PICO-BTS EQUIPMENT DESCRIPTION

(800MHZ CELLULAR BANDS)

Rev: 1.0

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Glossary

AC	Alternate Current
ACC	Analog Common Circuit, replaced by BAC
ACCA	Analog Common Card Assembly
ACE	Access Channel Element
ACRP	Adjacent Channel Power Rejection
ADC	Analog To Digital
AGC	Automatic Gain Controller
ANT	Antenna
BAC	Baseband Analog Circuit, replacing ACC
BBU	Base Band Unit
BCP	BTS Control Processor
BCM	BTS Configuration Management
BCOX	BTS Call Control Execution
BDAX	BCP Data Access Execution
BDC	Baseband Digital Card
BDIAX	BTS Diagnostic Execution
BDTU	BTS Diagnostic & Test Unit
BFMX	BTS Fault Management Execution
BIH	Backhaul Interface Handler - Software
BIU	Backhaul Interface Unit
BMEA	BCP Measurement
BLINK	BTS Link
BPF	Band Pass Filter
BPLX	BCP Processor Loader Execution
BRAX	BTS Resource Allocation Execution
BRMX	BTS Resource Management Execution
BS	Base Station
BSC	Base Station Controller
BSHX	BTS Status Handler Execution
BSM	Base Station Manager
BTS	Base Transceiver System
BW	Band Width
CAI	Common Air Interface
CCC	Channel Card Common, replaced by CEC
CCP	Call Control Processor
CDIAX	CCP Diagnostic Execution
CDMA	Code Division Multiple Access
CDMX	Configuration Data Management Execution
CE	Channel Element
CEC	Channel Element Controller, replacing CCC
CFMX	CCP Fault Management Execution
CMEA	CCP Measurement
CPLX	CCP Processor Loader Execution
CRAX	CCP Resource Allocation Execution
CSHX	CCP Status Handler Execution

CSM	Cell Site Modem
DAC	Digital to Analog Converter
DC	Direct Current
DD	Detailed Design
DDS	Direct Digital Synthesis
DM	Diagnostic Monitor
DU	Digital Unit
EMI	Electrical Magnetic Interface
FA	Frequency Allocation
FIFO	First-In-First-Out
FPGA	Field-Programmable-Gate_Array
GPIO	General Purpose Input / Output
GPS	Global Position System
HDLC	High Level Data Link Control
HLD	High Level Design
I	In_Phase
IF	Intermediate Frequency
IMC	Inter Module Communication
IMCB	Inter Module Communication Bus
IMCH	Inter Module Communication Handler - Software
IPC	Inter Processor Communication
LCIN	Local CCP Interconnection Network
LED	Light Emitting Diode
LNA	Low Noise Amplifier
LO1	Local Oscillator 1
LO2	Local Oscillator 2
LPA	Linear Power Amplifier
LPF	Low Pass Filter
MFP	Multi-Function Peripheral
MLNK	MSC Link
MMI	Man Machine Interface
MRB	Monitor/Report Block
MS	Mobile Station
MSC	Mobile Switch Center
MSPS	Mega Sample Per Second
MTBF	Mean Time Between Failure
MUX	Multiplexor
MVIP	Multiple Vendor Integrated Protocol
OC	Overload Controller
OPAID	Operation AID
PA	Power Amplifier
PCI	Peripheral Communication Interface
PCE	Paging Channel Element
PCS	Personal Communication System
PN	Pseudo-Noise Sequence
PLD	Program Load Data
PLL	Phase Lock Loop
PLX	Process Loading Execution
PP2S/	Pulse Per Two Second
PSCE	Pilot_Sync Channel Element

PSU	Power Subsystem Unit
PSU	Power Subsystem Unit
Q	Quadrature
RF	Radio Frequency
RFC	Radio Frequency Controller
RFFE	RF Front End
RFU	Radio Frequency Unit
ROM	Read Only Memory
RxFE	Receiver Front End
RxIF	Receiver IF
SCC	Serial Communication Controller
SIP	Selector Interface Processor
SNR	Signal To Noise Ratio
SRAM	Static Read Only Memory
SVE	Selector Vocoder Element
SVP	Selector Vocoder Processor
TBD	To Be Determined
T_BLK	Test Block
TCE	Traffic Channel Element
TDM	Time Division Multiplexing
TFC	Time & Frequency Controller
TxIF	Transmitter IF
TxFE	Transmitter Front End
TFU	Time and Frequency Unit
TSB	Transcoder Selector Bank
UART	Universal Asynchronous Receiver Transmitter
XCVC	Radio Frequency Transceiver

1. INTRODUCTION

1.1 Scope

This document describes the Pico Base Transceiver Station for CDMA cellular systems. The Pico-BTS provides the interface between the CDMA cellular mobile stations and the Base Station Controller (BSC) to form a Picocell. Picocells are used to enhance the coverage by covering the "dead spot" caused by shadowing in traditional "macrocell" based cellular networks. Also Picocells can be used to increase the capacity of the network as small underlay cells, providing more channels for traffic in dense urban areas with high volume of low speed traffic, such as malls, airports, train and subway stations, hotels, and office building areas.

1.2 Applicable Documents and Standards

1. TIA/EIA/IS-95-A, Mobile Station-Base Station Compatibility Standard for Dual-ModeWideband Spread Spectrum Cellular System, May 1995.
2. TIA/EIA/IS-97-A, Minimum Performance Standards for Base Stations Supporting Dual-Mode Wideband Spread Spectrum Cellular Mobile Stations, June 1997.
3. EIA/TIA IS-634, MSC-BS Interface for Public Wireless Communications Systems
4. NEMA 4X
5. ANSI 6241 Class B
6. FCC Part 15 for USA
7. FCC ICES-003 for Canada
8. FCC Part 22 in cellular band
9. FCC Part 68
10. FCC Part 2
11. TA-NWT-000487 R-127
12. TA-NWT-000063 R98
13. EIA/TIA IS-125, Recommended Minimum Performance Standard for Digital Cellular Wideband Spread Spectrum Speech Service Option 1.
14. EIA/TIA IS-126A, Mobile Station Loopback Service Option Standard

2. SPECIFICATIONS

The system requirements for the Pico-BTS are described in this chapter.

2.1 Functional Specifications

2.1.1 Operating Frequency

The Pico-BTS operates at frequencies specified in the following table.

Table 2.1.1-1 Operating Frequency

Unit	Frequency Range (MHz)
Transmitter	869 - 894
Receiver	824 - 849

The Pico-BTS can cover all sub-bands only replacing the duplexer / BFP.

2.1.2 Interface Specification

2.1.2.1 Air Interface

The Pico BTS shall comply with EIA/TIA/IS-95-A.

2.1.2.2 Backhaul(A-bis) Interface

The interface between the Pico-BTS and the BSC, i.e., A-bis interface, shall comply with Hyundai's CDMA Cellular BSC-BTS interface.

2.1.3 Operational and Maintenance

2.1.3.1 Operation/Configuration Management

The Pico-BTS is able to manage the data related to the operation and configuration of its subsystems. Some examples are as follows:

- Initial loading
- Radio resource management
- hardware configuration data management
- CDMA parameter management

2.1.3.2 Performance Management

The Pico-BTS is able to collect and analyze data related to the performance of the system, and send them to the appropriate higher level entity for management. Some examples are as follows:

- Call processing related parameters statistics collection
- Radio performance related parameters statistics collection
- Periodic reporting

2.1.3.3 Maintenance Management

The Pico-BTS is able to perform the detection, isolation, and restoration of elements operating abnormally. Some examples follow.

- Fault detection and management
- Alarm generation and processing
- Periodic test of maintenance/diagnosis
- Status management

2.1.4 Configuration Features

- The system supports one FA, omni-cell, or unidirectional sectored cell. It uses directional antenna to serve a sector.
- A 3-sector cell site can be configured with 3 Pico-BTSs as primary equipment in each direction. When any sectors need more capacity, additional Pico BTSs can be stacked on each sector separately. Multiple Pico-BTS can be daisy-chained using one T1/E1 trunk to BSC.
- The Pico BTS can serve as a stand-alone cell site, or it can be overlaid by another CDMA macro-cell.
- Due to the small capacity of the Pico-BTS, the backhaul efficiency may be a concern from the economic point of view. In order to avoid this, multiple Pico BTSs shall be able to share a single backhaul transmission facility.
- Any one of the channel elements may be configured to support one of the following:
    - ◊ A pilot channel and a sync channel
    - ◊ An access channel
    - ◊ A paging channel
    - ◊ A traffic channel

2.2 Performance Specification

2.2.1 System Delay

The total round-trip delay for the voice path, including the delay in the BSC, is less than 220 ms. A suggested delay budget for the reverse link path and the forward link path is as follows:

Table 2.2.1-1 Base Station Delay Budget

Reverse Link	Delay (ms)	Forward Link	Delay (ms)
Mobile Station	51	Mobile Station	18
Air Link	20	Air Link	20
Digital Unit	18	Digital Unit	2
Backhaul/Switching	6	CIN	8
TSB	1	TSB	1
Vocoder	3	Vocoder	49
Total	99	Total	98

2.2.2 Capacity

The Pico BTS is capable of physically supporting up to 32 channel elements, including all of the overhead channels.

2.3 Electrical Performance

2.3.1 Transmitter RF Power

The maximum CDMA power does not exceed 10 watts at the antenna port on the enclosure over operating temperature range.

2.3.2 Electric Power

2.3.2.1 Primary Power

The primary power source (or mains) for the Pico BTS is the commercial power which can be acquired very easily. The nominal voltage may be 120VAC, 60Hz, single phase. The power subsystem in the Pico BTS is capable of converting this commercial AC power into DC power with nominal voltage of +48V. The +48 DC is then converted into lower voltages such as +5V, +12V, -12V, +3.3V and +7.5V to be used in each subsystem.

The AC input ranges and the maximum power source requirement are as follows:

Table 2.3.2-1 Primary Power AC Input Voltage Range Requirement

Nominal Voltage	Voltage Range	Frequency Range	Phases
120VAC	108 to 132 VAC	54 to 66 Hz	single
220VAC	198 to 242 VAC	54 to 66Hz	single

Table 2.3.2-2 Maximum Primary Power Output Requirement

Voltage	Current	Comments
DC +48 V	Max 10 A	For RF power 8 watts

2.3.2.2 Battery Backup Power (Optional)

The Pico BTS shall have battery backup to cope with AC power failure. The battery shall be monitored during normal operation, and charged if necessary. The Optional backup battery is provided with an external compartment.

` Table 2.3.2-3 Battery Power Requirement

Configuration	DC Current/Power	Comments
Nominal RF Power 5 watt	5 Amps/240 VA	up to 4 Hours backup
Optional RF Power	10 Amps/480 VA	up to 4 Hours backup

2.4 Physical Specifications

Table 2.4-1 Physical Specifications

Configuration	Specifications
Size	Max. depth: 12 inched height: 32 in width: 22 in
Weight	max. 110 pounds
Mounting Location	pad, pole, wall, or vault

2.5 Environmental Specifications

The Pico BTS will meet the extended environmental specifications in rugged outdoor conditions. The following table summarizes the environmental specifications:

Table 2.5-1 Environmental Specifications

Configuration	Specifications	Comments
Environmental Sealing	NEMA 4X	
Lightning Protection	ANSI 6241 Class B	
Climatic Environment		
Internal Heat Load	300 watts max.	
Ambient Air Temp (outdoor)	$+50^0$C max. -40^0C min.	
Solar Load	70W/sq. ft	

2.6 Reliability Specifications

2.6.1 MTBF

System down-time shall be no more than 10 minutes per year on the average, assuming a 2hour repair (replacing) time for any failure.

2.6.2 Battery Backup time

The battery shall provide DC power until the cause of AC power is cleared. The nominal value of this time period for backup battery operation shall be no greater than 4 hours.

2.6.3 Quality Materials

The aluminum used for the Pico-BTS enclosure may be machined from aluminum 6082 in accordance with standard QQ-A-2501/II TEMP T6.

2.6.4 Grounding Requirements

The specification for grounding and electric safety shall comply with the requirement described in TR-NWT-001089.

2.6.5 Alarm Requirements

The Pico BTS shall require alarms for the new hardware equipment, status display information, and control capability to monitor the system performance as follows:

- AC power failure
- DC power failure
- Malfunction of major control processors
- High internal temperature
- Low internal temperature
- Battery failure

3. SYSTEM DESCRIPTION

3.1 System Functionality

The details of the hardware and software functionality are described in section 4 and section 5, respectively. In this section, only brief outlines and essential details of several critical factors are discussed.

3.1.1 Configuration

3.1.1.1 BSM Configurability

As an element of the existing network, Pico-BTS should be similar to existing BTSs from BSM's point of view. Therefore, the basic nomenclature of its subsystem dividing and configuration should be similar to that of existing network in which it is supposed to work. By doing this, it is possible to use the existing messages and BSM screen entities with which the BSM operator might be familiar, to configure and manage this new element.

3.1.1.2 Initialization - Configuration

No redundancy will be provided in the Pico-BTS. Therefore once the system is configured through the initialization process, hardware configuration is not changed unless the whole system is removed. The only change in hardware may be the number of channel card. The Pico-BTS can support 32 channel elements. The operator will be allowed to change software configurable parameters through on-line reconfiguration.

3.1.1.3 Expandability

When multiple Pico-BTSs are used to form a cell cluster or a set of sectors, those Pico-BTSs are located close together. In this case, it is desirable to connect the multiple BTSs in a single backhaul transmission facility such as T1 line, to increase the backhaul efficiency. The backhaul interface of the Pico-BTS supports this functionality by allowing daisy-chaining of the Pico-BTS. This functionality is useful when it requires to form a multi-sectored, multi-FA Picocell site.

3.1.2 Initialization

3.1.2.1 Startup

Unlike the current BTS, the Pico-BTS has a self-contained enclosure which does not allow the sequential, manual power-up for each subsystem. There shall be one power switch for the system. As the power is turned on, each subsystem initializes itself and gets the software code by downloading from its upper level controller. The configuration information for the Pico-BTS comes from BSM, through BSC.

