UM0685
User manual

CEC (consumer electronic control) C library using the STM32F101xx, STM32F102xx and STM32F103xx microcontrollers

Introduction

This user manual describes the CEC library using the STM32F10xxx microcontroller family. Consumer electronic control (CEC) is a feature of the HDMI interface 1.3 standard (high definition multimedia interface), which is used to transmit audio/video data for multimedia consumer products such as HDTV, DVDs, satellite receivers etc.

This library contains the following functions for a basic CEC communication:

- Send/Receive CEC Start bit
- Send/Receive CEC ACK bit “logical 0”
- Send/Receive CEC data bit
- Send/Receive CEC data byte
- Send/Receive CEC data frame

Note that the provided CEC library supports only messages addressed to a single device and not broadcast messages (please refer to HDMI - CEC specification).

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1 CEC library description

The STM32F10xxx CECLib is a set of common functions for CEC communication. It includes the following functions:

Table 1. STM32F10xxx CEC library functions

Function name	Description
CEC_Init	CEC initialization
CEC_NVIC_Configuration	CEC NVIC configuration
CEC_Wait100us	CEC timing for send/receive a CEC bit
CEC_TimingDelay_Decrement	CEC time base generation
CEC_SendStartBit	CEC send start bit
CEC_ReceiveStartBit	CEC receive start bit
CEC_SendAckBit	CEC send acknowledge bit
CEC_ReceiveAckBit	CEC receive acknowledge bit
CEC_SendDataBit	CEC send data bit
CEC_ReceiveDataBit	CEC receive data bit
CEC_SendByte	CEC send data byte
CEC_ReceiveByte	CEC receive data byte
CEC_SendFrame	CEC send data frame
CEC_ReceiveFrame	CEC receive data frame

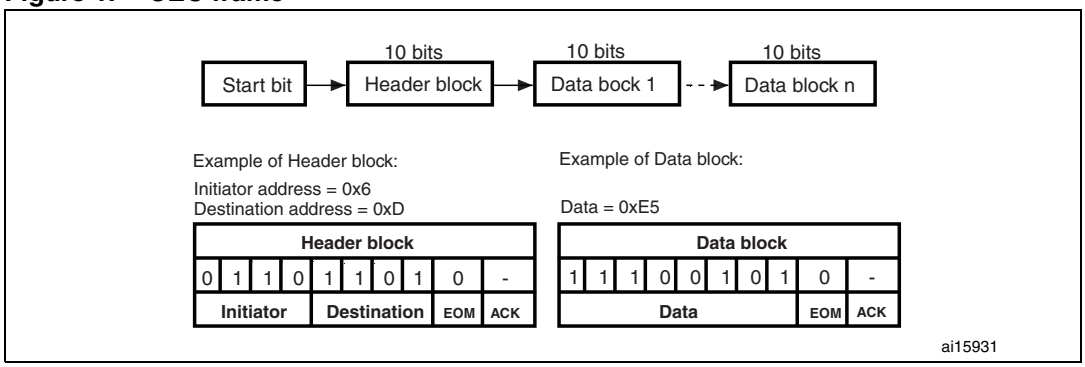
2 CEC communication

2.1 CEC frame

The CEC bus is a single-wire protocol that can connect up to 10 audiovisual devices through standard HDMI cabling.

The CEC transaction is made up of a start bit, a 10-bit header and a sequence of n 10-bit data blocks. The Header block and the Data blocks each contain an end-of-message (EOM) bit and an acknowledge (ACK) bit. *Figure 1* shows a CEC frame format.

