SAMSUNG ELECTRONICS

APPLICATION NOTE

S3F80KB

IR REMOTE CONTROLLER

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IR REMOTE CONTROLLER

1 OVERVIEW

The IR remote controller application note is designed for application designers and programmers who are using S3F80KBX microcontroller for IR remote controller application development.

This application note describes the learning remote controller of two types universal remote controller. One of the universal remote controller is learning remote controller and another one is a lookup table remote controller. Both types have their own advantages. Look up table remote controller have a previously stored lookup table codes. On the other hand learning remote controller doesn’t have it, but it can learn new codes from other remote controllers. So learning remote controller have to implement a transmission mode and reception mode. This application note describes both modes.

Application Note contents

- Application Note document
- Source code (included OpenICE-i2000 project file)
- Board schematic

1.1 S3F80KBX MICROCONTROLLER

The S3F80KBX single-chip CMOS microcontroller is fabricated using a highly advanced CMOS process and is based on Samsung's newest CPU architecture.

The S3F80KBX is the microcontroller which has 60-Kbyte Flash Memory ROM.

Using a proven modular design approach, Samsung engineers developed S3F80KBX by integrating the following peripheral modules with the powerful SAM8 RC core:

- Internal LVD circuit and 16-bit-programmable pins for external interrupts.
- One 8-bit basic timer for oscillation stabilization and watchdog function (system reset).
- One 8-bit Timer/counter with three operating modes.
- Two 16-bit timer/counters with selectable operating modes.
- One 8-bit counter with auto-reload function and one-shot or repeat control.

The S3F80KBX is a versatile general-purpose microcontroller, which is especially suitable for use as remote transmitter controller. It is currently available in a 32-pin SOP and 44-pin QFP package.

1.2 IR SIGNAL

All remote controller manufactures define IR protocol which is specified on their products or companies. This application note describes example of IR protocol. This IR protocol determines the bit 1 and 0 by pulse distance. Carrier freuqeuncy is 37.9kHz and the frame period is 108ms. Leader is the start of frame. Following custom code is remote controller manufacture's customer code. It consists of 2 Bytes which is same each bytes. Data code and Data bar which is complemented Data code is sequentially transmitted. Last the end bit is transmitted.

The example protocol is shown Figure 1 below. (Custom code: 0x07H, Datacode: 0x02H)