3.1.2.2 Loading Scheme

A major change will be made in the software loading scheme. In the current loading scheme, the software is downloded into BCPC from CCP, to which the software is downloaded from BSM, at power-up after the BIU initializes itself to acquire a path to the BSC for the download. Then BCP downloads the software to each subsystem in the Pico BTS. In the Pico BTS, the executable flash memory will be provided for all hardware modules except BDC. The software will be stored in the executable flash memory and copied into the DRAM at power-up. BDC software will be stored in the flash memory of the BCPC.

3.1.2.3 BS Network Addressing

Unlike the existing system which may have multiple trunk for a site, the Pico BTS can share a single trunk with adjacent neighbor Pico BTSs. Thus, in the BIU-CIN addressing field, the trunk number should be counted independently from the BTS identification.

3.1.3 Call Control

3.1.3.1 Normal Call/Handoff

The Pico BTS processes all the normal calls, either mobile origination or termination, as in the call control procedures of the existing BTS. For the handoff procedures, all except the intersector softer handoff is the same as those of the existing BTS. Therefore, it is possible to re-use existing software.

3.1.3.2 Intersector Softer Handoff

Pico BTS shall support the intersector softer handoff when more than one Pico-BTS are configured for the multi-sector support.

3.1.4 Maintenance and Administration

3.1.4.1 Normal Operation

During normal operation, Pico BTS performs various maintenance functions. The status supervision functionality is especially important because of the lack of redundancy in the architecture.

3.1.4.2 Fault Reporting/Alarm

In case of a fault in any part of the Pico-BTS, it is reported immediately to the BSC and BSM. Hardware fault reporting can be the same as the current system, except that the Pico-BTS does not allow the switch-over to the standby unit. When hardware faults happen, it means the discontinuation of service in that cell. Thus the fault reporting function is more important than any other functions. Also, since the Pico-BTS is not protected by an air-conditioned and secured room, the environmental alarm and invasion alarms are to be monitored.

3.1.4.3 Installation/Maintenance

The Pico-BTS is equipped in the self-enclosed packaging. Minimum effort is required to install and start-up the Pico-BTS. A small and simple panel for installation/maintenance personnel would be provided for minimal checkup procedures.

3.1.5 Network Operation

The following functionality is required for the Pico-BTS to work as an element of the CELLULAR network.

3.1.5.1 Resource Allocation

The Pico-BTS is an independent cell site. Thus the resources in the Pico-BTS are allocated independently through BSM. As in the current BTS, the channel elements, CDMA code channels, and the frame offsets are such resources.

3.1.5.2 Capacity Management

If required, the Pico-BTS can control its capacity by changing the limit for the number of active users it can support. This is done to maintain a specific quality of service. The detailed procedures and algorithms are the same as the one used in the existing system.

3.1.5.3 RF Operation

The Pico BTS supports cell blossoming and wilting mechanisms to facilitate the procedures of adding and removing the cell site, just as in the current BTS. The parameters for these processes shall be received from the BSM.

3.2 System Architecture
3.2.1 Functional Architecture

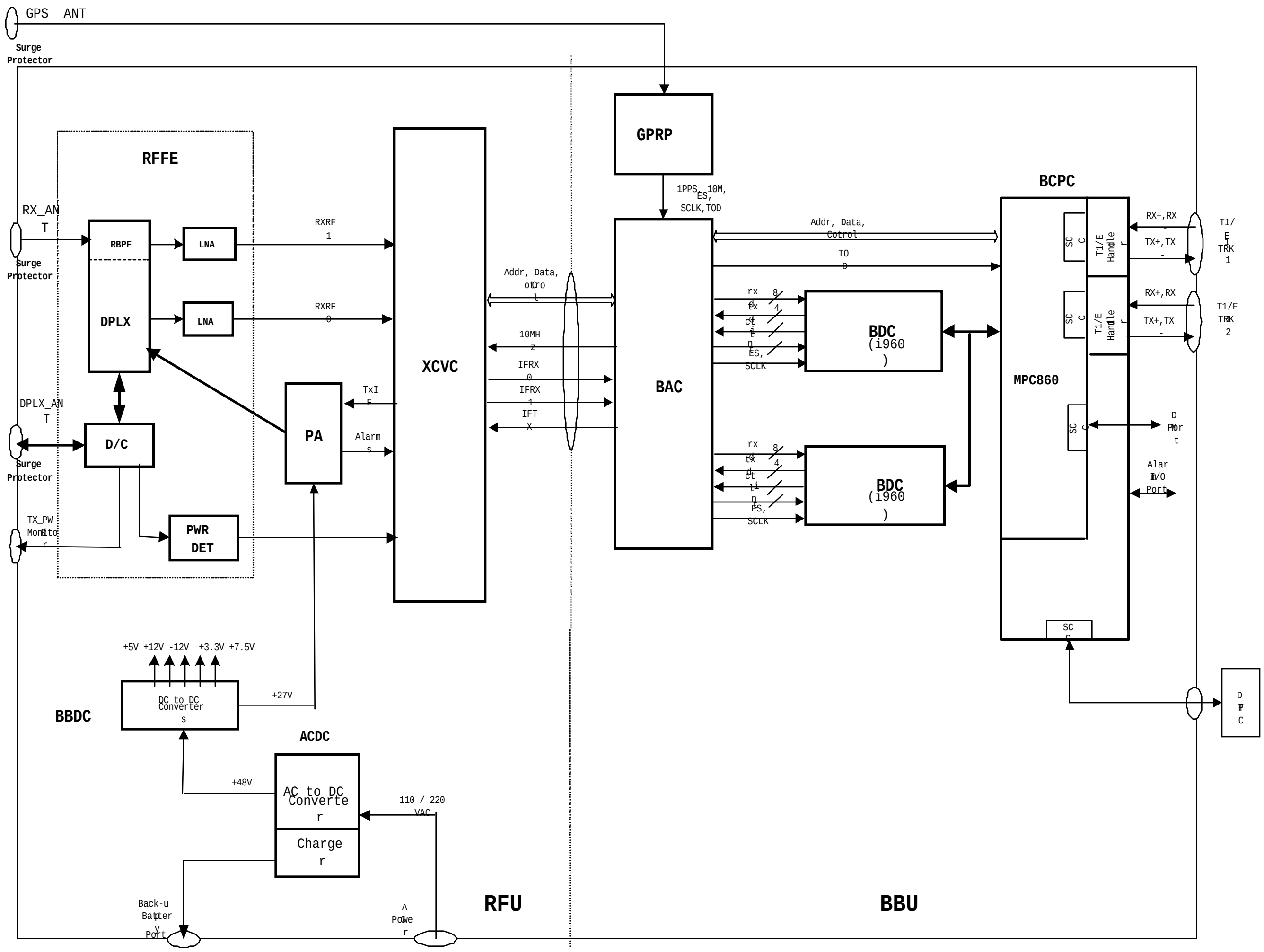


Figure.3.2-1 Functional Architecture

3.2.1.1 Transceiver Card (XCVC)

XCVC performs frequency conversion of transmitted and received signals, either RF to IF or IF to RF, and the amplification of the signals, both transmitted and received. On the reverse link, it amplifies the received weak signal sent by the mobile station, and changes the carrier frequency to 4.95 MHz IF band. On the forward link, it takes the IF band signal, converts it to the active RF carrier frequency, and then amplifies it to send through the antenna. In the Pico-BTS, only a single CDMA frequency is being supported to reduce the size and to make the configuration simple. Later, we can consider multi-FA Pico BTS as an option. In Pico BTS, XCVC and other RF unit controlling functions are consolidated into BCPC.

3.2.1.2 Baseband Digital Card (BDC)

BDC plays a central role in processing the CDMA baseband signal. There will be two BDCs in Pico BTS. Each BDC will support 16 Channel Elements. Major functionality of BDC is as follows:

- Signal Processing of CDMA baseband in forward and reverse link.
- Processing of messages relevant to call control and maintenance

3.2.1.3 BTS Control Processor Card (BCPC)

BCPC is the main controller for the Pico-BTS. Its main functions are call control and maintenance of Pico BTS. Functionality of BCPC is described briefly:

- Contains software for call control and maintenance
- Download the software into BDC at power up
- Processing of call setup and tear-down/ handoff
- Collects information for all hardware faults
- Control RF network operation
- Communication with BSC (CCP, TSB) for report and reception of upper-level control
- OPAID - Operational AID, such as alarm indications, ...
- BIU - Backhaul Interface Unit, this is the T1/E1 interface between BSC and Pico BTS.
- Message routing - BCPC will route the messages within Pico BTS.
- RF unit controlling function
- Process of the TOD and 1PPS received from the GPS receiver.

3.2.1.4 GPRP, BAC Card

GPRP generates timing and frequency references for Pico-BTS. The ultimate reference comes from the GPS. As other subsystems, the general functionality is similar to those of the existing system. However, redundancy is not used.

Basic functionality is described as follows:

- Generates system clock (19.6608 MHz), Buffered 10 MHz, EVEN-SEC clock.
- Generates local clock in case of GPS failure
- Frequency conversion of baseband signal to/from 4.95MHz IF signal

3.2.1.5 Backhaul Interface Unit (BIU)

BIU performs the communication between the subsystems of Pico BTS, and it is also the gateway to the BSC. Detailed architecture and functionality are described in chapter 4. In the Pico BTS, BCPC will function as the gateway to BSC handling all messages transmitted/received to/from BSC. BCPC includes the BIU.

3.2.1.6 Inter Module Communication (IMC)

In Pico BTS, the all other hardware modules are connected to BCPC through the point-to-point serial connection forming a start network. The modules will communicate each other via this serial connection. All messages will be transmitted in the HDLC format.

3.2.1.7 Power Subsystem Unit

The Pico BTS uses 120VAC or 220VAC as its power source. It is equipped with a rectifier, a backup battery, and a distribution panel. The specification for the power subsystem follows:

Table 3.2.1-1 Power Subsystem Units

Module	Specification	Comments
Rectifier	Input : 120 VAC or 220 VAC Output Voltage: +48 VDC Output Current : Max 10 Amps Input tolerance : 10 %	Size and weight limited
Battery (Optional)	Output : +48 VDC Capacity : 10 Amps Backup Time : 4 hours	Battery size and weight requirements may limit backup time.
DC-DC Converter	Input : +48 VDC Output : +5 V, +12 V, -12 V, +3.3 V, +7.5, +27 VDC.	Power for the hardware circuits

3.3 System Interface

3.3.1 External Interface

3.3.1.1 Air Interface

The air interface conforms to EIA/TIA/IS-95-A..

3.3.1.2 Network Interface

The interface to BSC conforms to the current specifications between BSC and BTS of Hyundai's CELLULAR system.

3.3.1.3 Electric Power

The specification for the input electrical power is as follows:

- Input Voltage : 120 VAC or 220 VAC optional, single phase.
- Tolerance : ±10 %

3.3.1.4 Man-Machine Interface

The Pico BTS will have following MMI's.

- A RS-232C port on the surface for portable PC connection.
- LED, RS-232C ports inside the cover, on each board.

3.4 System Availability, Maintenance, and Environmental Enhancement

3.4.1 System Availability

System down-time shall be no more than 10 minutes per year on the average, assuming a 2 hour repair (replacing) time for any failure.

3.4.2 System Maintenance

The Pico BTS maintenance features shall be designed to minimize the effects of failures on system performance and to provide technicians with the information and tools needed to identify the troubled system easily.

3.4.3 Environmental Enhancement

3.4.3.1 Mountable Kits

The Pico BTS is designed to meet a complete range of extended environmental standards, such as shock and vibration.

3.4.3.2 Convection Cooling

The Pico BTS uses natural convection cooling (heat sink). Major hardware components generating heat such as CPUs shall be thermally treated to reduce the contribution to increase the ambient temperature. The location of hardware shall be considered carefully from the thermal point of view, so that heat-generating elements can be located outer and/or upper portion of the cage.

