Traffic Light Controller

Design a traffic light controller for the intersection of two equally busy one-way streets. The goal is to maximize traffic flow, minimize waiting time at a red light, and avoid accidents.

The intersection has two one-ways roads with the same amount of traffic: North and East, as shown in Figure. In this system, the light pattern defines which road has right of way over the other. Since an output pattern to the lights is necessary to remain in a state, we will solve this system with a Moore FSM. It will have three inputs (car sensors on North and East roads and Emergency signal) and seven outputs (one for each light in the traffic signal.) The seven traffic lights are interfaced to Port B bits 6–0, and the three sensors are connected to Port E bits 2–0.

Limitations

- three switches, PE2=1 emergency mode
- six LEDs , PB0-PB5, as figure, PB6 connected to red LED

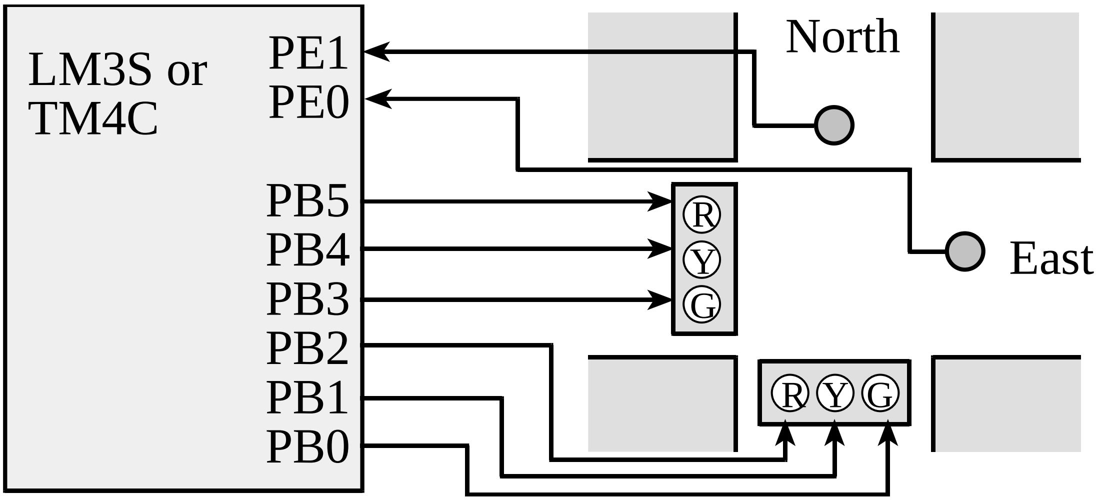
PE2=0, PE1=0, PE0=0 means no cars exist on either road

PE2=0, PE1=0, PE0=1 means there are cars on the East road

PE2=0, PE1=1, PE0=0 means there are cars on the North road

PE2=0, PE1=1, PE0=1 means there are cars on both roads

PE2-0=1XX, means emergency mode, cars do not enter in both directions. PB0-PB6 =0, emergency led PB6=1.



goN, PB6-0 = 0100001 makes it green on North and red on East

waitN, PB6-0 = 0100010 makes it yellow on North and red on East

goE, PB6-0 = 0001100 makes it red on North and green on East

waitE, PB6-0 = 0010100 makes it red on North and yellow on East

Emer, PB6-0 = 1000000 makes emergency led red on.

Note:

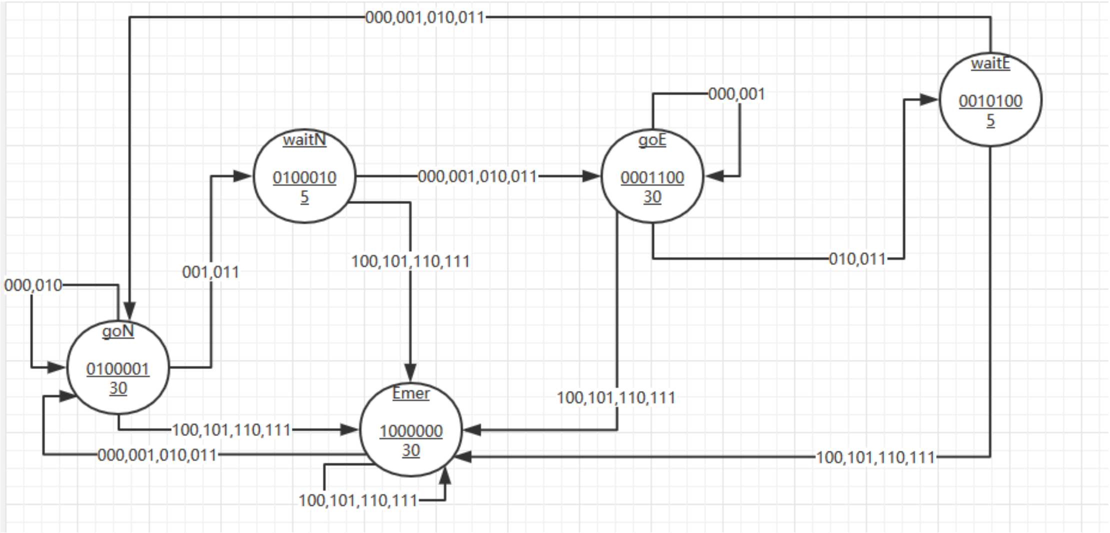
To add more complexity, we simply increase the size of the fsm[] structure, define the Out, Time, and Next pointers, increase the size of Next[8]. size = 2**(number of inputs)

设计思路：

此实验在原来的基础上，增加了 Emer 状态，导致增加一个输入位和一个输出位，用来表示紧急状态产生条件和输出紧急状态指示，通过在 SENSOR（输入）中增加一位 PE2（输入 1）表示紧急状态产生条件，在 LIGHT（输出）中增加一位 PB6 驱动一个红灯（输出 1）来输出紧急状态指示。

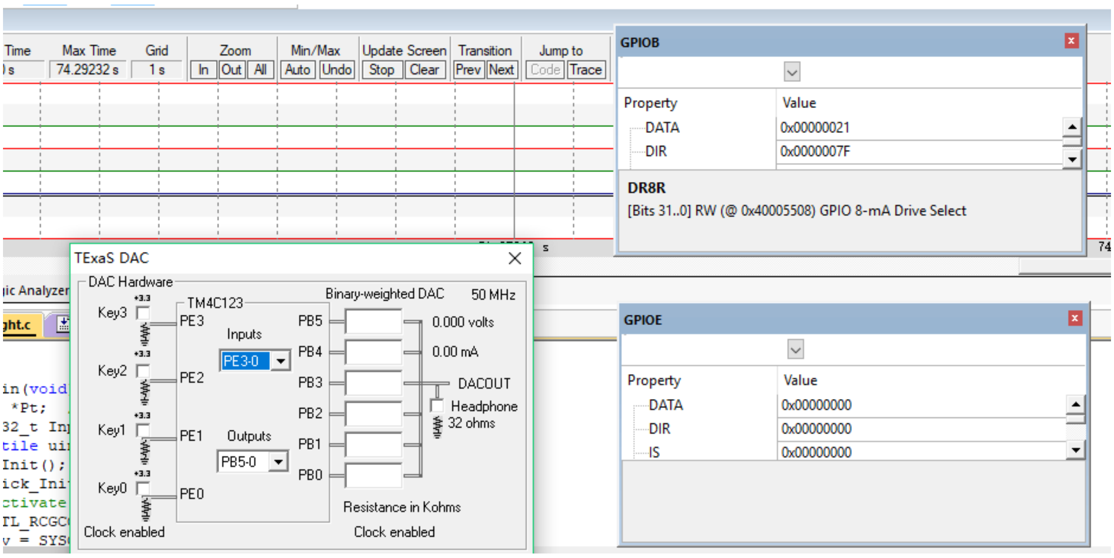
新的状态图如下，比原来的实验做出了如下改变：

1. 任何状态下，只要接收到紧急信号，则下一状态进入紧急状态
2. 紧急状态保持 30 秒（此处指应用在现实中 30 秒，程序中为了加快状态的转变，方便观察，只停留 3 秒）
3. 在紧急状态下，如果没有接收到紧急信号，则下一状态进入初始状态 goN



