4 Electrical Characteristics

Absolute Maximum Ratings		
Rating	**Min**	**Max**
Storage Temperature	-40°C	+150°C
Supply Voltage: VDD_RADIO, VDD_VCO, VDD_ANA, VDD_CORE	-0.40V	1.90V
Supply Voltage: VDD_PADS, VDD_PIO, VDD_MEM	-0.40V	3.60V

Recommended Operating Conditions		
Operating Condition	**Min**	**Max**
Operating Temperature Range(1)	-40°C	105°C
Supply Voltage: VDD_RADIO, VDD_VCO, VDD_ANA, VDD_CORE	1.70V	1.90V
Supply Voltage: VDD_PADS, VDD_PIO, VDD_MEM	1.70V	3.60V

Note:

(1) The device functions across this range. See RF characteristics for guaranteed performance over temperature.

Input/Output Terminal Characteristics				
Digital Terminals	**Min**	**Typ**	**Max**	**Unit**
Input Voltage				
V_{IL} input logic level low (VDD=3.0V)	-0.4		+0.8	V
(VDD=1.8V)	-0.4	-	+0.4	V
V_{IH} input logic level high	0.7VDD	-	VDD+0.4	V
Output Voltage				
V_{OL} output logic level low, (I_O = 4.0mA), VDD=3.0V	-	-	0.2	V
V_{OL} output logic level low, (I_O = 4.0mA), VDD=1.8V	-	-	0.4	V
V_{OH} output logic level high, (I_O = -4.0mA), VDD=3.0V	VDD-0.2	-	-	V
V_{OH} output logic level high, (I_O = -4.0mA), VDD=1.8V	VDD-0.4	-	-	V
Input and Tristate Current with:				
Strong pull-up	-100	-20	-10	µA
Strong pull-down	+10	+20	+100	µA
Weak pull-up	-5	-1	0	µA
Weak pull-down	0	+1	+5	µA
I/O pad leakage current	-1	0	+1	µA
C_I Input Capacitance	2.5	-	10	pF

Input/Output Terminal Characteristics (Continued)				
USB Terminals	**Min**	**Typ**	**Max**	**Unit**
Input threshold				
V_{IL} input logic level low	-	-	0.3VDD_PADS	V
V_{IH} input logic level high (VDD_PADS=3.46V)[2]	0.7VDD_PADS	-	-	V
Input leakage current				
VSS_PADS< VIN< VDD_PADS[1]	-1	-	1	µA
C_I Input capacitance	2.5	-	10	pF
Output levels to correctly terminated USB Cable				
V_{OL} output logic level low	0	-	0.2	V
V_{OH} output logic level high	2.8	-	VDD_PADS	V

Notes:

VDD_CORE, VDD_RADIO, VDD_VCO and VDD_ANA are at 1.8V unless shown otherwise

VDD_PADS, VDD_PIO and VDD_MEM are at 3.0V unless shown otherwise

Current drawn into a pin is defined as positive; current supplied out of a pin is defined as negative.

(1) Internal USB pull-up disabled.

(2) 3.46V = 3.3V+5%.

Input/Output Terminal Characteristics (Continued)				
Auxiliary DAC, 8-Bit Resolution	**Min**	**Typ**	**Max**	**Unit**
Resolution	-	-	8	Bits
Average output step size[1]	12.5	14.5	17.0	mV
Output Voltage		monotonic[1]		
Voltage range (I_O=0)	VSS_PIO	-	VDD_PIO	V
Current range	-10	-	+0.1	mA
Minimum output voltage (I_O=100µA)	0	-	0.2	V
Maximum output voltage (I_O=10mA)	VDD_PIO-0.3	-	VDD_PIO	V
High Impedance leakage current	-1	-	+1	µA
Offset	-220	-	+120	mV
Integral non-linearity[1]	-2	-	+2	LSB
Starting time (50pF load)	-	-	10	µs
Settling time (50pF load)	-	-	5	µs

Input/Output Terminal Characteristics (Continued)				
Crystal Oscillator	**Min**	**Typ**	**Max**	**Unit**
Crystal frequency [2]	8.0	-	32.0	MHz
Digital trim range [3]	5	6.2	8	pF
Trim step size [3]	-	0.1	-	pF
Transconductance	2.0	-	-	mS
Negative resistance [4]	870	1500	2400	Ω

Input/Output Terminal Characteristics (Continued)				
Power-on reset	**Min**	**Typ**	**Max**	**Unit**
VDD falling threshold	1.40	1.50	1.60	V
VDD rising threshold	1.50	1.60	1.70	V
Hysteresis	0.05	0.10	0.15	V

Notes:

VDD_CORE, VDD_RADIO, VDD_VCO and VDD_ANA are at 1.8V unless shown otherwise

VDD_PADS, VDD_PIO and VDD_MEM are at 3.0V unless shown otherwise

The same setting of the digital trim is applied to both XTAL_IN and XTAL_OUT.

