ECEN 5613 **Lab #4 Signoff Sheet** **Fall 2023**

You will need to obtain the signature of your TA on the following items in order to receive credit for your lab assignment. Print your name below, sign the honor code pledge, and then demonstrate your working hardware & firmware in order to obtain the necessary signatures.

Student Name: G. Tharuni

Honor Code Pledge: "On my honor, as a University of Colorado student, I have neither given nor received unauthorized assistance on this work. I have clearly acknowledged work that is not my own."

Student Signature: tharunj

Signoff Checklist

Part 1 Elements

- ☑ Pins and signals labeled and decoupling capacitors present on board
- ☑ C code for EEPROM functional, contents present after power cycle
- ☑ I^2C diagram/timing analysis

11/11/2023
TA signature and date

Part 2 Elements

- ☑ LCD functional, C code for basic LCD routines functional
- ☑ LCD control signal timing meets specifications (logic analyzer trace/diagram, analysis)
- ☑ Elapsed time stop, restart, reset to "00:00.0":
- ☑ Good integration with previous code, all functions work, no irregularities

11/11/2023

Part 3 Required and Supplemental Elements

- ☑ LCD Hex/DDRAM/CGRAM dumps, custom LCD characters, fun logo
- ☑ SPI interface, logic analyzer trace, compare with I^2C.
- ☐ ARM code development, 2 new features, ISR
- ☑ PCF8574 I^2C I/O Expander, input, output, ISR

Reshpande 11/19/23

FOR TA/INSTRUCTOR USE ONLY Part 1 Elements	Not Applicable	Poor/Not Complete	Meets Requirements	Exceeds Requirements	Outstanding
Schematics, SPLD code	☐	☐	☐	☑	☐
Hardware physical implementation	☐	☐	☐	☑	☐
Required Elements functionality	☐	☐	☐	☐ ✓	☐
Sign-off done without excessive retries		☐	☑		
Student understanding and skills	☐	☐	☐	☐ ✓	☐
Overall Demo Quality (Part 1 elements)	☐	☐	☐	☐ ✓	☐

FOR TA/INSTRUCTOR USE ONLY Part 2 Elements	Not Applicable	Poor/Not Complete	Meets Requirements	Exceeds Requirements	Outstanding
Schematics, SPLD code	☐	☐	☐	☑	☐
Hardware physical implementation	☐	☐	☐	☑	☐
Required Elements functionality	☐	☐	☐	☐ ✓	☐
Sign-off done without excessive retries		☐	☑		
Student understanding and skills	☐	☐	☐	☐ ✓	☐
Overall Demo Quality (Part 2 elements)	☐	☐	☐	☐ ✓	☐

FOR TA/INSTRUCTOR USE ONLY Part 3 Elements	Not Applicable	Below Expectation	Meets Requirements	Exceeds Requirements	Outstanding
Schematics, SPLD code	☐	☐	☐	☑	☐
Hardware physical implementation	☐	☐	☐	☑	☐
Required Elements functionality	☐	☐	☐	☑	☐
Supplemental Elements functionality	☐	☐	☐	☐ ✓	☐
Sign-off done without excessive retries		☐	☑		
Student understanding and skills	☐	☐	☐	☐ ✓	☐
Overall Demo Quality (Part 3 elements)	☐	☐	☐	☐ ✓	☐

TA/Instructor Comments ☐☐☐

Lab 4 Part 1

[#] I2C code
- [+] commands functional
- [+] Excellent UI
- [+] verified on logic analyzer

[+] Timing analysis presented.

Lab 4 Part 2

[#] LCD code
- [+] LCD commands functional
- [+] Good UI
- [+] String wrap around handled

[+] LCD timer is functional
- [+] LCD commands working

[+] Timing analysis presented

Part 3

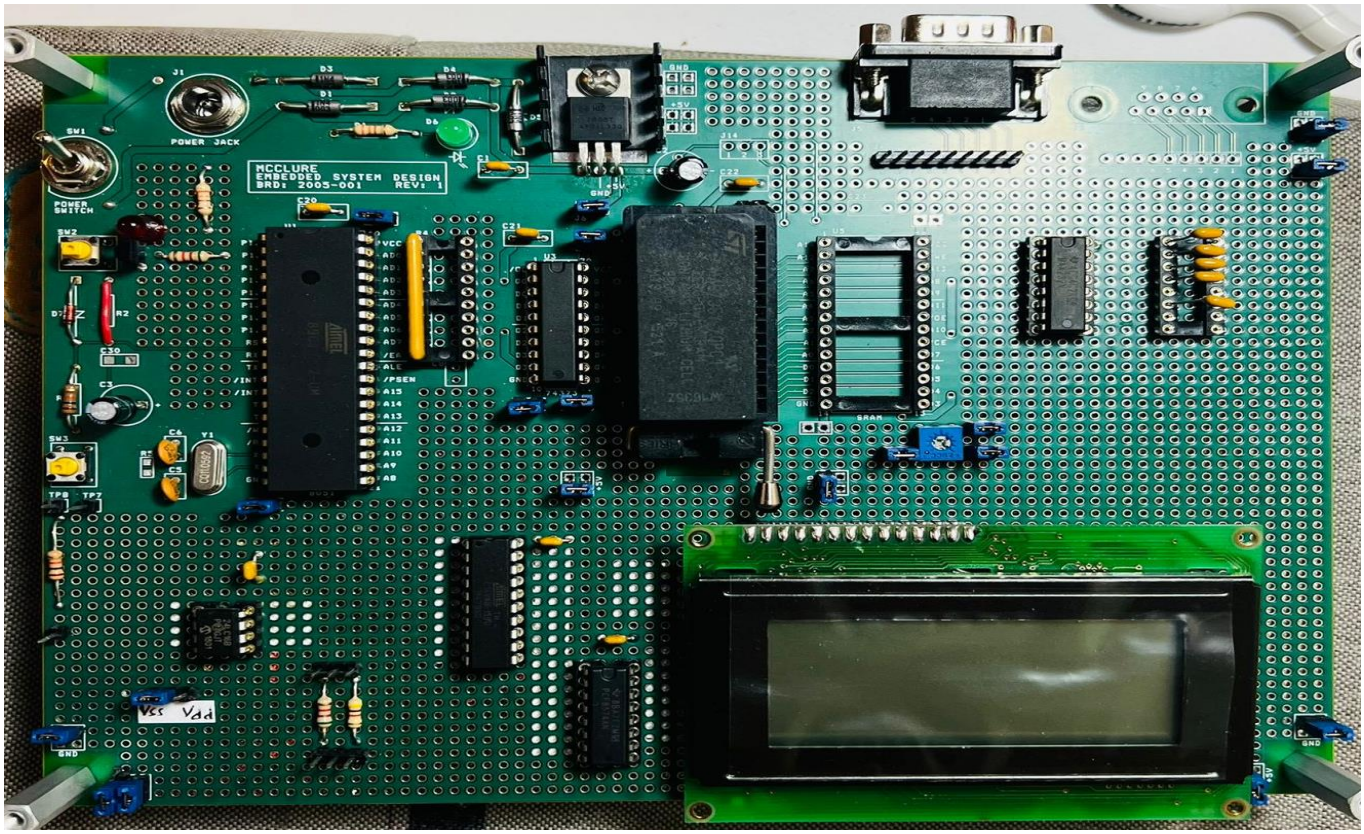
[+] Very good implementation of DAC using SPI
1) Sine, Square, Sawtooth & Square wave generated.
2) Adjustable gain.

[+] LCD → CGRAM, DDRAM, custom character verified.

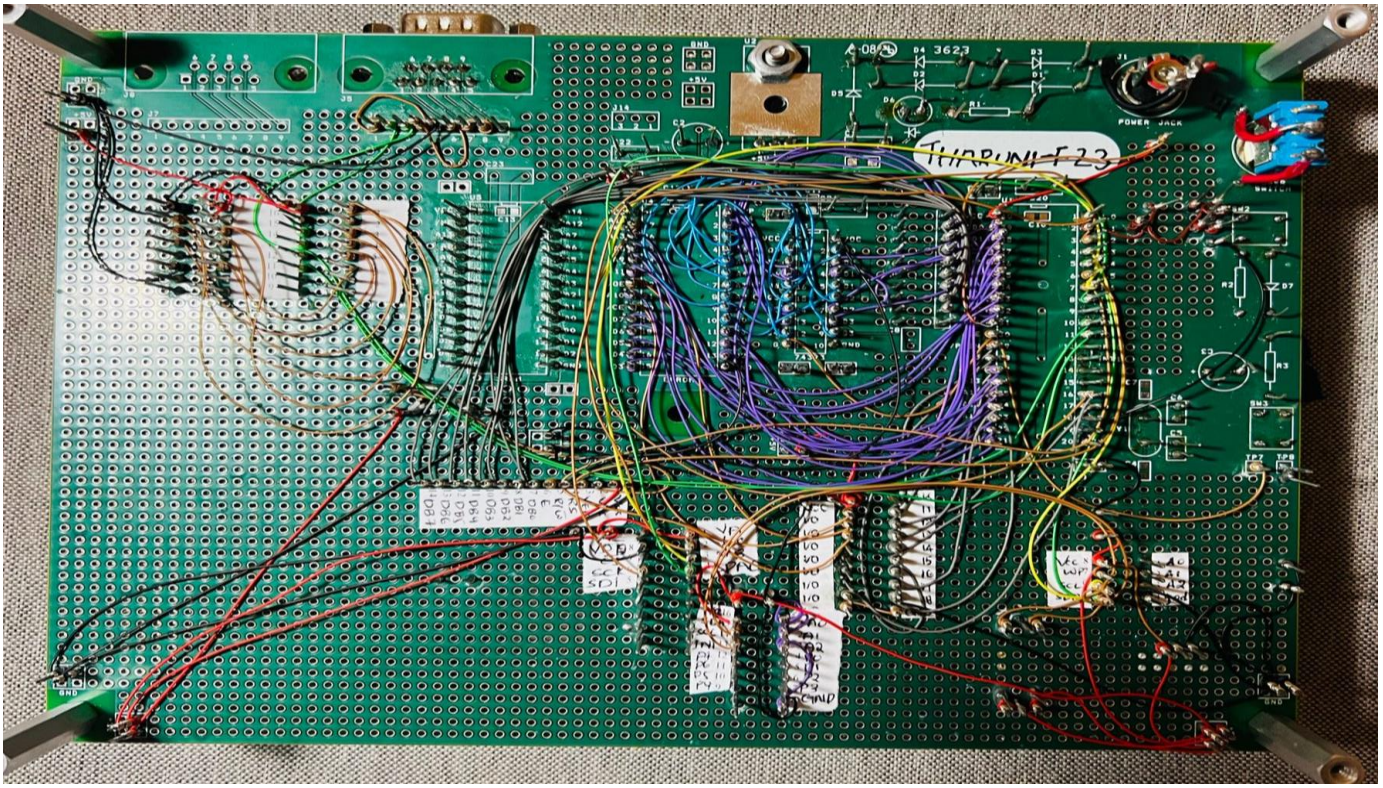
[+] I/O expander implemented & verified.