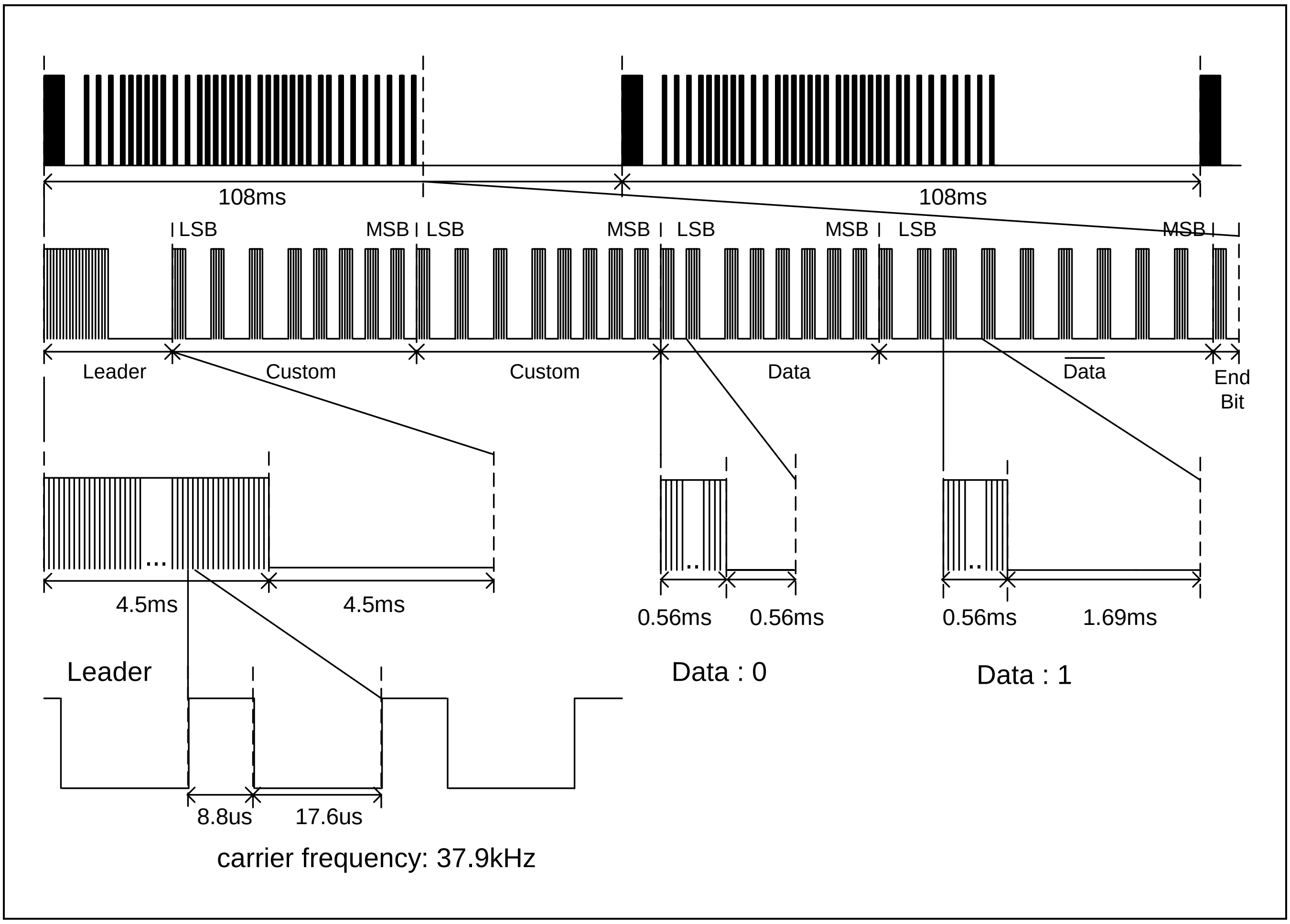

Figure 1. IR Signal

2 HARDWARE IMPLEMENTATION

2.1 IR REMOTE CONTROLLER SCHEMATIC

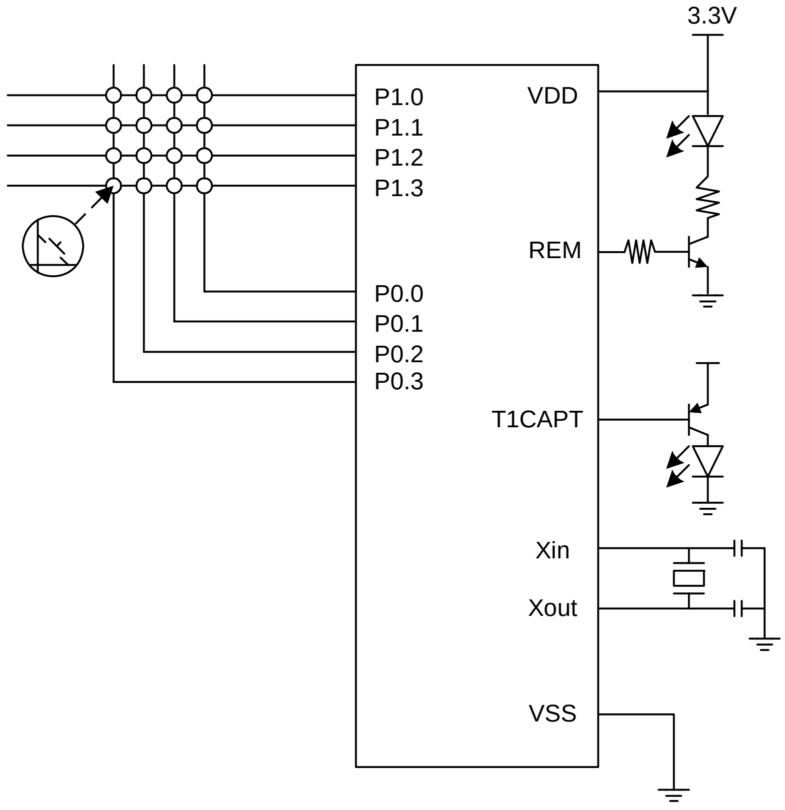

Figure 2. IR Remote Controller Schematic (44-pin)

2.2 APPLICATION FEATURES

- 4x4 Key matrix
- Port 3.1(REM) to transmit IR
- Port 3.3(T1CAPT) to Receive IR
- Counter A (Carrier frequency)
- 8-bit Timer0, 16-bit timer1

2.3 PIN ASSIGNMENTS

Table 1. Pin Configuration

Pin Names	Pin Type	Pin Description	44 Pin No.	Shared Functions
P0.0–P0.3	I/O	Input mode Pull-up resistors enabled Ext. INT enabled	30–33	Ext. INT (INT0–INT3) (INT4)
P1.0–P1.3	I/O	Open drain output mode	16,20–22	–
P3.1	O	REM	4	–
P3.3	I	T1CAPT	18	–
XOUT, XIN	–	System clock input and output pins	7,8	–
nRESET	I	System reset signal input pin and back-up mode input.	12	–
VDD	–	Power supply input pin	5	–
VSS	–	Ground pin	6	–

2.4 USED BLOCK

Table 2. Block Description

Block	Description
Counter A	Counter A is used to generate a Carrier frequency for Timer1's clock source and carry a carrier frequency when IR signal is transmitted through REM port.
Timer 1	In transmission mode, Timer1 use Carrier frequency to clock source and calcurates pulse distance to transmit leader, bit 0 and 1. In reception mode, Timer1 is used to calcurates a received IR signal pulse distance.
Timer 0	When reception mode, Timer0 countes learning mode operating time.

2.5 TRANSMISSION MODE

2.5.1 Counter A

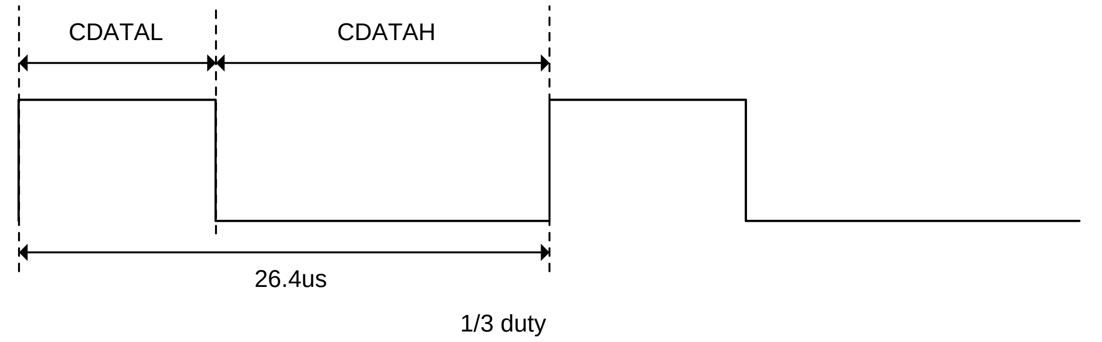

Figure 3. Carrier Frequency

Counter A is used to trasmit carrier frequency and supply a clock source to the Timer 1.

To make tLOW = 8.8 us and tHIGH = 17.6 us. fOSC = FX =8 MHz

[Method 1] When CAOF = 0,
tLOW = 8.8 us = (CADATAL + 2) / FX = (CADATAL + 2) x 125ns, CADATAL = 33.
tHIGH = 17.6 us = (CADATAH + 2) / FX = (CADATAH + 2) x 125ns, CADATAH = 68.

This is the example of counter A to generate a carrier frequency. CADATAL generates 17.5us low pulse. CADATAH generates 8.7us high pulse. Port 3.1 is configured REM to transmit carrier frequency. CounterA repeatedly countes CADATAH and CDATAL to transmit carrier frequency through P3.1. REM port can be controlled by setting P3.7. If P3.7 is setted to 1, REM signal is transmited through P3.1. If P3.7 is setted to 0, REM signal is not transmitted. But counterA doesn't stop counting. If you want to stop counting a counterA, you have to set CACON.2 to 1.

2.5.2 Timer 1

Timer 1 is used to generate the envelope pattern for the remote controller signal. Carrier frequency which is generated by Counter A is used as Timer 1's clock source by setting T1CON.7 to 1. Timer1 countes high and low length of the leader, bit 0 and 1. When Timer1 counter reaches the T1DATAH and T1DATAL value, Timer1 match interrupt is generated. Then IR signal is transmitted through P3.1(REM) that can be turned on or off by setting P3.7 to 1 or 0. Timer 1 match interrupt pending condition is not automatically cleared in interval timer mode. The T1INT pending condition must be cleared by application's interrupt servie routine by writing a '1' to the T1CON.0 interrupt pending bit.

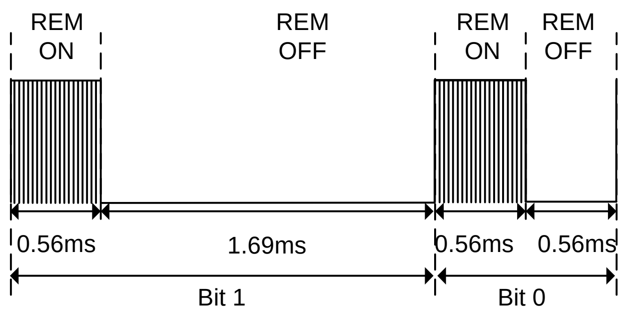

Figure 4. Timer1 IR Transmission

2.5.3 Port

Port 0 and Port 1 is used to implement Key matrix. Port 0.0 ~ 0.3 is configured as Input mode with external interrupt. Pull up resistor is enabled to generate interrupt at falling edge. Port 1.0 ~ 1.3 is configured as open drain mode. When the key is pressed, port 0.0 ~ 0.3 will be low by port 1.0~1.3, then external interrupt will be generated.

Port 3.1 is dedicated for IR drive pin. P3.7 is not configured for I/O pin and it only used to control carrier signal on/off.

