



Application Note

AN_102

CAN Plus Custom CAN Data Rates

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This Application Note provides guidelines for programming custom CAN data rates into the CAN Plus series of adapters.

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1 Introduction

The Connective Peripherals CAN Plus adapters utilize a Microchip PIC18Fx680 MCU with an integrated CAN controller. While most installations use one of the pre-defined data rates, there are applications that require a custom data rate. This application note describes the CAN data timing and how to select the PIC register values to be programmed with the ASCII "s" command or through the high-level API.

1.1 CAN Bit Timing

A single CAN bit time is divided into four segments: Sync, Propagation Delay, Phase 1 and Phase 2. Sync is similar to a start bit. Propagation delay allows for the physical CAN bus cabling. Phase 1 and Phase 2 allow for optimal placement of the bit sample time.

In order to allow for flexible sampling of a CAN bit, the four segments are defined by "Time Quanta" (Tq). A single CAN bit consists of anywhere from 8 Tq to 25 Tq. The bit is sampled between Phases 1 and 2. In addition, the sample time can be adjusted from 1 to 4 Tq to account for synchronization between the various CAN devices on the bus.

For optimal signalling, the bit sample point should be approximately 65% to 80% of the bit time.

Figure 1 shows the relation of the time quanta, phases and synchronization for a bit containing 12 Time Quanta.

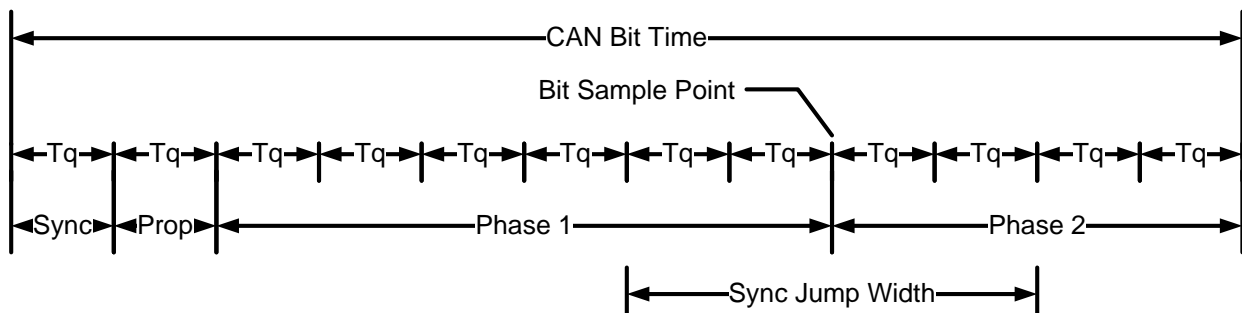


Figure 1 - CAN Bit Timing

2 CAN Plus Rate Calculations

The tables below show all of the available CAN bit rates available with the CAN Plus adapters.

In order to determine the duration of the various phases, follow these steps:

- 1) Select the desired baud rate from the tables below. There are likely several entries for a given CAN rate. Some values may not work in your application. Testing will be required. The defaults typically select a "middle value" for nTq.

The full range is of nTq (8 through 25) is divided into two tables. Check both tables for valid value.

Record both nTq and BRP values.

