

TC5032P

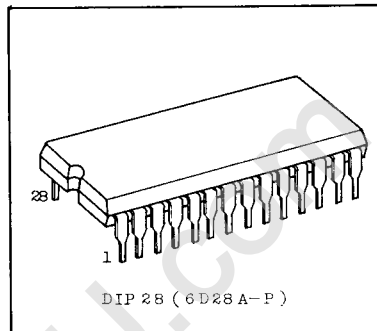
C²MOS DIGITAL INTEGRATED CIRCUIT
SILICON MONOLITHIC

TC5032P 6-DIGIT DECADE COUNTER

TC5032P is six digit decimal counter whose BCD output of each digit is dynamically output in sequence from the higher order digit on BCD OUTPUT in synchronism with SCAN input. As the carry outputs are available from all the digits, other counters and control circuits can be easily driven.

By using BC (Blanking Control) input, leading zero suppress from arbitrary digit can be achieved without external circuits.

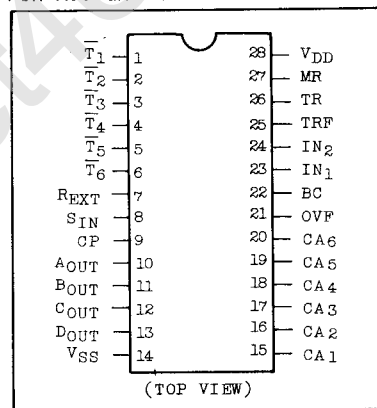
Since the first stage counter can respond up to 10MHz ($V_{DD}=5$ volts), this is also suitable for counting and frequency dividing of high frequency pulses.



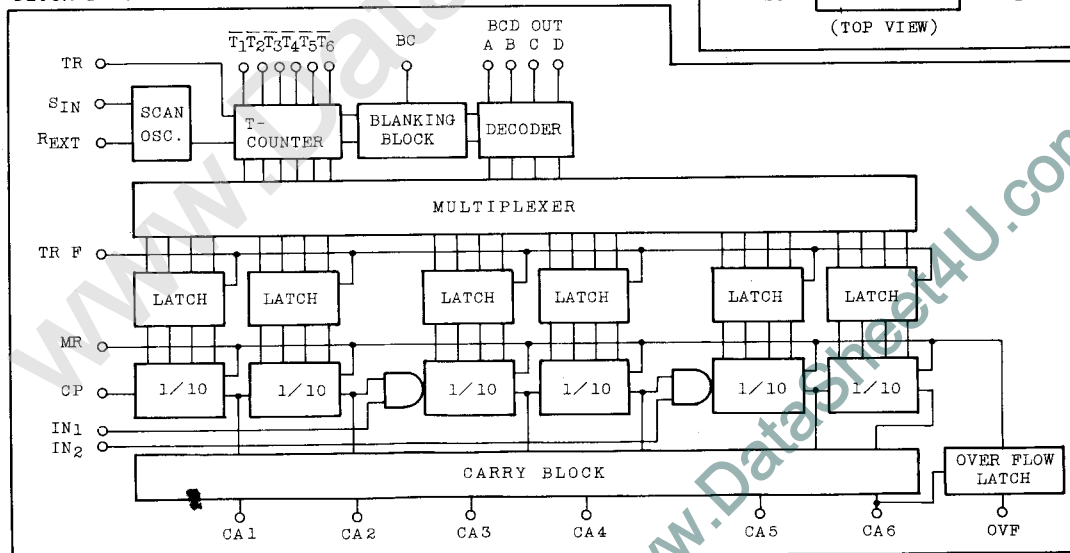
ABSOLUTE MAXIMUM RATINGS

| CHARACTERISTIC | SYMBOL | RATING | UNIT |
|---------------------------|-----------|------------------------------|-------------|
| DC Supply Voltage | V_{DD} | $V_{SS}-0.5 \sim V_{SS}+10$ | V |
| Input Voltage | V_{IN} | $V_{SS}-0.5 \sim V_{DD}+0.5$ | V |
| Output Voltage | V_{OUT} | $V_{SS}-0.5 \sim V_{DD}+0.5$ | V |
| DC Input Current | I_{IN} | ± 10 | mA |
| Power Dissipation | P_D | 300 | mW |
| Storage Temperature Range | T_{stg} | $-55 \sim 125$ | $^{\circ}C$ |
| Lead Temp./Time | T_{sol} | $260^{\circ}C \cdot 10sec$ | |