运行现象：

开始调试，进入初始状态，即 goN，此时 PE2=0, PE1=0, PE0=0 means no cars exist on either road，输出 0100001 ，makes it green on North and red on East



Max Time 74.29232 s, Grid 1 s

Inputs: PE3-0 ; Outputs: PB5-0 ; 0.000 volts ; 0.00 mA

GPIOB

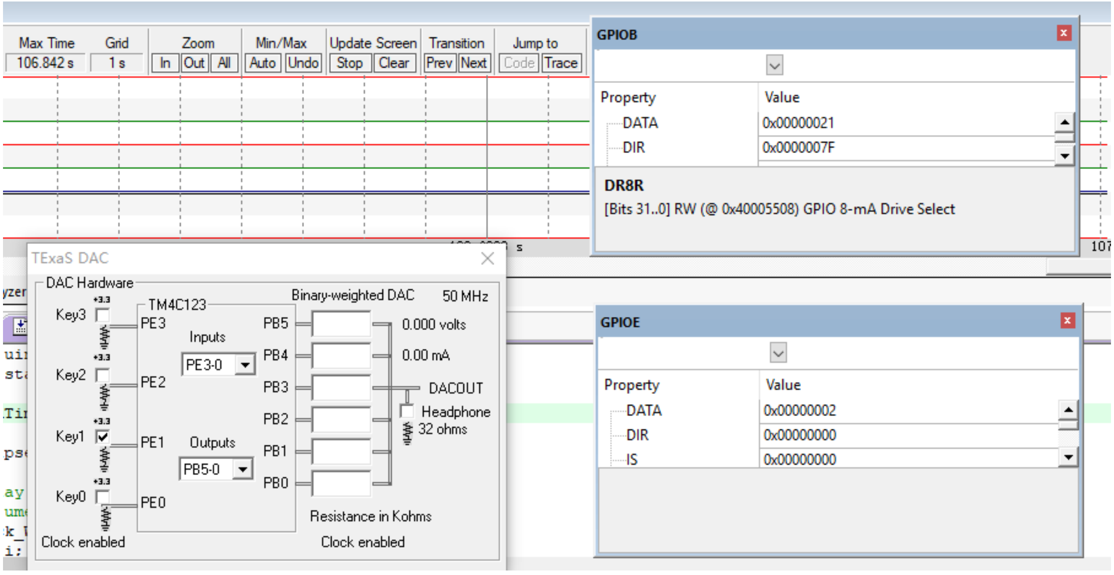
Property	Value
DATA	0x00000021
DIR	0x0000007F

DR8R
[Bits 31..0] RW (@ 0x40005508) GPIO 8-mA Drive Select

GPIOE

Property	Value
DATA	0x00000000
DIR	0x00000000
IS	0x00000000

超过 3 秒后输入 PE2=0, PE1=1, PE0=0 means there are cars on the North road，状态依旧为 goN



Max Time 106.842 s, Grid 1 s

Key1 ☑ ; Inputs: PE3-0 ; Outputs: PB5-0 ; 0.000 volts ; 0.00 mA

GPIOB

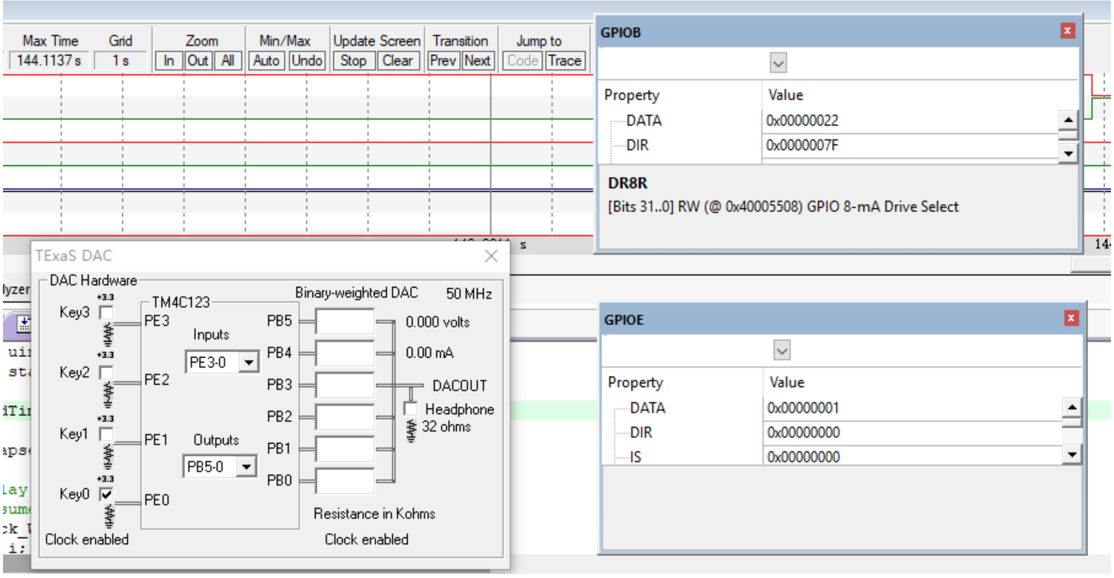
Property	Value
DATA	0x00000021
DIR	0x0000007F

DR8R
[Bits 31..0] RW (@ 0x40005508) GPIO 8-mA Drive Select

GPIOE

Property	Value
DATA	0x00000002
DIR	0x00000000
IS	0x00000000

超过 3 秒后输入 PE2=0, PE1=0, PE0=1 means there are cars on the East road， 此时状态从 goN 变为 waitN， 输出 0100010， makes it yellow on North and red on East



GPIOB

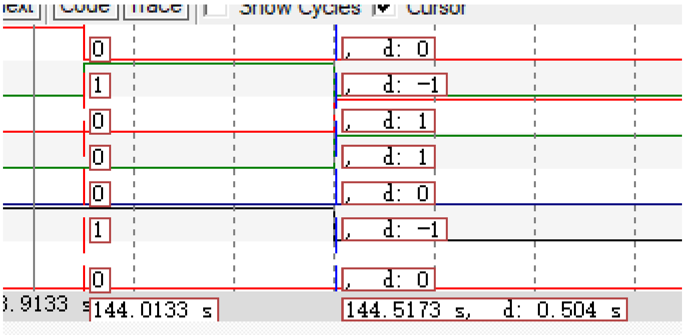
Property	Value
DATA	0x00000022
DIR	0x0000007F

