DigiPen Institute of Technology Singapore

Embedded Systems

CS 397

Trimester 3, AY 2021/22

Assignment 4

DAC, ADC, and CAN

Q1. Create a STM32 project with STM32CubeIDE to implement a STM32F767ZI microcontroller-based application. The implemented embedded program must have the following settings/functions:

1. Start a new STM32 Project using the Nucleo-F767ZI Board.
2. Disable ETH and USB_OTG_FS functions and reset all ETH and USB related pins.
3. Select, under Pinout & Configuration, System Core -> SYS -> Debug: Serial Wire
4. Use bypass high speed clock source (8 MHz) input.
5. Set PCLK1 (APB1 Peripheral Clock) = 54 MHz
6. Configure a debug channel via USART3 with baud rate = 115200 bits/s, 8 data bits, no parity, one stop bit, and oversampling at 16 samples.
7. Configure two 12-bit DAC channels (DAC_1 & DAC_2) (with both output buffers disabled) to output 0 – 3.3 V independently.
8. Set the two DAC channels to 0 V and 1.65 V initially.
9. Increase the DAC outputs in a step equal to 100 times the DAC resolution at the rate of 1 Hz.
10. Set any DAC channel to zero after the DAC reading > 4095 (3.3 V).
11. Configure four ADC channels; three for ST Zio terminals, A3 (PF3), A4 (PF5), and A5 (PF10), and one for internal temperature sensing. Each ADC sampling time is set at 480 ADC clock cycles.
12. Connect A3 to DAC_1 (PA4), A4 to DAC_2 (PA5), and leave A5 unconnected.
13. Use the interrupt enabled user-button (B1) to toggle the blue LED (LD2) and reset the DACs output to their initially values (0 V and 1.65 V) at any time.
14. Blink the green LED (LD1) at a rate of 1 Hz.
15. Turn on the red LED (LD3) when either DAC output is equal or greater than 3.0 V.
16. Configure two channels of Controller Area Network (CAN), i.e., CAN1 (PD0 & PD1) and CAN2 (PB12 & PB13). They are both operated at a baud rate of 125 kbps.

17. **CAN1** is used to transmit data obtained from the **two DACs** and **four ADCs** under the normal condition when the red LED is turned off, and the data sequence is **DAC_1, A3, DAC_2, A4, A5, and temperature reading**. When the red LED is turned on, **CAN1** is transmitting only the ID and one constant data byte of **0x55**. The CAN transmission rate is also set at 1 Hz per data sequence.
18. CAN1 starts the transmission with ID = **0x0397nn0**, where **nn (**= 01 to 19) is the serial number assigned to you (Please check with the lecturer).
19. A same CAN ID is used to transmit a data sequence in one or more data frames, and a different ID must be used for the next data sequence. The IDs are repeated from **0x0397nn0** to **0x0397nnF** in an interval of **0x1.**
20. CAN2 is used to receive the CAN1 data and other information on the CAN bus.
21. CAN2 implements only two filter banks; one is configured as Identifier Mask mode and the other is as Identifier List mode.
22. The Identifier Mask mode filter bank is assigned to FIFO 0 to receive data only from ID = **0x00397nn0** and **0x00397nn8.**
23. The Identifier List mode filters bank are assigned to FIFO 1 to receive data only from ID = **0x00397nn5** and **0x00397nnA.**
24. Use the debug channel (USART3) to display the transmitted (CAN1) and received (CAN2) data. The information is displayed in a few lines of texts for CAN1 and CAN2 FIFO 0 and FIFO 1 at the rate of 1 Hz. The example of display is as follows:

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CS397 CAN TX/RX ID : dac_1       A3          dac_2       A4          (ID)     A5          Temp
CAN1 TX : 0x397FF0 : 1400(1.13V) 1305(1.05V)  3400(2.74V) 3291(2.65V) 0x397FF0  4095(3.30V)  958(29.73 degC)
CAN2 F0 : 0x397FF0 : 1400(1.13V) 1305(1.05V)  3400(2.74V) 3291(2.65V) 0x397FF0  4095(3.30V)  958(29.73 degC)
CAN2 F1 : No data received.

CS397 CAN TX/RX ID : dac_1       A3          dac_2       A4          (ID)     A5          Temp
CAN1 TX : 0x397FF1 : 1500(1.21V) 1402(1.13V)  3500(2.82V) 3392(2.73V) 0x397FF1  4095(3.30V)  958(29.73 degC)
CAN2 F0 : No data received.
CAN2 F1 : No data received.