Figure 1. CEC frame



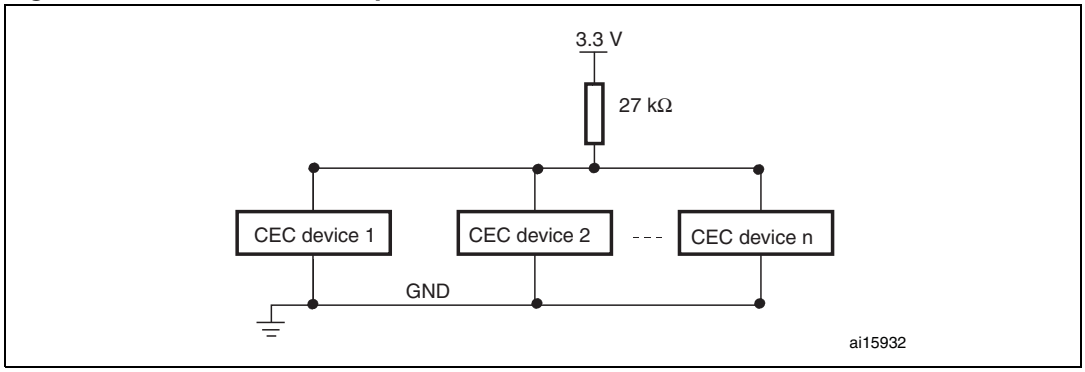
A Header block is a sequence of 10 bits: the 4-bit logical address of the Initiator, the 4-bit logical address of the Destination, the end-of-message (EOM) bit and the Acknowledge (ACK) bit.

A Data block is a sequence of 10 bits: an 8-bit field that represents the opcode or the operand, the end-of-message (EOM) bit and the Acknowledge (ACK) bit. The HDMI standard defines the opcodes and the possible number of operands for each message.

2.2 Hardware considerations

The physical connection to the HDMI network is straightforward. In accordance with the CEC specification, the CEC pin of the HDMI connector has to be pulled up to a 3.3 V supply voltage via a 27 kΩ resistor (refer to *Figure 2*).

Figure 2. CEC Hardware requirement



3 CEC library functions

The CEC library provides three types of functions:

- **Low level functions**: functions that initialize and configure peripherals to be ready for CEC communication.
- **Medium level functions**: functions doing elementary CEC routines.
- **High level functions**: functions sending/receiving CEC frames.

3.1 CEC low level functions

3.1.1 `CEC_Init` function

Table 2 describes the `CEC_Init` function.

Table 2. `CEC_Init` function

Function name	`CEC_Init`
Prototype	`void CEC_Init(void)`
Behavior description	Initializes the GPIO, system tick, NVIC and EXTI to communicate with the CEC protocol
Input parameter	None
Output parameter	None
Return parameter	None
Required preconditions	The software has to configure the different clocks and the NVIC vector table base before calling this function.

Example

```
int main(void)
{
/* RCC configuration */
RCC_Configuration();

/* NVIC configuration */
NVIC_Configuration();

/* CEC initialization */
CEC_Init();
....
....
}
```

3.1.2 `CEC_NVIC_Configuration` function

Table 3 describes the `CEC_NVIC_Configuration` function.

Table 3. `CEC_NVIC_Configuration` function

Function name	`CEC_NVIC_Configuration`
Prototype	`void CEC_NVIC_Configuration(void)`
Behavior description	Configures global interrupts of SystemTick and EXTI
Input parameter	None
Output parameter	None
Return parameter	None
Required preconditions	The SystemTick and EXTI global interrupt priorities used in the CEC library have to have the highest interrupt level in the application.

The used and reserved NVIC configurations for the CEC library are:

SystemTick: Preemption priority = 1, subpriority = 1

EXTI0: Preemption priority = 2, subpriority = 1

3.1.3 `CEC_Wait100us` function

Table 4 describes the `CEC_Init` function.

Table 4. `CEC_Wait100us` function

Function name	`CEC_Wait100us`
Prototype	`void CEC_Wait100us(__IO uint32_t nTime)`
Behavior description	Insert a delay in 100 µs unit.
Input parameter	`nTime` is the number of 100 µs units to be inserted. Delay = 100 µs × `nTime`
Output parameter	None
Return parameter	None
Required preconditions	None

3.1.4 `CEC_TimingDelay_Decrement` function

Table 5 describes the `CEC_TimingDelay_Decrement` function.

Table 5. `CEC_TimingDelay_Decrement` function

Function name	`CEC_TimingDelay_Decrement`
Prototype	`void CEC_TimingDelay_Decrement(void)`
Behavior description	Decrements the TimingDelay variable in the SysTick interrupt
Input parameter	None
Output parameter	None
Return parameter	None
Required preconditions	None

3.2 CEC medium level functions

3.2.1 `CEC_SendStartBit` function

Table 6 describes the `CEC_SendStartBit` function.