		n Tq - Allowable Range								
		8	9	10	11	12	13	14	15	16
BRP	0	N/A	N/A	N/A	N/A	1000000	923076.9	857142.9	800000	750000
	1	750000	666666.7	600000	545454.5	500000	461538.5	428571.4	400000	375000
	2	500000	444444.4	400000	363636.4	333333.3	307692.3	285714.3	266666.7	250000
	3	375000	333333.3	300000	272727.3	250000	230769.2	214285.7	200000	187500
	4	300000	266666.7	240000	218181.8	200000	184615.4	171428.6	160000	150000
	5	250000	222222.2	200000	181818.2	166666.7	153846.2	142857.1	133333.3	125000
	6	214285.7	190476.2	171428.6	155844.2	142857.1	131868.1	122449	114285.7	107142.9
	7	187500	166666.7	150000	136363.6	125000	115384.6	107142.9	100000	93750
	8	166666.7	148148.1	133333.3	121212.1	111111.1	102564.1	95238.1	88888.89	83333.33
	9	150000	133333.3	120000	109090.9	100000	92307.69	85714.29	80000	75000
	10	136363.6	121212.1	109090.9	99173.55	90909.09	83916.08	77922.08	72727.27	68181.82
	11	125000	111111.1	100000	90909.09	83333.33	76923.08	71428.57	66666.67	62500
	12	115384.6	102564.1	92307.69	83916.08	76923.08	71005.92	65934.07	61538.46	57692.31
	13	107142.9	95238.1	85714.29	77922.08	71428.57	65934.07	61224.49	57142.86	53571.43
	14	100000	88888.89	80000	72727.27	66666.67	61538.46	57142.86	53333.33	50000
	15	93750	83333.33	75000	68181.82	62500	57692.31	53571.43	50000	46875
	16	88235.29	78431.37	70588.24	64171.12	58823.53	54298.64	50420.17	47058.82	44117.65
	17	83333.33	74074.07	66666.67	60606.06	55555.56	51282.05	47619.05	44444.44	41666.67
	18	78947.37	70175.44	63157.89	57416.27	52631.58	48583	45112.78	42105.26	39473.68
	19	75000	66666.67	60000	54545.45	50000	46153.85	42857.14	40000	37500
	20	71428.57	63492.06	57142.86	51948.05	47619.05	43956.04	40816.33	38095.24	35714.29
	21	68181.82	60606.06	54545.45	49586.78	45454.55	41958.04	38961.04	36363.64	34090.91
	22	65217.39	57971.01	52173.91	47430.83	43478.26	40133.78	37267.08	34782.61	32608.7
	23	62500	55555.56	50000	45454.55	41666.67	38461.54	35714.29	33333.33	31250
	24	60000	53333.33	48000	43636.36	40000	36923.08	34285.71	32000	30000
	25	57692.31	51282.05	46153.85	41958.04	38461.54	35502.96	32967.03	30769.23	28846.15
	26	55555.56	49382.72	44444.44	40404.04	37037.04	34188.03	31746.03	29629.63	27777.78
	27	53571.43	47619.05	42857.14	38961.04	35714.29	32967.03	30612.24	28571.43	26785.71
	28	51724.14	45977.01	41379.31	37617.55	34482.76	31830.24	29556.65	27586.21	25862.07
	29	50000	44444.44	40000	36363.64	33333.33	30769.23	28571.43	26666.67	25000
	30	48387.1	43010.75	38709.68	35190.62	32258.06	29776.67	27649.77	25806.45	24193.55
	31	46875	41666.67	37500	34090.91	31250	28846.15	26785.71	25000	23437.5
	32	45454.55	40404.04	36363.64	33057.85	30303.03	27972.03	25974.03	24242.42	22727.27
	33	44117.65	39215.69	35294.12	32085.56	29411.76	27149.32	25210.08	23529.41	22058.82
	34	42857.14	38095.24	34285.71	31168.83	28571.43	26373.63	24489.8	22857.14	21428.57
	35	41666.67	37037.04	33333.33	30303.03	27777.78	25641.03	23809.52	22222.22	20833.33
	36	40540.54	36036.04	32432.43	29484.03	27027.03	24948.02	23166.02	21621.62	20270.27
	37	39473.68	35087.72	31578.95	28708.13	26315.79	24291.5	22556.39	21052.63	19736.84
38	38461.54	34188.03	30769.23	27972.03	25641.03	23668.64	21978.02	20512.82	19230.77	

