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Renesas Electronics Corporation

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H8/300L SLP Series

Auto Baud Rate Detection (AutoBaud)

Introduction

This application note describes the software implementation of baud rate detection of incoming data. The SLP MCU is used to demonstrate the detection of 1200, 4800, 9600, and 19200 bps.

This automatic detection is useful for establishing communication link between two devices. The slave device will be able to detect the baud rate of master controller and adjust accordingly.

This protocol can be implemented on any MCU that carries an asynchronous serial port with a baud rate generator.

In this application note, the protocol is demonstrated using the ALE300L emulator (the SLP MCU H8/38024) connected to the general application board. The SLP MCU is emulating as a slave device, whereas the PC (using the built-in HyperTerminal) acts as the master controller.

Target Device

H8/38024

Contents

1. Theory

1.1 Detection Algorithm

The detection algorithm is to read the sequence of bit received, based on a preset baud rate, and determine the incoming data rate.

In this example, the incoming data from the master is predefined as the “RETURN” character (0x0D), and the initial baud rate is preset to 9600 bps.

The detection algorithm can be classified into three main methods.

1. Baud < 1200
2. Baud > 1200 and baud <= 9600
3. Baud > 9600

The following are the communication mode settings:

Start Bit: 1
Data Bit: 8
Stop Bit: 1
Parity Bit: None
Flow Control: None

For the <RETURN> character (0x0D)

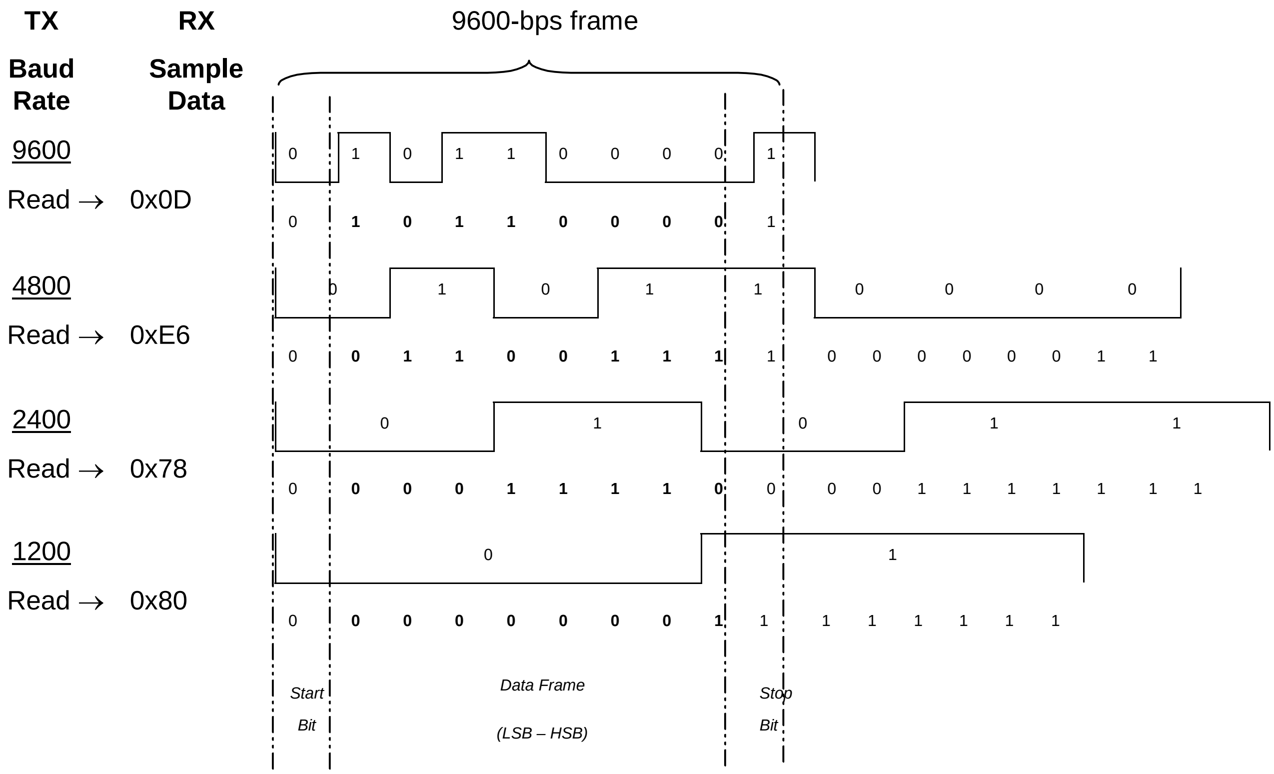
0	1	0	1	1	0	0	0	0	0
Start Bit	Data – 0x0D								Stop Bit

If data is sent based on 9600 baud, the receiver will receive the same data as the transmitted data if it is set at the same baud rate. This is because the incoming data is sampled correctly, upon the activation of start bit. The serial bus is normally in the mark state (high level). When a space (low level) is detected, identify as the start bit, the incoming serial data will be sampled. In SCI3 of the SLP MCU, the data is sampled on the 8th pulse of clock with the frequency that is 16 times larger than the bit rate (Data latched at the center of bit).

