BRU3 Logic and Radio System

Contents

1 General

The Base Radio Unit 3 (BRU3) is a complete one-channel radio base station which uses 8 kbps data signalling and is designed for the 400, 800 and 900 MHz frequency band. The BRU3, which may be installed outdoors and indoors, is a link between the mobile terminals (MOB) and the area exchanges (MOX) in the Mobitex Network.

The BRU3 includes main computer, internal power supply, internal heating, alarm handling, radio modem, radio transceiver, radio filters and I/O connections. Optional line modem and battery unit may be included.

2 Hardware Units

The BRU3 consists of two main mechanical parts:

FE Case Bottom Frame	FBF	(1)
FE Case Top Frame	FTF	(5)

The FBF comprises:

Weather-protected throughputs for the cabling

FE Connection Board	FNB	(11)
FE Power Supply Unit	FPU	(2)
FE Battery Unit, for power supply backup	FBU	(3)
FE Adaptation Board	FAB	(4)

The FTF is hinged to the bottom part and works as a cover as well as a cooling flange, offering good thermal management for the BRU3. The FTF comprises:

FE Computer Board	FCB	(6)
FE Modem Board	FMB	(7)
FE Radio Board	FRB	(8)
FE Filter Module	FFM	(9)
FE Heating Unit	FHU	(10)

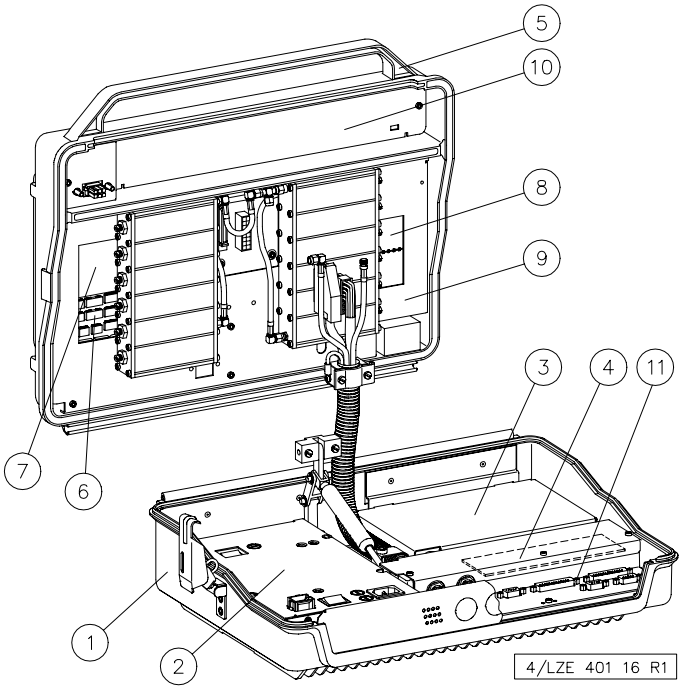

Figure 1 Base Radio Unit (BRU3).

3 Hardware Modules

The BRU3 hardware is shown in *Figure 1 "Base Radio Unit (BRU3)."*. The BRU3 Logic and Modem Equipment, Radio System and the Power Supply Equipment are housed in one single cabinet. The following subsections briefly describe the modules that are directly involved in the traffic flow and signal processing to be outlined below. Other hardware is described further on in this section.

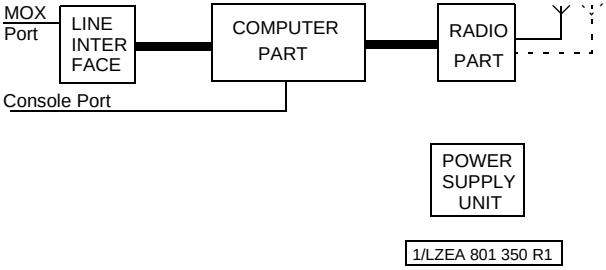

Figure 2 Hardware modules.

