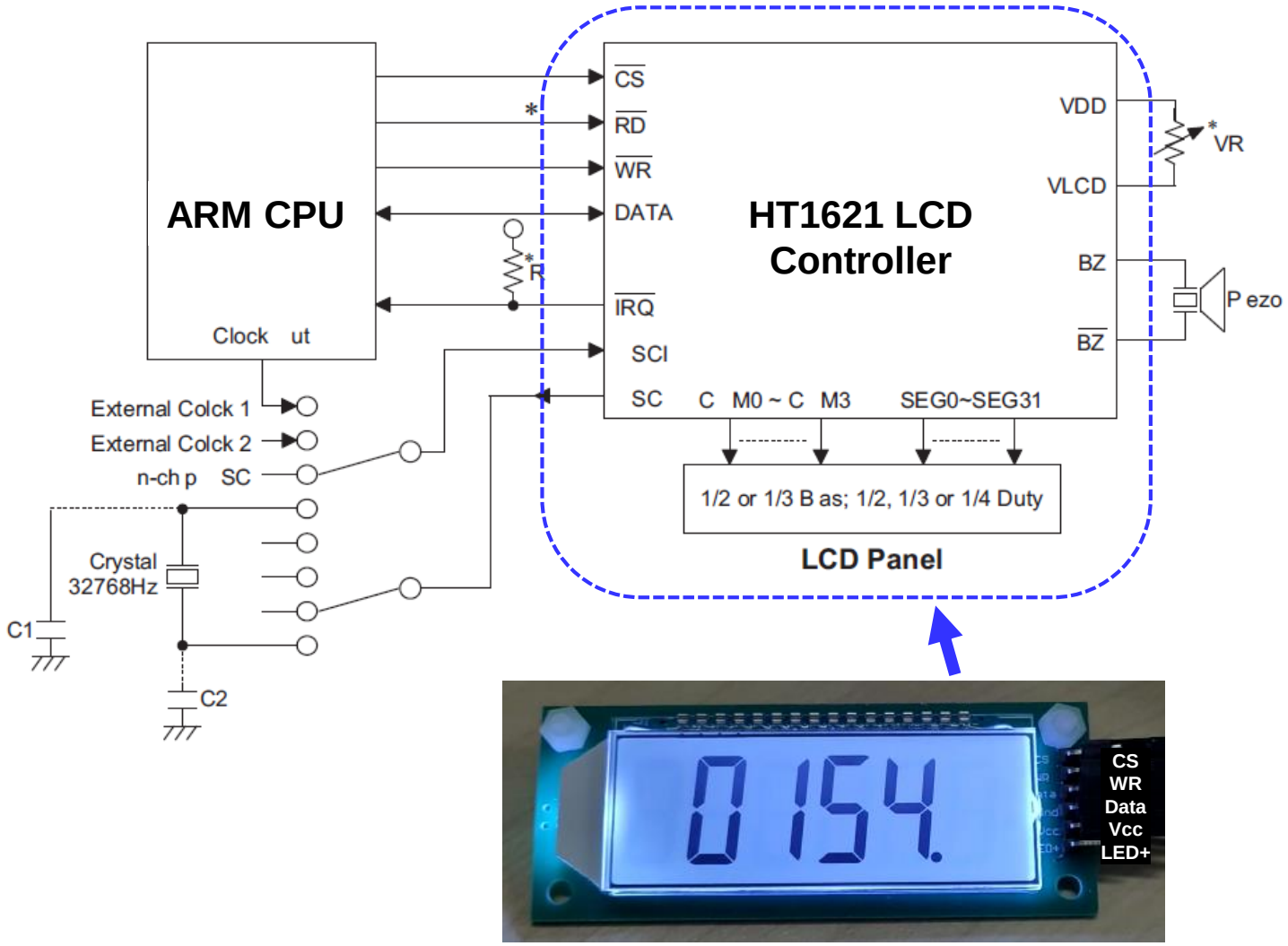
HT1621 LCD Controller & Display

Assignment #2

HT1621 LCD Controller

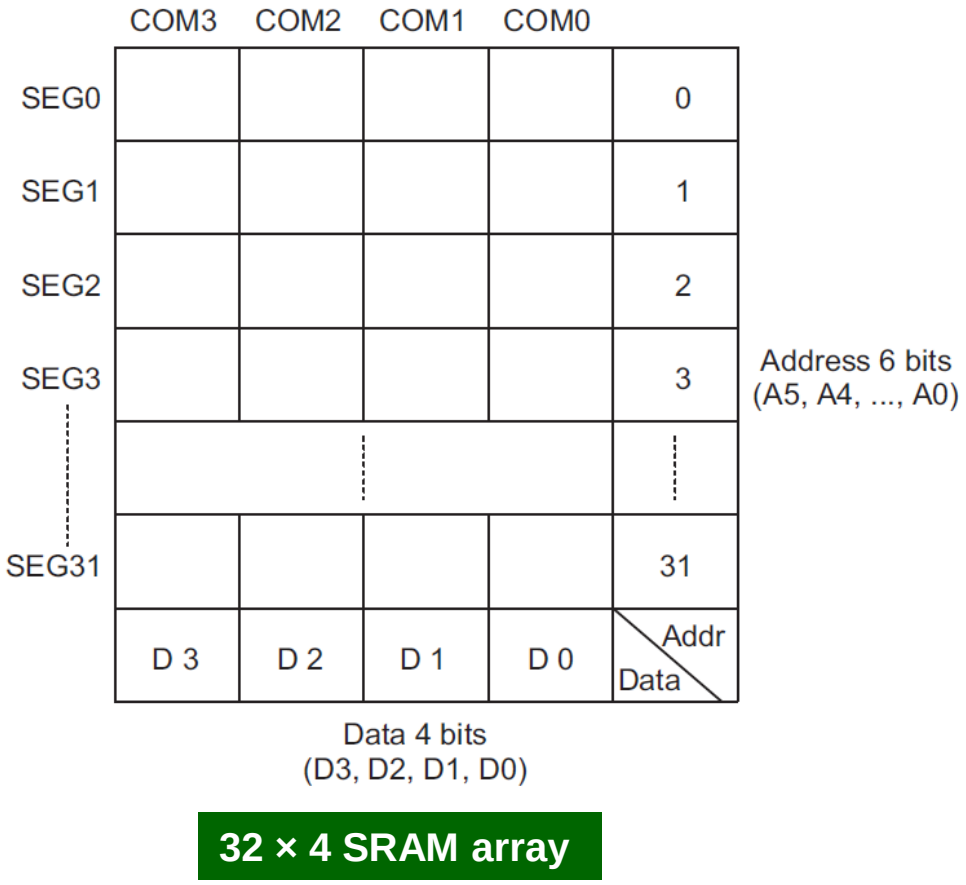
- HT1621 is a RAM-mapping LCD controller.
- Manufactured by Taiwanese company, Holtek.
  - Founded in 1998.
  - Main business in microcontrollers & peripherals.
- RAM size & organization : 32 × 4. The RAM stores the data to be displayed on a LCD.
- Serial communications protocol.
  - SPI subset?
- 4 signal lines are required to access the HT1621:
