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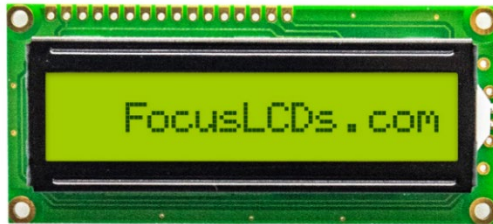
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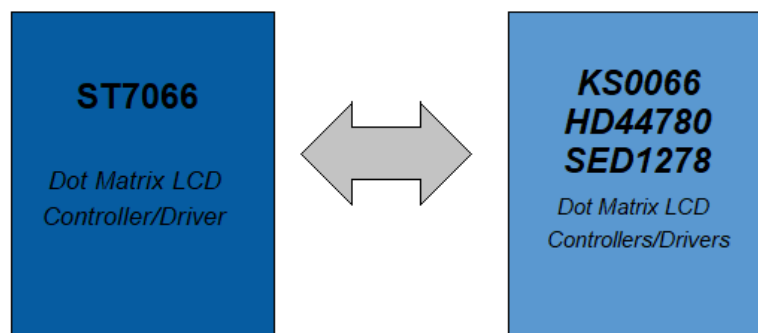
Character LCD Controller Compatibility for ST7066

Character LCD Controller Compatibility: ST7066

The note will discuss the controllers that are compatible with the ST7066 IC that is standard in Focus LCD character LCD displays. The interface for these displays is a 4/8-bit parallel connection used to communicate with the ST7066 controller. The displays are initialized through a sequence of commands defined by the controller's CGRAM to specify functions and characters. The commands used are a standard set seen in other character LCD IC controllers such as KS0066U, HD44780 and SED1278. The specification sheet for Focus LCD's character displays lists the controller as "ST7066 or equivalent. This resource will discuss some of the common equivalent controllers to ST7066.



The character LCD drivers embedded in the display are configured by the same method and commands specified in the data sheet of the controller. Each of these driver IC's communicate through 4/8-bit command and data sequences which can be interfaced with an 8-bit microcontroller. Features such as RAM, character generation, and LCD driving are internally provided by each of these controllers. The microcontroller used to communicate with these controllers can be minimal because the resources are included internally.



The commands and pin functionality are the same between controllers. Voltage ranges are compatible but should be verified for each display. The voltage is specified in ranges for operation voltage and drive voltage. Voltage maximum and minimums should be confirmed when interfacing with an equivalent controller.

Controller Comparison

The differences between each of the controllers will be minimal but are highlighted in this reference for troubleshooting purposes. These differences should not become an issue for most drop in equivalent controllers but can occur at maximum operating conditions. The errors derive from timing and delay variations and can be avoided with small adjustments to the program sequence.

Below is a review of the specifications of each of the controllers that have compatibility with the ST7066 IC. These are only a few examples of common character LCD controllers that share functionality and pin availability with the ST7066 chip but are not the only compatible drivers.

Parameter	ST7066	KS0066U	HD44780	SED1278	Unit
Interface	4/8				bit
Operating Voltage	2.7-5.5	2.7-5.5	2.7-7.0	3.0-7.0	V
LCD Drive Voltage	3.0-10.0	3.0-13.0	3.0-13.0	3.0-7.0	V
Display Data RAM	80				bytes
Character RAM	64				characters
Character ROM	240	236	240	240	characters
Pixel Fonts	5x8 / 5x11		5x8 / 5x10		pixels
Busy Flag Active After Power Up	20	30	15	30	ms
Duty Cycle	1/8, 1/11, 1/16				--
Oscillator Frequency (TYP.)	270		250		kHz
Enable Pulse Width	150	230	450	220	ns
No. of Instructions	11				--
Segment Outputs	40				SEG
COM Outputs	16				COM

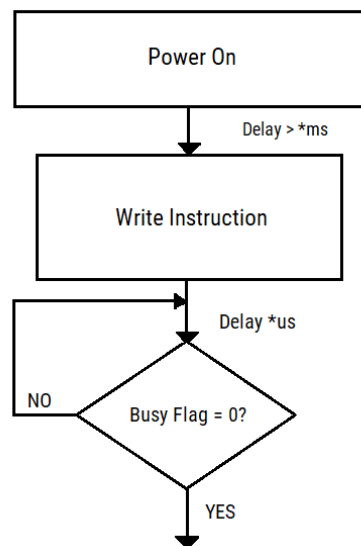
It can be seen in the specifications that each controller has the same interface, duty cycles, and memory types. The instructions sent to the display will be the same for each controller. There should be no changes in the commands used to communicate with any of the compatible controllers.

