (ICM7216A & B Only)	Frequency	D_0
	Period	D_7
	Frequency Ratio	D_1
	Time Interval	D_4
	Unit Counter	D_3
	Oscillator Frequency	D_2
RANGE INPUT Pin 14	.01 sec/1 Cycle	D_0
	.1 sec/10 Cycles	D_1
	1 sec/100 Cycles	D_2
	10 sec/1K Cycles	D_3
CONTROL INPUT Pin 1	Blank Display	D_3 and Hold
	Display Test	D_7
	1 MHz Select	D_1
	External Oscillator Enable	D_0
	External Decimal Point Enable	D_2
	(Test	D_4)
EXT. D.P. INPUT Pin 13, ICM7216C & D Only	Decimal point is output for same digit that is connected to this input	

CONTROL INPUT Functions

Display Test — All segments are enabled continuously, giving a display of all 8's with decimal points. The display will be blanked if Blank Display is selected at the same time.

Blank Display — To disable the drivers, it is necessary to tie D_3 to the CONTROL INPUT and have the HOLD input at V^+. The chip will remain in this "Display Off" mode until HOLD is switched back to GND. While in the "Display Off" mode, the segment and digit driver outputs are open, the oscillator continues to run with a typical supply current of 1.5mA with a 10 MHz crystal, and no measurements are made. In addition, inputs to the multiplexed inputs will have no effect. A new measurement is initiated when the HOLD input is switched to GND. Segment and Digit Drive outputs may thusly be bussed to drive a common display (up to 6 circuits).

1 MHz Select — The 1 MHz select mode allows use of a 1 MHz crystal with the same digit multiplex rate and time between measurements as with a 10 MHz crystal. The decimal point is also shifted one digit to the right in Period and Time Interval, since the lease significant digit will be in μsecond increments rather than 0.1 μsec increments.

External Oscillator Enable — In this mode the EXTERNAL OSCILLATOR INPUT is used instead of the on-chip oscillator for Timebase input and Main Counter input in Period and Time interval modes. The on-chip oscillator will continue to function when the external oscillator is selected. The external oscillator input frequency must be greater than 100 KHz or the chip will reset itself to enable the on-chip oscillator. Oscillator input (pin 25) must also be connected to EXT. OSC. input when using EXT. OSC. input.

External Decimal Point Enable — When external decimal point is enabled a decimal point will be displayed whenever the digit driver connected to EXTERNAL DECIMAL POINT input is active. Leading Zero Blanking will be disabled for all digits following the decimal point.

Test Mode — This is a special mode for testing purposes only. Contact factory for details.

RANGE INPUT

The RANGE INPUT selects whether the measurement is made for 1, 10, 100, 1000 counts of the reference counter. In all functional modes except **Unit Counter** a change in the RANGE INPUT will stop the measurement in progress without updating the display and then initiate a new measurement. This prevents an erroneous first reading after the RANGE INPUT is changed.

FUNCTION INPUT

The six functions that can be selected are: **Frequency, Period, Time Interval, Unit Counter, Frequency Ratio** and **Oscillator Frequency.** This Input is available on the ICM7216A and B only.

These functions select which signal is counted into the Main Counter and which signal is counted by the Reference Counter, as shown in Table 2. In Time Interval, a flip flop is toggled first by a 1-0 transition of Input A and then by a 1-0 transition of Input B. The oscillator is gated into the Main Counter from the time Input A toggles the flip flop until Input B toggles it. A change in the FUNCTION INPUT will stop the measurement in progress without updating the display and then initiate a new measurement. This prevents an erroneous first reading after the FUNCTION INPUT is changed.

TABLE 2

DESCRIPTION	MAIN COUNTER	REFERENCE COUNTER
Frequency (f_A)	Input A	100 Hz (Oscillator ÷ 10^5 or 10^4)
Period (t_A)	Oscillator	Input A
Ratio (f_A/f_B)	Input A	Input B
Time Interval (A → B)	Osc • (Time Interval FF)	Time Interval FF
Unit Counter (Count A)	Input A	Not Applicable
Osc. Freq. (f_{osc})	Oscillator	100 Hz (Oscillator ÷ 10^5 or 10^4)

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EXTernal DECimal Point Input — When the external decimal point is selected this input is active. Any of the digits, except D_7, can be connected to this point. D_7 should not be used since it will override the overflow output and leading zeros will remain unblanked after the decimal point. This input is available on the ICM7216C and D only.