Current drawn into a pin is defined as positive, current supplied out of a pin is defined as negative.

[1] Specified for an output voltage between 0.2V and VDD_PIO -0.2V

[2] Integer multiple of 250kHz.

[3] The difference between the internal capacitance at minimum and maximum settings of the internal digital trim.

[4] XTAL frequency = 16MHz; XTAL C_0 = 0.75pF; XTAL load capacitance = 8.5pF

Average Current Consumption [1]		
VDD=1.8V Temperature = 20°C		
Mode	**Avg**	**Unit**
SCO connection HV3 (40ms interval Sniff Mode) (Slave)	26.0	mA
SCO connection HV3 (40ms interval Sniff Mode) (Master)	26.0	mA
SCO connection HV1 (Slave)	53.0	mA
SCO connection HV1 (Master)	53.0	mA
ACL data transfer 115.2kbps UART (Master)	15.5	mA
ACL data transfer 720kbps USB (Slave)	53.0	mA
ACL data transfer 720kbps USB (Master)	53.0	mA
ACL connection, Sniff Mode 40ms interval, 38.4kbps UART	4.0	mA
ACL connection, Sniff Mode 1.28s interval, 38.4kbps UART	0.5	mA
Parked Slave, 1.28s beacon interval, 38.4kbps UART	0.6	mA
Standby Mode (Connected to host, no RF activity)	0.047	mA

Peak Current Consumption [1]			
VDD=1.7V to 1.9V Temperature = 20°C			
Mode	**Typ**	**Max [2]**	**Unit**
Peak RF current during TX burst (+6 dBm)	65.0	80.0	mA
Peak RF current during TX burst (0 dBm)	57.0	70.0	mA
Peak RF current during RX burst (-85 dBm)	47.0	70.0	mA

Deep Sleep Leakage Current			
VDD=1.7V to 1.9V Temperature = 20°C			
Mode	**Typ**	**Max [2]**	**Unit**
Deep Sleep	20.0	50.0	µA

Notes:

[1] Current consumption is the sum of both BC212015B and the flash.

[2] Over process and voltage.

These results are correct only for BlueCore2-External version B running version 14.x firmware.

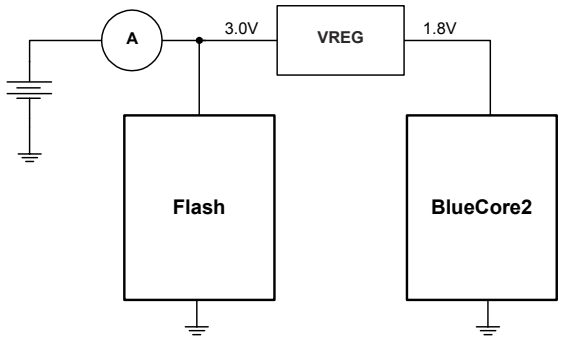

Figure 4.1: Current Measurement Circuit

5 Radio Characteristics

All radio characteristics were measured using the application circuit shown in figure 11.1 but with the RF filter removed. This circuit and associated RF board layout is correct for the 8×8 package. Other package types have slightly different RF impedance's as shown in Section 9 of this document and therefore need slightly different matching.

BlueCore2-External meets the Bluetooth specification when used in a suitable application circuit between -40°C and +85°C.