Table 6. `CEC_SendStartBit` function

Function name	`CEC_SendStartBit`
Prototype	`void CEC_SendStartBit(void)`
Behavior description	Sends the CEC start bit.
Input parameter	None
Output parameter	None
Return parameter	None
Required preconditions	None

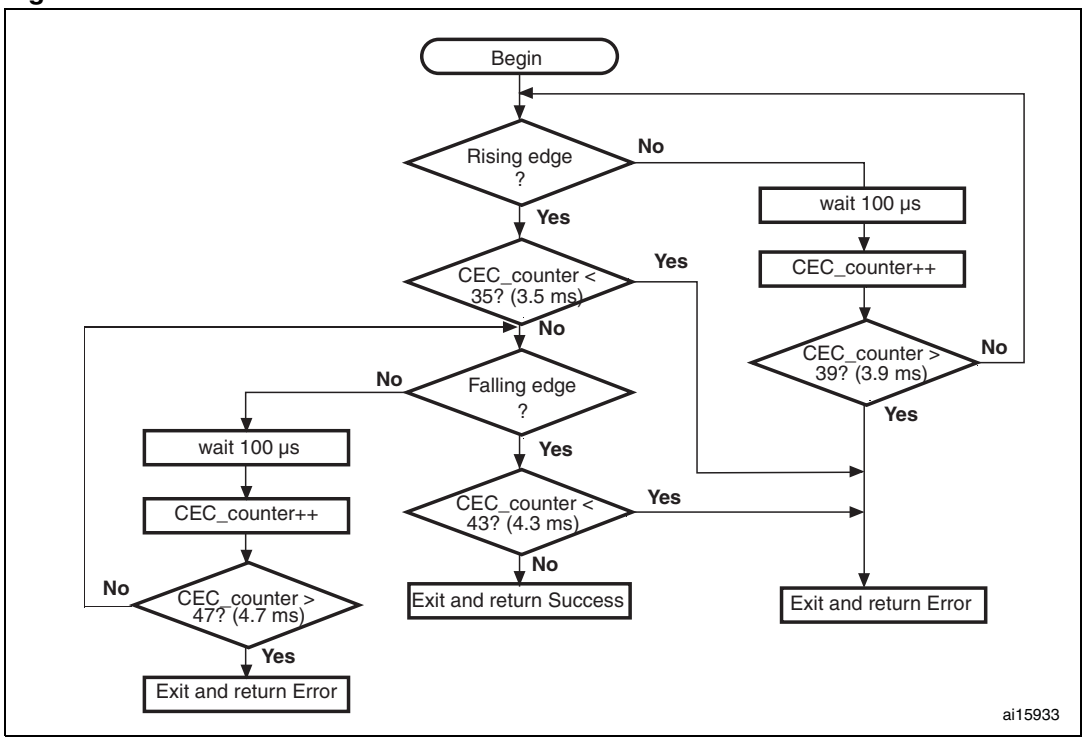
3.2.2 `CEC_ReceiveStartBit` function

Table 7 describes the `CEC_ReceiveStartBit` function.

Table 7. `CEC_ReceiveStartBit` function

Function name	`CEC_ReceiveStartBit`
Prototype	`uint8_t CEC_ReceiveStartBit(void)`
Behavior description	Receives the CEC start bit.
Input parameter	None
Output parameter	None
Return parameter	a uint8_t integer: 1: if the CEC start bit has been received correctly 0: if the CEC start bit has not been received correctly
Required preconditions	None

Figure 3. Receive start bit flowchart



3.2.3 `CEC_SendAckBit` function

Table 8 describes the `CEC_SendAckBit` function.

Table 8. `CEC_SendAckBit` function

Function name	`CEC_SendAckBit`
Prototype	`void CEC_SendAckBit(void)`
Behavior description	Sends the CEC ACK bit (ACK = logical 0)
Input parameter	None
Output parameter	None
Return parameter	None
Required preconditions	None

3.2.4 `CEC_ReceiveAckBit` function

Table 9 describes the `CEC_ReceiveAckBit` function.

Table 9. `CEC_ReceiveAckBit` function

Function name	`CEC_ReceiveAckBit`
Prototype	`uint8_t CEC_ReceiveAckBit(void)`
Behavior description	Receives the CEC ACK bit
Input parameter	None

Table 9. `CEC_ReceiveAckBit` function (continued)

Function name	`CEC_ReceiveAckBit`
Output parameter	None
Return parameter	a uint8_t integer: 0: receive ACK bit succeeded 0xFF: receive ACK bit failed
Required preconditions	None

3.2.5 `CEC_SendDataBit` function

Table 10 describes the `CEC_SendDataBit` function.