Some differences between the devices are in character size, busy flag delay times and acceptable voltage ranges. These differences are often not significant enough to cause issues when using one driver over another. The errors largely occur when operating the device at maximum recommended oscillator frequency.

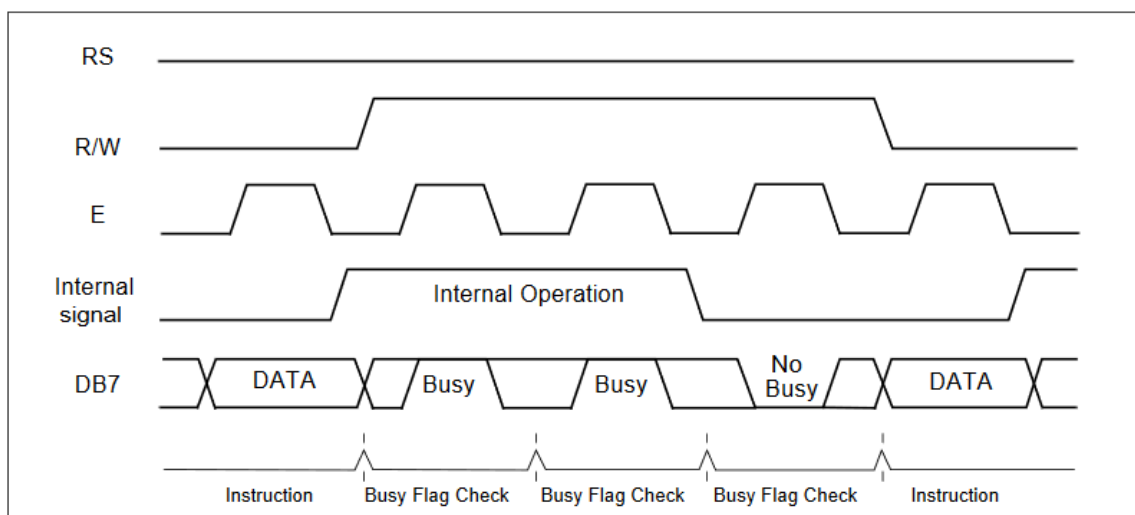
These error and inconsistencies in display data can be avoided by properly timing signals and ensuring the busy flag has enough time to turn off before sending the next instruction. This can be done by adding delays or lowering oscillator frequencies at certain times in the programming sequence.

Power on Timing

When switching between compatible character ICs, it is important to consider the delay time after reset. An automatic reset occurs on power up. There is a delay to reach a specified voltage threshold and a delay for the system to run the initializing command sequence. During this time, the display sets the busy flag active and no commands can be sent. A brief delay can be added after power up to prevent this error. This will allow enough time for the initialization sequence to complete and set the busy flag low.



The controllers can vary in required delay times from after this initialization begins to when the display can accept commands. The delay after the power on sequence is determined by the input oscillator frequency and the number of clock cycles it takes to complete these commands. It is important to check the datasheet for the individual controller to confirm this delay requirement is met. A delay of 250ms at the start of the programming sequence will be sufficient for all compatible controllers and microcontroller operating frequencies.



