



Solutions for a Real Time World

# NEMO Bluetooth Radio Module

Datasheet



**Unigen™**

**Unigen Corp. Wireless Module Products**

**NEMO Bluetooth Radio Modules**  
**UGWC821RSMA133**

Issue Date: 2-MAR-11

Revision: 2.3

## Revision History

Rev. No.	History	Issue Date	Remarks
1.0	Draft	Dec. 5 <sup>th</sup> 2008	Advanced information; Author: Allen B. Cabreros
1.1	Revision	Aug. 18 <sup>th</sup> 2009	Added dimensional drawings.
2.1	Revision	Oct. 30 <sup>th</sup> 2010	Part Number change. Pinout change, dimensions change, Application circuit change.
2.2	Revision	Feb. 14 <sup>th</sup> 2011	Added Radio characteristics
2.3	Revision	Mar. 3 <sup>rd</sup> 2011	Corrected pinout errors and descriptions; Correct Applications Schematic; Added SDIO_DATA information

THIS DOCUMENT IS PROVIDED "AS IS" WITH NO WARRANTIES WHATSOEVER, INCLUDING ANY WARRANTY OF MERCHANTABILITY, NON-INFRINGEMENT, FITNESS FOR ANY PARTICULAR PURPOSE, OR ANY WARRANTY OTHERWISE ARISING OUT OF ANY PROPOSAL, SPECIFICATION OR SAMPLE.

Unigen Corporation disclaims all liability, including liability for infringement of any proprietary rights, relating to use of information in this document. No license, expressed or implied, by estoppel or otherwise, to any intellectual property rights is granted herein.

\*Third-party brands, names, and trademarks are the property of their respective owners.

## TABLE OF CONTENTS

LIST OF FIGURES	4
LIST OF TABLES	5
PRODUCT INTRODUCTION	6
FEATURES AND BENEFITS	6
PRODUCT DESCRIPTION	8
NEMO Module	8
CSR BlueCore 6 ROM Transceiver IC	8
Functional Block Diagrams	9
PIN ASSIGNMENT	11
PIN FUNCTIONS	12
ABSOLUTE MAXIMUM RATINGS	13
RECOMMENDED OPERATING CONDITIONS	13
RF CHARACTERISTICS: BASIC RATE	14
Basic Rate Transmitter Performance	14
Basic Rate Receiver Performance	15
RF CHARACTERISTICS: ENHANCED DATA RATE (EDR)	15
EDR Receiver Performance	17
EXTERNAL SLOW CLOCK SOURCE CHARACTERISTICS	17
AGENCY CERTIFICATIONS (PRE-SCAN)	18
REGULATORY COMPLIANCE STATEMENT	18
FUNCTIONAL OVERVIEW	19
NEMO Hardware Functional Description	19
NEMO Firmware Functional Description	20
CSR BLUETOOTH SOFTWARE STACK	21
Key Features of the HCI Stack: Standard Bluetooth Functionality	22
Key Features of the HCI Stack: Extra Functionality	24
HOST INTERFACES	25
HIGH SPEED UART INTERFACE	25
BlueCore Serial Protocol (BCSP)	26
BlueCore Command (BCCMD) Protocol	27
SDIO INTERFACE	29
SDIO Deep Sleep Control Schemes	29
SDIO Retransmission	30
SDIO Signaling	30
AUDIO PCM AND I2S INTERFACES	30
PCM Interface Master/Slave	31
PCM Long Frame Sync	32
Short Frame Sync	33
Multi-slot Operation	34
GCI Interface	35
PCM Slots and Sample Formats	36

PCM Timing Information	37
PCM CLK and PCM SYNC Generation	39
PCM Configuration	40
Digital Audio Interface (I <sup>2</sup> S)	43
Figure 20: Digital Audio Interface Master Timing	46
POWER CONSUMPTION	47
BOOTING NEMO ROM	49
UART Boot Up	49
UART Auto Baud Rate	50
Persistent Store Keys (PSKEYS)	51
TYPICAL APPLICATION CIRCUITS	54
MECHANICAL DRAWINGS	55
REFERENCE DOCUMENTATION	58
CONTACT INFORMATION	58

## LIST OF FIGURES

Figure 1: NEMO Module Block Diagram	9
Figure 2: CSR BlueCore 6 ROM Block Diagram	10
Figure 3: NEMO Module Pin Locations	11
Figure 4: BlueCore Bluetooth HCI Stack	21
Figure 5: UART Host Connection	26
Figure 6: BCSP Context	27
Figure 7: BCCMD Interface	28
Figure 8: PCM Interface Master	31
Figure 9: PCM Interface Slave	31
Figure 10: Long Frame Sync (Shown with 8-bit Companded Sample)	32
Figure 11: Short Frame Sync (Shown with 16-bit Sample)	33
Figure 12: Multi-slot Operation: Two Slots * 8-bit Companded Samples	34
Figure 13: GCI Interface	35
Figure 14: 16-Bit Slot Length and Sample Formats	36
Figure 15: PCM Master Timing Long Frame Sync	38
Figure 16: PCM Master Timing Short Frame Sync	38
Figure 17: PCM slave Timing Short Frame Sync	39
Figure 18: I <sup>2</sup> S Mode Digital Audio Interface	44
Figure 19: Digital Audio Interface Slave Timing	45
Figure 20: Digital Audio Interface Master Timing	46
Figure 21: NEMO Example Application Circuit; No External Slow CLK	54
Figure 23: NEMO Mechanical Drawing 1	55

## LIST OF TABLES

TABLE 1: NEMO PIN FUNCTIONS	12
TABLE 2: ABSOLUTE MAXIMUM RATINGS	13
TABLE 3: RECOMMENDED OPERATING CONDITIONS	13
TABLE 4: TRANSMITTER PERFORMANCE – BASIC RATE	14
TABLE 5: BASIC RATE RECEIVER PERFORMANCE	15
TABLE 6: EDR TRANSMITTER PERFORMANCE	15
TABLE 7: EDR RECEIVER PERFORMANCE	17
TABLE 8: EXTERNAL SLOW CLOCK CHARACTERISTICS	17
TABLE 9: HOST INTERFACE SELECTION	25
TABLE 10: PCM TIMING TABLE	37
TABLE 11: PSKEY_PCM_LOW_JITTER_CONFIG DESCRIPTION	41
TABLE 12: PSKEY_PCM_CONFIG32 DESCRIPTION	41
TABLE 13: ALTERNATIVE FUNCTIONS OF THE DIGITAL AUDIO BUS INTERFACE ON THE PCM INTERFACE	43
TABLE 14: PSKEY_DIGITAL_AUDIO_CONFIG	43
TABLE 15: DIGITAL AUDIO INTERFACE SLAVE TIMING	45
TABLE 16: DIGITAL AUDIO INTERFACE MASTER TIMING	46
TABLE 17: OPERATING POWER CONSUMPTION FIGURES	47
TABLE 18: PEAK CURRENT	48
TABLE 19: BOOT PSKEY LIST FOR BCSP EXAMPLE	51
TABLE 20: REFERENCE DOCUMENTATION	58

## PRODUCT INTRODUCTION

The Nemo Bluetooth radio module enables Bluetooth functionality to any hosted system. Nemo supports Bluetooth version 2.1 with Enhanced Data Rate mode for up to 3Mbps throughput. Nemo's small module footprint and low power consumption makes it attractive for small, handheld, battery powered devices for short range wireless communications. Bluetooth is a cable replacement radio technology. The advanced Bluetooth protocol stack adds seamless, secure, adhoc, point to multi-point communications between other Bluetooth enabled devices regardless of manufacturer. Bluetooth enables personal area networks and short range communications between devices such as portable handhelds, personal computers, embedded devices and industrial communication devices.

## FEATURES AND BENEFITS

- Bluetooth v2.1+EDR compliant
- CSR BlueCore 6 ROM
- 2.40-2.480 GHz FHSS Radio
- Max Data Rate 3Mbps
- $\pm 10\text{PPM}$  Crystal Oscillator Included
- 4Mbit High Speed UART Interface
- Single 3.3V Power Supply
- Bluetooth Co-existence Support with 802.11
- Deep Sleep Mode of  $40\mu\text{A}$  With Fast Wake-up

## Applications

- Short Range Radio Systems
- Point-to-Point Systems
- Point-to-Multi-Point Systems
- Cable Replacement
- Portable Devices
- Mobile Phones
- Headsets
- Hand Free Kits
- Personal Computers
- Laptops
- Personal Hand Handhelds
- Remote Controls
- Mouse
- Keyboards
- Human Interface Devices (HID)
- Embedded Devices
- Asset Tracking
- Barcode Scanners
- Data Acquisition Devices

DRAFT

## PRODUCT DESCRIPTION

### NEMO Module

The Nemo module is a complete 2.4GHz radio transceiver operating in the license free ISM (Industrial, Scientific and Medical) band. The Nemo module has CSR's BlueCore 6 ROM Bluetooth solution. The CSR BlueCore 6 ROM is a single-chip radio and baseband IC for Bluetooth 2.4GHz systems including enhanced data rate (EDR) to 3Mbps. With the on-chip CSR Bluetooth software stack, it provides a fully compliant Bluetooth v2.1 + EDR specification system for data and voice communications. The module dimensions measure 6.5mm x 6.5mm x 1.5mm. A single 3.3V power supply input, single ended RF output/input, and a low 26 pin count makes the NEMO module easy to interface with.

### CSR BlueCore 6 ROM Transceiver IC

BlueCore™6-ROM is a single-chip radio and baseband IC for Bluetooth 2.4 GHz systems including enhanced data rates (EDR) to 3Mbits/s. With the on-chip CSR Bluetooth software stack, it provides a fully compliant Bluetooth system to v2.1 of the specification for data and voice communications.

BlueCore6-ROM has been designed to reduce the number of external components required which ensures production costs are minimized. BlueCore6-ROM includes the AuriStream baseband CODEC, which offers significant power reduction over the CVSD based system when used at both ends of the link. The device incorporates auto-calibration and built-in self-test (BIST) routines to simplify development, type approval and production test. All hardware and device firmware is fully compliant with the Bluetooth v2.1 +EDR specification (all mandatory and optional features). To improve the performance of both Bluetooth and 802.11b/g co-located systems a wide range of coexistence features are available including a variety of hardware signaling: basic activity signaling and Intel WCS activity and channel signaling.