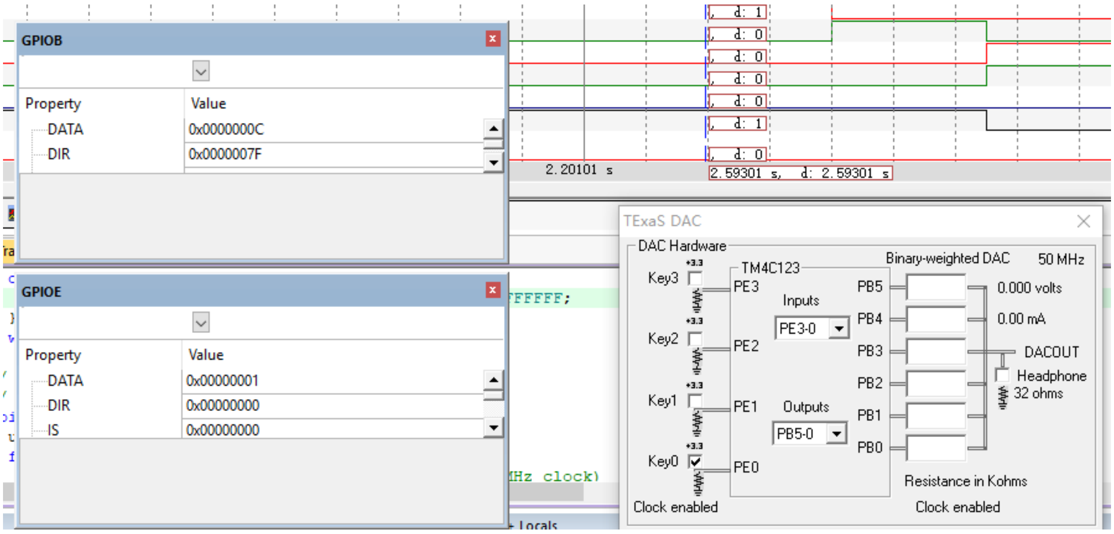
DR8R
[Bits 31..0] RW (@ 0x40005508) GPIO 8-mA Drive Select

GPIOE

Property	Value
DATA	0x00000001
DIR	0x00000000
IS	0x00000000

保持输入 PE2=0, PE1=0, PE0=1 means there are cars on the East road， 0.5 秒后， 状态变为 goE， 输出 00011000， makes it red on North and green on East





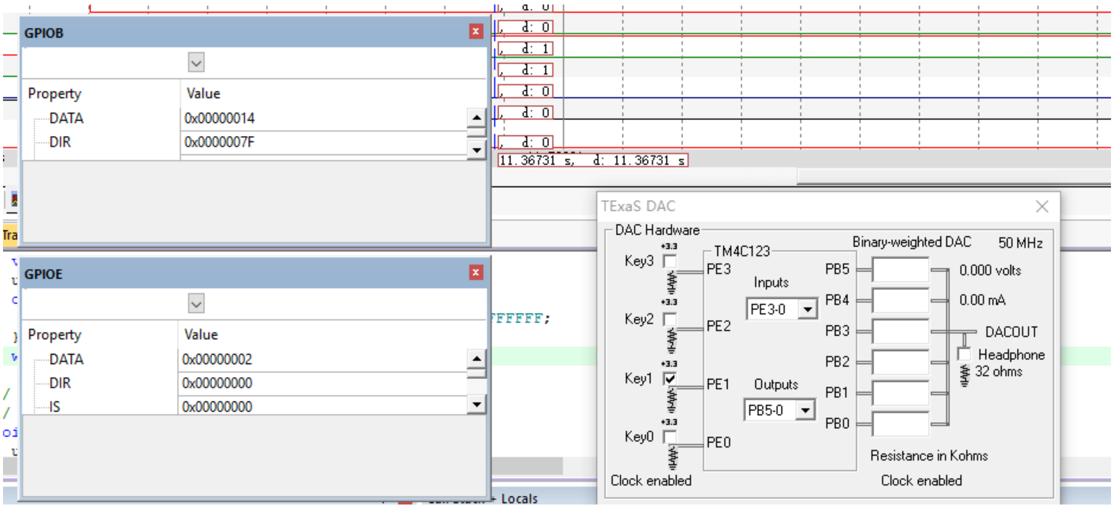
GPIOB

Property	Value
DATA	0x0000000C
DIR	0x0000007F

GPIOE

Property	Value
DATA	0x00000001
DIR	0x00000000
IS	0x00000000

3 秒后输入 PE2=0, PE1=1, PE0=0 means there are cars on the North road， 状态变为 waitE， 输出 0010100， makes it red on North and yellow on East



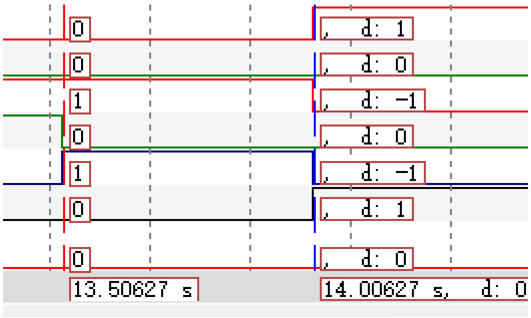
GPIOB

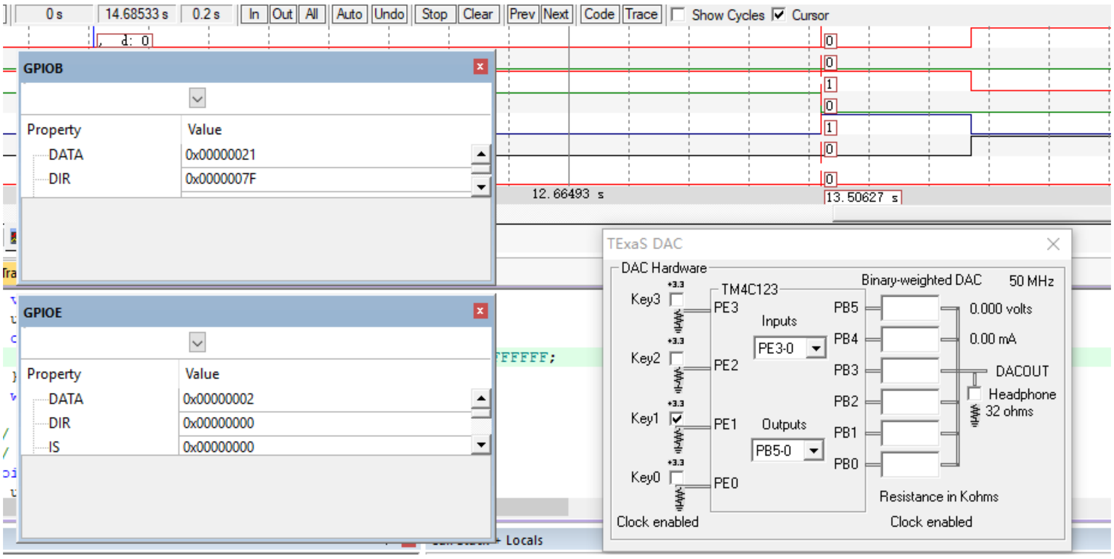
Property	Value
DATA	0x00000014
DIR	0x0000007F