  - CS (Chip Select)
  - WR (Write)
  - RD (Read)
  - DATA.

HT1621 LCD Controller



LCD Display Memory Mapping

- Display memory is organized as a **32 × 4 array** of RAM.
- The RAM stores the data to be displayed to the LCD display.
- Contents of the RAM are mapped directly to the contents of the LCD.
- Contents of the RAM can be accessed through WRITE, READ, or READ-MODIFY-WRITE commands.



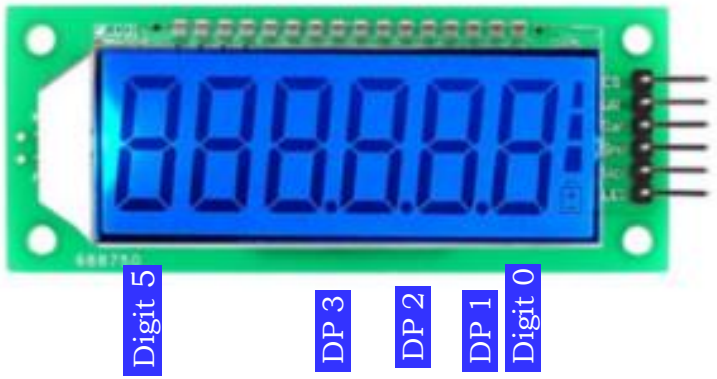
LCD Display Memory Mapping [1/2]