PIN ASSIGNMENT



BLOCK DIAGRAM

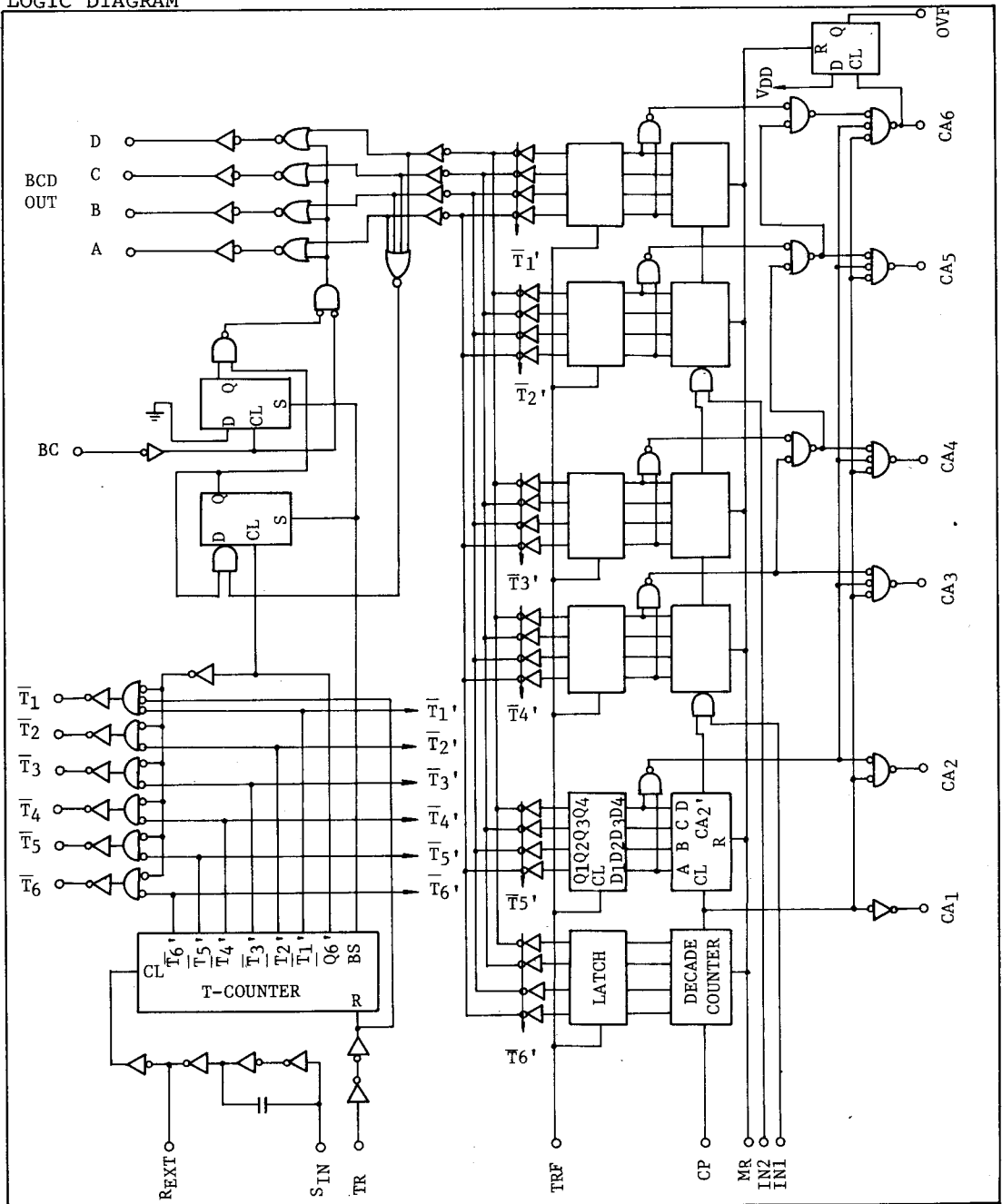


PIN FUNCTION & NAME

| PIN NO. | SYMBOL | NAME | FUNCTION | |
|---------|------------------|-------------------|--|--|
| 1 | $\overline{T1}$ | $\overline{T1}$ | Outputs to indicate the digit of output signals A _{OUT} through D _{OUT} , the sequence is descending order from $\overline{T1}$. With TR="H", all of $\overline{T1}$ through $\overline{T6}$ become "H", and when TR falls, $\overline{T1}$ becomes "L". Then, "L" is shifted in sequence T2, T3 --- by each 4 clocks of S _{IN} . | |
| 2 | $\overline{T2}$ | $\overline{T2}$ | | |
| 3 | $\overline{T3}$ | $\overline{T3}$ | | |
| 4 | $\overline{T4}$ | $\overline{T4}$ | | |
| 5 | $\overline{T5}$ | $\overline{T5}$ | | |
| 6 | $\overline{T6}$ | $\overline{T6}$ | | |
| 7 | R _{EXT} | RESISTOR EXTERNAL | Leave open when an external clock is applied from S _{IN} . When no external clock is available, clock can be generated by externally connecting a resistor between S _{IN} and R _{EXT} . | |
| 8 | S _{IN} | SCAN INPUT | T-COUNTER CLOCK input. T-COUNTER changes its state at the rising edge of S _{IN} . | |
| 9 | CP | CLOCK INPUT | Decimal counter clock input for the lowest order digit. | |
| 10 | A _{OUT} | A-OUTPUT | Decimal counter BCD output. When $\overline{T1}$ ="L", the highest order digit (6th digit) is output. Then, 5th digit is output with $\overline{T2}$ ="L", 4th digit with $\overline{T3}$ ="L", ---, 1st digit with $\overline{T6}$ ="L". During BLANKING, all the outputs become "H". | |
| 11 | B _{OUT} | B-OUTPUT | | |
| 12 | C _{OUT} | C-OUTPUT | | |
| 13 | D _{OUT} | D-OUTPUT | | |