GPIOE

Property	Value
DATA	0x00000002
DIR	0x00000000
IS	0x00000000

保持输入 PE2=0, PE1=1, PE0=0 means there are cars on the North road， 0.5 秒后状态变为 goN， 输出 0100001， makes it green on North and red on East





GPIOB

Property	Value
DATA	0x00000021
DIR	0x0000007F

GPIOE

Property	Value
DATA	0x00000002
DIR	0x00000000
IS	0x00000000

TExaS DAC

DAC Hardware

Key3 □ Key2 □ Key1 ☑ Key0 □

Inputs PE3-0

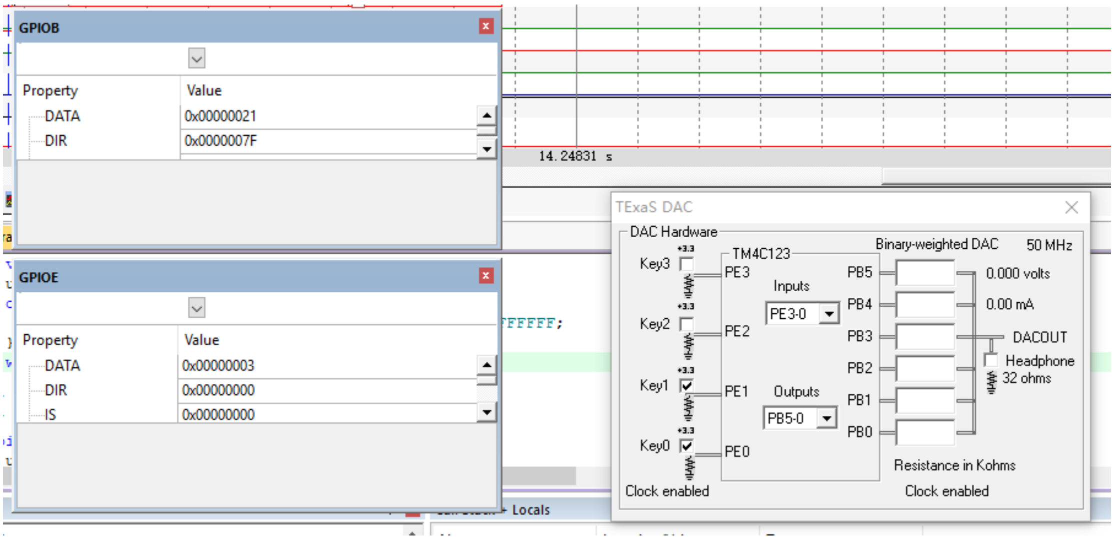
Outputs PB5-0

0.000 volts

0.00 mA

□ Headphone 32 ohms

输入 PE2=0, PE1=1, PE0=1 means there are cars on both roads，此时状态在 goN，waitN，goE，waitE 之间循环，间隔时间分别为上一阶段停留的时间。