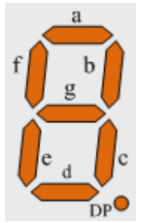
SEG0 to SEG11

COM0 to COM3

SEG / COM	0	1	2	3	4	5	6	7	8	9	10	11
D0	DP1	0D	DP2	1D	DP3	2D	BAT1	3D	BAT2	4D	BAT3	5D
D1	0C	0E	1C	1E	2C	2E	3C	3E	4C	4E	5C	5E
D2	0B	0G	1B	1G	2B	1G	3B	3G	4B	4G	5B	5G
D3	0A	0F	1A	1F	2A	2F	3A	3F	4A	4F	5A	5F

DP1: The first decimal point starting from the right side
DP2: The second decimal point starting from the right side
DP3: The third decimal point starting from the right side
BAT1: The battery icon and the bottom grid for the power
BAT2: the middle grid
BAT3: the top grid

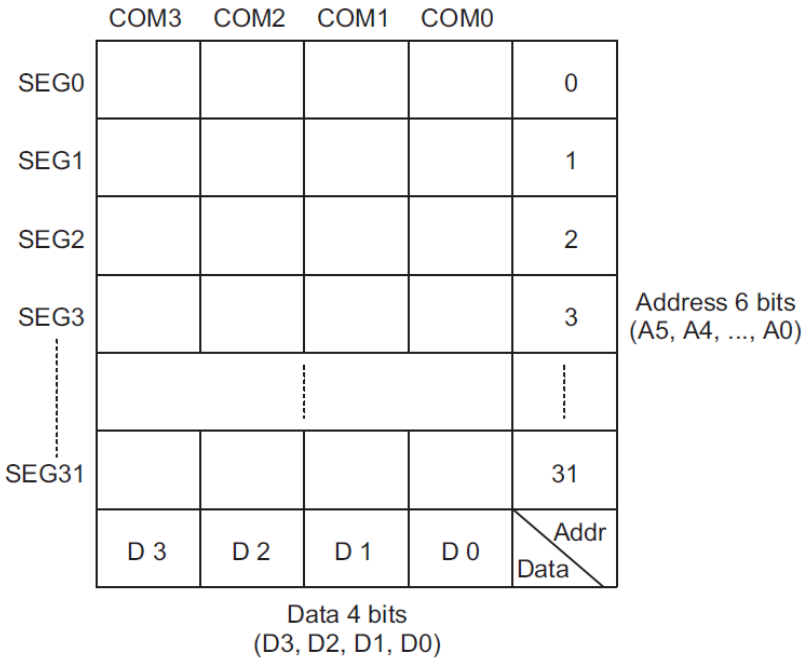


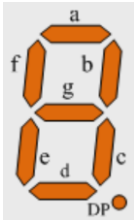


7-SEG DISPLAY

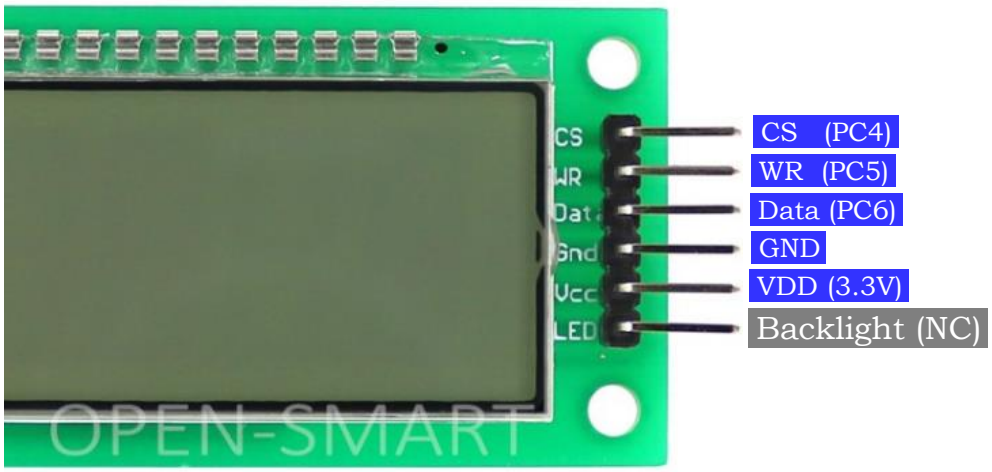
LCD Display Memory Mapping [2/2]