3.5 Pico-BTS Block Condiguration

3.5.1 Baseband Unit (BBU)

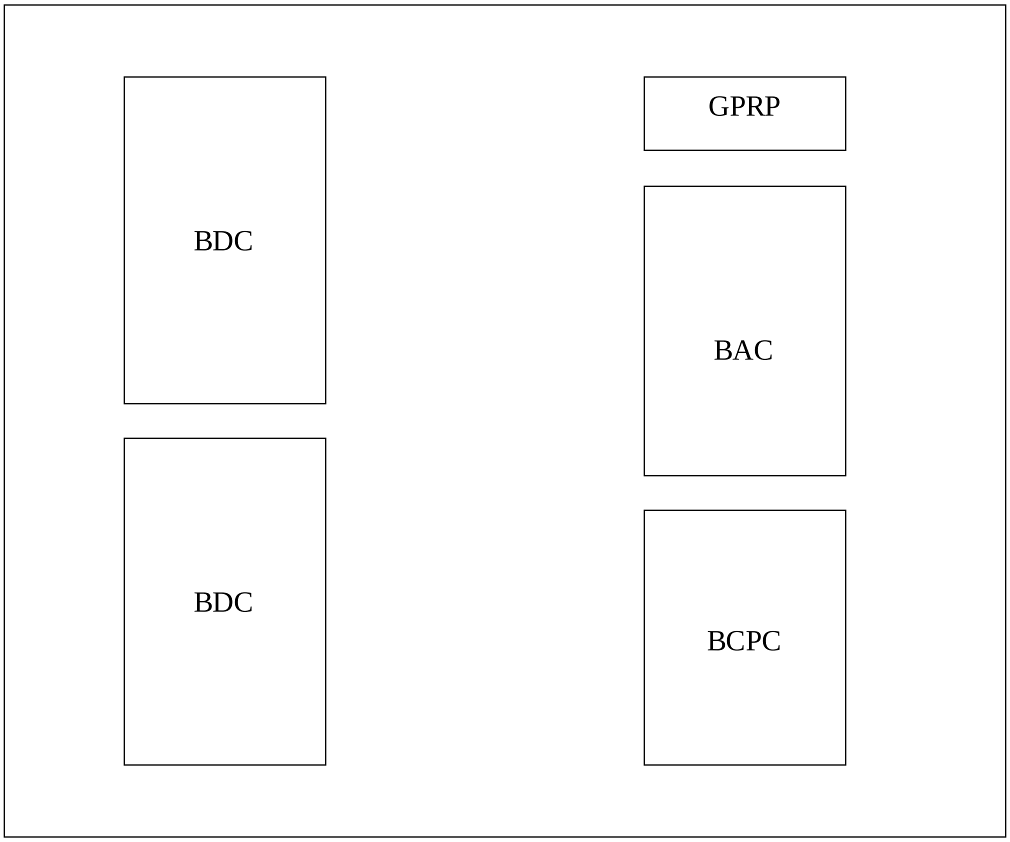


Figure 3.5.1-1 Base Band Unit

3.5.2 RF Unit (RFU)

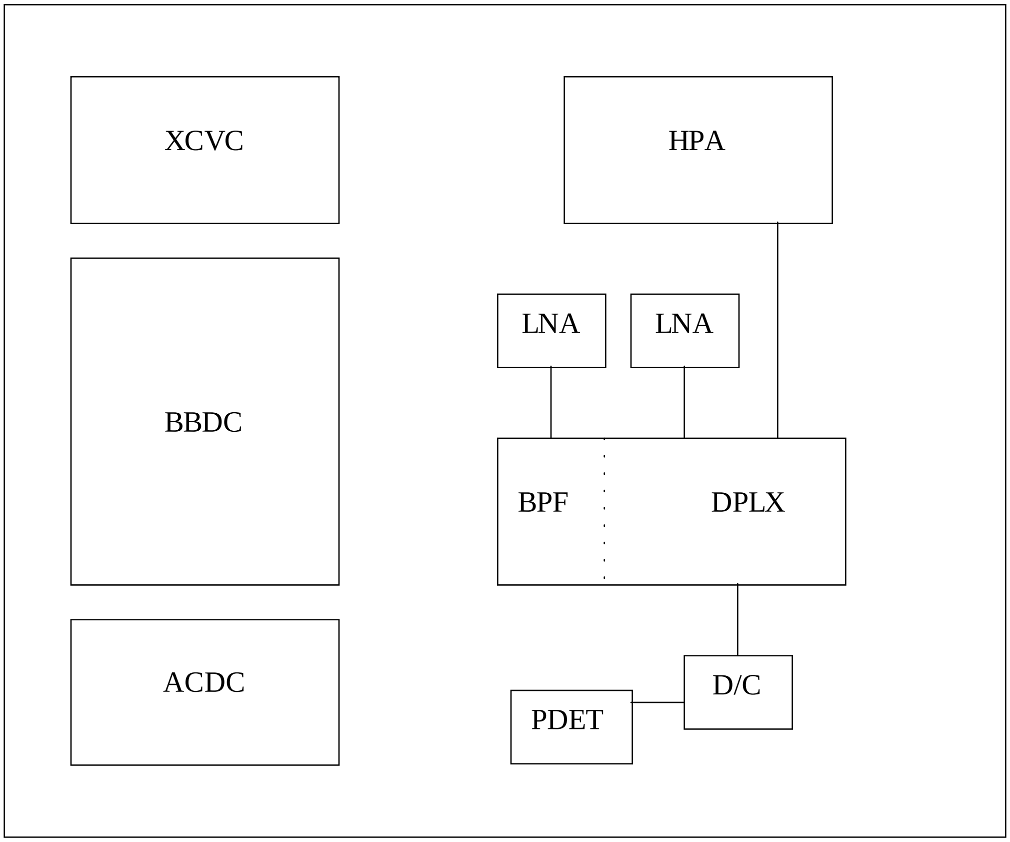


Figure 3.5.2-1 RF Unit

4. Hardware Structure and Functions

The system block diagram is shown again for better understanding of the hardware structure and PBA names.

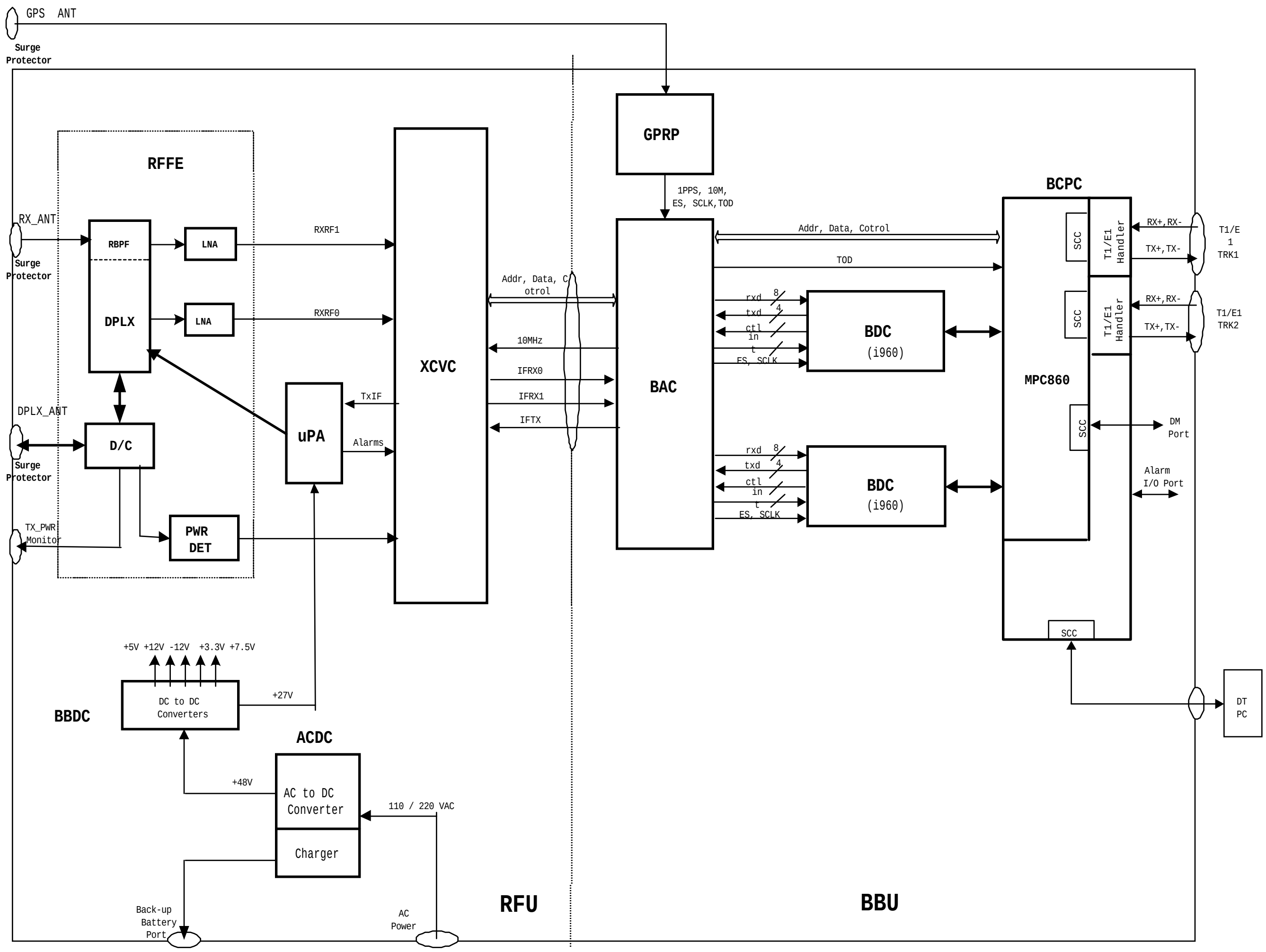


Figure 4.1-1 Hardware Functional Block Diagram

4.1 RF Subsystem

This section describes the RF subsystem which is composed of an RF Front End (RFFE), a High Power Amplifier(PA), and a Transceiver(XCVC).

4.1.1 Functionality

The main functions of the RF subsystem are listed as follows:

- CDMA frequency assignment(FA).
- 4.95MHz IF frequency up-conversion to cellular forward path frequencies and cellular reverse path frequencies down-conversion to 4.95MHz IF frequency.
- Providing software-controllable attenuators for cell blossoming, wilting and breathing.

- Forward power maintenance: pilot calibration and transmit power tracking loop functions.
- Diversity receive paths balancing.
- Reverse link gain control: providing a constant IF output over the operational dynamic range through Automatic Gain Control (AGC).
- Providing RF related data for system performance monitoring.

4.1.2 Architecture

Figure 4.1.2-1 shows the overall architecture of the RF subsystem.

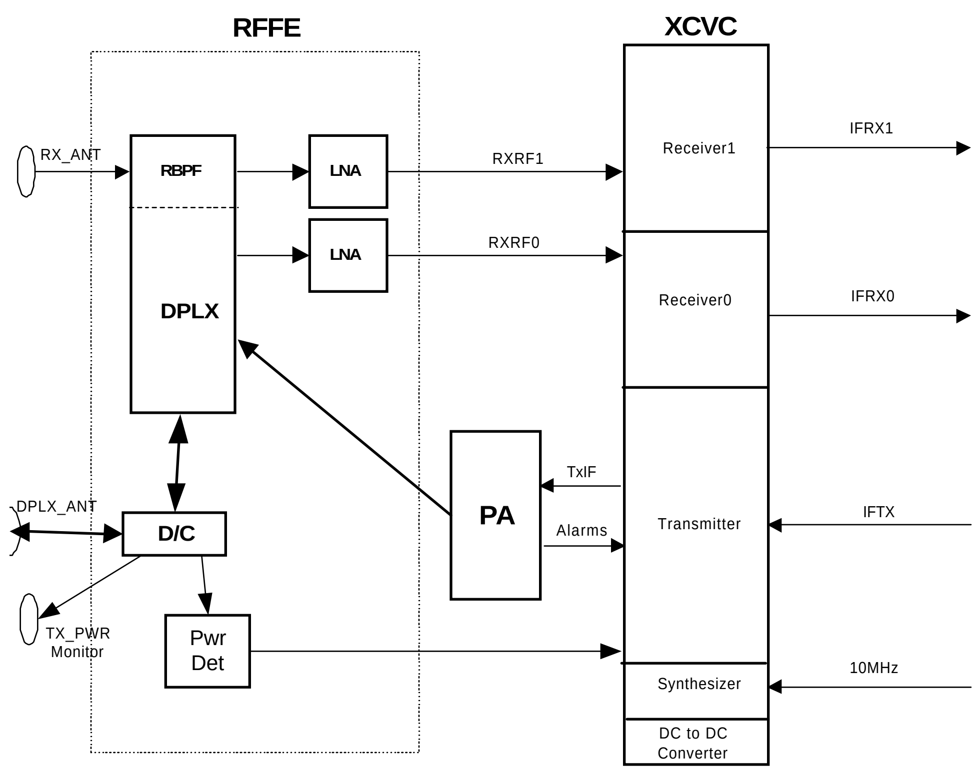


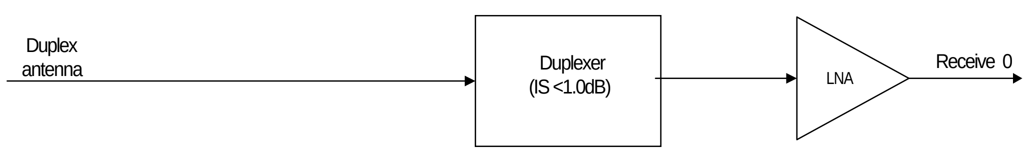
Figure 4.1.2-1 RF Subsystem Architecture

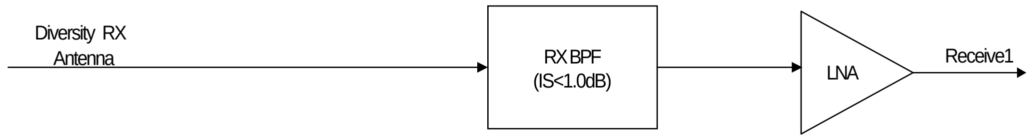
4.1.2.1 RF Front End

The RF Front End (RFFE) consists of RX Front end and TX Front End.

4.1.2.1.1 RX Front End(RXFE)

The architecture of the RXFE is shown in Figure 4.1.2-2.





(b)

Figure 4.1.2-2

Figure 4.1.2-2 RX Front End Architecture of (a) Duplex antenna, (b) Diversity RX antenna. The RX front end has two kinds of receive paths: a duplex RX path and a diversity RX path. The duplex RX path is composed of a duplexer, a low noise amplifier, and down-converter circuits. The duplexer is used for sharing a transmit antenna with a receive path. The diversity RX path is composed of a receive band pass filter, a low noise amplifier, and down-converter circuits.

4.1.2.1.2 Tx Front End(TXFE)

The architecture of the Tx Front End is shown in Figure 4.1.2-3.

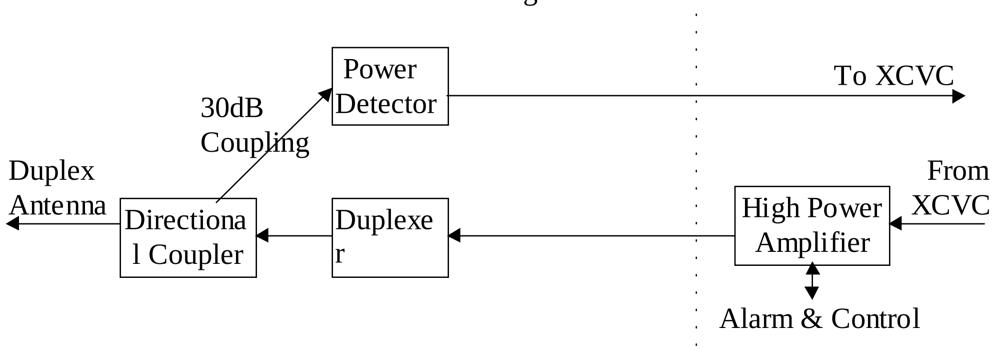


Figure 4.1.2-3 Tx Front End Architecture

The Tx Front End consists of a duplexer, a directional coupler, a transmit band pass filter, and a power detector. The major portion of the high power signal is sent to transmit antenna through a duplexer, and a directional coupler. A small portion of the signal is coupled to the power detector through the auxiliary port 1 of the directional coupler which monitors the output power level. A duplexer should be used for sharing the transmit antenna with a receive path. A duplexer with insertion loss less than 1.0dB should be used to minimize the transmit power loss.