GPIOB

Property	Value
DATA	0x00000021
DIR	0x0000007F

GPIOE

Property	Value
DATA	0x00000003
DIR	0x00000000
IS	0x00000000

TExaS DAC

DAC Hardware

Key3 □ Key2 □ Key1 ☑ Key0 ☑

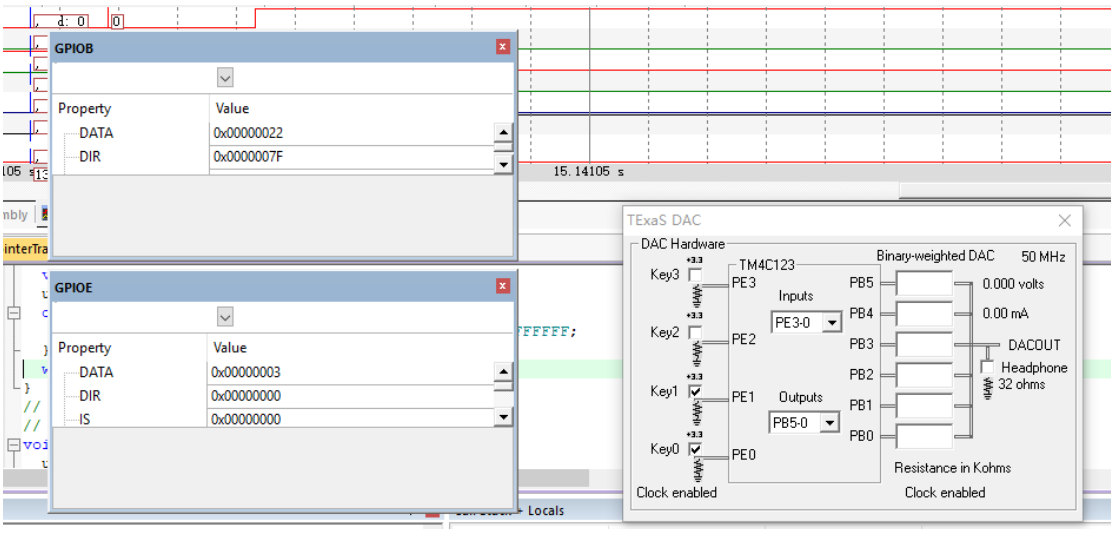
Inputs PE3-0

Outputs PB5-0

0.000 volts

0.00 mA

□ Headphone 32 ohms

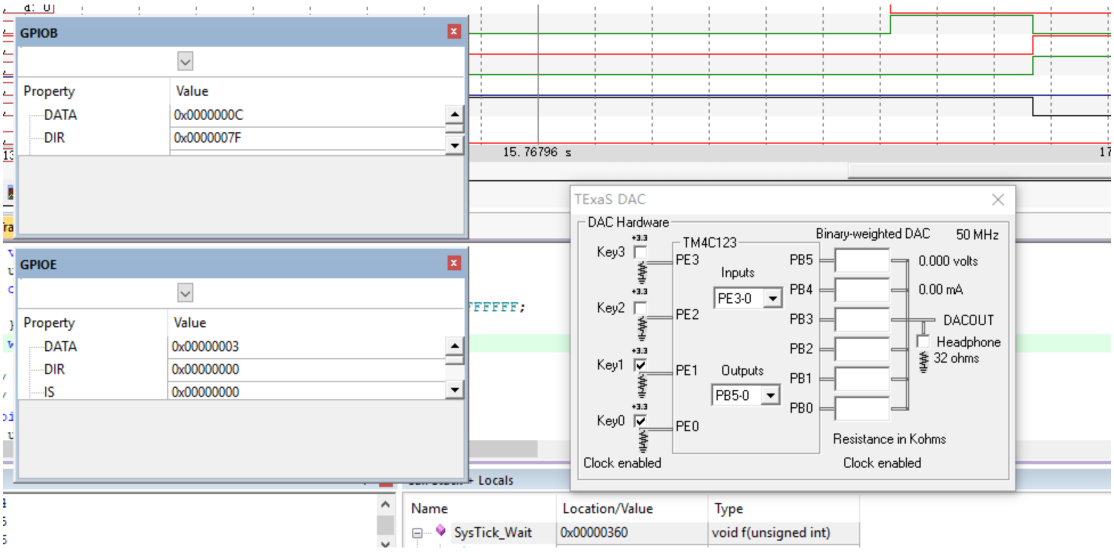


GPIOB

Property	Value
DATA	0x00000022
DIR	0x0000007F

GPIOE

Property	Value
DATA	0x00000003
DIR	0x00000000
IS	0x00000000



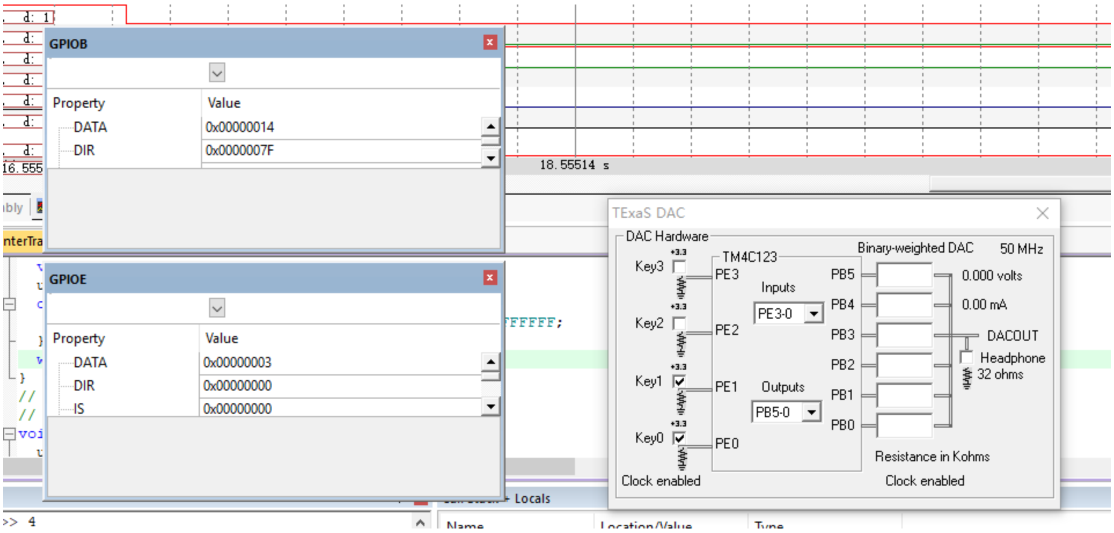
GPIOB

Property	Value
DATA	0x0000000C
DIR	0x0000007F

GPIOE

Property	Value
DATA	0x00000003
DIR	0x00000000
IS	0x00000000

Name	Location/Value	Type
SysTick_Wait	0x00000360	void f(unsigned int)

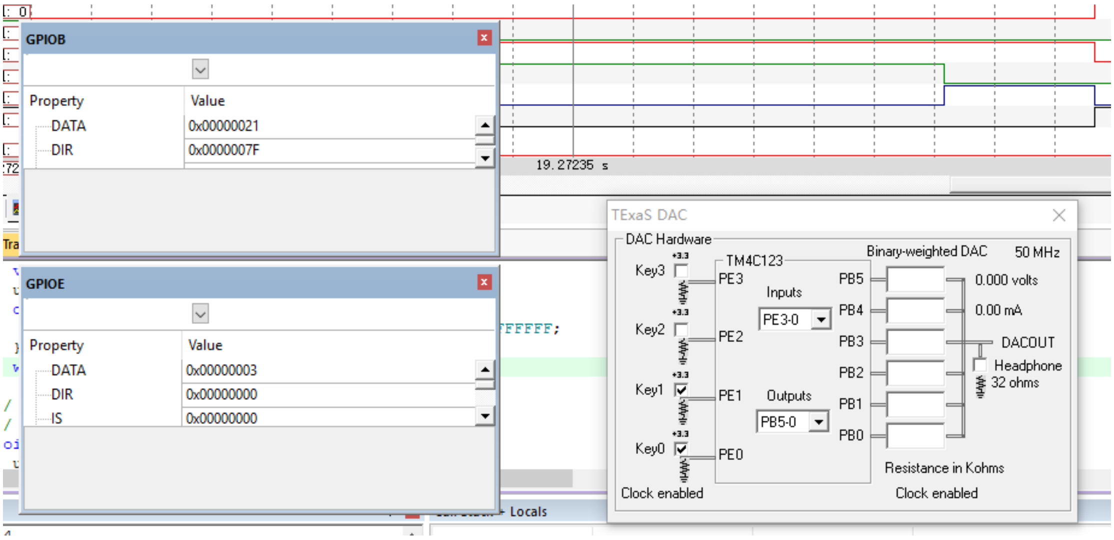


GPIOB

Property	Value
DATA	0x00000014
DIR	0x0000007F

GPIOE

Property	Value
DATA	0x00000003
DIR	0x00000000
IS	0x00000000


GPIOB

Property	Value
DATA	0x00000021
DIR	0x0000007F

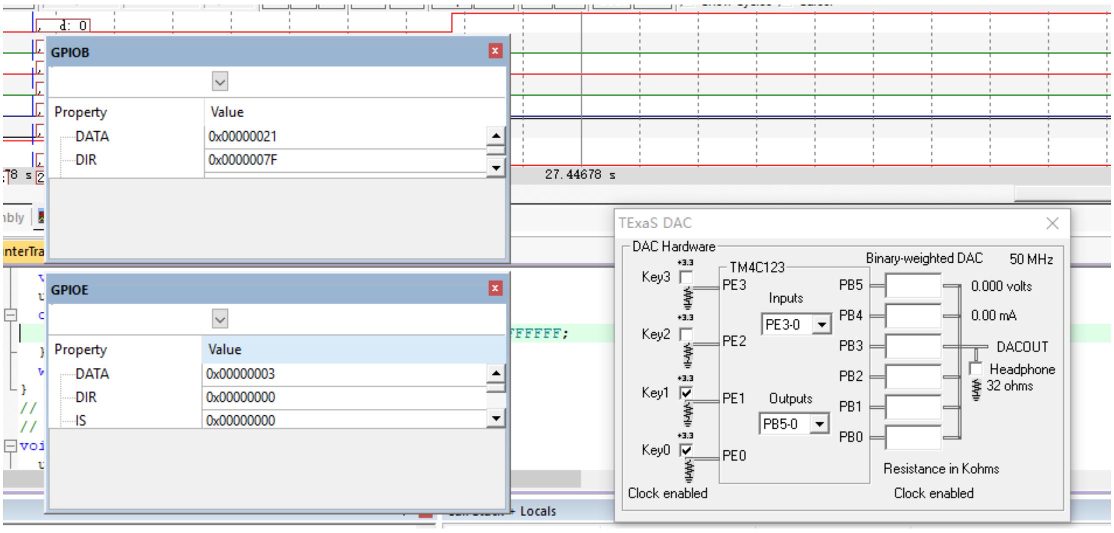
GPIOE

Property	Value
DATA	0x00000003
DIR	0x00000000
IS	0x00000000

至此，已测试原来实验的所有内容，全部符合要求。下面测试本实验增加的紧急状态。

测试方法：保持 PE1=1, PE0=1，使状态在 goN，waitN，goE，waitE 之间循环，然后在四个状态之中的每一个状态下，输入 PE2=1，观察是否在相应的状态保留时间之后，跳转至紧急状态。测试完最后的 waitE 跳入紧急状态后，输入 PE2=0，观察 3 秒后是否从紧急状态跳入初始状态，即 goN

