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| GENERAL INSTRUMENT | KB3600 KB3600-PRO |
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PRELIMINARY INFORMATION

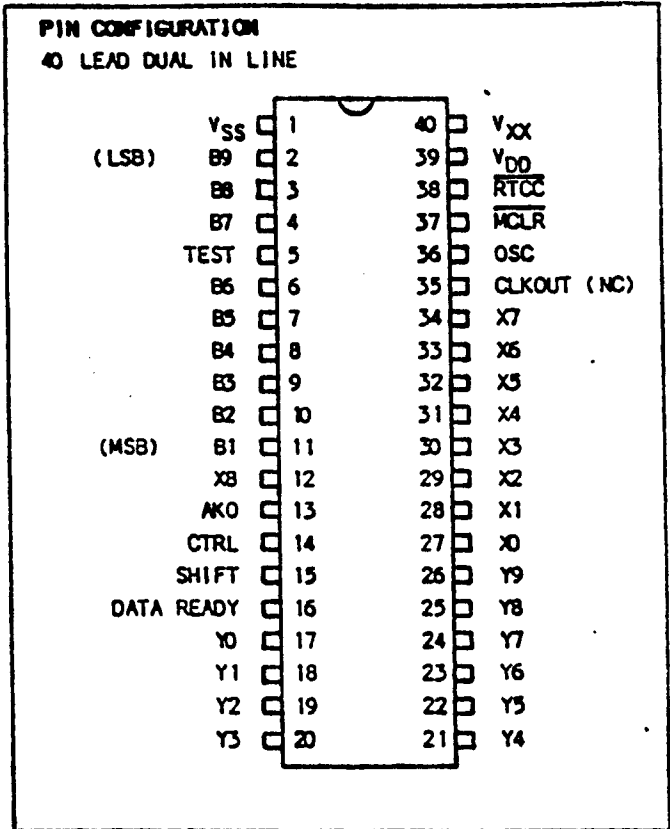
PROGRAMMABLE MICROCOMPUTER KEYBOARD ENCODERS

FEATURES

- Microcomputer-based keyboard encoders.
- N-key rollover or lock out operation.
- 9 output data bits.
- Output directly compatible with TTL/DTL or MOS.
- Output data buffer register included.
- Pulse or level Data Ready output signal.
- "Any Key Down" output signal.
- Mask programmable keyswitch debouncing period.
- ASCII or binary (PRO) versions available.
- Auto repeat mask option.
- 4.5 - 7.0 volt operation

DESCRIPTION

The KB3600 Series is based on the General Instrument PIC1650A microcomputer, which is programed to be functionally equivalent to the General Instrument AY-5-3600 PMOS keyboard encoder. This PIC-based keyboard encoder is designed to scan a 90 key keyboard, organized in a 9 x 10 matrix, and output a 9 bit user-defined code when a key closure is detected. DATA, ANY KEY DOWN, and DATA READY outputs are all buffered and directly compatible with any TTL/DTL or MOS device without the need for any special interface components. A simple RC circuit can be used for the oscillator input.



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PIN FUNCTIONS

| Signal | Function |
|-----------------------------------|--|
| OSC (input) | Oscillator input. This signal can be driven by an external oscillator if a precise frequency of operation is required, or an external RC network can be used to set the frequency of operation of the internal clock generator. This is a Schmitt trigger input. |
| \overline{RTCC} (input) | Must be grounded for normal operation. |
| \overline{MCLR} (input) | Master Clear. Used to initialize the internal ROM program to address 77 _h and latch all I/O register high. Should be held low at least 1ms past the time when the power supply is valid. This is a Schmitt trigger input. |
| CLK OUT (output) | Clock Out. This signal, one-fourth the oscillator frequency, is the instruction cycle frequency. No connection. |
| TEST | Used for testing purposes only. Must be grounded for normal operation. |
| V _{DD} , V _{XX} | 4.5V - 7.0V power supply input. |
| V _{SS} | Ground. |
| B1-B9 (LC outputs) | Nine bits data output. B1 is the MSB and B9 is the LSB. |
| X0-X8 (outputs) | Nine scan rows of the keyboard. |
| Y0-Y9 (LC inputs) | Ten scan columns of the keyboard. |
| SHIFT (input) | SHIFT key input. |
| CTRL (input) | CONTROL key input. |
| AKO (output) | Any Key Down output |
| DATA READY (output) | This is the data strobe output. Activated when data is available on B1-B9. |

MASK PROGRAMABLE FEATURES AND OPTIONS

The following mask programable options can be specified to suit individual requirements:

N-Key Rollover/N-Key Lockout

The KB3600 keyboard encoder is mask programmed to operate in either N-key rollover or N-key lockout mode. In either case, the debouncing period is $K \times 108$ microseconds where $1 \leq K \leq 255$. By specifying the value of K, the debouncing period can be customized.

a. N-Key Rollover

When a key closure is detected and the key has not been encoded, the switch debouncing routine is executed. If the key is still depressed at the end of the selected delay time, the 9 bit code for the depressed key is transferred to the data output lines. The DATA READY (strobe) signal is activated (either pulse or level output). Then the entire scanning process is started over again from coordinate X0, Y0. If another key closure is detected at some other coordinate,

the entire sequence is repeated, thus encoding the next key. When a key closure is detected for an already encoded key, it is ignored. The code of the last key encoded remains on the output data lines until the next code is strobed out.

b. N-Key Lockout

When a key closure is detected, the debouncing routine is executed. If the key is still depressed at the end of the debouncing period, the code for the depressed key is transferred to the data output lines. The DATA READY signal is activated (either pulse or level output). The keyboard scanning action is halted until the depressed key is released. Upon release, the keyboard encoder resumes scanning from coordinate X0, Y0. The data output lines remain with the code for the last key encoded.