HOLD Input — When the HOLD Input is at V^+, any measurement in progress is stopped, the main counter is reset and the chip is held ready to initiate a new measurement. The latches which hold the main counter data are not updated so the last complete measurement is displayed. When HOLD is changed to GND a new measurement is initiated.

$\overline{\text{RESET}}$ Input — The $\overline{\text{RESET}}$ Input is the same as an inverted HOLD Input, except the latches for the Main Counter are enabled, resulting in an output of all zeros, and the pin has a pull-up.

DISPLAY CONSIDERATIONS

The display is multiplexed at a 500 Hz rate with a digit time of 244 μsec. An interdigit blanking time of 6 μsec is used to prevent ghosting between digits. The decimal point and leading zero blanking assume right hand decimal point displays, and zeros following the decimal point will not be blanked. Also, the leading zero blanking will be disabled when the Main Counter overflows. Overflow is indicated by the decimal point on digit 7 turning on.

The ICM7216A and C are designed to drive common anode LED displays at peak current of 25mA/segment, using displays with V_F = 1.8 V at 25mA. The average DC current will be over 3mA under these conditions. The ICM7216B and D are designed to drive common cathode displays at peak current of 15mA/segment using displays with V_F = 1.8V at 15mA. Resistors can be added in series with the segment drivers to limit the display current in very efficient displays, if required. Figures 4,5,6 and 7 show the digit and segment currents as a function of output voltage.

To get additional brightness out of the displays, V^+ may be increased up to 6.0V. However, care should be taken to see that maximum power and current ratings are not exceeded.

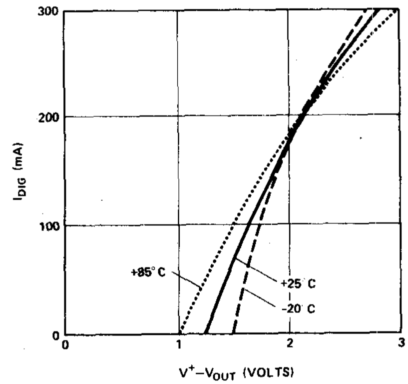


FIGURE 4. ICM7216A & C Typical I_{DIG} vs. $V^+ - V_{OUT}$, $4.5V \le V^+ \le 6.0V$