## Functional Block Diagrams

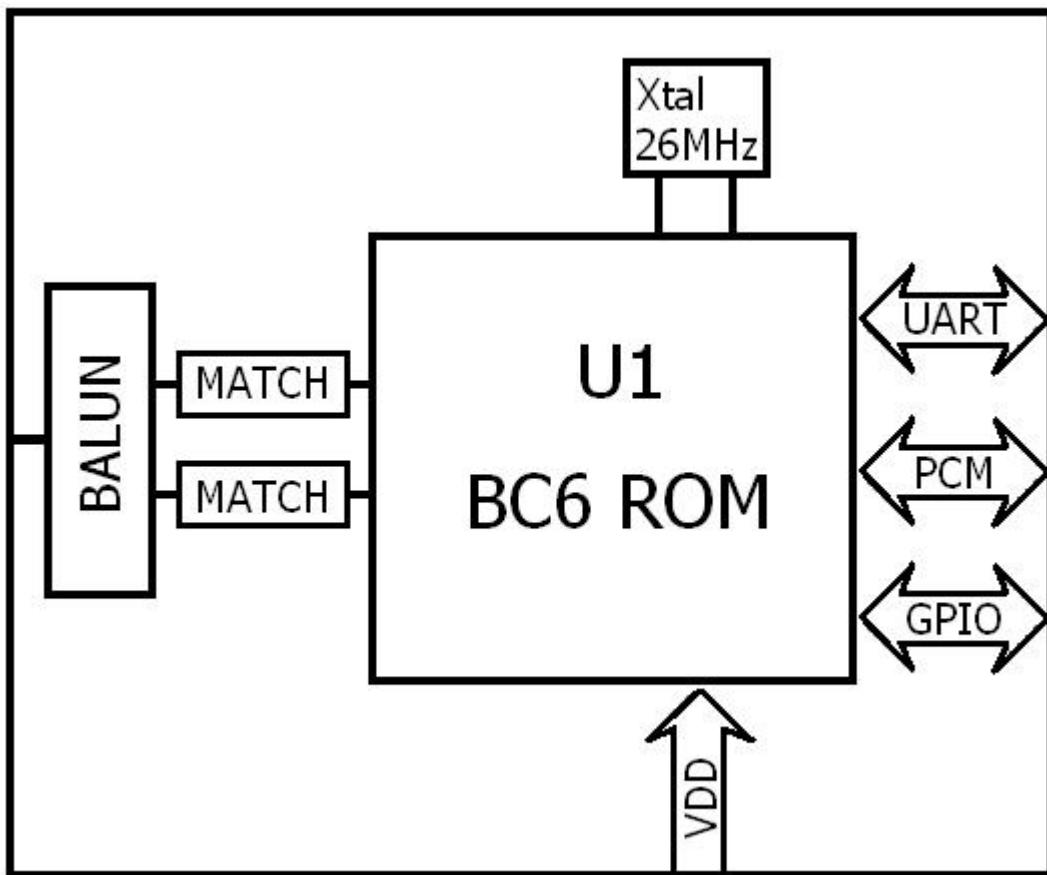


Figure 1: NEMO Module Block Diagram

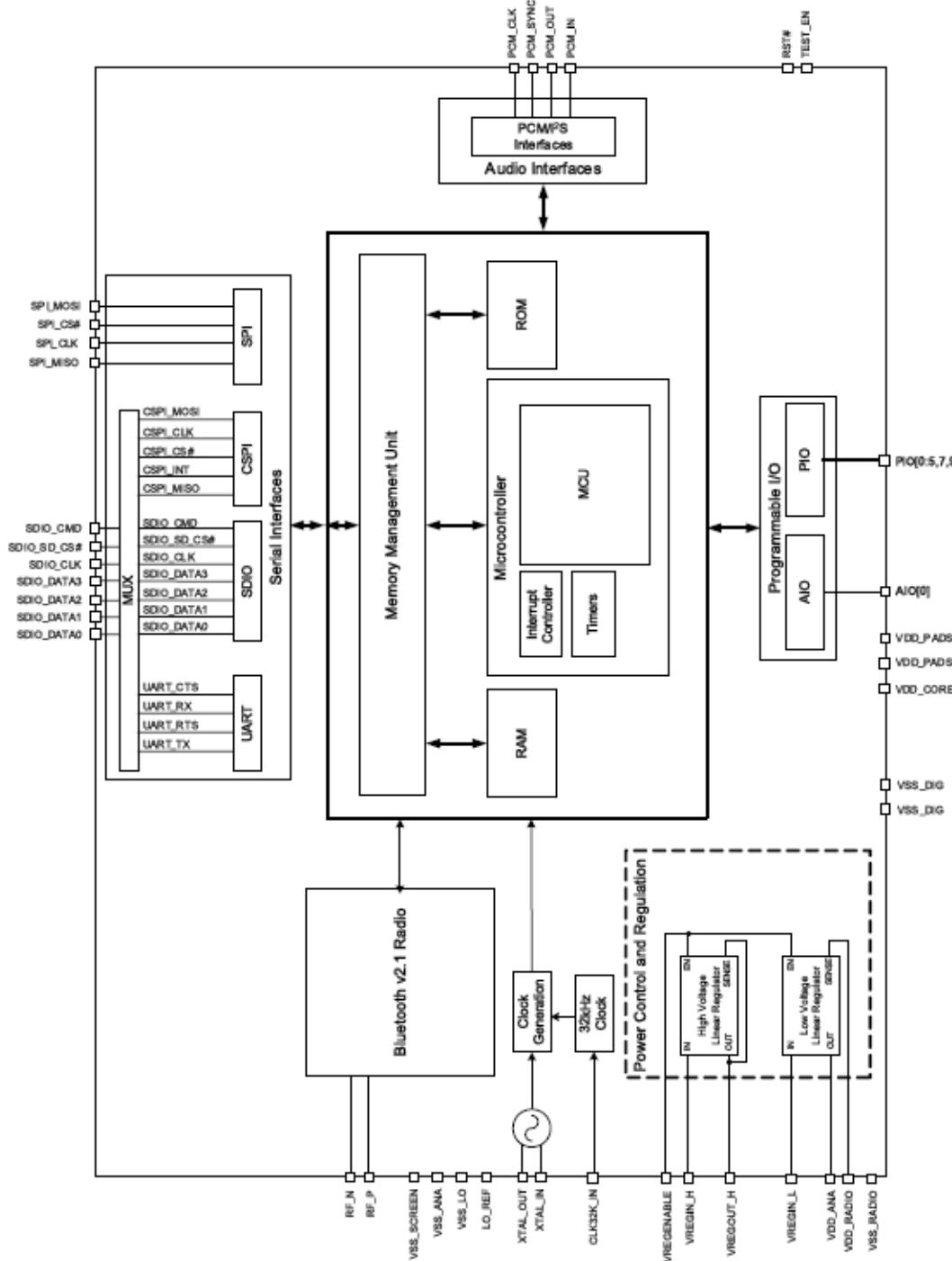
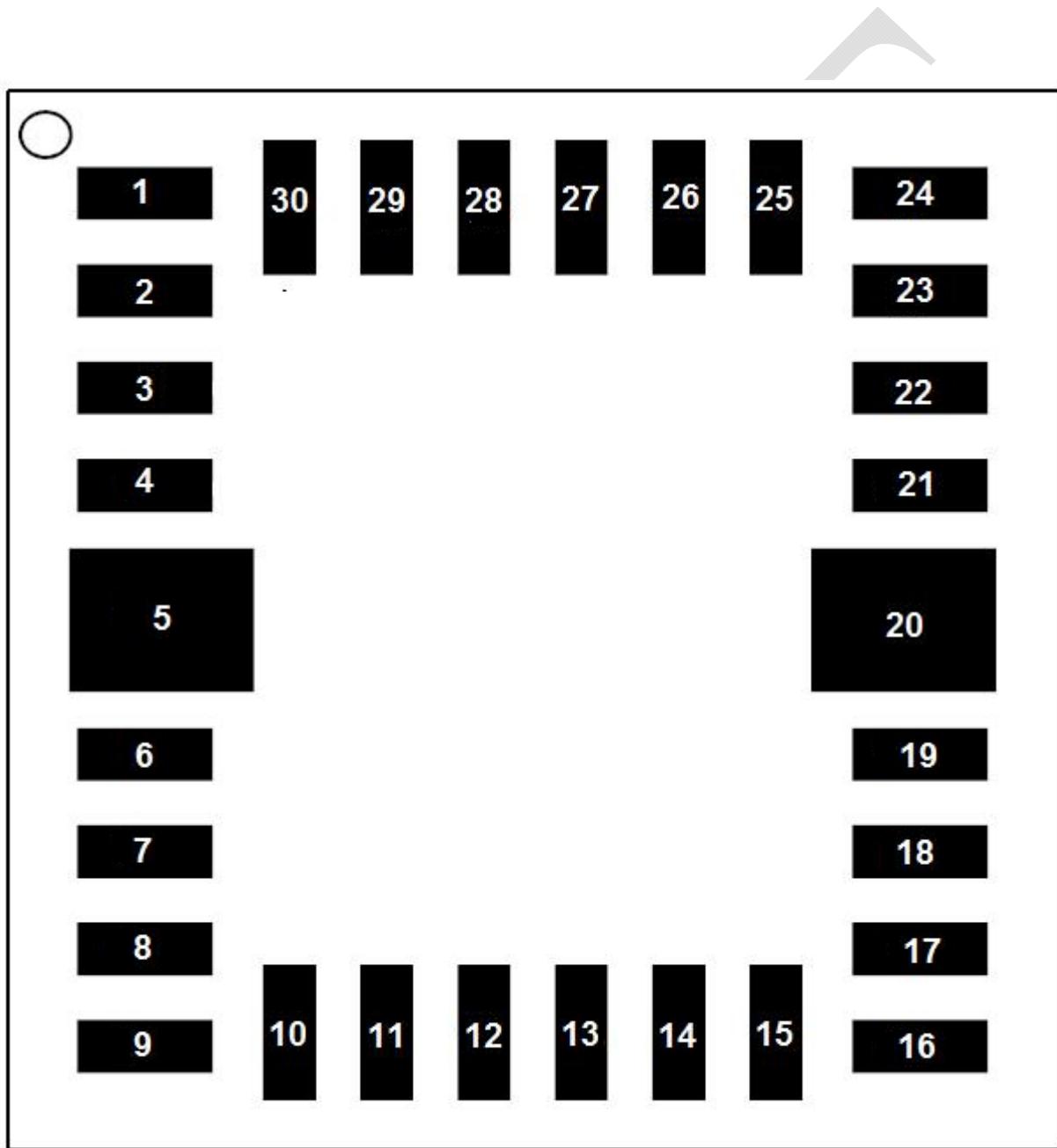


Figure 2: CSR BlueCore 6 ROM Block Diagram

**PIN ASSIGNMENT****Figure 3: NEMO Module Pin Locations**

## PIN FUNCTIONS

Table 1: NEMO Pin Functions

Pin	Signal Name	Type	Description
1	CLK32K_IN	Input	32.768kHz low power clock input
2	SDIO_SD_CSB	Input	SDIO Interface/Enable
3	SDIO_SD_CMD	--	SDIO Interface
4	SDIO_SD_CLK	--	SDIO Interface
5	GND	--	Ground Reference
6	PIO(0)	I/O	I/O or WiFi- Coex signal
7	PIO(1)	I/O	I/O or WiFi- Coex signal
8	PIO(4)	I/O	I/O or WiFi- Coex signal
9	PIO(5)	I/O	I/O or WiFi- Coex signal
10	PIO(7)	I/O	I/O
11	GND	--	Ground Reference
12	GND	--	Ground Reference
13	ANT_OUT	--	Antenna Output
14	GND	--	Ground Reference
15	GND	--	Ground Reference
16	PCM_CLK	--	PCM Interface
17	PCM_OUT	--	PCM Interface
18	PCM_IN	--	PCM Interface
19	PCM_SYNC	--	PCM Interface
20	GND	--	Ground Reference
21	UART_RX/SDIO_DATA[2]	I/O	UART/SDIO_DATA Interface
22	UART_RTS/SDIO_DATA[1]	I/O	UART/SDIO_DATA Interface
23	UARTCTS/SDIO_DATA[3]	I/O	UART/SDIO_DATA Interface
24	UART_TX/SDIO_DATA[0]	I/O	UART/SDIO_DATA Interface
25	GND	--	Ground Reference
26	BT_REG_CTRL_P	PWR	Internal Regulator Enable.
27	3V3	PWR	PWR Supply
28	3V3	PWR	PWR Supply
29	MODULE_RST_N	Input	Module Reset
30	VDD_RF	--	Output of Internal Regulator

Note: Active Low signals are designated with an '\_N' suffix, and Active High signals are designated with an '\_P' suffix.

## ABSOLUTE MAXIMUM RATINGS

Table 2: Absolute Maximum Ratings

Symbol	Definition	Min	Max	Unit
3V3	Supply Voltage	-0.4	4.9	VDC
Ts	Storage Temperature	-40	+85	°C

These are stress ratings only. Exposure to stresses beyond these maximum ratings may cause permanent damage to, or affect the reliability of this module. Avoid using the module outside the recommended operating conditions defined below. This module is ESD sensitive and should be handled and/or used in accordance with proper ESD mitigation.

## RECOMMENDED OPERATING CONDITIONS

Table 3: Recommended Operating Conditions

Symbol	Description	Value			
		Min	Typ	Max	Unit
3V3	Supply Voltage	2.4	3.3	4.9	VDC
T <sub>oc</sub>	Operating Temp. Range	-40*	25	85	°C
GND	Ground Voltage	-0.4	0	+0.4	VDC

\*Unigen and CSR do not guarantee EDR receiver sensitivity 8DPSK performance below -30°C.

## RF CHARACTERISTICS: BASIC RATE

### Basic Rate Transmitter Performance

Table 4: Transmitter Performance – Basic Rate

RF Characteristics		NEMO	Bluetooth Test Specification (Class 1)	Units
Average Output Power	Channel 0	+9.14	+0 to +20	dBm
Peak Output Power		+9.37		
Average Output Power	Channel 39	+9.22		
Peak Output Power		+9.55		
Average Output Power	Channel 78	+9.23		
Peak Output Power		+9.56		
RF Power Control Range		22	≥ 16	dB
RF Power Control Resolution	8 steps	± 3 to 4	-	dB
20dB bandwidth for modulated carrier		840	≤ 1000	kHz
Adjacent Channel Power	F = F <sub>0</sub> ± 2MHz	-35	≤ -20	dBm
	F = F <sub>0</sub> ± 3MHz	-43	≤ -40	dBm
	F = F <sub>0</sub> ± > 3MHz	-53	≤ -40	dBm
Δf <sub>1avg</sub> maximum modulation		166	140 < f <sub>1avg</sub> < 175	kHz
Δf <sub>2avg</sub> minimum modulation		158	≥ 115	kHz
Δf <sub>2avg</sub> /Δf <sub>1avg</sub>		.95	≥ 0.80	
Initial Carrier Frequency Tolerance (ICFT)	Channel 0	8	-75 < F <sub>c</sub> < +75	kHz
	Channel 39	9		
	Channel 78	9		
Max Carrier Frequency Drift (DH1)	Channel 0	-5.96	-25.00 to 25.00	kHz
Max Carrier Frequency Drift (DH3)		-5.48	-40.00 to 40.00	kHz
Max Carrier Frequency Drift (DH5)		-6.64	-40.00 to 40.00	kHz
Max Carrier Frequency Drift Rate (DH1) (/ 50 us)		-4.48	-20.00 to 20.00	kHz
Max Carrier Frequency Drift Rate (DH3) (/ 50 us)		-5.11	-20.00 to 20.00	kHz
Max Carrier Frequency Drift Rate (DH5) (/ 50 us)		6.39	-20.00 to 20.00	kHz
Max Carrier Frequency Drift (DH1)	Channel 39	-8.70	-25.00 to 25.00	kHz
Max Carrier Frequency Drift (DH3)		-8.34	-40.00 to 40.00	kHz
Max Carrier Frequency Drift (DH5)		-7.98	-40.00 to 40.00	kHz
Max Carrier Frequency Drift Rate (DH1) (/ 50 us)		4.12	-20.00 to 20.00	kHz
Max Carrier Frequency Drift Rate (DH3) (/ 50 us)		5.94	-20.00 to 20.00	kHz
Max Carrier Frequency Drift Rate (DH5) (/ 50 us)		-4.68	-20.00 to 20.00	kHz

Max Carrier Frequency Drift (DH1)	Channel 78	<b>-9.86</b>	-25.00 to 25.00	kHz
Max Carrier Frequency Drift (DH3)		<b>-11.30</b>	-40.00 to 40.00	kHz
Max Carrier Frequency Drift (DH5)		<b>-11.31</b>	-40.00 to 40.00	kHz
Max Carrier Frequency Drift Rate (DH1) (/ 50 us)		<b>-5.02</b>	-20.00 to 20.00	kHz
Max Carrier Frequency Drift Rate (DH3) (/ 50 us)		<b>5.26</b>	-20.00 to 20.00	kHz
Max Carrier Frequency Drift Rate (DH5) (/ 50 us)		<b>-5.30</b>	-20.00 to 20.00	kHz

## Basic Rate Receiver Performance

Table 5: Basic Rate Receiver Performance

RF Characteristics	NEMO	Bluetooth Test Specification (Class 1)	Units
Receiver Sensitivity	Channel 0	-70	dbm
Receiver Sensitivity	Channel 39		
Receiver Sensitivity	Channel 78		

## RF CHARACTERISTICS: ENHANCED DATA RATE (EDR)

The Bluetooth test specification measures relative transmit power between the header and the payload of each EDR packet. The header is modulated in basic rate GFSK and the payload is modulated with DPSK. The output power difference between the header and payload is the relative transmit power.

Table 6: EDR Transmitter Performance

RF Characteristics	NEMO	Bluetooth Test Specification (Class 1)	Units
Relative Transmit Power (2-DH5) Power DPSK - Power GFSK	Channel 0	<b>-1.23</b>	-4 to 1
Output Power GFSK Header (2-DH5)		<b>+5.83</b>	-
Output Power DPSK Payload (2-DH5)		<b>+4.61</b>	-
Relative Transmit Power (3-DH5) Power DPSK - Power GFSK		<b>-1.23</b>	-4 to 1
Output Power GFSK Header (3-DH5)		<b>+5.81</b>	-
Output Power DPSK Payload (3-DH5)		<b>+4.59</b>	-
Relative Transmit Power (2-DH5) Power DPSK - Power GFSK	Channel 39	<b>-1.24</b>	-4 to 1
Output Power GFSK Header (2-DH5)		<b>+5.52</b>	-