LAB 4 WRITE UP BY THARUNI GELLI

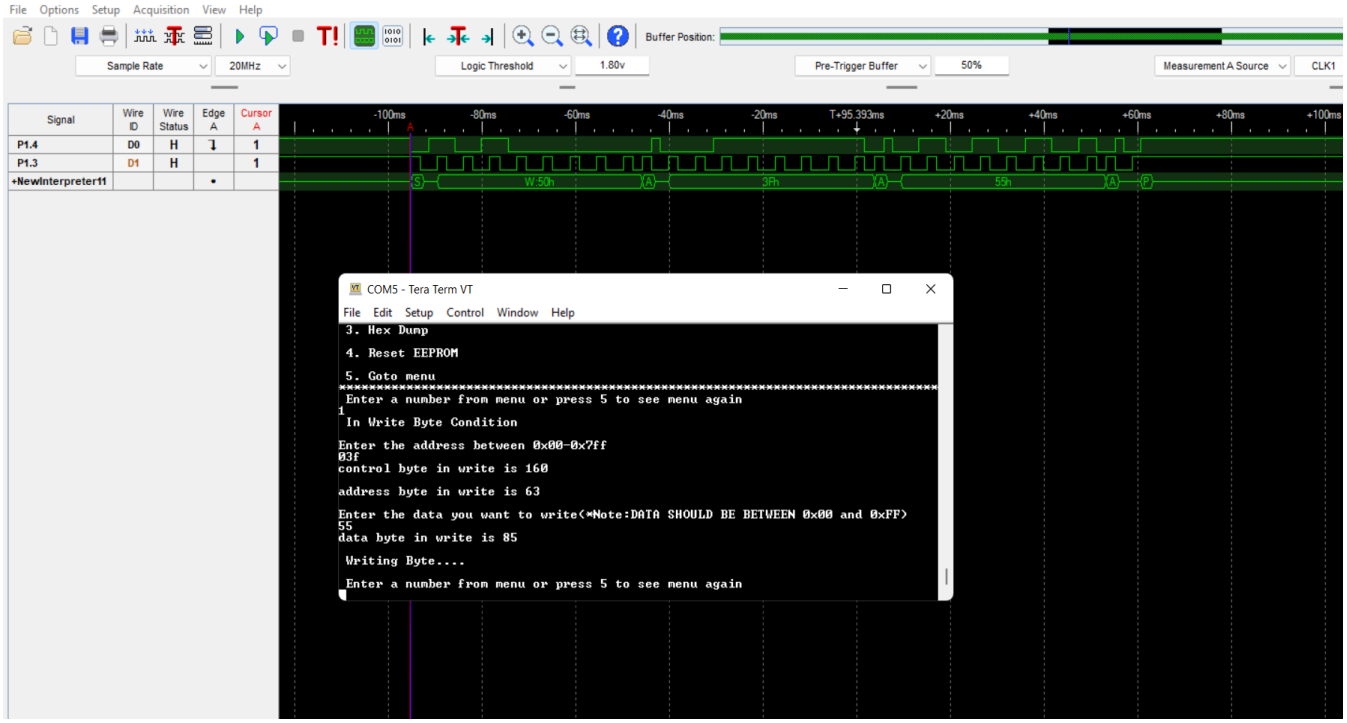
- Front side of 8051 development board



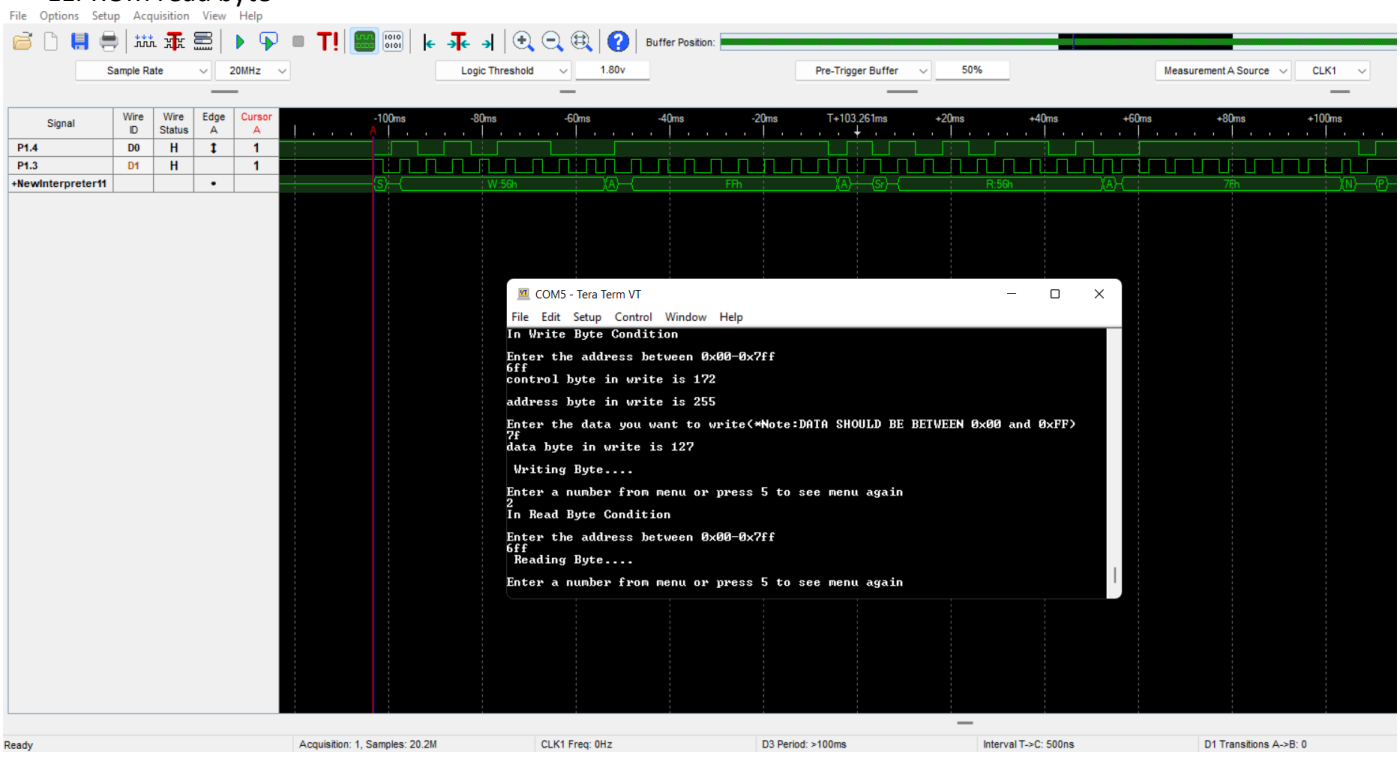
- Back side of 8051 development board



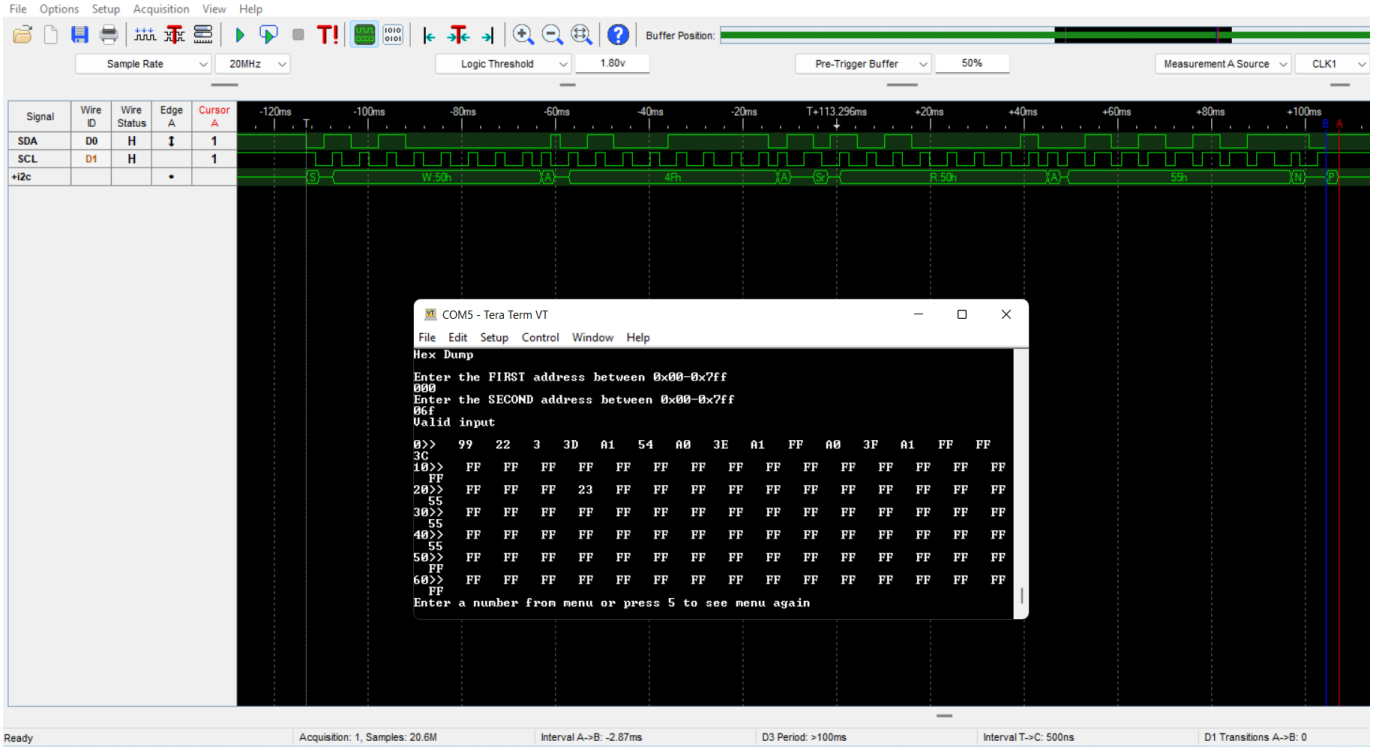
- EEPROM write byte



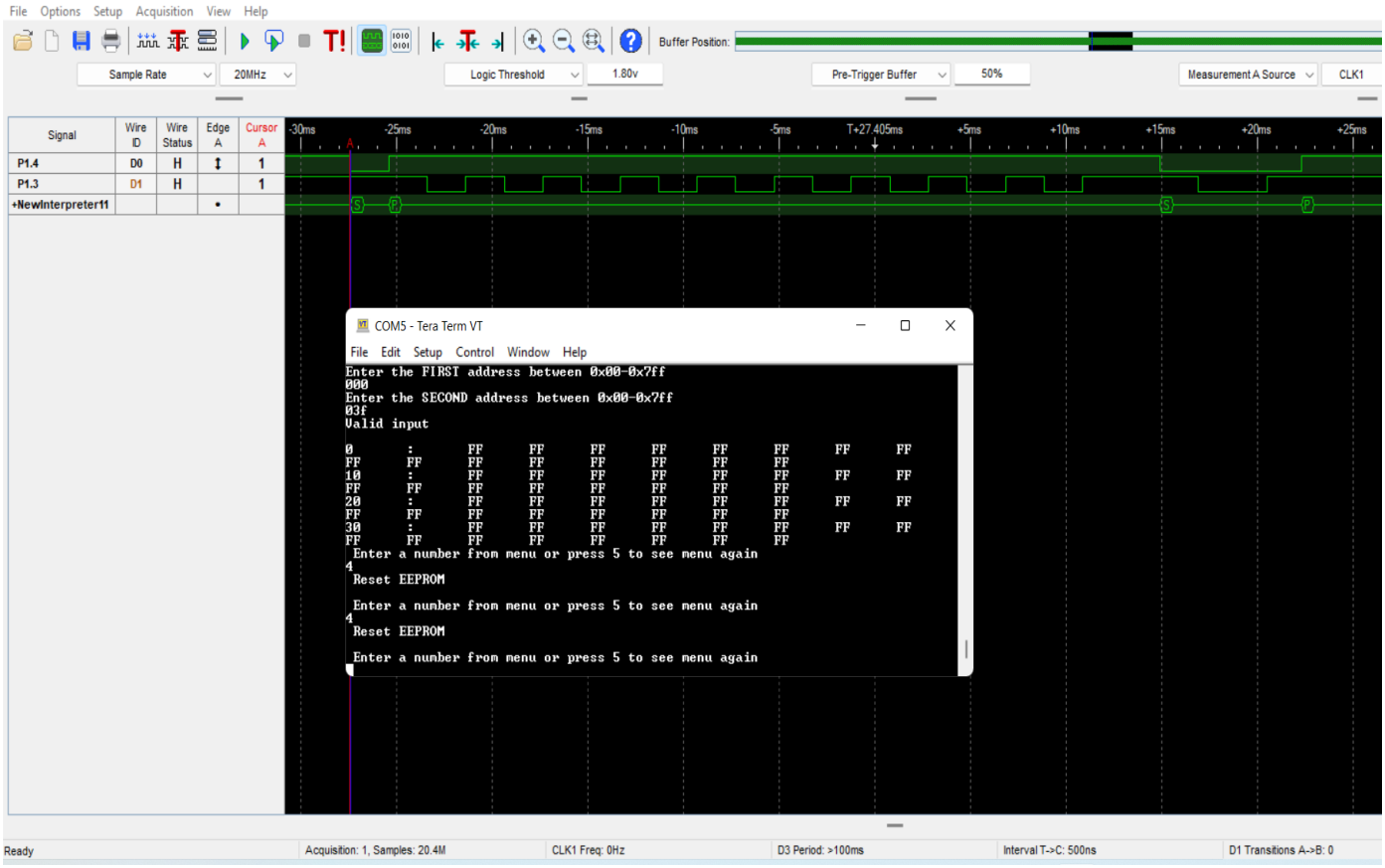
- EEPROM read byte



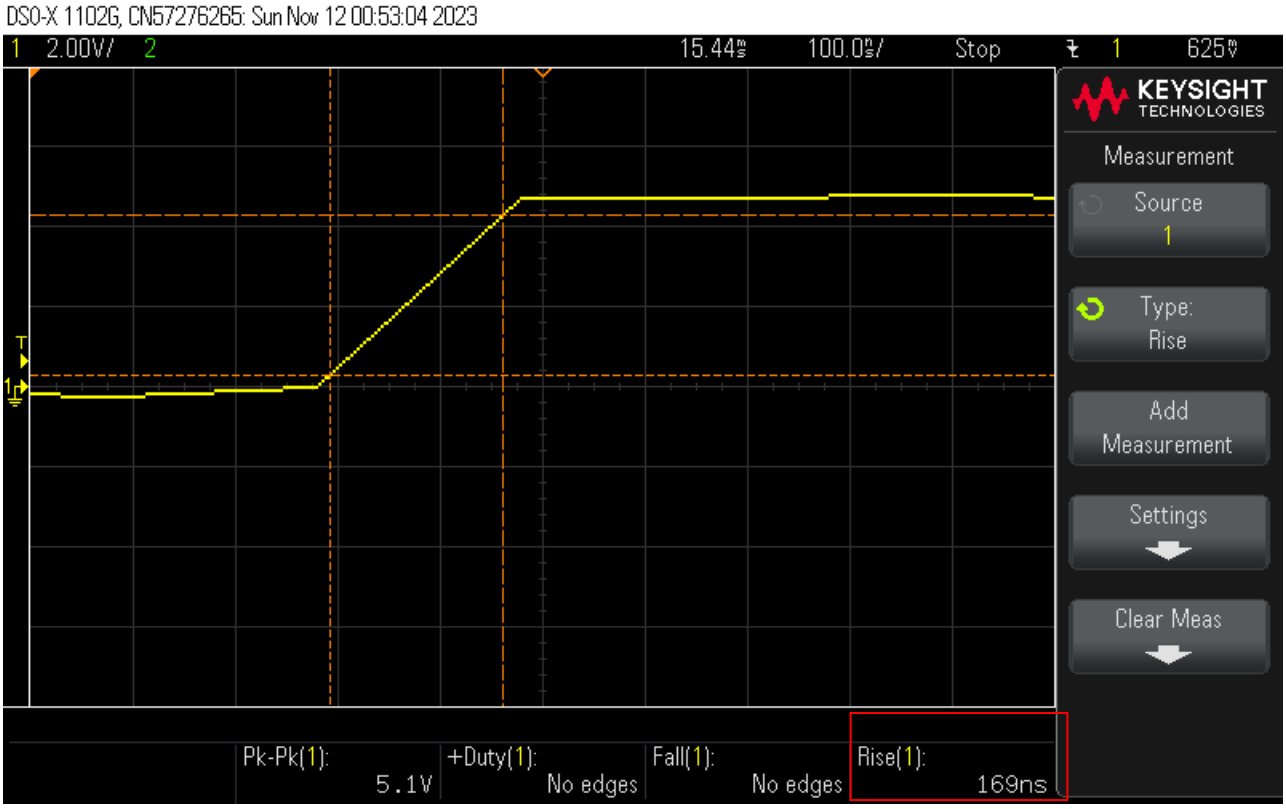
- Hex dump of EEPROM



- Reset of EEPROM

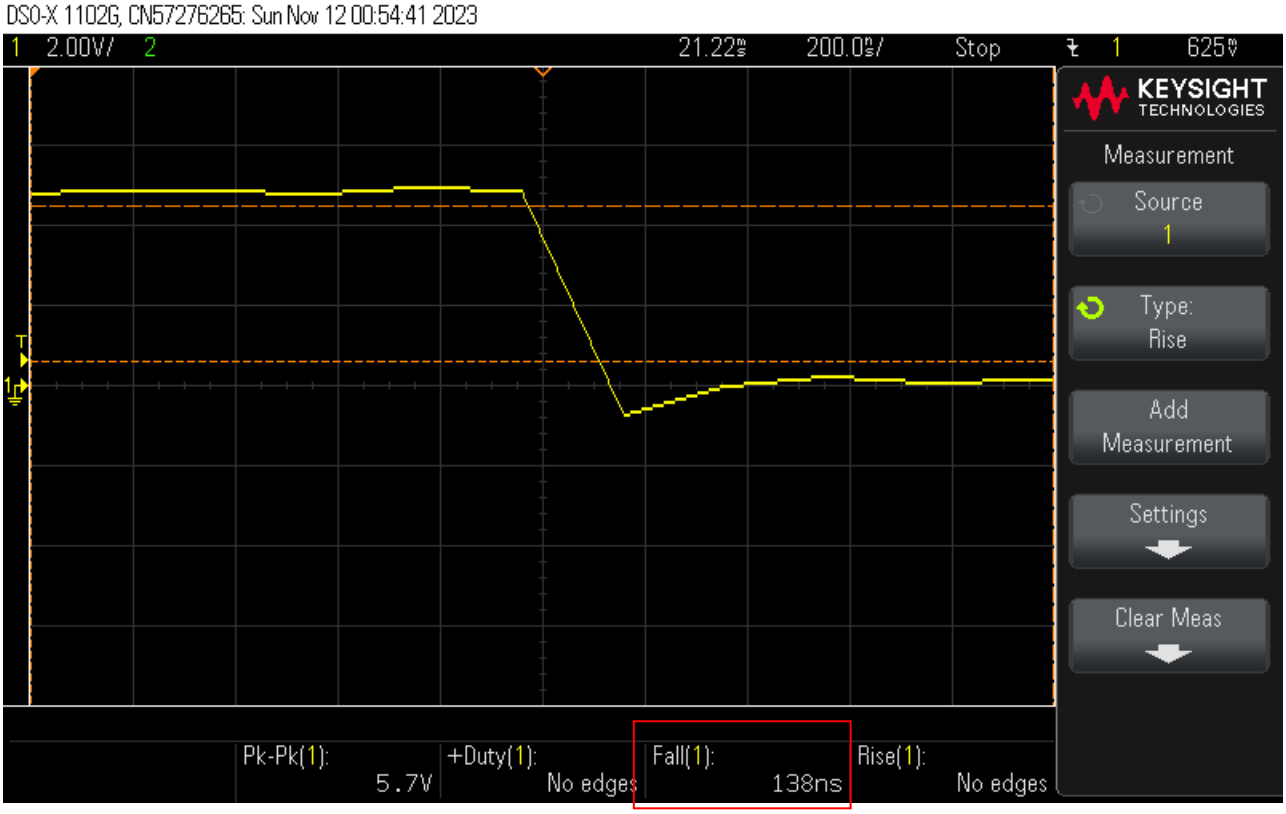


- Rise time on EEPROM SDA or SCL bus.



The rise time on sda and scl bus are in the acceptable range as per data sheet.

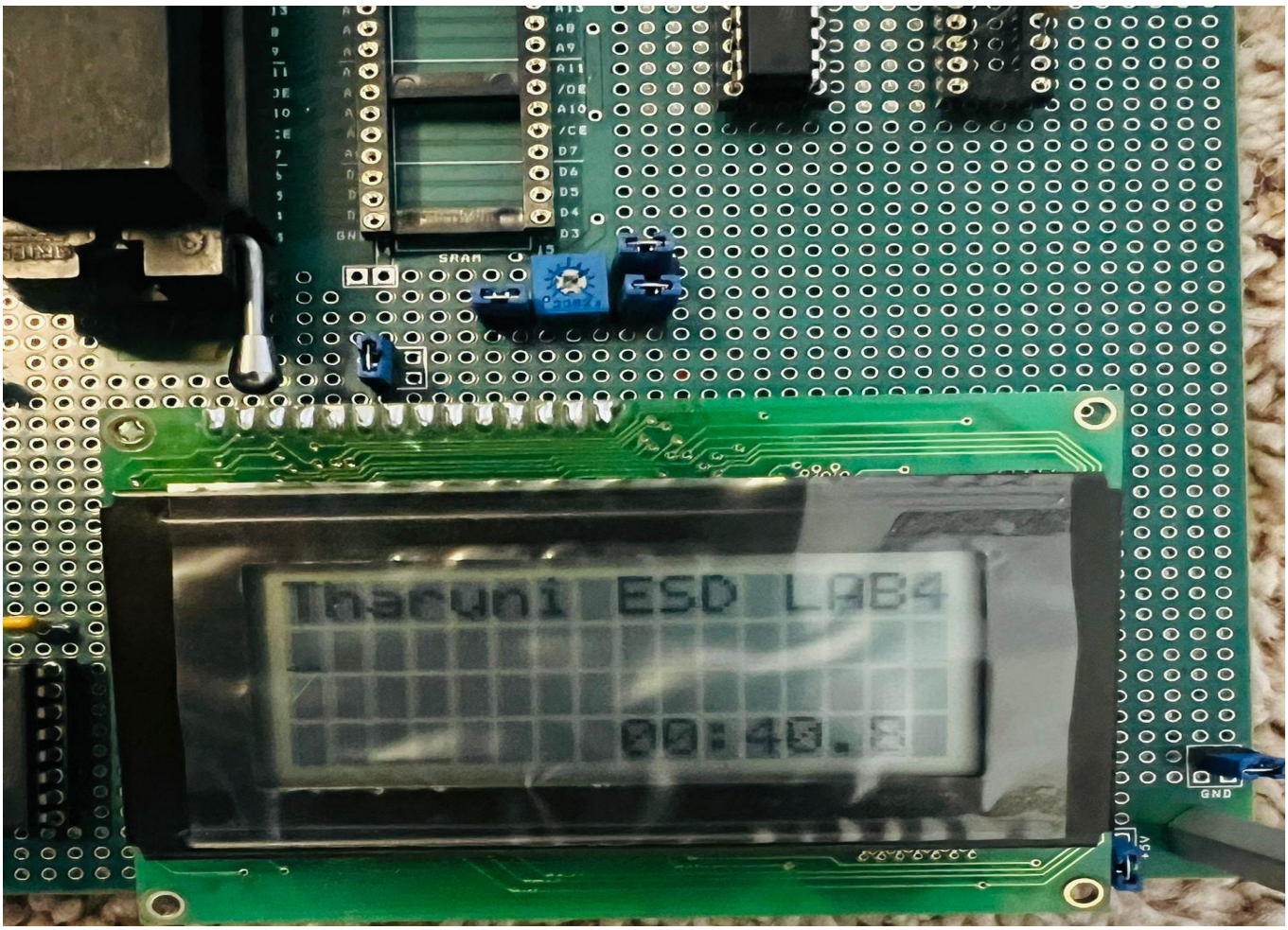
- Fall time on EEPROM SDA or SCL bus.



The fall time on sda and scl bus are in the acceptable range as per data sheet.

- LCD initialisation with timer

```
COM5 - Tera Term VT
File  Edit  Setup  Control  Window  Help

              Welcome to PAULMON2 v2.1, by Paul Stoffregen
  See PAULMON2.DOC, PAULMON2.EQU and PAULMON2.HDR for more information.

Program Name                    Location      Type
  List                            1000      External command
  Single-Step                     1400      External command
  Memory Editor (VT100)           1800      External command

PAULMON2 Loc:2000 > Jump to memory location

Jump to memory location (2000), or ESC to quit: 2000

running program:


**********HELLO :)**************************

WELCOME
Operation to choose:
 1. Put given string
 2. Clear LCD screen
 3. LCD Jump x y coordinates
 4. LCD Jump address
 5. Start or stop time
 6. Reset time
 7. LCD DDRAM Dump
 8. LCD CGRAM Dump
 9. Create custom character
Entered input:
**************************************************
```

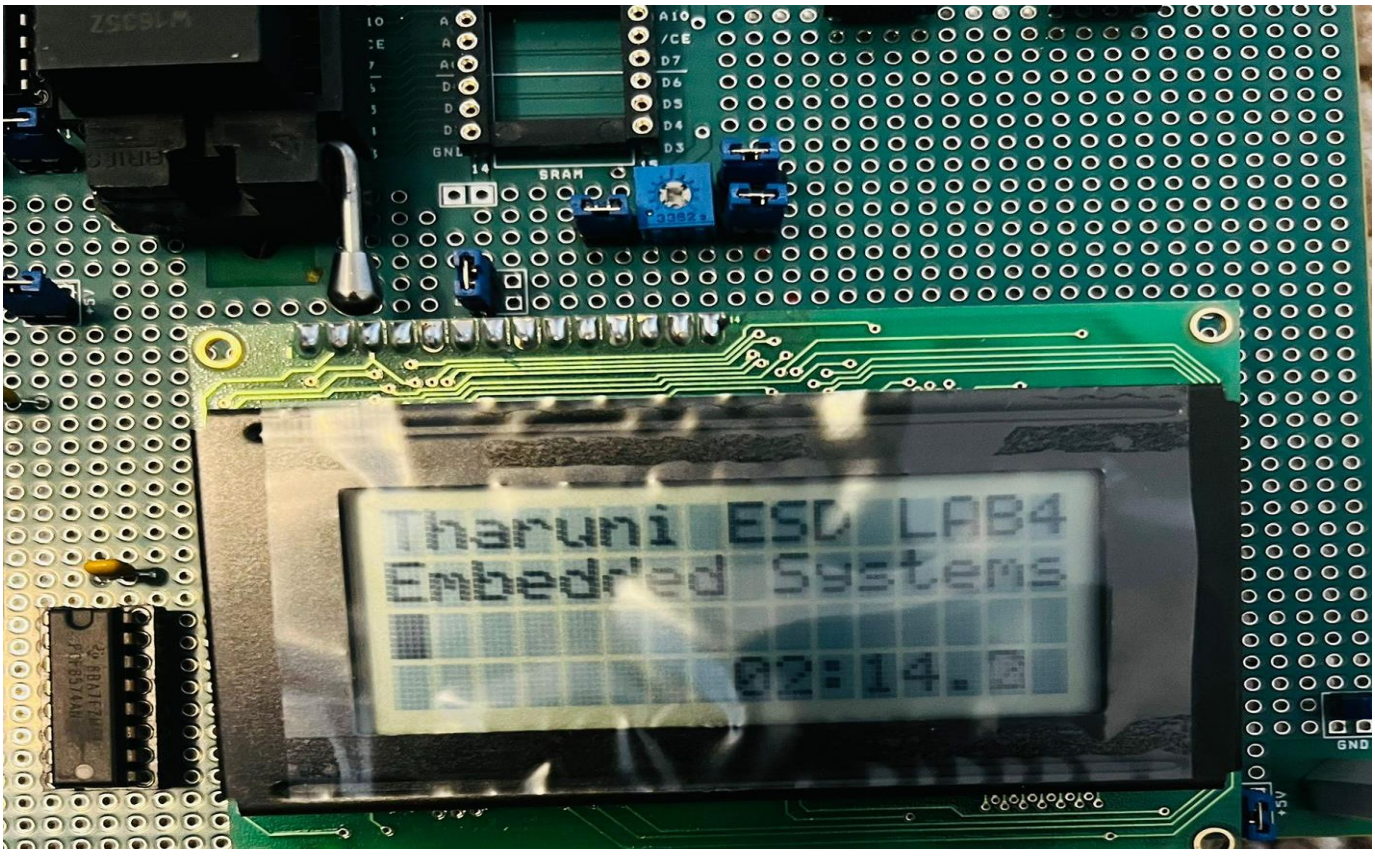


- LCD CGRAM and DDRAM dump along with put string output.