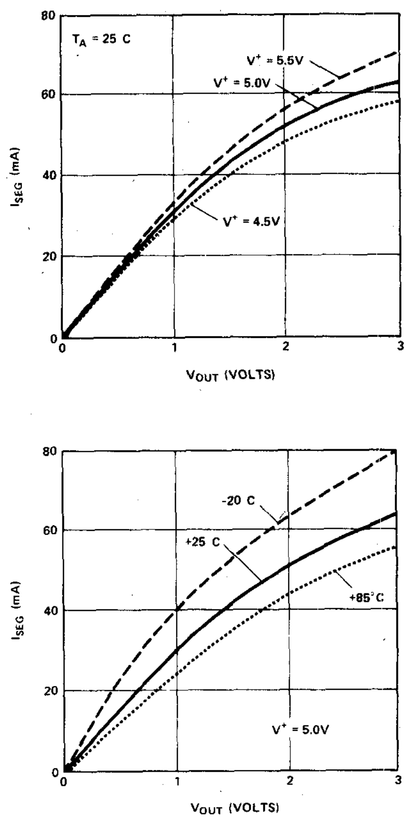


FIGURE 5. ICM7216A & C Typical I_{SEG} vs. V_{OUT}

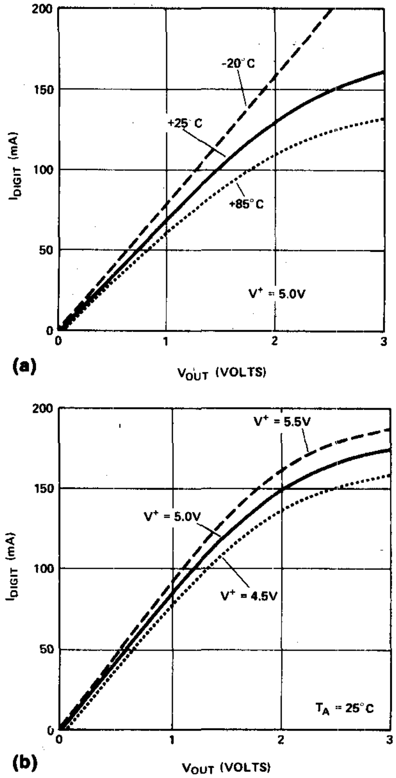


FIGURE 6. ICM7216B & D Typical I_{DIGIT} vs. V_{OUT}

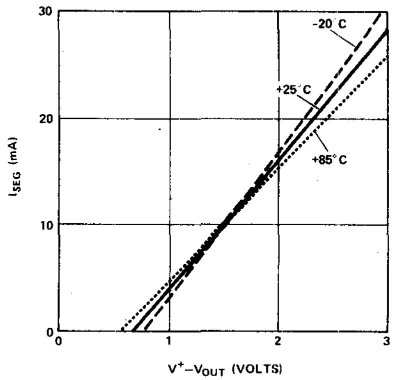
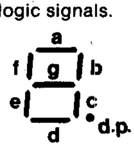


FIGURE 7. ICM7216B & D Typical I_{SEG} vs. $V^+ - V_{OUT}$, $4.5V \leq V^+ - V^- \leq 6.0V$

The segment and digit outputs in ICM7216's are not directly compatible with either TTL or CMOS logic when driving LEDs. Therefore, level shifting with discrete transistors may be required to use these outputs as logic signals.

Segment Identification:



ACCURACY

In a Universal Counter crystal drift and quantization errors cause errors. In Frequency, Period and Time Interval modes, a signal derived from the oscillator is used in either the Reference Counter or Main Counter. Therefore, in these modes an error in the oscillator frequency will cause an identical error in the measurement. For instance, an oscillator temperature coefficient of 20ppm/°C will cause a measurement error of 20ppm/°C.

In addition, there is a quantization error inherent in any digital measurement of ±1 count. Clearly this error is reduced by displaying more digits. In the Frequency mode the maximum accuracy is obtained with high frequency inputs and in Period mode maximum accuracy is obtained with low frequency inputs. As can be seen in Figure 8, the least accuracy will be obtained at 10 KHz. In Time Interval measurements there can be an error of 1 count per interval. As a result there is the same inherent accuracy in all ranges as shown in Figure 9. In Frequency Ratio measurement can be more accurately obtained by averaging over more cycles of INPUT B as shown in Figure 10.

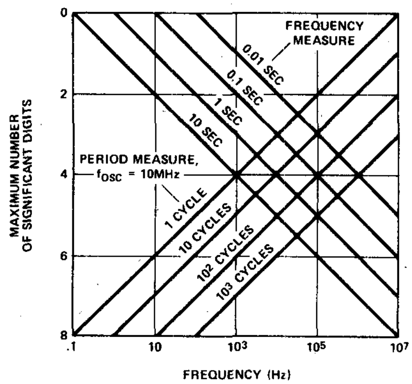


FIGURE 8. Maximum Accuracy of Frequency and Period Measurements Due to Limitations of Quantization Errors

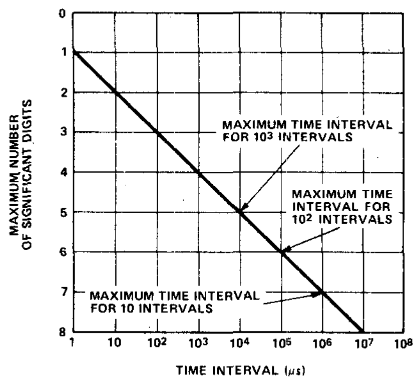


FIGURE 9. Maximum Accuracy of Time Interval Measurement Due to Limitations of Quantization Errors

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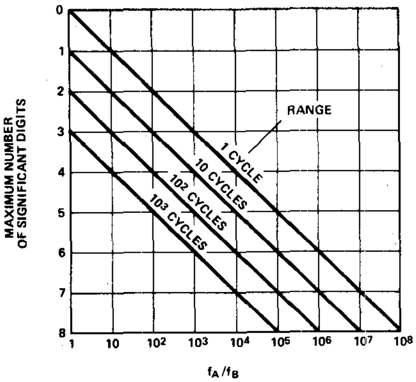

FIGURE 10. Maximum Accuracy for Frequency Ratio Measurement Due to Limitation of Quantization Errors

CIRCUIT APPLICATIONS

The ICM7216 has been designed for use in a wide range of Universal and Frequency counters. In many cases, prescalers will be required to reduce the input frequencies to under 10 MHz. Because INPUT A and INPUT B are digital inputs, additional circuitry is often required for input buffering, amplification, hysterisis, and level shifting to obtain a good digital signal.