	39	37500	33333.33	30000	27272.73	25000	23076.92	21428.57	20000	18750
BRP	n Tq - Allowable Range									
		8	9	10	11	12	13	14	15	16
	40	36585.37	32520.33	29268.29	26607.54	24390.24	22514.07	20905.92	19512.2	18292.68
	41	35714.29	31746.03	28571.43	25974.03	23809.52	21978.02	20408.16	19047.62	17857.14
	42	34883.72	31007.75	27906.98	25369.98	23255.81	21466.91	19933.55	18604.65	17441.86
	43	34090.91	30303.03	27272.73	24793.39	22727.27	20979.02	19480.52	18181.82	17045.45
	44	33333.33	29629.63	26666.67	24242.42	22222.22	20512.82	19047.62	17777.78	16666.67
	45	32608.7	28985.51	26086.96	23715.42	21739.13	20066.89	18633.54	17391.3	16304.35
	46	31914.89	28368.79	25531.91	23210.83	21276.6	19639.93	18237.08	17021.28	15957.45
	47	31250	27777.78	25000	22727.27	20833.33	19230.77	17857.14	16666.67	15625
	48	30612.24	27210.88	24489.8	22263.45	20408.16	18838.3	17492.71	16326.53	15306.12
	49	30000	26666.67	24000	21818.18	20000	18461.54	17142.86	16000	15000
	50	29411.76	26143.79	23529.41	21390.37	19607.84	18099.55	16806.72	15686.27	14705.88
	51	28846.15	25641.03	23076.92	20979.02	19230.77	17751.48	16483.52	15384.62	14423.08
	52	28301.89	25157.23	22641.51	20583.19	18867.92	17416.55	16172.51	15094.34	14150.94
	53	27777.78	24691.36	22222.22	20202.02	18518.52	17094.02	15873.02	14814.81	13888.89
	54	27272.73	24242.42	21818.18	19834.71	18181.82	16783.22	15584.42	14545.45	13636.36
	55	26785.71	23809.52	21428.57	19480.52	17857.14	16483.52	15306.12	14285.71	13392.86
	56	26315.79	23391.81	21052.63	19138.76	17543.86	16194.33	15037.59	14035.09	13157.89
	57	25862.07	22988.51	20689.66	18808.78	17241.38	15915.12	14778.33	13793.1	12931.03
58	25423.73	22598.87	20338.98	18489.98	16949.15	15645.37	14527.85	13559.32	12711.86	
59	25000	22222.22	20000	18181.82	16666.67	15384.62	14285.71	13333.33	12500	
60	24590.16	21857.92	19672.13	17883.76	16393.44	15132.41	14051.52	13114.75	12295.08	
61	24193.55	21505.38	19354.84	17595.31	16129.03	14888.34	13824.88	12903.23	12096.77	
62	23809.52	21164.02	19047.62	17316.02	15873.02	14652.01	13605.44	12698.41	11904.76	
63	23437.5	20833.33	18750	17045.45	15625	14423.08	13392.86	12500	11718.75	

Table 1 – Available CAN Rates (Part 1)

