1. Introduction to This Manual

This manual contains all the information necessary to install and maintain the Fixed Subscriber Unit (FSU).

1.1 Organization

This manual is organized to assist the installer and technician in gaining an understanding of the Fixed Subscriber Unit in terms of the system's physical characteristics, installation instructions, and maintenance methods. Listed below are descriptions of each chapter in this manual :

Introduction **-** Describes the contents of this manual.

General Description **-** Provides a high level description of the Fixed Subscriber Unit System.

System Construction **-** Provides a more detailed system description of physical characteristics.

Installation Instructions **-** Details all the steps necessary to install the device.

Acronyms and Abbreviations List **-** Provides definitions for each abbreviation and acronym used in this manual.

Appendix A : Specifications **-** Lists the specifications for the FSU.

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2. General Description

The Fixed Subscriber Unit (FSU) is the radio equipment that connects to fixed standard telephones and is located in the subscriber's residence. FSUs consist of a Radio Frequency (RF) interface and a telephone line interface. Together they manage the supplied line voltage, the ringing signal, Dial Tone (DT) and Busy Tone (BT) to the telephone, detect off-hook and on-hook states, and dialing.

In a zone near the Radio Port (RP), the FSU uses a 4.5 dBi, omni-directional, attached antenna. In zones far from the RP, the FSU uses a 10 dBi, directional, Yagi type, attached antenna. In mid-range zones, the FSU uses a 7 dBi omni-directional antenna. The telephone line interface consists of a BRSH (Battery supply, Ringing Supervision, Hybrid) circuit, service tone generator, DTMF receiver, and ADPCM CODEC.

The number of fixed standard connected telephones from the same battery supply circuit is three. The power of FSU is fed from the external DC power generated by AC adapter.

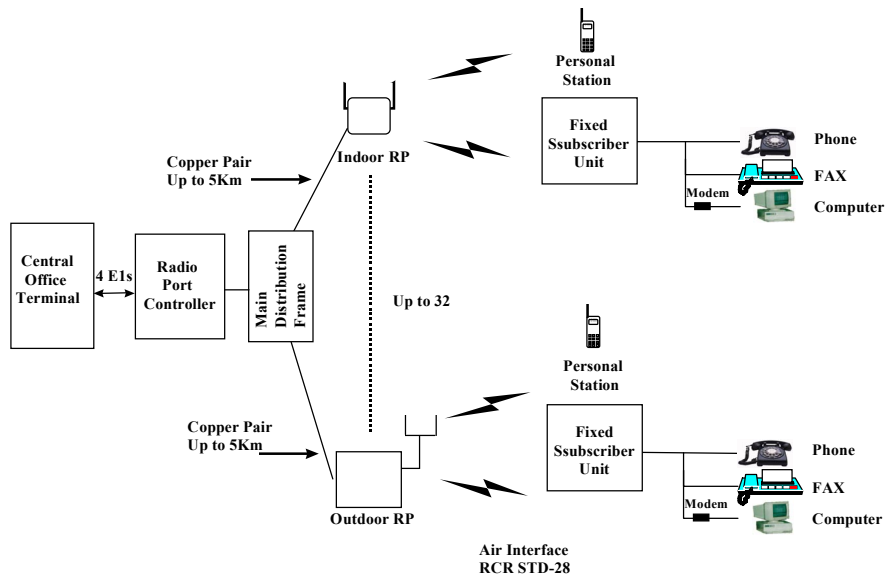Figure 2-1 shows the FSU in the Airstar-WLL system architecture.


Figure 2-1 : Overview of FSU in Airstar-WLL System

The following sections describe the air interface call handling procedures for outgoing and incoming calls. In addition, brief descriptions of the

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authentication, hooking signal transmission, and meter pulsing signal transmission functions are provided.