Radio Characteristics, VDD = 1.8V Temperature = +20°C						
	Frequency (GHz)	**Min**	**Typ**	**Max**	**Bluetooth Specification**	**Unit**
Sensitivity at 0.1% BER	2.402	-	-83	-80	≤-70	dBm
	2.441	-	-85	-82		dBm
	2.480	-	-85	-82		dBm
Maximum received signal at 0.1% BER	2.402	0	-	-	≥-20	dBm
	2.441	0	-	-		dBm
	2.480	0	-	-		dBm
RF transmit power (1)	2.402	3.0	6.0	-	-6 to +4(2)	dBm
	2.441	3.0	6.0	-		dBm
	2.480	3.0	6.0	-		dBm
Initial carrier frequency tolerance	2.402	-	12	75	±75	kHz
	2.441	-	10	75		kHz
	2.480	-	9	75		kHz
20dB bandwidth for modulated carrier	2.402	-	879	1000	≤1000	kHz
	2.441	-	816	1000		kHz
	2.480	-	819	1000		kHz
Drift (single slot packet)	2.402	-	-	25	≤25	kHz
	2.441	-	-	25		kHz
	2.480	-	-	25		kHz
Drift (five slot packet)	2.402	-	-	40	≤40	kHz
	2.441	-	-	40		kHz
	2.480	-	-	40		kHz
Drift Rate	2.402	-	-	20	20	kHz/50 µs
	2.441	-	-	20		kHz/50 µs
	2.480	-	-	20		kHz/50 µs
RF power control range		16	35	-	≥16	dB
RF power range control resolution		-	1.8	-	-	dB

Radio Characteristics, VDD = 1.8V Temperature = +20°C						
	Frequency (GHz)	**Min**	**Typ**	**Max**	**Bluetooth Specification**	**Unit**
$\Delta f1_{avg}$ "Maximum Modulation"	2.402	140	165	175	140<$\Delta f1_{avg}$<175	kHz
	2.441	140	165	175		kHz
	2.480	140	165	175		kHz
$\Delta f2_{max}$ "Minimum Modulation"	2.402	115	150	-	115	kHz
	2.441	115	150	-		kHz
	2.480	115	150	-		kHz
C/I co-channel		-	10	11	≤11	dB
Adjacent channel selectivity C/I $F=F_0+1MHz$ (3) (5)		-	-4	0	≤0	dB
Adjacent channel selectivity C/I $F=F_0-1MHz$ (3) (5)		-	-4	0	≤0	dB
Adjacent channel selectivity C/I $F=F_0+2MHz$ (3) (5)		-	-35	-30	≤-30	dB
Adjacent channel selectivity C/I $F=F_0-2MHz$ (3) (5)		-	-21	-20	≤-20	dB
Adjacent channel selectivity C/I $F\geq F_0+3MHz$ (3) (5)		-	-45	-	≤-40	dB
Adjacent channel selectivity C/I $F\leq F_0-5MHz$ (3) (5)		-	-45	-	≤-40	dB
Adjacent channel selectivity C/I $F=F_{Image}$ (3) (5)		-	-18	-9	≤-9	dB
Adjacent channel transmit power $F=F_0\pm2MHz$ (4) (5)		-	-35	-20	≤-20	dBc
Adjacent channel transmit power $F=F_0\pm3MHz$ (4) (5)		-	-55	-40	≤-40	dBc

Notes:

(1) BlueCore2-External firmware maintains the transmit power to be within the Bluetooth specification v1.1 limits.

(2) Class 2 RF transmit power range, Bluetooth specification v1.1

(3) Up to five exceptions are allowed in v1.1 of the Bluetooth specification

(4) Up to three exceptions are allowed in v1.1 of the Bluetooth specification

(5) Measured at F_0 = 2441MHz

Radio Characteristics, VDD = 1.8V Temperature = -40°C						
	Frequency (GHz)	**Min**	**Typ**	**Max**	**Bluetooth Specification**	**Unit**
Sensitivity at 0.1% BER	2.402	-	-83	-78	≤-70	dBm
	2.441	-	-85	-78		dBm
	2.480	-	-85	-78		dBm
Maximum received signal at 0.1% BER	2.402	0	-	-	≥-20	dBm
	2.441	0	-	-		dBm
	2.480	0	-	-		dBm
RF transmit power (1)	2.402	3.5	7.0	-	-6 to +4 (2)	dBm
	2.441	3.5	7.0	-		dBm
	2.480	3.5	7.0	-		dBm
Initial carrier frequency tolerance	2.402	-	15	75	±75	kHz
	2.441	-	15	75		kHz
	2.480	-	15	75		kHz
20dB bandwidth for modulated carrier	2.402	-	862	1000	≤1000	kHz
	2.441	-	830	1000		kHz
	2.480	-	828	1000		kHz
Drift (single slot packet)	2.402	-	-	25	≤25	kHz
	2.441	-	-	25		kHz
	2.480	-	-	25		kHz
Drift (five slot packet)	2.402	-	-	40	≤40	kHz
	2.441	-	-	40		kHz
	2.480	-	-	40		kHz
Drift Rate	2.402	-	-	20	20	kHz/50µs
	2.441	-	-	20		kHz/50µs
	2.480	-	-	20		kHz/50µs
$\Delta f1_{avg}$ "Maximum Modulation"	2.402	140	165	175	$140<\Delta f1_{avg}<175$	kHz
	2.441	140	165	175		kHz
	2.480	140	165	175		kHz
$\Delta f2_{max}$ "Minimum Modulation"	2.402	115	150	-	115	kHz
	2.441	115	150	-		kHz
	2.480	115	150	-		kHz
RF power control range		16	35	-	≥16	dB
RF power range control resolution		-	1.8	-	-	dB

Note:

The RF characteristics at –40°C are only guaranteed for BlueCore2-External version B.