		nTq - Allowable Range								
		17	18	19	20	21	22	23	24	25
BRP	0	705882.4	666666.7	631578.9	600000	571428.6	545454.5	521739.1	500000	480000
	1	352941.2	333333.3	315789.5	300000	285714.3	272727.3	260869.6	250000	240000
	2	235294.1	222222.2	210526.3	200000	190476.2	181818.2	173913	166666.7	160000
	3	176470.6	166666.7	157894.7	150000	142857.1	136363.6	130434.8	125000	120000
	4	141176.5	133333.3	126315.8	120000	114285.7	109090.9	104347.8	100000	96000
	5	117647.1	111111.1	105263.2	100000	95238.1	90909.09	86956.52	83333.33	80000
	6	100840.3	95238.1	90225.56	85714.29	81632.65	77922.08	74534.16	71428.57	68571.43
	7	88235.29	83333.33	78947.37	75000	71428.57	68181.82	65217.39	62500	60000
	8	78431.37	74074.07	70175.44	66666.67	63492.06	60606.06	57971.01	55555.56	53333.33
	9	70588.24	66666.67	63157.89	60000	57142.86	54545.45	52173.91	50000	48000
	10	64171.12	60606.06	57416.27	54545.45	51948.05	49586.78	47430.83	45454.55	43636.36
	11	58823.53	55555.56	52631.58	50000	47619.05	45454.55	43478.26	41666.67	40000
	12	54298.64	51282.05	48583	46153.85	43956.04	41958.04	40133.78	38461.54	36923.08
	13	50420.17	47619.05	45112.78	42857.14	40816.33	38961.04	37267.08	35714.29	34285.71
	14	47058.82	44444.44	42105.26	40000	38095.24	36363.64	34782.61	33333.33	32000
	15	44117.65	41666.67	39473.68	37500	35714.29	34090.91	32608.7	31250	30000
	16	41522.49	39215.69	37151.7	35294.12	33613.45	32085.56	30690.54	29411.76	28235.29
	17	39215.69	37037.04	35087.72	33333.33	31746.03	30303.03	28985.51	27777.78	26666.67
	18	37151.7	35087.72	33241	31578.95	30075.19	28708.13	27459.95	26315.79	25263.16
	19	35294.12	33333.33	31578.95	30000	28571.43	27272.73	26086.96	25000	24000
	20	33613.45	31746.03	30075.19	28571.43	27210.88	25974.03	24844.72	23809.52	22857.14
	21	32085.56	30303.03	28708.13	27272.73	25974.03	24793.39	23715.42	22727.27	21818.18
	22	30690.54	28985.51	27459.95	26086.96	24844.72	23715.42	22684.31	21739.13	20869.57
	23	29411.76	27777.78	26315.79	25000	23809.52	22727.27	21739.13	20833.33	20000
	24	28235.29	26666.67	25263.16	24000	22857.14	21818.18	20869.57	20000	19200
	25	27149.32	25641.03	24291.5	23076.92	21978.02	20979.02	20066.89	19230.77	18461.54
	26	26143.79	24691.36	23391.81	22222.22	21164.02	20202.02	19323.67	18518.52	17777.78
	27	25210.08	23809.52	22556.39	21428.57	20408.16	19480.52	18633.54	17857.14	17142.86
	28	24340.77	22988.51	21778.58	20689.66	19704.43	18808.78	17991	17241.38	16551.72
	29	23529.41	22222.22	21052.63	20000	19047.62	18181.82	17391.3	16666.67	16000
	30	22770.4	21505.38	20373.51	19354.84	18433.18	17595.31	16830.29	16129.03	15483.87
	31	22058.82	20833.33	19736.84	18750	17857.14	17045.45	16304.35	15625	15000
	32	21390.37	20202.02	19138.76	18181.82	17316.02	16528.93	15810.28	15151.52	14545.45
	33	20761.25	19607.84	18575.85	17647.06	16806.72	16042.78	15345.27	14705.88	14117.65
	34	20168.07	19047.62	18045.11	17142.86	16326.53	15584.42	14906.83	14285.71	13714.29
	35	19607.84	18518.52	17543.86	16666.67	15873.02	15151.52	14492.75	13888.89	13333.33
	36	19077.9	18018.02	17069.7	16216.22	15444.02	14742.01	14101.06	13513.51	12972.97
	37	18575.85	17543.86	16620.5	15789.47	15037.59	14354.07	13729.98	13157.89	12631.58
	38	18099.55	17094.02	16194.33	15384.62	14652.01	13986.01	13377.93	12820.51	12307.69
	39	17647.06	16666.67	15789.47	15000	14285.71	13636.36	13043.48	12500	12000
	40	17216.64	16260.16	15404.36	14634.15	13937.28	13303.77	12725.34	12195.12	11707.32
	41	16806.72	15873.02	15037.59	14285.71	13605.44	12987.01	12422.36	11904.76	11428.57
	42	16415.87	15503.88	14687.88	13953.49	13289.04	12684.99	12133.47	11627.91	11162.79
	43	16042.78	15151.52	14354.07	13636.36	12987.01	12396.69	11857.71	11363.64	10909.09
	44	15686.27	14814.81	14035.09	13333.33	12698.41	12121.21	11594.2	11111.11	10666.67
	45	15345.27	14492.75	13729.98	13043.48	12422.36	11857.71	11342.16	10869.57	10434.78

		nTq - Allowable Range								
		17	18	19	20	21	22	23	24	25
BRP	46	15018.77	14184.4	13437.85	12765.96	12158.05	11605.42	11100.83	10638.3	10212.77
	47	14705.88	13888.89	13157.89	12500	11904.76	11363.64	10869.57	10416.67	10000
	48	14405.76	13605.44	12889.37	12244.9	11661.81	11131.73	10647.74	10204.08	9795.918
	49	14117.65	13333.33	12631.58	12000	11428.57	10909.09	10434.78	10000	9600
	50	13840.83	13071.9	12383.9	11764.71	11204.48	10695.19	10230.18	9803.922	9411.765
	51	13574.66	12820.51	12145.75	11538.46	10989.01	10489.51	10033.44	9615.385	9230.769
	52	13318.53	12578.62	11916.58	11320.75	10781.67	10291.6	9844.135	9433.962	9056.604
	53	13071.9	12345.68	11695.91	11111.11	10582.01	10101.01	9661.836	9259.259	8888.889
	54	12834.22	12121.21	11483.25	10909.09	10389.61	9917.355	9486.166	9090.909	8727.273
	55	12605.04	11904.76	11278.2	10714.29	10204.08	9740.26	9316.77	8928.571	8571.429
	56	12383.9	11695.91	11080.33	10526.32	10025.06	9569.378	9153.318	8771.93	8421.053
	57	12170.39	11494.25	10889.29	10344.83	9852.217	9404.389	8995.502	8620.69	8275.862
	58	11964.11	11299.44	10704.73	10169.49	9685.23	9244.992	8843.036	8474.576	8135.593
	59	11764.71	11111.11	10526.32	10000	9523.81	9090.909	8695.652	8333.333	8000
	60	11571.84	10928.96	10353.75	9836.066	9367.681	8941.878	8553.1	8196.721	7868.852
	61	11385.2	10752.69	10186.76	9677.419	9216.59	8797.654	8415.147	8064.516	7741.935
	62	11204.48	10582.01	10025.06	9523.81	9070.295	8658.009	8281.573	7936.508	7619.048
	63	11029.41	10416.67	9868.421	9375	8928.571	8522.727	8152.174	7812.5	7500