| 14 | V _{SS} | V _{SS} | (GND) | |
| 15 | CA1 | CARRY 1 | Carry output from n-th digit "L" when count is "xxxxx6"~"xxxxx9", otherwise "H". "L" when count is "xxxx96"~"xxxx99", otherwise "H". "L" when count is "xx9996"~"xx9999", otherwise "H". "L" when count is "x99996"~"x99999", otherwise "H". "L" when count is "999996"~"999999", otherwise "H". | |
| 16 | CA2 | CARRY 2 | | |
| 17 | CA3 | CARRY 3 | | |
| 18 | CA4 | CARRY 4 | | |
| 19 | CA5 | CARRY 5 | | |
| 20 | CA6 | CARRY 6 | | |
| 21 | OVF | OVER FLOW | Detection terminal of OVER FLOW condition of counter. When the counter advances by one from "999999", it becomes "H". Once it has become "H", only MR can restore it to "L". | |
| 22 | BC | BLANKING CONTROL | "H" Zero suppress for all the digits. | If T _n is connected to BC, zero suppress is activated for the higher order digits than (n-1)th digit. |
| | | | "L" No zero suppress. | |
| 23 | IN1 | INPUT 1 | "H" All the digits are counted. | |
| | | | "L" Only the lower order two digits are counted. | |
| 24 | IN2 | INPUT 2 | "H" All the digits are counted. | |
| | | | "L" Only the lower order four digits are counted. | |
| 25 | TRF | TRANSFER | "H" Decimal counter output is transferred to the multiplexer as it is. | |
| | | | "L" Counter output at the falling edge of TRF is latched. | |
| 26 | TR | T-COUNTER RESET | T-counter is initialized to T1 by "H" level input and T1 retains "H" level only for the period of TR="H". | |
| 27 | MR | MASTER RESET | "H" level input resets the counter to count "000000" and OVER FLOW to "L". | |
| 28 | V _{DD} | V _{DD} | V _{DD} power supply (3~8 volts) | |