Output Power DPSK Payload (2-DH5)		+4.27	-	dBm
Relative Transmit Power (3-DH5)		-1.24	-4 to 1	dB
Power DPSK - Power GFSK		+5.51	-	dBm
Output Power GFSK Header (3-DH5)		+4.27	-	dBm
Output Power DPSK Payload (3-DH5)	Channel 78	-1.26	-4 to 1	dB
Relative Transmit Power (2-DH5)		+5.19	-	dBm
Power DPSK - Power GFSK		+3.93	-	dBm
Output Power GFSK Header (2-DH5)		-1.26	-4 to 1	dB
Output Power DPSK Payload (2-DH5)	Channel 0	+5.18	-	dBm
Relative Transmit Power (3-DH5)		+3.92	-	dBm
Power DPSK - Power GFSK		EDR Carrier Frequency Stability and Modulation Accuracy: Bluetooth Tests Specification "TRM/CA/11/C"		
Output Power GFSK Header (3-DH5)		omega i (2-DH5)	+3.51	-75 < Fc < +75 kHz
Output Power DPSK Payload (3-DH5)	Channel 39	omega i + omega o (2-DH5)	+2.82	-75 < Fc < +75 kHz
Relative Transmit Power (2-DH5)		omega o (2-DH5)	-1.41	-10 < Fc < +10 kHz
Power DPSK - Power GFSK		DEVM RMS 2-DH5	0.05	< 0.20 %
Output Power GFSK Header (2-DH5)		DEVM Peak 2-DH5	0.13	< 0.35 %
Output Power DPSK Payload (2-DH5)	Channel 78	DEVM 99% 2-DH5, Threshold: 0.30	100	> 99 %
Relative Transmit Power (3-DH5)		omega i (3-DH5)	2.77	-75 < Fc < +75 kHz
Power DPSK - Power GFSK		omega i + omega o (3-DH5)	2.75	-75 < Fc < +75 kHz
Output Power GFSK Header (3-DH5)		omega o (3-DH5)	-1.28	-10 < Fc < +10 kHz
Output Power DPSK Payload (3-DH5)	Channel 78	DEVM RMS (3-DH5)	0.04	< 0.13 %
Relative Transmit Power (2-DH5)		DEVM Peak (3-DH5)	0.12	< 0.25 %
Power DPSK - Power GFSK		DEVM 99% 3-DH5, Threshold: 0.20	100	> 99 %
Output Power GFSK Header (2-DH5)		omega i (2-DH5)	3.90	-75 < Fc < +75 kHz
Output Power DPSK Payload (2-DH5)	Channel 0	omega i + omega o (2-DH5)	2.92	-75 < Fc < +75 kHz
Relative Transmit Power (3-DH5)		omega o (2-DH5)	-3.03	-10 < Fc < +10 kHz
Power DPSK - Power GFSK		DEVM RMS 2-DH5	0.04	< 0.20 %
Output Power GFSK Header (3-DH5)		DEVM Peak 2-DH5	0.11	< 0.35 %
Output Power DPSK Payload (3-DH5)	Channel 39	DEVM 99% 2-DH5, Threshold: 0.30	100	> 99 %
Relative Transmit Power (2-DH5)		omega i (3-DH5)	2.78	-75 < Fc < +75 kHz
Power DPSK - Power GFSK		omega i + omega o (3-DH5)	2.91	-75 < Fc < +75 kHz
Output Power GFSK Header (3-DH5)		omega o (3-DH5)	-1.40	-10 < Fc < +10 kHz
Output Power DPSK Payload (3-DH5)	Channel 78	DEVM RMS (3-DH5)	0.04	< 0.13 %
Relative Transmit Power (2-DH5)		DEVM Peak (3-DH5)	0.11	< 0.25 %
Power DPSK - Power GFSK		DEVM 99% 3-DH5, Threshold: 0.20	100	> 99 %
Output Power GFSK Header (2-DH5)		omega i (2-DH5)	3.49	-75 < Fc < +75 kHz
Output Power DPSK Payload (2-DH5)		omega i + omega o (2-DH5)	2.94	-75 < Fc < +75 kHz

omega o (2-DH5)		-2.74	-10 < Fc < +10	kHz
DEVM RMS 2-DH5		0.05	< 0.20	%
DEVM Peak 2-DH5		0.13	< 0.35	%
DEVM 99% 2-DH5, Threshold: 0.30		100	> 99	%
omega i (3-DH5)		2.42	-75 < Fc < +75	kHz
omega i + omega o (3-DH5)		3.21	-75 < Fc < +75	kHz
omega o (3-DH5)		-0.83	-10 < Fc < +10	kHz
DEVM RMS (3-DH5)		0.04	< 0.13	%
DEVM Peak (3-DH5)		0.11	< 0.25	%
DEVM 99% 3-DH5, Threshold: 0.20		100	> 99	%

## EDR Receiver Performance

Table 7: EDR Receiver Performance

RF Characteristics	NEMO	Bluetooth Test Specification (Class 1)	Units
Receiver Sensitivity	Channel 0	-84.5	-70
Receiver Sensitivity	Channel 39		
Receiver Sensitivity	Channel 78		

## EXTERNAL SLOW CLOCK SOURCE CHARACTERISTICS

Table 8: External Slow Clock Characteristics

32kHz External Reference Clock	Min	Typ	Max	Units
Frequency	32748	32768	32788	Hz
Frequency deviation at 25°C	-	-	±20	ppm
Frequency deviation at -30°C to 85°C	-	-	±150	ppm
Input high level, square wave	0.625 x +VBT	-	-	V
Input low level, square wave	-	-	0.425 x +VBT	V
Duty cycle square wave	30	-	70	%
Rise and fall time	-	-	50	ns



Solutions for a Real Time World

# NEMO Bluetooth Radio Module

Datasheet

## AGENCY CERTIFICATIONS (PRE-SCAN)

Pending

## REGULATORY COMPLIANCE STATEMENT

Pending

DRAFT

## FUNCTIONAL OVERVIEW

### NEMO Hardware Functional Description

The NEMO is a complete Radio Transceiver Module operating in the license free ISM (Industrial Scientific and Medical) 2.4GHz band. The Nemo module is equipped an external 26MHz crystal oscillator and BALUN for a single ended RF input and output path. NEMO incorporates CSR BlueCore 6 ROM WLCP chipset that is fully compliant to the Bluetooth 2.1 specification with Enhanced Data Rate (EDR) radio for transfers up to 3Mbit throughput.

The Nemo module has uses CSR's BlueCore 6 built in voltage regulator for powering the radio and digital circuitry. The internal IO supply line for the digital interfaces such as the high speed UART and PCM port at different signal voltages to match the 3V3 supply. The built in CSR voltage regulators supplies the 1.8V supply to the radio and digital MCU blocks of the CSR chip.

The module converts the CSR differential RF output and input into a single ended RF path for transmit and receive. Matching circuitry is in line between the CSR device and the BALUN and Band Pass Filter for optimized transmit output and receive sensitivity.

The high speed UART interface, SDIO, PCM port, GPIO along with WLAN co-existence interface lines are all brought outside of the module. The UART interface communicates with an external host running the upper Bluetooth stack and using the BlueCore Serial Protocol (BCSP), H4, H4DS, & H5 over the Bluetooth defined Host Controller Interface (HCI) layer. The UART is used to send HCI commands and events to and from the external host to the NEMO module.

Asynchronous and Synchronous data is sent between the module and external host via the UART interface as well. Asynchronous data sent and received over an Asynchronous packet switched RF link defined by the Bluetooth specification as "Asynchronous ConnectionLess" (ACL). Synchronous data such as audio data uses "Synchronous Connection Oriented" (SCO) circuit switched RF links defined by the Bluetooth specification. ACL data links can retransmit lost or corrupted data continuously due to the packet switched connection. SCO data can provide fast reliable continuous synchronous data over the circuit-switched RF link.

Synchronous audio data received or transmitted over the air via a Bluetooth SCO connection can be immediately decoded over the air and passed directly through CSR's digital PCM port for audio applications. The module also support I2S digital formats through the same physical PCM port for systems supporting I2S interfaces.

A slow clock 32.768kHz input is brought out for support for Deep Sleep and Stand By low power modes in between radio transmissions. This is used to keep the CSR radio from drifting out of sync from the remote Bluetooth device during an active connection with "dead silence" and allows

BlueCore to enter Deep Sleep low power mode during “dead silence” to conserve power consumption.

## NEMO Firmware Functional Description

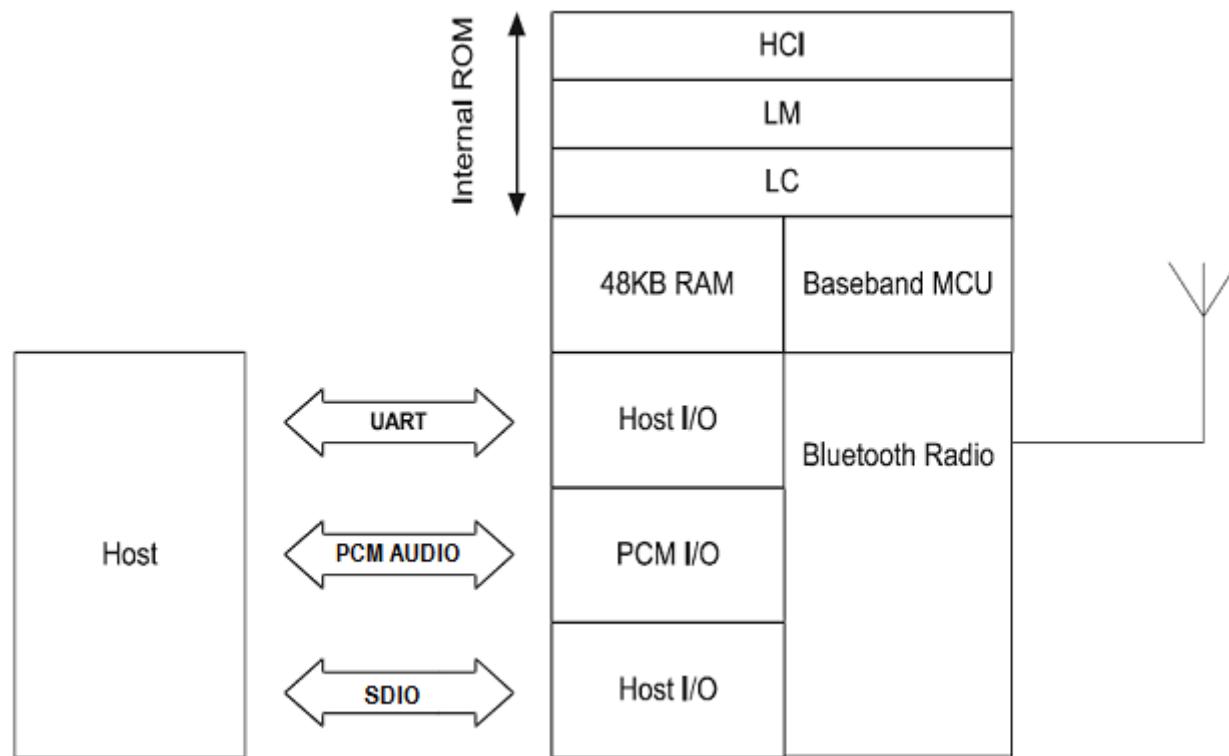
The Nemo module incorporates the CSR BlueCore 6 ROM chipset and ROM Bluetooth firmware. The firmware controls the CSR internal MCU, IO handling, radio control and also incorporates the lower Bluetooth protocol stack. The lower stack includes the Link Controller (LC), Link Manager or Link Manager Protocol (LM, LMP), Bluetooth radio Baseband (BB). These Bluetooth protocol stack components are all qualified to the Bluetooth v2.1+ EDR specification supporting all features such as Adaptive Frequency Hopping “AFH”, low power mode link modes (Hold, Sniff, Park) and Extended Synchronous Connection Oriented (eSCO) links.

The lower stack is a prequalified Bluetooth component. This means that the lower stack and baseband has already been tested and recognized by the Bluetooth Special Interest Group (SIG) as a working qualified software stack. No further testing of these lower stack components are necessary when seeking Bluetooth qualification. Protocol Implementation Conformance Statement (PICS) can be obtained from CSR or the Bluetooth SIG and submitted for these particular test cases and bypassed.

The firmware is burned into ROM within the CSR BlueCore 6 chipset. There is no need to load the firmware from an external memory device or from the host via a communication interface. The Nemo module and CSR chipset is initialized via a small subset of registers (PSKEYS) that can easily be programmed via the UART interface. These PSKEYS configure and control the radio behavior, interfaces (UART baud rate, PCM settings, etc), and holds information such as the Bluetooth address and country code of operation. Detailed descriptions of the necessary PSKEY that need to be set are discussed later in this document.

**CSR BLUETOOTH SOFTWARE STACK**

NEMO is supplied with the CSR BlueCore 6 ROM chip. CSR's BlueCore 6 ROM contains the lower layers of the Bluetooth stack. The stack is Bluetooth v2.1+EDR compliant and runs on the internal RISC microcontroller within BlueCore. The implementation shown below illustrates the internal processor of BlueCore running the Bluetooth stack up to the Host Controller Interface (HCI). The external host processor, external to NEMO, must provide all the upper layers of the Bluetooth stack including the application.

**Figure 4: BlueCore Bluetooth HCI Stack**

## Key Features of the HCI Stack: Standard Bluetooth Functionality

CSR supports the following Bluetooth v2.1 + EDR functionality:

- Secure simple pairing
- Sniff subrating
- Encryption pause resume
- Packet boundary flags
- Encryption
- Extended inquiry response

CSR supports the following Bluetooth v2.0 + EDR mandatory functionality:

- Adaptive frequency hopping (AFH), including classifier
- Faster connection - enhanced inquiry scan (immediate FHS response)
- LMP improvements
- Parameter ranges

Optional Bluetooth v2.0 + EDR functionality supported:

- Adaptive Frequency Hopping (AFH) as Master and Automatic Channel Classification
- Fast Connect - Interlaced Inquiry and Page Scan plus RSSI during Inquiry
- Extended SCO (eSCO), eV3 +CRC, eV4, eV5
- SCO handle
- Synchronization

The firmware was written against the Bluetooth v2.0+EDR specification.

- Bluetooth components:
  - Baseband (including LC)
  - LM
  - HCI
- Standard UART HCI Transport Layers
- All standard Bluetooth radio packet types
- Full Bluetooth data rate, enhanced data rates of 2 and 3Mbps
- Operation with up to seven active slaves
- Scatternet v2.5 operation
- Maximum number of simultaneous active ACL connections: 7
- Maximum number of simultaneous active SCO connections: 3
- Operation with up to three SCO links, routed to one or more slaves
- All standard SCO voice coding, plus transparent SCO
- Standard operating modes: Page, Inquiry, Page-Scan and Inquiry-Scan
- All standard pairing, authentication, link key and encryption operations
- Standard Bluetooth power saving mechanisms: Hold, Sniff and Park modes, including Forced Hold
- Dynamic control of peers' transmit power via LMP
- Master/Slave switch
- Broadcast
- Channel quality driven data rate
- All standard Bluetooth test modes

The firmware's supported Bluetooth features are detailed in the standard Protocol Implementation Conformance Statement (PICS) documents, available from <http://www.csr.com>.

## Key Features of the HCI Stack: Extra Functionality

The firmware extends the standard Bluetooth functionality with the following features:

- Supports BlueCore Serial Protocol (BCSP), a proprietary, reliable alternative to the standard Bluetooth UART Host Transport
- Provides a set of approximately 50 manufacturer-specific HCI extension commands. This command set, called BlueCore Command (BCCMD), provides:
  - Access to the chip's general-purpose PIO port
  - The negotiated effective encryption key length on established Bluetooth links
  - Access to the firmware's random number generator
  - Controls to set the default and maximum transmit powers; these can help minimize interference between overlapping, fixed-location piconets
  - Dynamic UART configuration
  - Bluetooth radio transmitter enable/disable. A simple command connects to a dedicated hardware switch that determines whether the radio can transmit.
- A block of BCCMD commands provides access to the chip's Persistent Store (PS) configuration database. The database sets the device's Bluetooth address, Class of Device, Bluetooth radio (transmit class) configuration, SCO routing, LM, constants, etc.
- A UART break condition can be used in three ways:
  - Presenting a UART break condition to the chip can force the chip to perform a hardware reboot
  - Presenting a break condition at boot time can hold the chip in a low power state, preventing normal initialization while the condition exists
  - With BCSP, the firmware can be configured to send a break to the host before sending data. (This is normally used to wake the host from a Deep-Sleep state.)
- A block of Bluetooth radio test or BIST commands allows direct control of the chip's radio. This aids the development of modules' radio designs, and can be used to support Bluetooth qualification.
- Hardware low power modes: Shallow Sleep and Deep-Sleep. The chip drops into modes that significantly reduce power consumption when the software goes idle.
- SCO channels are normally routed via HCI (over BCSP). However, up to three SCO channels can be routed over the chip's PCM ports (at the same time as routing any remaining SCO channels over HCI).