2.1 Outgoing calls

The call handling procedure for an outgoing call is depicted in Figure 2-2 and is described following the figure. A terminal on an FSU sends dialing information with standard in-band DTMF tones after recognizing dial tone.
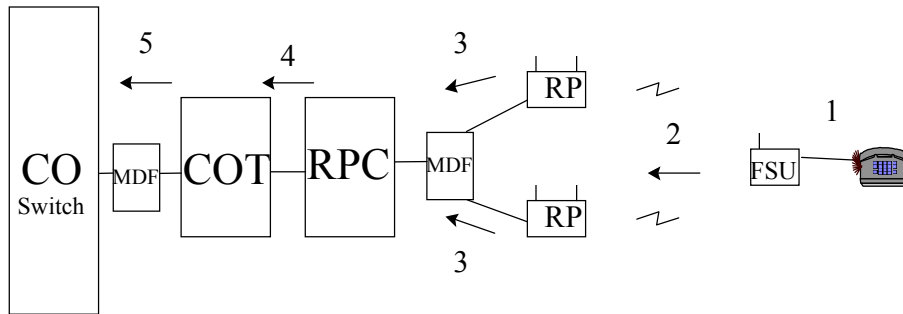
Figure 2-2 : Outgoing Call

1. When the fixed standard telephone connected to the FSU goes off-hook, the FSU detects the off-hook state, seizes the radio link to the RP, and generates a signal to the standard telephone. If all radio channels are occupied, a Busy Tone is heard. Otherwise the FSU stores the dial code from the standard telephone, converts the outgoing message with the telephone's number of Personal Handyphone System (PHS) protocol, and transmits the message to the RP.

2. The RP receives the message from that FSU through the radio link.

3. The RP resends the received message to the Radio Port Controller (RPC) through the twisted pair wires via the Main Distribution Frame (MDF).

4. The RPC converts the PHS protocol message to a Q.931 protocol message. In addition, the RPC extracts the dial code from the outgoing message, and changes it to DTMF signals. The Q.931 message is sent to the COT through the D-channel of the E1 line.

5. When the COT receives the outgoing message, it converts that message, selects and seizes the corresponding analog line interface to the CO, and returns the seized message to the RPC. The RPC sends the DTMF dialing signals to the CO Switch through the voice path via the MDF. After dialing, the RPC and RP connect all voice paths between the CO Switch and the FSU connected to the outgoing standard telephone. The destination telephone rings and is picked up, and the outgoing call is put through. A voice path is now established between the 2 telephones.

2.2 Incoming Call

The call handling procedure for an incoming call is depicted in Figure 2-3 and is described following the figure.
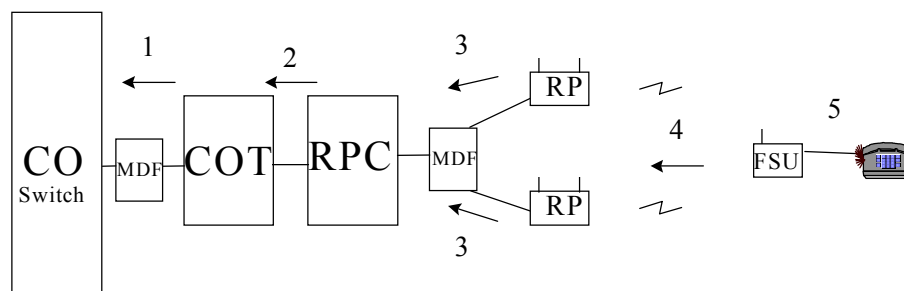

Figure 2-3 : Incoming Calls

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1. A specific analog line is rung in the CO. The signal is sent to the COT via the MDF.

2. The COT detects the ringing of the line and sends the incoming message with the Q.931 calling number to the RPC.

3. When the RPC receives the incoming message from the COT, the RPC converts that Q.931 message to the PHS incoming message protocol and sends it through the MDF to all of the RPs.

4. The RPs page all FSUs and PSs. When the corresponding FSU number receives the paging message from the RP, it rings the connected telephone.

5. If the ringing telephone is lifted off-hook, an off-hook message is sent to the CO switch through the RP, RPC and COT. Speech paths are established between the connected telephones.

NOTE : If a call is received while dialing out, the incoming call has priority. In the case of overlap sending, only DTMF dialing is availaable and DP is not supported.