COM5 - Tera Term VT

File Edit Setup Control Window Help

```
 2. Clear LCD screen
 3. LCD Jump x y coordinates
 4. LCD Jump address
 5. Start or stop time
 6. Reset time
 7. LCD DDRAM Dump
 8. LCD CGRAM Dump
 9. Create custom character
Entered input:
**************************************************
1
Enter the string Embedded Systems
Operation to choose:
 1. Put given string
 2. Clear LCD screen
 3. LCD Jump x y coordinates
 4. LCD Jump address
 5. Start or stop time
 6. Reset time
 7. LCD DDRAM Dump
 8. LCD CGRAM Dump
 9. Create custom character
Entered input:
**************************************************
7

DDRAM Hexdump
80: 54 68 61 72 75 6E 69 20 45 53 44 20 4C 41 42 34
90: 20 20 20 20 20 20 20 20 20 20 20 20 20 20 20 20
A0: 20 20 20 20 20 20 20 20 45 6D 62 65 64 64 65 64
B0: 20 53 79 73 74 65 6D 73 20 20 20 20 20 20 20 20
C0: 30 33 3A 32 30 2E 38 20 20 20 20 20 20 20 20 20
Operation to choose:
 1. Put given string
 2. Clear LCD screen
 3. LCD Jump x y coordinates
 4. LCD Jump address
 5. Start or stop time
 6. Reset time
 7. LCD DDRAM Dump
 8. LCD CGRAM Dump
 9. Create custom character
Entered input:
**************************************************
8

CGRAM Hexdump
00: 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
10: FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF
20: 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
30: FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF
Operation to choose:
 1. Put given string
 2. Clear LCD screen
 3. LCD Jump x y coordinates
 4. LCD Jump address
 5. Start or stop time
 6. Reset time
 7. LCD DDRAM Dump
 8. LCD CGRAM Dump
 9. Create custom character
Entered input:
**************************************************
```