Table 10. `CEC_SendDataBit` function

Function name	`CEC_SendDataBit`
Prototype	`void CEC_SendDataBit(uint8_t bit)`
Behavior description	Receives the CEC ACK bit (ACK = logical 0)
Input parameter	None
Output parameter	None
Return parameter	a uint8_t integer: 0: receive ACK bit succeeded 0xFF: receive ACK failed
Required preconditions	None

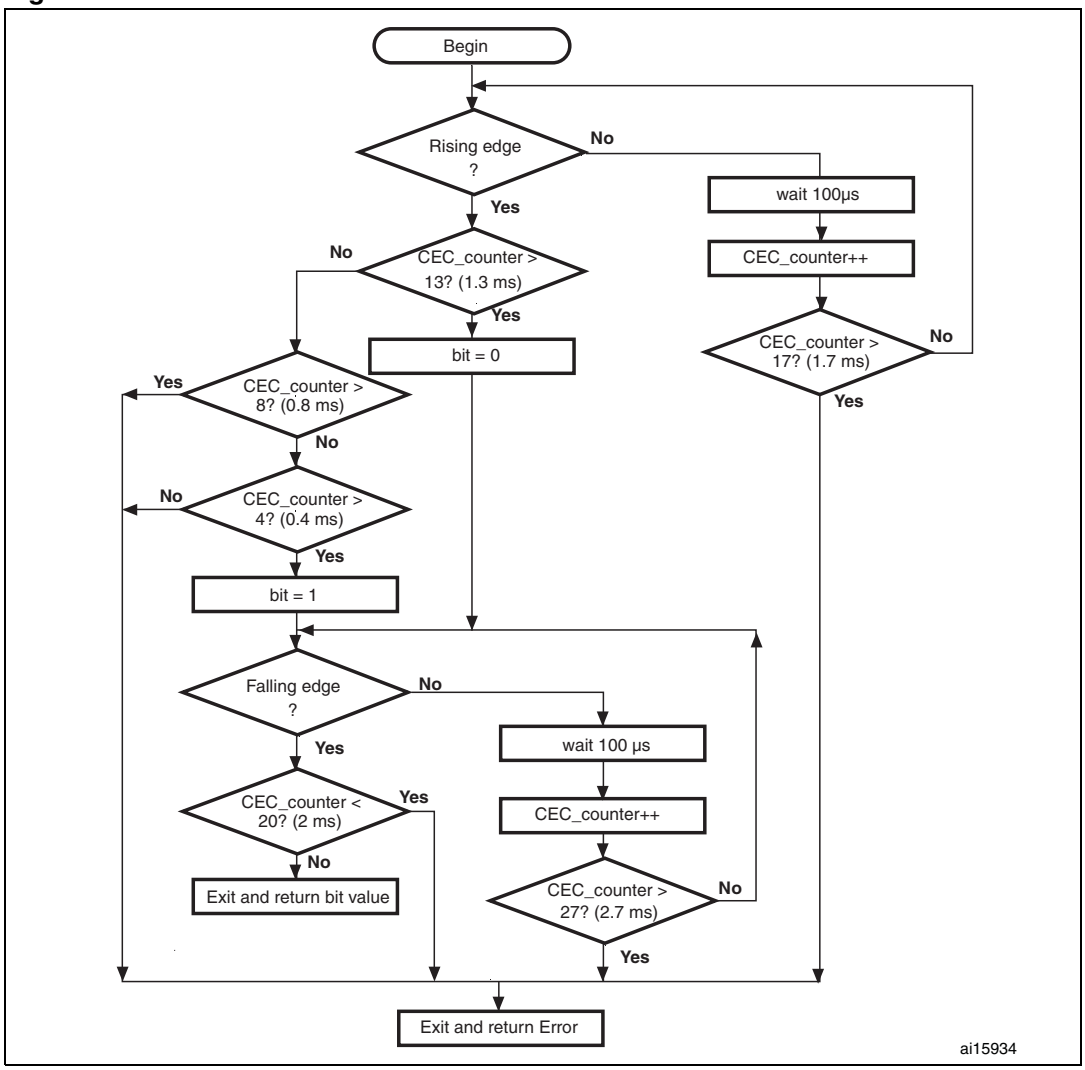
3.2.6 `CEC_ReceiveDataBit` function

Table 11 describes the `CEC_ReceiveDataBit` function.