Pulse or Level DATA READY Signal

DATA READY can be either an active high or active low pulse, or level signal. If a pulse is chosen, the minimum pulse width is 52 microseconds.

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ANY KEY DOWN OUTPUT

This signal is a level which can be either active high or active low. Whenever a key closure is detected, this signal is activated immediately with no debouncing period. Once activated, the ANY KEY DOWN signal will remain active until all keys are released.

Auto Repeat

If a single key closure condition sustains for a half second, the DATA READY signal will be asserted at a rate of 10 per second (i.e., one strobe every 100 milliseconds.) This auto strobing will stop immediately upon the release of the key or on the closure of another key. For the latter case, the codes for all depressed keys output singly without the auto repeat feature.

Parallel Data Output in ASCII or Binary

The 9 bit code can be output either in ASCII or binary format. Specify KB3600 for the ASCII version, or KB3600-PRO for the binary version.

During data output, bits 2-9 appear on the data lines at the same time. Bit 1 is output 8 microseconds later. After all nine bits are output, the DATA READY signal is activated.

ASCII Version Keyboard Encoder (KB3600)

The ASCII version provides an ASCII code output when a key is depressed.

The key coordinates are arranged to closely resemble a standard typewriter keyboard. See Figures 1 and 2.

PRO Version Keyboard Encoder (KB3600-PRO)

The PRO version provides a binary code output when a key is depressed. This binary code is the same as the key number of the key depressed. All keys are numbered from 00 to 89. The tens digit is the row number (X0-X8) and the units digit is the column number (Y0-Y9). For example, if the key at coordinate X2, Y3 is depressed, binary 23 is output. Seven bits (B1, B4-B9) are required to output binary 00 to 89 with B1 being the MSB. The other two bits (B2, B3) are used to output the CONTROL and SHIFT key respectively. If CONTROL key is depressed, B2 is cleared. If SHIFT key is depressed, B3 is cleared. If both are depressed, both B2 and B3 are cleared.

Standard Features

The following are the standard features included in both the KB3600 and KB3600-PRO keyboard encoders:

- o 9 bit parallel data output
- o ANY KEY DOWN output-active high level
- o DATA READY output-active high pulse of 52us
- o Auto repeat at a rate of 10 characters per second
- o N-Key rollover
- o Debounce period-5.4ms (50 108us periods)

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DIFFERENCES BETWEEN THE KE3600 KEYBOARD ENCODER AND THE AY-5-3600 KEYBOARD ENCODER

The following table gives a comparison of the two devices:

| <u>Feature</u> | <u>KE3600</u> | <u>AY-5-3600</u> |
|-----------------------------------|--|---|
| Maximum number of output data bit | 9 | 10 |
| Switch debouncing delay period | Mask programmable 108-27650 μ s. | Determined by external capacitor. |
| Power supply | +5V | +5V and -12V |
| N-Key rollover/lockout | Mask programmable | Selection under external control |
| Output complement control | Data cannot be complemented without extra hardware inverters | Data can be complemented under external control |
| Chip Enable | No | Yes |
| ANY KEY DOWN output | Yes | Yes |
| DATA READY pulse width | 52-104 μ s | 10-100 μ s |

*Timing data is based on $t_{CY}=4.0 \mu$ s ($f_{OSC} = 1$ MHz.)

Limitation on Choosing the 9-Bit Data Output Coding Scheme

The keyboard has four modes (NORMAL, SHIFT, CONTROL, AND CONTROL SHIFT MODE) with 90 keys for each mode. This gives a total of 360 possible codes. The AY-5-3600 keyboard encoder is capable of outputting 360 distinct codes. The PIC1650A-based keyboard encoder can store only about 200 distinct codes. Therefore a relationship must exist between codes if more are required. For example, there are only 81 distinct codes for the KE3600. When the SHIFT key is depressed together with another key, a formula

is used to transform the code from the NORMAL mode to the code for SHIFT mode. In the case of ASCII code, octal 40 is subtracted from the normal code to obtain the code for the SHIFT mode, and octal 140 is subtracted from the CONTROL AND CONTROL-SHIFT modes.

TIMING SPECIFICATIONS

Figure 1 shows the timing relation for different signals for parallel data output. (See above for the mask programmable debouncing period.) If no key is depressed, 13ms are required to scan all 90 keys.

