

## 32-Segment CMOS LCD Driver

### FEATURES

- Drives up to 32 LCD segments of arbitrary configuration
- CMOS process for: wide supply voltage range, low- power operation, high-noise immunity, wide temperature range
- CMOS and TTL-compatible inputs
- Electrostatic discharge protection on all pins
- Cascadable
- On-chip oscillator
- Requires only three control lines

### APPLICATIONS

- Industrial displays
- Consumer product displays
- Telecom product displays
- Automotive dashboard displays

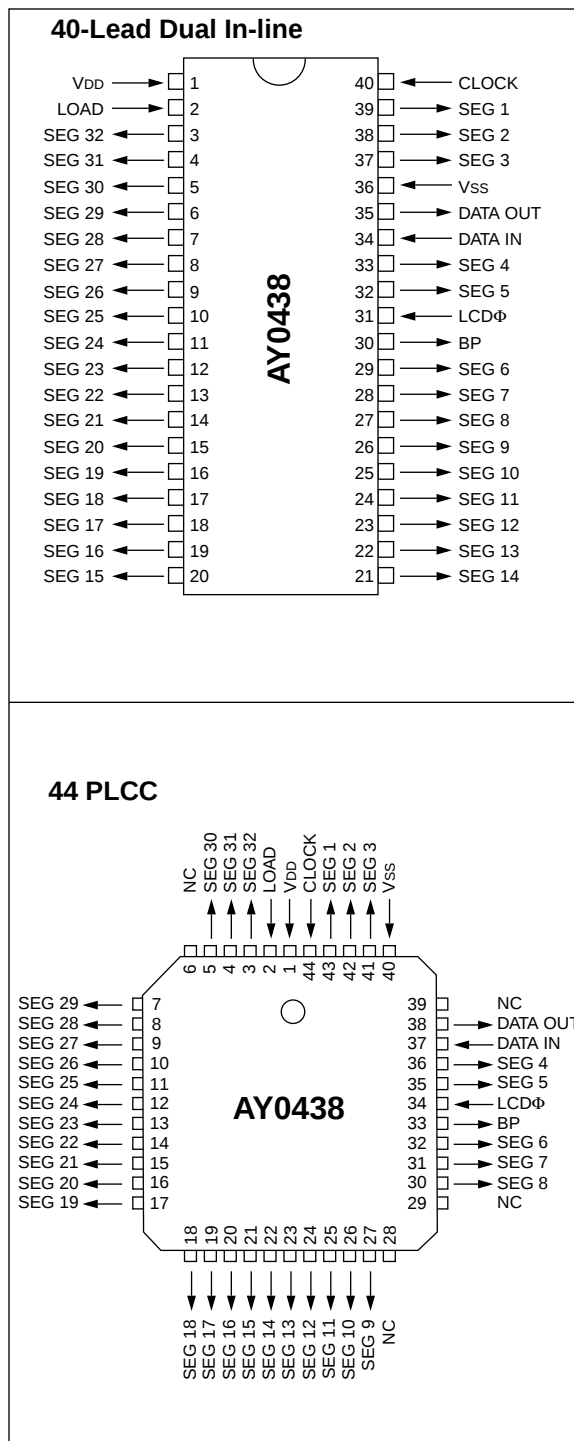
### DESCRIPTION

The AY0438 is a CMOS integrated device that drives a liquid crystal display, usually under microprocessor control. The part acts as a smart peripheral that drives up to 32 LCD segments. It needs only three control lines due to its serial input construction. It latches the data to be displayed and relieves the microprocessor from the task of generating the required waveforms.

The AY0438 can drive any standard or custom parallel drive LCD display, whether it be field effect or dynamic scattering; 7-, 9-, 14- or 16-segment characters; decimals; leading + or -; or special symbols. Several AY0438 devices can be cascaded. The AC frequency of the LCD waveforms can either be supplied by the user or generated by attaching a capacitor to the LCD input, which controls the frequency of an internal oscillator.

The AY0438 is available in 40-lead dual in-line plastic and 44-lead PLCC packages. Unpackaged dice are also available.