2.3 Authentication

Authentication is a function that prevents the unauthorized use of a subscriber's telephone number. The authentication procedure is performed during Outgoing Calls, Incoming Calls and Location Registration. At subscription time each FSU is configured with a unique authentication key and telephone number. The COT is also configured with the telephone numbers and authentication keys for all FSUs within its management database. After receiving an authentication key code from the COT, the RPC:

1. Generates a random authentication pattern and sends it to the FSU.

2. Receives the calculation result from the FSU.

3. Checks the result and sends both the calculation and check result to the COT.

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COT   RPC   FSU

Facility
(Authentication Required (Key))   Authentication Req

Authentication Req

Facility
(Authentication Result)   Authentication
operation
(calculation
and check)
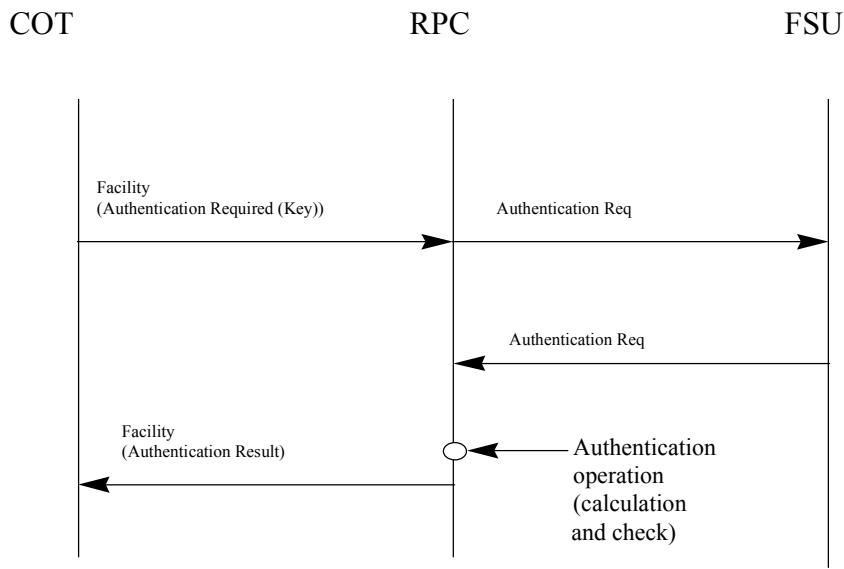
Figure 2-4 : Authentication

2.4 Hooking Signal Transmission

The hooking signal transmission function relays the hooking signal message from an FSU to a COT. The COT generates a hooking signal according to the message.

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3. System Construction

The Fixed Subscriber Unit, as shown in Figure 3-1, has the following dimensions:

- Length : 130mm

- Width : 175mm

- Depth : 40mm

Figure 3-1 : FSU - Main Unit

Refer to *Appendix A* for FSU specifications.

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4. Installation Instructions

This section provides instructions for installing an FSU. The flow-chart in Figure 4-1 defines the steps involved in an installation.
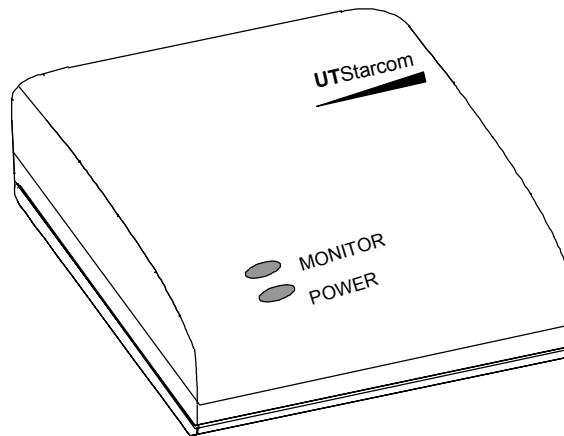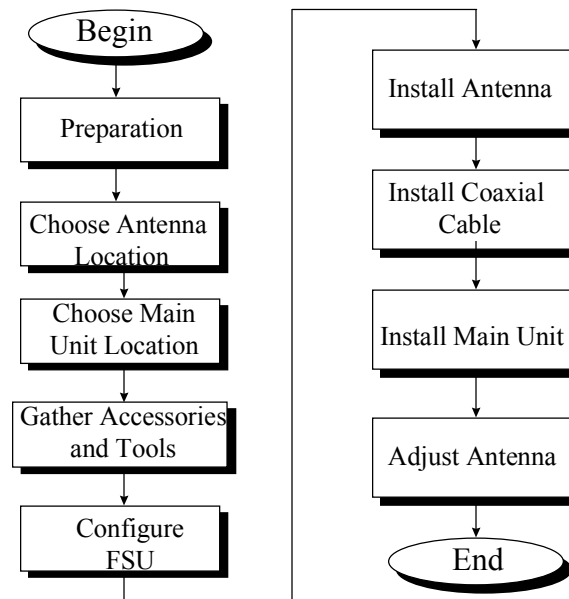
```
        ┌─────────┐                    ┌──────────────────┐
        │  Begin  │          ┌────────▶│  Install Antenna │
        └────┬────┘          │         └─────────┬────────┘
             ▼               │                   ▼
      ┌──────────────┐       │         ┌──────────────────┐
      │  Preparation │       │         │ Install Coaxial  │
      └──────┬───────┘       │         │      Cable       │
             ▼               │         └─────────┬────────┘
   ┌──────────────────┐      │                   ▼
   │ Choose Antenna   │      │         ┌──────────────────┐
   │    Location      │      │         │ Install Main Unit│
   └────────┬─────────┘      │         └─────────┬────────┘
            ▼                │                   ▼
   ┌──────────────────┐      │         ┌──────────────────┐
   │  Choose Main     │      │         │  Adjust Antenna  │
   │  Unit Location   │      │         └─────────┬────────┘
   └────────┬─────────┘      │                   ▼
            ▼                │              ┌─────────┐
   ┌──────────────────┐      │              │   End   │
   │ Gather Accessories│     │              └─────────┘
   │    and Tools     │      │
   └────────┬─────────┘      │
            ▼                │
   ┌──────────────────┐      │
   │   Configure      │      │
   │     FSU          │──────┘
   └──────────────────┘
```

