Application Note 2935
Design Considerations for CAN Bus and Asynchronous Serial

www.maxim-ic.com

INTRODUCTION

When designing a system that requires both CAN bus and asynchronous serial interfaces on a DS80C390 or DS80C400 processor, the designer may run into difficulty choosing a CPU crystal that allows use of standard bit rates on both interfaces. The CAN bus requires less than 0.5% error, while asynchronous serial requires 2.5% error or less. Common serial baud-rate crystals such as 11.0592MHz, 14.7456MHz, and 18.432MHz will not allow high bit-rate CAN transmission without violating CAN bus bit-error guidelines. To find the sweet spot for both interfaces, the designer must understand how each I/O block generates its bit clock.

CAN BUS TIMING

Bit rates for the CAN controller are generated from the crystal input to the microcontroller and are unaffected by the on-board crystal multiplier (doubling and quadrupling do not affect input clock to the CAN controller). The signal is first divided by the baud-rate prescaler (BPR), which determines the time quantum (t_{qu}). The CAN specification requires that each bit time be composed of between $8t_{qu}$ and $25t_{qu}$. After passing through the BPR, the clock signal is divided once again by the user-specified divisor, which is composed of t_{SEG1} and t_{SEG2} plus t_{SYNC_SEG} of $1t_{qu}$.

The bit rate is determined by the following equation:

$$CANbitrate = \frac{fosc}{BPR \times (t_{SYNC\_SEG} + t_{SEG1} + t_{SEG2})}$$

With the constraints:

$$8 \leq (t_{SYNC\_SEG} + t_{SEG1} + t_{SEG2}) \leq 25$$

$$1 \leq BPR \leq 256$$

Now, we calculate the reload and actual bit rate:

$$reload = \frac{fosc}{CANbitrate}$$

$$actualCANbitrate = \frac{fosc}{round(reload)}$$

All useful frequencies will have an error of less than 0.005.

REV: 080904

Example of unusable crystal for 1Mbps CAN bit rate:

reload = 18.432E6 / 1E6 = 18.432

actual bit rate = 18.432E6 / 18 = 1024000

error = (1024000 – 1000000) / 1000000 = 0.024

Example of acceptable crystal for 1Mbps CAN bit rate:

reload = 18E6 / 1E6 = 18

actual bit rate = 18E6 / 18 = 1000000

error = (1000000 – 1000000) / 1000000 = 0.0

$(t_{SEG1} + t_{SEG2} + t_{SYNC\_SEG}) = 18 / BPR$

Remembering t_{SYNC_SEG} is always 1, and choosing 1 for BPR gives:

$(t_{SEG1} + t_{SEG2}) = 17$

The designer picks appropriate TSEG values from this constraint.

ASYNC SERIAL USING TIMER 2

Bit rates for Serial Port 0 using Timer 2 are calculated while Timer 2 is in 16-bit auto-reload mode. Timer 2 runs off the crystal inputs and is not affected by any crystal multiplier settings. For more detailed information, refer to Section 12 of the *High-Speed Microcontroller User's Guide*.

The bit rate is determined by the following equations:

$$Serialbitrate = \frac{fosc}{32 \times reload}$$

$$reload = \frac{fosc}{32 \times Serialbitrate}$$

$$actual = \frac{fosc}{32 \times (round(reload))}$$

All useful frequencies will have an error of less than 0.025.

Example of unusable crystal for 115200 bit/s:

reload = 16E6 / (32 x 115200) = 4.340

actual = 16E6 / (32 x 4) = 125000

error = (125000 - 115200) / 115200 = 0.0851

Example of acceptable crystal for 115200 bit/s:

reload = 18E6 / (32 x 115200) = 4.883

actual = 18E6 / (32 x 5) = 112500

error = (112500 - 115200) / 115200 = 0.0234

ASYNC SERIAL USING TIMER 1

Bit rates for Serial Ports 0 and 1 using Timer 1 are calculated while Timer 1 is in 8-bit auto-reload mode. An added feature is the ability to generate baud rates based on divide-by-4 or -12 off the system clock. In divide-by-4 mode, the input clock is generated from the crystal multiplier, while in divide-by-12, the base frequency of the external crystal will be used. A serial baud-rate doubler may also be enabled by setting the appropriate SMOD (SMOD_0 or SMOD_1) bit. For more detailed information, refer to Section 12 of the *High-Speed Microcontroller User's Guide*.