3.1 Logic and Modem Equipment

The Logic and Modem Equipment contains the following boards:

FCB FE Computer Board

FMB FE Modem Board

FAB FE Adaptation Board

3.2 Radio Unit Modules

The BRU3 Radio Units contains the following boards:

FRB FE Radio Board

FFM FE Filter Module

3.3 Power Supply Equipment

FPU FE Power Supply Unit

FBU FE Battery Unit

FHU FE Heating Unit

FHB FE Heating Board

FHE FE Heating Element

4 Modem Equipment

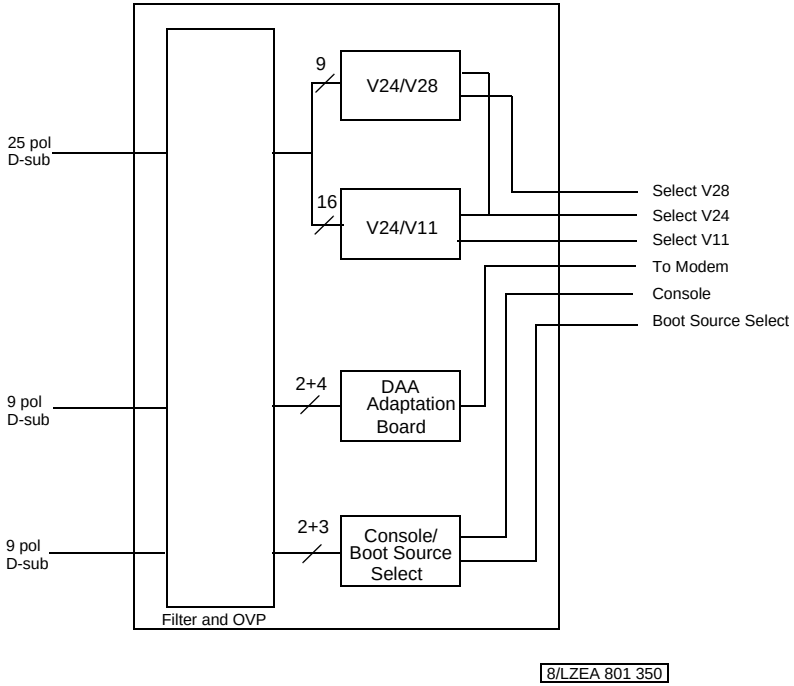

Figure 3 Line interface block diagram.

There are three alternative line interfaces for connection to a MOX:

- telephone modem V.32
- balanced serial interface V.24/V.11 (RS422)
- unbalanced serial interface V.24/V.28 (RS232)

The choice between telephone modem, balanced serial interface and unbalanced serial interface, is made by setting Switch 2 (SW2) as follows. To locate Switch 2, please refer to *FE Computer Board - FCB* in the *BRU3 Mechanical Design* section.

Switch 2			
SW2:1	**SW2:2**	**SW2:3**	**Comments**
Open or closed	Open	Open	V.32bis
Open	Open	Closed	V.28 (RS232)
Closed	Open	Closed	V.11 (RS422)
Other alternatives not allowed.			

SW2:4	Comments
Open	OEM Strap

Data communication between a base station and an area exchange (MOX) is using data connections with a X.25 protocol.

X.25 protocol can use either a leased line or a packet switched data network.

4.1 Telephone Modem Boards

The telephone modem, which supports the CCITT V.32 and V.32bis standards, consists of two separate boards, the FE Modem Board V.32 (FMB) and the FE Adaptation Board (FAB). Depending on national requirements issued by the telecommunications administration in your country, different versions of the FAB may be used. Also, depending on the BRU3 variant, the telephone modem may not be installed.

Two-wire leased, four-wire leased or switched lines are used for data transmission. The maximum transmission rate is 14 400 bits/sec. The modem is connected to the computer part via a synchronous serial circuit.

Asynchronously transferred AT/Hayes commands are used for modem configuration and control.

The software used by the modem is installed from the main processor and stored in a memory.

The FMB does not include a reset button. To reset the FMB and FAB, a power off-operation is necessary.

4.1.1 V.11 and V.28 Serial Interfaces

The FE Connection board (FNB) includes conversion circuits for V.11 and V.28 standards for the serial interfaces. It also includes voltage protection and filters for the modem, the V.11, the V.28 and the console ports.