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4.1.2.2 High Power Amplifier

The High Power Amplifier (PA) should have a minimum specification as follows:

Parameter	**Specification**
Operating frequency	849 - 894 MHz
Gain / Max.Power	45 dB / 10 Watts
Adjacent Channel Power Rejection (ACRP) (P_{out} = 10 W min. and CDMA BW = 1.23 MHz)	-47 dBc @f_0±885kHz with Integration BW = 30 kHz
Spurious Suppression Outside Frequency Block a) Adjacent Channel Power Level (P_{out} = 10 W min. and CDMA BW = 1.23 MHz) b) Adjacent Channel Power Level (P_{out} = 10 W min. and CDMA BW = 1.23 MHz)	 -13 dBm max. @f_0±1.25 MHz with Integration BW = 30 kHz -13 dBm max. @f_0±2.25 MHz with Integration BW = 1 MHz
Gain Variation vs. Frequency	±1.0 dB
Gain Variation over Temperature	+1.0dB / -1.5dB
Return Loss	16 dB (Input and Output)
DC Input Voltage	+27 V (Nominal)
DC Current	5.2 A max.
DC Power Dissipation	140 W max.
Operating Temperature	-30° to +85° C (Base plate)
Alarms	Over power, high temperature
Cooling	Passive convection cooling

Ταβλε 4.1.2–1 ΗΠΑ Σπεχιφιχατιονσ

4.1.2.3 Transceiver

The transceiver (XCVR) consists of a transmitter (up-converter), two receivers (down-converters), and a synthesizer. The transceiver should be realized as compact as possible.

4.1.2.3.1 Up-converter (Transmitter)

A block diagram of a transmitter is shown in Figure 4.1.2-4.

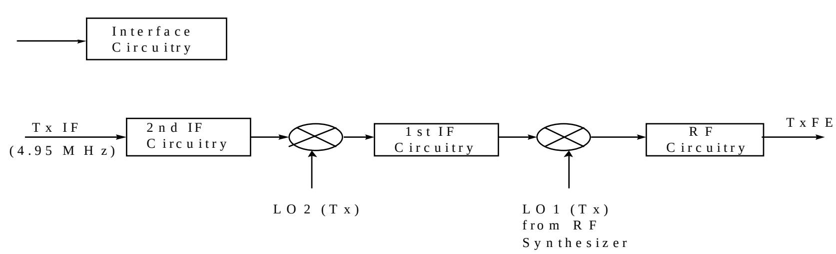


Figure 4.1.2-4 Up-converter Block Diagram

The up-converter accepts the 4.95 MHz signal, filters and attenuates the signal to a proper level, then performs a frequency conversion to the 150 MHz IF. This frequency was selected so that a common RF synthesizer could be used for both forward and reverse signal paths. Then it converts the 150MHz IF frequency up to an assigned cellular band frequency. The first IF circuitry includes filters, SAW filters, and PIN diode attenuators for forward link gain control and cell blossoming, wilting and breathing. The frequency agile RF synthesizer may be used for the final conversion.

4.1.2.3.2 Down-Converter (Receiver)

A block diagram of a down-converter is shown in Figure 4.1.2-5.

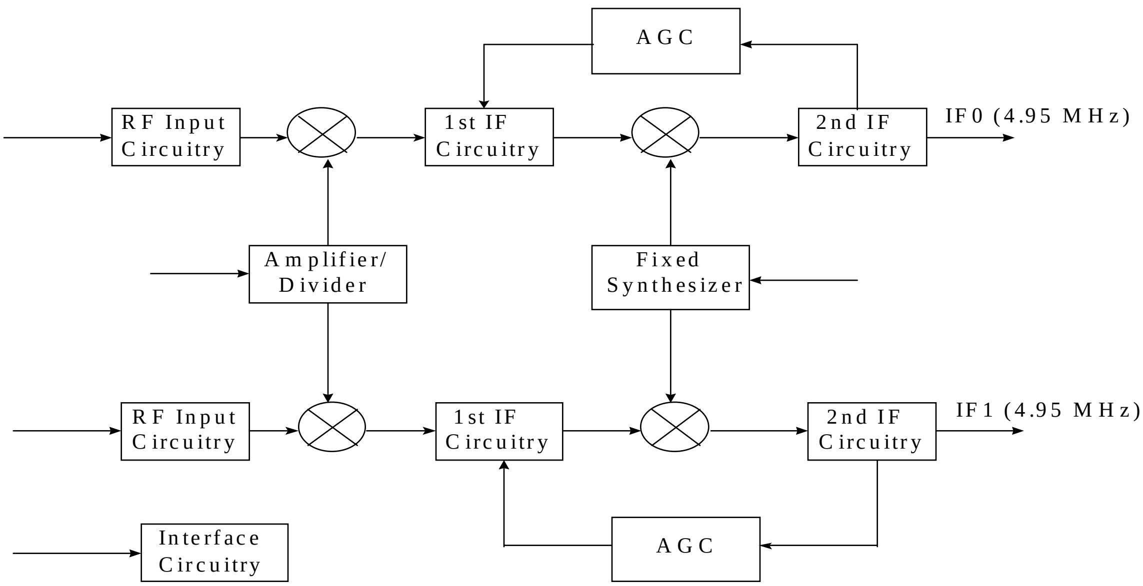


Figure 4.1.2-5 A Down-converter Block Diagram

The transceiver has two down-converters. Each down-converter has a low noise amplifier at the first part of its input circuitry to maximize the receive performance. The first conversion circuit provides the frequency agility for the receiver, which provides amplification and attenuation. The RF signal is then down-converted to the first IF of 70 MHz. The first IF circuitry contains matched filters and attenuators for automatic gain control (AGC). A fixed LO of 65.05 MHz is used to convert the first IF at 70 MHz to 4.95 MHz. The second IF circuitry consists of filters, amplifiers and AGC detectors.

4.1.2.3.3 Synthesizer

The synthesizer provides very fine reference frequency for the transmitter and receivers, and covers all frequency range of American cellular band with 30KHz resolution. The synthesizer circuit is implemented on the up-converter printed circuit board (PCB).

4.2 *Pico-Baseband Digital Card (BDC)*

4.2.1 Functionality

Figure Figure 4.2-1 illustrates the external interface between BDCs and other boards.

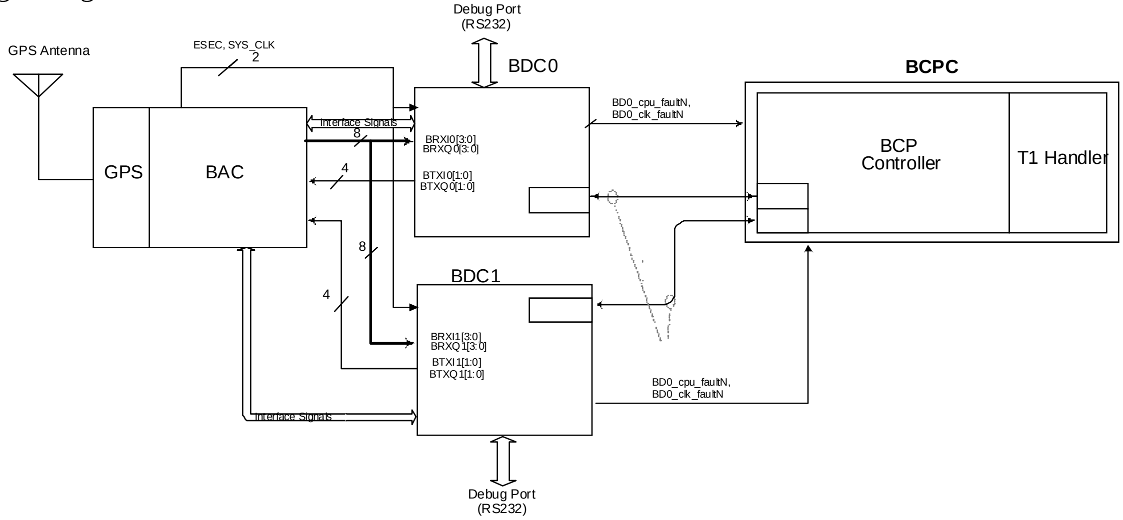


Figure 4.2-1 Major Interfaces of BDC

BDC's major functions are as follows:

1. Transmits pilot, sync, paging, and forward traffic channel messages. Receives access and reverse traffic channel messages.
2. Demodulates received CDMA I & Q signals from BAC.
3. Modulates the incoming voice/data packets from the T1 line and serially transfers to the BAC.
4. Performs actions according to the commands of BCPC.
5. Exchanges traffic and control data with BCPC through a SCC port.

4.3 *Pico BTS Control Processor Card (BCPC)*

The BCPC is the main control processor in the pBTS structure. It has a role to interface and communicate with other units and to process signaling messages for call management. It has following capacity and functions:

- computing power: larger than 15MIPS.
- Status and alarm monitoring for all units in BTS.
- Storing the program and data from BSC for BCPC and BDC.

In terms of hardware, BCPC provides the following functions:

- Core Processing Unit,
- BSC Interface,
- BDC Interface,
- BAC Interface,
- XCVC Interface,
- GPRP Interface.

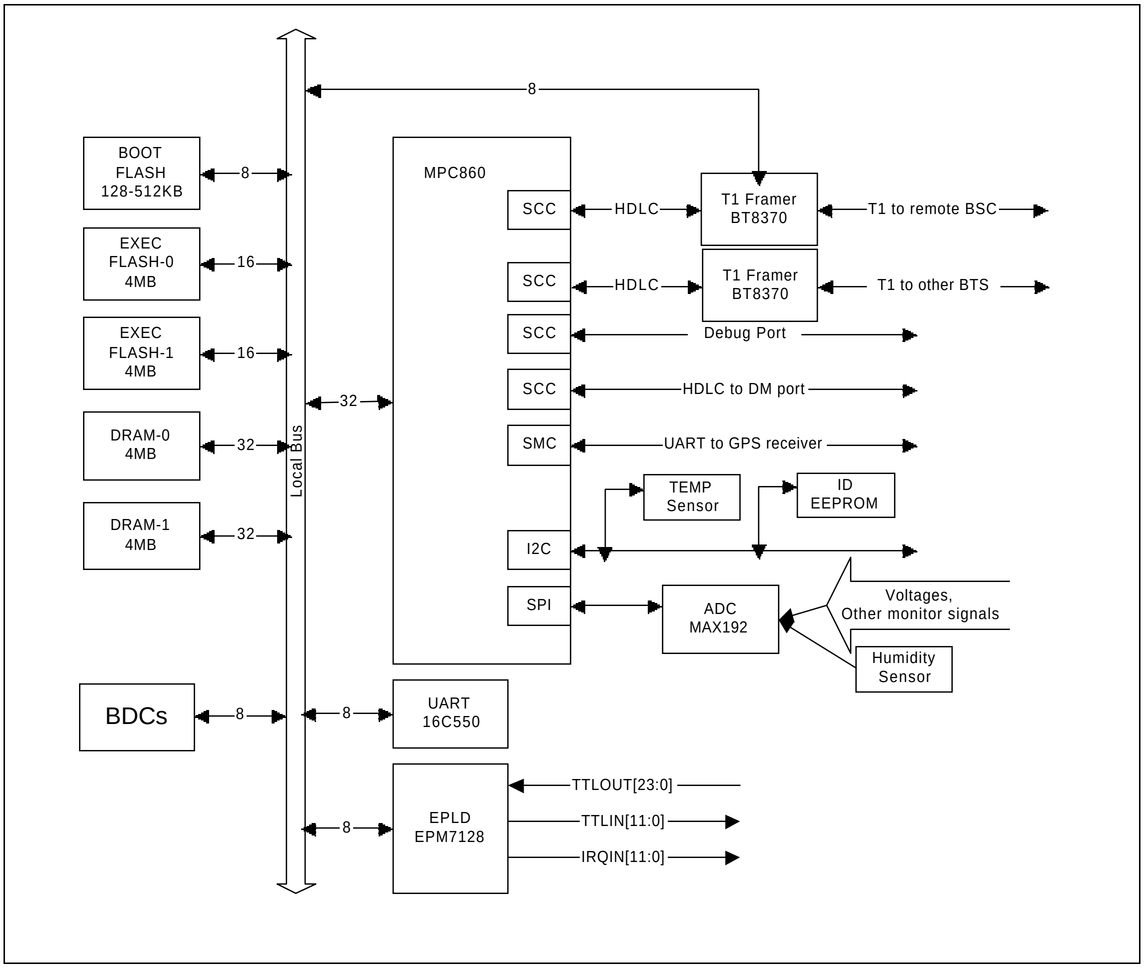


Figure 4.3-1

4.4 BTS Baseband Analog Card(BAC)

BAC has following functions:

- Digital summing of I & Q streams from two BDCs.
- Modulating digital-to-analog converted (DAC) baseband I & Q signals with 4.95 MHz I & Q intermediate frequency(IF) carriers and sending to XCVC.
- Demodulating the received 4.95Mhz IF signal from XCVC into I & Q baseband signals, analog-to-digital converting (ADC), and sending to BDCs.
- Providing the XCVC interface for BCPC.
- Providing GPS receiver processor (GPRP) interface for BTS and clock/frequency distribution.