It will receive (sample) different patterns of data from the transmitter when the transmitter is set to a different baud rate.

1.1.1 Baud >= 1200 and Baud <= 9600

The diagram below will illustrate the read data when 0x0D (RETURN) is send at various baud rates.



The transmitter's serial data stream, which is based on the different baud rate, will be fed into the 9600-bps receiver. Data will be sampled at this rate. The first data bit will be the LSB (least significant bit).

Based on the above illustration, when data is transmitted at 4800 bps (half slower than that of the receiver of 9600 bps), the initial start bit of transmitter will be lengthened. This will be treated as the start bit and first data bit in the receiver of 9600-bps frame.

Thus, the following data are received at 9600 bps:

- At 9600 bps, received data is 0x0D.
- At 4800 bps, received data is 0xE6.
- At 2400 bps, received data is 0x78.
- At 1200 bps, received data is 0x80.

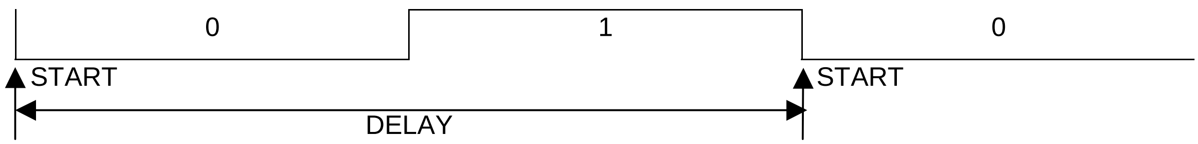
1.1.2 Baud < 1200

For the baud rate below 1200 (600 & 300 baud), the receiver will read the same data pattern of 0x00. This will not prevent the detection procedure. The <RETURN> (0x0D) has several transitions from high to low, which can signify a mark (start) of newly received byte at the higher baud rate receiver (In this case, 9600 bps).

In other words, the high baud rate receiver will be able to receive two more bytes of data from the low baud rate transmitter.

If the timing delay of the "new" byte is measured, the baud rate of transmitter can be predicted.

The following illustrates the initial bit stream of transmitter and the calculation of delay:



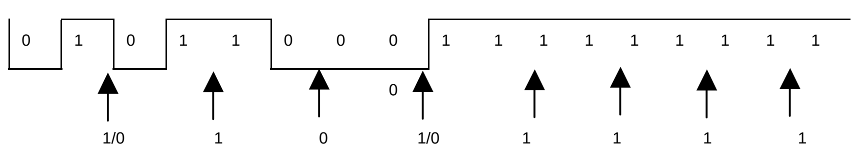
600 bps	16 '0'	16 '1'	16 '0'
	32 bit delay at 9600 Baud = 32* 1/9600 = 3.33 ms		
300 bps	32 '0'	32 '1'	32 '0'
	64 bit delay at 9600 Baud = 64* 1/9600 = 6.66ms		

1.1.3 Baud > 9600

For the baud rate above 9600 (19200 baud), the receiver will read different patterns, as the sampling window will capture the data transitions. The transitions of (0 to 1) and (1 to 0) may be interpret as '0' or '1'.

Thus, in this case,

TX Baud Rate	RX Sample Data
19200	F2, F3, FA, or FB



The sampled data can fall into few possibilities:

- 0xF2
- 0xF3
- 0xFA
- 0xFB

1.2 MCU SCI Setting

The serial communication interface (SCI) is set to

- 9600 baud
- 1 start bit
- 8 data bits
- 1 stop bit
- No parity bit

When the baud rate is determined, the SCI will have to set the following:

- CKS1 (bit 1) & CKS0 (bit 0) of SMR (Serial Mode Register) (**n**) [determine the input clock to the SCI]
- BRR (Bit Rate Register) (**N**) [Baud rate generator] (0<N<255)

n	Clock	SMR Setting	
		CKS1 (bit 1)	CKS0 (bit 0)
0	ϕ	0	0
0	$\phi w/2\phi w$	0	1
2	$\phi/16$	1	0
3	$\phi/64$	1	1

$$N = \frac{\phi OSC}{(64 \times 2^{2n} \times B)} - 1$$

whereby,

B — Bit Rate (bit/s)

N — Baud Rate Generator BRR setting (0<N<255)

OSC — Value of OSC (Hz)

n — Baud Rate Generator Input Clock Number (n = 0, 2, 3)

The above theory proves that detecting different baud rates is possible. However, due to the input clock selection, certain baud rates may not be feasible to be generated. The error rate may be too high (recommend < 1%).