Figure 4-1 : FSU Installation Flow Chart

4.1 Before Beginning

To ensure that the FSU installation goes smoothly, it is necessary to do adequate planning prior to the installation. Things to consider:

- Configuration of FSU

- Configuration of COT

- Placement of the Main Unit and the Antenna

- Accessories, Standard and Special Tools required

- Number of people needed to complete an installation.

An FSU installation is accomplished in two parts : the Main Unit that is installed indoors and the Antenna that is installed outdoors.

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4.1.1 Plan FSU Configuration

The FSU must be configured at subscription time with the subscriber's telephone number, authentication key, operator ID, and carrier channel. The subscriber's data must also be entered into the COT. The following data must be entered for each subscriber:

- Telephone number

- Authentication key

- FXO port

RP numbers of the RPs having the control channel for each FSU must also be entered in the COT. The RP numbers are determined either by the Coverage Map or by the installer at the subscriber's site. Once the FSU main unit and antenna are installed, the installer uses the PHS Field Analyzer or equivalent to determine which RP's signal is received by the FSU. This is accomplished by measuring the Received Signal Strength (RSS). Some FSUs will receive signals from multiple RPs, the installer must identify them and measure their RSS. Once RP number(s) are configured in the COT for the FSU, these RPs become the only RP(s) through which the FSU can place and receive calls. Refer to *Section 4.2* for additional information regarding FSU configuration instructions.

Use local procedures to ensure that the COT's System Administrator gets the RP numbers and the associated telephone numbers for entry into the COT. Until an FSU's RP numbers are configured in the COT, it will use any available RP for placing and receiving calls.

4.1.2 Antenna Orientation

Careful placement of the antenna is necessary to ensure clear reception. Position the antenna so that it is :

- In clear view of a Radio Port

- Not blocked by buildings, summer foliage nor heavy traffic of large vehicles

- At least 2 meters in height, use Coverage Map and on-site measurements to determine exact height, usually 2 meters or higher

- Directed towards the strongest RSS measurement, for directional antenna only

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- On a wall or pole that is sufficiently strong, make sure wall or pole can withstand winds common to the area

- Away from other objects such as poles, trees, buildings, and so on that block the signal from the Radio Port; in general the minimum distance is 750 mm.

4.1.3 Antenna Type Determination Guidelines

The Coverage Map shows Radio Port locations and the area covered by the RP. The type of antenna installed depends on its distance from the Radio Port. In general:

If distance is…	Then use…
Less than 500m	4.5 dBi omni or directional antenna
Between 400m and 700m	7 dBi omni or directional antenna
Greater than 700m	10 dBi directional antenna

Table 4-1 : Antenna Type Determination Guidelines

There may be exceptions to the requirements in Table 4-1 identified by on-site RSS measurements and/or by the specific radio environment.