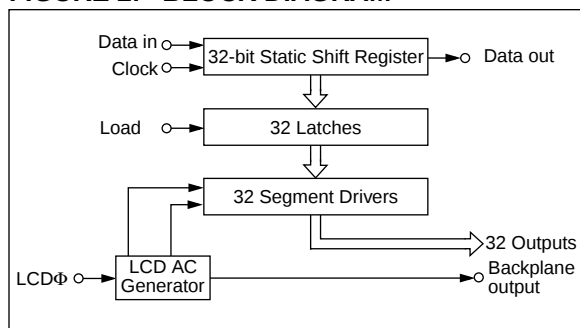
### PIN CONFIGURATION



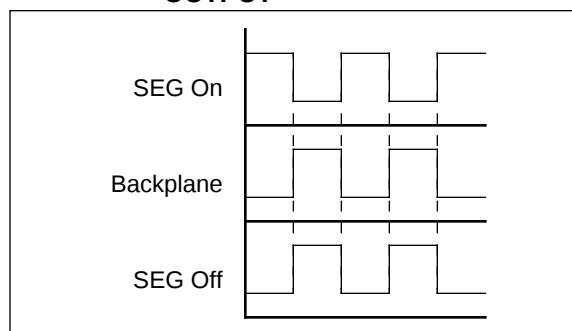
**FIGURE 1: PIN DESCRIPTIONS**

| Pin # (PDIP Only)   | Name     | Direction | Description                     |
|---------------------|----------|-----------|---------------------------------|
| 1                   | VDD      | -         | Supply voltage                  |
| 2                   | Load     | Input     | Latch data from registers       |
| 3-29, 32, 33, 37-39 | Seg 1-32 | Output    | Direct drive outputs            |
| 30                  | BP       | Output    | Backplane drive output          |
| 31                  | LCDΦ     | Input     | Backplane drive input           |
| 34                  | Data In  | Input     | Data input to shift register    |
| 35                  | Data Out | Output    | Data output from shift register |
| 36                  | Vss      | Ground    | Ground                          |
| 40                  | Clock    | Input     | System clock input              |

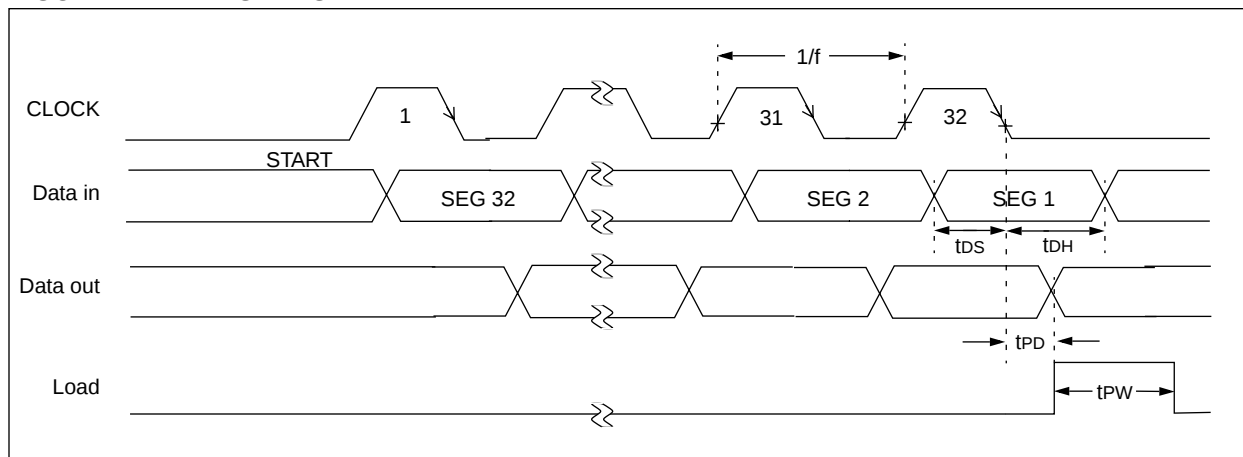
**FIGURE 2: BLOCK DIAGRAM**



**FIGURE 3: BACKPLANE AND SEGMENT OUTPUT**



**FIGURE 4: TIMING DIAGRAM**



## 1.0 OPERATION:

### 1.1 Data In and Clock

The shift register shifts and outputs on the falling edge of the clock. Every clock falling edge does a logical left shift. As an example, if 32 clock pulses are supplied as in Figure 4, then the data input at the first clock will output at SEG 32, and the last data input (# 32) will output at SEG 1 when a LOAD signal is enabled (Figure 2). It is recommended that a complete 32 bit transfer be done every time the outputs are updated. A logic 1 at the Data In causes the corresponding segment to be