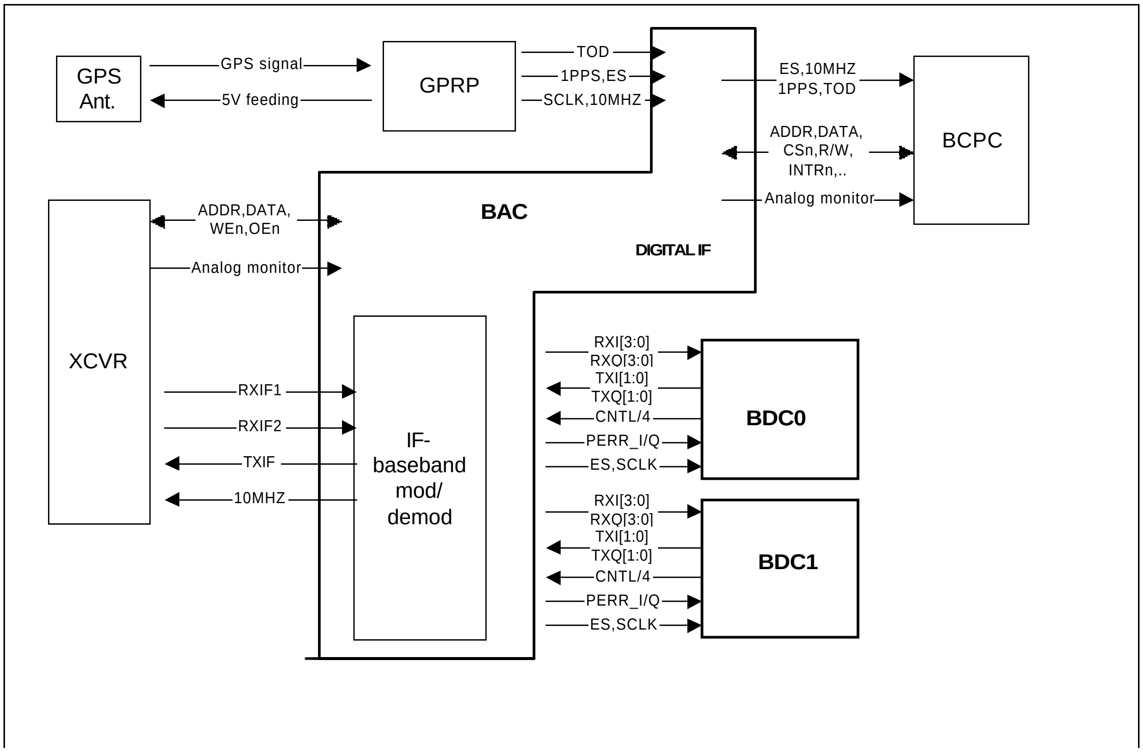


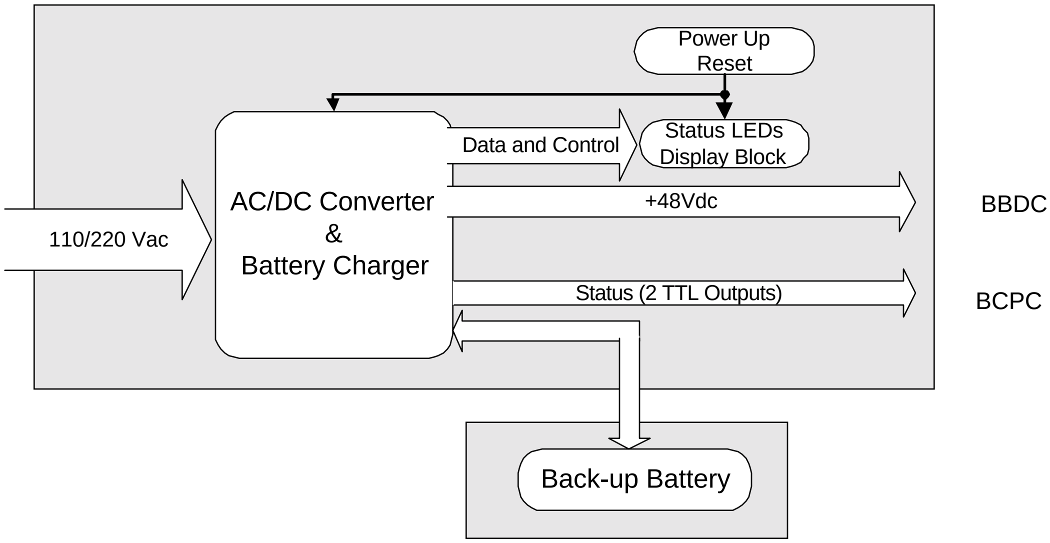
Figure 4.4-1 Overall Functional Block Diagram of BAC

4.5 GPS Receiver Processor (GPRP)

The Global Positioning System Receiver Processor (GPRP) derives accurate clock for the BTS system. It generates 10 MHz clock , System Clock 19.6608 MHz, 1 Pulse Per Second (1PPS) and Even Pulse Per 2 Seconds (EPP2S). Time of Day (TOD) information in ASCII code derives via null modem serial port. The GPRP is self-sustained module that combines a GPS receiver, double-oven precise oscillator and microprocessor. The GPRP provides time outputs synchronized with the GPS time and frequency accuracy of better than $1x10^{-11}$, averaged over 24 hours. When no satellites are being traced (holdover), the time output drifts less than +/- 7 microseconds in 24 hours and GPRP delivers clocks with accuracy of $+/-3x10^{-10}$ over a -20°C to +70° temperature range. At first startup GPSRP performs 24 hours survey to determine the antenna position and to discipline the frequency oscillator. The GPSRP provides reliable reception with the remote GPS antenna.

4.6 Power Supplies (ACDC, BBDC)

The ACDC converts the 110/220 (nominal) input to +48VDC. BBDC converts +48Vdc to +27Vdc, ±12Vdc, +5Vdc, and +3.3Vdc. ACDC supports optional battery backup through an external port on the housing. Seamless power switching from AC input power to back up battery power is achievable through the internal control circuitry which constantly monitors the DC output of the +48Vdc power supply and battery. If input power or power supply failure occurred, the internal circuitry automatically controls the relay to switch from input AC power to the back-up battery without glitch.



Φιγυρε 4.6–1 Φυνχτιοναλ Βλοχκ Διαγραμ οφ τηε Ποωερ Συππλιεσ

4.7 Mechanical / Thermal Design

4.7.1 Background

- The mechanical / thermal design will comply with all agency (NEMA, ANSI, FCC and UL) requirements for telecommunications equipment designed for outdoor use.
- It will also be lightweight, compact and easy to install.

4.7.2 Mechanical Characteristics / Requirements

- Size: Less than 22”(W) x 28”(H) x 12”(D).
- Weight: Less than 130 lbs.
- Material: Aluminum base and heat sink, structured foam (or equivalent) cover.
- Color: Blue and white (to conform with other Hyundai BTS).
- Mounting Locations: Pad, pole, wall or vault.

4.7.3 Thermal and Environmental Characteristics / Requirements

- Natural conduction and convection cooling, no fans.
- Heat pipes will be used when necessary for additional heat transfer.
- Outside ambient operating air temperature to be -30° to +50° C.
- Outside ambient humidity to be 5% to 95%.
- Solar load to be 70W/sq. ft.
- Internal heat load to be < 300W.

4.7.4 Design Strategies

Since the BTS has high power consumption and strict operational, environmental and thermal design requirements, the mechanical / thermal design has three major steps. These steps are Initial estimation; System level design and simulation; and Component and system level testing.

4.7.4.1 Initial Estimation

- Collect all thermally related information as it becomes available such as total system power, power consumption of each PCB and component, heat source location and power, etc. Use estimates where information is not yet available.
- Use heat transfer equations, thermal analysis tools(Flotherm, etc.), catalogs, related experience, etc. to estimate the major components temperature rise based on current design and choose suitable size and cooling system equipment (heat sinks, heat pipes, etc.).

4.7.4.2 System Level Design and Simulation

- Use mechanical solid design software tool (i.e. Pro/Engineer) to create entire BTS mechanical system which includes enclosure and cover design, heat sink and heat pipe locations and mounting design and components layout and system packaging.
- Use thermal design software tool (i.e. Flotherm) to simulate thermal model and do a complete system level analysis in order to eliminate possible problem areas and make design changes before prototypes are built. Analysis will include system temperature distributions, air flow patterns, components temperature rise and hot spot temperatures.

4.7.4.3 Component and System Level Testing

Based on the designed enclosure and mechanical layout, set up the system and conduct the necessary mechanical and thermal testing required to assure compliance with all the necessary requirements.

5. SOFTWARE DESCRIPTIONS

The software functions that will be provided may be divided into the following major categories:

- Call Processing functions; such as, call setup, call clearing, traffic handling, database updating.
- System maintenance functions; such as, diagnostics, software download, hardware device status monitoring, alarm reporting.
- System performance monitoring functions; such as, performance statistics gathering, overload monitoring.
- Board boot up, and initialization.
- Board diagnostics, low level debug port support.
- Low level communications support, this includes initiating software download from the BCPC or the CCP.

5.1 Pico BTS Control Processor Card (BCPC)

The BTS Control Processor Card (BCPC) is the hardware module whose primary function is providing call control and maintenance of Pico BTS. There are twelve software blocks running in the Pico BTS Control Processor Card which may be divided into the following major categories.

- Call processing control message handling between BSC and MS, which includes Paging Channel messages, and Access Channel Messages.
- System Maintenance functions; such as, resource management, fault management, data access management, status handling, processor loading, and diagnostics.
- Site alarm handling and reporting, this includes intrusion, temperature, humidity, AC power, battery, vibration, etc..
- The Radio Frequency Unit control function.
- Processing of the Time Of Day (TOD) message and 1 Pulse Per Second interrupt received from the GPS receiver.

5.1.1 Functional Overview

The primary responsibility of the Pico BTS Control Processor Card Controller is to provide call processing functions between BSC and Mobile Stations. This is accomplished by exchanging call control information associated with call setup, call clearing, and handoff between BCPC software blocks and BSC via Backhaul Interface Unit. BCPC software blocks also exchange call control information with Mobile Stations, via the pBDCX, to perform call processing related functions. Following is a list of functions that will be provided by the BCPC software blocks.

1. Call Processing - The BCPC Call Control block exchanges call processing control information regarding call setup, call clearing, handoff with the BSC, and the pBDCX.
2. Channel Element Management - Upon receiving commands from the BSM, the BCPC software blocks will send a command the pBDCX to setup the overhead channels, and traffic channels. This includes restoring, and removing individual channel elements, switching to standby overhead channels, adjusting RF output power gains, etc..
3. Device Status - The BCPC Status Handler block performs periodic status check of all hardware devices in the Pico BTS, and reports exceptions to BSM.
4. Diagnostic - The BCPC software blocks provide functions to process diagnostic requests from the BSM.
5. Resource Management - The BCPC Resource Management block performs resource management functions as requested by BSM.
6. Device Configuration Database - The BCPC software blocks manage local copy of device configuration database and reports any changes to the BSM.
7. Controlling the RF unit including Transceiver Control Unit (XCVC), RF Front End Unit(RFFE), and Power Amplifier(PA).
8. The GPS receiver interface specific functions, which include:
    - ◊ Processing the Time-Of-Day(TOD) message received from GPS receiver
    - ◊ Processing the 1PPS interrupt, which includes the generation of the system time to BDC at the even second.
9. Alarms - The BCPC software blocks monitors and manages alarm conditions from all local hardware devices and physical environments. All alarm conditions will be reported to BSM.
10. Software Download - The BCPC software will download the software into BDC upon power up or receipt of a request.
11. Debug Command Process - The BCPC software blocks will process commands received from the local debug port, which includes:
    - UI Support - Displays diagnostic menu on the console, and reads the input from the operator.
    - Parsing and processing the commands entered by the operator.
    - Displaying the results on the console.
12. Performance Statistics Gathering - BCPC software blocks gather performance statistics and forward it to BSM.

5.1.2 BCPC Boot Software (pBCPCb)

The BCPC boot software (pBCPCb) resides in the boot flash memory and receives control of the processor on power up or reset. The primary function of the pBCPCb is to initialize the BCPC hardware.

The pBCPCb provides the following functions:

- Initial board diagnostics via the Power On Self Test (POST)
- Debugging capabilities via the “PC” RS232 port.
- Initialization of the T1/E1 port for communication with BSC.
- Sending the software download request to the CCP to load the on-line software.
- Initiating the Pico BTS on-line software.

5.1.3 BCPC Software Architecture Overview

The pBTS Control Processor Card consists of twelve (12) software blocks, various Interrupt Service Routines including Backhaul Interface Handler, TOD Interrupt Handler, 1PPS Interrupt Handler, and the operating system. The blocks communicate with each other using the Inter-Task Communication mechanism provided by the Sylos real time operating system. Communication with external modules is through Inter Module Communication Handler.

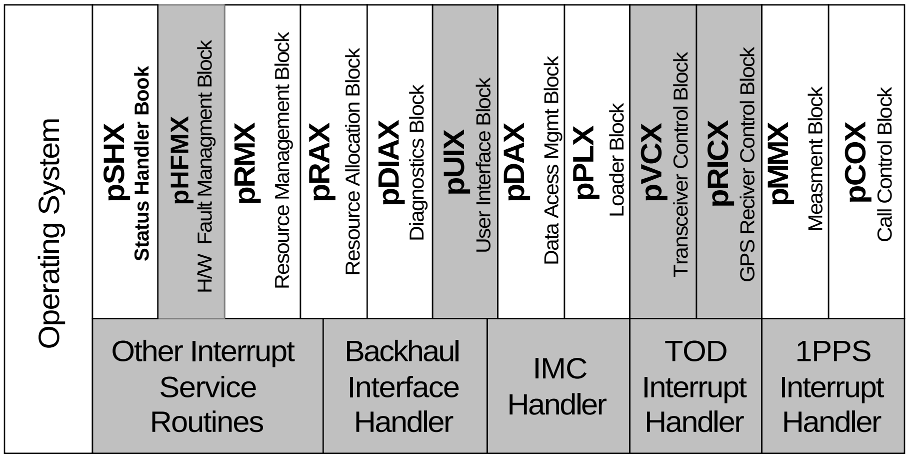


Figure 5.1.3-1 BCPC Software Architecture

5.1.4 Interfaces

This section describes the interface among the BCPC software blocks and with other external modules.

5.1.4.1 External Interface

- Interface with BSC/BSM

  The BCPC will communicate with the BSC/BSM via the Backhaul Interface Handler, which is described in section 5.5. The existing Gigacell IPC addressing scheme will be used for backward compatibility. Backhaul Interface Handler will format individual packet suitable for T1/E1 transmission to BSC/BSM. Conversely, Backhaul Interface Handler will de-format individual packet received from the BSC/BSM and forward the packet to the Inter Module Communication handler, which will send the packet to the destination whose address is specified in the destination address field.

- Interface with pBDCX

  The BCPC software blocks will communicate with the pBDCX via the Inter Module Communication mechanism described in section 5.4. The IPC addressing scheme currently implemented in the Gigacell Base Station will be used for the Inter Module Communication.

5.1.4.2 Inter-Task Communication

The inter-task communication among the BCPC software blocks is accomplished using Inter Module Communication mechanism described in section 5.4. The IPC addressing scheme currently implemented in the Gigacell Base Station will be used. The application software block will send an IPC message to the OS using sendsig(). The OS will check the destination address specified in the IPC header. If the specified destination address is the address assigned to the local module, then the OS will notify to the local task who is registered with the specified signal ID. If the specified address is the one assigned to a remote module, then the OS will send the message to the remote module via the serial connection or the backhaul interface.