The ICM7216A or B can be used as a minimum component complete Universal Counter as shown in Figure 11. This circuit can use input frequencies up to 10 MHz at INPUT A and 2 MHz at INPUT B. If the signal at INPUT A has a very low duty cycle it may be necessary to use a 74121 monostable multivibrator or similar circuit to stretch the input pulse width to be able to guarantee that it is at least 50ms in duration.

To measure frequencies up to 40 MHz the circuit of Figure 12 can be used. To obtain the correct measured value, it is necessary to divide the oscillator frequency by four as well as the input frequency. In doing this the time between measurements is also lengthened to 800 ms and the display multiplex rate is decreased to 125 Hz.

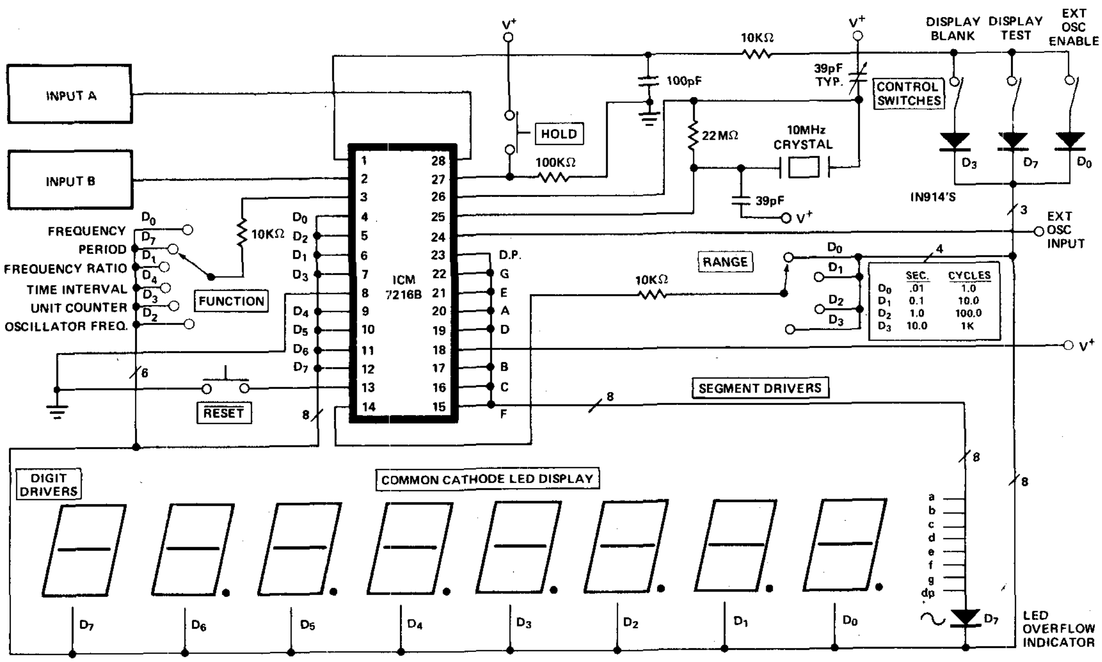

FIGURE 11. 10MHz Universal Counter

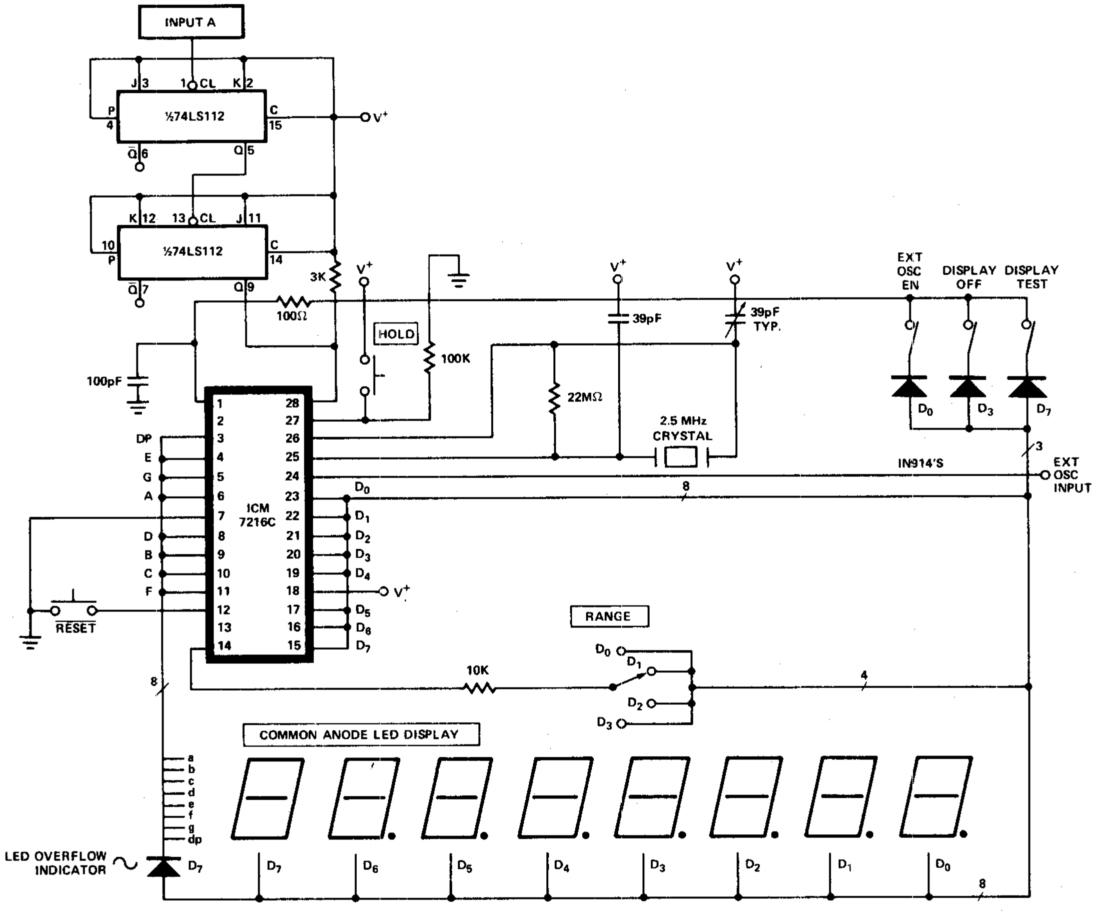

FIGURE 12. 40MHz Frequency Counter

If the input frequency is prescaled by ten, then the oscillator can remain at 10 or 1 MHz, but the decimal point must be moved one digit to the right. Figure 13 shows a frequency counter with a ÷10 prescaler and an ICM7216C. Since there is no external decimal point with the ICM7216A or B, the decimal point may be controlled with additional drivers as shown in Figure 14. Alternatively, if separate anodes are available for the decimal points, they can be wired up to the adjacent digit anodes. Note that there can be one zero to the left of the decimal point since the internal leading zero blanking cannot be changed. In Figure 15 additional logic has been added to count the input directly in period mode for maximum accuracy. In Figures 13 through 15, INPUT A comes from Q_C of the prescaler rather than Q_D to obtain an input duty cycle of 40%.

