COMPLEMENTARY MOS LED STOPWATCH CIRCUITS - 47

ORIG **ICM 7205** ✓

RES 002769

T-2769

INL

FEATURES

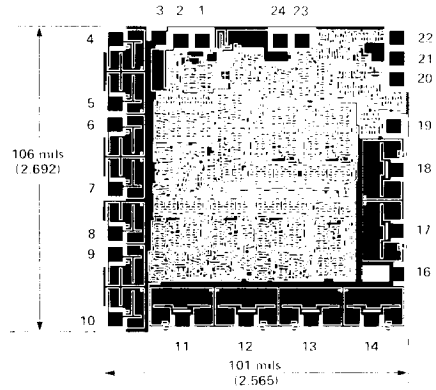
- Total integration oscillator, divider, decoder, segment and digit drivers on chip
- Six digit display: ranges up to 59 minutes 59.99 seconds Two functions: Split and Taylor
- Requires only three low cost SPST switches without loss of accuracy:
  - Start/Stop
  - Reset
  - Display Unlock
- Automatic power-up reset
- Low battery indicator on chip comes on well above minimum operating voltage
- Digit blanking on seconds and minutes to conserve battery life
- High LED drive current: 13mA per segment at 16.7% duty cycle with 3.8 volt supply
- Wide operating range: 2.0 to 5.0 volts
- Oscillator requires only 3.2768 MHz crystal and trimming capacitor
- 1KHz multiplex rate prevents flickering display
- Fully protected against static charge, no special handling precautions required.

GENERAL DESCRIPTION

The ICM 7205 is a fully integrated six digit LED stopwatch circuit fabricated with Intersil's low threshold metal gate CMOS process. The circuit interfaces directly with a six digit/seven segment common cathode LED display. The low battery indicator can be connected to the decimal point anode or to a separate LED lamp. The only components required for a complete stopwatch besides the display are: three SPST switches, a 3.2768 MHz crystal, a trimming capacitor, three AA batteries and an on-off switch. For a two function stopwatch one additional switch would be required.

The circuit divides the oscillator frequency by 2^{15} to obtain 100Hz which is fed to the fractional seconds, seconds and minutes counters. An intermediate frequency is used to obtain the 1/6 duty cycle 1.07KHz multiplex waveforms. The blanking logic provides leading zero blanking for seconds and minutes independently of the clock. The ICM7205 is packaged in a 24 lead plastic DIP.

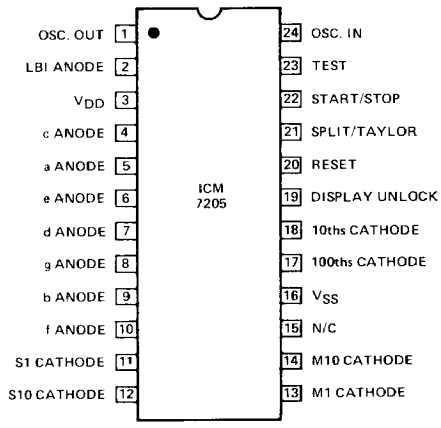
CHIP TOPOGRAPHY



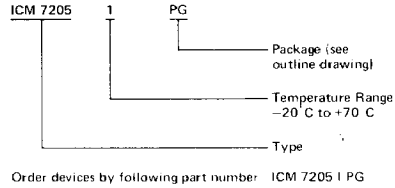
PAD SIZE 5 x 5 mils (0.127 x 0.127)

DIMENSIONS IN PARENTHESES ARE MM
OTHERS ARE INCHES

CONNECTION DIAGRAM



ORDERING INFORMATION



Order devices by following part number ICM 7205 I PG
Order dice by following part number ICM 7205 D