Table 11. `CEC_ReceiveDataBit` function

Function name	`CEC_ReceiveDataBit`
Prototype	`uint8_t CEC_ReceiveDataBit(void)`
Behavior description	Receives a CEC data bit.
Input parameter	None
Output parameter	None
Return parameter	The received data bit as a uint8_t integer: 1: if the data bit received was logical 1 0: if the data bit received was logical 0 0xFF: if the data bit has not been received correctly
Required preconditions	None

Figure 4. Receive data bit flowchart



3.2.7 `CEC_SendByte` function

Table 12 describes the `CEC_SendByte` function.

Table 12. `CEC_SendByte` function

Function name	`CEC_SendByte`
Prototype	`ErrorStatus CEC_SendByte(uint8_t byte)`
Behavior description	Sends a CEC Header or Data block
Input parameter	byte: the CEC opcode or operand to be transmitted
Output parameter	None
Return parameter	The status of the Header/Data block transmission: SUCCESS: CEC byte was acknowledged by the destination ERROR: CEC byte wasn't acknowledged by the destination
Required preconditions	None

3.2.8 CEC_ReceiveByte function

Table 13 describes the CEC_ReceiveByte function.

Table 13. CEC_ReceiveByte function

Function name	CEC_ReceiveByte
Prototype	uint8_t CEC_ReceiveByte(uint8_t HeaderDataIndicator)
Behavior description	Receives a CEC Header or Data block
Input parameter	HeaderDataIndicator: indicates if the byte to receive is a Header or Data block. It can be: HeaderBlock: for the Header block reception DataBlock: for the Data block reception
Output parameter	None
Return parameter	The received byte
Required preconditions	None

3.3 CEC high level functions

3.3.1 CEC_SendFrame function

Table 14 describes the CEC_SendFrame function.

Table 14. CEC_SendFrame function

Function name	CEC_SendFrame
Prototype	ErrorStatus CEC_SendFrame(uint8_t InitiatorAddress, uint8_t FollowerAddress, uint8_t MessageLength, uint8_t* Message)
Behavior description	Sends a CEC frame.
Input parameter	– InitiatorAddress: the initiator address: from 0 to 15 – FollowerAddress: the destination address: from 0 to 15 – MessageLength: the number of data bytes to send – Message: a pointer to the transmit buffer
Output parameter	None
Return parameter	The status of the CEC frame transmission: SUCCESS: If the destination received the full frame correctly ERROR: the destination does not receive the full frame correctly
Required preconditions	None

Example

```
#define MyDeviceAddress 0x6 /* My device address*/
#define FollowerAddress 0xF /* Follower address to send the frame */
uint8_t NumberOfTransmitAttempt = 5;
```

```
uint8_t
TransmitBuffer[10]={0xdf,0x12,0xd3,0x56,0x97,0xa1,0xec,0x7b,0x4f,0x
22};
ErrorStatus SendStatus = ERROR;

/* Send the CEC frame */
do
{
SendStatus = CEC_SendFrame(MyDeviceAddress, FollowerAddress, 10,
TransmitBuffer);
waitOneSecond();
NumberOfTransmitAttempt--;
}
while ((SendStatus =! SUCCESS) || (!NumberOfTransmitAttempt));
```

3.3.2 `CEC_ReceiveFrame` function

Table 15 describes the `CEC_ReceiveFrame` function.

Table 15. `CEC_ReceiveFrame` function

Function name	`CEC_ReceiveFrame`
Prototype	`uint32_t CEC_ReceiveFrame(uint8_t* Message, uint8_t FollLogAdd)`
Behavior description	Receives a CEC frame
Input parameter	– Message: a pointer to the receive buffer – FollLogAdd: the device address that will receive the frame: from 0 to 15
Output parameter	None
Return parameter	a uint32_t integer that contains some receive information (see below)
Required preconditions	Called by the EXTI interrupt routine

The contents of the uint32_t integer containing the CEC receive frame information returned by `CEC_ReceiveFrame` function are:

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
always read as 0														FSTM	RFS
15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
NbRB [15:8]								InitADD [7:0]							

Bits 31:18 always read as 0.