For more details on the CSR Bluetooth stack, limitations and firmware refer to CSR's firmware release note "BlueCore Unified 23c Release Note (CS-116212-RNP3).pdf"

## HOST INTERFACES

BlueCore6-ROM WLCSP switches between UART and SDIO transport at boot-up by reading the status of PIO[4]:

- PIO[4] = pulled low: UART mode is selected (internal default setting).
- PIO[4] = driven high: SDIO or CSPI host interface is selected.

The protocol used by the UART host interface is determined by the status of the SDIO\_CLK and SDIO\_CMD lines at the time PIO[4] is sampled. Table 6 lists the different protocols available along with the required configuration of CLK and CMD for each one.

To select a different UART Protocol, connect external  $100\text{k}\Omega$  pull-up and/or pull-down resistors as appropriate.

For example:

- To select BCSP, connect  $100\text{k}\Omega$  pull-downs to both SDIO\_CLK and SDIO\_CMD.
- To select H4DS, connect a  $100\text{k}\Omega$  pull-up to SDIO\_CLK and a  $100\text{k}\Omega$  pull-down to SDIO\_CMD.

See application schematic for BCSP example.

Table 9: Host Interface Selection

SDIO_SD_CLK	SDIO_SD_CMD	UART_PROTOCOL
0	0	BCSP
0	1	H4
1	0	H4DS
1	1	HS

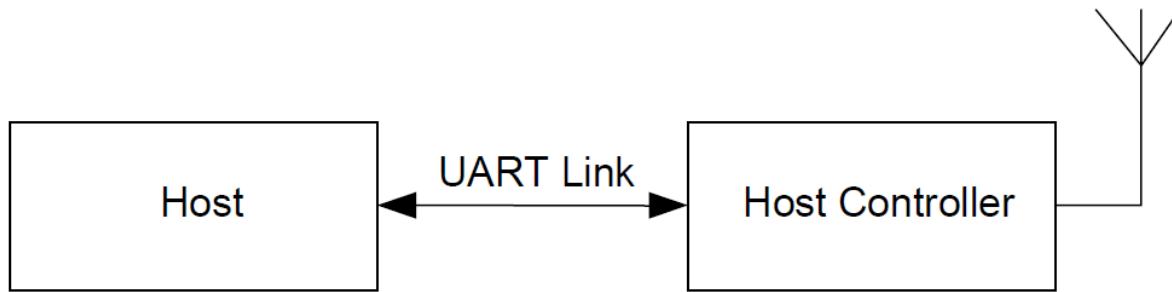
## HIGH SPEED UART INTERFACE

NEMO uses a standard UART interface for communicating to other serial devices. Four signals from NEMO implement the UART function. The high speed UART can support up to 4Mbits in throughput which is needed for data transfers using EDR RF link payloads with 3Mbit over the air throughput. The baud rate and other configuration parameters can be set via the firmware and PSKEYs during bootup and initialization.

**BlueCore Serial Protocol (BCSP)**

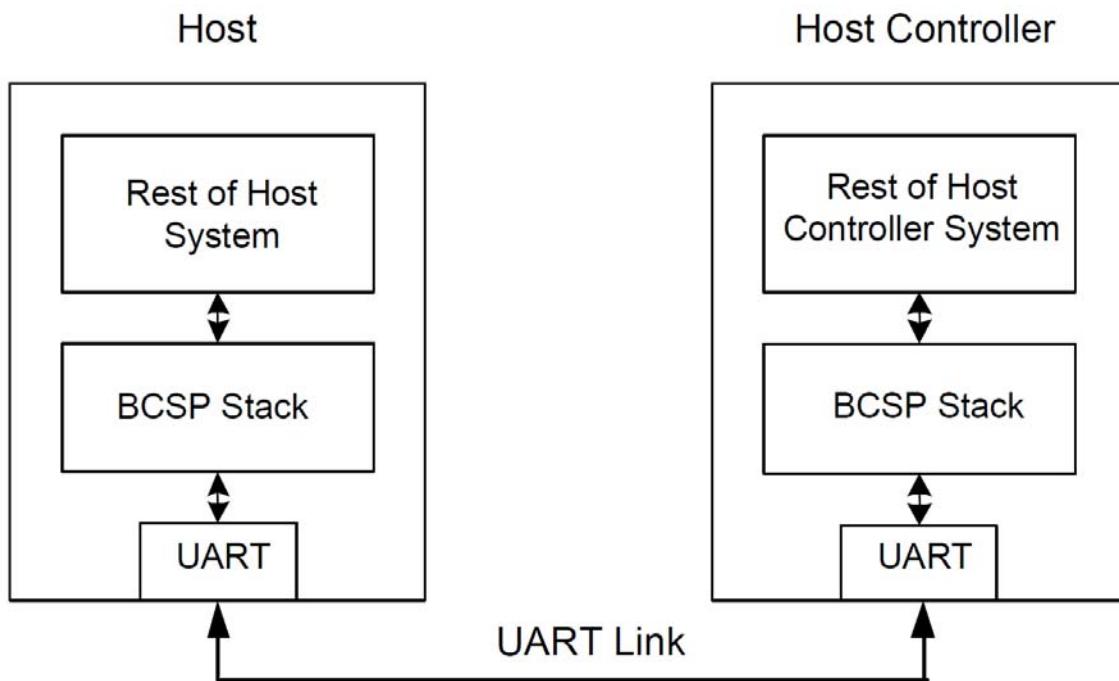
This document only describes CSR's BlueCore Serial Protocol overview and does not go into detail on BCSP implementation, packet structure and stack elements. Please refer to CSR's "BlueCore Serial Protocol (bcsp-sp-012Pb).pdf" document for more a detailed explanation and implementation. BCSP must be implemented on the Host to communicate to the NEMO module.

BlueCore Serial Protocol (BCSP) is a protocol used to carry data that flow through a reliable UART link. The Bluetooth stack has been designed to transfer data between a Bluetooth Host and a Host Controller (NEMO). The Bluetooth stack is intended to be used to carry the Bluetooth HCI (Host Controller Interface) protocols plus several others. BCSP is intended to be used with CSR based Host Controllers (NEMO), which provides hardware to support much of the Bluetooth stack functionality.



**Figure 5: UART Host Connection**

BCSP is used to control and format information that flows between the Bluetooth Host and the NEMO modules. The Bluetooth stack carries a set of parallel information that flows between the two process entities, multiplexing them over the single UART link.



**Figure 6: BCSP Context**

An instance of the BCSP stack runs on both the Host and the Host Controller (NEMO). The BCSP stack is layered above the UART on each side.

The top of the BCSP stack presents:

- One bidirectional reliable datagram service
- One bidirectional unreliable datagram service

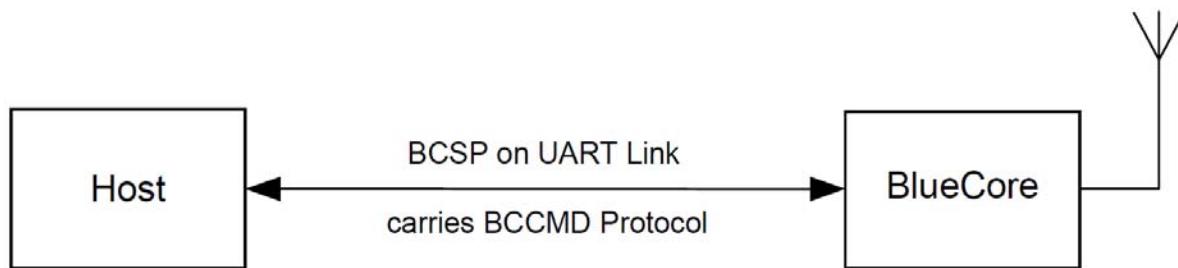
The BCSP protocol is defined to run on a 3-wire UART connection (TXD, RXD, & GND). However, BCSP can also run on a 5 wire UART connection (TXD, RXD, GND, CTS, RTS) which is common for higher baud rates.

### **BlueCore Command (BCCMD) Protocol**

This document only gives an overview of CSR's BCCMD Protocol overview and does not go into detail on BCCMD implementation, command set and events. The BlueCore Command Protocol (BCCMD) is used to configure parameters such as UART Baud Rate, Bluetooth address and initiate NEMO's radio. BCCMD and BCSP are protocols that need to be implemented on the Host connected to NEMO via the UART interface. For detailed information and implementation of CSR's BCCMD Protocol please refer to CSR's "BCCMD Protocol (bcore-sp-002Pc).pdf" document.

BCCMD describes a software interface to a command interpreter on a CSR BlueCore Bluetooth device, in this case the BlueCore 6 ROM chip inside NEMO. The command interpreter presents commands and events that allow monitoring and control of specific CSR chip functions outside of the Bluetooth stack protocol. The command set is not part of the Bluetooth protocol.

BCCMD allows the software on the Bluetooth Host to control and monitor the CSR BlueCore chip and flows alongside the normal Host Controller Interface (HCI) channels. The BCCMD protocol is carried over the UART link over a BCSP channel.



**Figure 7: BCCMD Interface**

## SDIO INTERFACE

This is a host interface which allows a SDIO host to gain access to the internals of the module. It provides all defined slave modes (SPI, SD 1bit, SD 4bit), but not SD host function.

The function provided includes generating responses to each command in hardware and implementing the state machines defined in the SDIO specification. Within the various modes of operation, it provides initialization functions (cmds 0,3,5,7,15,59) and two other functions:

- Function 1 provides Bluetooth type A support, and follows that specification
- Function 2 provides generic register access (cmd52 (byte read/write))

For more information, see the following specifications:

- *SD Specifications Part 1 Physical layer specification v1.10*
- *SD Specifications Part E1 SDIO specification v1.10*
- *SDIO Card Part E2 Type-A Specification for Bluetooth v1.00*

## SDIO Deep Sleep Control Schemes

This is the lowest power mode, where the processor, the internal reference (fast) clock, and much of the digital and analogue hardware are shut down. To support this power consumption reduction solution and to prevent any errors arising on the SDIO host interface there are two deep sleep control schemes.

- 1.) The host retransmits any packets that NEMO was unable to receive as a result of being in deep sleep.
- 2.) Introduces additional signaling to prevent the need for retransmissions.

During deep sleep the internal reference clock is turned off. However, the host transport protocols (SDIO/UART/CSPI) are driven from the SDIO clock and so continue to function during deep sleep, enabling access to the function 0 interface, but not the function 1 interface.

## SDIO Retransmission

Whenever NEMO becomes idle, it enters deep sleep. Then, when the host transmits a message on function 1, an illegal command error is signaled. The activity that this initiates on the SDIO Interface provokes NEMO into wakeup and the host re-transmits the original message.

NEMO waits for a configurable period of time before re-entering deep sleep, which ensures that the original packet is sent/received on retransmission. This control scheme is the default mode of operation.

## SDIO Signaling

Signaling between the host and NEMO enables host control over NEMO deep sleep mode. Consequently the host is aware of when it is appropriate to send NEMO HCI traffic over function 1.

The signals used by this scheme are HOST WAKEUP and READY STATUS INTERRUPT SELECT, implemented as register bits in the vendor-unique area of function 0.

## AUDIO PCM AND I2S INTERFACES

The NEMO module has a Pulse Code Modulation (PCM) audio port and I2S interface. These interfaces are intended to be used for quick transfer of synchronous audio data transmitted or received over Bluetooth SCO audio links for voice applications such as headsets and hands free kits..

PCM is a standard method for digitizing audio (particularly voice) for transmission over digital communications channels. The dedicated PCM port reduces overhead processing power for battery powered devices. The PCM port bi-directional digital audio interface is routed directly into the CSR radio baseband for fast encoding/decoding. The audio is not passed through the UART/HCI layer. The digitized audio through the baseband is sent and received via Bluetooth defined RF SCO links.

The PCM port can operate as a the PCM master generating an output clock of 128, 256, 512, 1536, and 2400kHz. When configured as a PCM slave, NEMO can support a master input clock up to 2400kHz. A variety of clock formats are supported including, Long Frame Sync, Short Frame Sync, and GCI timing environments.

It supports 13-bit or 16-bit linear, 8-bit  $\mu$ -law or A-law companded sample formats at 8ksamples/s. These samples can be received and transmitting through any selection of the first 3 out of the 4 timing slots following PCM\_SYNC.

### PCM Interface Master/Slave

When NEMO is configured as a PCM master, NEMO generates PCM\_CLK and PCM\_SYNC signals

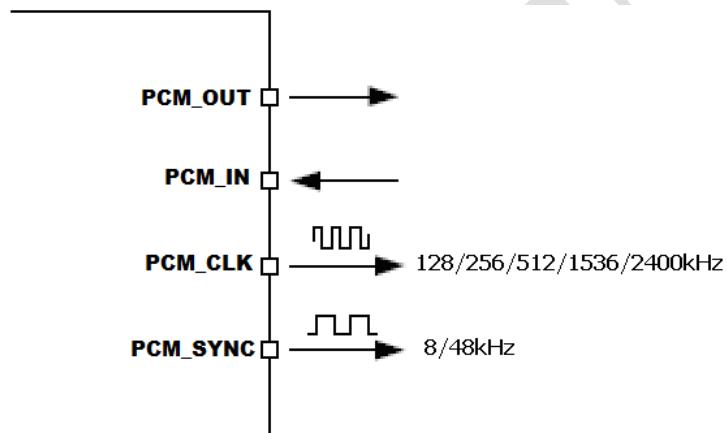


Figure 8: PCM Interface Master

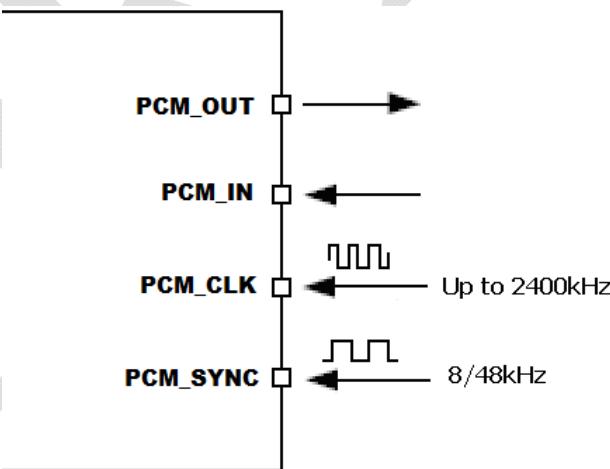
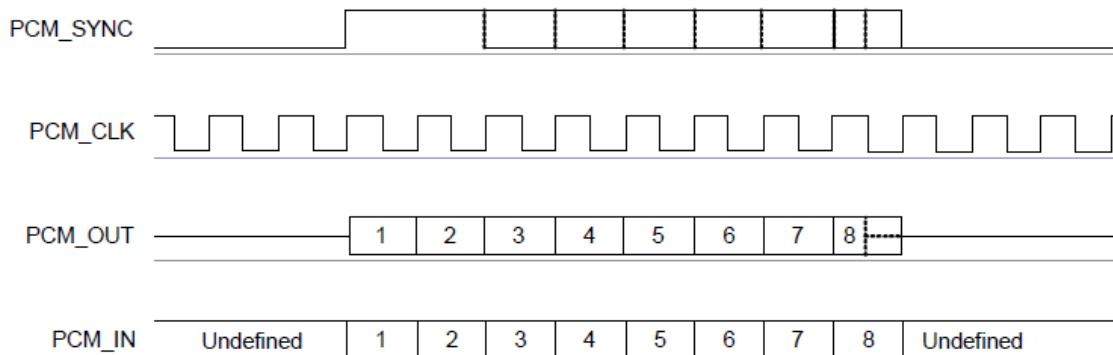


Figure 9: PCM Interface Slave

### PCM Long Frame Sync

Long Frame Sync is a clocking format that controls data transfer for PCM data words or sample between two devices. The rising edge of PCM\_SYNC indicates the start of a PCM word in Long Frame Sync. When NEMO is configured as a PCM master, generating PCM\_SYNC and PCM\_CLK\_P, the PCM\_SYNC is 8-bits long. As a PCM slave, PCM\_SYNC may be from two consecutive falling edges of PCM\_SYNC to half of the PCM\_SYNC rate, i.e 62.5us long.