4.1.4 Main Unit Site Selection

Choose a suitable location for the FSU Main Unit. Make sure the site will not expose the device to :

- Direct sunlight

- Dampness or moisture

- Dust

- Magnetic fields

- Vibration

- Extremes of heat, cold or humidity.

Install the FSU on a stable surface, such as a desk or wall. Consider the length of the AC Adapter cord in determining the Main Unit's location. To avoid possible interference from the connected telephone, make sure the Main Unit is installed at least 1 meter away. To minimize the length of coaxial cable

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between the main unit and the antenna, position the indoor main unit as close as possible to the outdoor antenna.

Note : Make sure that the FSU Main Unit is positioned so that the green LEDs are visible to the subscriber. When reporting trouble, the subscriber will be asked the status of the LEDs.

4.1.5 Installation Accessories, Standard and Special Tools

This section lists all the equipment needed for and FSU installation. Be sure to have all of these items on hand before beginning.

Accessories:

- Coaxial cable

- Coaxial cable connector (2 pieces)

- Marker

- PVC tape

- Self-adhesive rubber tape

- Earth cable

- Solderless grounding terminal (optional)

- Bracket for cable

- U-bolt for pole mount

- Terminal lug

- Terminal lug crimper

Note : In areas where lightning may strike, a lightning protector is required.

Standard Installation Tools:

- Wire cutter

- Adjustable wrench

- Pliers

- Cutter

- Flat screwdriver

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- Phillips (or Plus) screwdriver

- Electric drill

- Step ladder

- AC power extension cord

Special Tools for Cable Termination:

- Cable stripper

- Crimper

Antenna Orientation Instruments:

- Map

- Compass

- Binoculars

Measuring Receiver or Equivalent:

- Measuring receiver

- Memory card

- AC adapter

- Adapter (3-poles$\rightarrow$2-poles conversion)

- Coaxial cable adapter TNC-J/SM-J (optional)

- 5 meters of coaxial cable (optional)

- Power cable

4.2 FSU Configuration Instructions

The FSU's configuration data consists of dozens of parameters that are loaded at the factory. When a subscriber requests service, four of these parameters must be re-configured. Re-configuring the FSU entails writing the following information to the FSU's Electrically Erasable Programmable Read Only Memory (E^{2}PROM):

- PS-ID

- Telephone number [PS Number (1-11)]

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- Authentication key

- Operator ID

- Control carrier

The above data is entered using the PSJ_Jr. device connected to a PC that has been loaded with the FSUJ software.

Note : The FSUJ screens shown in this section are presented in inverse black and white for clarity.

WARNING : MAKE SURE THAT THE FSU'S CONFIGURATION DATA IS READ PRIOR TO WRITING THE NEW CONFIGURATION DATA. IF THE DATA IS WRITTEN BEFORE IT IS READ, ALL OF THE CONFIGURATION DATA ON THE CURRENT SCREEN WILL BE ERASED.

BE SURE TO COPY THE STANDARD CONFIGURATION DATA TO A FLOPPY DISK FROM ANY FSU. THIS BACK UP FLOPPY CAN THEN BE USED TO RE-LOAD CONFIGURATION DATA THAT ACCIDENTLY GETS ERASED.

Use the following procedures to configure an FSU:

1. Connect the PSJ_Jr. device to the PC running the FSUJ software. Attach the RS-232 connector to the COM1 port on back of the PC.

2. Make sure that the FSU's power cable is disconnected. Then connect the FSU to be configured to the PSJ_Jr. device. Raise the connector cover and attach the special FSU connector to the the back of the FSU. Refer to Figure 4-11. Attach the other end of the cable to the connector on the PSJ_Jr. device labeled PS.