Bit 17 **FSTM:** Frame sent to me
0: If the received frame does not have the same destination address
1: If the received frame has the same destination address

Bit 16 **RFS:** Receive frame status
0: The frame was not received correctly
1: The frame was received correctly

Bits 15:8 **NbRB:** Number of received bytes
This field contains the number of received data blocks.

Bits 7:0 **InitADD:** Initiator address

This field contains the frame sender address.

The FSTM, RFS and Initiator address masks are provided in the *stm32f10x_cec.h* file to check their status:

```
#define ReceiveFrameStatusMask  0x00010000
#define FrameSendToMeMask       0x00020000
#define InitiatorAddressMask    0x000000FF
```

Example

- **In the *stm32f10x.it.c* file**

```
#define MyDeviceAddress 0x6 /* My device address*/

/* Private variables ---------------------------------------------
------*/
uint8_t ReceiveBuffer[10];
uint8_t ReceivedFrame = 0;
uint32_t ReceiveFrameInfos = 0;

/* Send the CEC frame */
void EXTI0_IRQHandler(void)
{
  if(EXTI_GetITStatus(EXTI_Line0) != RESET)
  {
    /* Receive the CEC frame with my CEC address */
    ReceiveFrameInfos = CEC_ReceiveFrame(ReceiveBuffer,
MyDeviceAddress);
    /* Set ReceivedFrame software flag to say that a frame was
detected on the bus */
    ReceivedFrame = 1;
    /* Clear EXTI line 0 pending bit */
    EXTI_ClearITPendingBit(EXTI_Line0);
  }
}
```

- **In the *main.c* file**

```
#include <stdio.h>
/* Private variables ---------------------------------------------
-----*/
extern uint8_t ReceiveBuffer[10];
extern uint8_t ReceivedFrame;
extern uint32_t ReceiveFrameInfos;
uint8_t NbOfReceivedBytes = 0;

/* If a frame has been received */
    if (ReceivedFrame)
    {
      /* Check if the frame has been received correctly */
      if (ReceiveFrameInfos & ReceiveFrameStatusMask)
      {
        /* Check if the frame has been send to me */
        if (ReceiveFrameInfos & FrameSendToMeMask)
```

```
        {
          /* Glow the green LED */
          GlowGreenLED();
          /* Get the number of received bytes */
          NbOfReceivedBytes = (uint8_t) (ReceiveFrameInfos >> 8);
          /* Get the initiator address */
          InitiatorAddress = (uint8_t) (ReceiveFrameInfos &
InitiatorAddressMask);
          printf("Initiator Address: %x\n", InitiatorAddress);
          printf("Received data Frame: ", InitiatorAddress);
          for(i=0;i<NbOfReceivedBytes;i++)
          {
            /* Display the received frame */
            printf("%x ",ReceiveBuffer[i] );
          }
        }
       else /* The receive was successful, but I'm not the concerned
destination */
        {
          /* Glow the yellow LED */
          GlowYellowLED();
        }
      }
      else /* The receive was failed */
      {
       /* Glow the red LED */
         GlowRedLED();
      }
    }
    ReceivedFrame=0;
  }
```

4 How to run the CEC demo

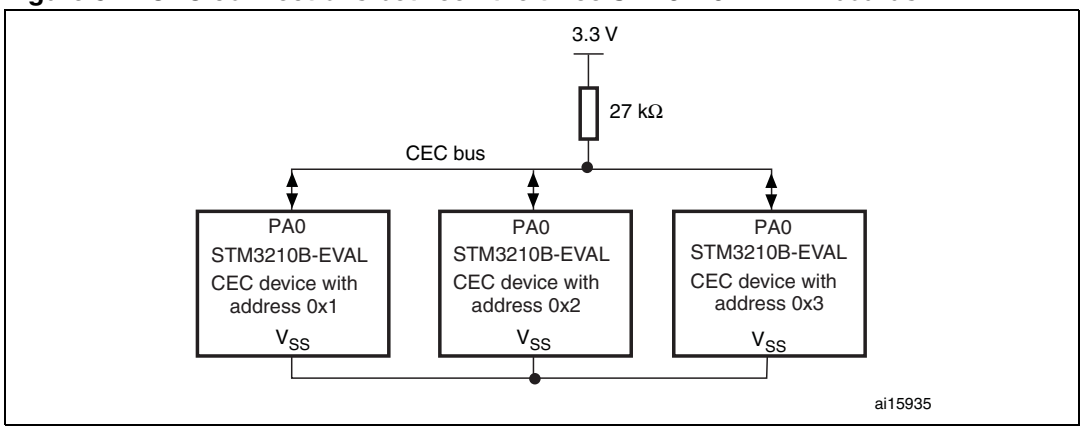
The demo provided with this user manual is intended to run on three STM3210B-EVAL evaluation boards. It can be run on only two boards but, in this case, the send to the third device is not achieved (refer to *Figure 8*).