从 goN 到紧急状态



27.44678 s

GPIOB

Property	Value
DATA	0x00000021
DIR	0x0000007F

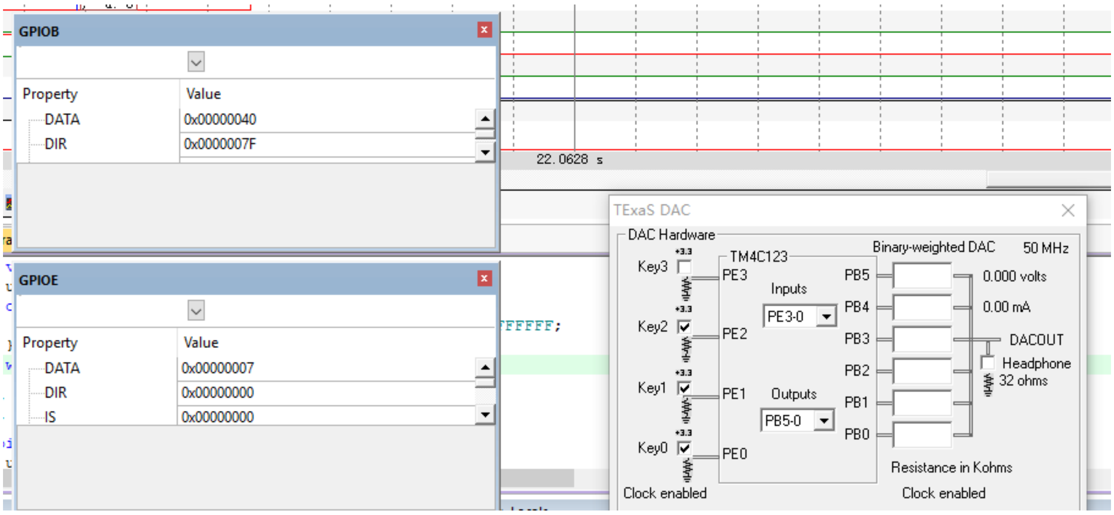
GPIOE

Property	Value
DATA	0x00000003
DIR	0x00000000
IS	0x00000000

TExaS DAC

□ Key3
□ Key2
☑ Key1
☑ Key0

Inputs PE3-0
Outputs PB5-0
0.000 volts
0.00 mA



22.0628 s

GPIOB

Property	Value
DATA	0x00000040
DIR	0x0000007F

GPIOE

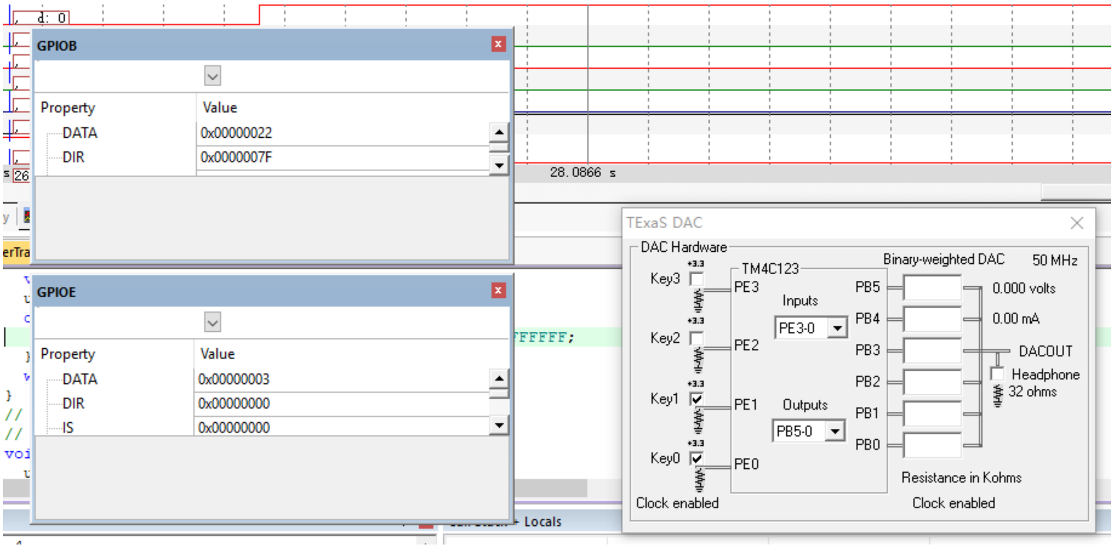
Property	Value
DATA	0x00000007
DIR	0x00000000
IS	0x00000000