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Figure 1
KE3600-ASCII KEYBOARD ENCODER CODE ASSIGNMENT

| SYMBOL | NORMAL | SHIFT | CONTROL | CONTROL-SHIFT |
|---------|--------|-------|---------|---------------|
| (GRAVE) | | X0Y8 | | |
| a | X0Y2 | | | |
| b | X3Y3 | | | |
| c | X2Y3 | | | |
| d | X2Y2 | | | |
| e | X2Y1 | | | |
| f | X3Y2 | | | |
| g | X4Y2 | | | |
| h | X5Y2 | | | |
| i | X7Y1 | | | |
| j | X6Y2 | | | |
| k | X7Y2 | | | |
| l | X8Y2 | | | |
| m | X7Y3 | | | |
| n | X6Y3 | | | |
| o | X8Y1 | | | |
| p | X6Y6 | | | |
| q | X0Y1 | | | |
| r | X3Y1 | | | |
| s | X1Y2 | | | |
| t | X4Y1 | | | |
| u | X5Y1 | | | |
| v | X4Y3 | | | |
| w | X1Y1 | | | |
| x | X1Y3 | | | |
| y | X3Y1 | | | |
| z | X0Y3 | | | |
| [| | X3Y6 | | |
|] | | X2Y8 | | |
| | | X4Y5 | | |
| | | X6Y4 | | |
| DEL | | X2Y9 | | |
| Ⓢ | X0Y8 | | | |
| A | | X0Y2 | | |
| B | | X3Y3 | | |
| C | | X2Y3 | | |
| D | | X2Y2 | | |
| E | | X2Y1 | | |
| F | | X3Y2 | | |
| G | | X4Y2 | | |
| H | | X5Y2 | | |
| I | | X7Y1 | | |
| J | | X6Y2 | | |
| K | | X7Y2 | | |
| L | | X8Y2 | | |

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KB3600-ASCII KEYBOARD ENCODER CODE ASSIGNMENT (continued)

| SYMBOL | NORMAL | SHIFT | CONTROL | CONTROL-SHIFT |
|--------|--------|-------|---------|---------------|
| M | | X7Y3 | | |
| N | | X6Y3 | | |
| O | | X8Y1 | | |
| P | | X5Y6 | | |
| Q | | X0Y1 | | |
| R | | X3Y1 | | |
| S | | X1Y2 | | |
| T | | X4Y1 | | |
| U | | X6Y1 | | |
| V | | X4Y3 | | |
| W | | X1Y1 | | |
| X | | X1Y3 | | |
| Y | | X5Y1 | | |
| Z | | X0Y3 | | |
| [| X3Y6 | | | |
| \ | X2Y8 | | | |
|] | X4Y5 | | | |
| ^ | X6Y4 | | | |
| _ | X2Y9 | | | |
| SPACE | X4Y9 | X4Y9 | X4Y9 | X4Y9 |
| ! | | X0Y0 | | |
| " | | X1Y0 | | |
| # | | X2Y0 | | |
| \$ | | X3Y0 | | |
| % | | X4Y0 | | |
| & | | X3Y0 | | |
| ' | | X6Y0 | | |
| (| | X7Y0 | | |
|) | | X8Y0 | | |
| * | | X3Y4 | | |
| + | | X8Y5 | | |
| , | X8Y3 | | | |
| - | X2Y4 | | | |
| . | X8Y4 | | | |
| / | X7Y4 | | | |
| 0 | X8Y8 | X8Y8 | X8Y8 | X8Y8 |
| 1 | X0Y0 | | | |
| 2 | X1Y0 | | | |
| 3 | X2Y0 | | | |
| 4 | X3Y0 | | | |
| 5 | X4Y0 | | | |
| 6 | X5Y0 | | | |
| 7 | X6Y0 | | | |
| 8 | X7Y0 | | | |
| 9 | X8Y0 | | | |

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KE3600-ASCII: KEYBOARD ENCODER CODE ASSIGNMENT (continued)

| SYMBOL | NORMAL | SHIFT | CONTROL | CONTROL-SHIFT |
|--------|--------|-------|------------|---------------|
| : | X3Y4 | | | |
| ; | X8Y3 | | | |
| < | | X8Y3 | | |
| = | | X2Y4 | | |
| > | | X8Y4 | | |
| ? | | X7Y4 | | |
| NUL | | | X7Y8 | X7Y8 |
| SOH | | | X7Y2 | X7Y2 |
| STX | | | X3Y3 | X3Y3 |
| ETX | | | X2Y3 | X2Y3 |
| EOT | | | X2Y2 | X2Y2 |
| ENQ | | | X2Y1 | X2Y1 |
| ACK | | | X3Y2 | X3Y2 |
| BEL | | | X4Y2 | X4Y2 |
| BS | | | X5Y2 | X3Y2 |
| HT | | | X7Y1 | X7Y1 |
| LF | X3Y9 | X3Y9 | X6Y2, X3Y9 | X6Y2, X3Y9 |
| VT | | | X7Y2 | X7Y2 |
| FF | | | X8Y2 | X8Y2 |
| CR | X1Y9 | X1Y9 | X7Y3, X1Y9 | X7Y3, X1Y9 |
| SO | | | X6Y3 | X6Y3 |
| SI | | | X8Y1 | X8Y1 |
| DLE | | | X6Y6 | X6Y6 |
| DC1 | | | X7Y1 | X7Y1 |
| DC2 | | | X3Y1 | X3Y1 |
| DC3 | | | X1Y2 | X1Y2 |
| DC4 | | | X4Y1 | X4Y1 |
| NAK | | | X6Y1 | X6Y1 |
| SYN | | | X4Y3 | X4Y3 |
| ETB | | | X1Y1 | X1Y1 |
| CAN | | | X1Y3 | X1Y3 |
| EM | | | X5Y1 | X5Y1 |
| SUB | | | X7Y3 | X7Y3 |
| ESC | X7Y9 | X7Y9 | X7Y9 | X7Y9 |
| FS | | | X2Y8 | X2Y8 |
| GS | | | X4Y5 | X4Y5 |
| RS | | | X6Y4 | X6Y4 |
| US | | | X2Y9 | X2Y9 |