INTERSIL, INC., 10710 N. TANTAU AVE., CUPERTINO, CA 95014 · (408) 996-5000 TWX: 910-338-0171

ABSOLUTE MAXIMUM RATINGS

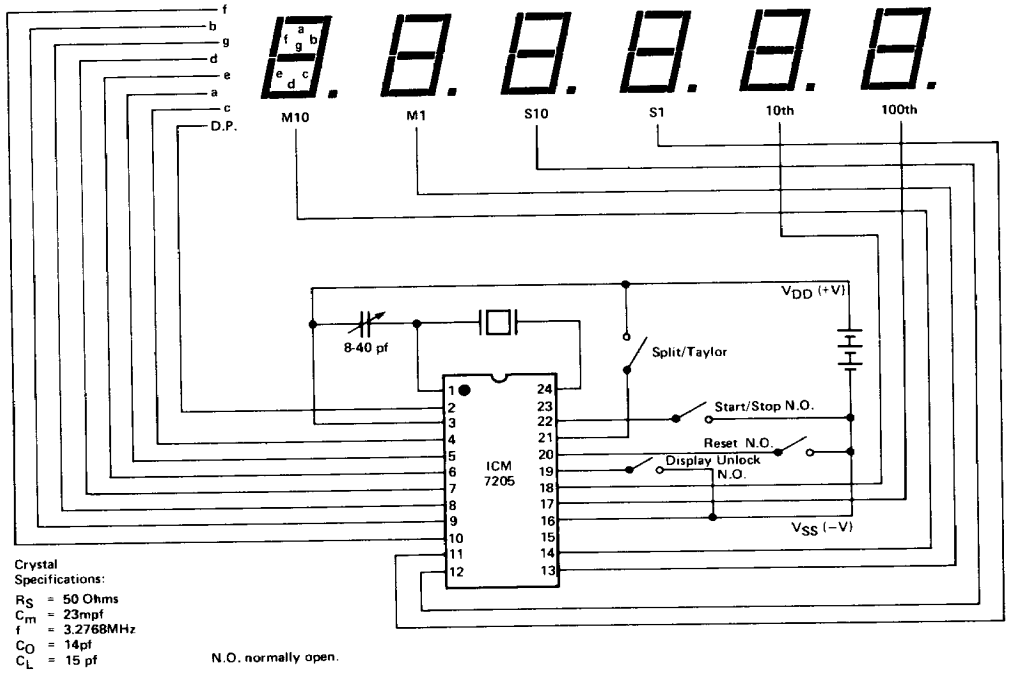
Supply Voltage	5.5 Volts
Power Dissipation (Note 1)	0.75 Watts
Operating Temperature	−20°C to +70°C
Storage Temperature	−55°C to +125°C
Input and Output Voltage	equal to but never exceeding the supply voltage

OPERATING CHARACTERISTICS $T_A = 25°C$, stopwatch circuit, $V_{DD} = 3.8V$ unless otherwise specified.

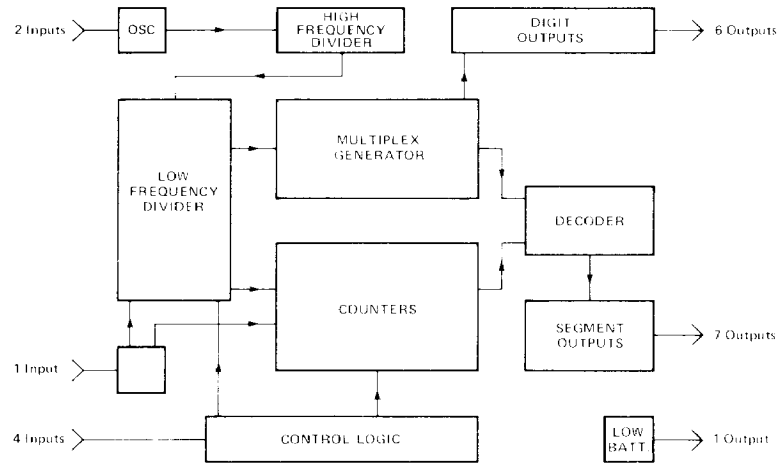
PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
Supply Voltage	$-20°C \leq T_A \leq 70°C$	2.0		5.0	Volts
Supply Current	Display disconnected		0.4	1.5	mA
Segment Current	5 segments lit				
Peak	1.8 Volts across display	9.0	13.2		mA
Average			2.2		mA
Switch Actuation Current			10	50	µA
Digit Leakage Current	$V_{DIGIT} = 2.0V$			50	µA
Segment Leakage Current	$V_{SEGMENT} = 1.8V$			100	µA
Low Battery Indicator		2.1		2.9	Volts
Trigger Voltage					
LBI Output Current	$V_{DD} = 2.0V$ $V_{LBI} = 1.6V$		1.3		mA
Oscillator Stability	$V_{DD} = 2.0V$ to $V_{DD} = 5.0V$		3		PPM
Oscillator Transconductance	$V_{DD} = 2.0V$	150			µmho
Oscillator Input Capacitance			28		pf