CS397 CAN TX/RX ID : dac_1       A3          dac_2       A4          (ID)     A5          Temp
CAN1 TX : 0x397FF2 : 1600(1.29V) 1495(1.20V)  3600(2.90V) 3496(2.82V) 0x397FF2  4081(3.29V)  958(29.73 degC)
CAN2 F0 : No data received.
CAN2 F1 : No data received.

CS397 CAN TX/RX ID : dac_1       A3          dac_2       A4          (ID)     A5          Temp
CAN1 TX : 0x397FF3 : 1700(1.37V) 1594(1.28V)  3700(2.98V) 3593(2.89V) 0x397FF3  4081(3.29V)  956(29.09 degC)
CAN2 F0 : No data received.
CAN2 F1 : No data received.

CS397 CAN TX/RX ID : dac_1       A3          dac_2       A4          (ID)     A5          Temp
CAN1 TX : 0x397FF4 : 0x55
CAN2 F0 : No data received.
CAN2 F1 : No data received.

CS397 CAN TX/RX ID : dac_1       A3          dac_2       A4          (ID)     A5          Temp
CAN1 TX : 0x397FF5 : 0x55
CAN2 F0 : No data received.
CAN2 F1 : 0x397FF5 : 0x55

CS397 CAN TX/RX ID : dac_1       A3          dac_2       A4          (ID)     A5          Temp
CAN1 TX : 0x397FF6 : 0x55
CAN2 F0 : No data received.
CAN2 F1 : No data received.
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CS397 CAN TX/RX ID : dac_1       A3          dac_2       A4          (ID)     A5          Temp
CAN1 TX : 0x397FF7 : 2100(1.69V) 1994(1.61V)  0(0.00V) 3995(3.22V) 0x397FF7  4084(3.29V)  959(30.05 degC)
CAN2 F0 : No data received.
CAN2 F1 : No data received.

CS397 CAN TX/RX ID : dac_1       A3          dac_2       A4          (ID)     A5          Temp
CAN1 TX : 0x397FF8 : 2200(1.77V) 2104(1.70V)  100(0.08V) 0(0.00V) 0x397FF8  4095(3.30V)  957(29.41 degC)
CAN2 F0 : 0x397FF8 : 2200(1.77V) 2104(1.70V)  100(0.08V) 0(0.00V) 0x397FF8  4095(3.30V)  957(29.41 degC)
CAN2 F1 : No data received.

CS397 CAN TX/RX ID : dac_1       A3          dac_2       A4          (ID)     A5          Temp
CAN1 TX : 0x397FF9 : 2300(1.85V) 2199(1.77V)  200(0.16V) 96(0.08V) 0x397FF9  4089(3.29V)  957(29.41 degC)
CAN2 F0 : No data received.
CAN2 F1 : No data received.

CS397 CAN TX/RX ID : dac_1       A3          dac_2       A4          (ID)     A5          Temp
CAN1 TX : 0x397FFA : 2400(1.93V) 2302(1.85V)  300(0.24V) 196(0.16V) 0x397FFA  4095(3.30V)  957(29.41 degC)
CAN2 F0 : No data received.
CAN2 F1 : 0x397FFA : 2400(1.93V) 2302(1.85V)  300(0.24V) 196(0.16V) 0x397FFA  4095(3.30V)  957(29.41 degC)

CS397 CAN TX/RX ID : dac_1       A3          dac_2       A4          (ID)     A5          Temp
CAN1 TX : 0x397FFB : 2500(2.01V) 2391(1.93V)  400(0.32V) 304(0.24V) 0x397FFB  4079(3.29V)  959(30.05 degC)
CAN2 F0 : No data received.
CAN2 F1 : No data received.

CS397 CAN TX/RX ID : dac_1       A3          dac_2       A4          (ID)     A5          Temp
CAN1 TX : 0x397FFC : 2600(2.09V) 2499(2.01V)  500(0.40V) 401(0.32V) 0x397FFC  4090(3.30V)  958(29.73 degC)
CAN2 F0 : No data received.
CAN2 F1 : No data received.

CS397 CAN TX/RX ID : dac_1       A3          dac_2       A4          (ID)     A5          Temp
CAN1 TX : 0x397FFD : 2700(2.18V) 2594(2.09V)  600(0.48V) 502(0.40V) 0x397FFD  4083(3.29V)  958(29.73 degC)
CAN2 F0 : No data received.
CAN2 F1 : No data received.

CS397 CAN TX/RX ID : dac_1       A3          dac_2       A4          (ID)     A5          Temp
CAN1 TX : 0x397FFE : 2800(2.26V) 2693(2.17V)  700(0.56V) 602(0.49V) 0x397FFE  4084(3.29V)  958(29.73 degC)
CAN2 F0 : No data received.
CAN2 F1 : No data received.