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KB3600 ASCII Keyboard Encoder Code Assignment Chart

| | | | | | | | | | | | |
|---|---|------|---------|---------|---------|-------|-------|---|---------|------------|----------------|
| | Y | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
| X | | | DC1 DC1 | SOH SOH | SUB SUB | | | | | NUL NUL | ESC ESC |
| 0 | | ! 1 | Q q | A a | Z z | | | | | - @ | ESC ESC |
| 1 | | " 2 | W w | S s | X x | | | | | | CR CR CR CR |
| 2 | | # 3 | E e | D d | C c | = - | | | | FS FS | US US DEL _ |
| 3 | | \$ 4 | R r | F f | | | | | | | LF LF LF LF |
| 4 | | % 5 | T t | G g | V v | | GS GS | | | | SP SP SP SP |
| 5 | | & 6 | Y y | H h | B b | * : | | | | | |
| 6 | | ' 7 | U u | J j | N n | RS RS | | | DLE DLE | | |
| 7 | | (8 | I i | K k | M m | ? / | | | | P p | |
| 8 | |) 9 | O o | L l | < , | > . | + ; | | | 0 0 0 0 | |

Notes:

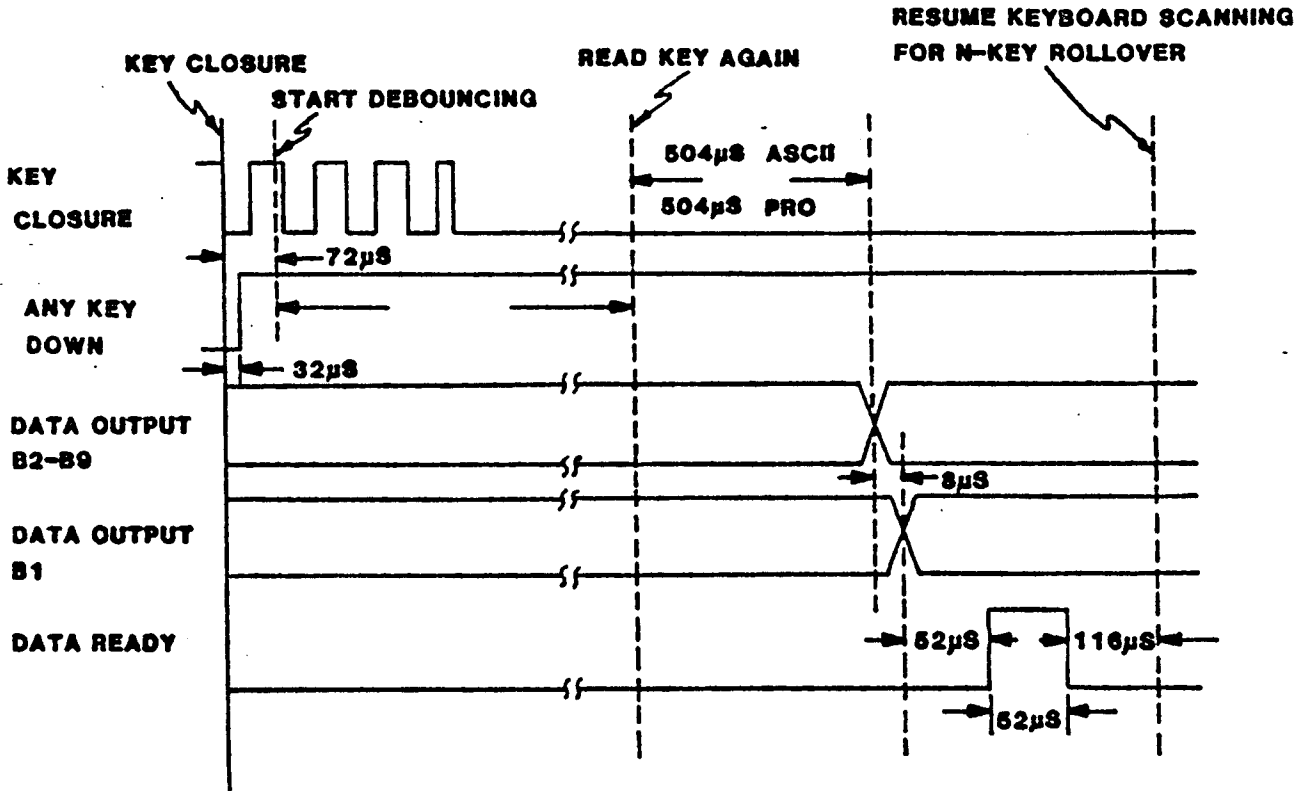
The unused matrix locations can have user-defined (mask defined) codes. Consult your local General Instrument sales office if such a requirement exists.