NOTE 1 This value of power dissipation refers to the package and will not be obtained under normal conditions. The output devices on the ICM 7205 have very low impedance characteristics, especially the digit cathode drivers. If these devices are shorted to a low impedance power supply the current could be as high as 300mA. This will not damage the device momentarily, but if the short circuit condition is not removed immediately probable device failure will occur.

STOPWATCH CIRCUIT

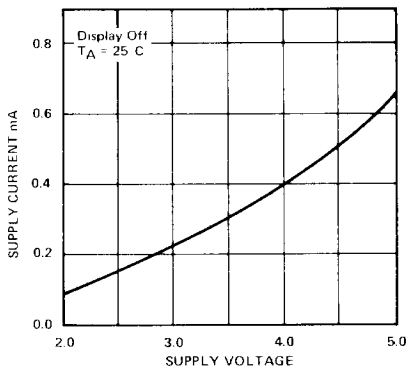


BLOCK DIAGRAM

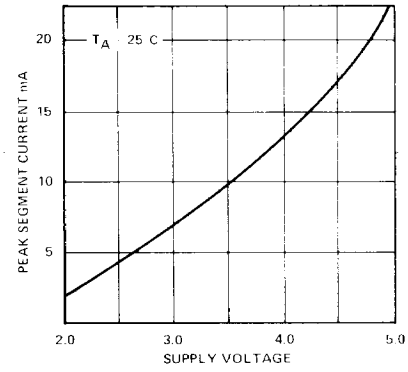


TYPICAL PERFORMANCE CHARACTERISTICS

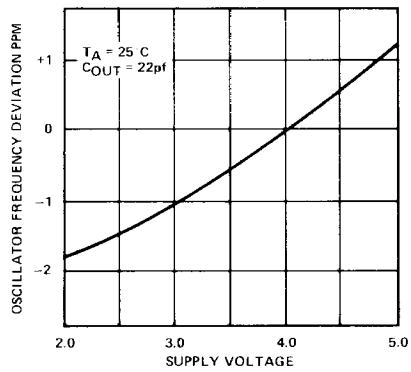
SUPPLY CURRENT VS VOLTAGE



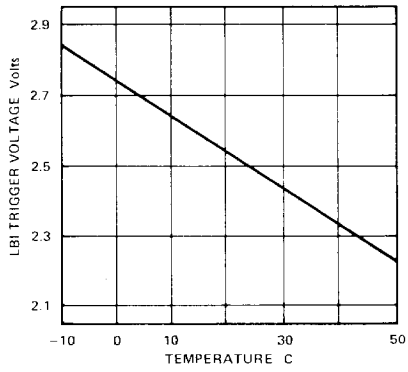
SEGMENT CURRENT VS SUPPLY VOLTAGE



OSC. STABILITY VS SUPPLY VOLTAGE



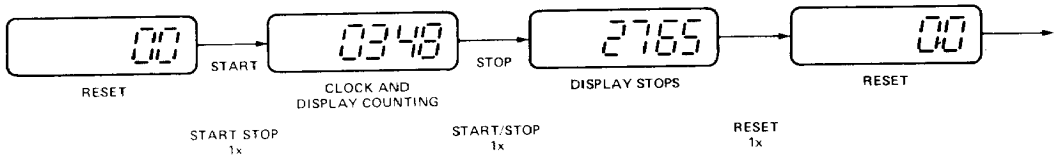
LBI TRIGGER VOLTAGE VS TEMPERATURE



FUNCTIONAL OPERATION

Turning on the stopwatch will bring up the reset state where the fractional seconds are on displaying 00 and the other digits are blanked. This display always indicates that the stopwatch is ready to go.