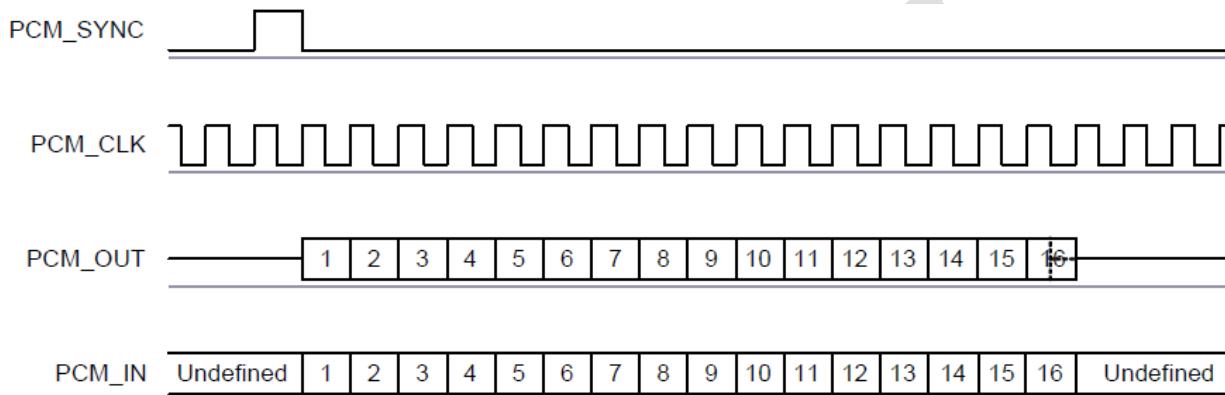


**Figure 10: Long Frame Sync (Shown with 8-bit Companded Sample)**

NEMO samples PCM\_IN on the falling edge of PCM\_CLK and transmits BT\_PCMTXD\_P on the rising edge of PCM\_CLK\_P. The PCM\_OUT signal maybe configured to be high impedance on the falling edge of PCM\_CLK in the LSB position or on the rising edge.

### Short Frame Sync

In Short Frame Sync, the falling edge of PCM\_SYNC indicates the start of the PCM word. PCM\_SYNC is always one clock cycle long.

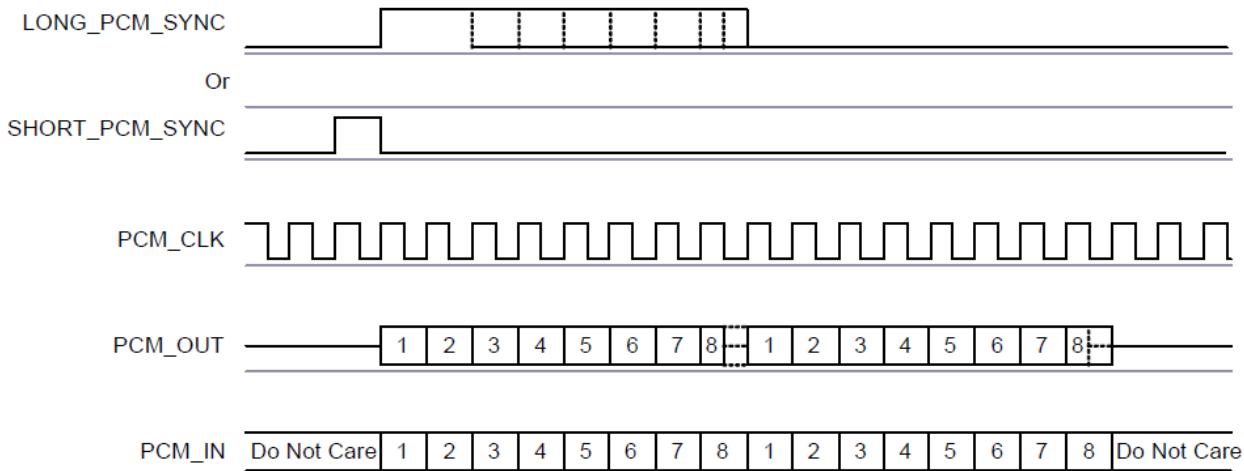


**Figure 11: Short Frame Sync (Shown with 16-bit Sample)**

Like with Long Frame Sync, NEMO samples PCM\_IN on the falling edge of PCM\_CLK and transmits PCM\_OUT on the rising edge. PCM\_OUT maybe configured to be high impedance on the falling edge of PCM\_CLK in the LSB position or on the rising edge.

**Multi-slot Operation**

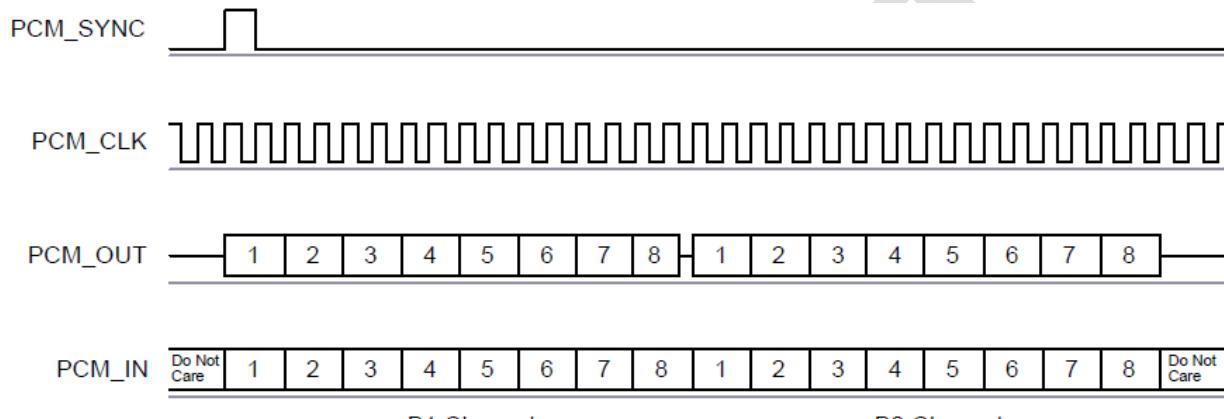
More than one audio Bluetooth SCO connection over the PCM interface is supported using multiple slots as more than one Bluetooth SCO connection can exist simultaneously. Up to three Bluetooth SCO connections can be handled simultaneously and can be carried over any of the first three out of the four slots of the PCM port.



**Figure 12: Multi-slot Operation: Two Slots \* 8-bit Companded Samples**

**GCI Interface**

NEMO is compatible with General Circuit Interface (GCI), a standard synchronous 2B+D ISDN timing interface. The two 64kbps B channels can be accessed when this mode is configured.

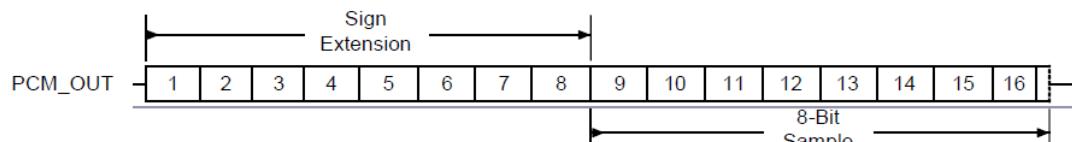
**Figure 13: GCI Interface**

The start of frame is indicated by the rising edge of PCM\_SYNC and runs at 8kHz. With NEMO in slave mode, the frequency of PCM\_CLK can be up to 4.096MHz.

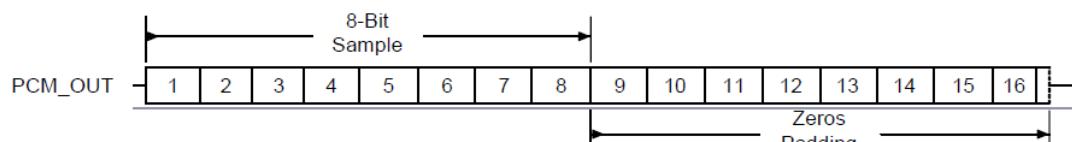
## PCM Slots and Sample Formats

NEMO can receive and transmit on any selection of the first four slots following each sync pulse. Slot durations can be either 8 or 16 clock cycles. Durations of 8 clock cycles may only be used with 8-bit sample formats. Durations of 16 clocks may be used with 8-bit, 13-bit or 16-bit sample formats. NEMO supports 13-bit linear, 16-bit linear and 8-bit  $\mu$ -law or A-law sample formats.

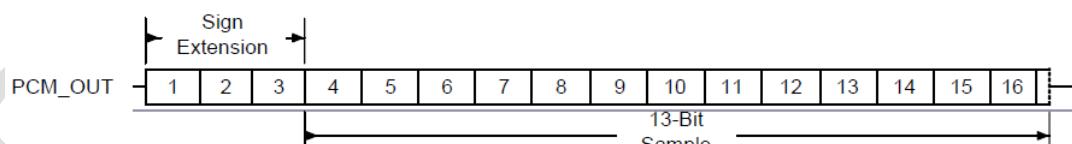
The sample rate is 8ksamples/s. The bit order may be little or big endian. When 16-bit slots are used, the 3 or 8 unused bits in each slot may be filled with sign extension, padded with zeros or a programmable 3-bit audio attenuation compatible with some Motorola CODECs.



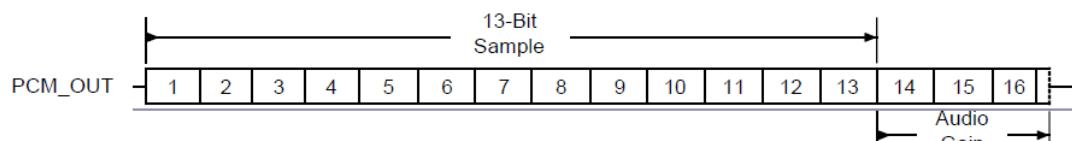
A 16-bit slot with 8-bit compounded sample and sign extension selected.



A 16-bit slot with 8-bit compounded sample and zeros padding selected.



A 16-bit slot with 13-bit linear sample and sign extension selected.



A 16-bit slot with 13-bit linear sample and audio gain selected.

**Figure 14: 16-Bit Slot Length and Sample Formats**

## PCM Timing Information

Table 10: PCM Timing Table

Symbol	Parameter		Min	Typ	Max	Unit
fmclk	PCM_CLK frequency	4MHz DDS generation. Selection of frequency is programmable. See Table XXXX	-	128	-	kHz
		48MHz DDS generation. Selection of frequency is programmable. See Table XXXX.		256		
	PCM_SYNC Frequency for SCO		2.9	-	-	kHz
tmclkh	PCM_CLK high	4MHz DDS generation	980	-	-	Ns
tmclkI	PCM_CLK low	4MHz DDS generation	730	-	-	Ns
-	PCM_CLK jitter	48MHz DDS generation.	-	-	21	ns pk-pk
tdmclksynch	Delay time from PCM_CLK high to PCM_SYNC high		-	-	20	Ns
tdmclkpout	Delay time from PCM_CLK high to valid PCM_OUT		-	-	20	Ns
tdmclklsyncl	Delay time from PCM_CLK low to PCM_SYNC low (Long Frame Sync only)		-	-	20	Ns
tdmclkhsyncl	Delay time from PCM_CLK high to PCM_SYNC low		-	-	20	Ns
tdmclklpoutz	Delay time from PCM_CLK low to BT_PCM_TXD high impedance		-	-	20	Ns
tdmclkhpoutz	Delay time from PCM_CLK high to PCM_OUT high impedance		-	-	20	Ns
tsupinclkI	Set-up time for PCM_IN valid to PCM_CLK low		30	-	-	Ns
thpinclkI	Hold time for PCM_CLK low to PCM_IN invalid		10	-	-	Ns