5.1.5 Software Blocks

As mentioned previously, the pBTS Control Processor consists of twelve software blocks and the interrupt service routines. In this section, the functions of each software block are described.

5.1.5.1 pBTS Call Processing eXecutive(pBCOX)

The Pico BTS Call Processing consists of two major components. The Pico BTS Configuration Management (BCM) and Call Processing (CP). CP performs various call processing functions to ensure the proper communication between MS and BSC. The BCM maintains the entire subsystem configuration within Pico BTS.

5.1.5.1.1 Pico BTS Configuration Management (BCM)

The Pico BTS Configuration Management maintains all the subsystem configuration within the Pico BTS.

The BCM provides the following functions:

- Initializes configuration parameters, flags, and timers that will be used for the configuration management.
- Update its configuration and display new configuration information through the debug port when device status changes.
- Registers the configuration signals that will be received from other devices.
- Initializes Pilot and Sync channel and starts Pilot and Sync channel processing.
- Initializes Paging channel and activates Paging channel processing.
- Sends report to pBRMX during parameter change.
- Sends report to pBSHX for device status.
- Sends CDMA channel list report to BSM.
- Performs channel card remove/restore operation.
- Performs forward power management.

5.1.5.1.1.1 BCM Software Interface

The BCM, which is part of pBCOX, uses signals described in the previous section to exchange configuration data with the following software blocks and devices:

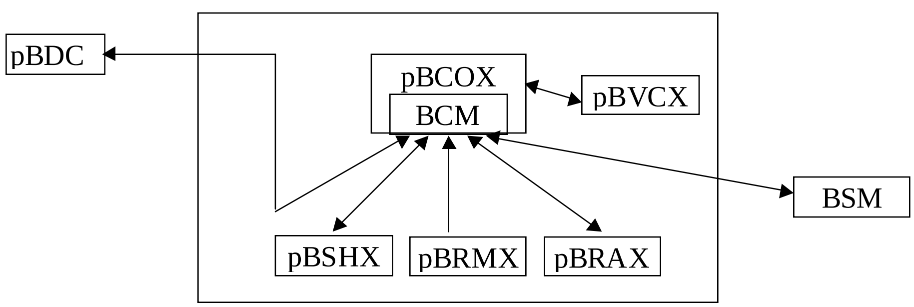


Figure 5.1.5-1 BCM external interface diagram

5.1.5.1.2 Call Processing (CP)

The Pico BTS Call Processing complies with EIA/TIA/IS-95-A. It processes messages that flow between MS and Pico-BTS as well as those between Pico-BTS and BSC. The different types of message are described bellow:

- A-bis Messages

A-bis Messages are Hyundai proprietary messages that are used between BSC and Pico-BTS through T1/E1 interface. Pico-BTS shall format A-bis Messages and forward to BSC. Pico-BTS will also de-format the received A-bis Messages and deliver to the proper destinations.

- CAI Messages

  CAI Messages are the messages used between Pico-BTS and MS through Paging, Access, Sync, and Traffic channels. CAI Messages comply with EIA/TIA/IS-95-A. The channel elements format CAI Messages and send to MS. Channel elements de-format the received CAI Messages and deliver to proper destinations. Pico BTS complies with the Acknowledgment Procedures as defined in EIA/TIA/IS-95-A.

- Pico-BTS Internal Messages

  Pico-BTS Internal Messages are proprietary messages, which are used within the Pico-BTS between the different subcomponents via the Inter Module Communication bus.

Call Processing consists of CP initialization and CP related activities. Call Processing provides the following functions:

- CP initialization:
  1. Initializes nodes address.
  2. Initializes call state machine, Layer 2 parameters and device data.
  3. Initializes registration information and sets up registration timer.
  4. Initializes pages count, handoff count, and release reasons.
  5. Resets measurement data.
  6. Initializes CP parameters, and test call information.
  7. Registers user commands such as pBCOX Menu, display device configuration and call information etc.
  8. Activates Layer 2 timer.
  9. Activates paging message timer.

- CP activities:
  10. Registers signals which are sending/receiving to/from BSC, other devices or internal tasks.
  11. Performs normal calls for origination and termination side.
  12. Performs traffic channel assign when handoff occurred.
  13. Performs registration procedure.
  14. Performs internal call state machine.
  15. Performs service configuration and negotiation.
  16. Processes statistics for call processing.
  17. Performs supplementary services.
  18. Performs configuration and parameters update.
  19. Performs simulation and message trace for maintenance purpose.

5.1.5.2 pBTS Resource Management eXecutive(pBRMX)

The Pico BTS Resource Management loads the Pico BTS common data received from the BSM via CCP (CRMX), processes the MMI commands, updates PLD, retrieves hardware alarm data upon request, sends alarm data to pBHFMX, and sends the request for changing channel elements to CRMX when requested by pBCOX or pBRAX. It also provides functions to display all Pico BTS related PLD data.

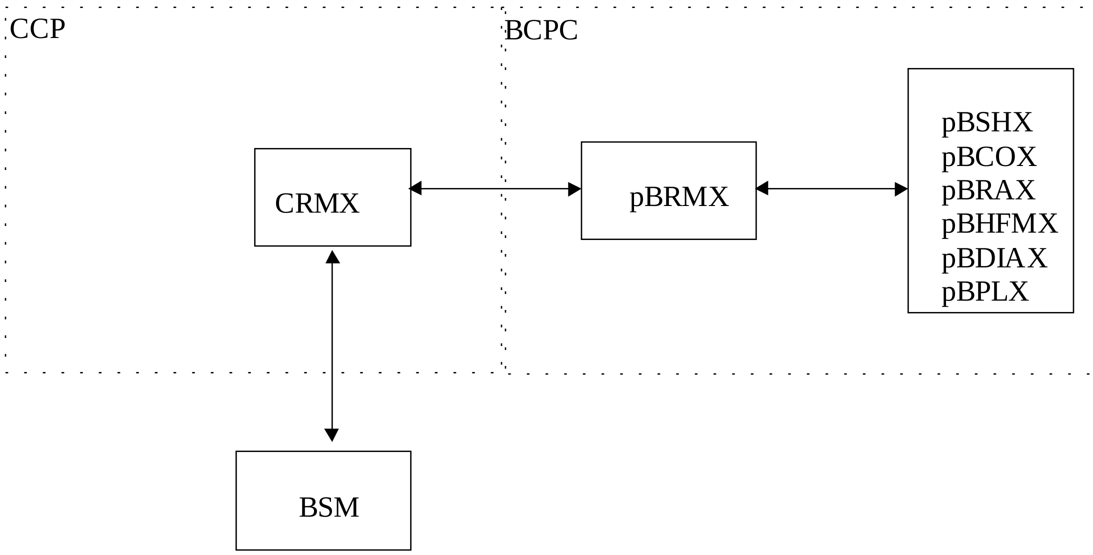


Figure 5.1.5-2 pBRMX external interface diagram

The pBRMX provides following functions:

- Loads the common data from the BSM - Below is a list of the common data:
  - ◊ Pico-BTS configuration and status data.
  - ◊ Sector configuration and status data.
  - ◊ CDMA channel ID list data.
  - ◊ T1/E1 configuration and status data.
  - ◊ Subcell configuration and status data.
  - ◊ OTA system parameters.

  After completely loading the common data, pBRMX will send the end of loading message to the BSM and pBPLX.
- Processes the MMI commands received from BSM - The commands are:
  - ◊ Blocking/unblocking Pico-BTS resources.
  - ◊ Adding/removing the neighbor set.
  - ◊ Updating the common data and local data in PLD.
- Processes channel element configuration change requests - This is requested from pBCOX or pBRAX.
- Processes hardware alarm requests - pBRMX receives request for updated alarm data from pBHFMX, retrieves the data and sends the data to pBHFMX.
- Displays PLD data by debugging port.

5.1.5.3 pBTS Status Handler eXecutive(pBSHX)

The pBTS Status Handler manages pBTS hardware device status, controls the pBTS overloading to avoid abnormal status, and periodically checks the resource utilization. The pBSHX also provides functions to handle manual diagnostics of pBTS hardware device.

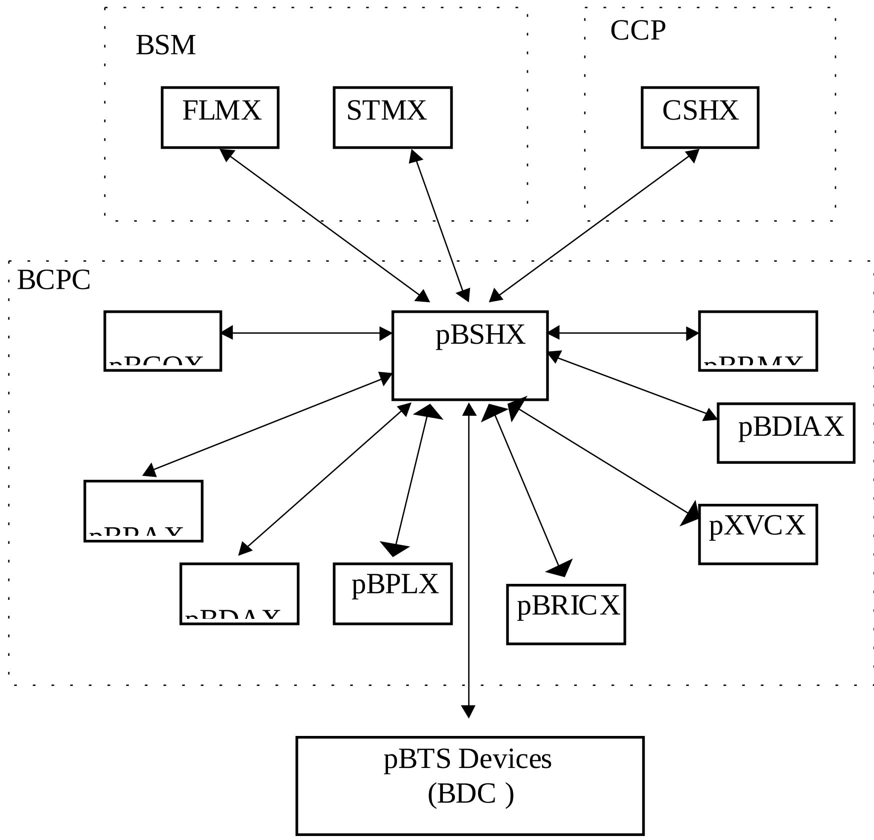


Figure 5.1.5-3 pBSHX external interface diagram

The pBSHX provides following functions:

- Main function
    - ◊ Initializes the global variables.
    - ◊ Registers signals.
    - ◊ Processes MMI commands and sends results to BSM.
- BDC Related Functions
    - ◊ Monitors BDC
    - ◊ Processes channel element software alarm.
    - ◊ Processes overhead channel status changes.
    - ◊ Processes traffic channel status changes.

- RFC Related Functions
    - ◊ Processes PA status changes.
    - ◊ Processes XCVC (RF Transceiver) status changes.
    - ◊ Processes Up converter and Down converter status changes.
    - ◊ Processes RFFE(RF Front End) status changes.
- Overload Monitoring
    - ◊ Initializes overload data.

- ◊ Monitors the traffic channel and processor overload status.
- ◊ Determines the traffic channel overload level.
- ◊ Reports overload conditions to BSM.
- ◊ Rejects calls when overload condition is detected.

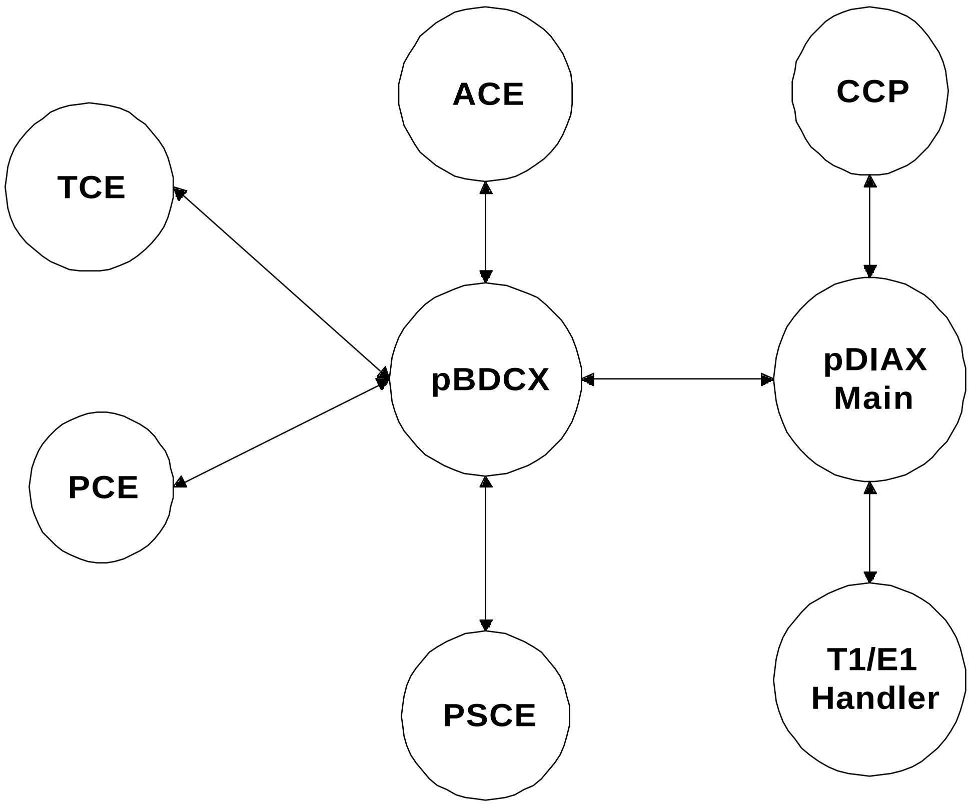
- T1/E1 Monitoring
  - ◊ Monitors and handles T1/E1 status.
- pBTS Hardware Device Manual Diagnostics
  - ◊ Displays BDC current status.
  - ◊ Displays BDC fault registers
  - ◊ Sends BDC keep alive message and prints the results.
  - ◊ Restart BDC test.
  - ◊ Restart CE test.
  - ◊ Displays pBAC current status.
  - ◊ Displays pBAC fault registers.
  - ◊ Blocks pBAC / Unblocks pBAC.
  - ◊ Initializes Phased Locked Loop in pBAC.
  - ◊ Displays the status of the GPS receiver.
  - ◊ Displays XCVC status.
  - ◊ Displays PA status.
  - ◊ PA disable test.
  - ◊ PA enable test.
  - ◊ PA restart test.