TExaS DAC

□ Key3
☑ Key2
☑ Key1
☑ Key0

Inputs PE3-0
Outputs PB5-0
0.000 volts
0.00 mA

从 waitN 到紧急状态



28.0866 s

GPIOB

Property	Value
DATA	0x00000022
DIR	0x0000007F

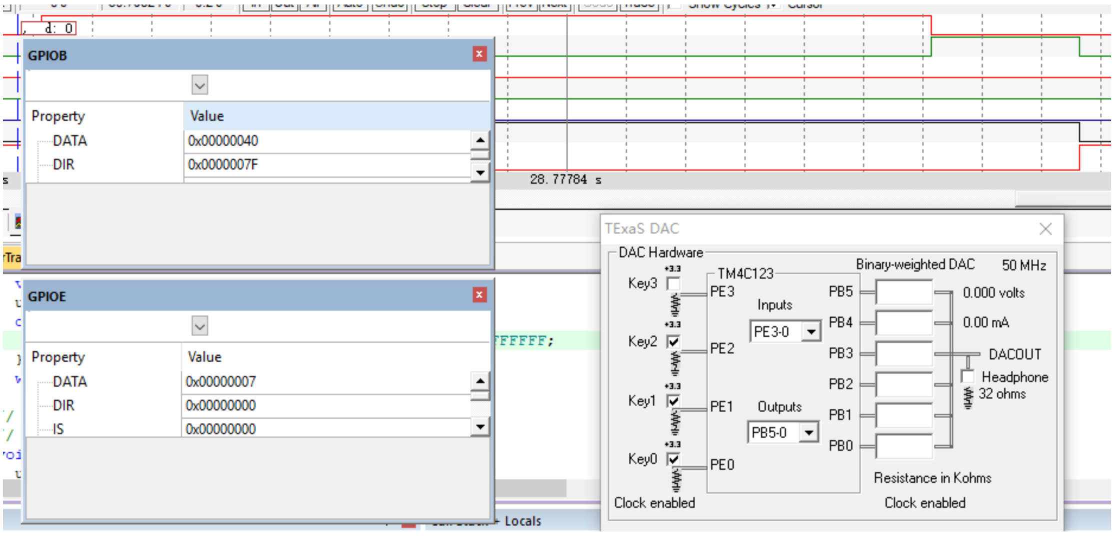
GPIOE

Property	Value
DATA	0x00000003
DIR	0x00000000
IS	0x00000000

TExaS DAC

□ Key3
□ Key2
☑ Key1
☑ Key0

Inputs PE3-0
Outputs PB5-0
0.000 volts
0.00 mA



GPIOB

Property	Value
DATA	0x00000040
DIR	0x0000007F

GPIOE

Property	Value
DATA	0x00000007
DIR	0x00000000
IS	0x00000000

28.77784 s

TExaS DAC

Key3 □ Key2 ☑ Key1 ☑ Key0 ☑

Inputs PE3-0

Outputs PB5-0

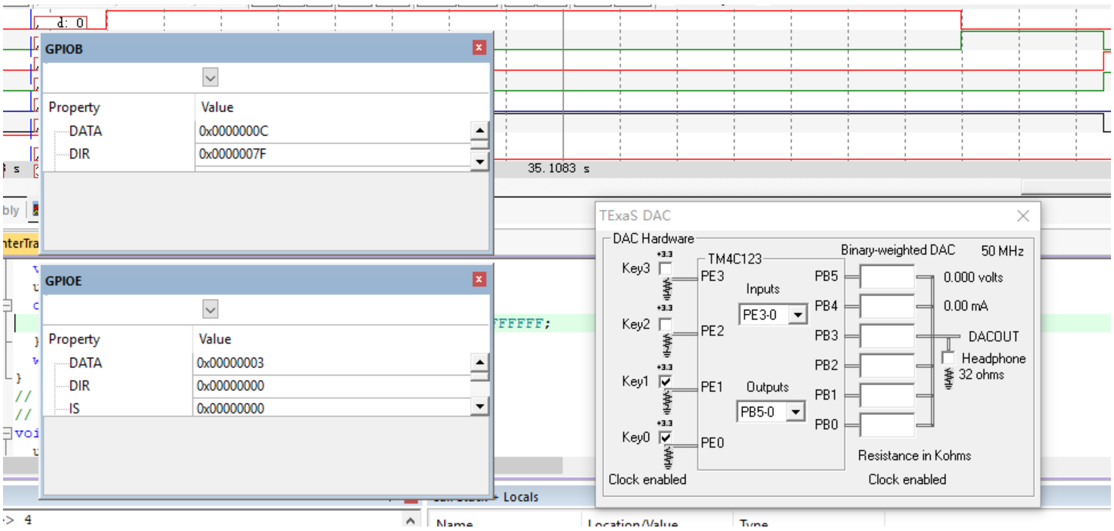
0.000 volts

0.00 mA

□ Headphone 32 ohms

50 MHz

从 goE 到紧急状态



GPIOB

Property	Value
DATA	0x0000000C
DIR	0x0000007F

GPIOE

Property	Value
DATA	0x00000003
DIR	0x00000000
IS	0x00000000

35.1083 s

TExaS DAC

Key3 □ Key2 □ Key1 ☑ Key0 ☑

Inputs PE3-0

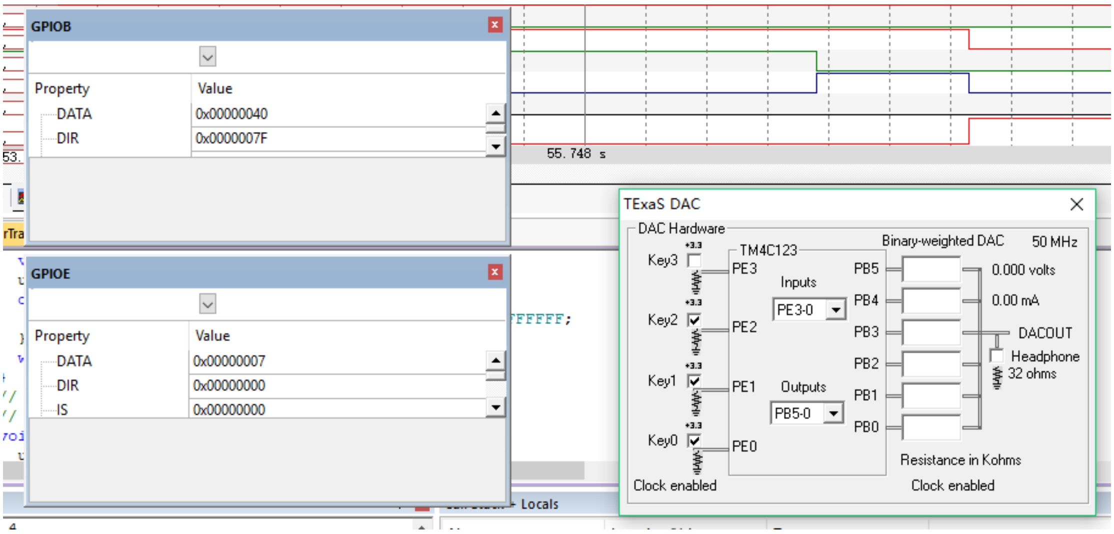
Outputs PB5-0

0.000 volts

0.00 mA

□ Headphone 32 ohms

50 MHz



GPIOB

Property	Value
DATA	0x00000040
DIR	0x0000007F

GPIOE

Property	Value
DATA	0x00000007
DIR	0x00000000
IS	0x00000000

55.748 s

TExaS DAC

DAC Hardware

Key3 □ Key2 ☑ Key1 ☑ Key0 ☑

Inputs PE3-0

Outputs PB5-0

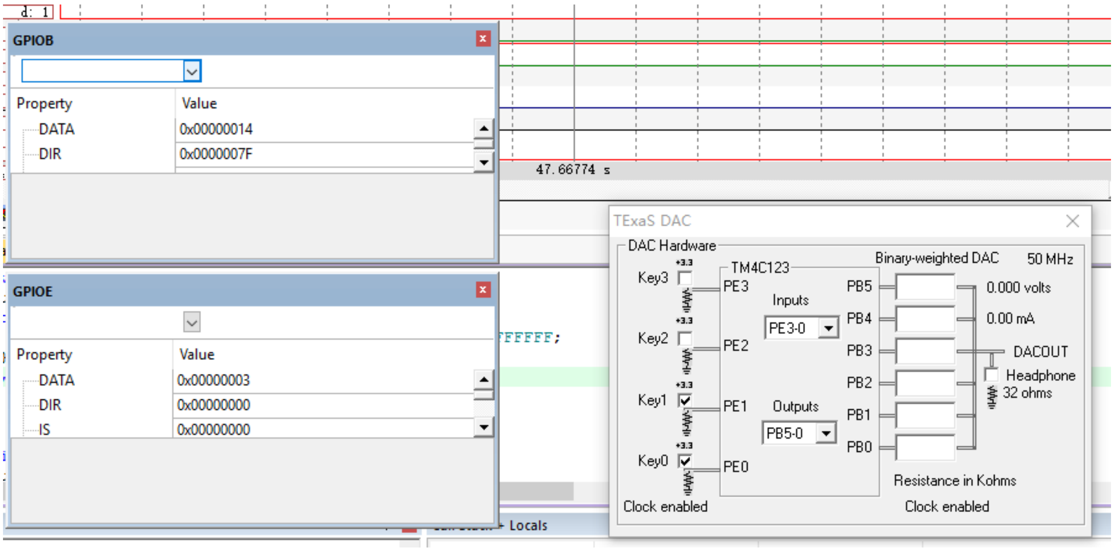
0.000 volts

0.00 mA

Headphone □ 32 ohms

Clock enabled

从 waitE 到紧急状态