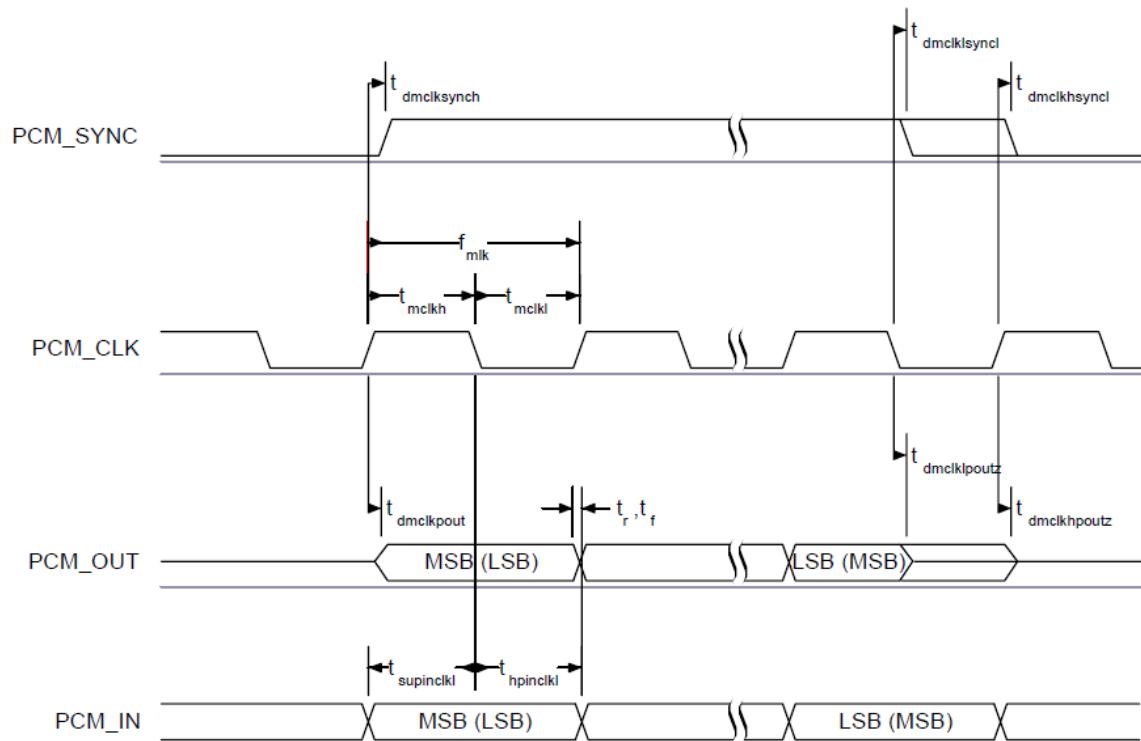


Figure 15: PCM Master Timing Long Frame Sync

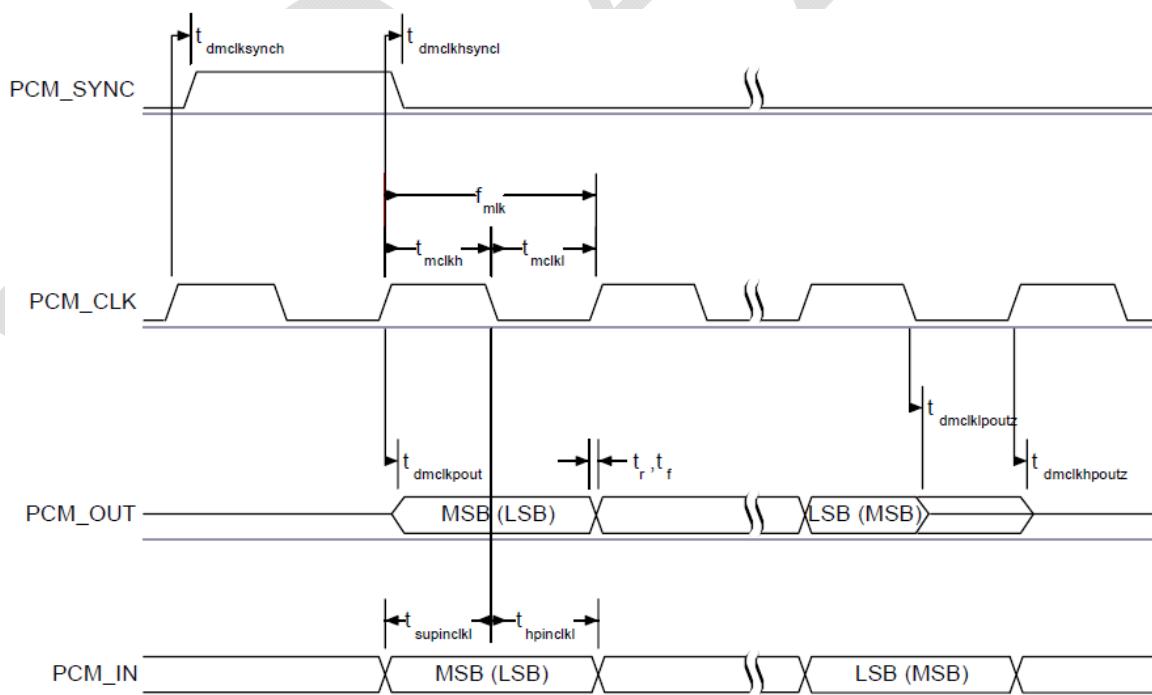


Figure 16: PCM Master Timing Short Frame Sync

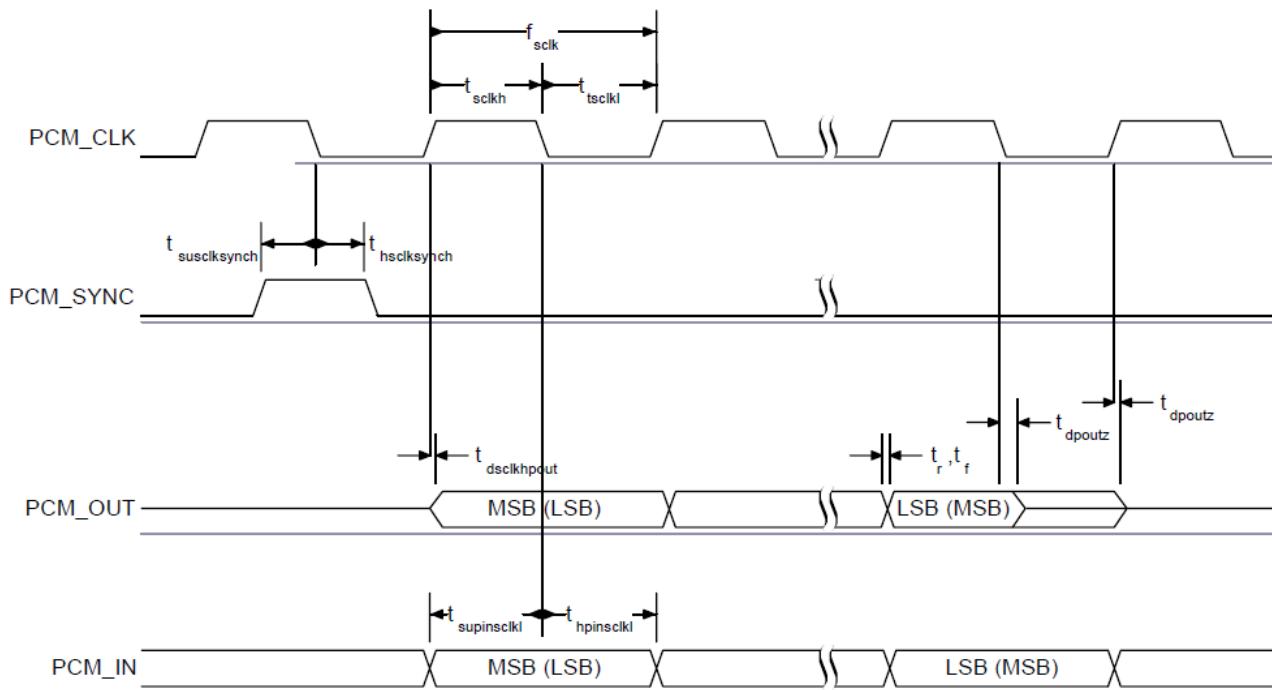


Figure 17: PCM slave Timing Short Frame Sync

## PCM CLK and PCM SYNC Generation

NEMO has two methods of generating the PCM CLK and PCM SYNC in master mode:

- Generating signals by Direct Digital Synthesis (DDS) from internal 4MHz clock. Using this mode limits PCM\_CLK to 126, 256 or 512kHz, and PCM\_SYNC to 8kHz.
- Generating these signals by DDS from an internal 48MHz clock (which allows greater range of frequencies to be generated with low jitter but consumes more power). This method is selected by setting bit 48M\_PCM\_CLK\_GEN\_EN in the PSKEY\_PCM\_CONFIG32 key. When in this mode and with long frame sync, the length of the PCM\_SYNC can either be 8 or 16 cycles of PCM\_CLK\_P, determined by LONG\_LENGTH\_SYNC\_EN bit in the PSKEY\_PCM\_CONFIG32 key.

The equation below describes the PCM CLK frequency when being generated using the internal 48MHz clock:

$$f = \frac{\text{CNT\_RATE}}{\text{CNT\_LIMIT}} \times 24\text{MHz}$$

The frequency of the PCM SYNC relative to the PCM CLK is set using either of the two equations below by setting the value of PCM\_SYNC\_MULT (see Table 10.4):

$$f = \frac{\text{PCM\_CLK}}{\text{SYNC\_LIMIT} \times 8}$$

$$f = \frac{\text{PCM\_CLK}}{\text{SYNC\_LIMIT}}$$

CNT\_RATE, CNT\_LIMIT and SYNC\_LIMIT are set using PSKEY\_PCM\_LOW\_JITTER\_CONFIG. As an example, to generate PCM\_CLK at 512kHz with PCM\_SYNC at 8kHz, set PSKEY\_PCM\_LOW\_JITTER\_CONFIG to 0x08080177.

## PCM Configuration

The PCM configuration is set using the PS Keys, PSKEY\_PCM\_CONFIG32 described in Table 10.4 and PSKEY\_PCM\_LOW\_JITTER\_CONFIG in Table 10.3. The default for PSKEY\_PCM\_CONFIG32 is 0x00800000, i.e., first slot following sync is active, 13-bit linear voice format, long frame sync and interface master generating 256kHz PCM\_CLK from 4MHz internal clock with no tri-state of PCM\_OUT. For more information in regards to PS keys and their usage refer to the Persistent Store section of this document.

**Table 11: PSKEY\_PCM\_LOW\_JITTER\_CONFIG Description**

Name	Bit Position	Description
CNT_LIMIT	[12:0]	Sets the PCM CLK counter limit
CNT_RATE	[23:16]	Sets the PCM CLK count rate
SYNC_LIMIT	[31:24]	Sets the PCM SYNC division relative to PCM CLK

**Table 12: PSKEY\_PCM\_CONFIG32 Description**

Name	Bit Position	Description
	0	Set to 0
SLAVE_MODE_EN	1	0 = Master mode with internal generation of the PCM_CLK and PCM_SYNC. 1 = Slave mode requiring externally generated PCM CLK and the PCM SYNC signals.
SHORT_SYNC_EN	2	0 = Long Frame Sync mode (rising edge indicates start of frame). 1 = Short Frame Sync mode (falling edge indicates start of frame).
	3	Set to 0
SIGN_EXTENDED_EN	4	0 = Padding of 8 or 13-bit voice sample into a 16-bit slot by inserting extra LSBs. When padding is selected with 13-bit voice sample, the 3 padding bits are the audio gain setting; with 8-bit sample the 8 padding bits are zeroes. 1 = Sign-extension.
LSB_FIRST_EN	5	0 = MSB first of transmit and receive voice samples. 1 = LSB first of transmit and receive voice samples.
TX_TRISTATE_EN	6	0 = Drive PCM_OUT continuously. 1 = Tri-state PCM_OUT immediately after falling edge of PCM_CLK in the last bit of an active slot, assuming the next slot is not active.
TX_TRISTATE_RISING_EDGE_EN	7	0 = Tri-state PCM_OUT immediately after falling edge of PCM_CLK in last bit of an active slot, assuming the next slot is also not active. 1 = Tri-state BT_PCM_TXD after rising edge of PCM_CLK_P.

SYNC_SUPPRESS_EN	8	0 = enable PCM_SYNC output when master. 1 = suppress PCM_SYNC while keeping PCM_CLK running. Some CODECS use this to enter a low power state.
GCI_MODE_EN	9	1 = enable GCI mode.
MUTE_EN	10	1 = force PCM_OUT to 0.
48M_PCM_CLK_GEN_EN	11	0 = set PCM_CLK and PCM_SYNC generation via DDS from internal 4MHz clock. 1 = set PCM_CLK and PCM_SYNC generation via DDS from internal 48MHz clock.
LONG_LENGTH_SYNC_EN	12	0 = set PCM_SYNC length to 8 PCM_CLK cycles. 1 = set length to 16 PCM_CLK cycles. Only applies for long frame sync and with 48M_PCM_CLK_GEN_EN set to 1.
PCM_SYNC_MULT	13	0 = Sync limit = SYNC_LIMIT x 8. 1 = SYNC_LIMIT.
	[20:16]	Set to 0b00000
MASTER_CLK_RATE	[22:21]	Selects 128 (0b01), 256 (0b00), 512 (0b10) kHz PCM_CLK+P frequency when master and 48M_PCM_CLK_GEN_EN (bit 11) is low.
ACTIVE_SLOT	[26:23]	Default is 0001. Ignored by firmware.
SAMPLE_FORMAT	[28:27]	Selects between 13 (0b00), 16 (0b01), 8 (0b10) bit sample with 16-cycle slot duration or 8 (0b11) bit sample with 8-cycle slot duration.

## Digital Audio Interface (I<sup>2</sup>S)

The digital audio interface supports the industry standard formats for I<sup>2</sup>S, left-justified (LJ) or right-justified (RJ). The interface shares the same pins as the PCM interface, which means each audio bus is mutually exclusive in its usage. Table 7 lists these alternative functions.

**Table 13: Alternative Functions of the Digital Audio Bus Interface on the PCM Interface**

PCM Interface	I <sup>2</sup> S Interface
PCM_OUT	SD_OUT
PCM_IN	SD_IN
PCM_SYNC	WS
PCM_CLK	SCK

Table 8 describes the values for the PS Key (PSKEY\_DIGITAL\_AUDIO\_CONFIG) that is used to set-up the digital audio interface. For example, to configure an I<sup>2</sup>S interface with 16-bit SD data set PSKEY\_DIGITAL\_CONFIG to 0x0406.

**Table 14: PSKEY\_DIGITAL\_AUDIO\_CONFIG**

Bit	Mask	Name	Description
D[0]	0x0001	CONFIG_JUSTIFY_FORMAT	0 for left justified, 1 for right justified.
D[1]	0x0002	CONFIG_LEFT_JUSTIFY_DELAY	For left justified formats: 0 is MSB of SD data occurs in the first SCLK period following WS transition. 1 is MSB of SD data occurs in the second SCLK period.
D[2]	0x0004	CONFIG_CHANNEL_POLARITY	For 0, SD data is left channel when WS is high. For 1 SD data is right channel.
D[3]	0x0008	CONFIG_AUDIO_ATTEN_EN	For 0, 17 bit SD data is rounded down to 16 bits. For 1, the audio attenuation defined in CONFIG_AUDIO_ATTEN is applied over 24 bits with saturated rounding. Requires CONFIG_16_BIT_CROP_EN to be 0.
D[7:4]	0x00F0	CONFIG_AUDIO_ATTEN	Attenuation in 6 dB steps.

D[9:8]	0x0300	CONFIG_JUSTIFY_RESOLUTION	Resolution of data on SD_IN, 00=16 bit, 01=20 bit, 10=24 bit, 11=Reserved. This is required for right justified format and with left justified LSB first.
D[10]	0x0400	CONFIG_16_BIT_CROP_EN	For 0, 17 bit SD_IN data is rounded down to 16 bits. For 1 only the most significant 16 bits of data are received.