Legend:

| | |
|---------------|---------|
| CONTROL-SHIFT | CONTROL |
| SHIFT | NORMAL |

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Fig. (1) Timing Diagram For Parallel Data Output*



Timing Based on $T_{CY} = 4 \mu s$ ($F_{OSS} = 1 \text{ MHz}$)

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ELECTRICAL CHARACTERISTICS

Maximum Ratings*

| | |
|---|-----------------|
| Temperature Under Bias | 125°C |
| Storage Temperature | -55°C to +150°C |
| Voltage on any pin with Respect to V _{SS} | -0.3V to +12.0V |
| Power Dissipation | 1000mW |
| Power Dissipated by any one I/O pin (Note 1)..... | 60mW |
| Power Dissipated by all I/O pins (Note 1)..... | 600mW |

* Exceeding these ratings could cause permanent damage to the device. This is a stress rating only and functional operation of this device at these conditions is not implied - operating ranges are specified in Standard Condition. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

Data labeled "typical" is presented for design guidance only and is not guaranteed.

Standard Conditions (unless otherwise stated):

DC CHARACTERISTICS

Operating Temperature T_A = 0°C to +70°C

| | Sym | Min | Typ | Max | Units | Conditions |
|---|------------------|--------------------|------|-----------------|-------|---|
| Primary Supply Voltage | V _{DD} | 4.5 | - | 7.0 | V | |
| Output Buffer Supply Voltage | V _{XX} | 4.5 | - | 10.0 | V | (Note 2) |
| Primary Supply Current | I _{DD} | - | 30 | 55 | mA | All I/O pins high |
| Output Buffer Supply Current | I _{XX} | - | 1 | 5 | mA | All I/O pins high (Note 3) |
| Input Low Voltage | V _{IL} | -0.2 | - | 0.8 | V | |
| Input High Voltage (except MCLR RTCC & OSC when driven externally) | V _{IH1} | 2.4 | - | V _{DD} | V | |
| Input High Voltage (MCLR, RTCC & OSC) | V _{IH2} | V _{DD} -1 | 2.6 | V _{DD} | V | |
| Output High Voltage | V _{OH} | 2.4 | - | V _{DD} | V | I _{OH} = -100 μA provided by internal pullups (Note 4) I _{OH} = 0 |
| Output Low Voltage (I/O only) | V _{OL1} | - | - | 0.45 | V | I _{OL} = 1.6mA, V _{XX} = 4.5V |
| | | | | 0.90 | V | I _{OL} = 5.0mA, V _{XX} = 4.5V |
| | | | | 0.90 | V | I _{OL} = 5.0mA, V _{XX} = 8.0V |
| | | | | 1.20 | V | I _{OL} = 10.0mA, V _{XX} = 8.0V |
| | | | | 2.0 | V | I _{OL} = 20.0mA, V _{XX} = 8.0V (Note 5) |
| Output Low Voltage (CLKOUT) | V _{OL2} | - | - | 0.45 | V | I _{OL} = 1.6mA (Note 5) |
| Input Leakage Current (MCLR, RTCC) | I _{LC} | -5 | - | +5 | μA | V _{SS} ≤ V _{IN} ≤ V _{DD} |
| Output Leakage Current (open drain I/O pins) | I _{OLC} | - | - | 10 | μA | V _{SS} ≤ V _{PIN} ≤ V _{DD} |
| Input Low Current (all I/O ports) | I _{IL} | -0.2 | -0.6 | -1.6 | mA | V _{IL} = 0.4V Internal pullup |
| Input High Current (all I/O ports) | I _{IH} | -0.1 | -0.4 | -1.4 | mA | V _{IH} = 2.4V |

NOTES:

- Power dissipation for I/O pins is calculated by

$$\sum (V_{CC} - V_{IL}) (|I_{IL}|) + \sum (V_{CC} - V_{OH}) (|I_{OH}|) + \sum (V_{OL}) (I_{OL})$$
The term I/O refers to all interface pins: input, output or I/O.
- V_{XX} supply drives only the I/O ports.
- The maximum I_{XX} current will be drawn when all I/O ports are outputting a High.
- Positive current indicates current into pin. Negative current indicates current out of a pin.
- Total I_{OL} for all output pins (I/O ports plus CLK OUT) must not exceed 225mA.

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Standard Conditions (unless otherwise stated):