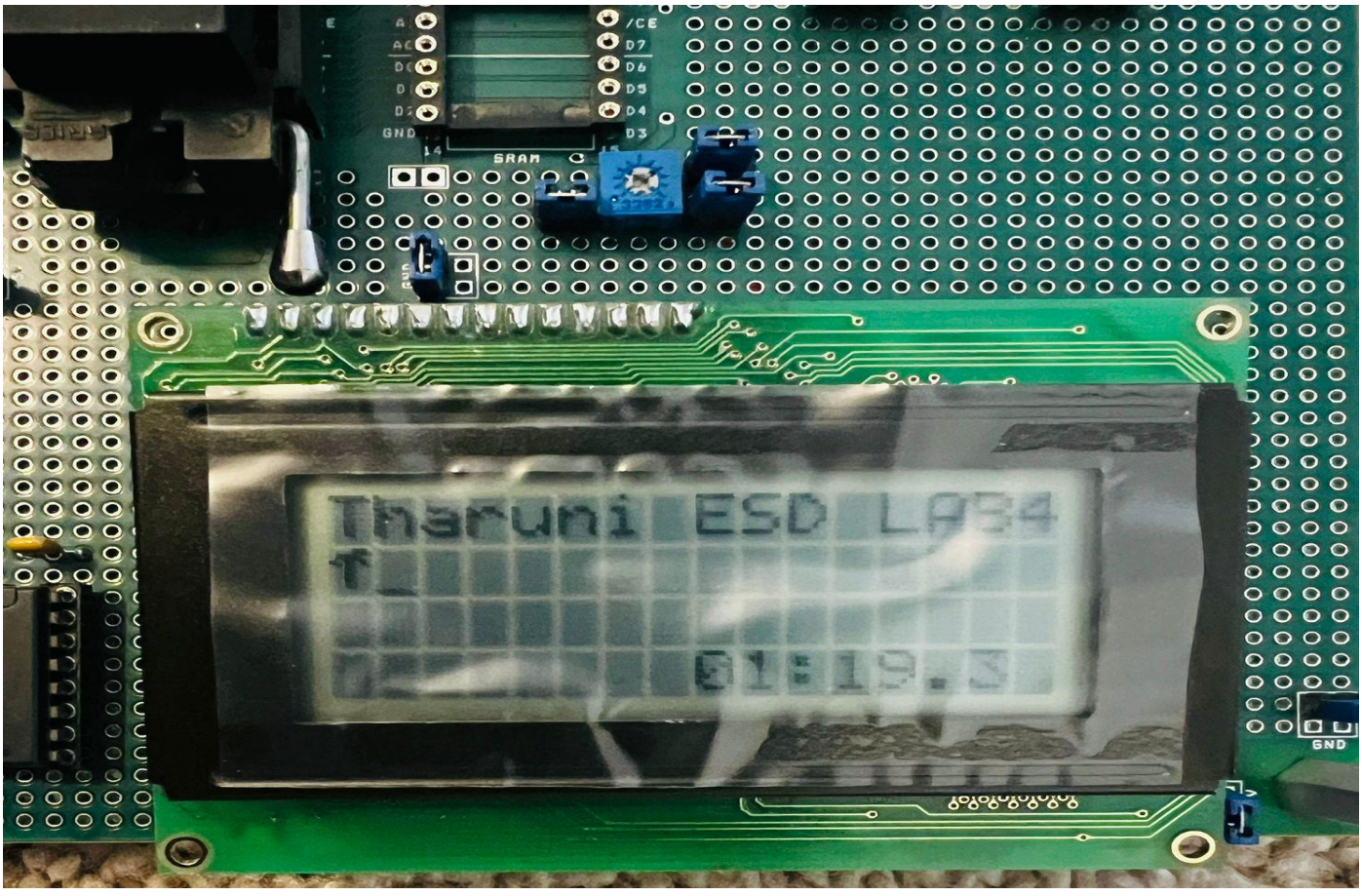


- LCD Custom character which is upward arrow.

COM5 - Tera Term VT

File Edit Setup Control Window Help

```
             Welcome to PAULMON2 v2.1, by Paul Stoffregen

  See PAULMON2.DOC, PAULMON2.EQU and PAULMON2.HDR for more information.


Program Name                    Location      Type
  List                            1000      External command
  Single-Step                     1400      External command
  Memory Editor (VT100)           1800      External command

PAULMON2 Loc:2000 > Jump to memory location

Jump to memory location (2000), or ESC to quit: 2000

running program:


**********HELLO :)**************************

WELCOME
Operation to choose:
 1. Put given string
 2. Clear LCD screen
 3. LCD Jump x y coordinates
 4. LCD Jump address
 5. Start or stop time
 6. Reset time
 7. LCD DDRAM Dump
 8. LCD CGRAM Dump
 9. Create custom character
Entered input:
**************************************************
9

Create Custom Character
Enter character code (0-7): 2
Enter pixel pattern for character 2 (in hex):
Row 0: 03
Row 1: 0E
Row 2: 15
Row 3: 04
Row 4: 04
Row 5: 04
Row 6: 04
Row 7: 00ccode=2
row vals=3      row vals=E      row vals=15     row vals=4      row vals=4      row vals=4      row vals=4      row vals=0
Custom character created with code 2.
Operation to choose:
 1. Put given string
 2. Clear LCD screen
 3. LCD Jump x y coordinates
 4. LCD Jump address
 5. Start or stop time
 6. Reset time
 7. LCD DDRAM Dump
 8. LCD CGRAM Dump
 9. Create custom character
Entered input:
**************************************************
```

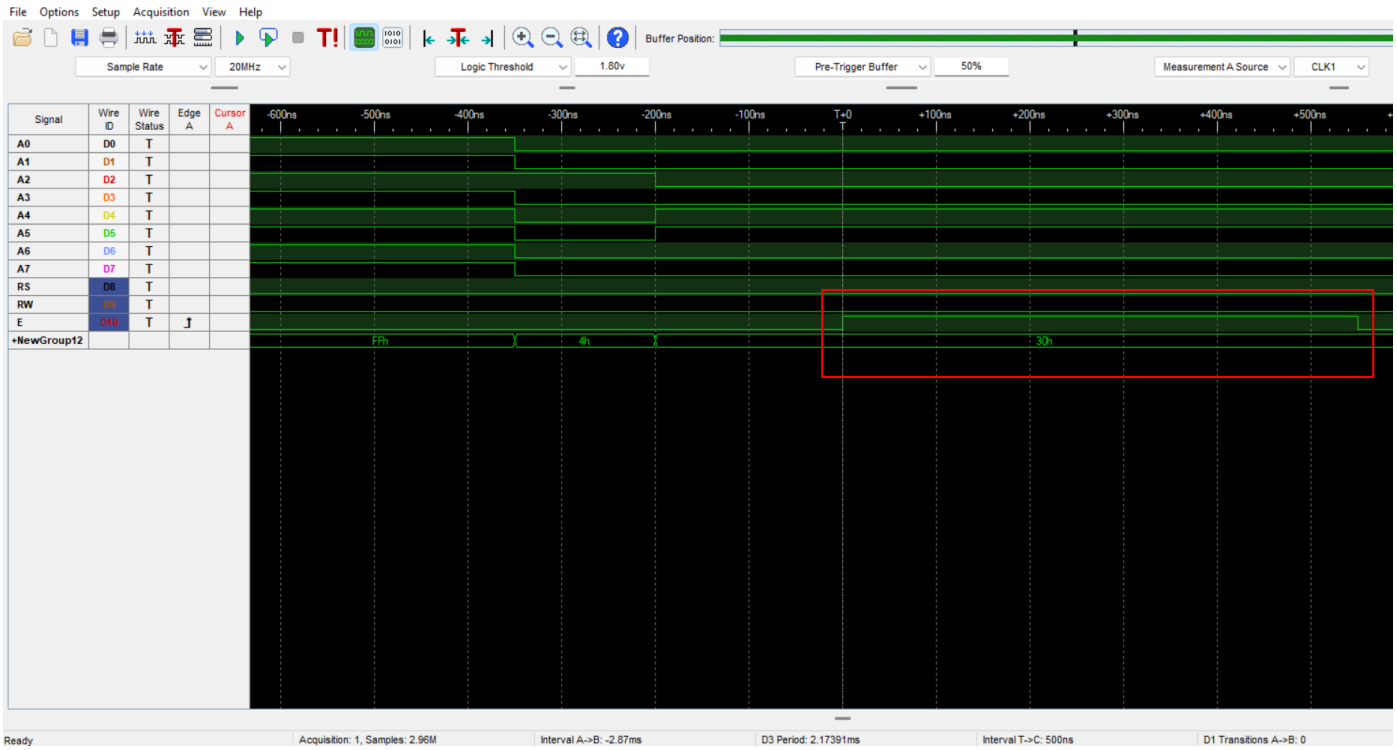


- LCD go to address and go to x y coordinates operations

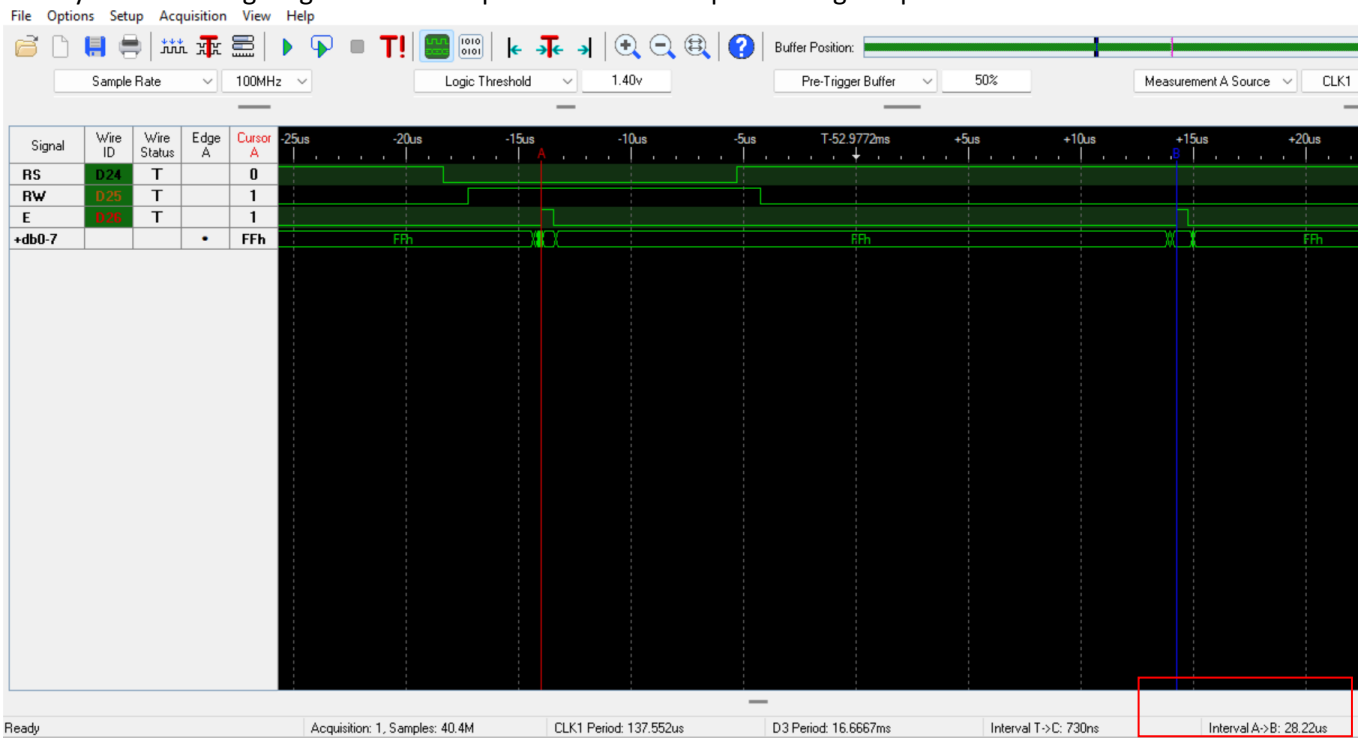
```
COM5 - Tera Term VT
File  Edit  Setup  Control  Window  Help
Custom character created with code 2.
Operation to choose:
 1. Put given string
 2. Clear LCD screen
 3. LCD Jump x y coordinates
 4. LCD Jump address
 5. Start or stop time
 6. Reset time
 7. LCD DDRAM Dump
 8. LCD CGRAM Dump
 9. Create custom character
Entered input:
*****************************************************
3

LCD Jump coordinates
Enter X coordinate(row):
Enter Y coordinate(row):3
Operation to choose:
 1. Put given string
 2. Clear LCD screen
 3. LCD Jump x y coordinates
 4. LCD Jump address
 5. Start or stop time
 6. Reset time
 7. LCD DDRAM Dump
 8. LCD CGRAM Dump
 9. Create custon character
Entered input:
*****************************************************
3

LCD Jump coordinates
Enter X coordinate(row):3
Enter Y coordinate(row):13
Operation to choose:
 1. Put given string
 2. Clear LCD screen
 3. LCD Jump x y coordinates
 4. LCD Jump address
 5. Start or stop time
 6. Reset time
 7. LCD DDRAM Dump
 8. LCD CGRAM Dump
 9. Create custon character
Entered input:
*****************************************************
4

 LCD Jump address
 Enter the address:     89
Operation to choose:
 1. Put given string
 2. Clear LCD screen
 3. LCD Jump x y coordinates
 4. LCD Jump address
 5. Start or stop time
 6. Reset time
 7. LCD DDRAM Dump
 8. LCD CGRAM Dump
 9. Create custon character
Entered input:
*****************************************************
```

