HT162x Application Guidelines

D/N：AN0468E

Introduction

Holtek's HT162x series of devices are a range of LCD drivers which can drive multiple displays and which can also directly map their internal RAM to the LCD corresponding LCD display. These devices also include serial communication, a WDT and Time Base functions. A tone function provides a fixed frequency output and an integrated power saving mode greatly reduces power consumption, making the devices suitable for LCD display driving product applications such as meters, home appliances, car instrumentation and industrial instrumentation.

This guideline will first introduce the HT162x series LCD driving MCUs principles of operation and then introduce some application methods and notes.

Functional Description

According to LCD driving principles, an AC voltage needs to be applied to both COM and SEG pins to drive the LCD. If only a DC voltage is applied to an LCD segment then the liquid crystal may experience permanent damage over time. The LCD display contrast is determined by the RMS value of the voltage on the COM pin minus the voltage applied to the SEG pin. This differential RMS voltage must be greater than the LCD saturation voltage for the pixel to be on and less than the threshold voltage for the pixel to be off. The LCD driver will generate the simulation drive waveform required for LCD lighting by using system control, and the corresponding pixel to achieve a display effect.

The HT162x series will provide multiple COM and SEG output selections for different LCD displays. The specific differences are indicated in the following selection table.

The HT162x series selection table：

	HT1620	HT1621	HT1622	HT16220	HT1623	HT1625	HT1626
Operation Voltage	2.4~3.3V	2.4~5.2V	2.7~5.2V	2.7~5.2V	2.7~5.2V	2.7~5.2V	2.7~5.2V
LCD Voltage	3/2 V_{DD}	≤ V_{DD}	≤ V_{DD}	≤ V_{DD}	≤ V_{DD}	≤ V_{DD}	≤ V_{DD}
Display RAM	32×4 bits	32×4 bits	64×4 bits	64×4 bits	96×4 bits	128×4 bits	192×4 bits
COM	4	4	8	8	8	8	16
SEG	32	32	32	32	48	64	48
Bias	1/2 or 1/3 bias	1/2 or 1/3 bias	1/4 bias	1/4 bias	1/4 bias	1/4 bias	1/5 bias
Duty	1/2 or 1/3 or 1/4 duty	1/2 or 1/3 or 1/4 duty	1/8 duty	1/8 duty	1/8 duty	1/8 duty	1/16 duty
Built-in Osc.	—	√	√	—	√	√	√
Crystal Osc.	√	√	—	√	√	√	√

Operating Principles

The HT162x series LCD driving MCUs support serial communication. The master can carry out READ, WRITE, READ-MODIFY-WRITE operations by sending the corresponding configuration commands and also set the LCD screen display effects by setting the operating frequency, Time Base, WDT, LCD On/Off etc. The HT162x series communication modes and some functional operations will be described in the following section.

HT162x Serial Communication

The HT162x series supports serial communication which contains three serial communication pins $\overline{RD}$, $\overline{WR}$, DATA, and a chip select signal $\overline{CS}$ pin. The pin functions are shown in the following table:

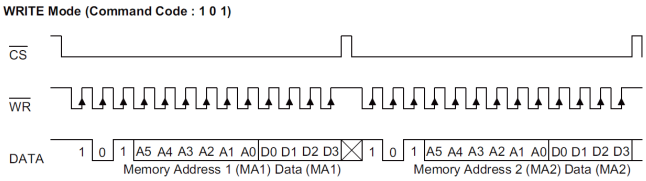
Pin Name	Input/Output	Pin Function Description
$\overline{CS}$	Input	Chip select signal. When $\overline{CS}$ is logic high, the data and commands to read from or write to the HT162x series are invalid. When $\overline{CS}$ is logic low, the data and commands to read from or write to the HT162x series are valid.
$\overline{RD}$	Input	READ clock signal. The HT162x data is output on the DATA pin at the falling edge of the $\overline{RD}$ signal, the master can read the data at the rising edge of the $\overline{RD}$ signal.
$\overline{WR}$	Input	WRITE a clock signal, data on the DATA pin is written to the HT162x at the rising edge of the WR $\overline{WR}$ signal.
DATA	Input/Output	Serial Data

When $\overline{CS}$ is high, communication between the HT162x and the master is disabled. When $\overline{CS}$ is low, serial communication is enabled. DATA is a serial data input /output pin. Reading and writing data and writing command operations are carried out on the DATA pin.