SEG	COM3	COM2	COM1	COM0	Addr (0x)
0	0A	0B	0C	DP1	0
1	0F	0G	0E	0D	1
2	1A	1B	1C	DP2	2
3	1F	1G	1E	1D	3
4	2A	2B	2C	DP3	4
5	2F	2G	2E	2D	5
6	3A	3B	3C	BAT1	6
7	3F	3G	3E	3D	7
8	4A	4B	3C	BAT2	8
9	4F	4G	4E	4D	9
10	5A	5B	5C	BAT3	A
11	5F	5G	5E	5D	B
Data	**D3**	**D2**	**D1**	**D0**	





LCD Connections to LaunchPad



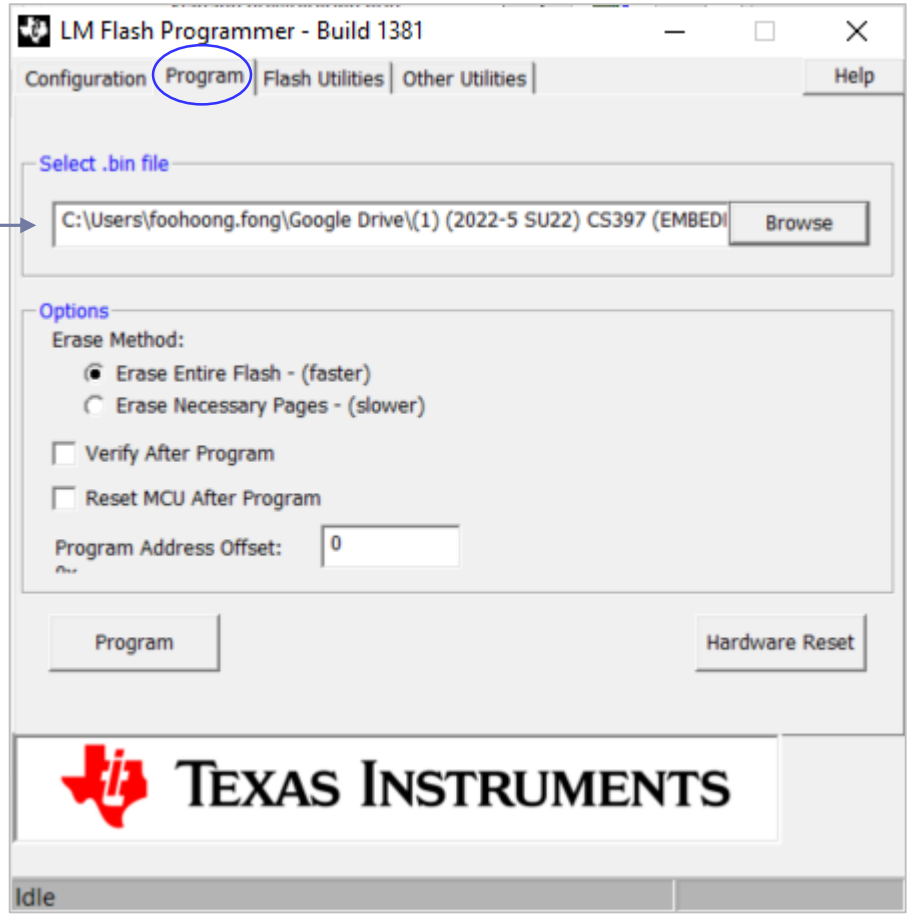
- To test your LCD & connections:
  - Download the file 'HT1621_LCD.BIN' from Moodle.
  - Use the 'LM Flash Programmer' utility to download the BIN file to the Tiva LaunchPad *(see next slide)*. The LCD should then display a running sequence of digits.
  - LCD display backlight should light up (even though the 'Backlight' pin is not connected as power to the Backlight is already connected on the LCD board.

NC = No Connect

You may change to other GPIO pins, if you wish.