4.1.2 Interface signals

The following table shows the signals included in the interface. The same signals appear both for V.11 and V.28.

I/O Signal	CCITT V.24 Circuit No.	Description
GND	101	Protective Ground
SG	102	Signal Ground
TD	103	Transmit Data
RD	104	Receive Data
RTS	105	Request to Send
DTR	108	Data Terminal Ready
DCD	109	Data Carrier Detect
ETC	113	External Transmit Clock
TC	114	Transmit Clock
RC	115	Receive Clock

4.1.3 Connector

A 25p d-sub connector is used for both V.11 and V.28. The following table shows the signals used:

Pin	Connector P4 V.28 (RS232)	Connector P5 V.11 (RS422)
1	Protective Ground (101)	Protective Ground (101)
2	TD (103)	TD- (103)
3	RD (104)	RD- (104)
4	RTS (105)	RTS- (105)
5	-	-
6	-	-
7	GND (102)	GND (102)
8	DCD (109)	DCD- (109)
9	-	DCD+ (109)
10	-	-
11	-	TD+ (103)
12	-	RD+ (104)
13	-	RTS+ (105)
14	-	TC+ (114)
15	TC (114)	TC- (114)
16	-	-
17	RC (115)	RC- (115)
18	-	-
19	-	RC+ (115)
20	-	-
21	-	-
22	-	-
23	-	ETC+ (113)
24	ETC (113)	ETC- (113)
25	-	-

5 Logic Equipment

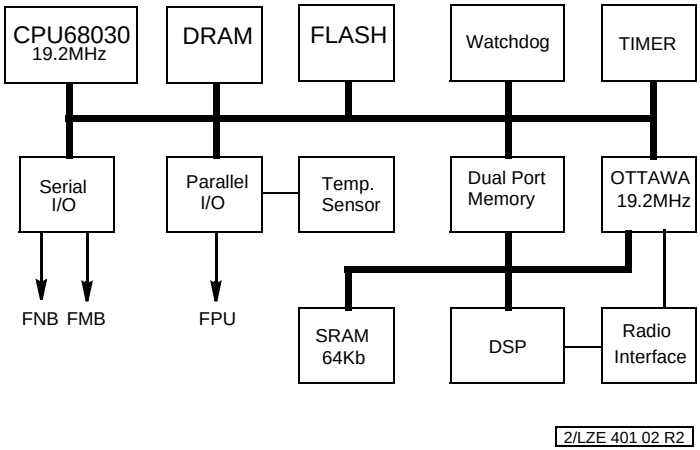

Figure 4 MAIN computer block diagram.

The FE Computer Board (FCB) contains the main computer block which consists of:

- Synchronous serial circuit
- Main CPU including memory
- Memory for main CPU
- Dual port memory
- Signal processor unit (SPU) with memory
- Console ports
- LEDs for Watchdog alarm and status indication
- Reset button
- Switch 2 (SW2) for setting line interface alternative.

5.1 Synchronous Serial Circuit

An integrated circuit, Z16C35, is used as a synchronous serial circuit with Direct Memory Access (DMA). The integrated circuit contains two serial ports. Communication drivers are available in the Mobitex SW.

5.2 Main CPU including Memory

The main CPU consists of a MC68EC030-25RP running at 19.2 MHz.

The DRAM is used for data storage and program execution. The Flash PROM is used to store the system software. There is also a Boot Flash-PROM. The program file for this area is loaded to the Flash-PROM via the console port using a VT100-compatible portable PC. (For more information, please refer to *Software Commissioning Procedure* in the *Commissioning Procedure* section of the *BRU3 - General* module.)

There are no EPROM, EEPROM or SRAM for the main CPU.

The main CPU also comprises the following functionalities:

- Watchdog
- Parallel inputs for alarms.
- Parallel outputs for LEDs and other controls.
- Clock-tick generator, fed by the reference oscillator.

5.3 Dual Port Memory

The dual port memory transfers data between the main CPU and the Signal processing unit (SPU). The size is 2Kbit * 16. The memory is implemented in a dual port memory chip.