The demo runs at 72 MHz. The CPU load for the 10-byte CEC receive or send frames over 15 seconds will be of around 2%.

4.1 Example of hardware connections between the three evaluation boards

To run the CEC demo you have to connect the three evaluation boards as shown in *Figure 5*. That is, you have to connect the board grounds together, then all the PA0 pins together (they constitute the CEC bus). Finally, you have to connect a pull-up resistor (27 kΩ) between the CEC bus and the 3.3 V power supply. The latter can be provided by any of the boards.

Figure 5. CEC connections between the three STM3210B-EVAL boards



4.2 CEC demo guidelines

There are three folders in the CEC_Demo folder: 1rst_CEC_Device, 2nd_CEC_Device and 3rd_CEC_Device.

Each folder contains the project of a device that should be compiled and loaded into one board. If only two boards are available, compile and load any pair (1st_Device, 2nd_Device), (1st_Device, 3rd_Device) or (2nd_Device, 3rd_Device) to the first board and the second board, respectively. Run the demo on each board and the LCD display shown in *Figure 6* will appear.

Begin the send/receive transactions by pressing the “key” button on any board.

Example: if you are pressing the key button on the board with the address 0x1 (1st_Device), this board will send a frame to the board with the address 0x2 (2nd_Device). The next time you press on the “key” button, another frame will be sent to the board with the address 0x3 (3rd_Device).

For more details refer to sections *4.3* and section *4.4*.

If you are using another type of board, you can show the send/receive frame on the toolchain live watch.

By default, the GPIO pin used for the CEC configuration is PA0. You can use another GPIO pin by modifying some configuration in the CEC library: the used GPIO, the GPIO that generates the EXTI interrupt and the NVIC IRQ channel. You also have to call the `CEC_ReceiveFrame` function in the appropriate EXTI interrupt routine.

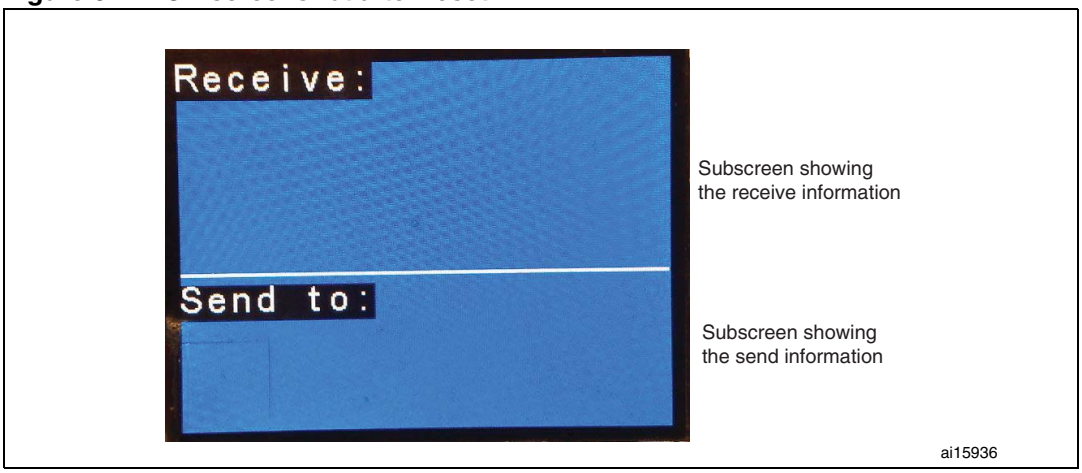
4.3 CEC send/receive information display on the LCD

The LCD screen is divided into two parts:

- a subscreen that shows the CEC receive information
- a subscreen that shows the CEC send information

After reset, each board displays the screen shown in *Figure 6*.