Timer 1 in Divide-by-12 Mode

The bit rate is determined by the following equations:

$$Serialbitrate = \frac{2^{SMOD} \times fosc}{384 \times reload}$$

$$reload = \frac{2^{SMOD} \times fosc}{384 \times (Serialbitrate)}$$

$$actual = \frac{2^{SMOD} \times fosc}{384 \times round(reload)}$$

All useful frequencies will have an error of less than 0.025.

Example of unusable crystal for 115200 bit/s:

reload = 18E6 / (192 x 115200) = 0.814

actual = 18E6 / (192 x 1) = 93750

error = (93750 - 115200) / 115200 = 0.186

Example of acceptable crystal for 115200 bit/s:

reload = 22E6 / (192 x 115200) = 0.995

actual = 22E6 / (192 x 1) = 114583

error = (114583 - 115200) / 115200 = 0.0054

Timer 1 in Divide-by-4 Mode

$$Serialbitrate = \frac{2^{SMOD} \times f_{MULT}}{128 \times reload}$$

$$reload = \frac{2^{SMOD} \times f_{MULT}}{128 \times Serialbitrate}$$

$$actual = \frac{2^{SMOD} \times f_{MULT}}{128 \times round(reload)}$$

All useful frequencies will have an error of less than 0.025.

Example of unusable crystal:

reload = 20E6 / (64 x 115200) = 2.713

actual = 20E6 / (64 x 3) = 104167

error = (104167 - 115200) / 115200 = 0.096

Example of acceptable crystal:

reload = 22E6 / (64 x 115200) = 2.984

actual = 22E6 / (64 x 3) = 114583

error = (114583 - 115200) / 115200 = 0.0054

SUGGESTED CRYSTAL VALUES FOR 115200 SERIAL AND CAN BUS

The following table includes examples of crystal frequencies that allow 115,200bps asynchronous serial using Serial 0 and Timer 2 and 1Mb CAN bus.

Note: These values assume the designer is not using the system clock multiplier.

CRYSTAL	CAN ERROR (%)	SERIAL ERROR (%)
11000000	0.00	0.54
15000000	0.00	1.73
18000000	0.00	2.34
26000000	0.00	0.76
30000000	0.00	1.73
33000000	0.00	0.54
34000000	0.00	2.48
36000000	0.00	2.34
40000000	0.00	1.36
44000000	0.00	0.54
45000000	0.00	1.73
48000000	0.00	0.16
51000000	0.00	1.18
52000000	0.00	0.76
54000000	0.00	2.34
55000000	0.00	0.54
56000000	0.00	1.27
60000000	0.00	1.73
63000000	0.00	0.53
64000000	0.00	2.12
65000000	0.00	2.04
66000000	0.00	0.54
68000000	0.00	2.48
69000000	0.00	1.49
70000000	0.00	0.06
72000000	0.00	2.34
75000000	0.00	1.73

RELEVANT LINKS

Dallas Semiconductor Microcontroller User Guides: **www.maxim-ic.com/user_guides**

MAXIM/DALLAS SEMICONDUCTOR CONTACT INFORMATION

Company Addresses:
Maxim Integrated Products, Inc.
120 San Gabriel Drive
Sunnyvale, CA 94086
Phone: 408-737-7600
Fax: 408-737-7194

Dallas Semiconductor
4401 S. Beltwood Parkway
Dallas, TX 75244
Phone: 972-371-4448
Fax: 972-371-4799

Product Literature/Samples Requests:
800-998-8800
408-737-7600

Sales and Customer Service:

Website:
www.maxim-ic.com

Product Information:
http://www.maxim-ic.com/products.cfm

Ordering Information:
http://www.maxim-ic.com/sales/

FTP Site:
ftp://ftp.dalsemi.com