5.4 Signal Processor Unit with Memory

The TMS320C25 Signal processor unit is used for modulation, demodulation and radio control. The SPU contains an 8 kbit * 16 SRAM with 25 ns access time. No EPROM or FLASH is included. The BOOT program is loaded to the dual port memory by the main CPU.

5.5 Console Ports

The FCB contains two ports for serial communication, both handled by the integrated circuit Z16C35.

Port A implies complete synchronous functionality, and also, limited modem support. By the FNB and FMB, this port can be used for V.24/V.28, V.24/V.11 or V.24/V.32.

Port B is intended for the use of a console via the FNB with the V.24 signals, RX and TX.

5.6 LEDs

LED	Colour	Function
Status indicator	Yellow	Lit when the processor is operating OK.
Watchdog alarm	Red	Lit when the Watchdog is released. If so, a reset pulse is generated. The Watchdog LED is lit and the signal WDSTATUS, read by the CPU, peaks.

5.7 Reset Button

To enable a hardware reset of the FCB and the FMB (Modem Board), and also, the FRB (FE Radio Board), the FCB is equipped with a reset button located next to the LED Status indicator. To reach the button for a reset operation, use a long and narrow, non-conductive object (pen or similar). A reset of the FCB may be generated for the following reasons:

1. Power-on reset: The reset is generated at power-on, and also, when a power drop occurs.

2. Switch reset: The reset is activated when the reset button is pressed.

3. Watchdog reset. The reset is activated by the watchdog function if not maintained.

4. CPU reset: The reset is performed by the CPU when a reset instruction is executed. In this specific case, no reset of the CPU itself is carried out.

6 Radio System

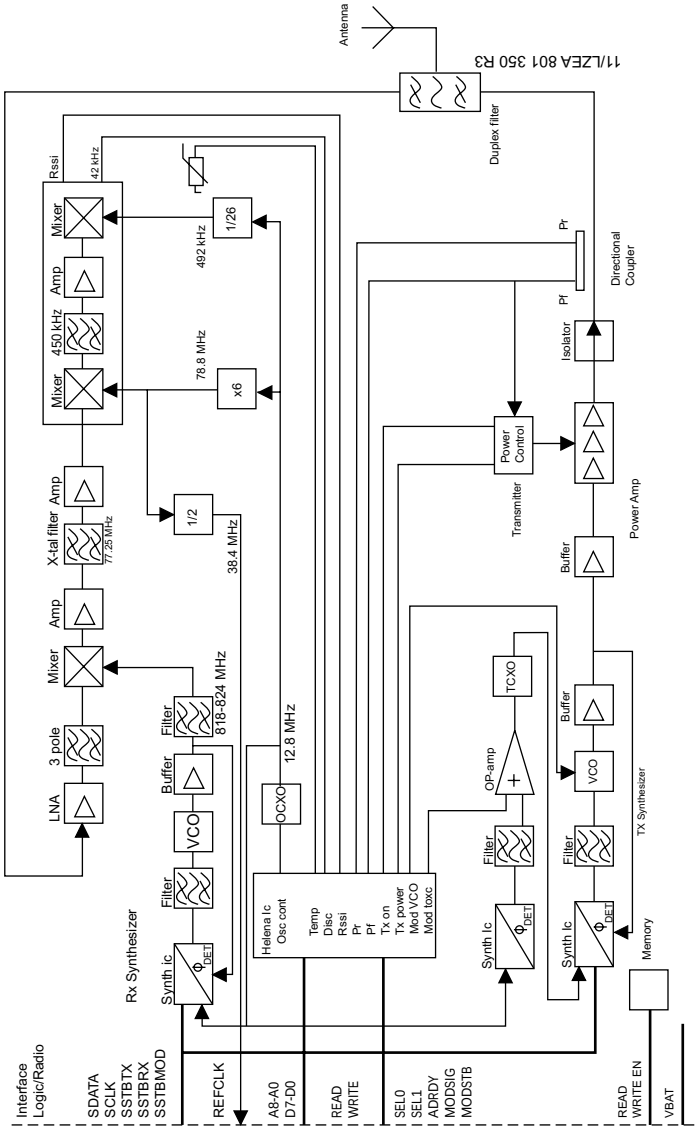

Figure 5 Radio system block diagram.