LM Flash Programmer

File: HT1621_LCD.BIN



LCD Commands & Format

- Communications with the HT1621 is through set of **Command ID (3 bits)** followed by the **Command Codes (10 bits)**.
- Command ID determines the **Mode**: Data or Command.
- Example: To write data to the LCD display, we would issue a Command ID of 0b101 (Write), followed by 10 bits of Command Codes to identify the display RAM to write to:

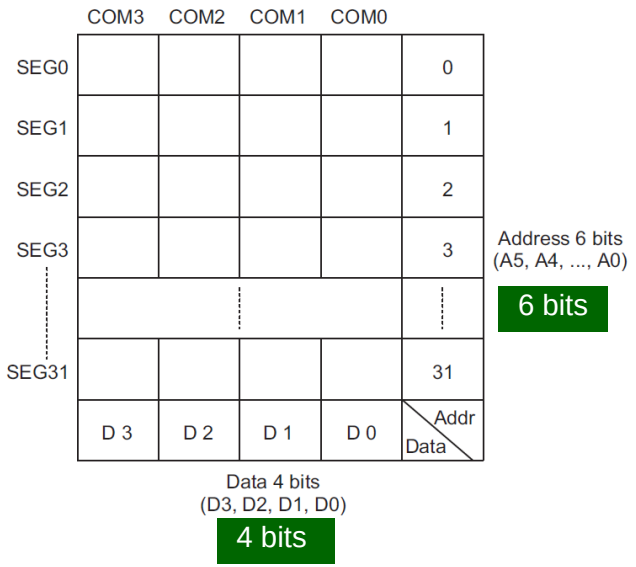
Operation	Mode	ID
Read	Data	1 1 0
Write	Data	1 0 1
Read-Modify-Write	Data	1 0 1
Command	Command	1 0 0

0b101. A5A4A3A2A1A0. D3D2D1D0

Command ID

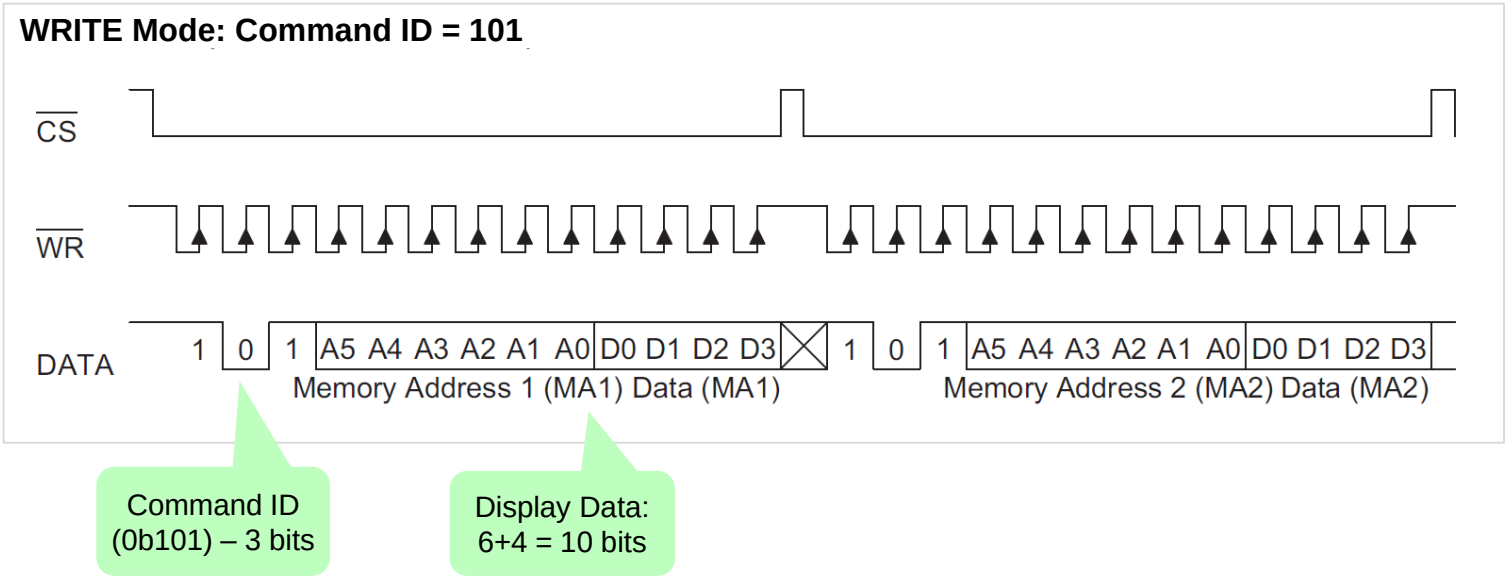
Display RAM address (6 bits)

Display RAM data (4 bits)



Display memory organization

Writing to Display Memory of HT1621



- Communications with the HT1621 is through issuing Write commands to the CS, WR & DATA pins.
- CS signal initiates (CS going 'L') & terminates (CS going 'H') the Write cycle.
- WR signal serves as the Clock.
- Data at the DATA pin is clocked in at the rising clock edge of WR signal.