enabled or visible, i.e. the output at Segment Output is 180° out-of-phase with the Backplane output (Figure 3).

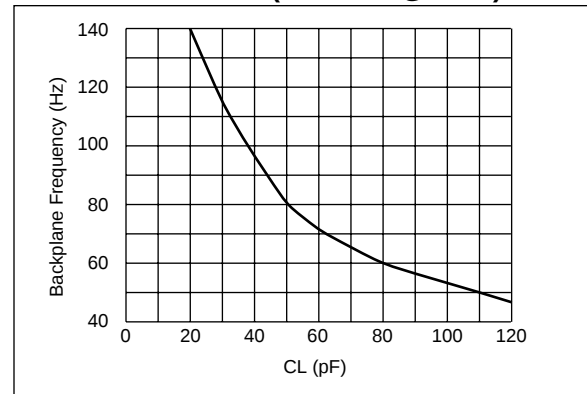
### 1.2 Load

A logic 1 at the Load input (Figure 2) causes the parallel load of the data in the shift register into the latches that control the segment drivers. If the Load signal is tied high, then the latches become transparent and the segment drivers are always connected to the shift registers.

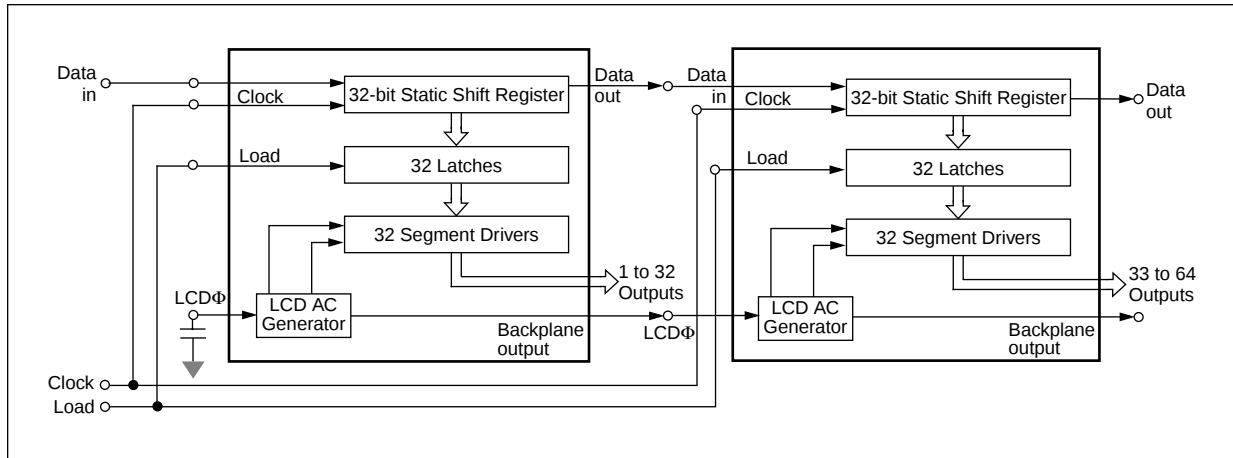
## 1.3 LCD $\phi$

LCD $\phi$  can be driven by an external signal or by connecting a capacitor between LCD $\phi$  and ground (GND), which will enable the on-chip oscillator required to generate the backplane output voltage. Figure 5 shows the relationship between capacitance value and output frequency. Leaving the LCD $\phi$  input unconnected is not recommended. When driven by an external clock, the backplane output is in phase with the input clock. When cascading two AY0438 devices (Figure 6 and Figure 7), the backplane output can be generated using a capacitor to GND on the first AY0438. This backplane output can then be connected to the LCD $\phi$  input of the second AY0438. The backplane output of the second device is then used to drive the backplane of the LCD module.