CS397 CAN TX/RX ID : dac_1       A3          dac_2       A4          (ID)     A5          Temp
CAN1 TX : 0x397FFF : 2900(2.34V) 2795(2.25V)  800(0.64V) 697(0.56V) 0x397FFF  4093(3.30V)  958(29.73 degC)
CAN2 F0 : No data received.
CAN2 F1 : No data received.

CS397 CAN TX/RX ID : dac_1       A3          dac_2       A4          (ID)     A5          Temp
CAN1 TX : 0x397FF0 : 3000(2.42V) 2903(2.34V)  900(0.73V) 788(0.63V) 0x397FF0  4095(3.30V)  957(29.41 degC)
CAN2 F0 : 0x397FF0 : 3000(2.42V) 2903(2.34V)  900(0.73V) 788(0.63V) 0x397FF0  4095(3.30V)  957(29.41 degC)
CAN2 F1 : No data received.

CS397 CAN TX/RX ID : dac_1       A3          dac_2       A4          (ID)     A5          Temp
CAN1 TX : 0x397FF1 : 3100(2.50V) 2993(2.41V)  1000(0.81V) 906(0.73V) 0x397FF1  4081(3.29V)  957(29.41 degC)
CAN2 F0 : No data received.
CAN2 F1 : No data received.

CS397 CAN TX/RX ID : dac_1       A3          dac_2       A4          (ID)     A5          Temp
CAN1 TX : 0x397FF2 : 3200(2.58V) 3091(2.49V)  1100(0.89V) 1000(0.81V) 0x397FF2  4083(3.29V)  958(29.73 degC)
CAN2 F0 : No data received.
CAN2 F1 : No data received.

CS397 CAN TX/RX ID : dac_1       A3          dac_2       A4          (ID)     A5          Temp
CAN1 TX : 0x397FF3 : 3300(2.66V) 3195(2.57V)  1200(0.97V) 1102(0.89V) 0x397FF3  4082(3.29V)  956(29.09 degC)
CAN2 F0 : No data received.
CAN2 F1 : No data received.

CS397 CAN TX/RX ID : dac_1       A3          dac_2       A4          (ID)     A5          Temp
CAN1 TX : 0x397FF4 : 3400(2.74V) 3293(2.65V)  1300(1.05V) 1193(0.96V) 0x397FF4  4095(3.30V)  956(29.09 degC)
CAN2 F0 : No data received.
CAN2 F1 : No data received.

CS397 CAN TX/RX ID : dac_1       A3          dac_2       A4          (ID)     A5          Temp
CAN1 TX : 0x397FF5 : 3500(2.82V) 3391(2.73V)  1400(1.13V) 1299(1.05V) 0x397FF5  4084(3.29V)  957(29.41 degC)
CAN2 F0 : No data received.
CAN2 F1 : 0x397FF5 : 3500(2.82V) 3391(2.73V)  1400(1.13V) 1299(1.05V) 0x397FF5  4084(3.29V)  957(29.41 degC)

CS397 CAN TX/RX ID : dac_1       A3          dac_2       A4          (ID)     A5          Temp
CAN1 TX : 0x397FF6 : 3600(2.90V) 3498(2.82V)  1500(1.21V) 1393(1.12V) 0x397FF6  4095(3.30V)  957(29.41 degC)
CAN2 F0 : No data received.
CAN2 F1 : No data received.

CS397 CAN TX/RX ID : dac_1       A3          dac_2       A4          (ID)     A5          Temp
CAN1 TX : 0x397FF7 : 3700(2.98V) 3592(2.89V)  1600(1.29V) 1499(1.21V) 0x397FF7  4083(3.29V)  958(29.73 degC)
CAN2 F0 : No data received.
CAN2 F1 : No data received.

CS397 CAN TX/RX ID : dac_1       A3          dac_2       A4          (ID)     A5          Temp
CAN1 TX : 0x397FF8 : 0x55
CAN2 F0 : 0x397FF8 : 0x55
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CAN2 F1 : No data received.

CS397 CAN TX/RX ID : dac_1       A3           dac_2       A4          (ID)     A5           Temp
CAN1 TX : 0x397FF9 : 0x55
CAN2 F0 : No data received.
CAN2 F1 : No data received.