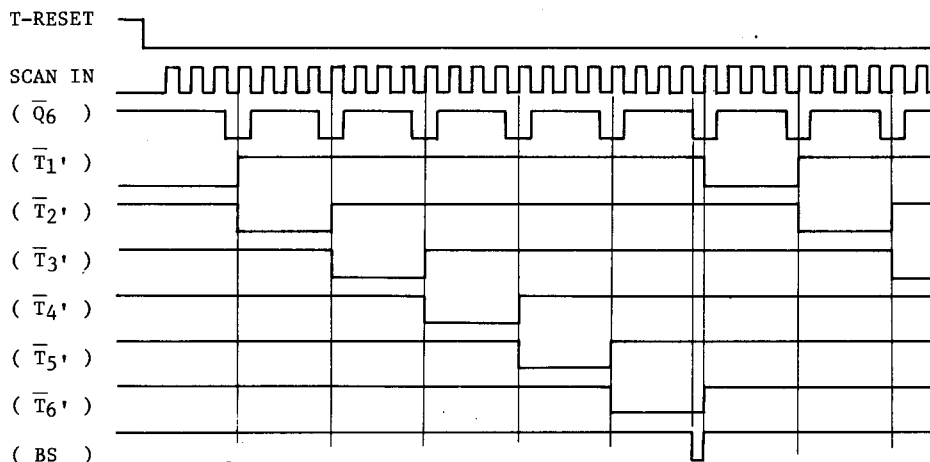
TC5032P

LOGIC DIAGRAM

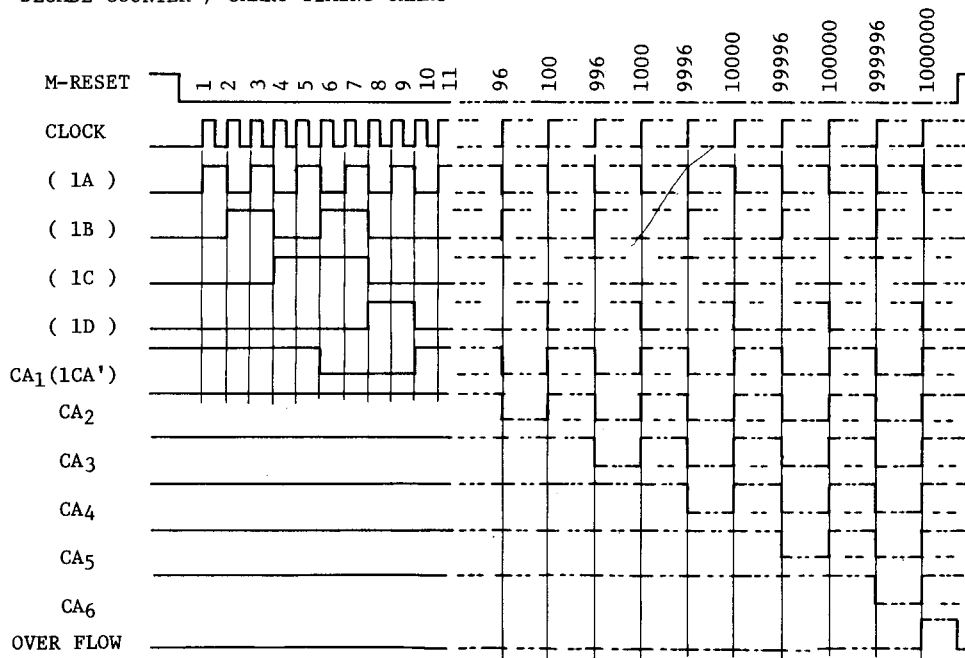


TIMING CHART

T-COUNTER TIMING CHART



DECADE COUNTER / CARRY TIMING CHART



* Waveform marked with () are timings of LSI's internals. (Refer to LOGIC DIAGRAM)

OPERATING CONSIDERATION

* Count Operation

Set input terminals IN1, IN2 and TRANSFER to "H" and apply "H" level to M-RESET terminal, then return it to "L" level. If pulse is fed to CLOCK terminal in this condition, the counter advances its count at the rising edge of CLOCK up to 999999.