The error can be calculated as below:

$$\text{Error (\%)} = \frac{\text{B (rate obtained from n, N, OSC)} - \text{R (desired bit rate)}}{\text{R (desired bit rate)}} \times 100$$

The following is the recommended generated settings for n & N, based on the main input clock.

Frequency OSC (MHz)	n	Desired bps B	Calculated N	Selected N	New bps B	Error %
9.8304	0	1200	127.00	127	1200.00	0.00%
	0	2400	63.00	63	2400.00	0.00%
	0	4800	31.00	31	4800.00	0.00%
	0	9600	15.00	15	9600.00	0.00%
	0	19200	7.00	7	19200.00	0.00%
	0	31250	3.92	4	30720.00	-1.70%
	2	1200	7.00	7	1200.00	0.00%
10	0	1200	129.21	129	1201.92	0.16%
	0	2400	64.10	64	2403.85	0.16%
	0	4800	31.55	31	4882.81	1.73%
	0	9600	15.28	15	9765.63	1.73%
	0	19200	7.14	7	19531.25	1.73%
	0	31250	4.00	4	31250.00	0.00%
	2	1200	7.14	7	1220.70	1.73%
16	0	1200	207.33	207	1201.92	0.16%
	0	2400	103.17	103	2403.85	0.16%
	0	4800	51.08	51	4807.69	0.16%
	0	9600	25.04	25	9615.38	0.16%
	0	19200	12.02	12	19230.77	0.16%
	0	31250	7.00	7	31250.00	0.00%
	2	1200	12.02	12	1201.92	0.16%

For other frequency settings, please refer to the MCU hardware manual.

1.3 Alternative Solution

The simple alternative is to create a protocol so that the master controller will continue to send a series of characters such as 0xA, 0xB, and 0xC at the desired baud rate and wait for response. On the slave end, the MCU will switch itself to different baud rates, in order to capture the correct data stream, and send acknowledgment when the pattern of data is recognized.

2. Operation

Objective: The SLP will be able to switch to the respective baud rates (1200, 4800, 9600, & 19200 bps), based on the single character (Return- 0x0D) send from the HyperTerminal on PC.

2.1 Environment Setup

The setup is illustrated in figure 1.

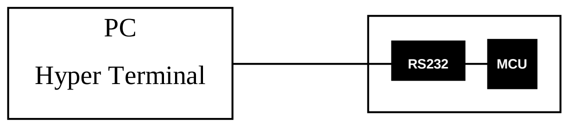
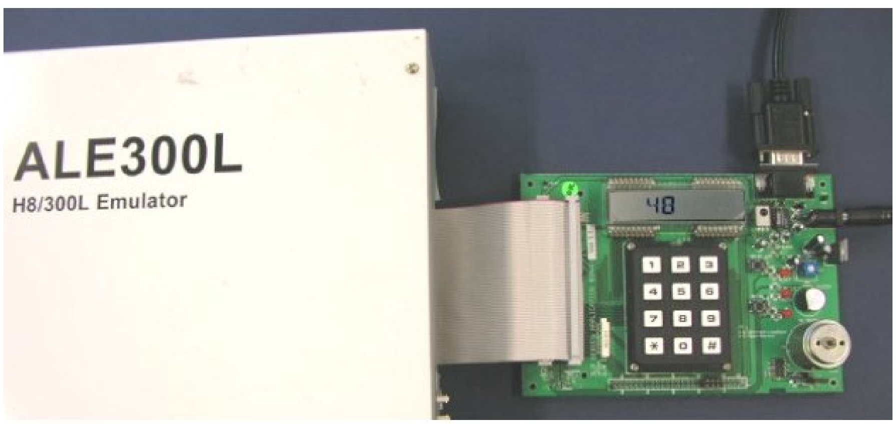


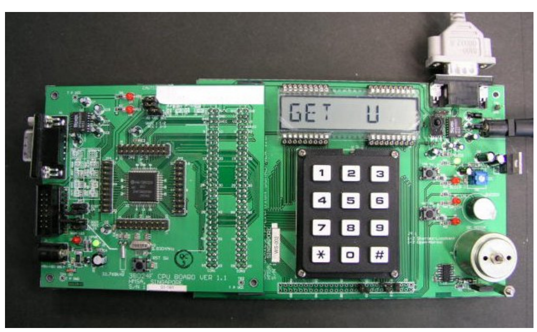
Figure 1 Basic Block Diagram

The setup of tools is shown in figure 2.