Radio Characteristics, VDD = 1.8V Temperature = -20°C						
Receiver	**Frequency (GHz)**	**Min**	**Typ**	**Max**	**Bluetooth Specification**	**Unit**
Sensitivity at 0.1% BER	2.402	-	-83	-80	≤-70	dBm
	2.441	-	-85	-82		dBm
	2.480	-	-85	-82		dBm
Maximum received signal at 0.1% BER	2.402	0	-	-	≥-20	dBm
	2.441	0	-	-		dBm
	2.480	0	-	-		dBm
RF transmit power (1)	2.402	3.5	6.5	-	-6 to +4 (2)	dBm
	2.441	3.5	6.5	-		dBm
	2.480	3.5	6.5	-		dBm
Initial carrier frequency tolerance	2.402	-	18	75	±75	kHz
	2.441	-	17	75		kHz
	2.480	-	18	75		kHz
20dB bandwidth for modulated carrier	2.402	-	906	1000	≤1000	kHz
	2.441	-	844	1000		kHz
	2.480	-	819	1000		kHz
Drift (single slot packet)	2.402	-	-	25	≤25	kHz
	2.441	-	-	25		kHz
	2.480	-	-	25		kHz
Drift (five slot packet)	2.402	-	-	40	≤40	kHz
	2.441	-	-	40		kHz
	2.480	-	-	40		kHz
Drift Rate	2.402	-	-	20	20	kHz/50µs
	2.441	-	-	20		kHz/50µs
	2.480	-	-	20		kHz/50µs
$\Delta f1_{avg}$ "Maximum Modulation"	2.402	140	165	175	$140<\Delta f1_{avg}<175$	kHz
	2.441	140	165	175		kHz
	2.480	140	165	175		kHz
$\Delta f2_{max}$ "Minimum Modulation"	2.402	115	150	-	115	kHz
	2.441	115	150	-		kHz
	2.480	115	150	-		kHz
RF power control range		16	35	-	≥16	dB
RF power range control resolution		-	1.8	-	-	dB

Radio Characteristics, VDD = 1.8V Temperature = +85°C						
Receiver	**Frequency (GHz)**	**Min**	**Typ**	**Max**	**Bluetooth Specification**	**Unit**
Sensitivity at 0.1% BER	2.402	-	-81	-78	≤-70	dBm
	2.441	-	-83	-80		dBm
	2.480	-	-83	-80		dBm
Maximum received signal at 0.1% BER	2.402	0	-	-	≥-20	dBm
	2.441	0	-	-		dBm
	2.480	0	-	-		dBm
RF transmit power [1]	2.402	0	3.5	-	-6 to +4[2]	dBm
	2.441	0	3.5	-		dBm
	2.480	0	3.5	-		dBm
Initial carrier frequency tolerance	2.402	-	30	75	±75	kHz
	2.441	-	31	75		kHz
	2.480	-	32	75		kHz
20dB bandwidth for modulated carrier	2.402	-	853	1000	≤1000	kHz
	2.441	-	813	1000		kHz
	2.480	-	801	1000		kHz
Drift (single slot packet)	2.402	-	-	25	≤25	kHz
	2.441	-	-	25		kHz
	2.480	-	-	25		kHz
Drift (five slot packet)	2.402	-	-	40	≤40	kHz
	2.441	-	-	40		kHz
	2.480	-	-	40		kHz
Drift Rate	2.402	-	-	20	20	kHz/50µs
	2.441	-	-	20		kHz/50µs
	2.480	-	-	20		kHz/50µs
$\Delta f1_{avg}$ "Maximum Modulation"	2.402	140	165	175	$140<\Delta f1_{avg}<175$	kHz
	2.441	140	165	175		kHz
	2.480	140	165	175		kHz
$\Delta f2_{max}$ "Minimum Modulation"	2.402	115	150	-	115	kHz
	2.441	115	150	-		kHz
	2.480	115	150	-		kHz
RF power control range		16	35	-	≥16	dB
RF power range control resolution		-	1.8	-	-	dB

Notes:

[1] BlueCore2-External firmware maintains the transmit power to be within the Bluetooth specification v1.1 limits.