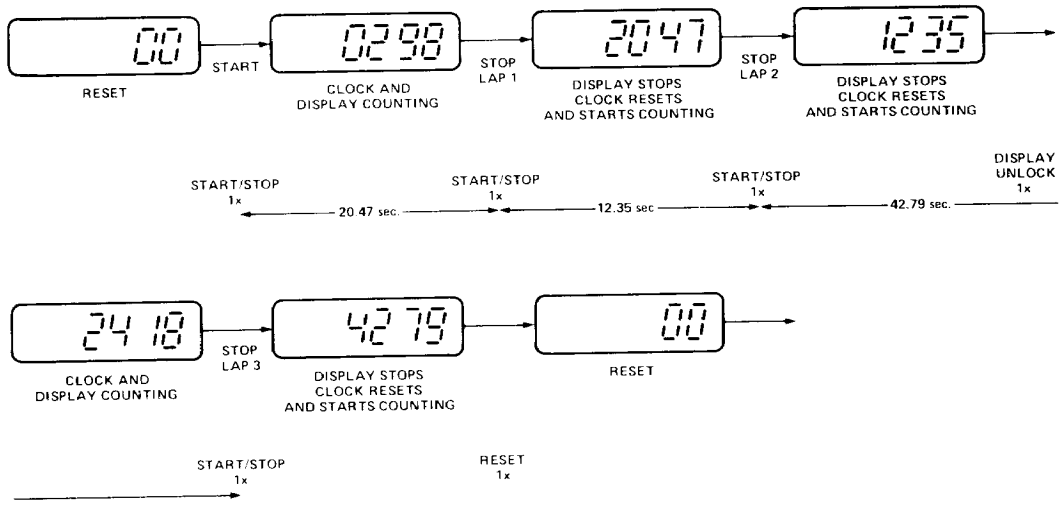
START/STOP



The start/stop modes can be used for a single event timing with the split/taylor input in either state. The illustration indicates the operations and the results. To time another event the reset switch must be used prior to the start of the event. Seconds will be displayed after one second, minutes after 1 minute. The range of the stopwatch is 59 minutes 59.99 seconds. If an event exceeds one hour, the number of hours must be remembered by the user. Leading zeros are not blanked after one hour.

TAYLOR

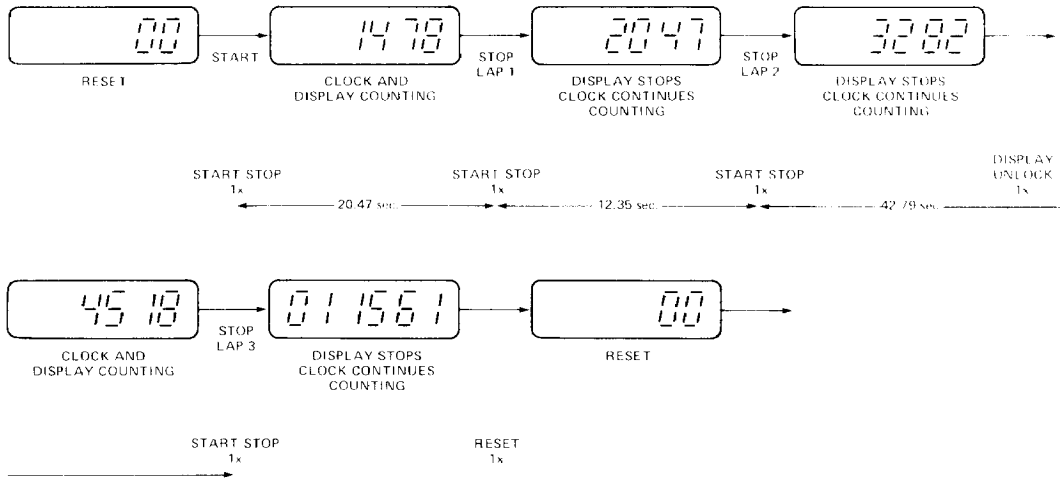
When the split/taylor input is left open circuit or is connected to V_{SS}, the stopwatch can be used in the taylor or sequential mode.