LOGIC ANALYZER OUTPUTS OF LCD

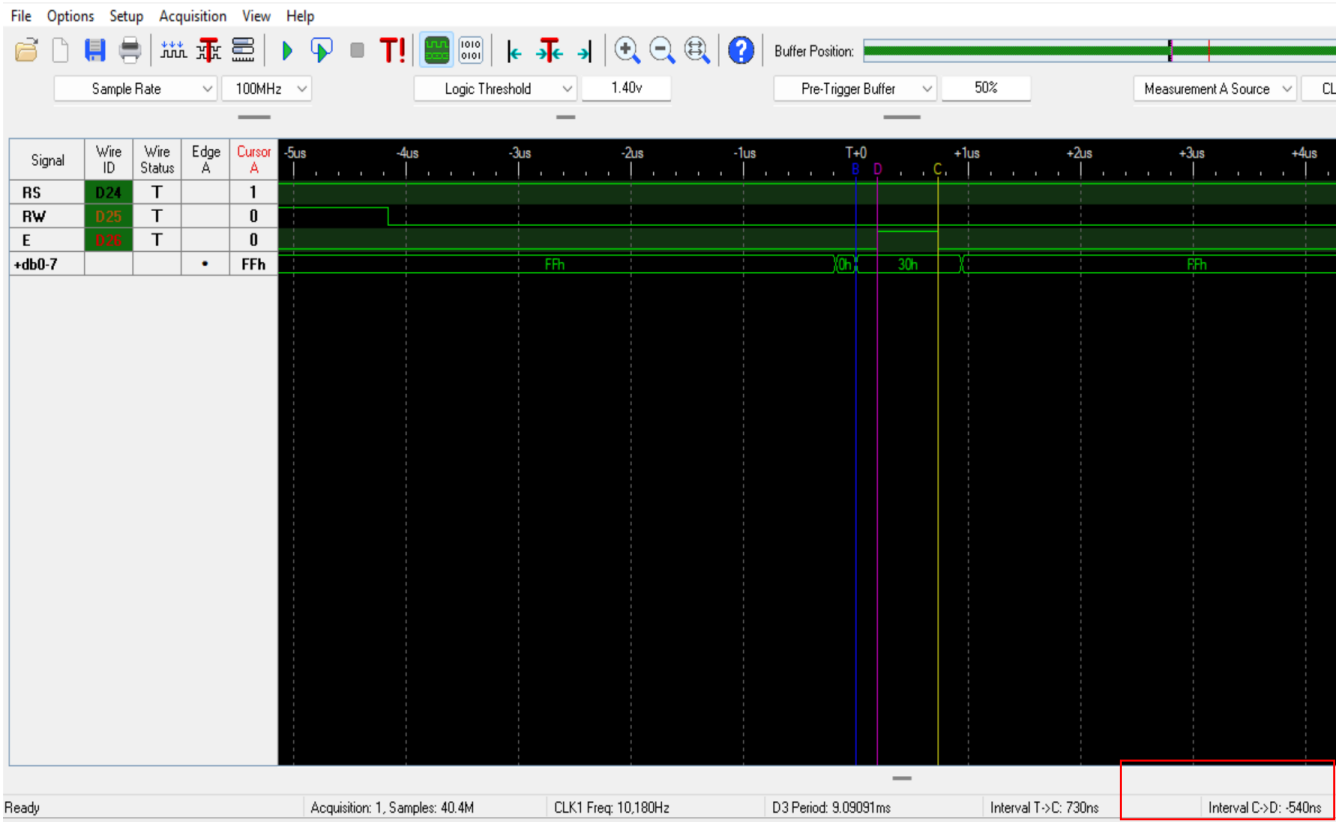
- Checking for Enable pin of LCD(Enable pin is high only for LCD operations and 30h is written on data bus initially)



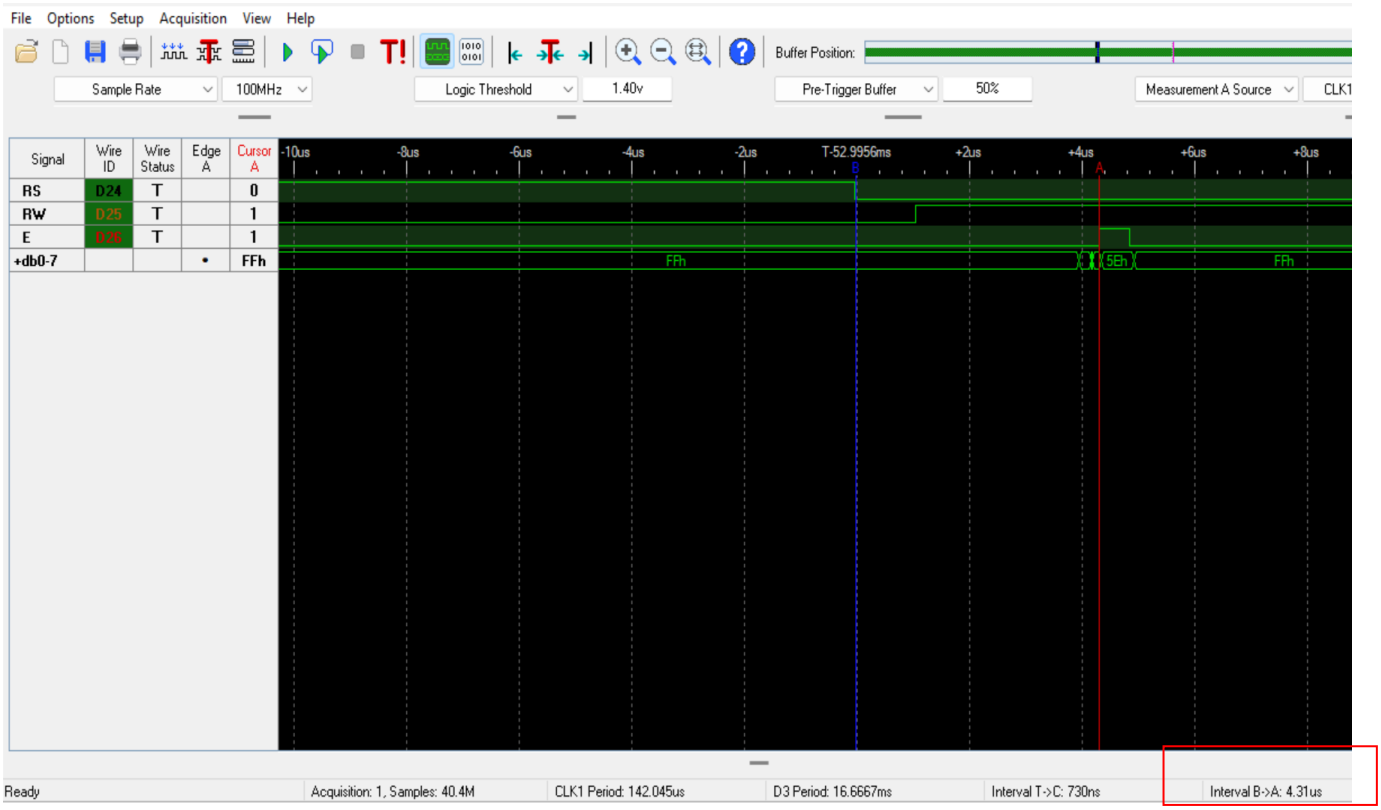
- Tcy Enable timing diagram for LCD E pin which is in acceptable range as per datasheet



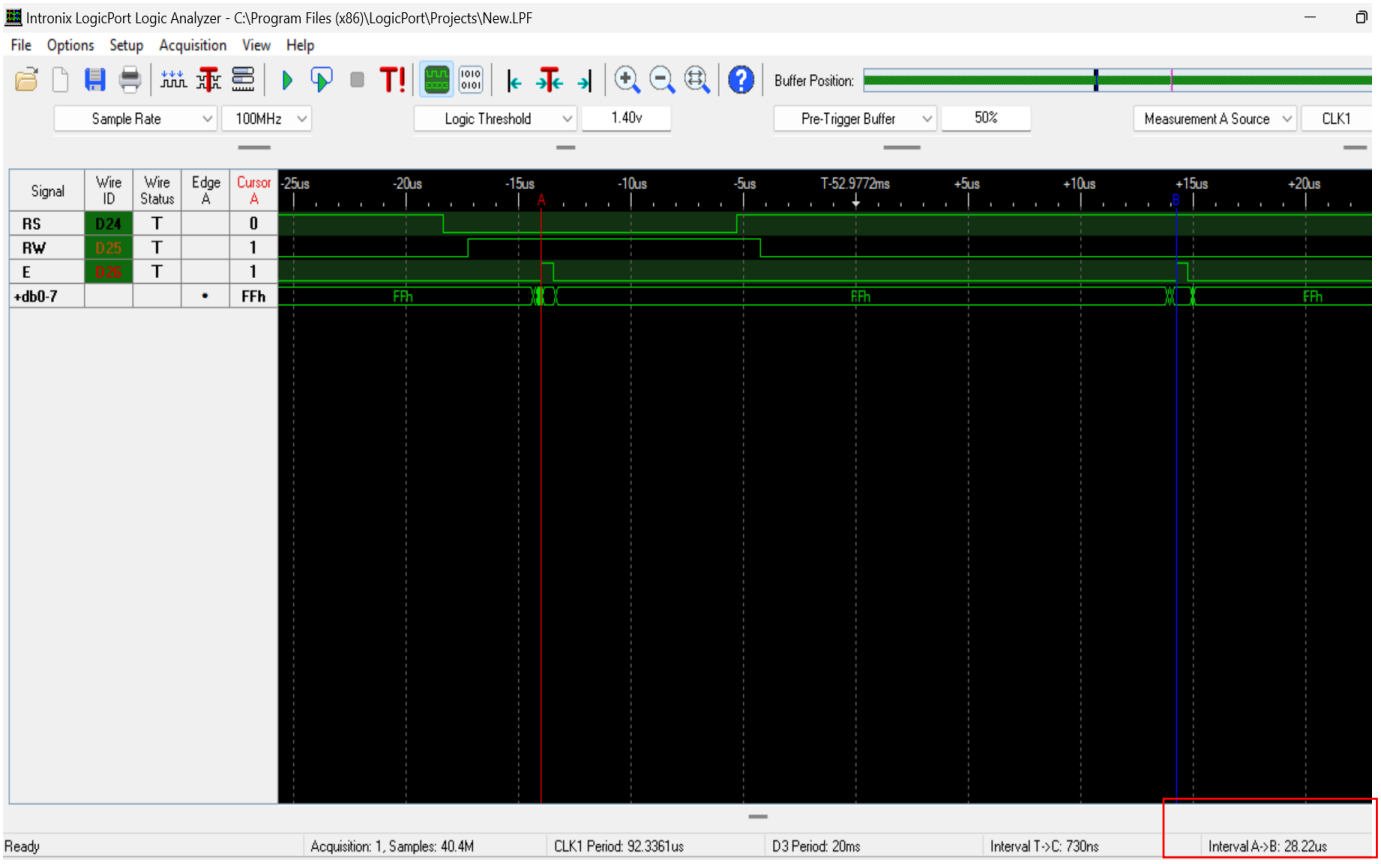
- Pulse width of enable pin of LCD which is in acceptable range.



- Setup time Tas which is in acceptable range.



- Hold time Tah which is in acceptable range.