[2] Class 2 RF transmit power range, Bluetooth specification v1.1

6 Device Diagram

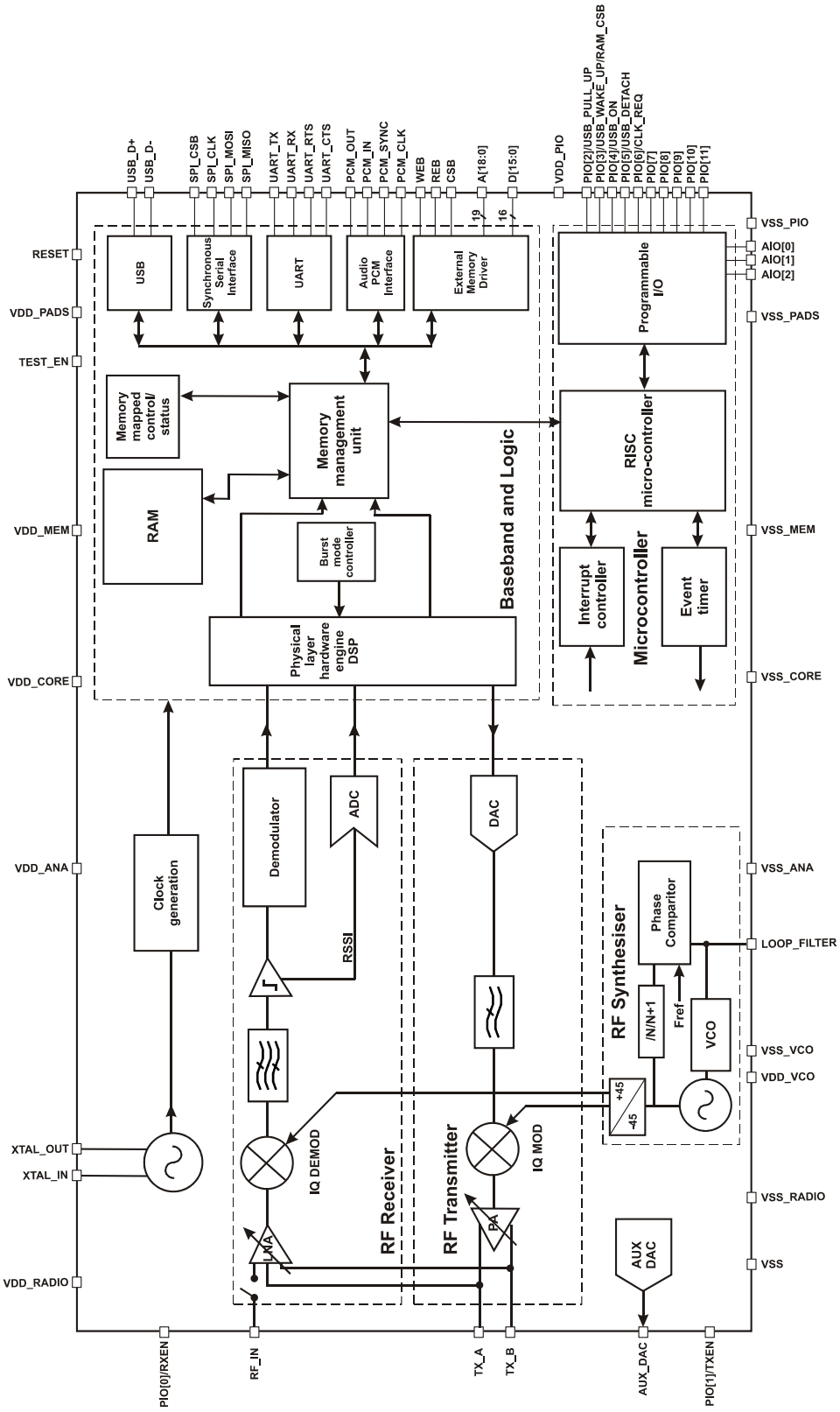

Figure 6.1: BlueCore2-External Device Diagram

7 Description of Functional Blocks

7.1 RF Receiver

The receiver features a near-zero Intermediate Frequency (IF) architecture that allows the channel filters to be integrated on to the die. Sufficient out-of-band blocking specification at the Low Noise Amplifier (LNA) input allows the radio to be used in close proximity to Global System for Mobile Communications (GSM) and Wideband Code Division Multiple Access (W-CDMA) cellular phone transmitters without being desensitised. The use of a digital Frequency Shift Keying (FSK) discriminator means that no discriminator tank is needed and its excellent performance in the presence of noise allows BlueCore2-External to exceed the Bluetooth requirements for co-channel and adjacent channel rejection.