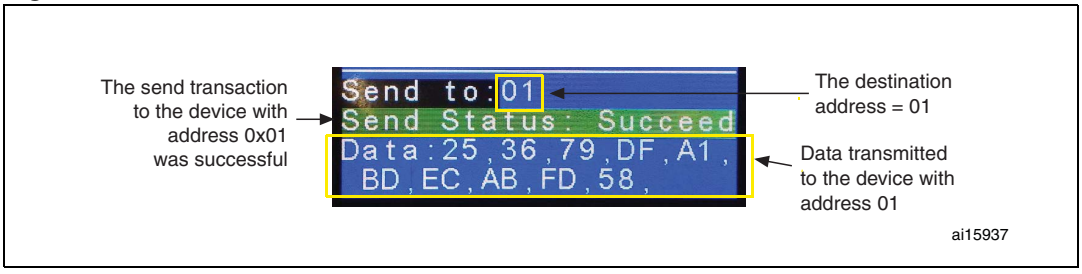
Figure 6. LCD screenshot after reset



4.4 Send subscreen information

Figure 7 shows that the frame was received without error by the device with address 0x1. The receiver has acknowledged the frame (0x25,0x36,0x79,0xDF,0xA1,0xBD, 0xEC, 0xAB, 0xFD, 0x58).

Figure 7. LCD screenshot of a successful send transaction



In *Figure 8* the frame (0xAA, 0x55,0x7E) was not sent to the intended destination (address 0x3). The frame is not acknowledged by the receiver.

Figure 8. LCD screen shot of a failed send transaction

4.5 Receive subscreen information

Figure 9 shows that the device has correctly received the frame from the sender with address 0x1. The data length (only data block) of the received frame is 0xA (10 bytes).

The received data are: 0xDF, 0x12, 0xD3, 0x56, 0x97, 0xA1, 0xEC, 0x7B, 0x4F, 0x22

Figure 9. LCD screenshot of a successful receive transaction

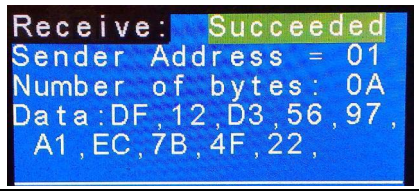


Figure 10 shows that the device detected a frame on the bus coming from the device with address 0x2, but it did not receive it because it is not the frame destination.

Figure 10. LCD screenshot of a detected frame

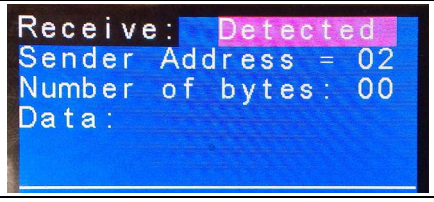
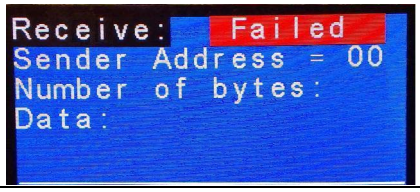


Figure 11 shows that an error has occurred while receiving the message.

Figure 11. LCD screenshot of a failed receive transaction



5 Conclusion

This user manual describes the STM32F10xxx CEC library, which contains the basic functions to communicate with the CEC protocol:

- `CEC_Init`: CEC initialization.
- `CEC_SendStartBit`: send CEC start bit.
- `CEC_ReceiveStartBit`: receive CEC start bit.
- `CEC_SendAckBit`: send CEC ACK bit (logical 0).
- `CEC_ReceiveAckBit`: receive CEC ACK bit.
- `CEC_SendDataBit`: send CEC data bit.
- `CEC_ReceiveDataBit`: receive CEC data bit.
- `CEC_SendByte`: send CEC Header/Data block
- `CEC_ReceiveByte`: receive CEC Header/Data block
- `CEC_SendFrame`: Send CEC frame with addressed messages.
- `CEC_ReceiveFrame`: receive CEC frame with addressed messages.

6 Revision history

Table 16. Document revision history

Date	Revision	Changes
06-Mar-2009	1	Initial release.
02-Nov-2009	2	`u8` changed to `uint8_t`. `u32` changed to `uint32_t`. `vu32` changed to `__IO uint32_t`. `void NVIC_Configuration(void)` code removed from *Example on page 8*.

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