2.6 RECEPTION MODE

2.6.1 Timer 1

When the remote controller mode is IR reception mode, Timer1 interrupt is configured as capture mode and fast inerrupt. Timer1 is used to generate a capture interrupt when falling edge is detected from IR signal which is received by IR sensor. Timer1 fast interrupt service routine stores up time when fast interrupt is generated. It is to count between falling edge and next falling edge of the IR signal. At the same time fast interrupt service routine countes the number of times of the fast interrupt. It is to counte a distance of the high and low signal.

2.6.2 Timer 0

Timer0 countes learning mode operation time. Timer 0 is configured as pwm mode and it generates overflow interrupt to compute a duration from start time to end time of the learning mode.

3 SOFTWARE IMPLEMENTATION

Table 3. Used Libraries

File Names	Description
keycode.tbl	Key code table definition
Init.src	80KB block initialization
define.pub	User macro define
Isr.src	Interrupt service routine
Keyscan.src	Key scan
Signal.src	1-bit , 8-bit, frame IR signal generation
Common.src	User variable declaration
segment.src	To display transmited or received remocon codes.
transmit.src	Transmission mode setup.
receive.src	Reception mode setup.
learnmode.src	Learning mode setup.

3.1 TRANSMISSION MODULE

3.1.1 IR Transmission Description

There are three sections to explain transmission module. IR signal is consist of the frame. Frame is consist of leader, custom code, data code and end bit. It is consist of the bit which is combined with crrier frequency.

3.1.2 Bit Transmission

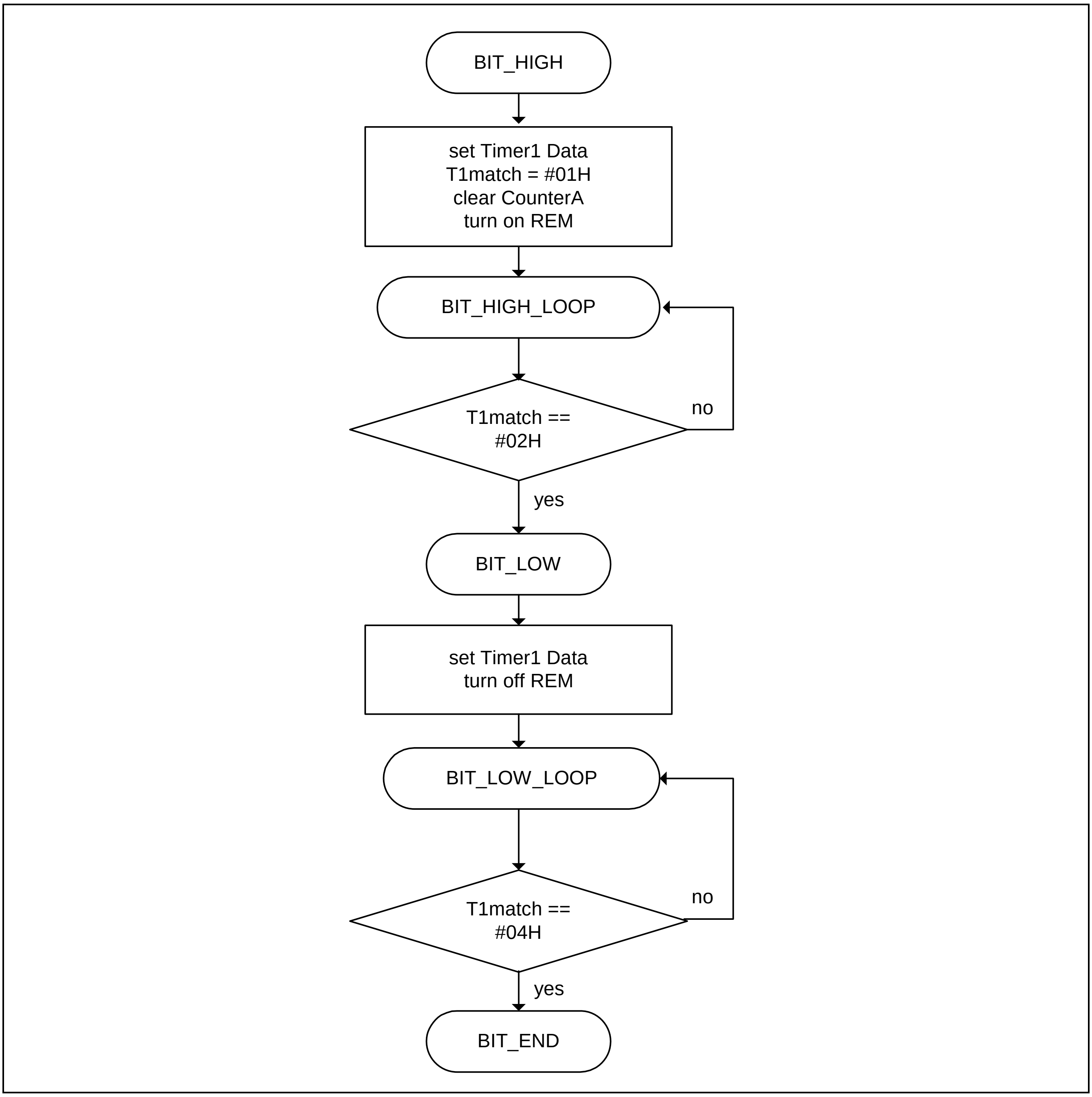

Figure 5. Bit Transmission Flow

Bit 0 or Bit 1 Transmission Module

Bit transmission module is used to transmit bit 0 or bit 1. Timer1's T1DATAH and T1DATAL value have to be setted before this module is used. SIGNAL_1BIT_PERIOD can be used to set that value. If SIGNAL_1BIT_PERIOD is setted, Timer1 countes until the match interrupt is generated. This code turn on REM during high sinal and turn off REM during low signal.

source 1 signal.src

```
;==========================================================================;
; @brief 1 Bit transmission                                                ;
; @input  : T1match = Timer1 match interrupt counter                       ;
; @input  : High_DataH = Bit 1's period                                    ;
; @input  : Low_DataH  = Bit 0's period                                    ;
; @output : NONE                                                           ;
; @ToDo   : T1match = #00H , Bit 1 and 0's period                          ;
;==========================================================================;
BIT_HIGH:                                   ;transmit Bit 1 high & low
        LDW     T1DATAH,High_DataH
        LD      T1match,#01H

        OR      CACON,#00000100B            ;\ clear counterA
        AND     CACON,#~00000100B           ;/

        EnableREM
        TurnIrOn
        OR      T1CON,#00001000B
BIT_HIGH_LOOP:
        TM      T1match,#02H
        JR      Z,BIT_HIGH_LOOP
BIT_LOW:                                    ;transmit Bit 0 high &l ow
        LDW     T1DATAH,Low_DataH
        DisableREM
        TurnIrOff
        OR      T1CON,#00001000B
BIT_LOW_LOOP:
        TM      T1match,#04H
        JR      Z,BIT_LOW_LOOP
BIT_END:
        RET
```