3. To execute the FSUJ software, double click on the *f.bat* icon.

4. Enter the password and the FSUJ Menu shown in Figure 4-2 displays.

```
        FSUJ MENU
        WLLSO setup
        FSU reset
```

Figure 4-2 : FSUJ Menu

5. Use the ↓ key to move the cursor to the **WLLSO Setup** option and press the Enter ↵ key. This displays a WLLSO Setup screen similar to the one shown in Figure 4-3.

```
M#> - IBM_FSUJ                                               _ □ ✕
Auto      ▼  [ ]    🖾  🖾   🖾🖾  A
FSUJ   special    FSU    offline WLLSO setup
                                                    page NO.(01)
                      HEX                DEC                address
PS-ID information flg  FF                 255                 0000
PS-ID                 FF FF FF FF        255 255 255 255      0005
public SO valid offset FF                 255                 0057
public SO valid flg   FF                 255                 005C
-PS number(1-11)      FF FF FF FF FF FF  255 255 255 255 255 255  005D
-PS number(12,13)     FF                 255                 0063
-priority designation FF                 255                 0064
-authentication       FF FF FF FF FF     255 255 255 255 255  0068
-operator info length FF                 255                 007D
-operator ID          FF                 255                 007E
-control carrier      FF                 255                 007F
paging disconnect flg FF                 255                 00A7
paging disconnect timer FF               255                 00A8
country number        FF FF              255 255              00A9
en-block sending select FF               255                 00FE

   E2writ E2read              FDread FDwrit
```

Figure 4-3 : WLLSO Setup Screen Without Configuration Data

6. To read the factory configured data, press the F2 key. On the screen, this key is labeled E2read.

7. A confirmation box appears prompting **execute to read to E2PROM. OK (Y/N).** Enter **Y**. The screen is populated with the factory configured data. Refer to Figure 4-4.
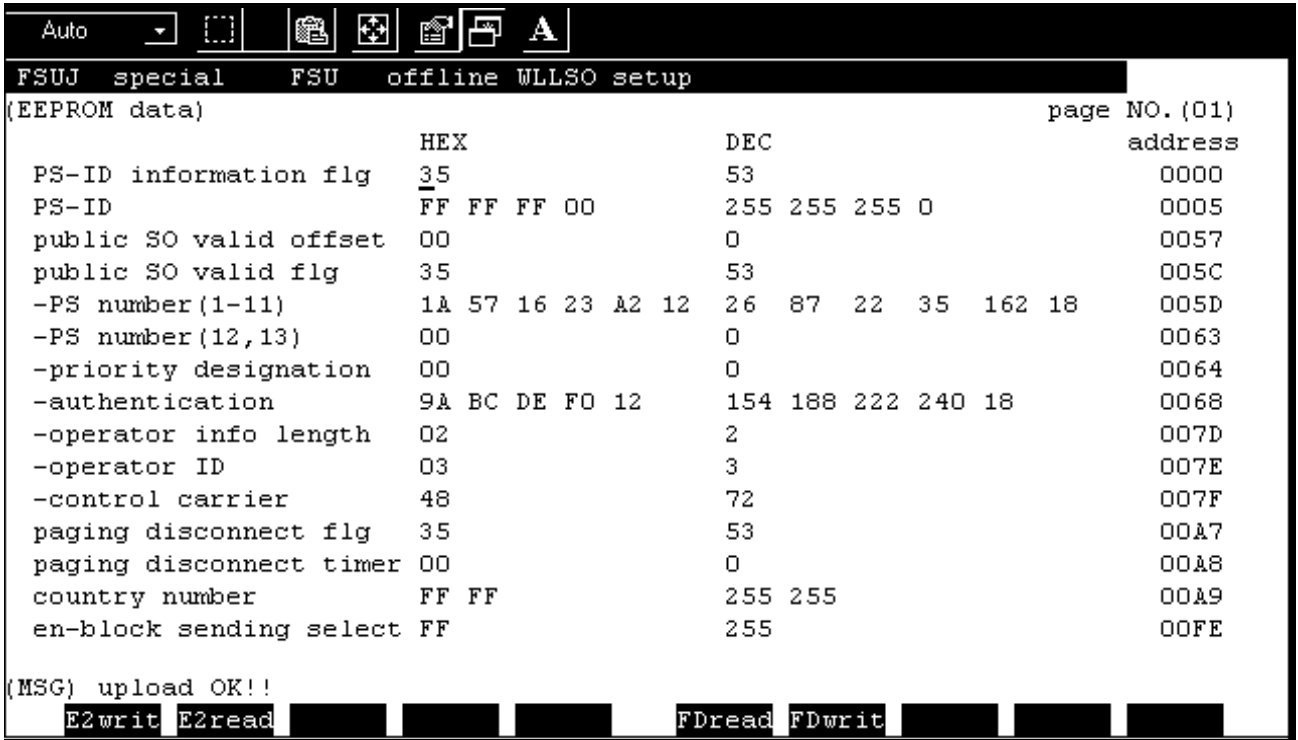
```
Auto      ▾  [ ]   ⊞  ⊠  ⬚⊟  A
FSUJ  special    FSU   offline WLLSO setup
(EEPROM data)                                               page NO.(01)
                      HEX                 DEC                   address
 PS-ID information flg  35                 53                    0000
 PS-ID                  FF FF FF 00        255 255 255 0         0005
 public SO valid offset 00                 0                     0057
 public SO valid flg    35                 53                    005C
 -PS number(1-11)       1A 57 16 23 A2 12  26  87  22  35  162 18  005D
 -PS number(12,13)      00                 0                     0063
 -priority designation  00                 0                     0064
 -authentication        9A BC DE F0 12     154 188 222 240 18    0068
 -operator info length  02                 2                     007D
 -operator ID           03                 3                     007E
 -control carrier       48                 72                    007F
 paging disconnect flg  35                 53                    00A7
 paging disconnect timer 00                0                     00A8
 country number         FF FF              255 255               00A9
 en-block sending select FF                255                   00FE

(MSG) upload OK!!
    E2writ E2read            │       │       │    FDread FDwrit    │       │       │
```