CS397 CAN TX/RX ID : dac_1       A3           dac_2       A4          (ID)     A5           Temp
CAN1 TX : 0x397FFA : 0x55
CAN2 F0 : No data received.
CAN2 F1 : 0x397FFA : 0x55

CS397 CAN TX/RX ID : dac_1       A3           dac_2       A4          (ID)     A5           Temp
CAN1 TX : 0x397FFB : 0(0.00V) 3993(3.22V)  2000(1.61V) 1898(1.53V) 0x397FFB  4092(3.30V)  958(29.73 degC)
CAN2 F0 : No data received.
CAN2 F1 : No data received.

CS397 CAN TX/RX ID : dac_1       A3           dac_2       A4          (ID)     A5           Temp
CAN1 TX : 0x397FFC : 100(0.08V) 10(0.01V)  2100(1.69V) 1995(1.61V) 0x397FFC  4095(3.30V)  956(29.09 degC)
CAN2 F0 : No data received.
CAN2 F1 : No data received.

CS397 CAN TX/RX ID : dac_1       A3           dac_2       A4          (ID)     A5           Temp
CAN1 TX : 0x397FFD : 200(0.16V) 101(0.08V)  2200(1.77V) 2094(1.69V) 0x397FFD  4095(3.30V)  957(29.41 degC)
CAN2 F0 : No data received.
CAN2 F1 : No data received.

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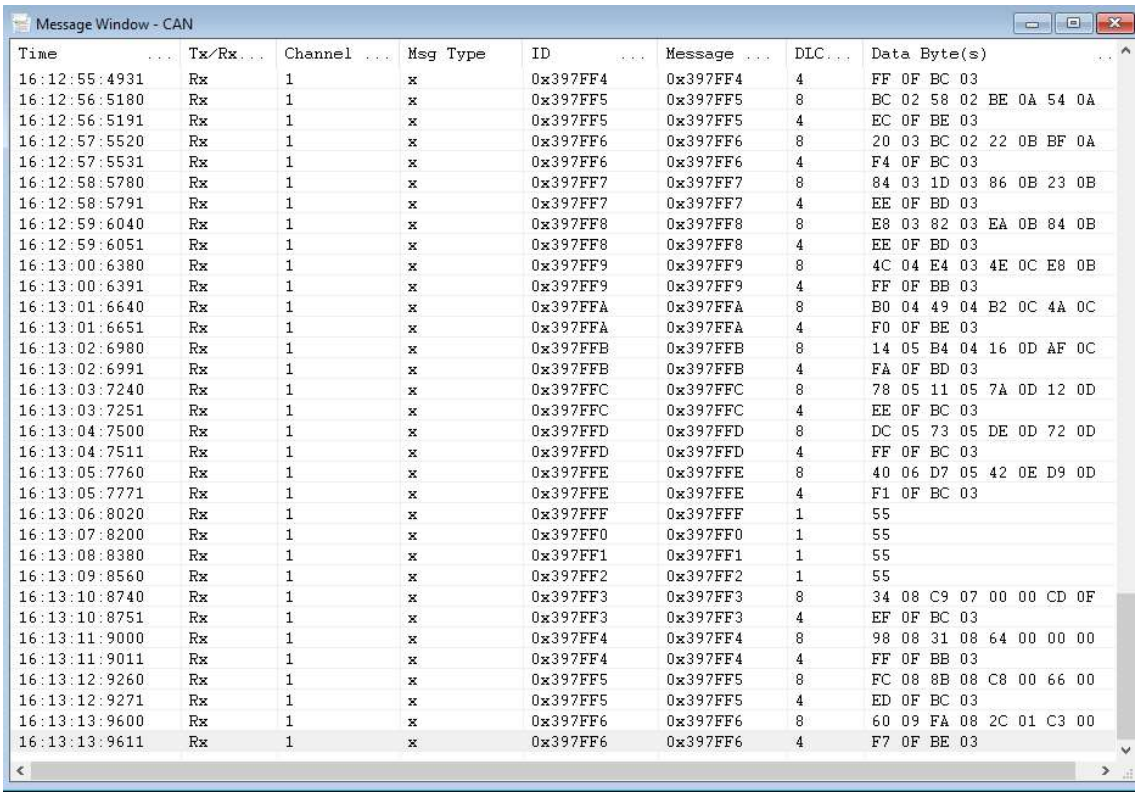
25. The data can be **0x55** or **DAC_1, A3, DAC_2, A4, A5, & temperature** or "**No data received.**". Note that, for each CAN2 FIFO, "No data received." is displayed if there is no update of data in the FIFO.
26. The display formats for **DAC_1, A3, DAC_2, A4,** and **A5** are integers and analogue values with 2 decimal places.
27. The temperature is shown as an integer and float with 2 decimal places, and the unit, ℃ or degC, must be clearly shown.