GPIOB

Property	Value
DATA	0x00000014
DIR	0x0000007F

GPIOE

Property	Value
DATA	0x00000003
DIR	0x00000000
IS	0x00000000

47.66774 s

TExaS DAC

DAC Hardware

Key3 □ Key2 □ Key1 ☑ Key0 ☑

Inputs PE3-0

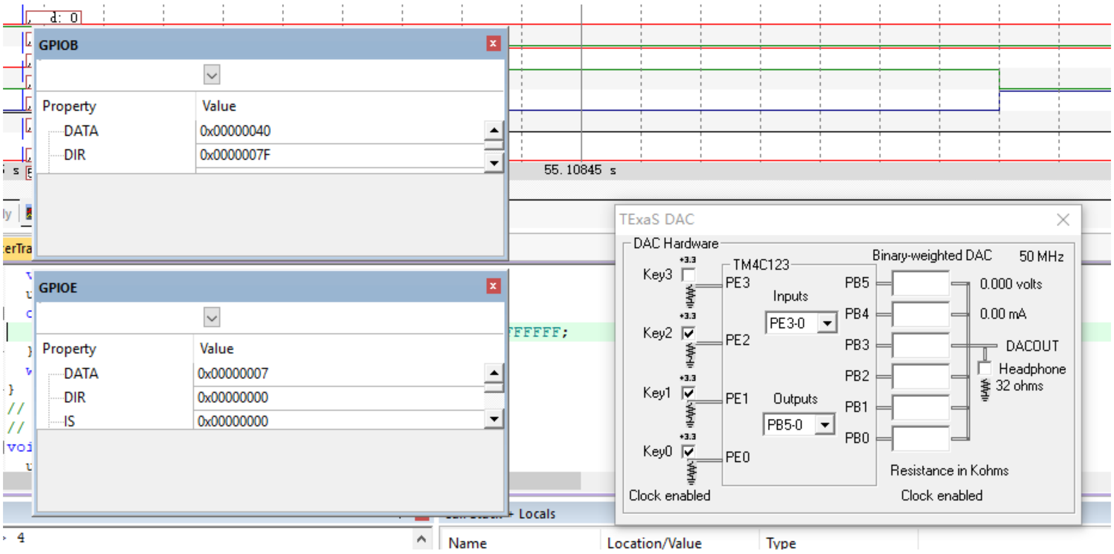
Outputs PB5-0

0.000 volts

0.00 mA

Headphone □ 32 ohms

Clock enabled



GPIOB

Property	Value
DATA	0x00000040
DIR	0x0000007F

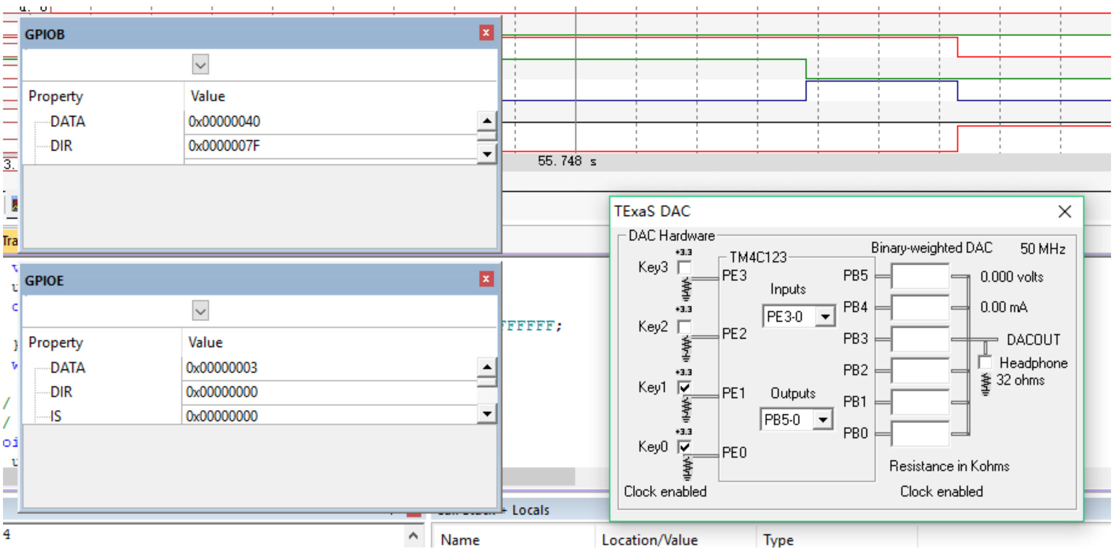
GPIOE

Property	Value
DATA	0x00000007
DIR	0x00000000
IS	0x00000000

TExaS DAC

Key3 □ PE3
Key2 ☑ PE2
Key1 ☑ PE1
Key0 ☑ PE0
Inputs: PE3-0
Outputs: PB5-0
0.000 volts
0.00 mA
□ Headphone 32 ohms

从紧急状态到初始状态 goN



GPIOB

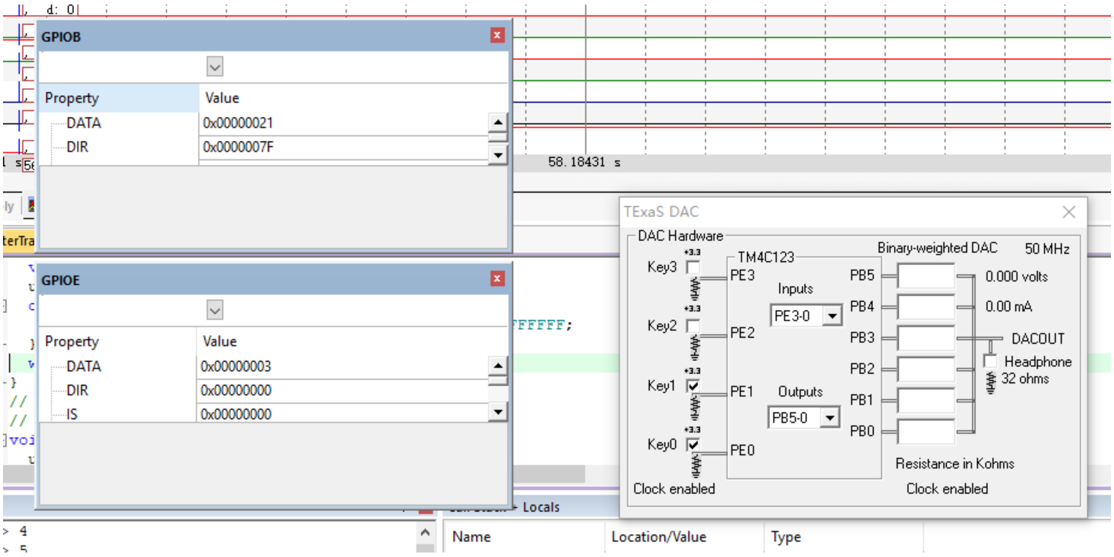
Property	Value
DATA	0x00000040
DIR	0x0000007F

GPIOE

Property	Value
DATA	0x00000003
DIR	0x00000000
IS	0x00000000

TExaS DAC

Key3 □ PE3
Key2 □ PE2
Key1 ☑ PE1
Key0 ☑ PE0
Inputs: PE3-0
Outputs: PB5-0
0.000 volts
0.00 mA
□ Headphone 32 ohms



GPIOB

Property	Value
DATA	0x00000021
DIR	0x0000007F

GPIOE

Property	Value
DATA	0x00000003
DIR	0x00000000
IS	0x00000000

58.18431 s

TExaS DAC

DAC Hardware

Key3 □ PE3
Key2 □ PE2
Key1 ☑ PE1
Key0 ☑ PE0

TM4C123

Inputs PE3-0

Outputs PB5-0

Binary-weighted DAC 50 MHz

0.000 volts

0.00 mA

DACOUT

□ Headphone 32 ohms

Resistance in Kohms

Clock enabled

Clock enabled

至此，已完成所有的测试，符合要求