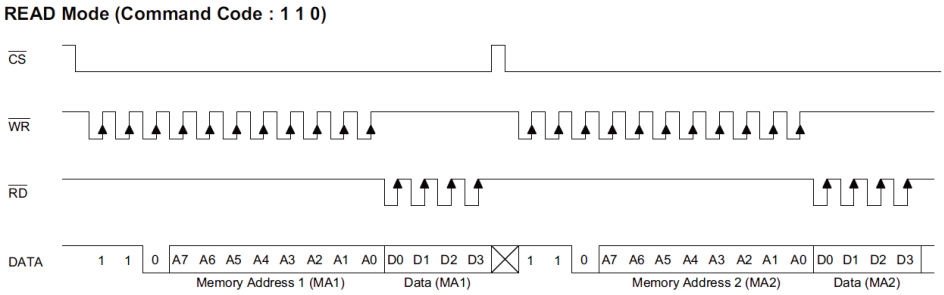
The $\overline{RD}$ pin is a READ clock input pin. The data is output on the DATA pin at the falling edge of the $\overline{RD}$ signal. The master can read data between the rising edge of the $\overline{RD}$ signal and the next falling edge when $\overline{RD}$ is high.

The $\overline{WR}$ pin is a WRITE clock input pin. The Data, address, and command on the DATA pin are written to the HT162x at the rising edge of the $\overline{WR}$ signal.

When writing to the HT162x, the input clock for the write command or data is derived from the $\overline{WR}$ pin. The timing diagram for writing data is as follows:



To read display the RAM data from the HT162x, the READ input clock is derived from the $\overline{RD}$ pin. The timing diagram for reading data is as follows:



HT162x READ/WRITE Operations

Before the HT162x operates, it needs to send an operation code to indicate what kind of status is required for operation. The operation codes are defined in the following table.

Operation	Status	Operation Code
READ	Data	110
WRITE	Data	101
READ - MODIFY - WRITE	Data	101
Control	Command	100

The process to writing a single section of RAM data is shown as follows:

DATA	1	0	1	A5	A4	A3	A2	A1	A0	D0	D1	D2	D3

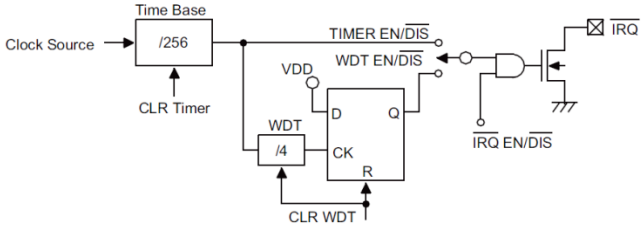
A write data operation should first place data on the DATA pin and then generate a WRITE clock signal on the $\overline{WR}$ pin. After this the data should be presented bit by bit until all of them have been written. During the write process, first send an operation code 101, indicating that a write operation is to be execute, after which the corresponding display RAM address code A5~A0 should be sent. D0~D3 is the corresponding display data to write display data to LCD. If the bit is "1", it will illuminate the corresponding display bit, while for a "0", the corresponding bit will not be displayed.

The process for continuously writing RAM data is shown as follows:

DATA	1	0	1	A5	A4	A3	A2	A1	A0	D0	D1	D2	D3	D0	D1	D2	D3	D0 …
				Memory Address (MA)						Data(MA)				Data(MA+1)				…

A continuous write operation requires only the start address, which will automatically be incremented by one after the operation has completed. During a read process, except for different operation codes, the READ clock input is the $\overline{RD}$ pin.