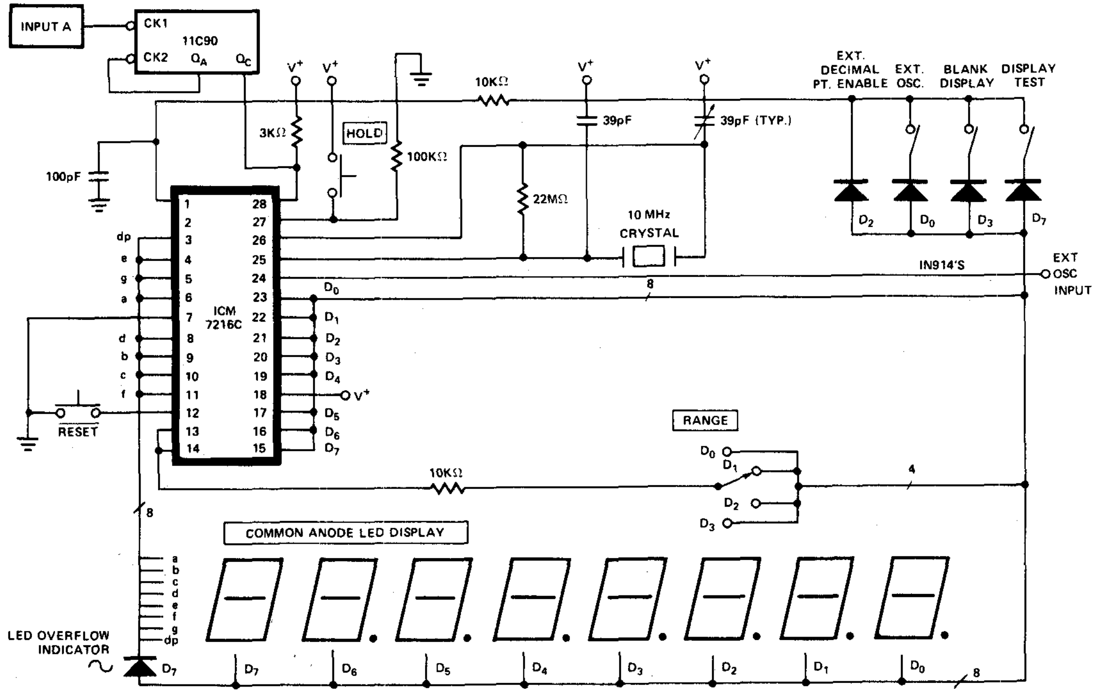

FIGURE 13. 100MHz Frequency Counter

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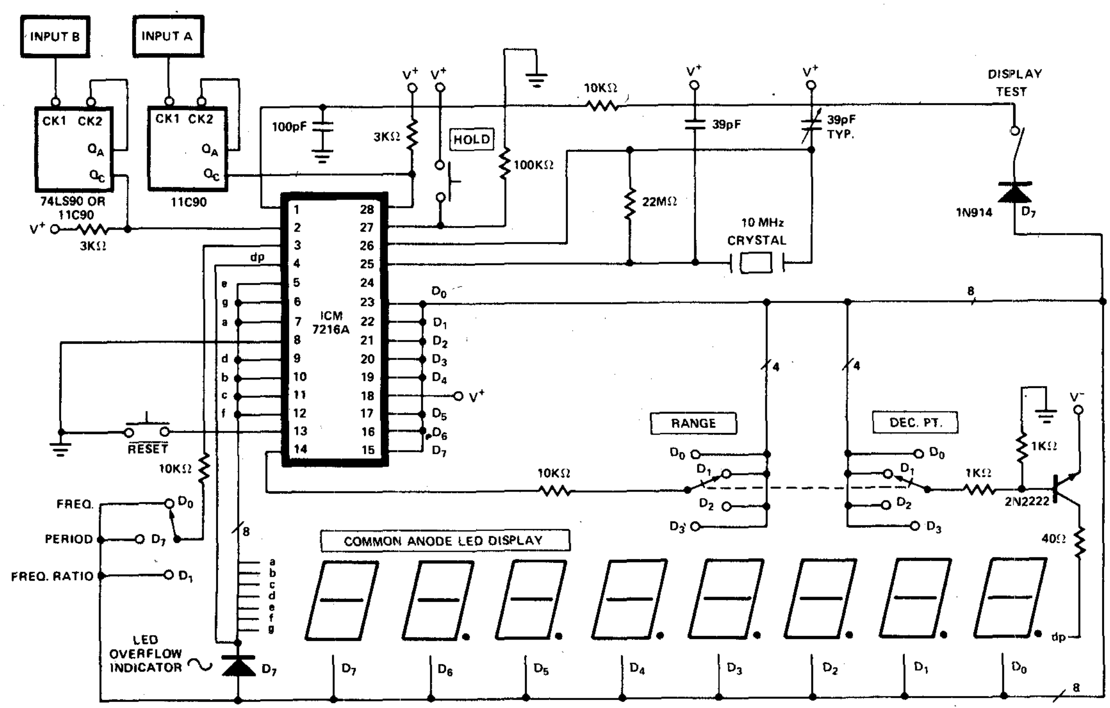