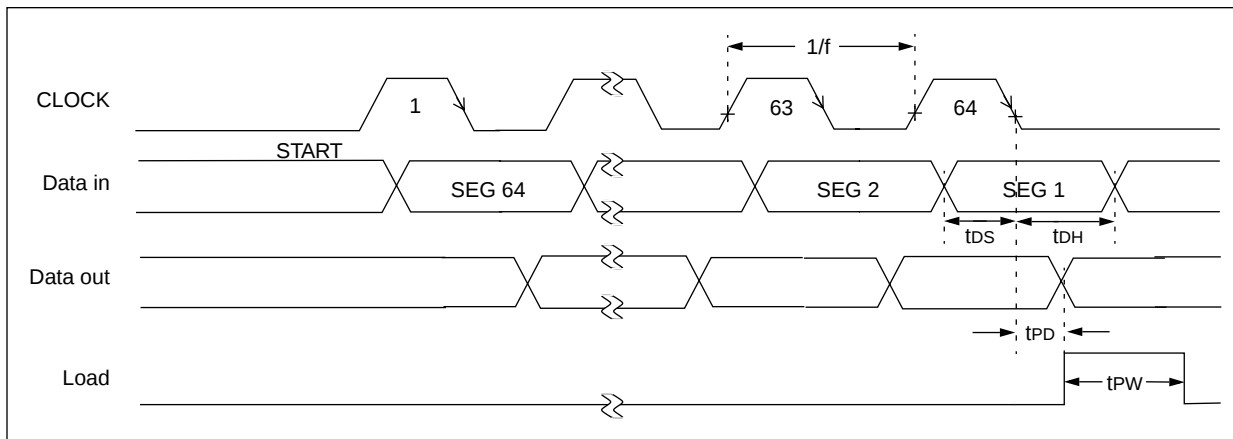
**FIGURE 5: OSCILLATOR FREQUENCY GRAPH (TYPICAL @ 25°C)**



**FIGURE 6: CASCADING TWO AY0438 DEVICES**



**FIGURE 7: CASCADE TIMING DIAGRAM**



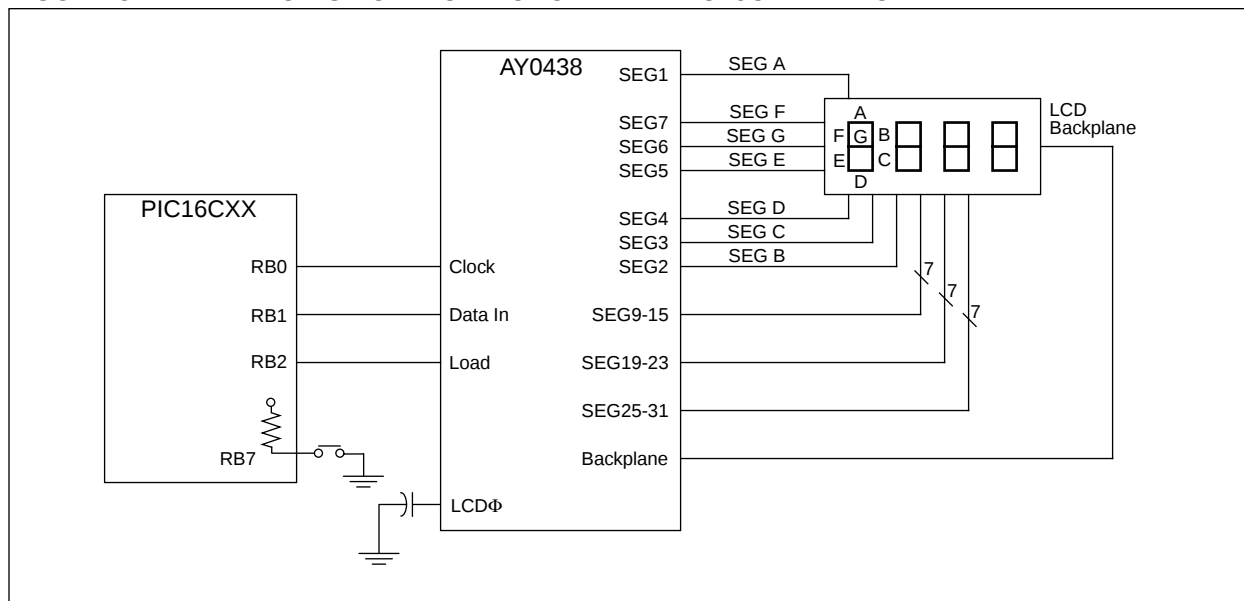
## 1.4 General

In order to avoid any race conditions, the Data In and Load signals should not be changed during a falling edge of the Clock. Figure 4 and Figure 7 show a typical timing diagram for a 32 segment and 64 segment LCD module.

## 1.5 Interfacing to a LCD Module and PIC16CXX Device

Figure 8 shows a typical layout of an AY0438 connected to a LCD module and interfaced to a PIC16CXX family device. Example 1 lists code used to program the PIC16CXX device. This code was compiled using MPASM.

**FIGURE 8: INTERFACING TO A LCD MODULE AND PIC16CXX DEVICE**



### EXAMPLE 1: EXAMPLE CODE

```

;*****
;This program shows an interface between a PIC16CXX device
;and the AY0438 LCD controller to control a 7 Segment
;4 digit LCD module.
;The PIC16CXX interface to the AY0438 Hardware:
;
;    PORTB bit 0 --> CLK
;    PORTB bit 1 --> DATA IN
;    PORTB bit 2 --> LOAD
;
;The LCD module is connected to the AY0438 as follows:
;    Most Significant digit --> seg1 to seg7
;    3rd Significant digit  --> seg9 to seg15
;    2nd Significant digit  --> seg17 to seg 23
;    Least Significant digit --> seg25 to seg 31
;

```

```

;The DP are not connected, but can be connected to seg8, 16, 24 & 32.
;For each digit, the segments are connected as:
;
;    Seg A --> seg(8*n + 1)
;    Seg B --> seg(8*n + 2)
;    Seg C --> seg(8*n + 3)
;    Seg D --> seg(8*n + 4)
;    Seg E --> seg(8*n + 5)
;    Seg F --> seg(8*n + 6)
;    Seg G --> seg(8*n + 7)
;where n = 0, 1, 2 and 3 for MSD, 3rdSD, 2ndSD and LSD respectively.
;The firmware uses the values in registers:
;
;    MSD, THRDSD, SCNDSD and LSD    to determine the values to be
;pulsed to the AY0438.
;In this example, a pushbutton connected to PORTB bit 7
;is checked periodically to see if it has been pressed. If so,
;the LCD values in locations MSD to LSD are updated.
;*****
;
;    list p=16c71,f=inhx8m
;
;
;
MSD      equ      0x20
THRDSD   equ      0x21
SCNDSD   equ      0x22
LSD      equ      0x23
count    equ      0x24
temp     equ      0x25
PORTB    equ      0x06
#define CLK      PORTB,0
#define DATAIN  PORTB,1
#define LOAD     PORTB,2
#define UPDATELCD PORTB,7
w        equ      0
STATUS   equ      0x03
C        equ      0
RP0      equ      5
OPTION   equ      0x81
RBPU     equ      7
PCL      equ      0x02
PCLATH   equ      0x0A
;
;
;
;    org      0
;    goto     start
;    org      0x10
;
;
;This DecodeValue table must reside in page 0 for this program to work
;
DecodeValue
    addwf     PCL
    retlw     B'00111111'    ;decode for 0
    retlw     B'00000110'    ;decode for 1
    retlw     B'01011011'    ;decode for 2
    retlw     B'01001111'    ;decode for 3
    retlw     B'01100110'    ;decode for 4
    retlw     B'01101101'    ;decode for 5