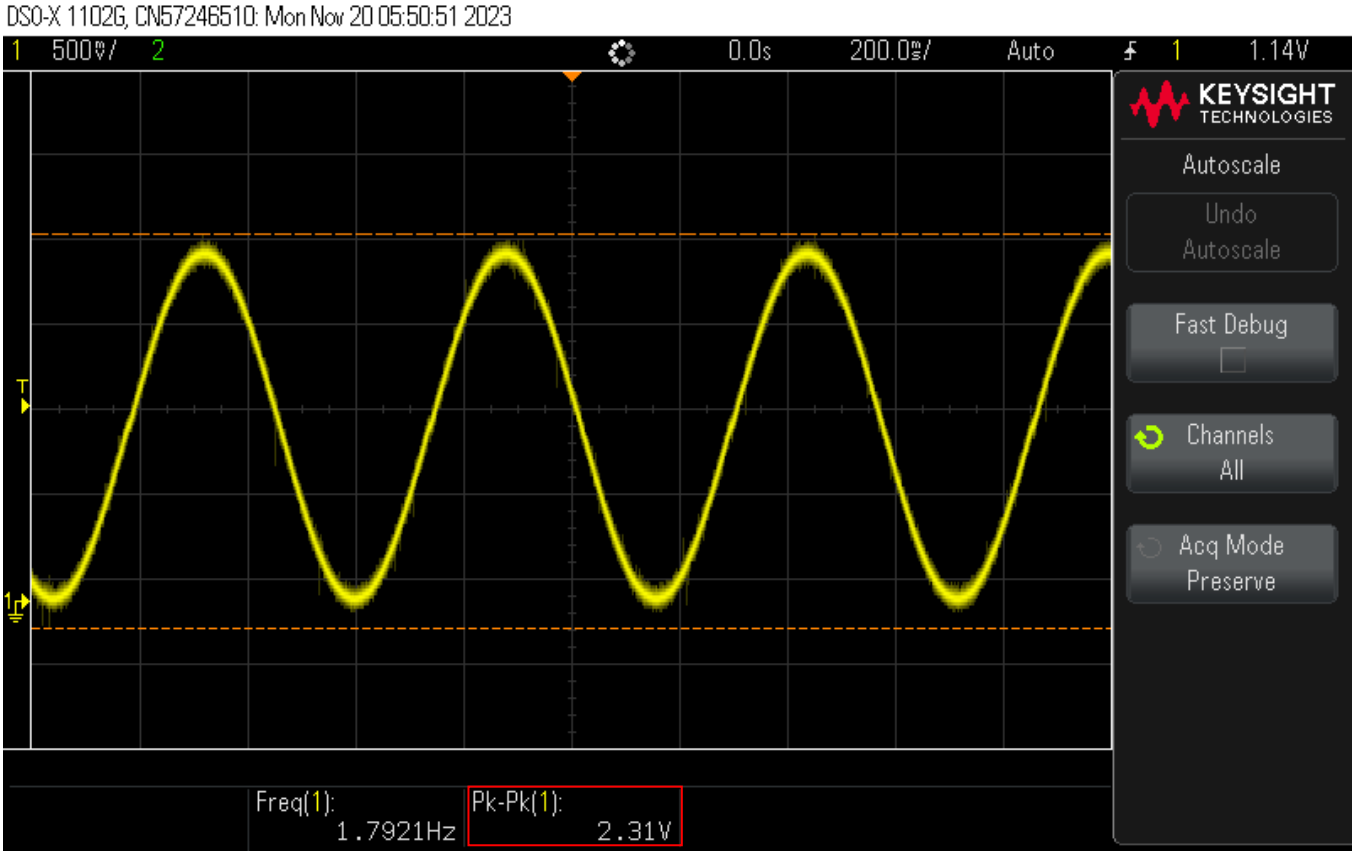


SPI DAC OUTPUTS

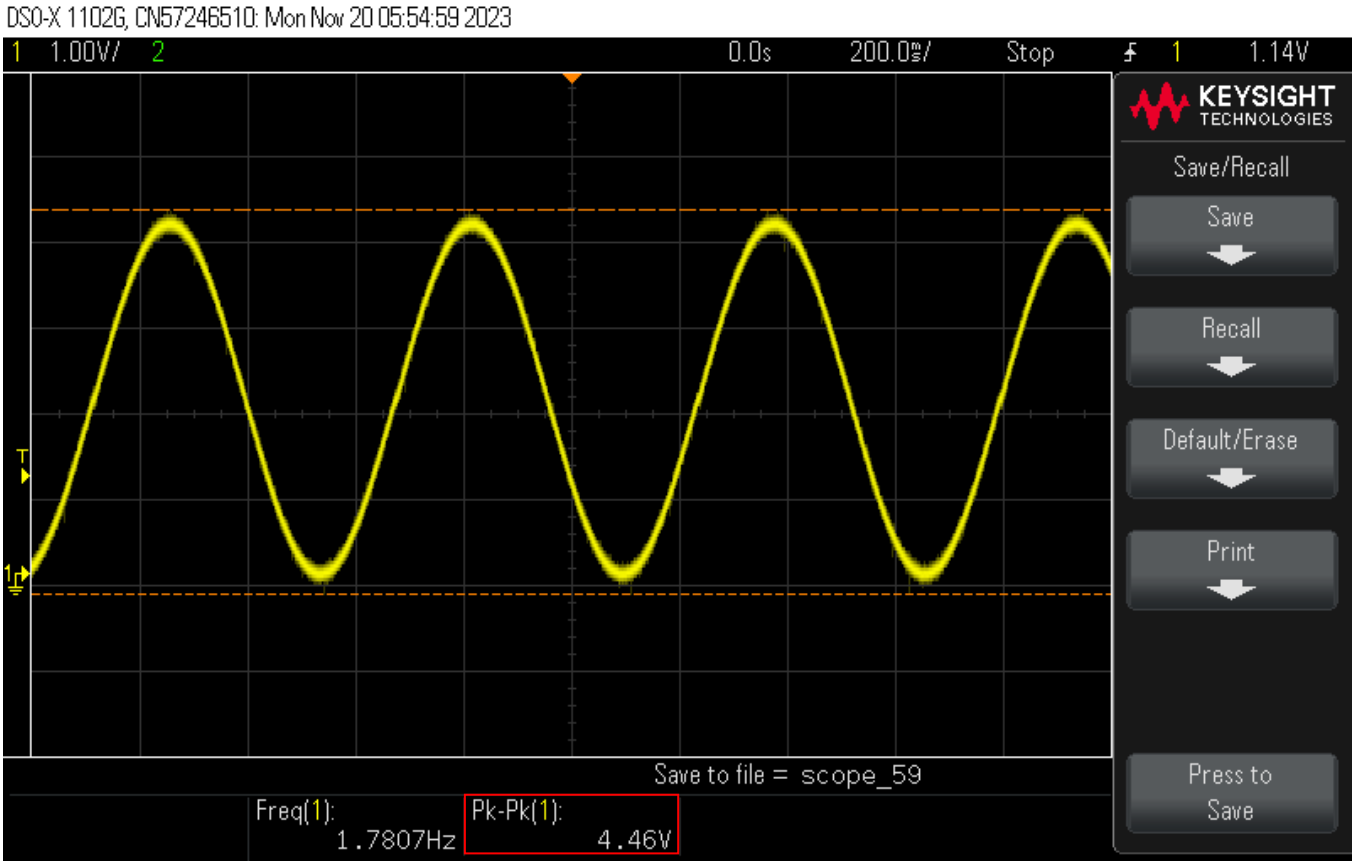
- DAC initialisation with implemented operation

```
COM5 - Tera Term VT
File  Edit  Setup  Control  Window  Help
  Single-Step                   1400      External command
  Memory Editor (VT100)         1800      External command

PAULMON2 Loc:2000 > Jump to memory location

Jump to memory location (2000), or ESC to quit: 2000

running program:


Tharuni ESD Lab 4 Supplemental
'D'->DAC Data Input,
'Z'-> mode change,
'N'-> Next wave,
'+'-> Increase DAC voltage,
'-'-> Decrease DAC voltage,
'?'-> Display Menu
```