LCD Commands & Format

Name	ID	Command Code	D/C	Function	Def.
READ	**1 1 0**	A5A4A3A2A1A0D0D1D2D3	D	Read data from the RAM	
WRITE	**1 0 1**	A5A4A3A2A1A0D0D1D2D3	D	Write data to the RAM	
READ-MODIFY-WRITE	**1 0 1**	A5A4A3A2A1A0D0D1D2D3	D	READ and WRITE to the RAM	
SYS DIS	**1 0 0**	0000-0000-X	C	Turn off both system oscillator and LCD bias generator	Yes
SYS EN	**1 0 0**	0000-0001-X	C	Turn on system oscillator	
LCD OFF	**1 0 0**	0000-0010-X	C	Turn off LCD bias generator	Yes
→ LCD ON	**1 0 0**	0000-0011-X	C	Turn on LCD bias generator	
TIMER DIS	**1 0 0**	0000-0100-X	C	Disable time base output	
WDT DIS	**1 0 0**	0000-0101-X	C	Disable WDT time-out flag output	
TIMER EN	**1 0 0**	0000-0110-X	C	Enable time base output	
WDT EN	**1 0 0**	0000-0111-X	C	Enable WDT time-out flag output	

Note: X : Don't care
A5~A0 : RAM addresses
D3~D0 : RAM data
D/C : Data/command mode
Def. : Power on reset default

Arrows (→) indicate setting to be used for Assignment #2.

LCD Commands & Format

Name	ID	Command Code	D/C	Function	Def.
TONE OFF	**1 0 0**	0000-1000-X	C	Turn off tone outputs	Yes
TONE ON	**1 0 0**	0000-1001-X	C	Turn on tone outputs	
CLR TIMER	**1 0 0**	0000-11XX-X	C	Clear the contents of time base generator	
CLR WDT	**1 0 0**	0000-111X-X	C	Clear the contents of WDT stage	
XTAL 32K	**1 0 0**	0001-01XX-X	C	System clock source, crystal oscillator	
→ RC 256K	**1 0 0**	0001-10XX-X	C	System clock source, on-chip RC oscillator	Yes
EXT 256K	**1 0 0**	0001-11XX-X	C	System clock source, external clock source	
BIAS 1/2	**1 0 0**	0010-abX0-X	C	LCD 1/2 bias option ab=00: 2 commons option ab=01: 3 commons option ab=10: 4 commons option	
→ BIAS 1/3	**1 0 0**	0010-abX1-X	C	LCD 1/3 bias option ab=00: 2 commons option ab=01: 3 commons option ab=10: 4 commons option ←	
TONE 4K	**1 0 0**	010X-XXXX-X	C	Tone frequency, 4kHz	
TONE 2K	**1 0 0**	011X-XXXX-X	C	Tone frequency, 2kHz	
$\overline{\text{IRQ}}$ DIS	**1 0 0**	100X-0XXX-X	C	Disable $\overline{\text{IRQ}}$ output	Yes
$\overline{\text{IRQ}}$ EN	**1 0 0**	100X-1XXX-X	C	Enable $\overline{\text{IRQ}}$ output	