6.1 Radio Parameters

Radio data transmission rate	8 kbps
Modulation	modified GMSK
Traffic mode	duplex
Channel bandwidth	12.5 kHz
Sensitivity	-117 dBm at 1% BER

6.1.1 Frequency Band 400 MHz (HRB 104 43/xx)

Frequency range			
	Tx: within the 400	MHz	range.
	Rx: within the 400	MHz	range.
Frequency stability	±0.2	ppm	
Antenna output power	6	W	Duplex filter
	6	W	TxBP filter
Antenna impedance	50	ohms	

For a list of all Product Numbers, please refer to the *Introduction and Product Specification* section in the *BRU3 - General* module.

6.1.2 Frequency Band 800 MHz (HRB 104 43/C20)

Frequency range			
	Tx: 864.0 - 870.0	MHz	
	Rx: 819.0 - 825.0	MHz	
Duplex spacing	45	MHz	
Frequency stability	±0.1	ppm	
Antenna output power	6	W	Duplex filter
	6	W	TxBP filter
Antenna impedance	50	ohms	

For a list of all Product Numbers, please refer to the Introduction and Product Specification section in the BRU3 - General module.

6.1.3 Frequency Band 900 MHz (HRB 104 43/C2, C4, C5, C6)

Frequency range			
	Tx: 935.0125 - 940.9875	MHz	
	Rx: 896.0125 - 901.9875	MHz	
Duplex spacing	39	MHz	
Frequency stability	±0.1	ppm	
Antenna output power	3	W	Duplex filter
	3	W	TxBP filter
Antenna impedance	50	ohms	

For a list of all Product Numbers, please refer to the *Introduction and Product Specification* section in the *BRU3 - General* module.

6.1.4 Frequency Band 900 MHz (HRB 104 43/C7, C8)

Frequency range			
	Tx: 935.0125 - 940.9875	MHz	
	Rx: 896.0125 - 901.9875	MHz	
Duplex spacing	39	MHz	
Frequency stability	±0.1	ppm	
Antenna output power	6	W	Duplex filter
	6	W	TxBP filter
Antenna impedance	50	ohms	

For a list of all Product Numbers, please refer to the *Introduction and Product Specification* section in the *BRU3 - General* module.

6.2 Radio Units

The BRU3 Radio Unit is operated locally on site by using a VT-100 compatible terminal, e.g., a portable PC, and FB-TEST. By using FBTEST, it is possible to set TX and RX frequencies, transmitter power, alarm levels, parameters etc.

The BRU3 is designed for duplex traffic 8 kbit GMSK modulation. The radio unit consists of the following main parts:

- transmitter including synthesizer
- receiver including synthesizer
- modulation synthesizer
- reference oscillator
- radio control circuit
- memory for radio parameters
- filter.

6.2.1 Transmitter

The modulated output signal to the transmitter is generated by the transmitter synthesizer. The synthesizer output signal is isolated from the transmitter power amplifier by two buffer amplifiers. These buffer amplifiers will prevent the power amplifiers from altering the signal when the transmitter power is switched on.

The power amplifier supplies the desired power level from the transmitter. An isolating device after the power module will suppress unwanted external signals from generating intermodulation products with the transmitted signal.

A directional coupler is used to measure the output power from the transmitter and the reflected power from the antenna. The output power from the transmitter is controlled by an ALC (Automatic Level Control).

The modulation of the transmitter is achieved using a two point modulation method. The VCO is modulated directly with a signal from the radio control integrated circuit. The other modulated signal is applied to the reference frequency input of the transmitter synthesizer.

By using this modulation method, it is possible to obtain a fast settling time for the transmitter synthesizer and maintain a low cut-off frequency for the GMSK modulated signal.

6.2.2 Modulation Synthesizer

A modulated reference signal to the transmitter synthesizer reference is generated using an extra reference synthesizer. The modulation signal is added to the control voltage of the Voltage controlled crystal oscillator (VCXO). In order to keep the high frequence accuracy of the reference oscillator, the VCXO is phase-locked to this signal. This loop is designed to be very slow in order to get a low cut-off frequency for the modulated signal.