Figure 4-4 : WLLSO Setup Screen With Configuration Data

Note : This application uses the letter A for zero. Zero is used for a delimiter.

8. Use the ↓ key to move the cursor to the PS-ID field, enter the new PS-ID number to be assigned to this FSU by striking over the old numbers.

CAUTION : THE PS-ID NUMBER MUST BE UNIQUE ACROSS ALL PSs AND FSUs IN THE SYSTEM.

9. In a similar manner, enter the telephone number, the authentication key, operator ID, and the control carrier to be assigned to this FSU.

10. When the new configuration data is entered, press the F1 key. This key is labeled E2writ on the screen. A confirmation box appears prompting **execute to write to E2PROM OK? (Y/N).** Enter **Y**. The new configuration data is written to the E^2PROM within the FSU.

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4.3 Coaxial Cable Installation

Once the locations for the antenna and the main unit have been determined, use the procedures in this section to install the cable.

1. Measure and cut a length of cable to fit between the main unit and the antenna.

2. Run the cable between the main unit and the antenna.

3. Using the cable stripper, strip both ends of the coaxial cable. Refer to the figure below for exact dimensions to strip.
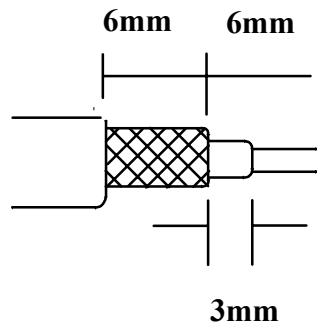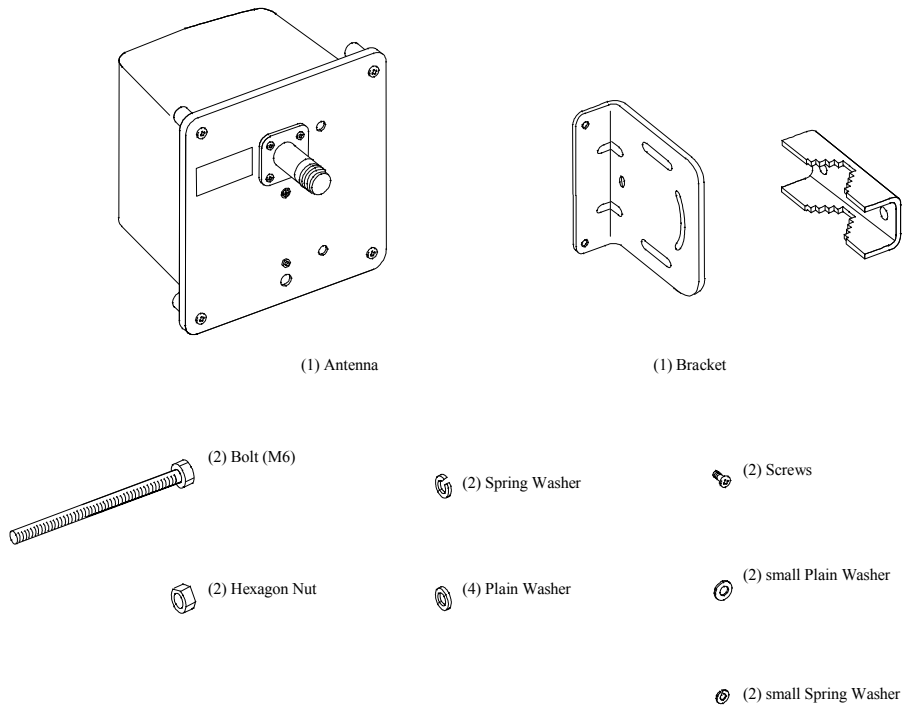
6mm   6mm