Since CARRY outputs from all the digits are output in negative logic, the control of other CMOS logics can be easily achieved.

$\overline{CA1} - \overline{CA6}$ are output with "L" level for four clock periods. (Refer to the timing chart.)

If one more clock is given in the count of 999999, OVER FLOW terminal becomes "H" indicating the overflow condition of COUNTER. Once OVER FLOW terminal has become "H", it will never return to "L" unless M-RESET is applied.

* Latch Operation

When the level of TRANSFER terminal is "H", the counter output is transferred to the multiplexer as it is with the output always indicating the counter output, but if TRANSFER terminal changes the level from "H" to "L", the count output which has been being output immediately prior to the falling edge of TRANSFER is stored in the latch and even if the counter output varies, AOUT - DOUT will not vary.

If TRANSFER terminal is returned to "H" again, the correct counter output appears on AOUT - DOUT.

* Scan Operation

BCD outputs of all digits are output to common AOUT - DOUT on the time sharing basis and the basic clock for this operation is fed from outside to SCAN IN (leaving R_{EXT} open in this case) or obtained by connecting a resistor between R_{EXT} and SCAN IN.

BCD output for each digit appears on AOUT - DOUT corresponding to each digit of 6 digit scan signals (digit signals) which are in synchronism with the rising edge of SCAN IN. The digit output for digit selection is output with "L" level on $\overline{T1} - \overline{T6}$. As BCD outputs are output starting from the highest order digit ($\overline{T1}$ - 6th digit, $\overline{T6}$ - 1st digit), data transfer can be easily achieved.

- * The relationship between external resistor between R_{EXT} and SCAN IN and oscillating frequency is given below

$$f \doteq \frac{1}{44 \times R} \times 10^{12} \text{ [Hz]}$$

* Blanking

By controlling BLANKING CONTROL terminal, leading zero suppress to an arbitrary digit can be easily achieved. When zero suppress is activated, all of AOUT - DOUT become "H".

BC Terminal and Zero Suppress

| BRANKING CONTROL | Leading Zero Suppress |
|-------------------------------|--|
| L | No zero suppress |
| H | Zero suppress for all digits * |
| Connected to $\overline{T_6}$ | Zero suppress for five higher order digits and no zero suppress for the lowest order digit. * |
| Connected to $\overline{T_5}$ | Zero suppress for four higher order digits and no zero suppress for two lower order digits. * |
| Connected to $\overline{T_4}$ | Zero suppress for three higher order digits and no zero suppress for three lower order digits. * |
| Connected to $\overline{T_3}$ | Zero suppress for two higher order digits and no zero suppress for four lower order digits. * |
| Connected to $\overline{T_2}$ | Zero suppress for the highest order digit and no zero suppress for five lower order digits. * |

* When carry is generated from lower order digit, the normal output may not be obtained only one cycle of T-COUNTER.

TC5032P

RECOMMENDED OPERATING CONDITIONS ($V_{SS}=0V$)

| CHARACTERISTIC | SYMBOL | MIN. | TYP. | MAX. | UNIT |
|-----------------------|-----------|------|------|----------|----------|
| Supply Voltage | V_{DD} | 3 | - | 8 | V |
| Input Voltage | V_{IN} | 0 | - | V_{DD} | V |
| Operating Temperature | T_{opr} | -30 | - | 85 | °C |
| External Resistance | R_{EXT} | 20K | - | 10M | Ω |

ELECTRICAL CHARACTERISTICS ($V_{SS}=0V$)