6.2.3 Receiver

The input signal from the antenna is filtered by a duplex filter, then amplified in a Low Noise Amplifier (LNA). Further filtering is obtained in a ceramic filter after the LNA.

The signal is down-converted to 77.25 MHz in a double balanced high-level mixer. A Local Oscillator (LO) signal to the mixer is generated by the receiver synthesizer. The LO signal is filtered before it is fed into the mixer.

After the mixer, the signal is amplified and filtered in a 77.25 MHz crystal filter. An IF-integrated circuit with two mixers and limiting amplifiers, are used to get the 42 kHz signal to the discriminator. Also, there is an output signal with a voltage proportional to the input signal strength (RSSI), from this circuit. The oscillator signal to the IF-section is generated from the overtones and divided signals from the reference oscillator.

6.2.4 Reference Oscillator

The reference oscillator is a oven-controlled high-performance crystal oscillator. The output frequency is adjusted with an input control voltage. For information on how to adjust the reference oscillator, please refer to *Software Commissioning Procedure* in the *Commissioning Procedure* section of the *BRU3 - General* module.

6.2.5 Radio Control Circuit

The radio is controlled by a custom-made integrated circuit. This circuit includes a digital discriminator for the receiver. Control of the radio and trimming of the modulation index of the transmitter is performed by D/A converters in the circuit. Alarm and other signals from the radio part (RSSI, Temperature, Transmitter power and Reflected power) are measured with A/D converters in this circuit.

6.2.6 Filter

A high performance low loss duplex filter is used to achieve sufficient isolation between the receiver and the transmitter.

7 Power Supply Equipment

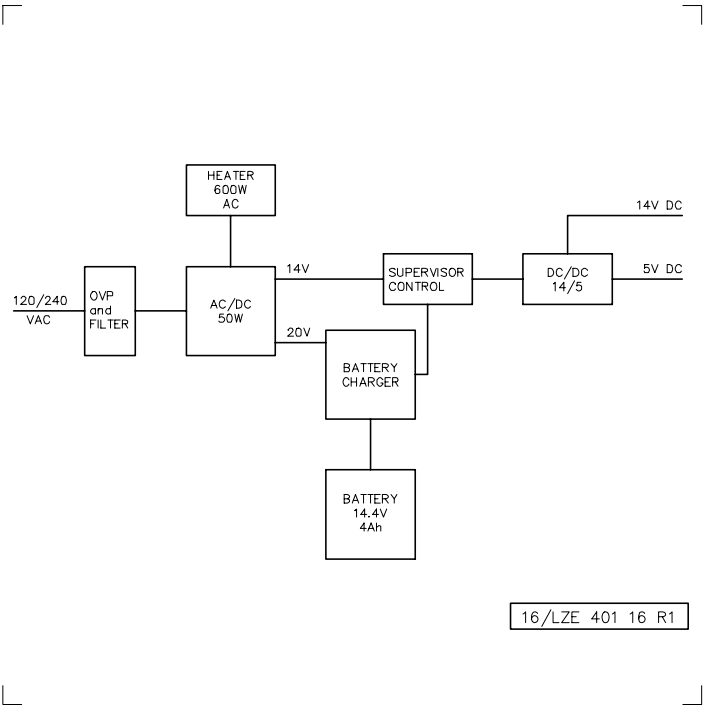

Figure 6 Power supply block diagram.

The BRU3 power supply parts are located in the FE Case Bottom Frame (FBF). The power supply parts include the FE Power Supply Unit (FPU) and the FE Battery Unit (FBU). The FE Heating Unit (FHU) located in the FE Case Top Frame (FTF), is also regarded as a part of the power supply.

The power supply parts are to be used for:

- Uninterruptible power supply with distribution of 14V and 5 V DC to the FCB and FRB
- Lightning protection
- Fused mains feed-through to the FHU.