3.2 8-BIT TRANSMISSION

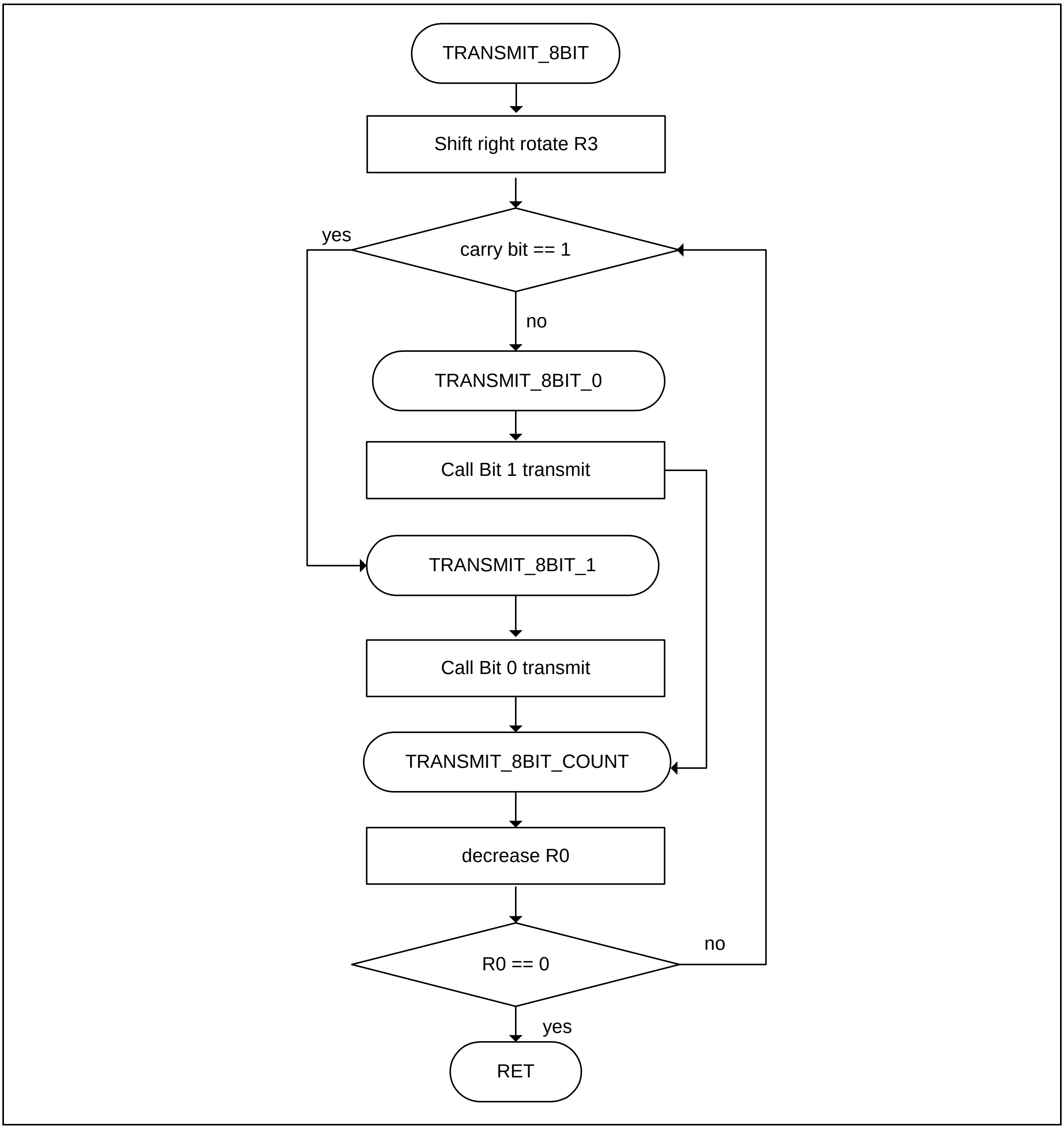

Figure 6. 8-Bit Transmission Flow

3.2.1 8-Bit Data Transmission Module

Custom code is consist of 16-bit. Data and data bar code is consist of each 8-bit. This module is implemented to transmit 8-bit IR signal.

source 2 signal.src

```
;==========================================================================;
; @brief 8Bit code transmit                                                ;
; @input  : R3 = 8Bit code                                                 ;
; @input  : R0 = 8Bit counter                                              ;
; @output : NONE                                                           ;
; @ToDo   : Set R3 to code and R0 to #08H                                  ;
;==========================================================================;
TRANSMIT_8BIT:
            ;RL     R3                      ; MSB first transmition
            RR      R3                      ; LSB first transmition
            JR      C,TRANSMIT_8BIT_1
TRANSMIT_8BIT_0:                            ; call bit 0 transmition
            CALL    BIT0_INIT
            JR      TRANSMIT_8BIT_COUNT
TRANSMIT_8BIT_1:
            CALL    BIT1_INIT               ; call bit 1 transmition
TRANSMIT_8BIT_COUNT:
            DJNZ    R0,TRANSMIT_8BIT
            RET
```