HT162x Timer and WDT Functions



Timer and WDT Structure

The Time base generator and WDT share the same divided counter. The Time base generator can be enabled by the TIMER EN or WDT EN command. When the $\overline{IRQ}$ EN and WDT EN commands are enabled, the system clock will pass through WDT module after passing through the Time base generator. Once a WDT time-out occurs, the $\overline{IRQ}$ pin will remain at a logic low level until the CLR WDT or the $\overline{IRQ}$ DIS command is issued. If the TIMER EN command is enabled, the system clock will be directly output on the $\overline{IRQ}$ pin after passing through Time base generator. The $\overline{IRQ}$ pin will be disabled and remain in a floating state following an $\overline{IRQ}$ DIS command.

If an external clock is selected as the system clock source, the SYS DIS command is invalid and the power down mode will not be entered. In the Power down mode, the Time base and WDT functions are disabled.

HT162x Tone Output

The Tone output function provides a fixed frequency output driving signals on the BZ and $\overline{BZ}$ pins for driving piezoelectric buzzers or for applications that require a fixed frequency. A 4kHz or 2kHz output frequency can be selected by software using the TONE 4K or TONE 2K commands. Once the system clock is disabled or the Tone output function is switched off, the BZ and $\overline{BZ}$ output will remain at a low level. The following table lists the related control commands for Tone output functions. TONE ON is the specific TONE output command for the HT1621. Other HT162x series MCUs only need to turn on the Tone output function to output the corresponding frequency by directly software configuring the TONE 4K or TONE 2K commands

Operation	Operation Code	Command Code		Function	Power-on Reset
TONE OFF	100	0000-1000-X	Command	Turn off Tone output function	Yes
TONE ON	100	0000-1001-X	Command	Turn on Tone output function	
TONE 4K	100	010X-XXXX-X	Command	Tone output frequency 4kHz	
TONE 2K	100	011X-XXXX-X	Command	Tone output frequency 2kHz	

HT162x LCD Driving Operation

The HT162x series provide multiple SEG and COM selections for driving different LCD display screens. The following section will take the HT1621 as an example to show how the HT1621 drives an LCD.

The HT1621 is a 128 pattern (32×4) LCD driver, which can be configured with 1/2 or 1/3 Bias and 1/2, 1/3 or 1/4 Duty by software to make it suitable for multiple LCD display types. The LCD driving clock is derived from the system clock, which can be a selected external clock, a 32768 crystal oscillator or an internal RC oscillator.

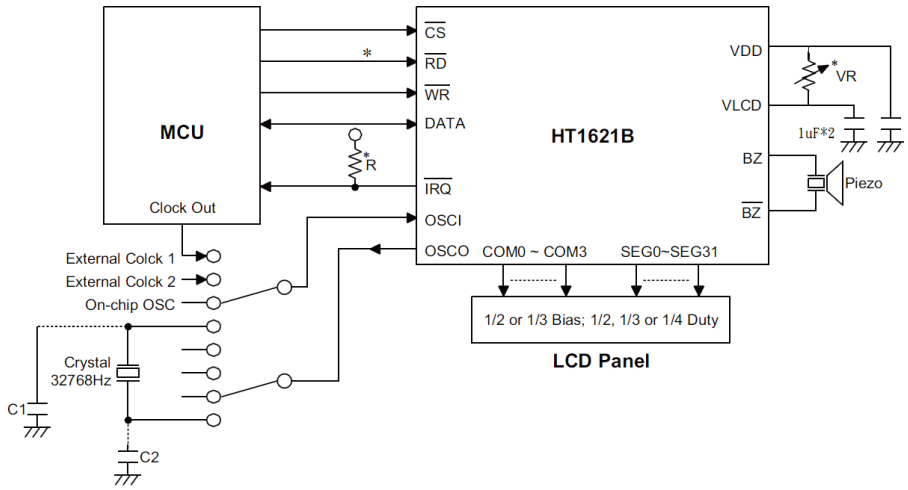
The master can send the BIAS and COM commands to the HT1621 and set the BIAS and Duty of the driving waveform. LCD ON/OFF commands are used to control the on/off switching of the LCD bias generator to control the LCD display. The related configuration commands for the HT1621 LCD driver are shown in the following table:

Operation	Operation Code	Command Code	Status	Function	Power-on Reset
LCD OFF	100	0000-0010-X	Command	Turn off LCD output function	Yes
LCD ON	100	0000-0011-X	Command	Turn on LCD output function	
BIAS & COM	100	0010-abXc-X	Command	c=0: 1/2 bias option c=1: 1/3 bias option ab=00: 2 commons option ab=01: 3 commons option ab=10: 4 commons option	

Hardware Description

Application Circuits

The HT162x driving MCUs will be connected to the master interface with 4 or 5 wires, which can realise communication between the master and the driving MCUs to control the LCD display. Taking the HT1621 as an example, the application circuit is shown in the following figure.



Note: The connection of the $\overline{IRQ}$ and $\overline{RD}$ pins can be selected according to the specific MCU requirements.

The voltage applied to the power pin VLCD must be equal or lower than V_{DD}.

Adjust VR to match the user LCD panel display voltage (VLCD)

The power pins VDD and VLCD should be connected to a 1μF filter capacitor. The capacitor should be located as close the pins as possible.

In order to obtain an accurate frequency, the C1 and C2 capacitors can be increased in value. The capacitors value should be determined according to the crystal oscillator error. Refer to the values in the following table.

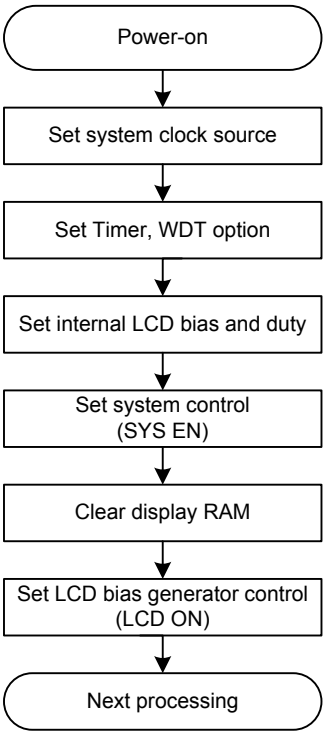
Crystal oscillator error	Capacitor value
±10ppm	0~10p
10~20ppm	10~20p

Software Description

HT162x Operation flow

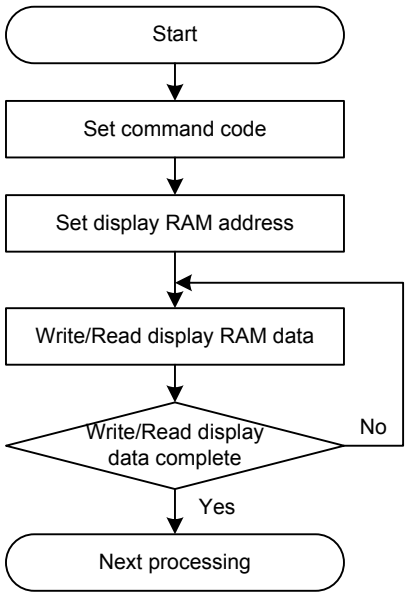
Initialisation

The initialisation flow chart for HT162x is shown in the following figure. After the system has been powered on, first select the 32.768kHz crystal oscillator, the internal RC oscillator or the external clock as the system clock source. Then set the Timer and WDT functions according to the actual design requirements. The $\overline{IRQ}$ output function will be disabled by default after power on. After setting the LCD Bias and Duty values, turn on the system oscillator using the SYS EN command. Finally, clear the LCD display RAM and then turn on the LCD bias generator. If the LCD bias generator is switched on without first clearing the LCD display RAM, the value of the display RAM will be indeterminate and garbled characters will appear.