7.1 Power Supply Unit

The FPU includes the following main parts:

- AC/DC module
- DC/DC module
- Battery charge
- DC alarm supervisor control
- Lightning protection
- Connectors
- Switches
- LEDs (Status indicators)
- Fuses.

7.1.1 AC/DC Module

The AC/DC module is an isolated switchmode power supply which supplies the DC/DC module, the charge control and the radio part with 14V.

7.1.2 DC/DC Module

The DC/DC module is a non-isolated step-down converter that supplies the logic with 5V.

7.1.3 Battery Charge

The charge control circuit supplies the battery with the correct charge. The charger is charging the battery with a constant current. To protect the batteries, the current is reduced in both low and high temperature. Therefore, the charging time depends on the ambient temperature.

7.1.4 DC Alarms

If either of the output voltages, 14 V or 5 V, is outside normal value, the FPU will indicate this to the FCB. This failure mode will also be indicated on the FPU.

7.1.5 Lightning Protection

The FPU is equipped with a lightning protector which protects the unit according to IEC 801-5.

7.1.6 Connectors

Connector	Type	To/From
MAINS INLET	J1	120 or 230V AC power input to the FPU
POWER OUTLET TO HEATER	J2	120 or 230V AC power output to the FHU
POWER OUTLET INT. SUPPLY	J3	Power output to the FCB (5V and 14.7V) and power input from the FBU (14.7V).

7.1.7 Switches

Switch	Function
MAINS SWITCH	AC power supply on/off switch
BATTERY SWITCH	Battery power supply on/off switch

7.1.8 LEDs

LED	Colour	Function
MAINS	Yellow	Lit when incoming 120 or 230V AC power is OK.
14V	Yellow	Lit when 14V DC power distribution to the radio unit and the DC/DC module is OK.
ERROR	Red	Sum alarm, indicates unspecified power failure in the FPU.

7.1.9 Fuses

Fuse	Type	Safety device for
F1 6.3AT 250V	6.3AT 5x20 mm	Mains input.
F2 6.3AT 250V	6.3AT 5x20 mm	
F3 6.3AF 250V	6.3AF 5x20 mm	Power to/from the FBU.

7.2 Battery Unit

The FE Battery Unit (FBU), located in the FTF, consists of a battery pack of 12 NiCd cells 1.2V 4Ah with extended temperature range. The battery is designed to withstand continuous charge.

8 Heating unit

The FE Heating Unit (FHU) is located in the FE Case Top Frame (FTF). The FHU ensures that the temperature inside the BRU3 is within set limits.

The unit consists of the FE Heating Board (FHB), including a heating regulator, a heating element and an overheating protection device.

When the temperature on the surface of the FTF is about 25 °C or lower, the FHU starts heating the BRU3.
If the temperature rises to about 55 °C due to a temperature regulating failure, the overheating protection will cut off the power supply to the FHU.

9 BRU3 Connections

The following table gives a brief description of the BRU3 connections used. The position numbers found in the “Position” column refer to the corresponding position numbers in *Figure 7 “BRU3 external connections.”*.

Pos.	Connector	Type of connector	Connection To/From
3	MAINS INLET	IEC	120/230V AC input from BRU3 site power supply.
1	RX ANT.	TNC	Signals from the receiving antenna (RX).
2	TX ANT. ALT. RX/TX ANT.	TNC	Signals to the transmitting antenna TX. Signals to/from the combined RX/TX antenna.
4	P3-TELEPHONE	9p d-sub	Telephone line connection.
5	P5-RS422B	25p d-sub	Connection to MOX via balanced serial interface RS422B.
6	P4-RS232C	25p d-sub	Connection to MOX via un-balanced serial interface RS232C.
7	P2-ALARM	9p d-sub	Connection used for external alarm. Defined by the operator.
8	P1-CONSOLE	9p d-sub	Connection used for Console/ NODOP terminal.