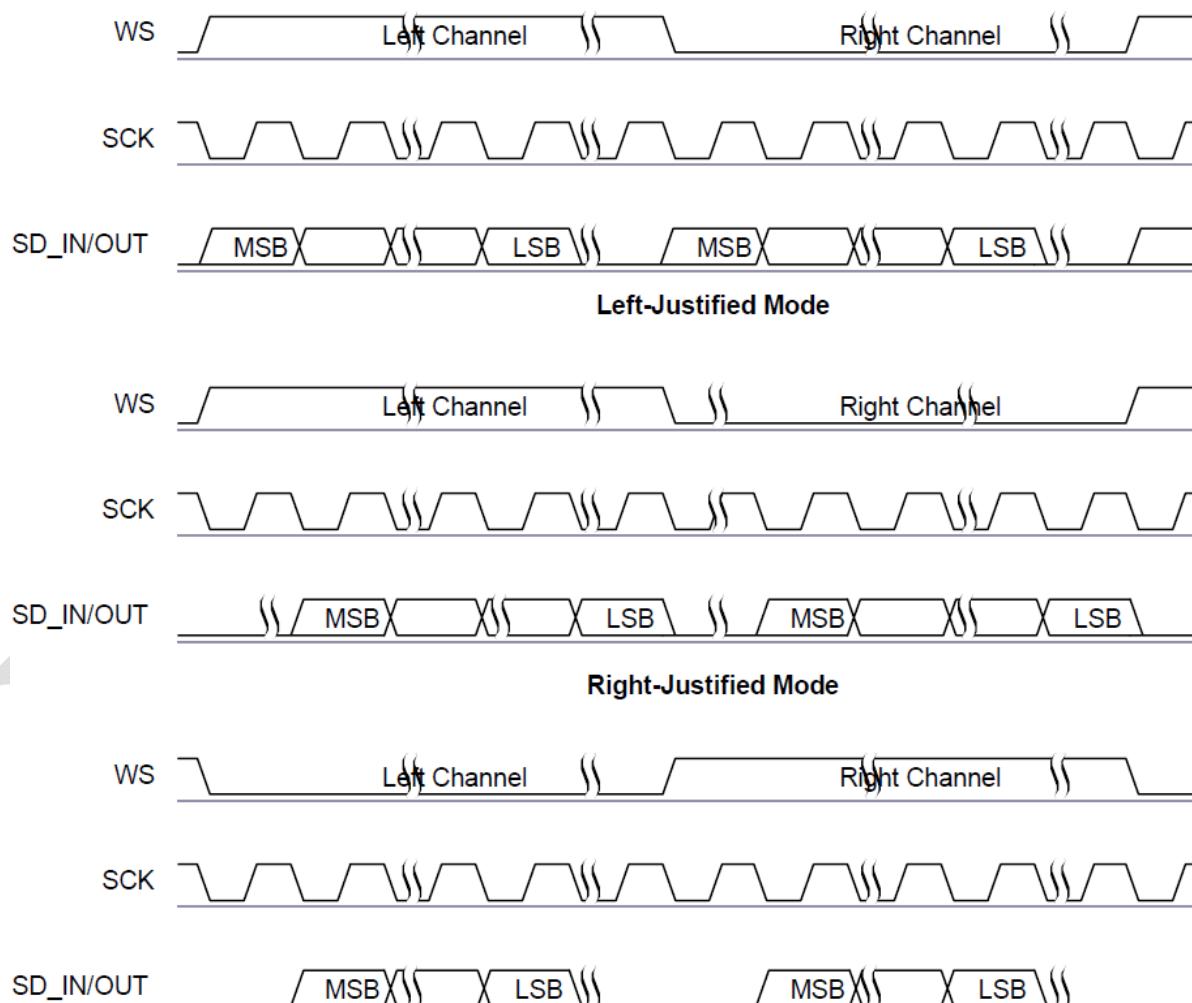


Figure 18: I<sup>2</sup>S Mode Digital Audio Interface

Table 15: Digital Audio Interface Slave Timing

Symbol	Parameter	Min	Typ	Max	Unit
-	SCK Frequency	-	-	6.2	MHz
-	WS Frequency	-	-	96	kHz
tch	SCK high time	80	-	-	Ns
tcl	SCK low time	80	-	-	Ns
topd	SCK to SD_OUT delay	-	-	20	Ns
tssu	WS to SCK set-up time	20	-	-	Ns
tsh	WS to SCK hold time	20	-	-	Ns
tisu	SD_IN to SCK set-up time	20	-	-	Ns
tih	SD_IN to SCK hold time	20	-	-	Ns

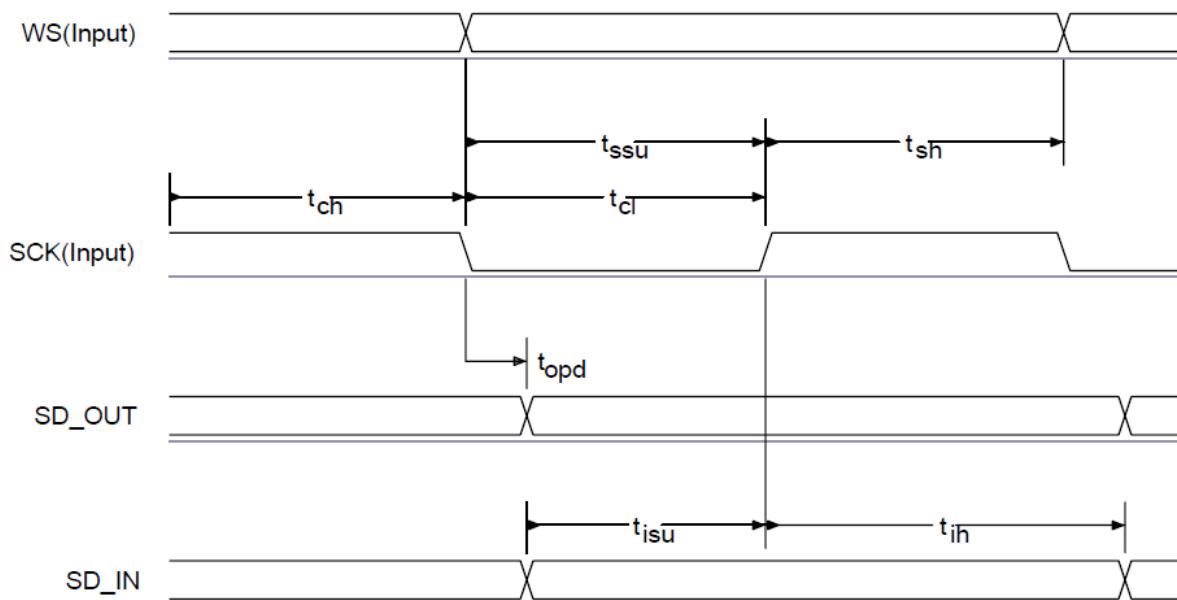


Figure 19: Digital Audio Interface Slave Timing

Table 16: Digital Audio Interface Master Timing

Symbol	Parameter	Min	Typ	Max	Unit
-	SCK Frequency	-	-	6.2	MHz
-	WS Frequency	-	-	96	kHz
topd	SCK to SD_OUT delay	-	-	20	Ns
tspd	SCK to WS delay	-	-	20	Ns
tisu	SD_IN to SCK set-up time	20	-	-	Ns
tih	SD_IN to SCK hold time	10	-	-	Ns

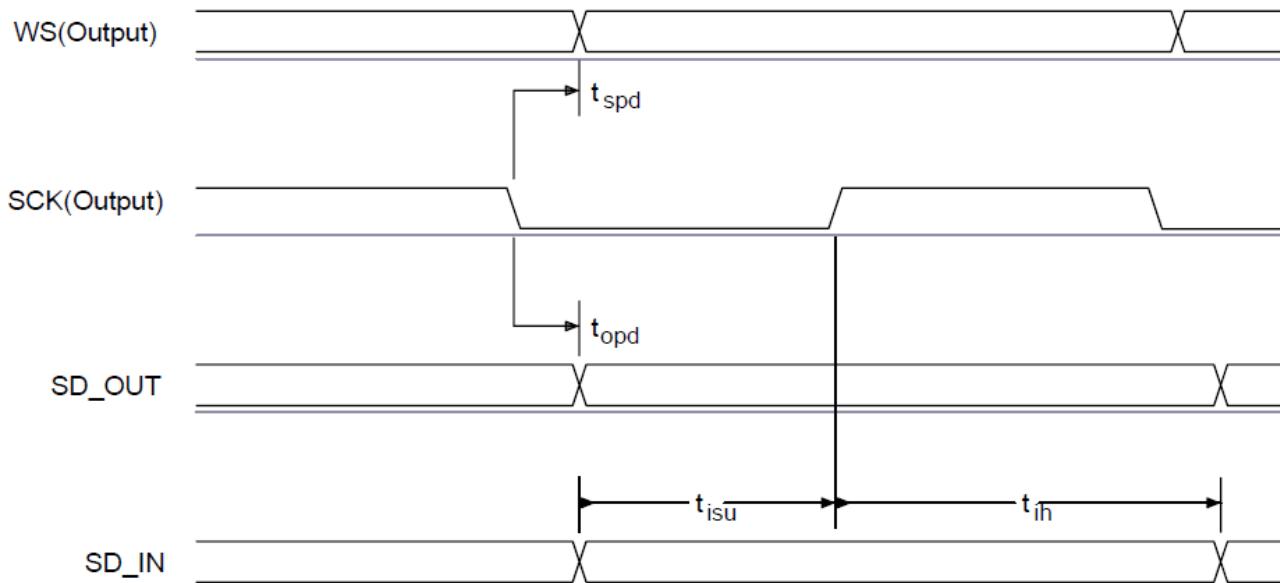


Figure 20: Digital Audio Interface Master Timing

## POWER CONSUMPTION

Table 17: Operating Power Consumption Figures

Operation Mode	Connection Type	Average	Unit
Page scan, time interval 1.28s	-	0.4	mA
Inquiry and page scan, time interval 1.28s	-	0.8	mA
ACL no traffic	Master	4	mA
ACL with file transfer	Master	9	mA
ACL 40ms sniff	Master	2	mA
ACL 1.28s sniff	Master	0.2	mA
eSCO EV5	Master	12	mA
eSCO EV3	Master	18	mA
eSCO EV3 - hands-free - setting S1	Master	18.5	mA
SCO HV1	Master	37	mA
SCO HV3	Master	17	mA
SCO HV3 30ms sniff	Master	17	mA
ACL no traffic	Slave	14	mA
ACL with file transfer	Slave	17	mA
ACL 40ms sniff	Slave	1.6	mA
ACL 1.28s sniff	Slave	0.2	mA
eSCO EV5	Slave	19	mA
eSCO EV3	Slave	23	mA
eSCO EV3 - hands-free - setting S1	Slave	23	mA
SCO HV1	Slave	37	mA
SCO HV3	Slave	23	mA
SCO HV3 30ms sniff	Slave	16	mA
Standby host connection (Deep-Sleep)	-	40	µA
Reset (active low)	-	39	µA

Note Conditions: 20°C, +VBT = 3.15V, +VBT = 3.15V, UART BAUD rate = 115.2kbps.

Table 18: Peak Current

Typical Peak Current @ 20°C	
Device Activity/State	Current (mA)
Peak current during cold boot	45
Peak TX current Master	45
Peak RX current Master	40
Peak TX current Slave	45
Peak RX current Slave	45
Conditions	
VREGIN_H, VDD_PADS	3.15
Host Interfaces	UART
UART Baud rate	115200
RF output power	0dBm

## BOOTING NEMO ROM

The NEMO module contains the CSR BlueCore 6 ROM device. The firmware is loaded from BlueCore's internal ROM. The NEMO module can be boot strapped to boot to use the UART or SDIO interface upon power up.

### UART Boot Up

Configuration of NEMO is handled through the UART interface and BCCMD protocol. The Bluetooth address, UART baud rate, PCM configuration and country code are all parameters that can be configured on the ROM device upon power up. These parameters are programmed into Persistent Store Keys (registers) in RAM and are loaded into firmware after a soft reset.

#### NEMO Boot Process UART

1. Power up NEMO with PIO4 pulled low or left floating.
2. Initialize HOST communications over the UART link.
3. Load and program the PSKEYS via BCCMD commands necessary for the initialization
4. Issue BCCMD warm\_reset command
5. Re-initialize HOST communications
6. Module is ready for operation and Bluetooth HCI stack initialization

#### NEMO Boot Process SDIO

1. Power up NEMO with PIO4 pulled high.
2. Initialize HOST communications over SDIO.
3. Load and program the PSKEYS via BCCMD vendor specific commands necessary for the initialization
4. Issue BCCMD warm\_reset command
5. Re-initialize HOST communications
6. Module is ready for operation and Bluetooth HCI stack initialization

This process needs to be performed during every cold boot or hard reset on NEMO.

## UART Auto Baud Rate

The NEMO module can support booting into UART mode without pre-configuration of the baud rate, and clock reference. Although a 26MHz internal crystal oscillator is built into the module, the CSR BlueCore device needs to be configured to use the clock reference for radio and UART communication purposes. The CSR device support an "AUTOBAUD" adaption algorithm where the Host can communicate over the UART link to load configuration PSKEYS into RAM and perform initialization of the module.

The AUTOBAUD UART baud rate adaption mechanism starts by treating the UARTS RXD data line as a simple PIO input, and it records the hosts initial UART traffic in a buffer. The mechanism then examines the recorded data stream to determine the times between signal level transitions and, from this, derives the baud rate the host is using. The mechanism then matches the measured baud rate.

The BCSP stack is used on the host to send sync messages from the host to the NEMO module. The Sync message packet is a reasonably good data set for the analysis to complete, though at high baud rates several sync messages from the BCSP stack may need to be sent.

This AUTOBAUD mechanism must complete before any normal UART traffic is passed to or from the host transport. For example, the BCSP Link Establishment messages described in CSR's BlueCore Serial Protocol document are neither transmitted or responded to until the UART's baud rate has been set by this mechanism.

The mechanism is designed to operate between 38.4 kbaud and 691.2 kbaud. However, testing from CSR has only been concentrated on operation between 56 kbaud and 115.2 kbaud. Implementers are therefore advised to choose a bootup baud rate within these ranges.

During cold boot, the CSR BlueCore device can operate where the systems clock frequency is unknown. This causes BlueCore to run more slowly than normal. Consequently, the range of acceptable baud rates is shifted down pro-rata. The radio is not operational until the external system clock is defined in the PSKEY setting. This is due to the PLL not locking to a known external clock frequency. Therefore, the system clock must be programmed upon boot-up via the PSKEY\_ANA\_FREQ persistent store key in order for the radio to operate.

Operation with an unknown system clock implies dual-boot initialization of NEMO. The approach is for the host to use a safe tested baud rate at the during cold boot (115.2 kbaud), then to set the external clock frequency to 26MHz and the actual baud rate via PSKEYS then issue a "warm reset" command to NEMO over the same UART interface.

Solutions for a Real Time World

For more details on AUTOBAUD rate of the CSR device, please refer to the "UART Baud Rate Adaption (bcore-me-019Pd).pdf" document available from CSR directly.

## Persistent Store Keys (PSKEYS)

Persistent Store Keys are configuration settings that are used to configure and initiate the CSR BlueCore 6 device within NEMO. These PSKEYS are written using the BCCMD protocol to send commands to the CSR BlueCore devices. PSKEY are written using BCCMD write commands that are interpreted by the CSR device within NEMO.

PSKEYS configure the CSR chips behavior from its interfaces to radio performance. Data such as Bluetooth address, product ID and country code is also stored in PSKEYS and are necessary information in some cases. Programming these various PSKEYS are vital to initializing NEMO upon cold boot. PSKEYS are address locations with specific values. The values are used for configuration of different systems of the NEMO.

***Please contact Unigen for a list and file of PSKEYS for the module to match the mode of operation specifically for your application.***

The following are PSKEYS needs to be written and programmed during a cold boot of NEMO as a minimum. For a full PSKEY list for best performance, please contact Unigen support for a PSKEY file.

Table 19: Boot PSKEY List For BCSP Example

PSKEY Name	PSKEY Address	Value	Description
PSKEY_ANA_FREQ	0x01FE	0x6590	This sets CSR BlueCore to use a 26MHz reference clock built into NEMO.
PSKEY_HOST_INTERFACE	0x01f9	0x0001	Sets the Host interface to use BCSP over the UART interface

# NEMO Bluetooth Radio Module

PSKEY_UART_BAUDRATE	0x01be	-	<p>When the system is configured to use a UART-based host transport, i.e. if PSKEY_HOST_INTERFACE selects BCSP, H4, H5 or User (VM access to the UART), then the UART's Baud rate is set to the value of this PS key when the firmware boots. The PS key's value is:</p> <p>Baud rate = pskey_value/0.004096</p> <p>Some common values are:</p> <ul style="list-style-type: none"> <li>38k4 baud - 157 (0x009d)</li> <li>57k6 baud - 236 (0x00ec)</li> <li>115k2 baud - 472 (0x01d8)</li> <li>230k4 baud - 944 (0x03b0)</li> <li>460k8 baud - 1887 (0x075f)</li> <li>921k6 baud - 3775 (0x0ebf)</li> <li>1382k4 baud - 5662 (0x161e)</li> </ul>
PSKEY_BDADDR	0x0001	-	<p>This is the local device's Bluetooth address. This should be unique to this device and allocated by the manufacturer. Bluetooth addresses are distributed by IEEE in the same manner as MAC addresses.</p>
PSKEY_COUNTRYCODE	0x0002	-	<p>North America and most of Europe use a particular block of 79 radio frequencies for Bluetooth, but not all countries allow use of these frequencies. Some countries allow the use of different blocks of frequencies. This key selects the frequency blocks used by these exceptional countries.</p> <p>0 North America and Europe            1 France            2 Spain            3 Japan</p>

PSKEY_DEEP_SLEEP_ EXTERNAL_CLOCK_SOURCE	0x03c3	Enable the use of an external 32kHz clock source for more reliable low power mode and radio synchronization.
PSKEY_PCM_CONFIG32	0x01b3	See Table 6 for more description of this PSKEY.