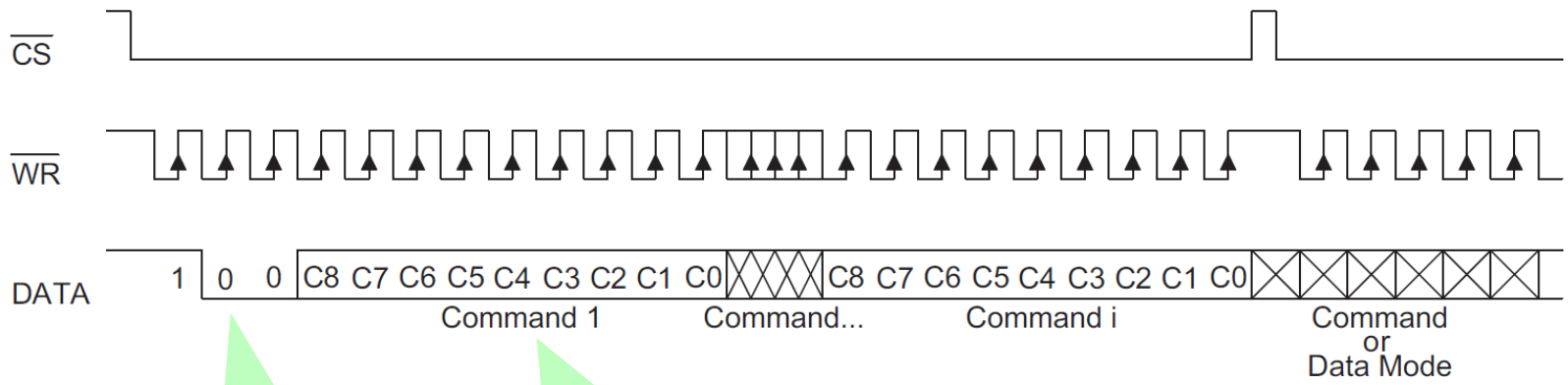
Arrows (→) indicate setting to be used for Assignment #2.

LCD Commands & Format

Name	ID	Command Code	D/C	Function	Def.
F1	**1 0 0**	101X-X000-X	C	Time base/WDT clock output:1Hz The WDT time-out flag after: 4s	
F2	**1 0 0**	101X-X001-X	C	Time base/WDT clock output:2Hz The WDT time-out flag after: 2s	
F4	**1 0 0**	101X-X010-X	C	Time base/WDT clock output:4Hz The WDT time-out flag after: 1s	
F8	**1 0 0**	101X-X011-X	C	Time base/WDT clock output:8Hz The WDT time-out flag after: 1/2s	
F16	**1 0 0**	101X-X100-X	C	Time base/WDT clock output:16Hz The WDT time-out flag after: 1/4s	
F32	**1 0 0**	101X-X101-X	C	Time base/WDT clock output:32Hz The WDT time-out flag after: 1/8s	
F64	**1 0 0**	101X-X110-X	C	Time base/WDT clock output:64Hz The WDT time-out flag after: 1/16s	
F128	**1 0 0**	101X-X111-X	C	Time base/WDT clock output:128Hz The WDT time-out flag after: 1/32s	Yes
TEST	**1 0 0**	1110-0000-X	C	Test mode, user don't use.	
NORMAL	**1 0 0**	1110-0011-X	C	Normal mode	Yes

Sending a Command to HT1621

WRITE Mode: Command ID = 100



Command ID (0b100) – 3 bits

Command Code: C[8:0] - 9 bits

Assignment #2 Task

- As an embedded engineer working on a project, you are tasked to develop a program on the Tiva LaunchPad to control a LCD display to implement a simple digital clock.
- The LCD display is controlled by the HT1621 LCD driver.
- The LCD displays the current time.
  - Use the SysTick Timer to derive the time-base for the clock. Set SysTick interrupt interval to 1ms.
- The digital clock operates in two modes: Time Display & Seconds Display.
- **Time Display mode:** In this mode, the current time is displayed in format **HH.MM** in 24-hr format.
  - Toggle the 'dot' (DP3 – *slide 5*) in HH.MM every second.
  - Sound the buzzer for 5ms at each crossing of Seconds back to 00.
- **Seconds Display mode:** This mode is entered when SW1 (LaunchPad) is held down & stays in this mode while SW1 is being held down.
  - Seconds data is displayed in format **.SS**. Toggle the 'dot' in .SS every second.
  - When SW1 is released, it exits this mode and returns to Time Display mode.
- Setting of the current Time is achieved through a Command sent through the Virtual Com Port (VCP). Set VCP to 115,200 bps, 8 data bits, 1 Stop bit & Even parity.
  - Command format: **STHHMMSS** or **stHHMMSS**, where 'ST' or 'st' denotes Set Time. (Assume a 24-hr time format).
  - Example: ST164105 = Set Time to 16:41:05.