5.1.5.4 pBTS Diagnostic eXecutive(pBDIAX)

The pBDIAX is the diagnostic component of the BCPC. It processes diagnostic commands received from the BSM. The pBDIAX may also be invoked through local debug port. If invoked through the debug port, it displays two test choices. The first test is to test the channel elements using KA (keep_alive), and the second one is BIT (built_in_test).

pBDIAX will provide the following functions:

- T1/E1 diagnostic tests.
- CE diagnostic tests.
- CE KA (keep_alive) test.
- Monitoring BCPC overload status.



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Diagnostic requests are stored in individual arrays for each equipment type. The arrays are:

- Pilot and SYNC channel element array (psce_req_table[]),
- Paging channel element array (pce_req_table[]),
- Access channel element array (ace_req_table[]),
- Traffic channel element array (tce_req_table[]), and
- Channel control array (cc_req_table[]).

5.1.5.5 pBTS Processor Loader eXecutive(pBPLX)

The pBTS Processor Loader handles downloading software from the CCP to the BCPC processor, and downloading software from the BCPC to the pBDCX processor.

The pBPLX has the following functions:

- Initializes global parameters and loading table.
- Registers signals.
- Loads BCPC software blocks, and pBDCX.
- Updates subsystem loading status.
- Performs loading error report.
- Performs checksum for data/text transactions.

5.1.5.6 pBTS Data Access eXecutive(pBDAX)

The pBTS Data Access task provides access methodology to the pBTS PLD database. The pBDAX provides various database access functions to access PLD.

The pBDAX has the following functions:

- Sets up PLD database access function addresses.
- Provides select, add, delete and update functions to access PLD.
- Provides index and sequential access methods to access PLD.

5.1.5.7 pBTS Resource Allocation eXecutive(pBRAX)

The pBTS Resource Allocation allocates and deallocates the pBTS resources for call related functions, stores statistical data for measurement and retrieves device status for status handler.

When the pBCOX (Call Control) processes normal call setup or handoff, the pBCOX requests the pBRAX to provide the available resources. The pBRAX will try to allocate the available resource upon receiving the request. If the pBRAX allocates the resources successfully, it returns a successful message to the pBCOX. If the pBRAX cannot allocate the required resources completely, the pBRAX deallocates all allocated resources associated with the current request, and sends the error code to the pBCOX.

pBRAX provides the following functions:

- Normal Call and Handoff Related Functions
  - ◊ Carrier selection.
  - ◊ Allocation / deallocation of the frame offset.
  - ◊ Allocation / deallocation of CDMA channel index.
  - ◊ Allocation / deallocation of power gain.
  - ◊ Allocation / deallocation of Walsh code.
  - ◊ Allocation / deallocation of traffic channel.
  - ◊ Processes handoff status message received from pBCOX.
- RF and CE Related Functions
  - ◊ Initializes global variables which are used to store CEs data.
  - ◊ CE resource allocation / deallocation when requested
- T1/E1 Related Functions
  - ◊ Retrieves current T1/E1 handler data and sends the data together with T1/E1 utilization to pBMMX.
- STATISTICS Related Functions
  - ◊ Displays traffic statistics and system performance statistics as requested by pBMMX.
- Device Configuration
  - ◊ Update configuration data of each device.

5.1.5.8 pBTS Measurement eXecutive(pBMMX)

The pBTS Measurement (pBMMX) handles statistical measurements. It starts or stops the pBTS statistical measurement upon receiving request from the BSM. The pBMMX also provides functions to display the statistical data and to simulate statistical measurements. Upon receiving the request, the pBMMX starts taking the specified statistical measurements based on received message id. The pBMMX will collect and store the statistical data and send them to the BSM via CMMX. The statistical data include call performance statistics, T1/E1 statistics, air interface statistics, CEs statistics and the BCPC processor statistics.

pBMMX provides following functions:

- Processes messages received from the BSM to start or stop taking statistical measurements. The pBMMX requests and receives the statistical data from following software blocks or devices:
  - ◊ Air interface statistics from the pBDCX.
  - ◊ T1/E1 statistics from BIH.
  - ◊ CEs statistics from the pBCOX.
  - ◊ Performance statistics from the pBRAX which generated by the pBCOX.
  - ◊ The BCPC processor statistics by calling OS library function.
- Displays traffic statistics.
- Displays the Pico-BTS performance data.
- Displays T1/E1 traffic statistics.
- Displays error statistics for air interface.
- Displays common air interface statistics.
- Simulates statistical measurements.

5.1.5.9 XCVC Control eXecutive (XVCX)

The Pico XCVC Control eXecutive (pXVCX) is a software block that resides in the BCPC. The major functionality provided by pXVCX is controlling the RF unit including Transceiver Control Unit(XCVC), RF Front End Unit(RFEE), and Power Amplifier(PA). This functionality is provided by the dedicated control board called, TCCA, in the Gigacell.

However, in the Pico BTS, the RF unit controlling functionality is consolidated into the BCPC. This change has been made in order to reduce the number of boards and, as a result, reduce the power consumption. In Pico BTS, the BCPC will control the RF unit through the parallel interfaces.

5.1.5.9.1 Functional Overview

As mentioned earlier, the primary functionality of the pXVCX is controlling the RF unit including Transceiver Control Unit (XCVC), RF Front End Unit (pRFEU), and Power Amplifier (PA). In this section, the functions provided by the pXVCX are described:

1. Attenuator/AGC Configuration

   Three attenuators will be allocated to each XCVC, one for the transmit path and two for the receive path. The pXVCX will configure the attenuators of a XCVC based on the information specified in the XCVC configuration table 1) at the initialization time, 2) upon receipt of “RCONF” command from the diagnostic port, or 3) upon receipt of a command from BCPC.

   The XCVC may be configured to perform the one of the following functions:

   - Normal Operation:
     Configuration of the XCVC for the normal operation include:
     - ◊ Configuration of the attenuator for transmit path
     - ◊ Configuration of the attenuators for receive path
     - ◊ Configuration of Frequency Synthesizer
   - Reverse Power Management:
   - Reverse Capacity Management:
   - Transmit Adjust:
     Adjust the transmit power.

2. Frequency Configuration: Configure the register of the Frequency Synthesizer to set the transmit and receive frequency.

3. Initialization and management of the local devices; such as, the RF Transceiver (XCVC)**,** the RF Front End (RFFE), and the Power Amplifier (PA) via the parallel interfaces.

4. Diagnostic and fault management of the XCVC, the pRFFE, and the pPA.

5. Process the commands received from the pBCOX.

6. Execute the diagnostic commands entered by the user via the RS232 port and display the results. This function includes validating the command, executing the command, and displaying the result on the console.

5.1.5.10 Pico GPS Receiver Controller eXecutive (pGRICX)

The Pico GPS Receiver Controller eXecutive (pGRICX) is a software block that resides in the BCPC. The major functionality provided by pGRICX is processing One Pulse Per Second (1PPS) and Time Of Day (TOD) received from the GPS receiver, generating the system time to other module, and monitoring the status of the GPS receiver. This functionality is provided by TFCA, which is a Motorola 68302 based board, in the Gigacell. However, in the pBTS, the functionality to process the TOD and 1PPS is consolidated into the BCPC in order to simplify the architecture and, as a result, reduce the power consumption.

5.1.5.10.1 Functional Overview

The primary functionality of the pGRICX is processing the 1PPS and TOD received from the GPS receiver. In this section, the functions provided by the pGRICX are described in detail:

1. Processes 1 PPS Received from the GPS receiver. Upon receipt of 1 PPS, pGRICX will send the system time to BCM block and pBDCX at even second.

2. Checks the 1 PPS existence. If 1 PPS is missing for more than 10 times, then pGRICX will generate an alarm.

3. Processes the TOD received from the GPS receiver via the serial port.

4. Validates the TOD format.

5. Checks the TOD existence. If the TOD is missing for more than 10 times, then pGRICX will notify to BSM.

6. Processes the commands received from the pBCOX.

7. Executes the diagnostic commands entered by the user via the RS232 port and display the results. This function includes validating the command, executing the command, and displaying the result on the console.

5.1.6 Interrupt Service Routines

The following interrupt service routines will be implemented in BCPC to handle various interrupts generated by the external/internal devices:

- Real Timer Clock Handler - This is used to update system time, performs timer related functions.
- DMA Transmit Status - This includes three routines to handle DMA data transmit status. One routine to signal DMA transmit completed successfully, the second routine to signal DMA transmit error, the third routine indicates serial port (MPCC) transmit error.
- DMA Receive Status - This includes three routines to handle DMA data receive status. One routine to signal DMA receive completed successfully, the second routine to signal DMA receive error, the third routine indicates serial port (MPCC) receive error.
- Exception Handlers - This interrupt handles hardware-related failures on the BCPC.
- System Call Traps - BCPC software blocks uses Sylos as the real time operating system. Sylos system calls are executed through the “trap” mechanism. All existing system calls in the Gigacell will be supported in the pBTS.
- TOD Interrupt - To process the interrupt generated by the SMC1 upon receipt of the TOD message from the GPS receiver.
- 1PPS Interrupt Handler - To process the interrupt generated upon receipt of the 1PPS from the GPS receiver.

5.2 Baseband Digital Card (BDC)

The Baseband Digital Card (BDC) is the hardware module whose primary function is providing the digital signal processing of the CDMA waveform within pBTS. Two different software blocks will be run in the BDC, the Pico Baseband Digital Card Boot software (pBDCb) and the Pico Baseband Digital Card eXecutive(pBDCX). The pBDCb, which resides in the boot PROM, is to boot the BDC at the power up. The pBDCX is the software block that will be stored in the executable flash of BCPC. At the system initialization, the pBDCX will be downloaded into the DRAM of BDC and executed there. The primary function of pBDCX is controlling the CDMA Cell Site Modem (CSM) chips. This section describes the functional requirements and software architecture of the pBDCX.

5.2.1 Functional Overview

The primary responsibility of the pBDCX is controlling the CDMA Cell Site Modem (CSM) ASIC, which is a CDMA baseband modem for reverse link demodulation and forward link modulation. It also processes the calls within the Base station Transceiver System (BTS) by sending and receiving the control information associated with call setup, call clearing, and handoff to/from the BCPC via the Inter Module Communication mechanism. The following is a list of the functions that will be provided by the pBDCX:

1. Channel Element Configuration

   At initialization time, the pBDCX configures each Channel Element based on the configuration information received from the BCPC; thus, each Channel Element performs one of the four functions, Pilot and Sync Channel, Paging Channel, Access Channel, and Traffic Channel as follows:

- Pilot and Sync Channel:
  The configuration of the Pilot and Sync Channel consists of setting up interrupt generation related to the Sync Channel data encoding, configuring the Long Code PN generators, configuring the Reverse Link, and configuring the Forward Link.

- Paging Channel:
  In order to configure to transmit a Paging channel from a single CSM to a single sector, the pBDCX is required to set up interrupt generation related to the Paging Channel data encoding, configure the Long Code PN generators, configure the Reverse Link, and configure the Forward Link.

- Access Channel:
  The Access channel configuration consists of setting up interrupt generation related to the Access Channel data decoding, configuring the Long Code PN generators, and configuring the Reverse Link.

- Traffic Channel:
  In order to transmit and receive a Traffic channel, the pBDCX needs to set up interrupt generation related to the Traffic Channel data encoding/decoding, configure the Long Code PN generators, configure Reverse Link, and configure the Forward Link. For the Reverse Link Traffic Channel, the initial configuration requires disabling all four Fingers, configuring the Demodulator, and configuring the Decoder. For the Forward Link Traffic Channel, initial configuration requires configuring the Encoder for Traffic Channel encoding, configuring a Transmit Section for proper modulation, and configuring the Transmit Summer to route the Traffic Channel to the correct sector.

2. Channel Element Maintenance

   Once the channels have been configured, the pBDCX will maintain the channels. The functions taken by the pBDCX for the maintenance vary depending on the channel types as follows:

- Pilot Channel:
  No channel maintenance is required for the Pilot channel.

- Sync Channel:
  Maintaining the Sync Channel consists of writing the Sync Channel data, which consists of an 80 ms superframe, into the Encoder buffer. Each superframe is divided into three 26.67 ms frames to be written to the Encoder.

- Paging Channel:
  Paging Channel maintenance consists of writing the Paging Channel data into the Encoder buffer. Paging Channel data consists of a series of message capsules which are divided into 10ms half- frames. These half-frames are paired up and combined into 20 ms frames that are written to the Encoder.

- Access Channel:
  Maintenance of the Access Channel consists of watching for Access probes using the Searcher, assigning Fingers to any Access probes that are detected, and reading the incoming data frame from the Decoder.

- Traffic Channel:
  Maintenance is required for both the Reverse Link and Forward Link as follows:

  ◊ Reverse Link maintenance consists of using the Searcher to watch for the best signal offsets, assigning Fingers to these offsets, and reading Decoder data frames.
  ◊ Forward Link maintenance consists of writing Encoder data frames, and monitoring the Encoder status.

3. Overhead Channel Redundancy: The overhead channel redundancy will be provided. In order to implement this function, the BCPC will monitor the status of the BDC using the polling scheme. Upon detection of the failure of the BDC in which the overhead channels, i.e., Pilot, Sync, Page, Access channels, are configured, the BCPC will request other BDC to configure the overhead channels. If enough channels are not available for the overhead channels, the pBDCX will clear the traffic channels and reconfigure them as the overhead channels.

4. The pBDCX transmits and receives the control information, regarding the call setup, call clearing and handoff, and traffic data to/from TSB via the Inter-Module Communication and Backhaul interface.

5. The pBDCX exchanges the control information required for the call setup, call clearing and handoff with the BCPC via the IMC.

6. Checks the status of each Channel Element and reports the status to the BCPC periodically.

7. Board Power On Start-up Test (POST).

8. Processes the commands received via the debug port, which includes:
   - UI Support - Displays menu on the console and reads the input entered by the operator.
   - Interpretation of the command entered by the operator.
   - Processing the command.
   - Displaying of the result on the console.

   The types of command to be supported will be determined during the detailed design phase..