## TYPICAL APPLICATION CIRCUITS

NEMO with out external 32kHz slow clock source using UART interface with ***BCSP transport serial protocol***. For more information on UART transport serial protocols and selection, please see section "Host Interfaces" in this document.

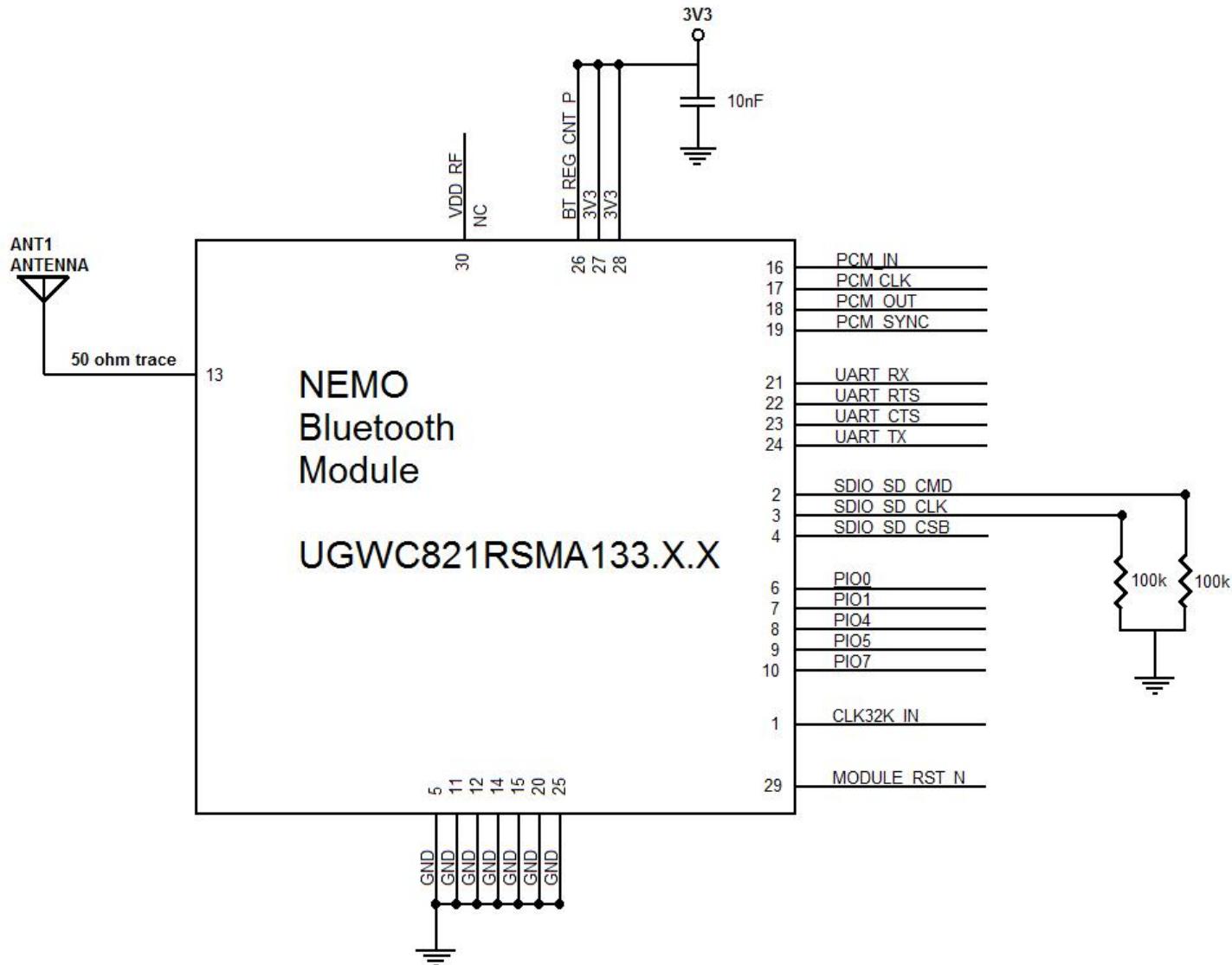


Figure 21: NEMO Example Application Circuit; No External Slow CLK

## MECHANICAL DRAWINGS

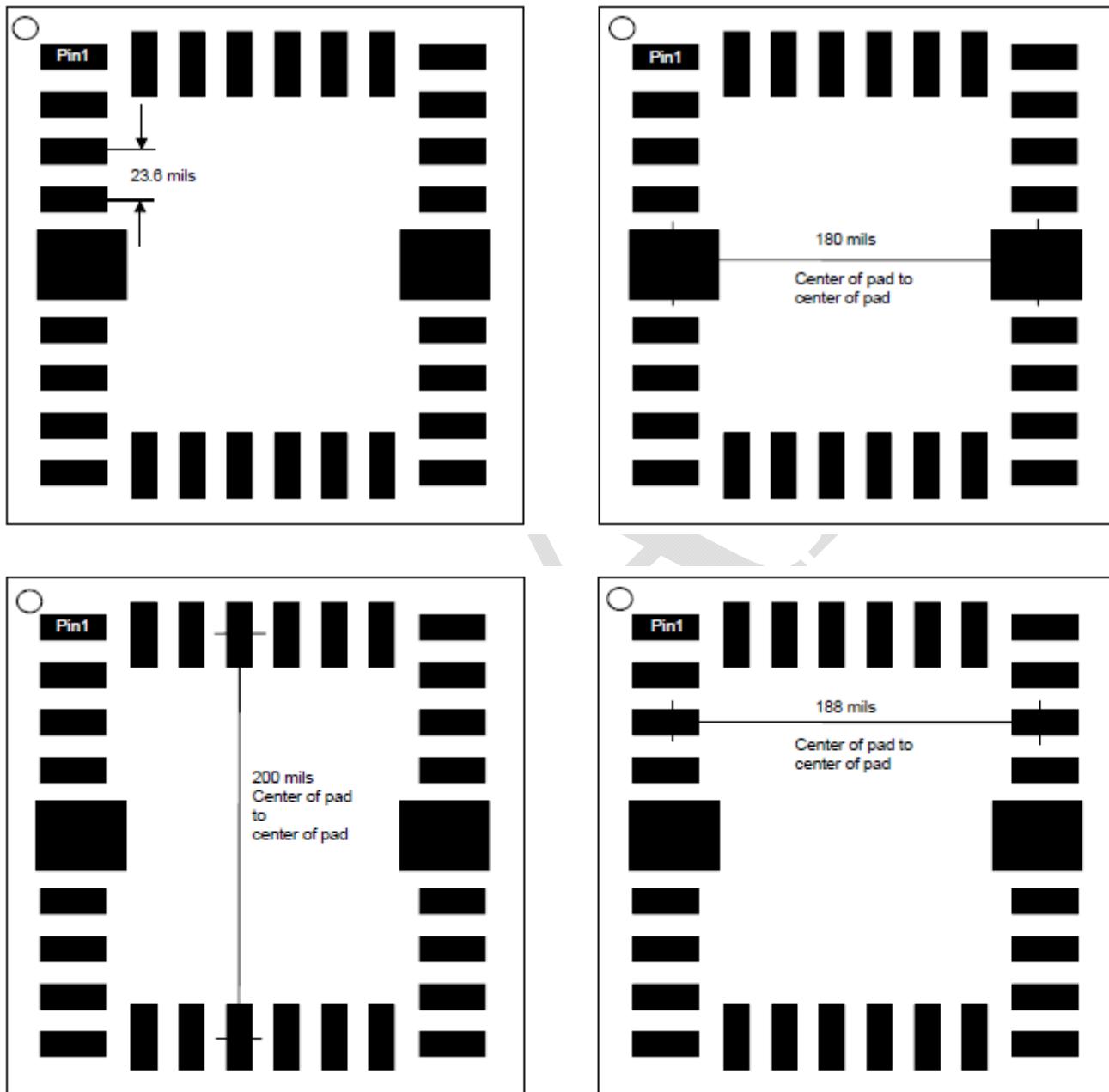
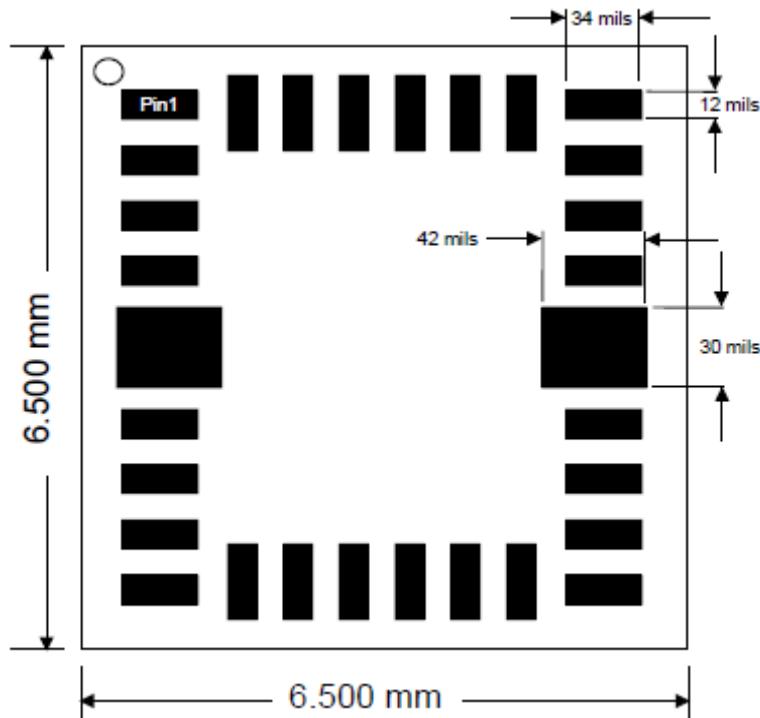
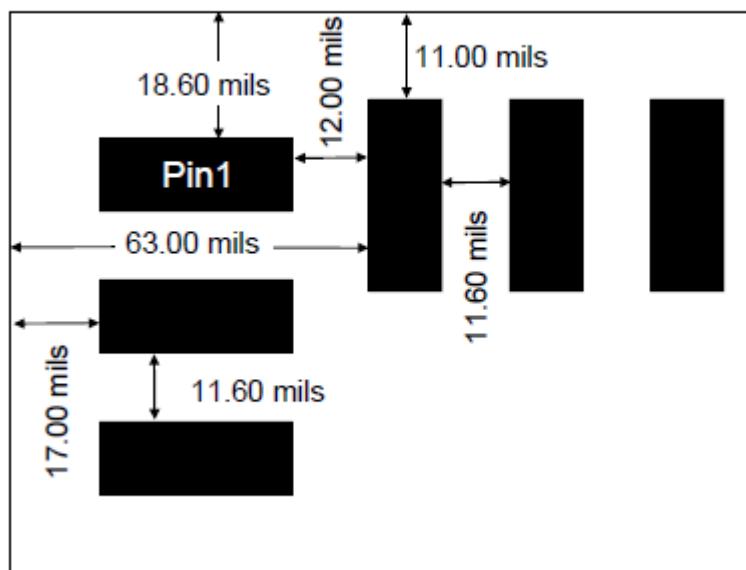
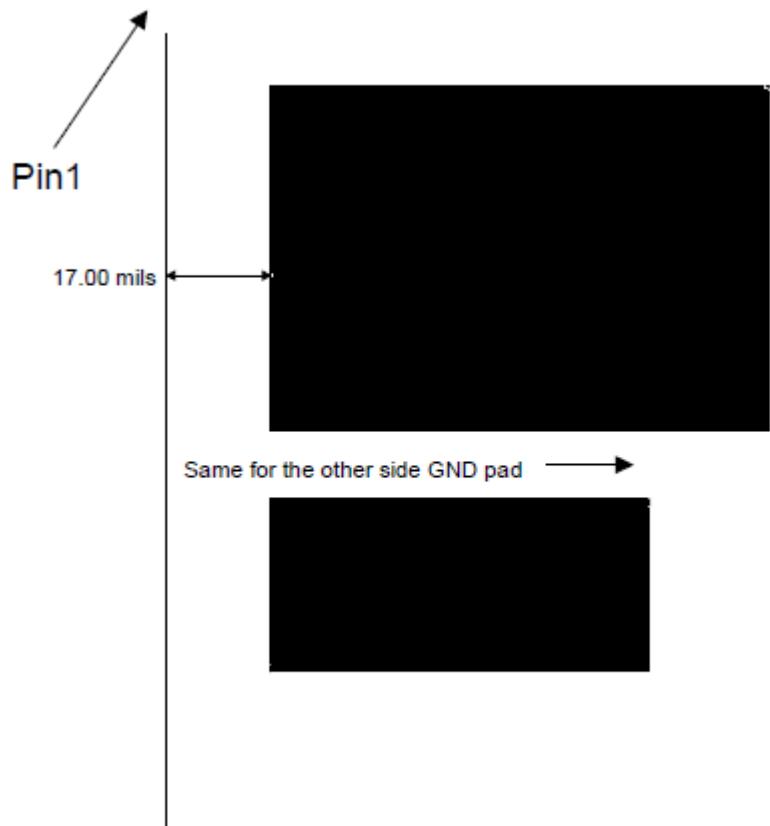


Figure 23: NEMO Mechanical Drawing 1



Distance is from edge of pad to edge of module





DKY

## REFERENCE DOCUMENTATION

Table 20: Reference Documentation

Document	Name	Rev/Date	Source
CSR BlueCore 6 ROM Datasheet	"BC6ROM_WLCSP_CS-113960-DSP12.pdf"	Issue 12	CSR
Firmware Release Note	"BlueCore Unified 23c Release Note (CS-116212-RNP3).pdf"	Issue 3	CSR
AUTOBAUD rate adaption	"UART Baud Rate Adaption (bcore-me-019Pd).pdf"	Jun-05	CSR
BCSP	"BlueCore Serial Protocol (bcore-sp-012Pb).pdf"	Jul-04	CSR
BCCMD	"BCCMD Protocol (bcore-sp-002Pc).pdf"	Jul-04	CSR

## CONTACT INFORMATION

### CORPORATE HEADQUARTERS

Unigen Corporation  
45388 Warm Springs Boulevard  
Fremont, CA 94539

Telephone: 1 (510) 688-2088  
Fax: 1 (510) 668-2788  
Email: Support@unigen.com  
Web: www.unigen.com  
Toll Free: 1 (800) 826-0808