Time Display

Seconds Display

Assignment #2 Notes [1/2]

- LCD screen:
  - The LCD is able to display up to 6 digits. For the Clock display, make use of the middle 4 digits (Digit 1 to Digit 4) *[slide 5]*.
- HT1621 Initialization:
  - HT1621 needs to be initialized correctly to the following:
    - Use the internal RC oscillator (256 kHz): command ID – 'RC 256K' *[slide 11]*.
    - Set LCD to 1/3 & 4 COM pins: command ID – 'BIAS 1/3' *[slide 11]*.
- Make use of the bit-band feature of the ARM Cortex-M CPUs to make your code more efficient. *[see examples of usage in lecture slides]*.
- Switch SW1 should be programmed to work in Interrupt mode.
- Have sufficient comments to explain & document your codes.
- Refer to the HT1621 datasheet for full details and explanation on use and programming of the IC.

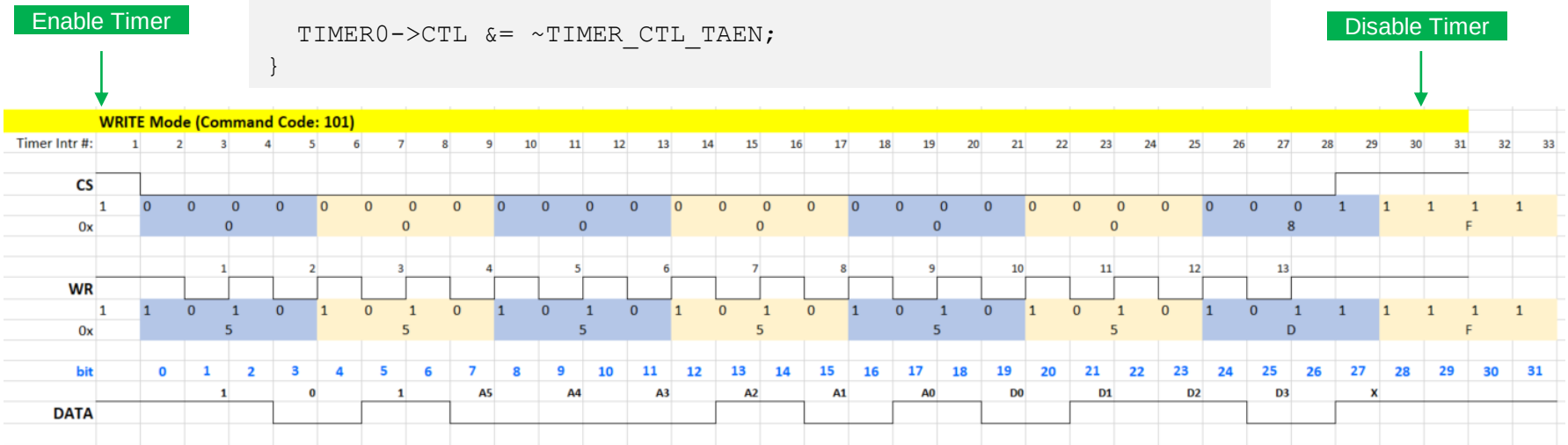
Assignment #2 Notes: [2/2]
Generating Clock Signal to HT1621

- The WR pin on the HT1621 serves as the clock signal.
- Generate a clock signal to the HT1621 WR pin in the following manner:
  - Set Timer 0A to Periodic 16-bit mode.
  - At each Timer Time-Out interrupt, use program control to generate the signal waveforms for WR (clock) as well as for CS & DATA. *See example waveform below.*
  - Make use of the Digilent Analog Discovery to check your waveforms. It would be a good debugging tool.

```
void TIMER0A_IRQHandler( uint32_t Status )
{
  TIMER0->ICR |= TIMER_ICR_TATOCINT; /* clear intr   */

  // toggle WR signal to generate clock to HT1621
  // also generate the CS & DATA signals

  TIMER0->CTL &= ~TIMER_CTL_TAEN;
}
```



Assignment #2 Submission:

- Assignment due a week after break:
  - End of Week 8, 3 Jul 22, Sun, 23:59 hrs.
  - Submit Zipped folder of your program.
  - Short video of your implementation.