3.3 FRAME TRANSMISSION

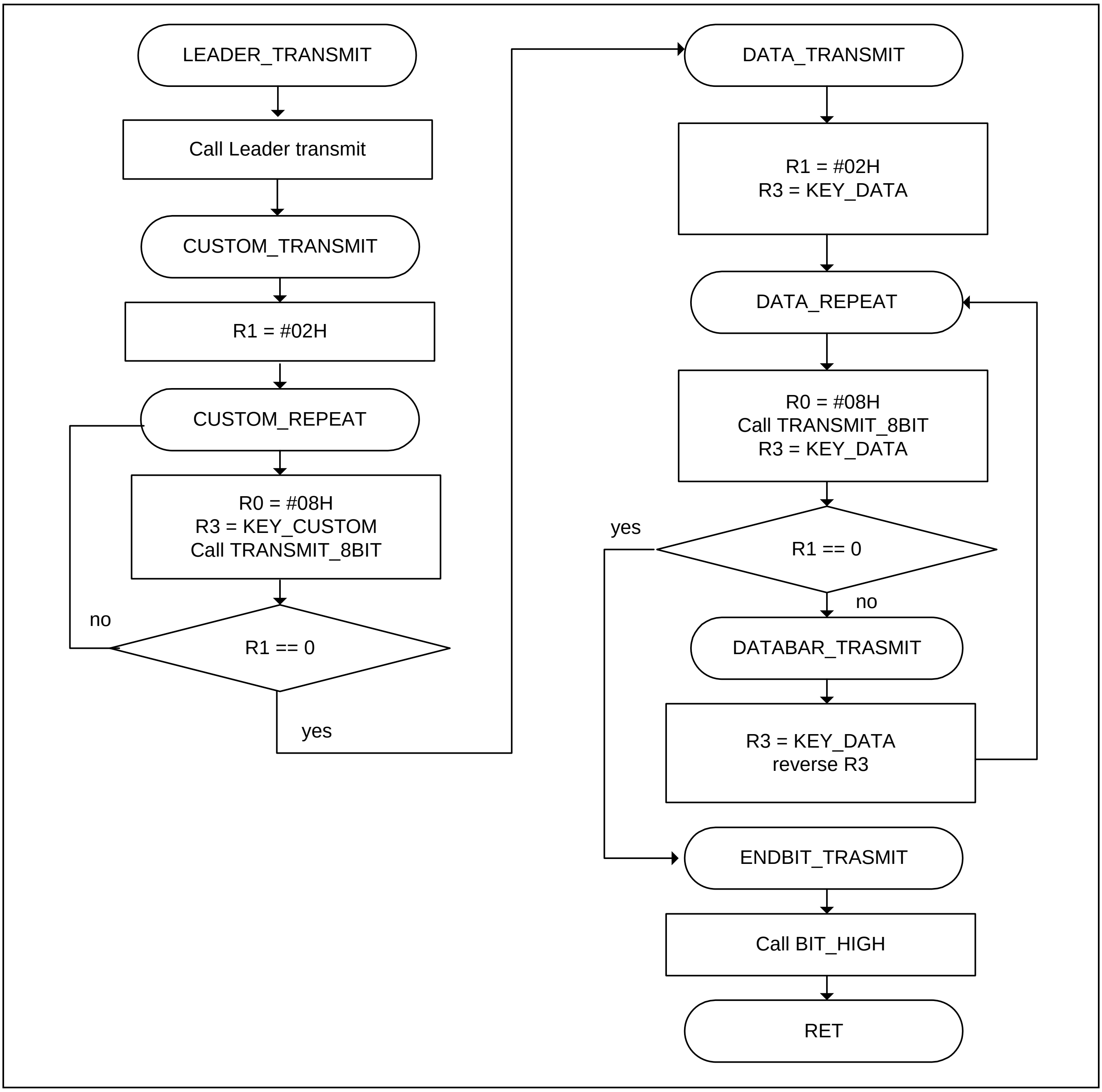

Figure 7. Frame Transmission Flow

3.3.1 Frame Transmission Module

Frames can be transmitted by using this code from leader to end bit. First leader will be transmitted, and next each 8bit, custom, data and data bar will be transmitted. Last the end bit will be transmitted.

source 3 signal.src

```
;==========================================================================;
; @brief IR signal transmit                                                ;
; @input  : KeyCustom = Customer code                                      ;
; @input  : KeyData = Data code                                            ;
; @output : NONE                                                           ;
; @brief Last - Start                                                      ;
;==========================================================================;
; @working register usages                                                 ;
;               R0 = 8Bit counter                                          ;
;               R1 = 2Byte counter                                         ;
;               R3 = Complemented KeyData                                  ;
;==========================================================================;
LEADER_TRANSMIT:
            CALL    LEADER_INIT
CUSTOM_TRANSMIT:
            LD      R1,#02H                     ;for CUSTOM loop 2
CUSTOM_REPEAT:
            LD      R0,#08H                     ;for loop 8bit CUSTOM
            LD      R3,KeyCustom
            CALL    TRANSMIT_8BIT
            DJNZ    R1,CUSTOM_REPEAT            ; R1--
DATA_TRANSMIT:
            LD      R1,#02H                     ; for DATA & DATA bar
            LD      R3,KeyData                  ; DATA code
DATA_REPEAT:
            LD      R0,#08H
            CALL    TRANSMIT_8BIT
            DJNZ    R1,DATABAR_TRANSMIT
ENDBIT_TRANSMIT:
            CALL    BIT_HIGH                    ; End bit
            RET
DATABAR_TRANSMIT:
            LD      R3,KeyData                  ; DATA bar
            COM     R3
            JR      DATA_REPEAT
```

3.4 IR RECEPTION MODULE

3.4.1 IR reception description

- Port 3.3 is configured as Timer1 Capture mode and falling edge interrupt. Timer1 is configured fast interrupt by setted SYM.
- When fast interrupt is generated, fast interrupt service routine increase the counter and calcurates leader length and every bit length. It will check limit of each signal length. If the signal is wrong, it exit from this routine.
- If all frame is normally received, it cofirmes data correction. Custom code compare each other and data code compare with a complemented data bar.
- If this data does not have error, the data code will be stored at pressed keypad buffer and data flag will be set to 1. (This is to transmit stored data code next time)
- Whenever Timer0 overflow interrupt is generated, it will increase a counter variable. If this counter is exceeded a learning mode limit, It will exit from learning mode.

3.5 LEADER RECEPTION

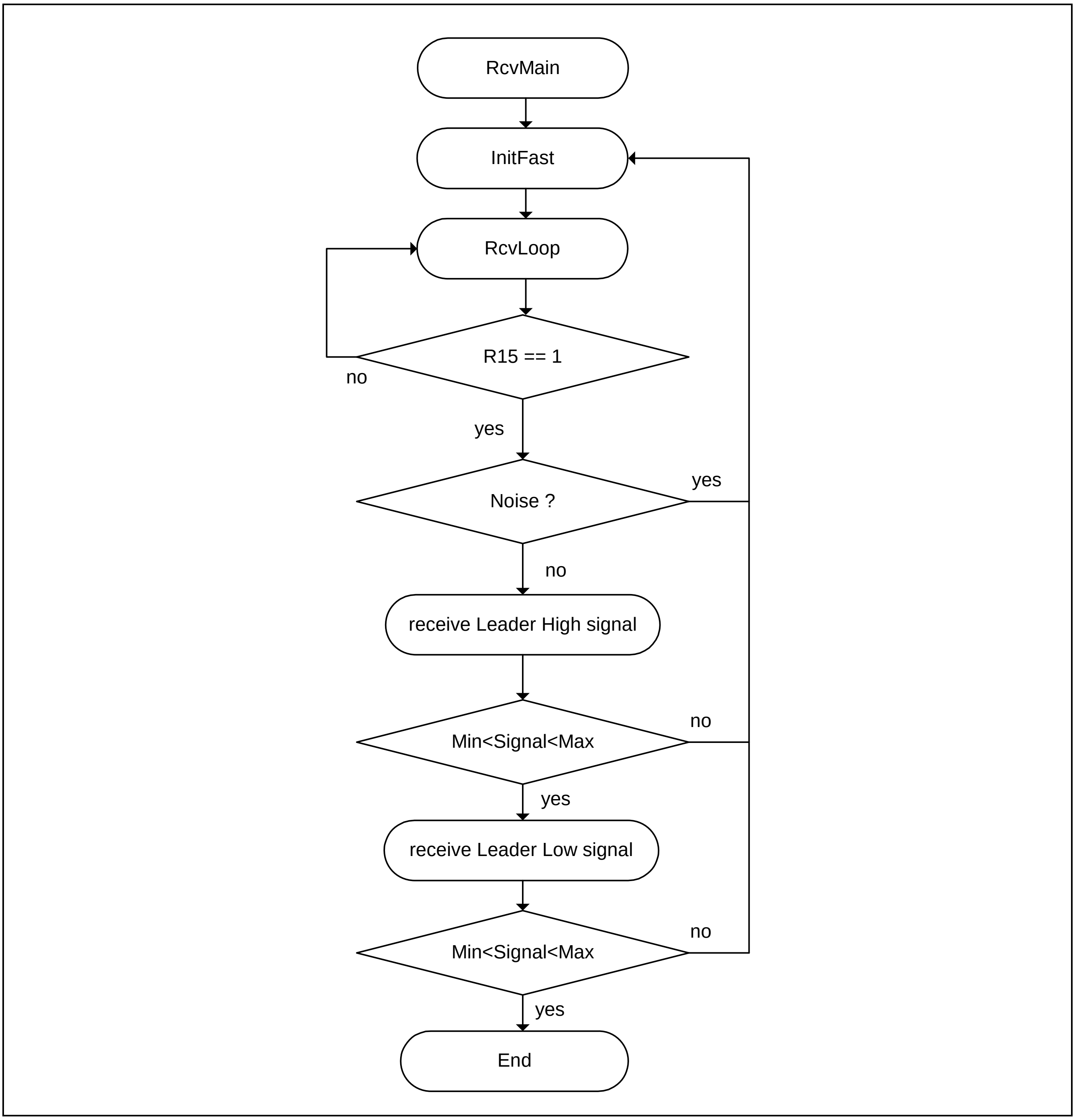

Figure 8. Leader Reception Flow

In the learning mode it will wait for falling edge input signal. When the first signal is received, this module will check if it's leader.