As depicted graphically above, each split time is measured from zero in the taylor mode, i.e., after stopping the watch, the counters reset to zero momentarily and start counting the next interval. The time displayed is the time elapsed since the last activation of start/stop. The display is stationary after the first interval unless the display unlock is used to show the running clock. Reset can be used at any time.

SPLIT

When the split/taylor input is connected to V_{DD} the stopwatch is in the split mode.



The split mode differs from the taylor in that the lap times are cumulative in the split mode. The counters do not reset or stop after the first start until reset is activated. Any time displayed is the cumulative time elapsed since the first start after reset. Display unlock can be used to let the display 'catch up' with the clock. Reset can be used at any time.

LOW BATTERY INDICATOR

The on-chip low battery indicator is intended for use with a small LED lamp or with the decimal points on a standard LED display. The output is the drain of a P-channel transistor of approximately half the size of one of the segment drivers. The LBI circuitry is designed to always provide a voltage difference between the LBI trigger voltage and the minimum operating voltage, i.e., the lower the LBI trigger voltage the lower the minimum operating voltage. In this way a stopwatch using three AA batteries will provide at least 15 minutes of accurate timekeeping after the LBI comes on.

SWITCH CHARACTERISTICS

The ICM7205 is designed for use with SPST switches throughout. On the display unlock and reset inputs the characteristics of the switches are unimportant, since the circuit responds to a logic level held for any length of time, however short. Switch bounce on these inputs does not need to be specified. The start/stop input, however, responds to an edge and it requires a switch with less than 15ms of switch bounce. The bounce protection circuitry has been specifically designed to let the circuit respond to the first edge of the signal, so as to preserve the full accuracy of the system.

APPLICATION NOTES

OSCILLATOR DESIGN

The oscillator of the ICM 7205 includes all components on chip except the 3.2768 MHz crystal and the trimming capacitor. The oscillator input capacitance has a nominal value of 28 pf. The circuit is designed to work with a crystal with a load capacitance of approximately 15 pf. If the crystal has characteristics as shown on page 2, an 8-40pf trimming capacitor will be adequate for a tuning tolerance of ±30 PPM on the crystal. If the crystal's static capacitance is significantly lower, a narrower trimming range may be selected.

After deciding on a crystal and a nominal load capacitance, take the worst case values of C_{in}, C_{out} and R_S and calculate the g_m required by:

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

C_O = static capacitance
R_S = series resistance
C_{in} = input capacitance
C_{out} = output capacitance
ω = 2π X crystal frequency

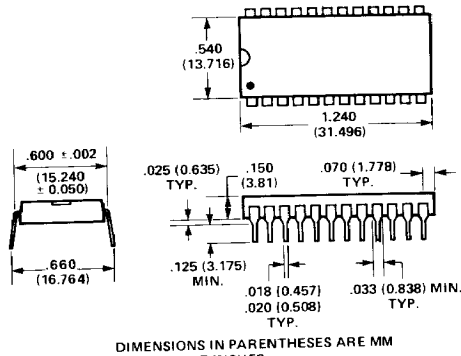
The resulting g_m should be less than half the g_m specified for the device. If it is not, a lower value of crystal series resistance and/or load capacitance should be specified.

LATCHUP CONSIDERATIONS

Due to the inherent structure of junction isolated CMOS devices, the circuit can be put in a latchup mode if large currents are injected into device inputs or outputs. For this reason special care should be taken in a system with multiple power supplies to prevent voltages being applied to inputs and/or outputs before power is applied to V_{DD} and V_{SS}. If only inputs are affected latchup can also be prevented by limiting the current into the input terminal to less than 1 mA.

PACKAGE DIMENSIONS

24 PIN PLASTIC



DIMENSIONS IN PARENTHESES ARE MM
OTHERS ARE INCHES