AC CHARACTERISTICS

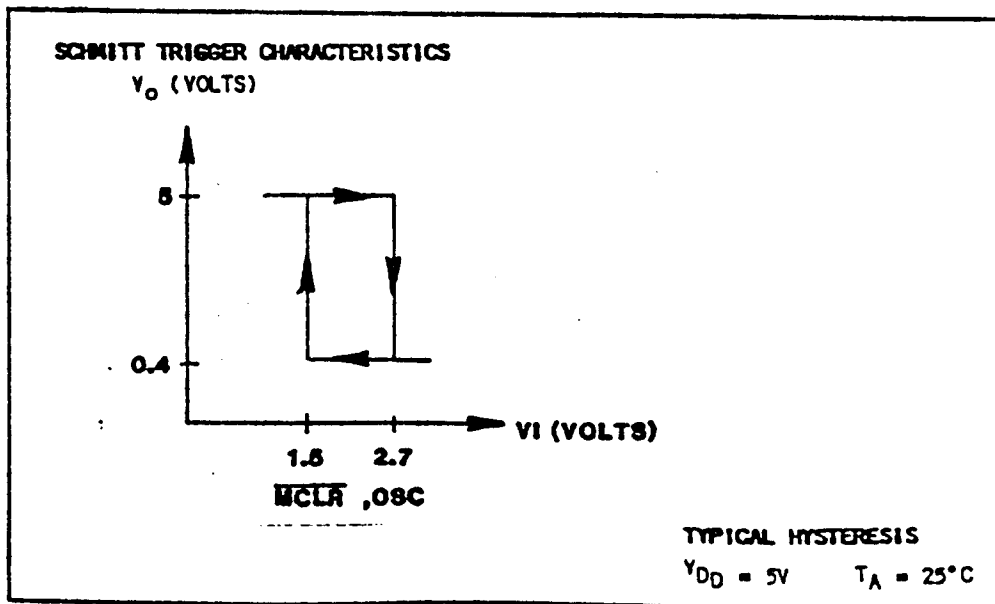
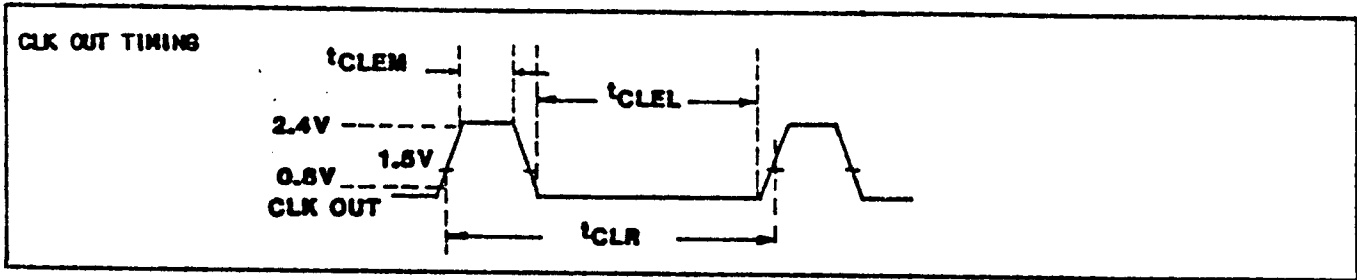
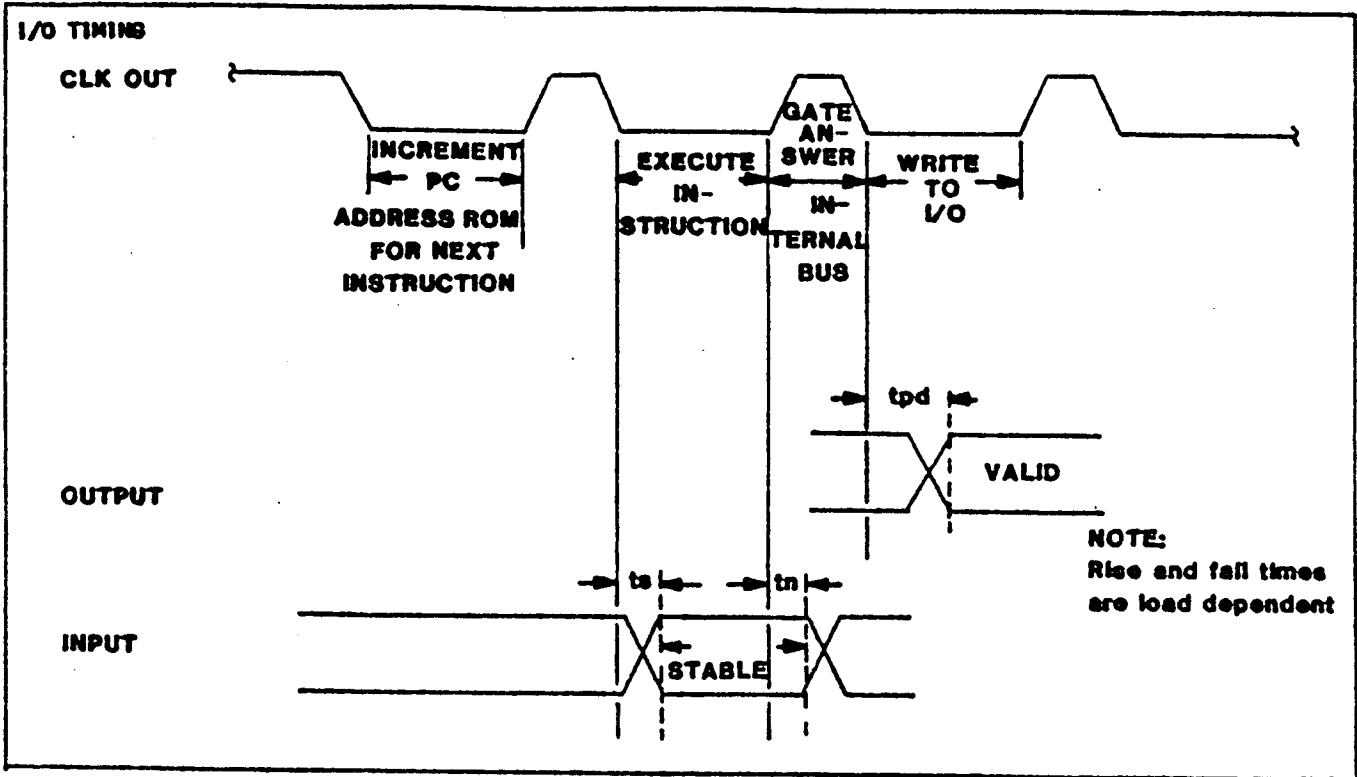
Operating Temperature $T_A = 0^\circ\text{C}$ to $+70^\circ\text{C}$