Table 2 - Available CAN Rates (Part 2)

- 2) Select values for the Sync (syncTq) Propagation (prTq), Phase 1 (ph1Tq) and Phase 2 (ph2Tq) segments such that *all* of the following are true:
 - a. syncTq = 1 (This is a constant value of the PIC)
 - b. prTq, ph1Tq and ph2Tq are values between 1 and 8.
 - c. prTq <= ph1Tq
 - d. 20% of nTq <= ph2Tq <= 35% of nTq
The sample point is between 65% and 80% of the total bit time, nTq
 - e. syncTq + prTq + ph1Tq + ph2Tq = nTq
- 3) Select values for Synchronization Jump Width (SJW) and Number of Samples (SAM):
 - a. SJW(1:0) = 01
One bit of jump adjustment is typical for most applications. Noisy environments may require settings up to 4.
 - b. SAM = 0
A single sample is typical for most applications. Noisy environments may set this to 1 to indicate a triple sample.
- 4) Other bits with fixed values:
 - a. WAKDIS = 0
Always wake on CANbus activity
 - b. WAKFIL = 0
Do not filter the WakeUp
 - c. SEG2PHTS = 0
Always use at least 2Tq for Phase 1, even if SEG1PH < 2
(The total still needs to equal nTq)
- 5) Assign the bit values for the timing chosen in steps 1 and 2:
 - a. BRP(5:0) = the value from the table, in Binary
 - b. PRSEG(2:0) = prTq - 1, in Binary
 - c. SEG1PH(2:0) = ph1Tq - 1, in Binary
 - d. SEG2PH(2:0) = ph2Tq - 1, in Binary

3 Microchip PIC Registers

The PIC18Fx680 MCU has three registers to set the CAN bit timing: BRGCON1, BRGCON2 and BRGCON3. While the CAN Plus ASCII and API commands offer pre-defined settings for common rates, the BRGCONx registers can also be set with values directly related to the bits defined in these registers. A brief summary of the register definitions follows. For a complete discussion of these registers, refer to the PIC18Fx680 datasheet (39625c.pdf) and AN574 "Understanding Microchip's CAN Module Bit Timing" (00754.pdf), available from the [Microchip Web Site](#).

The Connective Peripheral CAN Plus adapters utilize a 24MHz clock for the PIC18Fx680. This frequency is required for the CAN bit rate calculations.

3.1 BRGCON1

BIT7	BIT6	BIT5	BIT4	BIT3	BIT2	BIT1	BIT0
SJW.1	SJW.2	BRP.5	BRP.4	BRP.3	BRP.2	BRP.1	BRP.0

Table 3 - BRGCON1

SJW = Synchronization Jump Width Length, measured in Tq

- 00 through 11 = (SJW+1) * Tq

BRP = Baud Rate Prescaler, Tq duration as a multiple of 1/Tosc

- 000000 through 111111 = function to calculate Tq = (2 * (BRP + 1)) / 24MHz
- Select from tables in Section 2

3.2 BRGCON2

BIT7	BIT6	BIT5	BIT4	BIT3	BIT2	BIT1	BIT0
SEG2PHTS	SAM	SEG1PH.2	SEG1PH.1	SEG1PH.0	PRSEG.2	PRSEG.1	PRSEG.0

Table 4 - BRGCON2

SEG2PHTS = Phase Segment 2 Time Select

- 0 = SEG1PH is Greater of SEG1PH or Information Processing Time (2Tq for the PIC18Fx680).
- 1 = Freely Programmable

SAM = Sampling of the CAN bus

- 0 = Sample once at the sample point
- 1 = Sample signal three times prior to the sample point