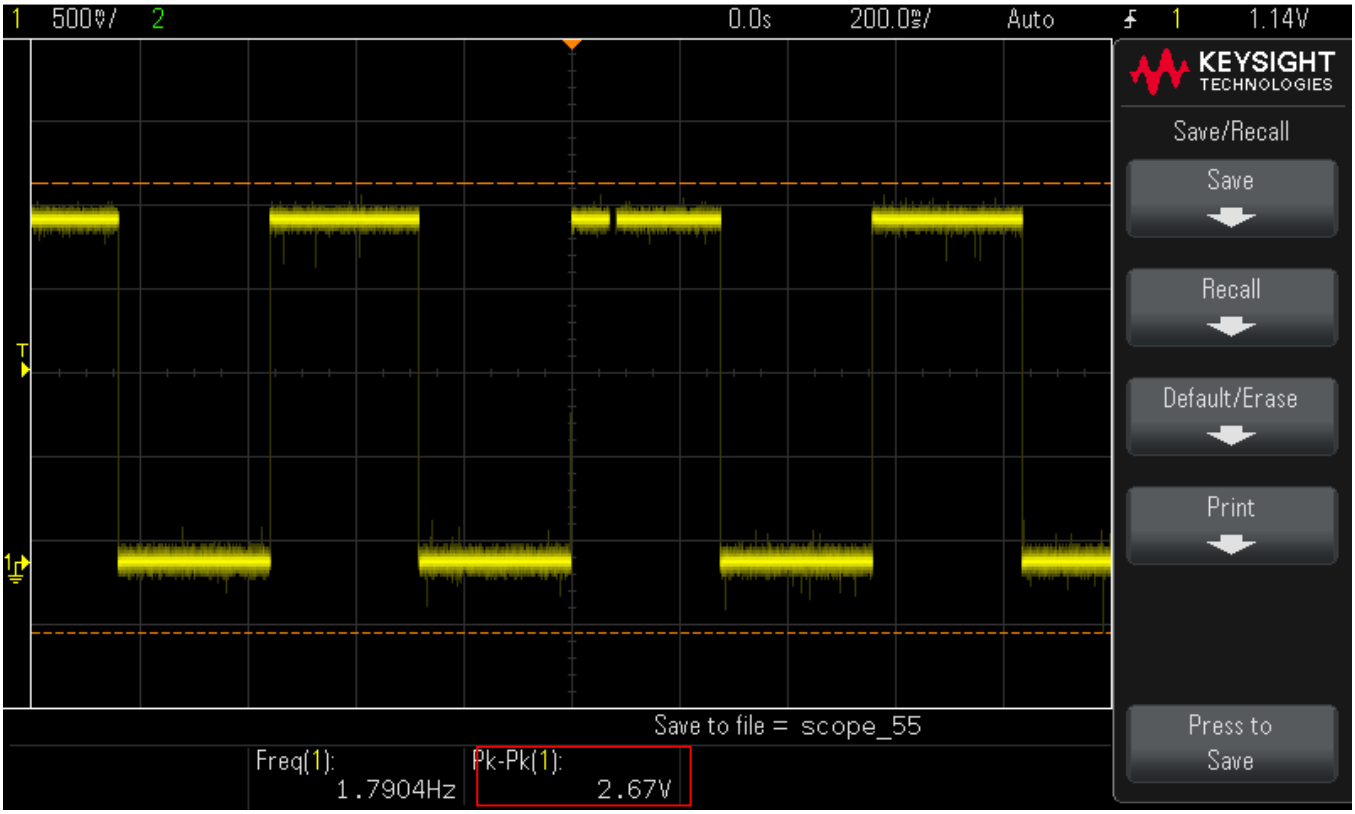
- Sine wave with gain 1



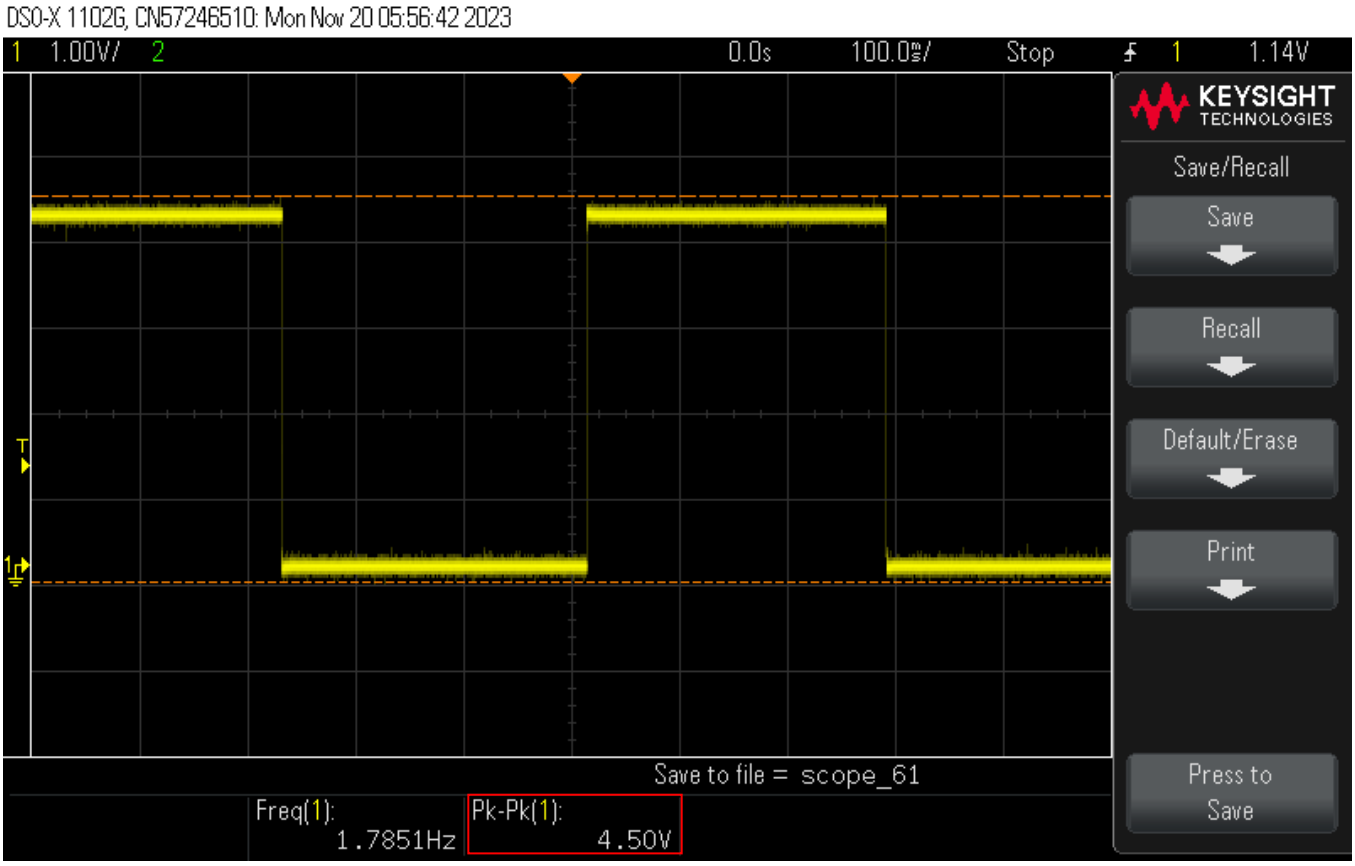
- Sine wave with gain 2



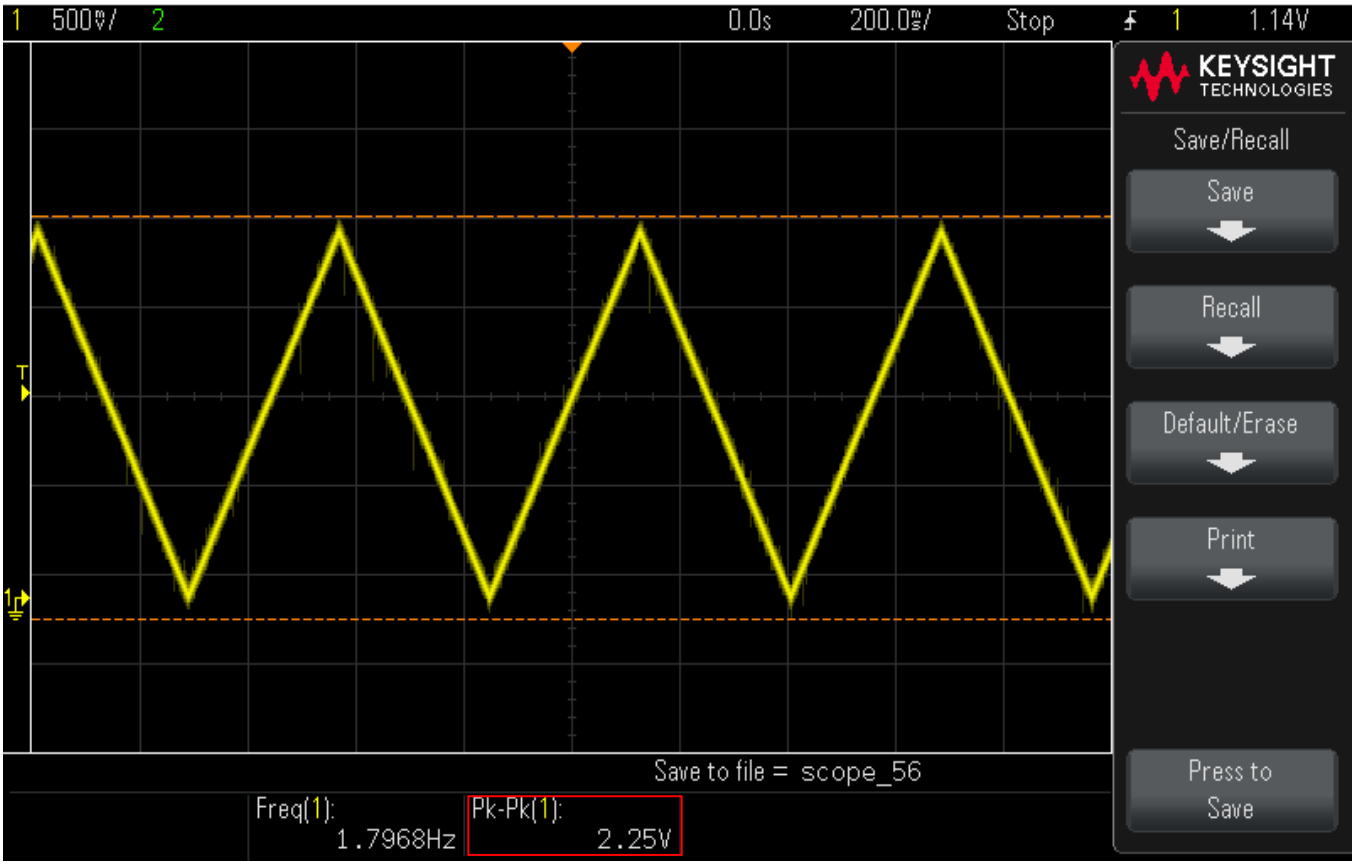
- Square wave with gain 1



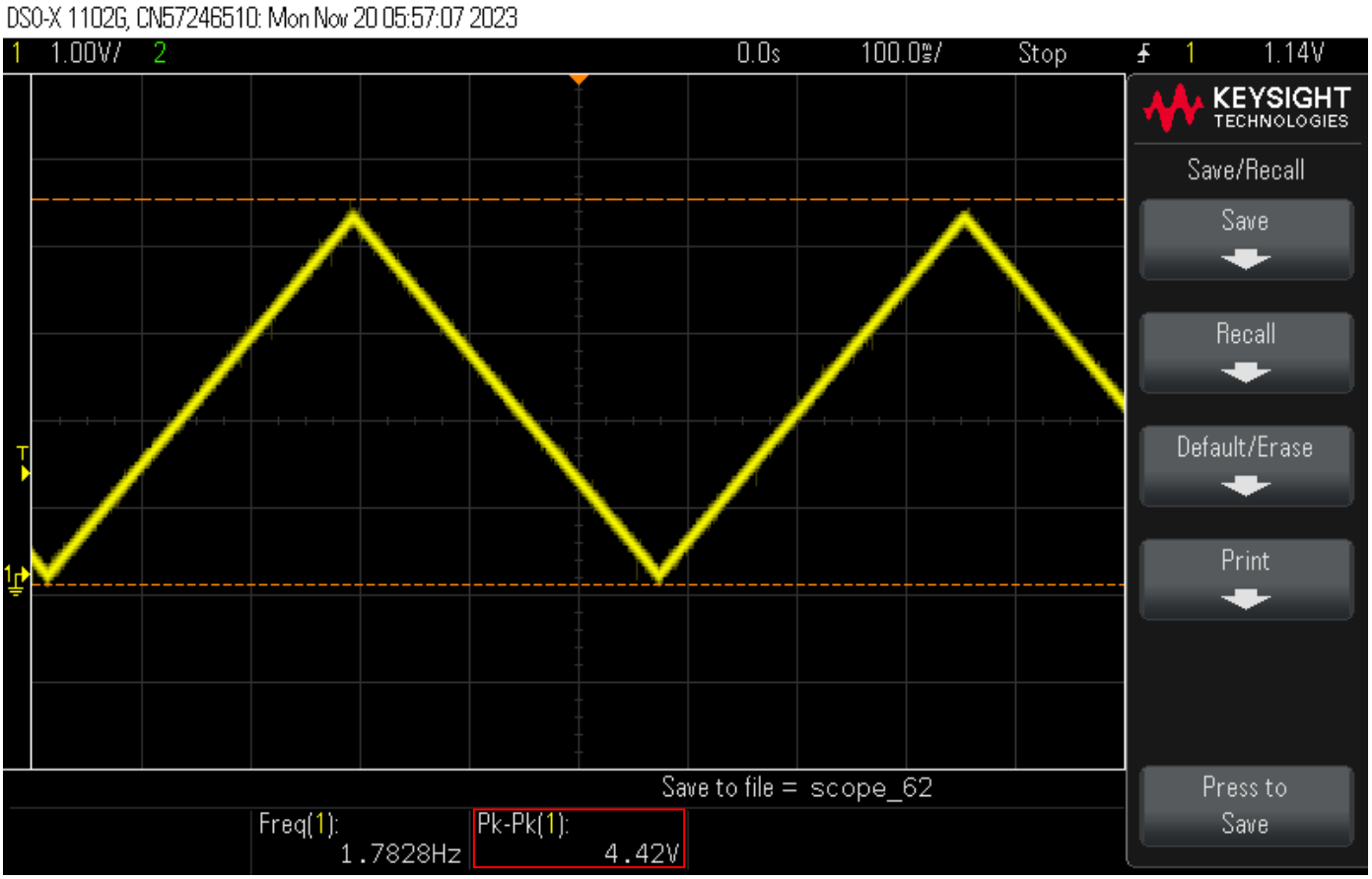
- Square wave with gain 2



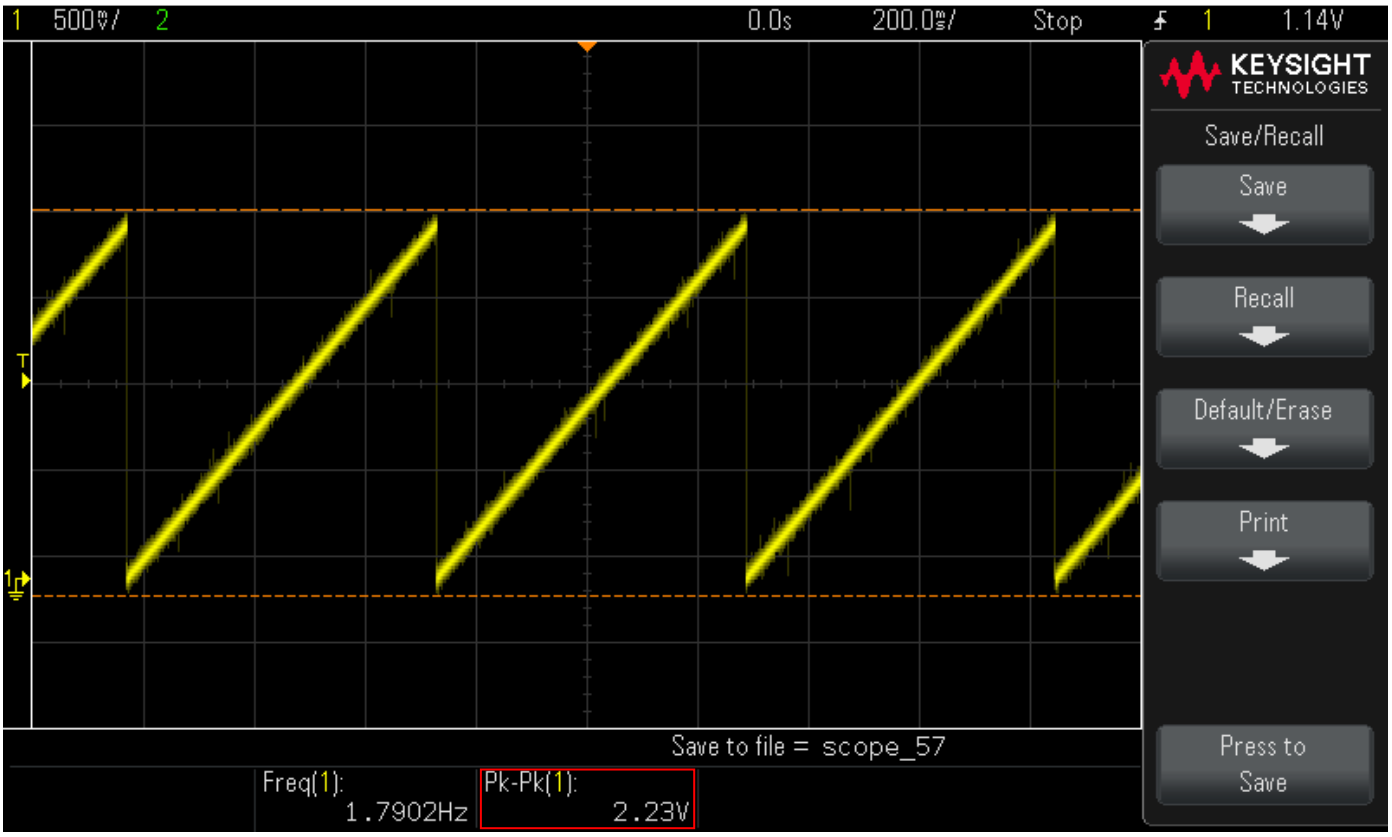
- Triangular wave with gain 1



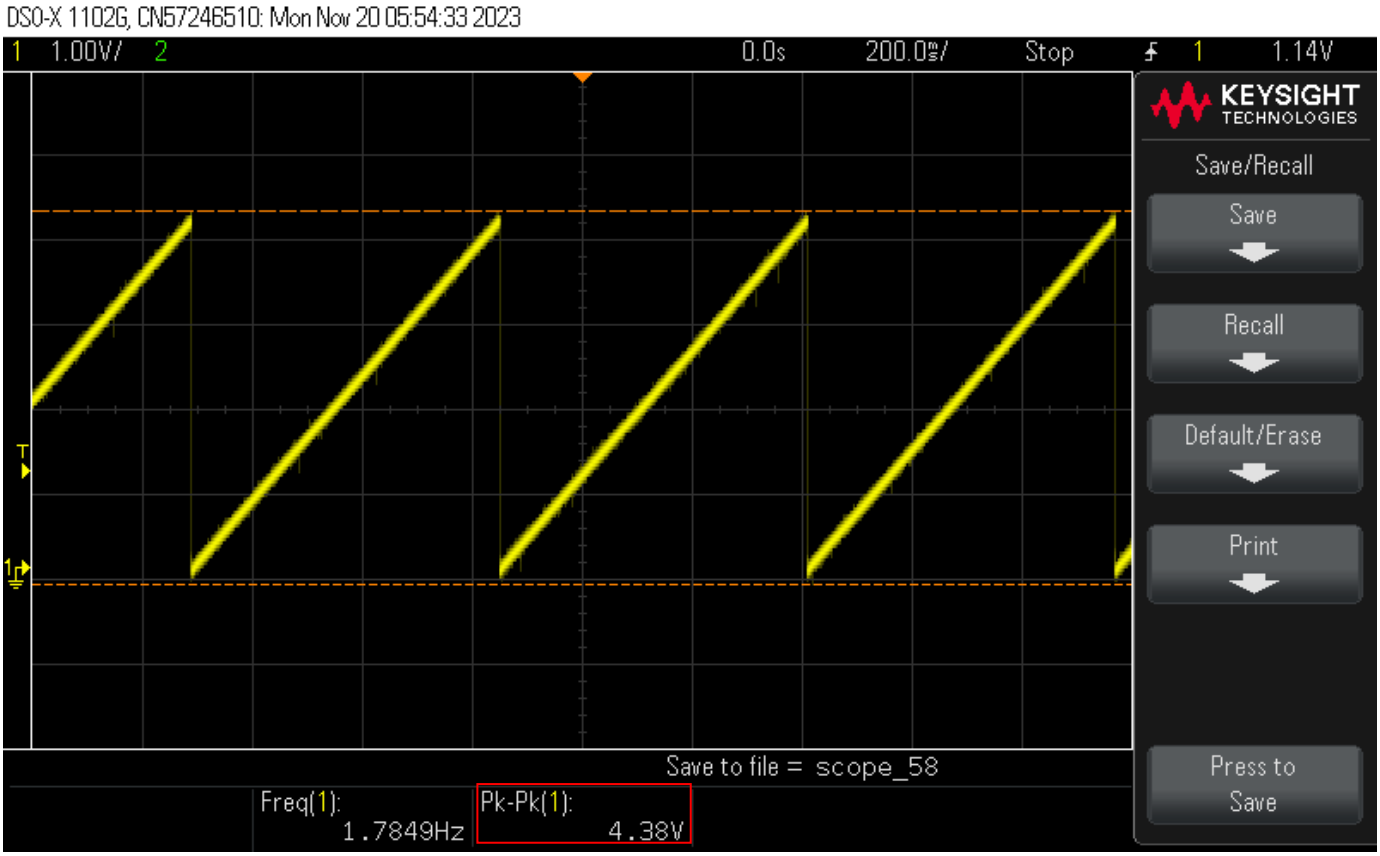
- Triangular wave with gain 2



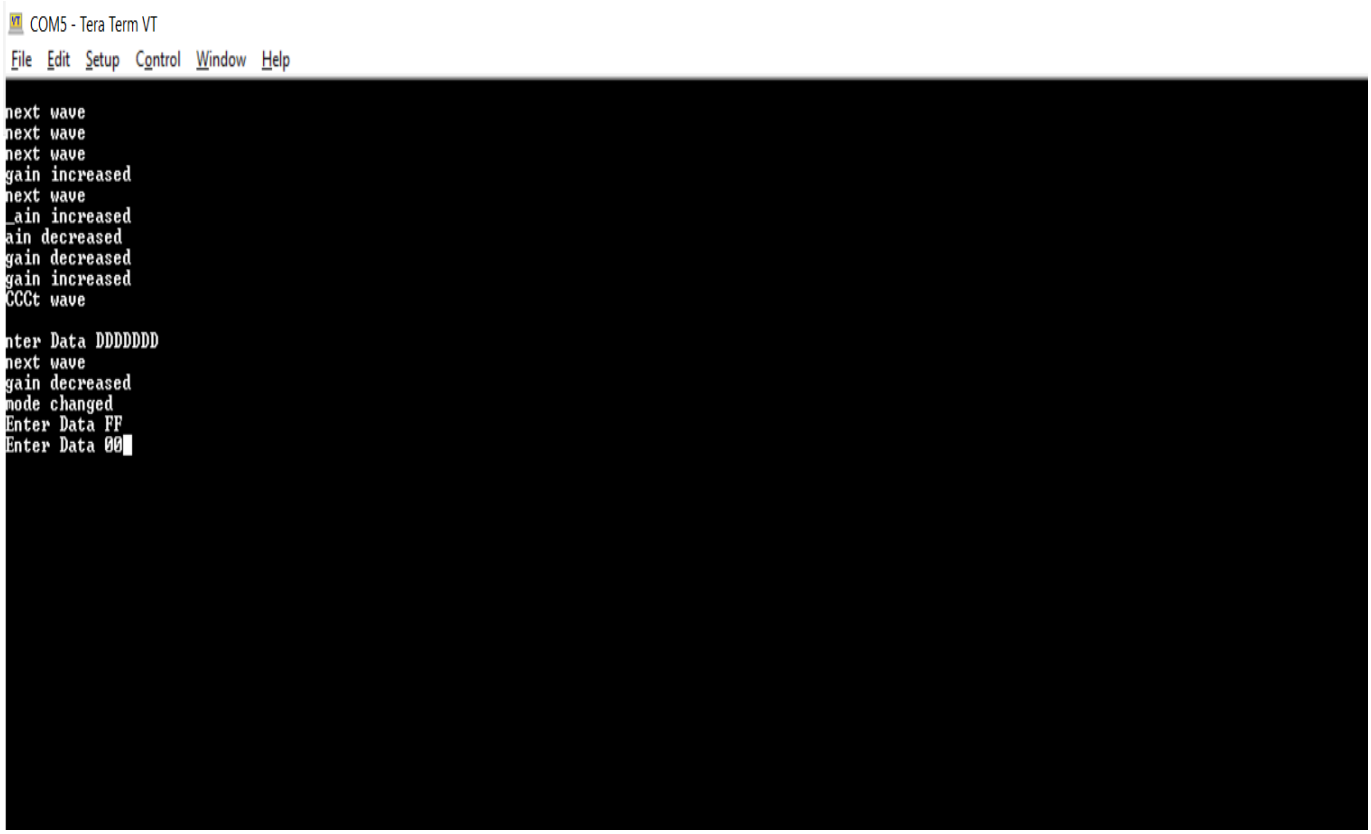
- Saw tooth wave with gain 1



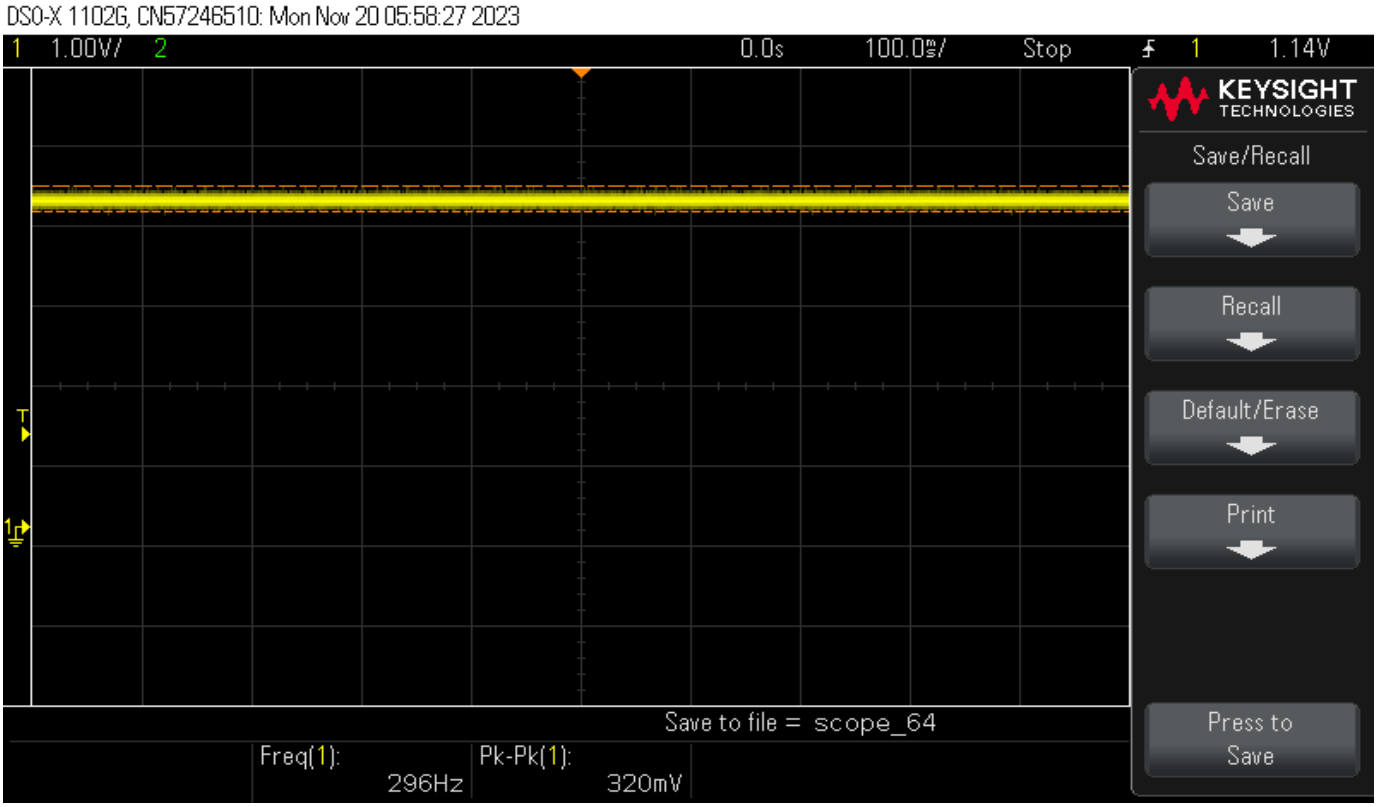
- Saw tooth wave with gain 2



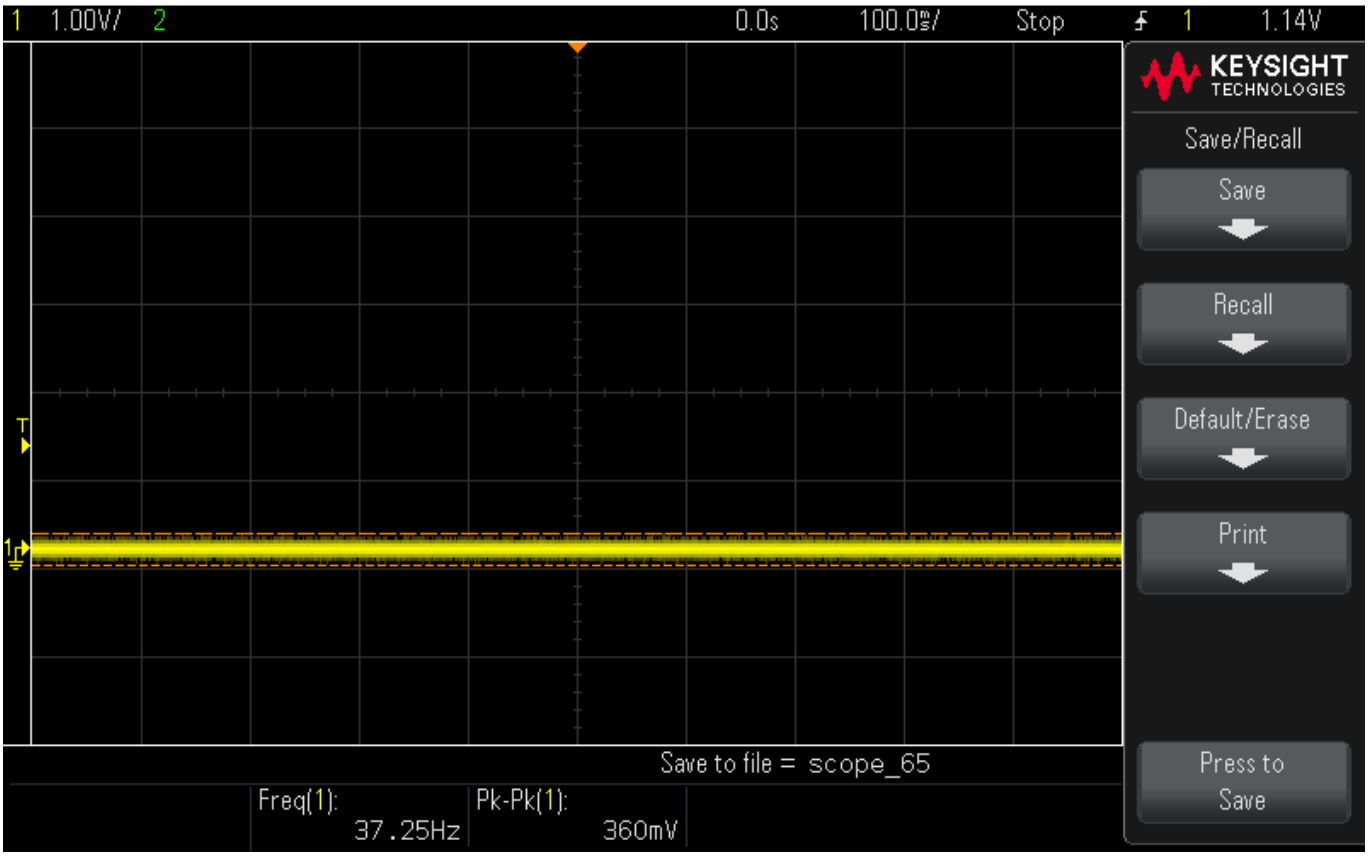
- Set mode operation has also been implemented where on this mode Output at A and B is as per the given data.



- Output on oscilloscope when FF data is written



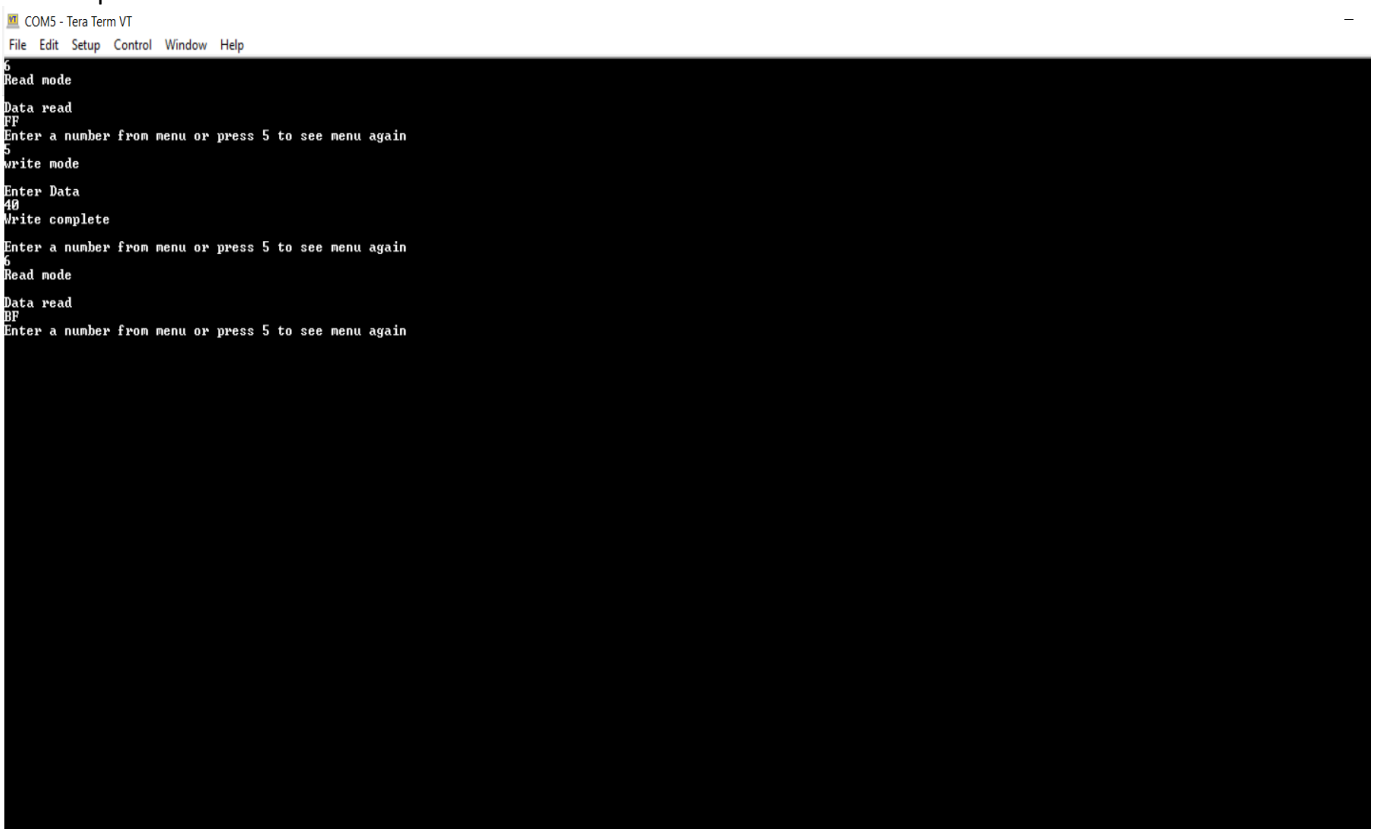
- Output on oscilloscope when 00 data has been written



IO EXPANDER OUTPUTS

- Read data on p0-p7 pins of IO expander

- Logic for IO expander: When P7 is detected low, complement the data on p0-p6 pins and reads the complemented data.



- In 0x40 bit p7 is low, hence the data 0x40 is complemented and we get the complemented data when read which is 0xBF.

SUBMISSION QUESTIONS

1) What operating system (including revision) did you use for your code development?
Ans: Windows 11

2) What compiler(s) (including revision) did you use?
Ans: SDCC with code blocks

3) What exactly (include name/revision if appropriate) did you use to build your code (an IDE, make/makefile, or command line)?
Ans: Code blocks IDE

4) Did you install and use any other software tools to complete your lab assignment?
Ans: Teraterm

5) Did you experience any problems with any of the software tools? If so, describe the problems.
Ans: No issues with any kind of software tools used