| Characteristic | Sym | Min | Typ | Max | Units | Conditions |
|-------------------------------|-------------|-----|--------|----------------------|---------------|---|
| Instruction Cycle Time | T_{CY} | 4 | - | 10 | μs | 0.4 - 1.0 MHz. external time base (Note 1) |
| I/O Ports | | | | | | |
| Data Input Setup Time | T_S | - | - | $1/4 t_{CY}$ -125 | ns | |
| Data Input Hold Time | T_H | 0 | - | - | ns | |
| Data Output Propagation Delay | T_{PD} | - | 500 | 800 | ns | Capacitive load = 50 pF |
| OSC Input | | | | | | |
| External Input Impedance High | $R_{D SCH}$ | - | 120 | - | | $V_{OSC} = 5V$ |
| External Input Impedance Low | R_{OSCL} | - | 10^6 | - | | $V_{OSC} = 0.4V$ Applies to external OSC drive only |

Notes:

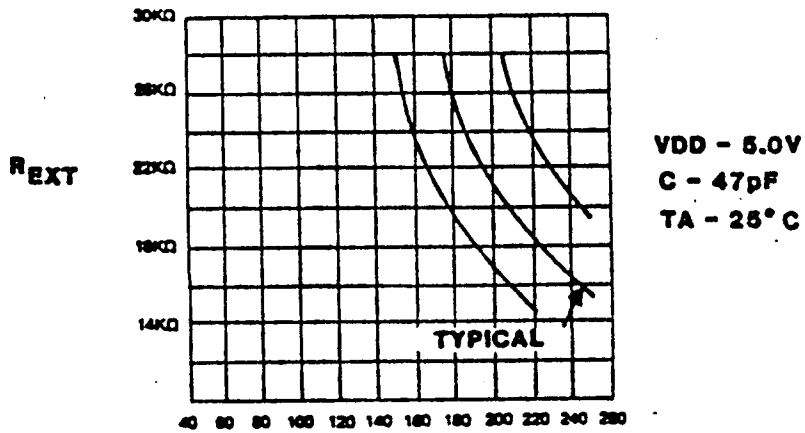
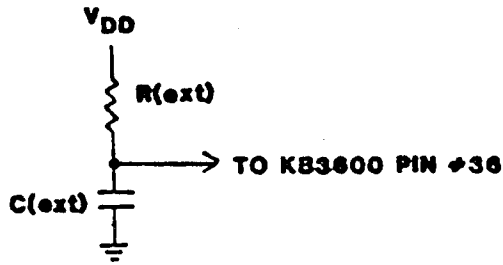
1. Instruction cycle period (t_{CY}) equals four times the input oscillator time base period.

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KE3600 OSCILLATOR OPTIONS (TYPICAL CIRCUITS)

RC OPTION OPERATION

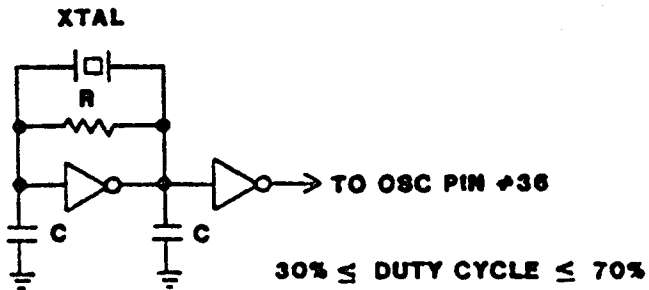


INSTRUCTION CYCLE TIME (KHz)

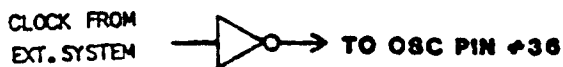
Oscillator Frequency With Typical Unit to Unit Variance

Unit to Unit Variation at $V_{DD} = 5.0V$, $T_A = 25^\circ C$ is + 25%
 Variation from $V_{DD} = 4.5V - 7.0V$ referenced to 5V is -3%, +9%
 Variation from $T_A = 0^\circ C - 70^\circ C$ referenced to 25°C is +3%, -5%