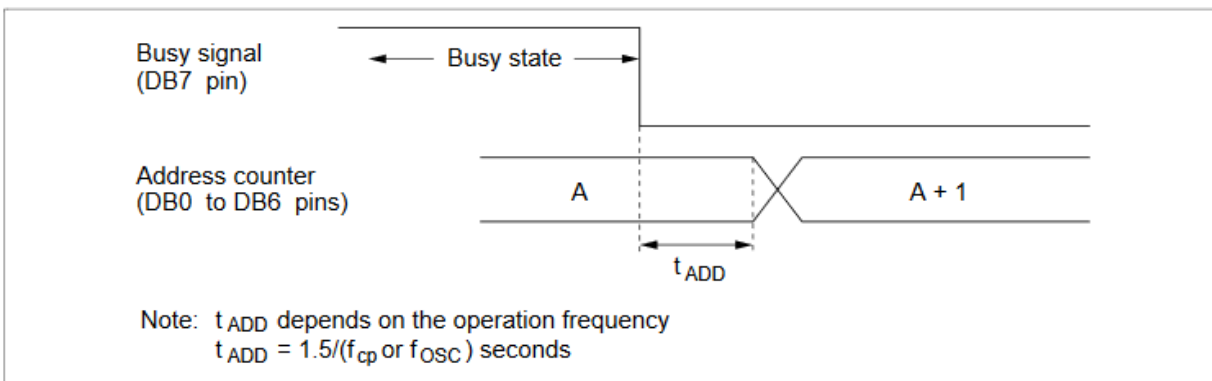
Below is a table of the delays specified in the initialization sequence for each of the compatible controllers. During this time, the busy flag will be active, and no commands will be accepted. This can cause issues if commands are sent immediately after powering on the device. Specified delays should be added after power up and before any commands are sent to the device in order to ensure the initialization process has had enough time to complete.

f_{osc}	ST7066	KS0066	HD44780	SED1278	Unit
270MHz	20	30	10	10	ms

If the power up initialization fails to complete, the initialization commands will need to be sent by the microcontroller to properly initialize the chip. The reset initialization will fail if the power supply conditions and the power on delay requirements are not met as specified in the datasheet of the controller.

Address Counter Increment/Decrement Timing

After execution of read or write operations into RAM, the RAM address counter is incremented or decremented by 1. This changes the position of the cursor and the location in memory in the RAM. If not executed while the busy flag is low, an error in the location of the cursor or memory may occur. The RAM address counter will only be updated after the busy flag turns off.



The time elapsed after the busy flag turns off and the address counter is updated may vary between devices. This is represented as t_{ADD} in the figure above. The busy flag status can be read at pin DB7 when $RS=0$ and $RW=1$. If the busy flag is returned as 1, it may be necessary to half the frequency of the oscillator before executing the next instruction. If the busy flag is not checked, a delay should be included to ensure the instruction has enough time to execute.

The time after writing or reading RAM data and changing the address counter for each of the controllers is listed in the data sheet of the specified controller. During this time, the busy flag will be active, and no instructions will be accepted.

If the busy flag is active during this period of changing the cursor and the address counter, you will notice that the cursor may be in the wrong position. If you notice that this occurs on your display, you should verify that the address counter increment/decrement timing requirements are met specified by the controller datasheet.

Command Descriptions and Timings

The ST7066 controller and the equivalent drivers mentioned in this resource have 11 commands that can be programmed to specify functionality of the display. These commands are the same for all of the controllers mentioned. There are slight timing differences in the execution of these commands. The command descriptions and controller timings are compared below.

Instruction	Description	ST7066	KS0066	HD44780	SED1278
Clear Display	Writes 20H to RAM and set RAM address to 00H from address counter	1.52ms	1.53ms	1.52ms	1.51ms
Return Home	Sets RAM address to 00H in address counter and return cursor to original position	1.52ms	1.53ms	1.52ms	1.51ms
Entry Mode Set	Sets cursor direction and display shift direction	37us	39us	37us	37us
Display ON/OFF	Turns display and cursor on or off	37us	39us	37us	37us
Cursor or Display Shift	Set cursor and display shift control bit and direction	37us	39us	37us	37us
Function Set	Set interface	37us	39us	37us	37us
Set CGRAM Address	Set CGRAM address in address counter	37us	39us	37us	37us
Set RAM Address	Set RAM address in address counter	37us	39us	37us	37us
Read Busy Flag and Address	Read busy flag and contents of the address counter	0us	0us	0us	0us
Write Data to RAM	Write into internal RAM	43us	43us	37us	37us
Read Data from RAM	Read from internal RAM	43us	43us	37us	37us

Note: MCU $f_{osc}=270kHz$

The execution time for each of these commands changes as the microcontroller oscillator frequency changes. With a slower frequency oscillator these command execution times will increase. The command execution timing differences for each of the drivers typically will not cause an issue between devices.

If an instruction is sent while the busy flag is high, the overall time between the first instruction and next instruction will be longer than the initial instruction time by itself. This is why it is important to check to busy flag and meet the minimum time requirements as referenced in the table and datasheets.

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