5.2.2 BDC Boot Software(pBDCb)

The pBDCb will reside in the boot flash memory of the BDC. The primary responsibility of the BDC Boot Software (pBDCb) is booting the BDC at the power up. It will perform the Power On Start-up Test (POST), initialize the BDC hardware board, and initiate the software download procedure by sending the software download request message to the BCPC. Upon completion of the initialization procedure, the BDC boot software will jump to the on-line code. Booter also provides debugging capability through RS232C interface with debug terminal.

The POST consists of the followings:

1. pBDCX board RAM test
2. CSM initialization
3. Sanity checks on the physical communication paths between pBDCX board and other hardware modules.
4. Vendor provided diagnostic tests.
5. RS232 debugging port initialization.

Any failure detected during the POST will be notified to the operator using the LED.

5.2.3 pBDCX Software Architectural Overview

The pBDCX consists of seven background tasks, two foreground tasks, and the operating system. The tasks communicate each other using a set of message queues and the event flags provided by the real time operating system. The real time operating system for the pBDCX is to be determined.

Figure 5.2.3-1 depicts the software architecture of the Pico Baseband Digital Card Controller

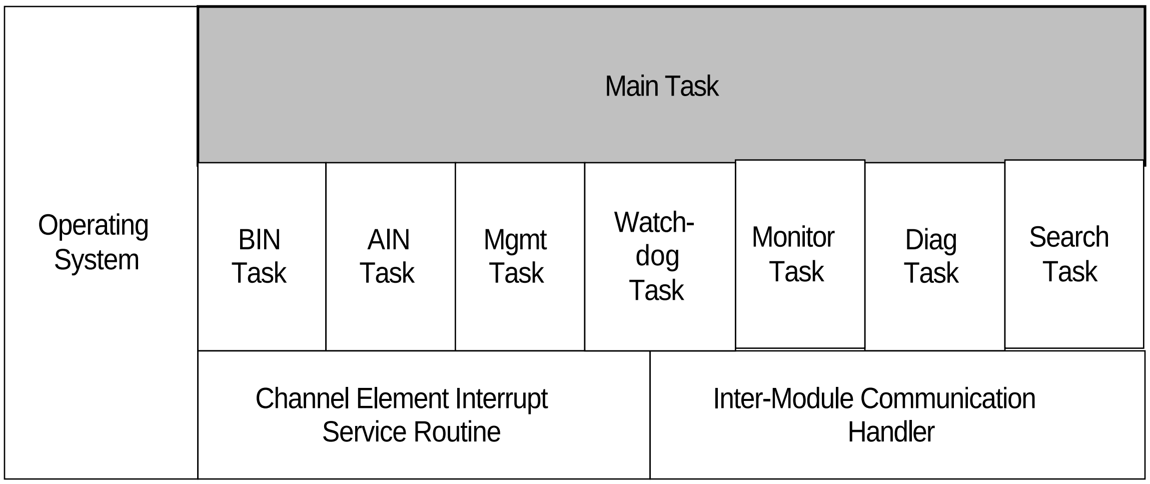

Figure 5.2.3-1 Software Architecture of Baseband Digital Card Controller

5.2.4 Interfaces

This section describes the interfaces between pBDCX and other hardware modules. This section also describes inter-task communication of pBDCX.

5.2.4.1 Interface with Channel Elements(CEs)

The pBDCX interfaces with the Channel Element via the registers provided by the Channel Element. The registers of the Channel Element are functionally grouped together as follows:

1. General Registers:
2. PN Registers:
3. Per Finger Registers:
4. Demodulator Registers
5. Searcher Registers
6. Decoder Registers
7. Forward Link Registers:
8. Per Transmit Section Registers
9. Transmit Summer Registers:

5.2.4.2 Interface with Other Modules

- Interface with the pBTS Control Processor Card(BCPC):

The pBDCX will communicate with the BCPC. The IPC addressing scheme currently implemented in the GigaCell Base Station will be used for the inter module communication. The pBDCX will transmit/receive a packet to/from the BCPC.

- Interface with the TSB/BSC:

The pBDCX will communicate with the TSB via the Backhaul Interface Handler, which is described in the section 5.5. As mentioned earlier, the traffic destined to BSC is handled by BCPC. Thus, the pBDCX will communicate with TSB/BSC via the BCPC, which functions as a gateway to BSC in pBTS. In order to maintain compatibility, the IPC addressing scheme currently implemented in the GigaCell Base Station will be used when the pBDCX communicates with the TSB.

5.2.4.3 Inter-Task Communication

The inter-task communication will be accomplished using the message queues and event flag provided by the Real Time Operating System. That is, when each task is created, a message queue and an event flag will be created and assigned to each task. When a task needs to send a message to other task, it will put the message in the queue assigned to the destination task before setting the appropriate bit of the event flag to notify the task. The size of the message queue will be determined later.

5.2.5 Software Blocks

As mentioned earlier, the pBDCX consists of seven background tasks and two foreground tasks, In this section, functions provided by each software block are described.

5.2.5.1 Background Tasks

1. Main Task

The Main Task will perform the following functions:

- Creates and invokes other tasks, namely, BIN Task, AIN Task, Management Task, Watchdog Task, Monitor Task, Diagnostic Task, and Loader.
- Creates and initializes the message queues and event flags that will be used for the inter-task communication.
- Invokes the watchdog timers for the tasks.
- Processes the reset or shutdown signal. Upon receipt of the reset or shutdown signal, the main task will terminate all tasks and exit.
- Initialization of the registers, timers. memory select, chip select, DMA controller, interrupt controller at initialization time. It also configures the Channel Elements at the initialization time.

2. Air Interface Layer(AIN) Task

The primary responsibility of the AIN task is to handle the interface between the Air and the pBDCX. The AIN task will provide the following functions:

- Builds paging channel message - When the Channel Element interrupt handler sends the signals, AIN task packs the paging channel message and put it in the forward link convolutional encoder before sending a message to the BCPC.
- Sends the paging channel response to the BCPC.
- Builds the sync channel message when the Channel Element interrupt handler sends signals and put it in the forward link convolutional encoder.
- Processes the following command messages received from the management task.
- Processes the access channel Over-The-Air (OTA) messages sent by the Channel Element interrupt handler by checking the CRC and sends the message to the BCPC

3. Monitoring Task

- Creates the Diagnostic Monitoring Report messages based on the information received from other tasks and sends them to the Diagnostic Monitor.
- Sends the total number of messages it failed to transmit to the Diagnostic Module during the last period of time if there is any.

4. Management Task

- Sends a Round Trip Delay(RTD) report to TSB upon expiration of RTD timer.
- Sends all messages waiting for the acknowledgment from TSB to the BIN task upon expiration of the ACK timer. The BIN task will retransmit the messages to TSB.
- Sends a forward power report to the BCPC upon expiration of the forward power report timer
- Resynchronizes the Channel Element upon expiration of the Channel Element Reset timer, which is started when the Channel Element is reset.
- Processes the following messages received from the BIN task:

5. pBTS Interconnect (BIN) Task

The primary responsibility of the pBTS Interconnect (BIN) task is processing the messages received or transmitted from/to the TSB or BCPC via the Inter Module Communication bus. The following are the descriptions of the functions of the BIN task.

- Processes the Reverse traffic. It can be either a packet included normal traffic or a Markov packet. For the packet with the normal traffic, BIN task will forward it to TSB while it determines the rate and category and keeps statistics for the Markov packet.

6. Diagnostic Task

The diagnostic task processes the on-line diagnostic request message received from the Diagnostic Monitor(DM). Upon receipt of the diagnostic request from DM, the diagnostic task performs the diagnostic test on the specified Channel Element and sends the result to the DM. The following are functions performed by the Diagnostic Task.

- Processes the well & alive message from BCPC by responding to it.
- Sends a status report to BCPC periodically.

7. Search Done(srch_done) Task

The srch_done task, which is created by the AIN task at the system initialization time, is a background task that handles the search done interrupt generated by the CSM chip. The CSM will generate the search done interrupt upon completion of searching for the followings:

- Access channel preambles
- Traffic channel preambles
- Traffic channel multipath

8. Watch-Dog Task

When a task fails to alert the watchdog on a regular basis, Watch-Dog task will report an error condition and take an appropriate recovery action.

5.3 Inter Processor Communication (IPC)

Inter Processor Communication (IPC) is a software protocol used by processors within the Pico-BTS to communicate with other processors. This is a very simple protocol, which defines the data packet format to be used, and the addressing scheme. The maximum data packet length is 128 bytes within the pBTS, and between the pBTS and the BSC. The Pico-BTS will use the same IPC mechanism as well as the addressing scheme as Gigacells'.

5.4 *Inter Module Communication (IMC)*

Inter Module Communication mechanism is used for communication between the different hardware components within Pico-BTS. IPC data packet, and addressing scheme, as defined attachment A, are used for Inter Module Communication. The following paragraphs describes the different IMC paths available in the Pico-BTS.

- BCPC Software Blocks and pBDCX
  There are two pBDCXs in the pBTS. BCPC has two separate SCC ports providing direct point to point connection with each pBDCX. The speed is at 2.048Mbps.
- BCPC Software Blocks and Backhaul Interface
  This is a parallel connection between BCPC software blocks and the Backhaul Interface Handler (BIH). The interface between Backhaul Interface and BSC is described in section 5.5.

5.4.1 Functional Overview

The primary responsibility of Inter Module Communication (IMC) mechanism is to provide message communication capabilities between the different processors and BSC within the Pico-BTS. As such, the IMC capability is provided on every card that has a processor.

Following is a list of functions required for IMC in the pBDCX cards.

Receiving message

- Receive incoming message
- Verify destination of the received message
- Error checking incoming message
- Store the received message into a buffer
- Use existing mechanism to notify upper layer of incoming message

Sending message

- Verifying there is message to be sent
- Verifying the destination
  - ♦ If destination is another task within the same card, then loop back and stop
- Put the message into proper buffer location, and activate DMA to transmit the message

The IMC requirements for BCPC are much more complex. The IMC must provide router capabilities to route messages between the processors. IMC must also provide gateway capabilities for messages between BSC and pBTS. Both requirements are new and will be implemented in BCPC. Following is a list of functions required for IMC in BCPC.

Router capabilities

- Receive incoming message
- Error checking incoming message
- Verify destination address
  - ♦ If the destination is BCPC software blocks, then store the received message into the buffer for BCPC
  - ♦ Use existing mechanism to notify upper layer of incoming message
- Put one BCPC software block message into proper buffer, activate DMA to transmit the message (This includes message destined for BSC)

Gateway capabilities

Receiving message

- Receive incoming message from BSC
- Verify destination of the received message
- Error checking incoming message

- Store the received message into the buffer for router
    - ♦ If the destination is BCPC, then store the received message into the buffer for BCPC software blocks.
    - ♦ Use existing mechanism to notify upper layer of incoming message
- Notify router of incoming message

Sending message

- Verify there is message to be sent
- Verify the destination
- Put the message into proper buffer location, and activate DMA to transmit the message

5.4.2 Firmware

IMC capabilities are included in the boot flash memory for the pBDCX to facilitate the initial system boot up communication with the BCPC software blocks, this includes software download if required. For the BCPC, IMC capability included in the boot flash memory is the gateway function to facilitate communication with BSC and BSM upon system boot up. The boot flash memory in BCPC will also initialize the Backhaul Interface on system boot up, so that messages can be exchanged between BSC and BCPC.

5.4.3 Software Architecture Overview

The software architecture for the pBDCX is different from the that for BCPC. IMC for the BCPC software blocks has two separate parts - Router and Gateway functions.

5.4.3.1 pBDCX

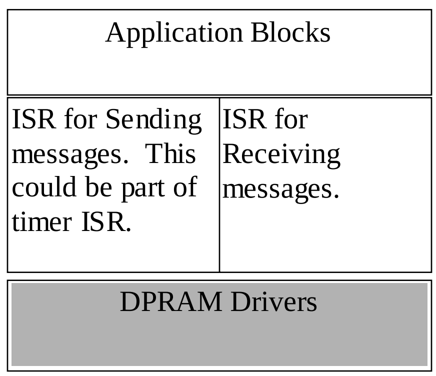

Figure 5.4.3-1 IMC SW architecture

5.4.3.2 BCPC

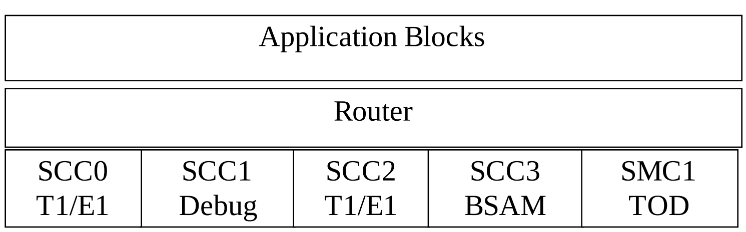

Figure 5.4.3-2 BCPC IMC software architecture

Router switches messages between different ports. BCPC is represented here as a port. It is treated as such by the Router. Gateway to/from BSC is also treated just as a port from the Router's perspective.

5.5 Backhaul Interface Handler (BIH)

Backhaul interface handler (BIH) is the software that handles the messages exchanged between the pBTS and the BSC. This interface uses T1/E1 to connect BSC and Pico-BTS.

- This section describes the functional requirements and software architecture of the BIH.

5.5.1 Functional Overview

The primary responsibility of the BIH is to provide the interface between the BSC and the Pico-BTS through T1/E1. This is accomplished by exchanging information associated with signal flow between the BCPC software blocks and the BSC. Following is a list of functions that will be provided by the BIH.

1. Interface to T1/E1.
2. Pack data to HDLC format.
3. Retrieve data from received HDLC packet.
4. Address translations.
5. Send / Receive data packets to / from BSC and BSM.
6. Backhaul link diagnostics:
    - Local loopback allow link test from BSC,
    - Local loopback allow link test from Pico-BTS.
7. Monitor T1/E1 frame errors.
8. Set/clear T1/E1 link alarms.
9. Backhaul link RTS / OOS / BUSY / IDLE / TEST.
10. BCPC boot ROM will initialize BIH chip set (Bt8370),
11. Initializes T1/E1 interface.
12. A new Inter Module Communication (IMC) mechanism will be used to replace BIN. This IMC will be responsible for all Pico-BTS internal communications.