LAB LEARNINGS

Part 1 Elements:

1. **Pins and Signals:**
    - Understanding the importance of labeling pins and ensuring proper connections.
    - The presence of decoupling capacitors for stable power supply.
2. **EEPROM Functionality:**
    - Writing C code for EEPROM functionality.
    - Verifying that EEPROM contents persist after a power cycle.
3. **I2C Communication:**
    - Developing an I2C diagram/timing analysis.
    - Ensuring proper timing for successful I2C communication.

Part 2 Elements:

1. **LCD Functionality:**
    - Developing functional C code for basic LCD routines.
    - Ensuring the LCD functions as expected.
2. **LCD Control Signal Timing:**
    - Analyzing and verifying LCD control signal timing.
    - Using a logic analyzer to trace and diagram signal timings.
3. **Elapsed Time Handling:**
    - Implementing functionalities for elapsed time stop, restart, and reset to "00:00.0".
    - Ensuring proper integration with existing code.

Part 3 Required and Supplemental Elements:

1. **LCD Dumps and Custom Characters:**
    - Creating and displaying LCD Hex/DDRAM/CGRAM dumps.
    - Designing and incorporating custom LCD characters.
2. **SPI Interface:**
    - Implementing SPI interface.
    - Comparing SPI with previously implemented I2C.
3. **PCF8574 I2C I/O Expander:**
    - Integrating PCF8574 I2C I/O Expander.
    - Implementing input/output functionalities and handling ISR.

Overall, the lab covers a range of essential concepts, including hardware connections, communication protocols (I2C and SPI), LCD control, EEPROM usage, ARM code development, and interrupt handling. The experience gained in implementing and debugging these functionalities contributes to a comprehensive understanding of embedded systems.