```

```

        retlw    B'01111101'    ;decode for 6
        retlw    B'00000111'    ;decode for 7
        retlw    B'01111111'    ;decode for 8
        retlw    B'01101111'    ;decode for 9
;
;
start
        clrf     PORTB
        bsf      STATUS,RP0      ;set portb 0,1&2 as outputs
        movlw    B'11111000'    ;
        movwf    PORTB          ;
        bcf      OPTION,RBP0     ;enable pull-up for switch
        bcf      STATUS,RP0
wait
        btfsc    UPDATELCD      ;see if update switch is low
        goto     wait           ;no then wait
        bcf      LOAD           ;make sure load is disabled
        movf     LSD,w          ;get least significant value
        clrf     PCLATH         ;PCH = 0
        call     DecodeValue     ;decode the value
        call     Send8          ;serially output the seg values
        movf     SCNDSD,w       ;get 2nd significant digit
        call     DecodeValue     ;decode it
        call     Send8          ;serially output it
        movf     THRDSD,w       ;get 3rd significant digit
        call     DecodeValue     ;decode it
        call     Send8
        movf     MSD,w          ;get Most significant value
        call     DecodeValue     ;decode it
        call     Send8          ;serially send it
        bsf      LOAD           ;toggle the LOAD line
        bcf      LOAD           ;to enable the latches
KeyReleased
        btfss    UPDATELCD      ;wait for key to be released
        goto     KeyReleased
        goto     wait           ;repeat loop.
;
;Send8, sends the 8 bits in the W register
Send8
        movwf    temp           ;save in temp
        movlw    .8             ;init count
        movwf    count          ;to 8
sendloop
        bcf      DATAIN        ;make sure DATAIN is low
        rrf      temp           ;rotate value through carry
        btfsc    STATUS,C       ;if bit clear then skip
        bsf      DATAIN        ;else set data bit
        bsf      CLK            ;toggle clock
        bcf      CLK            ;
        decfsz   count          ;see if 8 done
        goto     sendloop       ;no then do all
        return                  ;else return

end

```

## 2.0 ELECTRICAL CHARACTERISTICS

### Maximum Ratings\*

|                                       |                                          |
|---------------------------------------|------------------------------------------|
| V <sub>DD</sub> .....                 | -0.3V to +12V                            |
| Inputs (CLK, Data In, Load) .....     | V <sub>CC</sub> to V <sub>DD</sub> +0.3V |
| LCDΦ Input .....                      | -0.3V to V <sub>DD</sub> +0.3V           |
| Power Dissipation.....                | 250 mW                                   |
| Storage Temperature.....              | -65°C to +125°C                          |
| Operating Temperature Industrial..... | -40°C to +85°C                           |

\* 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 Conditions. 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.

**TABLE 2: DC CHARACTERISTICS**

| V <sub>DD</sub> = +5V unless otherwise noted, T <sub>A</sub> = 40°C to +85°C |                        |                     |      |                     |       |                                                           |
|------------------------------------------------------------------------------|------------------------|---------------------|------|---------------------|-------|-----------------------------------------------------------|
| Characteristics                                                              | Sym                    | Min                 | Typ  | Max                 | Units | Conditions                                                |
| Supply Voltage                                                               | V <sub>DD</sub>        | +3.0                | —    | +8.5                | V     |                                                           |
| Supply Current                                                               | I <sub>DD</sub>        | —                   | 25   | 60                  | μA    | LCDΦ OSC < 15 kHz                                         |
|                                                                              |                        | —                   | 13   | 30                  | μA    | LCDΦ OSC < 100 Hz                                         |
| Input High Level                                                             | V <sub>IH</sub>        | 0.5 V <sub>DD</sub> | —    | V <sub>DD</sub>     | V     |                                                           |
| Input Low Level                                                              | Clock V <sub>IL1</sub> | 0                   | —    | 0.1 V <sub>DD</sub> | V     | 3.0V ≤ V <sub>DD</sub> ≤ 8.5V                             |
|                                                                              | Data, V <sub>IL2</sub> | 0                   | —    | 0.1 V <sub>DD</sub> | V     | 3.0V ≤ V <sub>DD</sub> ≤ 8.5V                             |
| Input Leakage Current                                                        | Load I <sub>L</sub>    | —                   | 0.01 | ±10                 | μA    | V <sub>IN</sub> = 0V and +5.0V                            |
| Input Capacitance                                                            | C <sub>I</sub>         | —                   | —    | 5.0                 | pF    | V <sub>DD</sub> = +5.0V                                   |
| Segment Output Voltage                                                       | V <sub>OH</sub>        | 0.8 V <sub>DD</sub> | —    | V <sub>DD</sub>     | V     | I <sub>OH</sub> = -100 μA                                 |
|                                                                              | V <sub>OL</sub>        | 0                   | —    | 0.1 V <sub>DD</sub> | V     | I <sub>OL</sub> = 100 μA                                  |
| LCDΦ Input High Level                                                        | V <sub>IN</sub>        | 0.9 V <sub>DD</sub> | —    | V <sub>DD</sub>     | V     |                                                           |
| LCDΦ Input Low Level                                                         | V <sub>IL</sub>        | 0                   | —    | 0.1 V <sub>DD</sub> | V     |                                                           |
| LCDΦ Input Leakage                                                           | I <sub>L</sub>         | —                   | —    | 10                  | μA    | V <sub>IN</sub> = 0V and +5.0V<br>V <sub>DD</sub> = +5.0V |