BUFFERED CRYSTAL INPUT OPERATION

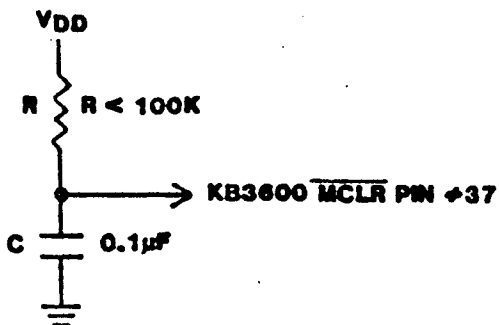


EXTERNAL CLOCK INPUT OPERATION



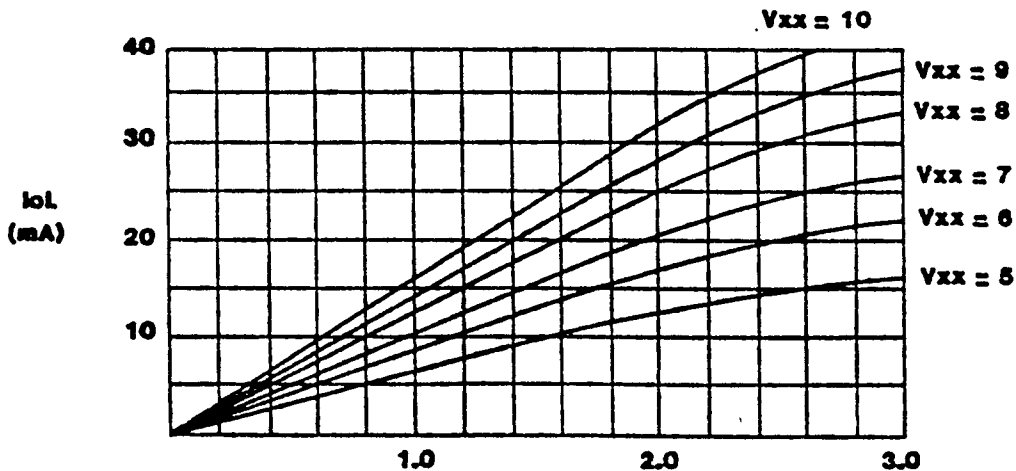
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MASTER CLEAR



Master Clear requires >1.0ms delay before activation after power is applied to the V_{DD} pin. To achieve this, an external RC configuration as shown can be used (assuming V_{DD} is applied as a step function).

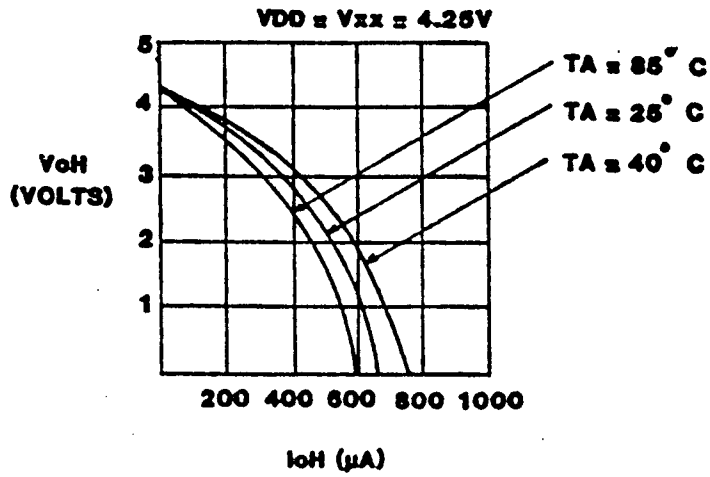
OUTPUT SINK CURRENT GRAPH



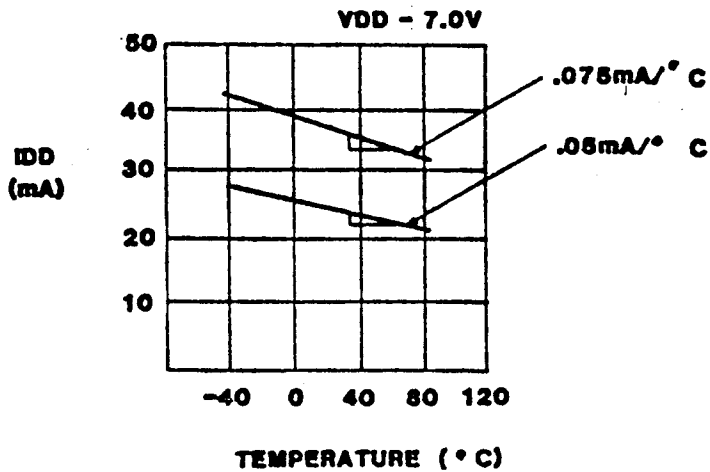
V_{OL} (VOLTS)
 I_{OL} vs. V_{OL} TYP @ 25°C

The Output Sink Current is dependent on the V_{xx} supply and the output load. This chart shows the typical curves used to express the output drive capability.

V_{OH} VS I_{OH} (I/O PORTS)



POWER SUPPLY CURRENT VS TEMPERATURE



| | |
|-----------------------|-------------------|
| GENERAL INSTRUMENT | KB3600 ORDER FORM |
|-----------------------|-------------------|

Customer Name _____

Address _____

City _____ State _____ Zip _____ Country _____

Telephone Number _____ Ext. _____

Customer Contact _____ Title _____ Date _____

1. N-Key Rollover: Yes _____ No _____ (N-Key Lockout)

2. Debouncing period is: _____ 108 (microseconds)
(1-255)

3. DATA READY Signal:

a. Active Level: High _____ Low _____

b. Active Pulse: High _____ Low _____

Pulse Width is: _____ (microseconds)
(52-104 μ s in 12 μ s increments only)

4. ANY KEY DOWN Signal: Active High _____ Active Low _____

5. Auto Repeat at a rate of 10 characters per second: Yes _____ No _____

6. Code: _____ ASCII: KB3600 _____ Binary: KB3600-PRO _____ Customer Assigned _____
(Attach Code Assignment)