7.1.1 Low Noise Amplifier

The LNA can be configured to operate in single-ended or differential mode. Single-ended mode is used for Class 1 Bluetooth operation; differential mode is used for Class 2 operation.

7.1.2 Analogue to Digital Converter

The Analogue to Digital Converter (ADC) is used to implement fast Automatic Gain Control (AGC). The ADC samples the Received Signal Strength Indicator (RSSI) voltage on a slot-by-slot basis. The front-end LNA gain is changed according to the measured RSSI value, keeping the first mixer input signal within a limited range. This improves the dynamic range of the receiver, improving performance in interference limited environments.

7.2 RF Transmitter

7.2.1 IQ Modulator

The transmitter features a direct IQ modulator to minimise the frequency drift during a transmit timeslot which results in a controlled modulation index. A digital baseband transmit filter provides the required spectral shaping.

7.2.2 Power Amplifier

The internal Power Amplifier (PA) has a maximum output power of +6dBm allowing BlueCore2-External to be used in Class 2 and Class 3 radios without an external RF PA. Support for transmit power control allows a simple implementation for Class 1 with an external RF PA.

7.3 RF Synthesiser

The radio synthesiser is fully integrated onto the die with no requirement for an external Voltage Controlled Oscillator (VCO) screening can, varactor tuning diodes or LC resonators.

7.4 Baseband and Logic

7.4.1 Memory Management Unit

The Memory Management Unit (MMU) provides a number of dynamically allocated ring buffers that hold the data which is in transit between the host and the air or vice versa. The dynamic allocation of memory ensures efficient use of the available Random Access Memory (RAM) and is performed by a hardware MMU to minimise the overheads on the processor during data/voice transfers.

7.4.2 Burst Mode Controller

During radio transmission the Burst Mode Controller (BMC) constructs a packet from header information previously loaded into memory-mapped registers by the software and payload data/voice taken from the appropriate ring buffer in the RAM. During radio reception, the BMC stores the packet header in memory-mapped registers and the payload data in the appropriate ring buffer in RAM. This architecture minimises the intervention required by the processor during transmission and reception.

7.4.3 Physical Layer Hardware Engine DSP

Dedicated logic is used to perform the following:

- Forward error correction
- Header error control
- Cyclic redundancy check
- Encryption
- Data whitening
- Access code correlation
- Audio transcoding

The following voice data translations and operations are performed by firmware:

- A-law/μ-law/linear voice data (from host)
- A-law/μ-law/Continuously Variable Slope Delta (CVSD) (over the air)
- Voice interpolation for lost packets
- Rate mismatches

7.4.4 RAM

32Kbytes of on-chip RAM is provided and is shared between the ring buffers used to hold voice/data for each active connection and the general purpose memory required by the Bluetooth stack.

7.4.5 External Memory Driver

The External Memory Driver interface can be used to connect to the external Flash memory and also to the optional external RAM for memory intensive applications.

7.4.6 USB

This is a full speed Universal Serial Bus interface for communicating with other compatible digital devices. BlueCore2-External acts as a USB peripheral, responding to requests from a Master host controller such as a PC.

7.4.7 Synchronous Serial Interface

This is a synchronous serial port interface for interfacing with other digital devices. The SPI port can be used for software debugging and for programming the external Flash memory.

7.4.8 UART

This is a standard Universal Asynchronous Receiver Transmitter (UART) interface for communicating with other serial devices.

7.4.9 Audio PCM Interface

The Audio Pulse Code Modulation (PCM) Interface supports continuous transmission and reception of PCM encoded audio data over Bluetooth.

7.5 Microcontroller

The microcontroller, interrupt controller and event timer run the Bluetooth software stack and control the radio and host interfaces. A 16-bit Reduced Instruction Set Computer (RISC) microcontroller is used for low power consumption and efficient use of memory.

7.5.1 Programmable I/O

BlueCore2-External has a total of 15 (12 digital and 3 analogue) programmable I/O terminals. These are controlled by firmware running on the device.