| CHARACTERISTIC | SYMBOL | TEST CONDITIONS | V_{DD} (V) | -30°C | | 25°C | | | 85°C | | UNIT | |
|-------------------------------|------------|-------------------|----------------------|-------|------|-------|-----------|------|-------|------|------|---------|
| | | | | MIN. | MAX. | MIN. | TYP. | MAX. | MIN. | MAX. | | |
| Output Voltage | High Level | V_{OH} | $I_{OH}=-1\mu A$ | 5 | 4.95 | - | 4.95 | - | - | 4.95 | - | V |
| | Low Level | V_{OL} | $I_{OL}=1\mu A$ | 5 | - | 0.05 | - | - | 0.05 | - | 0.05 | |
| Output Current | High Level | I_{OH} | $V_{OH}=2.5V$ | 5 | -0.7 | - | -0.6 | -2 | - | -0.5 | - | mA |
| | Low Level | I_{OL} | $V_{OL}=0.4V$ | 5 | 0.52 | - | 0.44 | 1.3 | - | 0.36 | - | |
| Input Voltage | High Level | V_{IH} | $V_{OUT}=0.5V, 4.5V$ | 5 | 3.5 | - | 3.5 | 2.75 | - | 3.5 | - | V |
| | Low Level | V_{IL} | $V_{OUT}=0.5V, 4.5V$ | 5 | - | 1.5 | - | 2.25 | 1.5 | - | 1.5 | |
| Input Current | High Level | I_{IH} | $V_{IH}=8V$ | 8 | - | 0.15 | - | - | 0.15 | - | 1.0 | μA |
| | Low Level | I_{IL} | $V_{IL}=0V$ | 8 | - | -0.15 | - | - | -0.15 | - | -1.0 | |
| Quiescent Current Consumption | I_{DD} | At all conditions | 5 | - | 0.4 | - | 10^{-5} | 0.4 | - | 0.8 | mA | |
| | | | 8 | - | 0.5 | - | 10^{-5} | 0.5 | - | 1.0 | | |

SWITCHING CHARACTERISTICS ($T_a=25^\circ C$, $V_{SS}=0V$, $C_L=15_P F$)

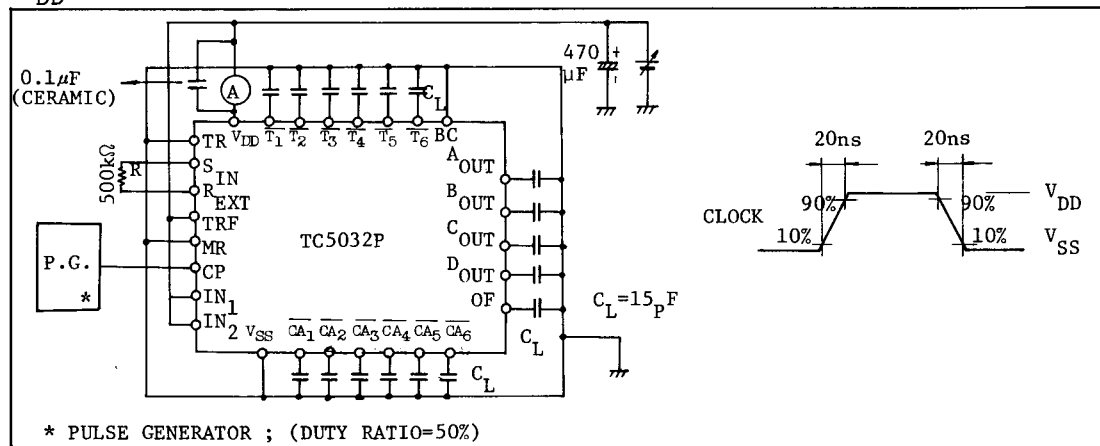
| CHARACTERISTIC | SYMBOL | TEST CONDITIONS | V_{DD} (V) | MIN. | TYP. | MAX. | UNIT |
|--|----------------------------|-----------------------|-----------------|------|-------|------|---------|
| Propagation Delay Time (CP - BCD OUT) | t_{PLH} | $(\overline{T6} = L)$ | 5 | - | 800 | 2000 | ns |
| | | $(\overline{T5} = L)$ | 5 | - | 1000 | 2200 | |
| | t_{PHL} | $(\overline{T4} = L)$ | 5 | - | 1250 | 2500 | |
| | | $(\overline{T3} = L)$ | 5 | - | 1500 | 3000 | |
| | | $(\overline{T2} = L)$ | 5 | - | 1750 | 3500 | |
| Propagation Delay Time (CP - CARRY OUT) | t_{PLH} | CA1 | 5 | - | (200) | 500 | ns |
| | | CA2 | 5 | - | (200) | 500 | |
| | | CA3 | 5 | - | (250) | 750 | |
| | t_{PHL} | CA4 | 5 | - | (250) | 750 | |
| | | CA5 | 5 | - | (300) | 1000 | |
| | | CA6 | 5 | - | (300) | 1000 | |
| Max. Clock Rise Time Max. Clock Fall Time | $t_{r\phi}$ $t_{f\phi}$ | CP, IN_1 , IN_2 | 5 | 20 | - | - | μs |
| Min. Clear Pulse Width | $t_w(MR)$ | MASTER RESET | 5 | - | - | 500 | ns |
| | $t_w(TR)$ | T-COUNTER RESET | | - | - | 400 | |