Display RAM Read/Write Operations

For display RAM read/write operations, it is only necessary to write the first address. Users can directly read/write to the corresponding address of the display RAM data, the address is automatically incremented by one after the operation has completed. Users can continue to read/write to the display RAM data of the next address. The read/write operation flow chart is shown in the following figure.



Application Notes

First clear RAM in the initialisation process

During initialisation, the HT162x must first clear the LCD RAM and then turn on the LCD display by sending out an LCD On command. This will avoid garbled characters appearing on the LCD after power-on. The main reasons for this are as follows.

After the HT162x is powered on, the internal LCD RAM data is indeterminate. The LCD RAM data is directly mapped to the LCD driver. If the LCD RAM content is not first cleared to zero, the LCD On command will be directly sent to turn on the LCD Bias transmitter, which will cause LCD to display garbled characters.

Therefore before sending LCD On command, turn off all the display points by writing zero to all the LCD RAM values. After clearing RAM is complete, send an LCD On command to turn on the LCD bias generator to avoid garbled characters.

Power Down Order

In practical applications, if power is separately supplied on the VLCD and VDD pins, it is recommended to turn off the LCD driving voltage V_{LCD} before turning off the logic supply voltage V_{DD} during power-down. This will prevent the LCD display from displaying garbled characters due to different power-down sequences when VDD pin is powered off for the following reasons:

First turn off the V_{DD} and then turn off the V_{LCD}. V_{DD} is the IC internal logic power supply. After V_{DD} has been turned off, the HT162x internal LCD bias generator will stop working. COM is the scan signal whose level will stay at a certain level and whose power comes from V_{LCD}. If there is a voltage on the VLCD pin, the COM and SEG pins will have a dropout voltage caused by the garbled characters.

It is recommended to turn off the LCD display by sending an LCD Off command before VDD is powered down. Both the COM and SEG pins are set high and even if there is voltage on the VLCD pin, it will not cause garbled characters to appear on the LCD.

Conclusion

This guideline describes applications for the HT162x series LCD driving MCUs, users can use the HT162x to drive the LCD display according to the specific designs.

Version and Modification Information

Date	Author	Issue and Revision
2017.10.26	Aidi Lan(蓝爱娣)	First Version

Disclaimer

All information, trademarks, logos, graphics, videos, audio clips, links and other items appearing on this website ('Information') are for reference only and is subject to change at any time without prior notice and at the discretion of Holtek Semiconductor Inc. (hereinafter 'Holtek', 'the company', 'us', 'we' or 'our'). Whilst Holtek endeavors to ensure the accuracy of the Information on this website, no express or implied warranty is given by Holtek to the accuracy of the Information. Holtek shall bear no responsibility for any incorrectness or leakage.

Holtek shall not be liable for any damages (including but not limited to computer virus, system problems or data loss) whatsoever arising in using or in connection with the use of this website by any party. There may be links in this area, which allow you to visit the websites of other companies. These websites are not controlled by Holtek. Holtek will bear no responsibility and no guarantee to whatsoever Information displayed at such sites. Hyperlinks to other websites are at your own risk.

Limitation of Liability

In any case, the Company has no need to take responsibility for any loss or damage caused when anyone visits the website directly or indirectly and uses the contents, information or service on the website.

Governing Law

This disclaimer is subjected to the laws of the Republic of China and under the jurisdiction of the Court of the Republic of China.

Update of Disclaimer

Holtek reserves the right to update the Disclaimer at any time with or without prior notice, all changes are effective immediately upon posting to the website.