Note: 1. The ADC polling method is not allowed in this implementation.
2. Enable the EXTI line [15:10] interrupts.
2. Generate peripheral initialization as a pair of '.c/.h' files per peripheral.

Notes on Submission:

1. A new STM32 project must be created with project name:
   A4_SN_name_24Jul2022
   where SN is your serial number (A01 – A19).
2. Submit the implemented project in a zip file with filename:
   A4_SN_name_24Jul2022.zip
3. The above zip file should include all STM32 project folders and files (except with debug folder deleted), and generated report files (.pdf &.txt).
4. Submission deadline is on **24 July 2022, 2359 hrs.**

The sample of CAN analyzer received (Rx) data



Message Window - CAN

Time	Tx/Rx	Channel	Msg Type	ID	Message	DLC	Data Byte(s)
16:12:55:4931	Rx	1	x	0x397FF4	0x397FF4	4	FF 0F BC 03
16:12:56:5180	Rx	1	x	0x397FF5	0x397FF5	8	BC 02 58 02 BE 0A 54 0A
16:12:56:5191	Rx	1	x	0x397FF5	0x397FF5	4	EC 0F BE 03
16:12:57:5520	Rx	1	x	0x397FF6	0x397FF6	8	20 03 BC 02 22 0B BF 0A
16:12:57:5531	Rx	1	x	0x397FF6	0x397FF6	4	F4 0F BC 03
16:12:58:5780	Rx	1	x	0x397FF7	0x397FF7	8	84 03 1D 03 86 0B 23 0B
16:12:58:5791	Rx	1	x	0x397FF7	0x397FF7	4	EE 0F BD 03
16:12:59:6040	Rx	1	x	0x397FF8	0x397FF8	8	E8 03 82 03 EA 0B 84 0B
16:12:59:6051	Rx	1	x	0x397FF8	0x397FF8	4	EE 0F BD 03
16:13:00:6380	Rx	1	x	0x397FF9	0x397FF9	8	4C 04 E4 03 4E 0C E8 0B
16:13:00:6391	Rx	1	x	0x397FF9	0x397FF9	4	FF 0F BB 03
16:13:01:6640	Rx	1	x	0x397FFA	0x397FFA	8	B0 04 49 04 B2 0C 4A 0C
16:13:01:6651	Rx	1	x	0x397FFA	0x397FFA	4	F0 0F BE 03
16:13:02:6980	Rx	1	x	0x397FFB	0x397FFB	8	14 05 B4 04 16 0D AF 0C
16:13:02:6991	Rx	1	x	0x397FFB	0x397FFB	4	FA 0F BD 03
16:13:03:7240	Rx	1	x	0x397FFC	0x397FFC	8	78 05 11 05 7A 0D 12 0D
16:13:03:7251	Rx	1	x	0x397FFC	0x397FFC	4	EE 0F BC 03
16:13:04:7500	Rx	1	x	0x397FFD	0x397FFD	8	DC 05 73 05 DE 0D 72 0D
16:13:04:7511	Rx	1	x	0x397FFD	0x397FFD	4	FF 0F BC 03
16:13:05:7760	Rx	1	x	0x397FFE	0x397FFE	8	40 06 D7 05 42 0E D9 0D
16:13:05:7771	Rx	1	x	0x397FFE	0x397FFE	4	F1 0F BC 03
16:13:06:8020	Rx	1	x	0x397FFF	0x397FFF	1	55
16:13:07:8200	Rx	1	x	0x397FF0	0x397FF0	1	55
16:13:08:8380	Rx	1	x	0x397FF1	0x397FF1	1	55
16:13:09:8560	Rx	1	x	0x397FF2	0x397FF2	1	55
16:13:10:8740	Rx	1	x	0x397FF3	0x397FF3	8	34 08 C9 07 00 00 CD 0F
16:13:10:8751	Rx	1	x	0x397FF3	0x397FF3	4	EF 0F BC 03
16:13:11:9000	Rx	1	x	0x397FF4	0x397FF4	8	98 08 31 08 64 00 00 00
16:13:11:9011	Rx	1	x	0x397FF4	0x397FF4	4	FF 0F BB 03
16:13:12:9260	Rx	1	x	0x397FF5	0x397FF5	8	FC 08 8B 08 C8 00 66 00
16:13:12:9271	Rx	1	x	0x397FF5	0x397FF5	4	ED 0F BC 03
16:13:13:9600	Rx	1	x	0x397FF6	0x397FF6	8	60 09 FA 08 2C 01 C3 00
16:13:13:9611	Rx	1	x	0x397FF6	0x397FF6	4	F7 0F BE 03

_ End _