source 4 receive.src

```
;==========================================================================;
; @brief IR reception                                                      ;
; @input NONE                                                              ;
; @output NONE                                                             ;
; @ToDo                                                                    ;
;==========================================================================;
; Used register description                                                ;
;       R0      - CheckNoise Count                                         ;
;       R1      - 4time count (Custom,Custom,Data,Databar)                 ;
;       R2      - 8Bit counter                                             ;
;       R3      - calcaurate temp                                          ;
;       RR4     - signal start                                             ;
;       RR6     - signal last                                              ;
;       RR8     - IP address                                               ;
;       R10     - calcurate temp                                           ;
;       R11     - Data buffer pointer                                      ;
;       RR12    - Old Time                                                 ;
;       RR14    - pulse count                                              ;
;==========================================================================;

RcvMain::
        DI
        AND   P3,#0FEH           ;\
        LD    P0CONH,#0AAH       ; | Set 7segment to display the learned code
        LD    P0,#00H            ; |
        LD    P1,#00H            ;/
        OR    P3CON,#11000110B   ;enable capture mode
        LD    IMR,#00000011B     ;Mask IRQ0 and IRQ1 interrupts
        LD    SYM,#00000110B     ;Enable IRQ fast int
        ;LD   T1CON,#00101010B   ;Enable T1 capt int. , falling edge
        LD    T1CON,#00011010B   ;rising edge
                                 ;Disable T1 overflow int
                                 ;Reset timer1
                                 ;Set FOSC/4
                                 ;T1 overflow enable
        LD    T0CON,#01111100B   ;Enable T0 overflow int
                                 ;Reset timer0
```

```
                                        ;Set FOSC/256
          LD     T0OvrCntH,#00H
InitFast:
          AND    T1CON,#11111110B  ;Clear Timer1 interrupt pending bit
          OR     T1CON,#00001000B  ;Clear Timer1 counter

          LDW    IPH,#T1FastInt1st    ;Load address of fast ISR

          LD     T1FastFlag,#00H      ;fast inerrupt flag
          LD     T0OvrCnt,#00H        ;T0OVR ISR counter
          LD     PulseCnt,#00H        ;falling edge counter
          LD     R0,#080H
          LD     R2,#08H
          LDW    RR14,#0000H
          LD     R11,#0BH             ;IR_Cnt pointer
          LD     R1,#04H
          EI
RcvLoop:                              ;loop until the first pulse received
          TM     T0OvrCntH,#04H       ;check learning mode counter limit
          JP     NZ,LearningMode      ;if T0OvrCntH > #04H,exit loop
          TM     R15,#01H             ;pulse received
          JR     NZ,CheckNoise
          JR     RcvLoop
CheckNoise:
          LD     R3,P3
          AND    R3,#00001000B
          ;JP    NZ,InitFast           ;If P3.3 is not low, Pulse is noise
          LDW    RR12,RR6
          ;DJNZ  R0,CheckNoise         ;Check P3.3 for 3 times.
          LD     T0OvrCnt,#00H
          ;OR    T1CON,#00001000B
;==========================================================================;
; @brief Leader signal capture                                             ;
;==========================================================================;
LeaderHInit:
          LDW    RR4,SignalStart       ;first signal time
Wait:
          DJNZ   R0,Wait               ;Wait for the low signal
```

```
          ;LDC    R11,#KEY_CODE+1[0]
          CP      R15,#080H;TDataHH;   ;\
          JP      lt,InitFast          ; | signal min,max
          CP      R15,#0D4H;TDataHL    ; |
          JP      gt,InitFast          ;/
LeaderLInit:
          LDW     RR14,#0000H
          LDW     RR4,RR6
          LD      T1FastFlag,#00H
Wait2:                                 ;wait for the next bit pulse
          TM      T1FastFlag,#01H
          JR      NZ,LeaderL_Start
          JR      Wait2
LeaderL_Start:
          CP      R6,R4                ;\
          JR      lt,LeaderL_T1Ovr     ; |
          LastSubStart                 ; |
          JR      LeaderL_Min1         ; |
LeaderL_T1Ovr:                         ; |
          T1OvrCal                     ; |
LeaderL_Min1:                          ; |
          CP      R6,#01AH             ; |signal min,max
          JP      lt,InitFast          ; |
          JR      nz,LeaderL_Max1      ; |
          CP      R7,#05EH             ; |
          JP      lt,InitFast          ; |
LeaderL_Max1:                          ; |
          CP      R6,#02BH             ; |
          JP      gt,InitFast          ; |
          JR      nz,BitHInit          ; |
          CP      R7,#0F2H             ; |
          JP      gt,InitFast          ;/
```