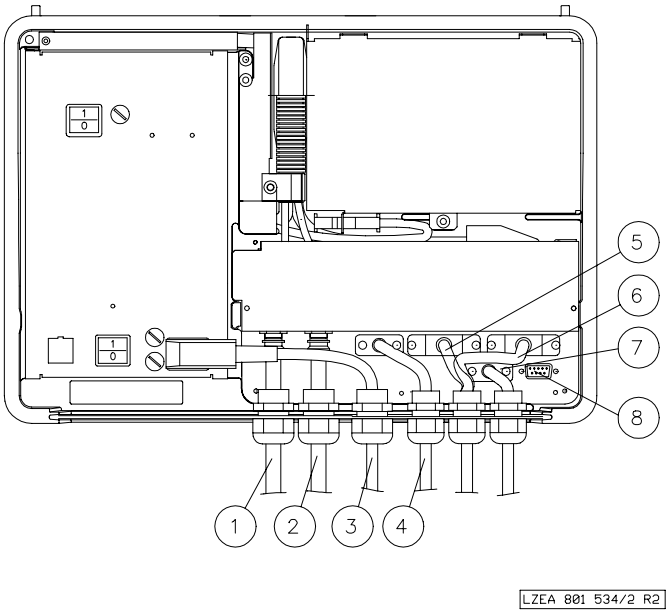

Figure 7 BRU3 external connections.

1. RX Antenna
2. TX Antenna
3. Power Connection
4. Telephone Line Connection
5. Modem Connection RS232
6. Modem Connection RS422
7. Alarm Connection
8. Console Connector.

Pos 2 is used as the antenna connection when a combined RX/TX antenna is used, i.e., in case an optional duplex filter is installed.

The ground connection is to be found on the outside of the BRU3.

9.1 I/O CONNECTIONS

MOX connection:

Number of ports		3 DMA support
Port locations		FNB
Alternative 1 (One alternative at a time only)		
	Communication interface	RS232D
	Communication baudrate	Max. 19.2 kbps
Alternative 2		
	Communication interface	RS422
	Communication baudrate	Max. 64 kbps
Alternative 3		
	Communication interface	V.32
	Communication baudrate	Max 9.6 kbps
Alternative 4		
	Communication interface	V.32bis
	Communication baudrate	Max 14.4 kbps

Console/NODOP connection:

Number of ports	1
Port location	FNB
Communication interface	RS232D
Communication baudrate	9.6 kbps

External hardware alarm connections:

Number of alarm inputs	2
Port location	FNB

One of the external alarm loops is by default strapped for the open case alarm.

Antenna connections:

Number of connections	1 or 2 (Duplex or Bandpass filter), Located on FNB
Connector type	TNC, female

10 Software Description

The software is divided into the following blocks:

BOOT software:	PREBOOT FE BOOT FE
Switch software:	MAIN FE
Miscellaneous software:	FBTEST X.25 LOADER FE
Modem application software:	

10.1 PREBOOT FE

The main purpose of PREBOOT is to act as a PROM programmer for the Flash PROMs mounted on the FE Computer Board (FCB).

When the base station has been restarted and the main CPU starts to run, PREBOOT is the first program to be executed. When PREBOOT starts to execute it will perform a number of hardware initializations. These initializations are made to set the hardware to a defined state.

Depending on the setting of a hardware jumper, PREBOOT will enter one of two different states upon start-up. In the first state, which is the normal state, PREBOOT will check whether or not the Flash-area is valid. If the area is valid, the control of execution will be handed over to the BOOT program. If the area is not valid, the second state will be entered. In the second state, PREBOOT acts as a PROM programmer. PREBOOT is now able to receive programming information from the Console Port. When the programming information has been received, it is programmed into the specified Flash-area and PREBOOT will make a CPU restart.

PREBOOT offers the service of programming Flash-areas to other blocks. This service is accessed via a lookup at a fixed address in the area where PREBOOT resides.

The process of receiving programming information from the Console Port is called program loading.

10.2 BOOT FE

BOOT takes care of the initialization of the hardware and starts the execution of an application program.

10.3 MAIN FE

The MAIN block is an application program that implements the Mobitex network services, i.e., packet switching, subscription authorization, creation of traffic logs and monitoring operation.

The MAIN block also includes the handling of the radio channels.

10.4 FBTEST

FBTEST is an application program that executes a number of test procedures for the base station hardware.

For further information, please refer to the *FBTEST Reference Manual*.