SEG1PH = Phase Segment 1 time

- 000 through 111 = (SEG1PH + 1) * Tq

PRSEG = Propagation Time Select Bits

- 000 through 111 = (PRSEG + 1) * Tq

3.3 BRGCON3

BIT7	BIT6	BIT5	BIT4	BIT3	BIT2	BIT1	BIT0
WAKDIS	WAKFIL	UNUSED	UNUSED	UNUSED	SEG2PH.2	SEG2PH.1	SEG2PH.0

Table 5 - BRGCON3

WAKDIS = Wake-up Disable Bit

- 0 = Enable wake-up on CAN activity (Do not use for CAN Plus firmware)
- 1 = Disable wake-up on CAN activity (REQUIRED for CAN Plus firmware)

WAKFIL = Selects CAN Line Filter for Wake-up Bit

- 0 = Use CAN line filter for wake-up (Don't Care with Wake-up Disabled)
- 1 = Do Not use CAN line filter for wake-up (Don't Care with Wake-up Disabled)

UNUSED

- 0 = Set to zero

SEG2PH = Phase Segment 2 time

- 000 through 111 = $(SEG2PH + 1) * Tq$

4 Example

This example will show values for 500Kbps CAN bit rate. Following the steps in section 2:

- 1) $nTq = 12$, $BRP = 1$
- 2) Selecting the various segment timing
 - a. $syncTq = 1$ (This is a constant value of the PIC)
 - b. $prTq = 1$
 - c. $ph1Tq = 6$
 - d. $ph2Tq = 4$
 - e. $syncTq + prTq + ph1Tq + ph2Tq = nTq$
 $1 + 1 + 6 + 4 = 12$
- 3) $SJW = 01$, $SAM = 0$
- 4) $WAKDIS = 0$, $WAKFIL = 0$, $SEG2PHTS = 0$
- 5) Assign the bit values for the timing chosen in steps 1 and 2:
 - a. $BRP(5:0) = 000001$
 - b. $PRSEG(2:0) = 000$
 - c. $SEG1PH(2:0) = 101$
 - d. $SEG2PH(2:0) = 011$

Putting this all together into the actual BRGCON registers, we get:

BRGCON1 = 0x41

BIT7	BIT6	BIT5	BIT4	BIT3	BIT2	BIT1	BIT0
SJW.1	SJW.2	BRP.5	BRP.4	BRP.3	BRP.2	BRP.1	BRP.0
0	1	0	0	0	0	0	1

BRGCON2 = 0x28

BIT7	BIT6	BIT5	BIT4	BIT3	BIT2	BIT1	BIT0
SEG2PHTS	SAM	SEG1PH.2	SEG1PH.1	SEG1PH.0	PRSEG.2	PRSEG.1	PRSEG.0
0	0	1	0	1	0	0	0

BRGCON3 = 0x03

BIT7	BIT6	BIT5	BIT4	BIT3	BIT2	BIT1	BIT0
WAKDIS	WAKFIL	UNUSED	UNUSED	UNUSED	SEG2PH.2	SEG2PH.1	SEG2PH.0
0	0	0	0	0	0	1	1

Table 6 - Example BRGCON Registers

This determines the values to pass to the "s" ASCII command or the API.

For a CAN rate of 500Kbps the full "s" command would be:

s412803

NOTE: Some experimentation may be necessary depending on the characteristics of the CAN bus, such as cable length, electrical noise, tolerance of the other CAN devices on the network, etc.

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Appendix A – References

Document References

PIC18Fx680 datasheet (39625c.pdf)

AN574 "Understanding Microchip's CAN Module Bit Timing" (00754.pdf)

Acronyms and Abbreviations

Terms	Description
API	Application Programming Interface
ASCII	American Standard Code for Information Interchange,
BRP	Bit Rate Prescaler - A clock divisor within the Microchip PIC ECAN module to determine Time Quanta
CAN	Controller Area Network
DLL	Dynamic Link Library
ECAN	Enhanced CAN module – contained in the Microchip PIC
MCU	Micro Controller Unit
Time Quanta	Minimum portion of a CAN bus bit time

Appendix B – List of Figures & Tables

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Appendix C - Revision History

Revision	Changes	Date
1.0	Initial release	2009-07-22
1.1	Re-branding to reflect the migration of the product from EasySync to Connective Peripherals name – logo change, copyright changed, contact information Changed, all internal hyperlinks changed.	2019-03-21