SWITCHING CHARACTERISTICS (Ta=25°C, V_{SS}=0V, C_L=15 pF)

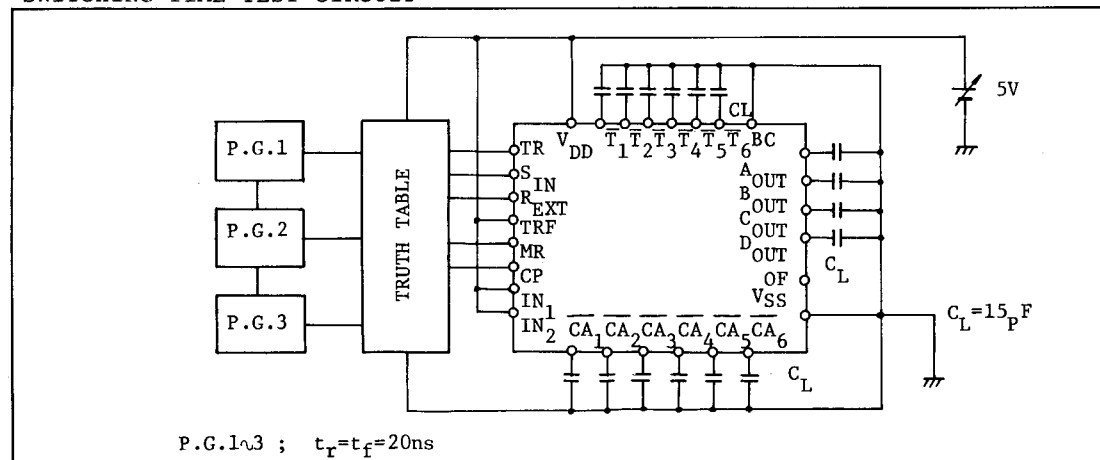
| CHARACTERISTIC | SYMBOL | TEST CONDITIONS | V _{DD} (V) | MIN. | TYP. | MAX. | UNIT | |
|------------------------|------------|-------------------------------------|---------------------|------|------|------|------|-----|
| Propagation Delay Time | (High-Low) | t _{pHL} | MR-BCD OUT | 5 | - | - | 2000 | ns |
| | (Low-High) | t _{pLH} | TR-DIGIT OUT | 5 | - | - | 1500 | |
| Propagation Delay Time | | t _{pLH} , t _{pHL} | SIN-BCD OUT | 5 | - | 1000 | 2500 | |
| | | t _{pLH} , t _{pHL} | SIN-DIGIT OUT | 5 | - | 500 | 1000 | |
| Max. Frequency | | f _{CL-1} | CLOCK IN * | 5 | 10.0 | 14.0 | - | MHz |
| | | f _{CL-2} | | 5 | 1.0 | 2.0 | - | |
| | | f _{CL} SIN | SCAN IN | 5 | 0.5 | - | - | |

* f_{CL-1}; Clock burst mode. f_{CL-2}; BCD outputs enable.