FIGURE 14. 100MHz Multifunction Counter

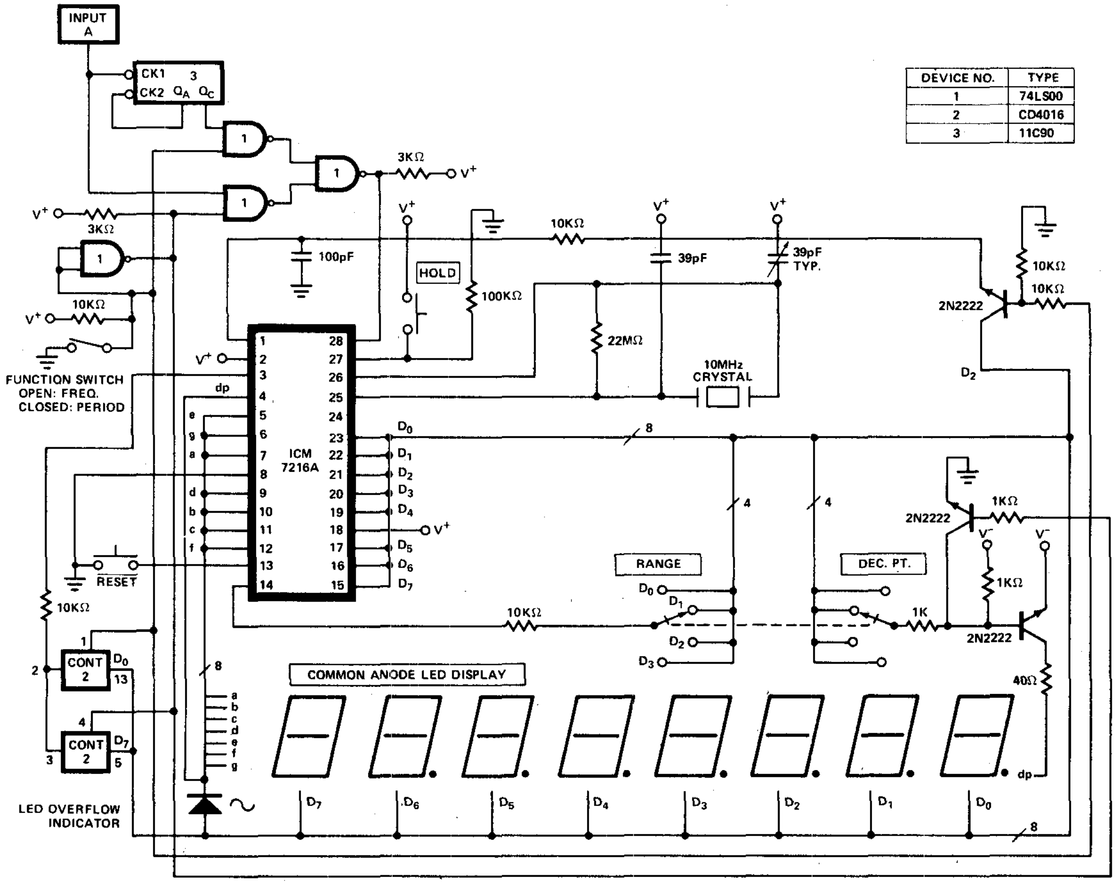


FIGURE 15. 100MHz Frequency, 2MHz Period Counter

OSCILLATOR CONSIDERATIONS

The oscillator is a high gain complementary FET inverter. An external resistor of 10MΩ to 22MΩ should be connected between the OSCillator INPUT and OUTPUT to provide biasing. The oscillator is designed to work with a parallel resonant 10 MHz quartz crystal with a static capacitance of 22pF and a series resistance of less than 35 ohms.

For a specific crystal and load capacitance, the required g_m can be calculated as follows:

$$g_m = \omega^2 C_{in} C_{out} R_S \left(1 + \frac{C_O}{C_L}\right)^2$$

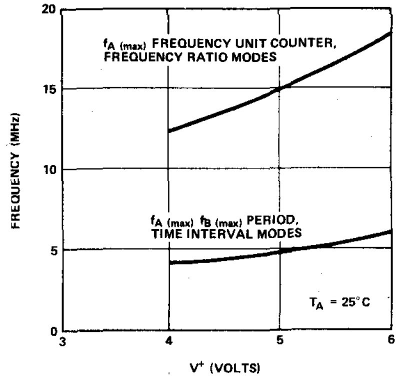
$$\text{where } C_L = \left(\frac{C_{in} C_{out}}{C_{in} + C_{out}}\right)$$

C_O = Crystal Static Capacitance
R_S = Crystal Series Resistance
C_{in} = Input Capacitance
C_{out} = Output Capacitance
$\omega = 2\pi f$

The required g_m should exceed the g_m specified for the ICM7216 by at least 50% to insure reliable startup. The OSCillator INPUT and OUTPUT pins each contribute about 5pF to C_{in} and C_{out}. For maximum stability of frequency, C_{in} and C_{out} should be approximately twice the specified crystal static capacitance.