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3.6 DATA BIT RECEPTION

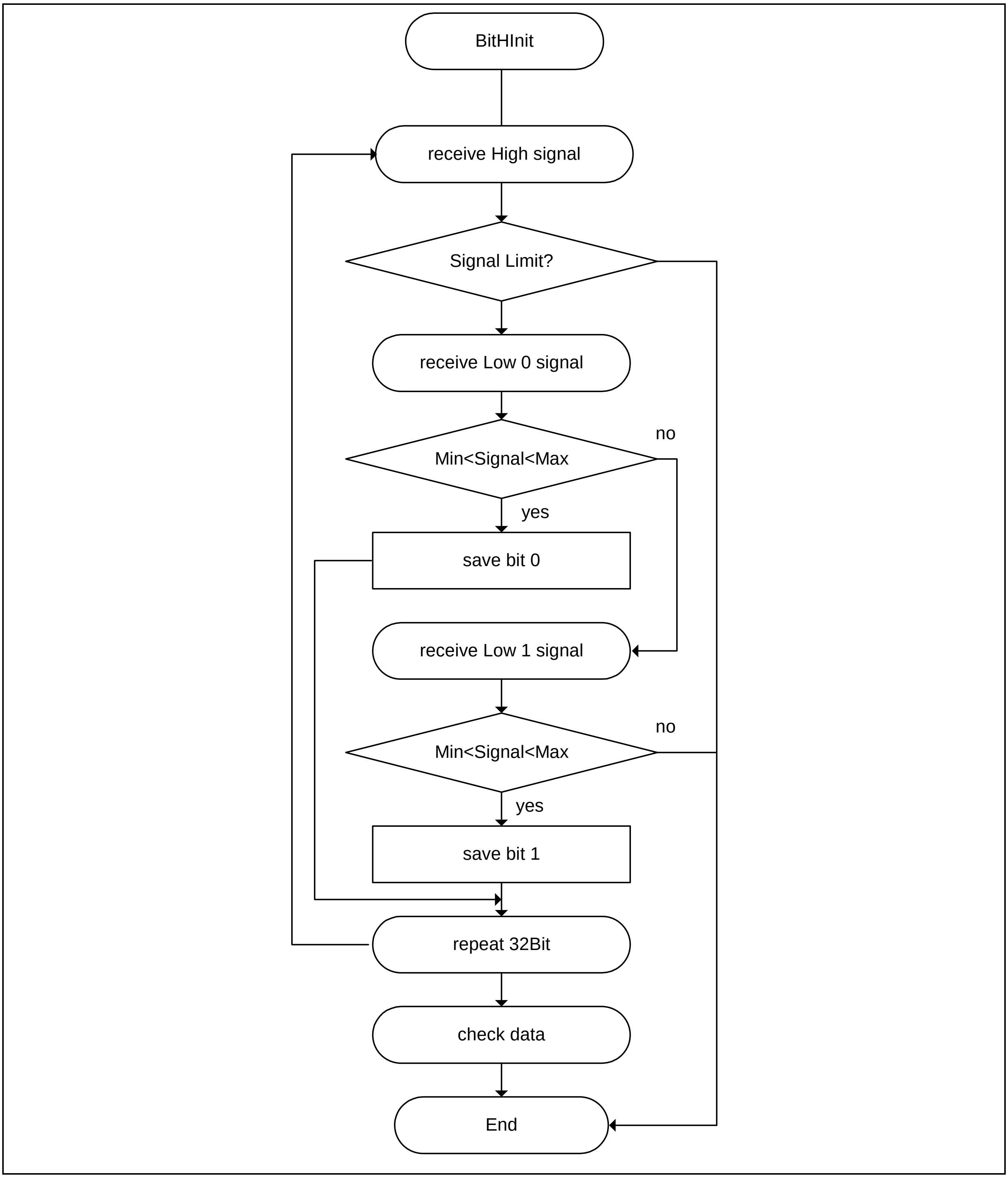

Figure 9. Bit Reception Flow

This module process reception 32-bit signal and the end bit after the leader signal is received. If there is not error, data code is stored in the buffer.

source 5 receive.src

```
;===========================================================================;
; @brief bit signal capture                                   ;
;===========================================================================;
BitHInit:
        LDW     RR14,#0000H
        LDW     RR4,RR6
Wait3:                          ;Wait for the low signal
        DJNZ    R0,Wait3        ;192us
        CP      R15,#10H        ;\
        JP      lt,InitFast     ; |signal min,max
        CP      R15,#1AH        ; |
        JP      gt,InitFast     ;/
BitLInit:
        LDW     RR14,#0000H
        LDW     RR4,RR6
        LD      T1FastFlag,#00H
Wait4:                          ;wait for next bit pulse
        TM      T1FastFlag,#01H
        JR      NZ,BitL_Start
        JR      Wait4
BitL_Start:
        CP      R6,R4
        JR      lt,BitL_T1Ovr
        LastSubStart
        JR      BitL_Min1
BitL_T1Ovr:
        T1OvrCal
BitL_Min1:                          ;\
        BTJRT   BitL_Min1_L,R6.3    ; |;If R6>#08H
        CP      R6,#03H             ; |
        JP      lt,InitFast         ; |
        JR      nz,BitL_Max1        ; |
        CP      R7,#04CH            ; |
```

```
        JP      lt,InitFast         ; |signal min,max
BitL_Max1:                          ; |
        CP      R6,#05H             ; |
        JP      gt,InitFast         ; |
        JR      nz,Bit0             ; |
        CP      R7,#07EH            ; |
        JP      gt,InitFast         ;/
Bit0:                               ;store 0 bit
        RCF
        RRC     @R11
        ;RLC    @R11
        LDW     RR14,#0000H
        DEC     R2
        JR      NZ,BitHInit         ;8bit count until R2 is 0  (Initial R2 value is #08H)
        JR      EndByte             ;if 8bit received
BitL_Min1_L:                        ;\
        CP      R6,#09H             ; |
        JP      lt,InitFast         ; |
        JR      nz,BitL_Max1_L      ; |
        CP      R7,#0E7H            ; |#20H;
        JP      lt,InitFast         ; |
BitL_Max1_L:                        ; |signal min,max
        CP      R6,#10H             ; |
        JP      ge,InitFast         ; |
        JR      nz,Bit1             ; |
        CP      R7,#081H            ; |#34H;
        JP      gt,InitFast         ;/
Bit1:                               ;store 0 bit
        SCF
        RRC     @R11
        ;RLC    @R11                ;store the recevied bit to buffer
        LDW     RR14,#0000H
        DEC     R2                  ;8bit counter
        JP      NZ,BitHInit         ;Jump if 8bit is not received
EndByte:
        ADD     R11,#01H            ;increase the received data buffer address
        LD      R2,#08H             ;initialize 8bit counter
        DEC     R1
```

```
            JP      NZ,BitHInit             ;Jump if 4Byte is not received
ConfirmData:                                ;Compare the received signal
            CP    IR_Custom,IR_Custom2
            JP      NZ,InitFast
            LD      R2,IR_Databar
            COM     R2
            CP      IR_Data,R2
            JP      NZ,InitFast
;=========================================================================;
; @brief Exit capture                                                      ;
;=========================================================================;
CaptExit:
            LD      R4,LKeyOffset
            LD      R6,#22H                 ;LearningKey address = #22H
            ADD     R6,R4
            LD      @R6,IR_Data

            LD      SegData,IR_Data         ;display data code on the 7Segment
            CALL    Segment

            AND     P2,#00H

            LD      R11,#3BH                ;LearnedKey address = #3BH
            ADD     R11,R4
            LD      @R11,#01H
            JP      LearningMode
```