Detection of

Baud Rate - 4800 bps



Detection of

Character – ‘U’ from PC

Figure 2 Use of ALE300L Emulator or the SLP CPU Board with the General Application Board

If the general application board is not available, a simple serial driver will have to be built to condition the signal level between the SLP MCU & the PC serial port. Users can confirm the data on the LCD panel in the application board.

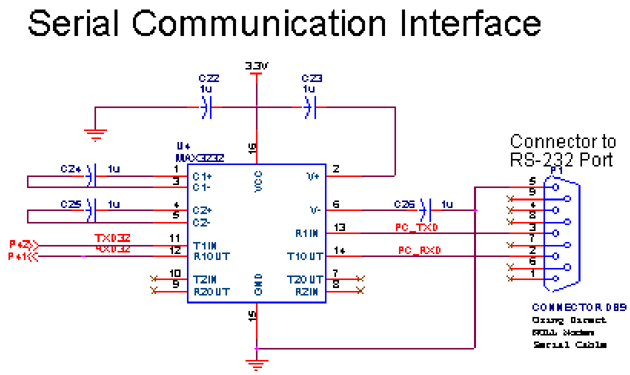


Figure 3 RS232C Serial Connection

The HyperTerminal setting on PC is shown in figure 4.

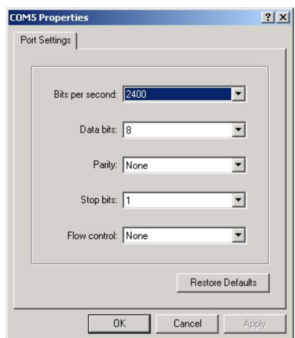


Figure 4 The HyperTerminal setting on PC

2.2 Operation & Observation

1. Set the PC to any baud rate (1200, 4800, 9600, or 19200)
2. Hit the <RETURN> key
3. The LCD display shows the baud rate detection, and a stream of data (“BAUD DETECT”) is sent back to the PC.
4. Press any key
   a. The key pressed will be displayed on the LCD display and sent back to the PC.
5. Press ‘a’ to abort
6. Go to step 1
   a. Click on [Call/ Disconnect] in the HyperTerminal.
   b. Click on [File/ Property/Configure] to re-configure to a new baud rate.

3. Code Listing

The attached code is generated using the HEW project generator targeting at the H8/38024 SLP MCU. The tool chain used is the free SLP/TINY tool chain.

The main routines of the auto baud rate detection are attached as follows.