In cases where non decade prescalers are used it may be desirable to use a crystal which is neither 10 MHz or 1 MHz. In that case both the multiplex rate and time between measurements will be different. The multiplex rate is $f_{max} = \frac{f_{osc}}{2 \times 10^4}$ for 10 MHz mode and $f_{max} = \frac{f_{osc}}{2 \times 10^3}$ for the 1 MHz mode. The time between measurements is $\frac{2 \times 10^6}{f_{osc}}$ in the 10 MHz mode and $\frac{2 \times 10^5}{f_{osc}}$ in the 1 MHz mode.

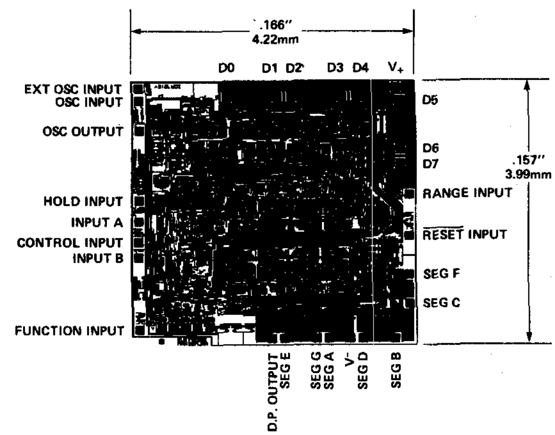
The crystal and oscillator components should be located as close to the chip as practical to minimize pickup from other signals. Coupling from the EXTERNAL OSCILLATOR INPUT to the OSCILLATOR OUTPUT or INPUT can cause undesirable shifts in oscillator frequency.



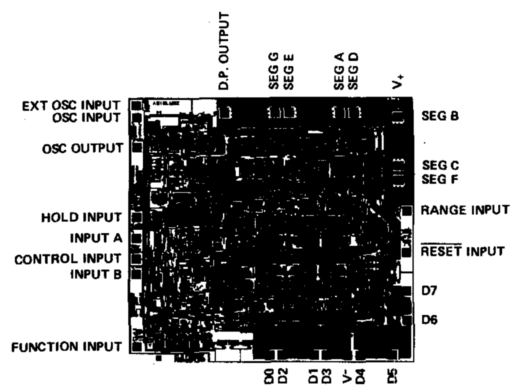
$f_A(max)$, $f_B(max)$ as a Function of V^+

FIGURE 16. Typical Operating Characteristics

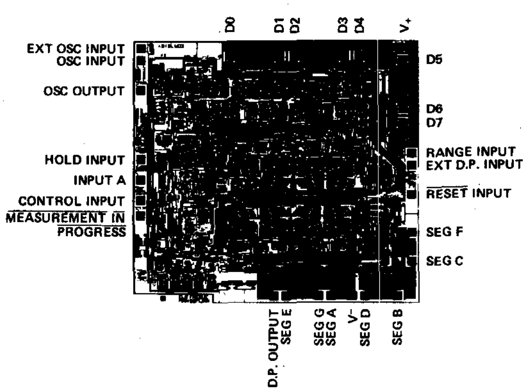
CHIP TOPOGRAPHY



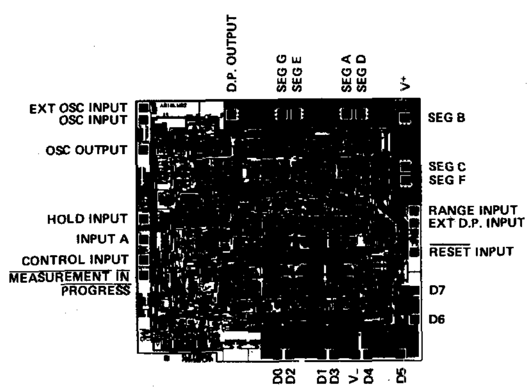
ICM7216A



ICM7216B



ICM7216C



ICM7216D