4 TEST METHOD

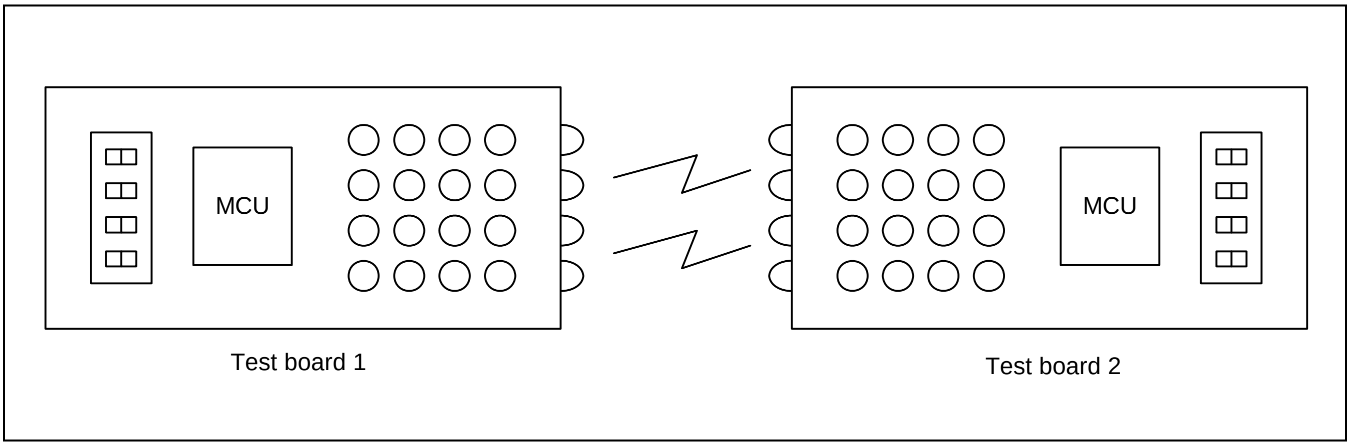

Figure 10. Application Concept Diagram

4.1 IR TEST METHOD

1. Place two remote controllers to front each other
2. Configure test board 1 to transmission mode.
   - The initial mode is transmission mode after reset.
   - At the end of the learning mode, mode is go into transmission mode.
3. Configure test board 2 to reception mode.
   - Press Key(SW2 ~SW5) and next press key(SW6~17) to store IR data code
4. Press Key(Sw6 ~ Sw17) of the signal which want to transmit
5. Check 7-segment to confirm the transmission and reception is completed
   - To confirm, check test board 1 and test board 2's word displayed in 7-segment. If test board 1 and test board 2's word is same, it's normal, otherwise it's abnormal. Check test board 2 displayed word in 7-segment after press the key stored data code. If test board 1 and test board 2's word is same, it's normal, otherwise it's abnormal.

4.2 IR TEST FLOW

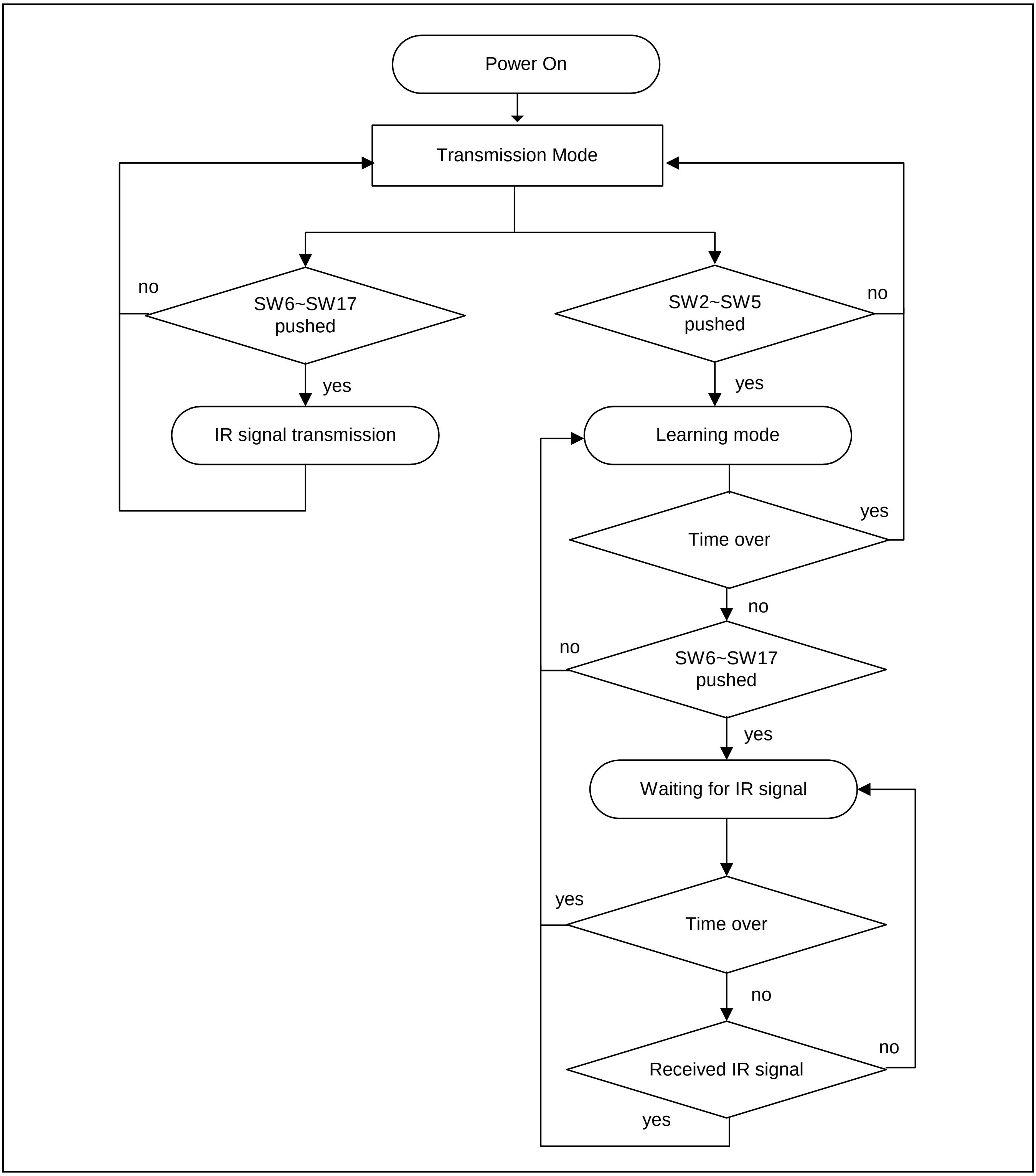

Figure 11. IR Test Flow

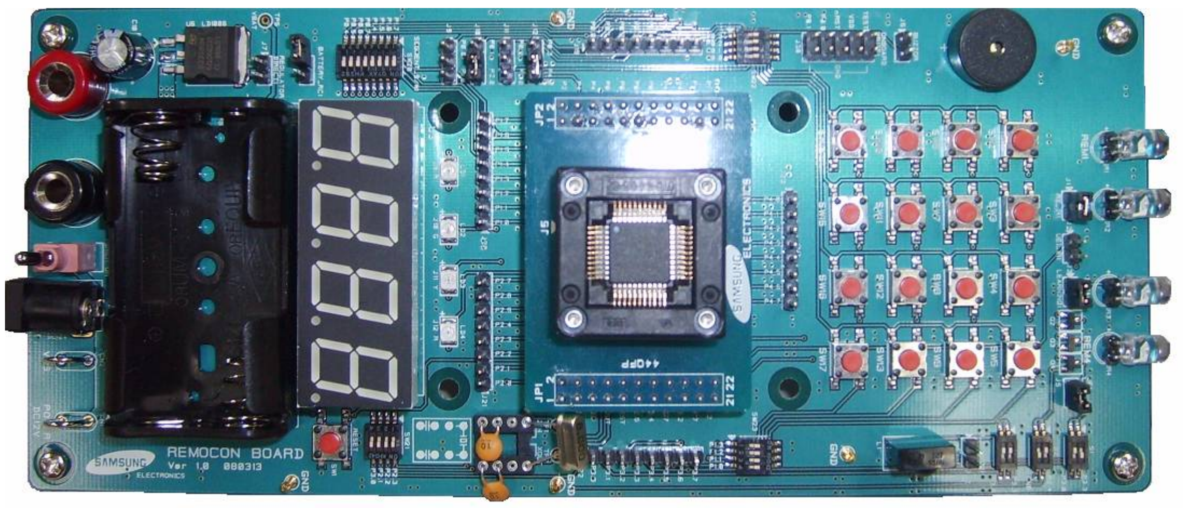

Figure 12. IR Remote Controller Test Board

NOTES