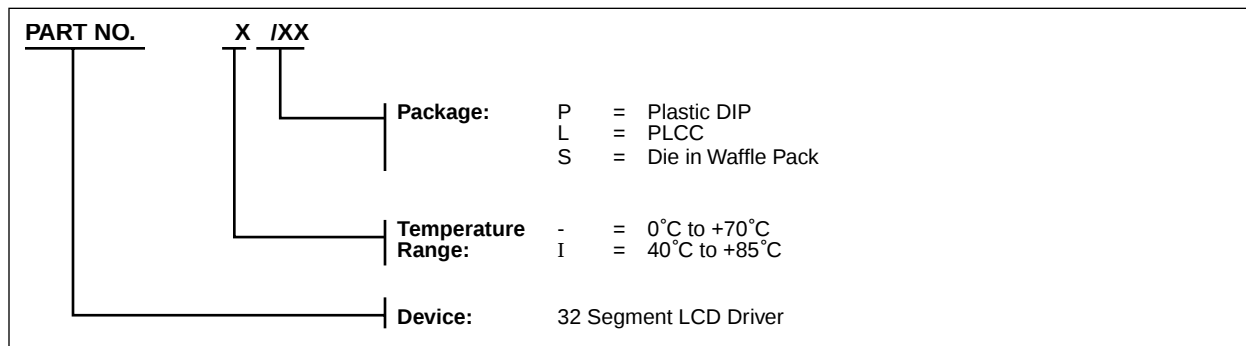
**TABLE 3: AC CHARACTERISTICS**

| Characteristics      | Sym             | Min | Typ | Max | Units | Conditions                      |
|----------------------|-----------------|-----|-----|-----|-------|---------------------------------|
| Clock Rate           | f               | DC  | —   | 1.5 | MHz   | 50% duty cycle                  |
| Data Set-up Time     | t <sub>DS</sub> | 150 | —   | —   | nsec  | Data change to Clk falling edge |
| Data Hold Time       | t <sub>DH</sub> | 50  | —   | —   | nsec  |                                 |
| Load Pulse Width     | t <sub>PW</sub> | 175 | —   | —   | nsec  |                                 |
| Data Out Prop. Delay | t <sub>PD</sub> | —   | —   | 500 | nsec  | C <sub>L</sub> = 55 pF          |

NOTES:

## AY0438 Product Identification System

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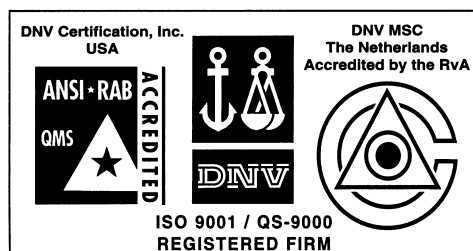
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