In summary, the code provides a basic framework for users to have a quick start. The code is made to be readable, and thus it is not optimized. The Bprintf() function (customized printf()) is detailed in the application note "Writing a printf function to LCD & serial port."

```
// autobaud.c
#include "iodefine.h"
#include "auto_baud.h"
#include <machine.h>

int lcd_cursor_pos=8;

void main(void)
{
   init_io();
   init_lcd();

   while(1)
   {
      init_sci();
      auto_detect();
   }
}

unsigned char auto_detect(void)
{
   static unsigned char sequence='1';
   unsigned char b_data, b_data2;
   unsigned int baudrate,i;

   // Start up message with sequence numering
   lcd_cursor_pos=8;
   Bprintf("BAUD %c ", (BYTE)sequence,(DWORD)SPACE);
   sequence++;

   b_data              = sci_charget();
   P_SCI3.SCR3.BIT.RE  = 0x0;            //disable
   P_SCI3.SSR.BYTE     = 0x00;           //84 clear error

   if (b_data==0x00)                     //low baud rate
   {
      // start timer
      // watch for sci_charget()
      // Measure time
      // Determine new Baud
      lcd_cursor_pos=8;
      Bprintf("LOW BR", (BYTE)baudrate,(DWORD)b_data);
      P_SCI3.SCR3.BIT.RE = 0x1;          //enable
      P_SCI3.SSR.BYTE = 0x00;            //84 clear error

      //clear leftover data
      for(i=0;i<10000;i++);              // delay
      if ((P_SCI3.SSR.BIT.RDRF) == 0)
         b_data2=P_SCI3.RDR;
      return(0);
   }

   //to prevent latching in of the leftover data
   //dummy read to clear the initial unwanted data
```

```
for(i=0;i<10000;i++);                // delay
if ((P_SCI3.SSR.BIT.RDRF) == 0)
   b_data2=P_SCI3.RDR;

if (b_data == 0x80)                  // 1200 bps
{  baudrate = BR1200;
   P_SCI3.SMR.BYTE |=BR12_CKS;
   P_SCI3.BRR     = BR12_BRR;
}

else if (b_data == 0x78)             //2400 bps
{  baudrate = BR2400;
   P_SCI3.SMR.BYTE |=BR24_CKS;
   P_SCI3.BRR     = BR24_BRR;
}

else if (b_data == 0xE6)             // 4800 bps
{  baudrate = BR4800;
   P_SCI3.SMR.BYTE |=BR48_CKS;
   P_SCI3.BRR     = BR48_BRR;
}

else if (b_data == 0x0D)             // 9600 bps
{  baudrate = BR9600;
   P_SCI3.SMR.BYTE |=BR96_CKS;
   P_SCI3.BRR     = BR96_BRR;
}

else if (b_data == 0xF2   ||
       b_data == 0xF3      ||
       b_data == 0xFA     ||
       b_data == 0xFB )              // 19200 bps
{  baudrate = BR19200;
   P_SCI3.SMR.BYTE |=BR192_CKS;
   P_SCI3.BRR     = BR192_BRR;
}
else                                 // unknown Baud
{  baudrate = 0xFF;
   lcd_cursor_pos=8;
   Bprintf("X %x ", (BYTE)b_data,(DWORD)SPACE);
   P_SCI3.SCR3.BIT.RE = 0x1; //enable
   P_SCI3.SSR.BYTE = 0x00; //84 clear error
   return(0);
}

lcd_cursor_pos=8;
Bprintf("%x      ", (BYTE)baudrate,(DWORD)SPACE);

P_SCI3.SCR3.BIT.RE = 0x1;            //enable
P_SCI3.SSR.BYTE = 0x00;              //84 clear error

sci_putstr("BAUD ");
sci_charput('D');
sci_charput('E');
```

```
    sci_charput('T');
    sci_charput('E');
    sci_charput('C');
    sci_charput('T');
    sci_charput(' ');

    while(1)    // send back receive character based on new Baudrate
    {
       b_data= sci_charget();
       lcd_cursor_pos=8;
       Bprintf("GET  %c%c ", (BYTE)b_data,(DWORD)SPACE);
       sci_charput(b_data);

       if(b_data=='a' || b_data=='A')
          break;
    }
}

void sci_charput(char OutputChar)      //Serial Port
{
    while ((P_SCI3.SSR.BIT.TDRE) == 0);
    P_SCI3.TDR = OutputChar;
    P_SCI3.SSR.BIT.TDRE = 0;
}


unsigned char sci_charget(void)        //Serial Port
{
    while ((P_SCI3.SSR.BIT.RDRF) == 0);
    return(P_SCI3.RDR);
}

void sci_putstr(char *str)
{
     while(*str !='\0')
       sci_charput(*str++);
}

void init_sci(void)
{
    P_SCI3.SCR3.BYTE  = 0x30;
    P_SCI3.SMR.BYTE   = 0x00;
    P_SCI3.BRR        = BR96_BRR;
    P_SCI3.SPCR.BYTE  = 0xE0;
    P_SCI3.SSR.BYTE   = 0x84;
}
```

```
// autobaud.h
///////////////////////DEFINE////////////////////////////
// For auot baud rate
//#define OSC_16M
#define OSC_98304M

#define BR19200   0x19
#define BR9600    0x96
#define BR4800    0x48
#define BR2400    0x24
#define BR1200    0x12

#ifdef OSC_16M
#define BR192_CKS 0
#define BR192_BRR 12
#define BR96_CKS  0
#define BR96_BRR  25
#define BR48_CKS  0
#define BR48_BRR  51
#define BR24_CKS  0
#define BR24_BRR  103
#define BR12_CKS  0
#define BR12_BRR  207
#endif

#ifdef OSC_10M
#define BR192_CKS 0
#define BR192_BRR 12
#define BR96_CKS  0
#define BR96_BRR  0
#define BR48_CKS  0
#define BR48_BRR  0
#define BR24_CKS  0
#define BR24_BRR  64
#define BR12_CKS  0
#define BR12_BRR  129
#endif

#ifdef OSC_98304M
#define BR192_CKS 0
#define BR192_BRR 7
#define BR96_CKS  0
#define BR96_BRR  15
#define BR48_CKS  0
#define BR48_BRR  31
#define BR24_CKS  0
#define BR24_BRR  63
#define BR12_CKS  0
#define BR12_BRR  127
#endif
```

Revision Record

Rev.	Date	Description	
		Page	Summary
1.00	Sep.10.04	—	First edition issued

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