I_{DD} TEST CIRCUIT

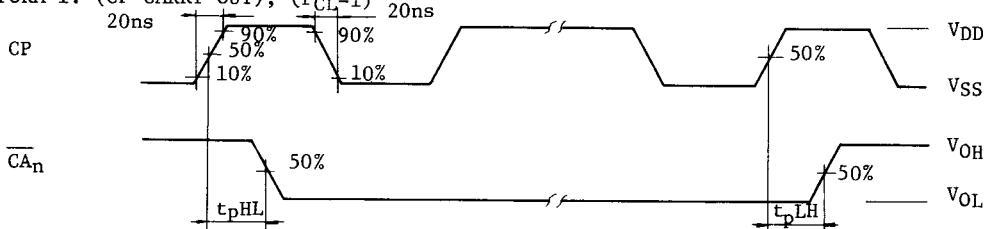


SWITCHING TIME TEST CIRCUIT



SWITCHING TIME TEST WAVEFORMS

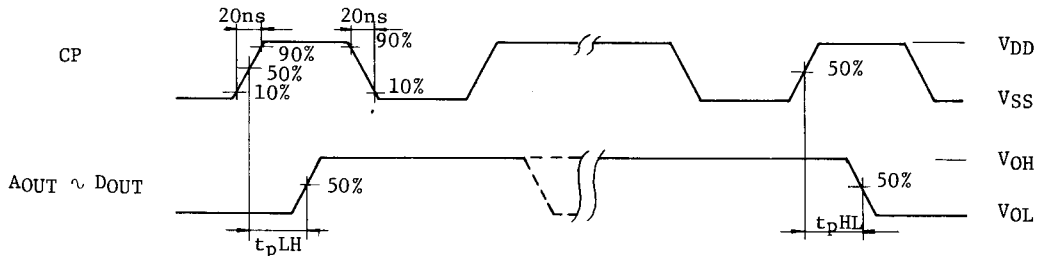
WAVEFORM 1. (CP-CARRY OUT), (f_{CL-1})



*MR, TR, S_{IN} = "L"

**CP INPUT : $f=500\text{kHz}$ (except f_{CL}), DUTY RATIO=50%

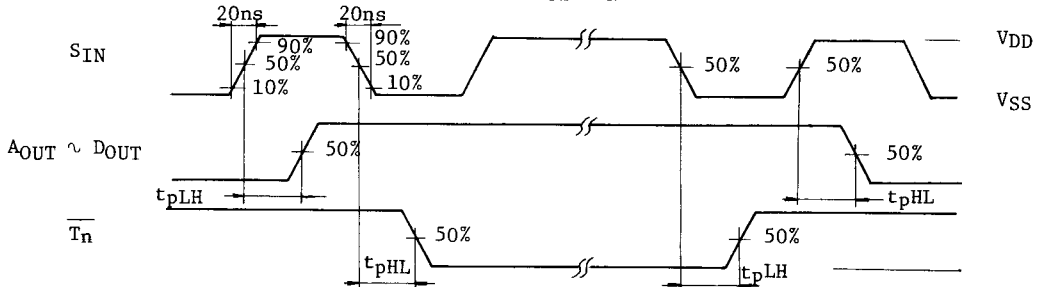
WAVEFORM 2. (CP-BCD OUT), (f_{CL-2})



* MR, TR="L" S_{IN}=MANUAL PULSE

**CP INPUT : $f=250\text{kHz}$ (except f_{CL}), DUTY RATIO=50%

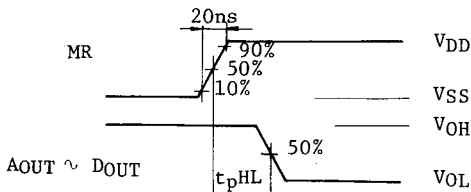
WAVEFORM 3. (S_{IN}-DIGIT OUT), (S_{IN}-BCD OUT), (f_{CL} S_{IN})



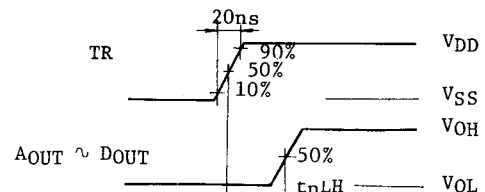
*MR, TR="L", CP : MANUAL PULSE

**S_{IN} : $f=250\text{kHz}$, DUTY RATIO = 50%

WAVEFORM 4. (MR-BCD OUT)



WAVEFORM 5. (TR-DIGIT OUT)



*TR="L", CP: PULSE GENERATOR, S_{IN}:MANUAL PULSE *MR="L", S_{IN}:MANUAL PULSE,

CP: PULSE GENERATOR