3mm

Figure 4-5 : Stripped Coaxial Cable

4. Carefully mount the coaxial cable terminals onto the cable ends.

5. Affix the cable terminals using the crimper.

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4.4 Antenna Installation

NOTE : The antenna shown in this manual is one of the three types of antennae used in the Airstar-WLL system.

1. Unpack the FSU Antenna and accessories. Make sure all parts are in good condition.   The FSU Antenna and accessories are shown in Figure 4-6.

(1) Antenna   (1) Bracket

(2) Bolt (M6)   (2) Spring Washer   (2) Screws

(2) Hexagon Nut   (4) Plain Washer   (2) small Plain Washer

(2) small Spring Washer

Figure 4-6 : FSU Antenna and Accessories

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2. Assemble the FSU antenna by attaching the bracket to the antenna according to Figure 4-7.
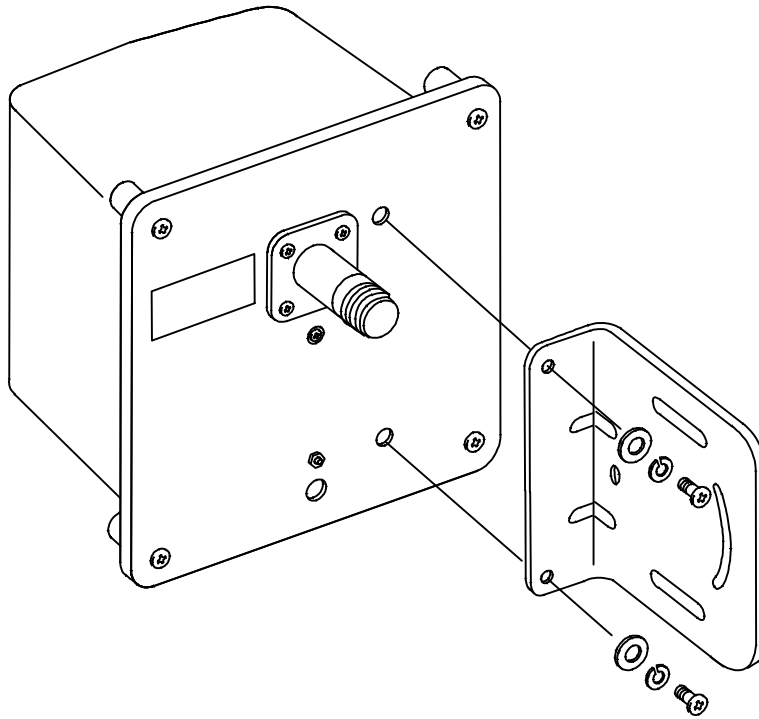
Figure 4-7 : Antenna Bracket Assembly

3. After installing the antenna, use the PHS Signal Analyzer to check the receiving signal level. Measure the reception level (RX LVL) at the TNC connector on the FSU. Target values are as follows :

- RX LVL: more than -78dBm (35dBμV)

- Frame Error Rate: less than 2%

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4. At the site selected for the FSU antenna, tentatively mount the antenna and take several RSS measurements approximately 15 cm from the antenna. Position the antenna where it receives that strongest signal. Then mount the antenna on a pole. Refer to the figure below for assembly of the bracket onto the pole
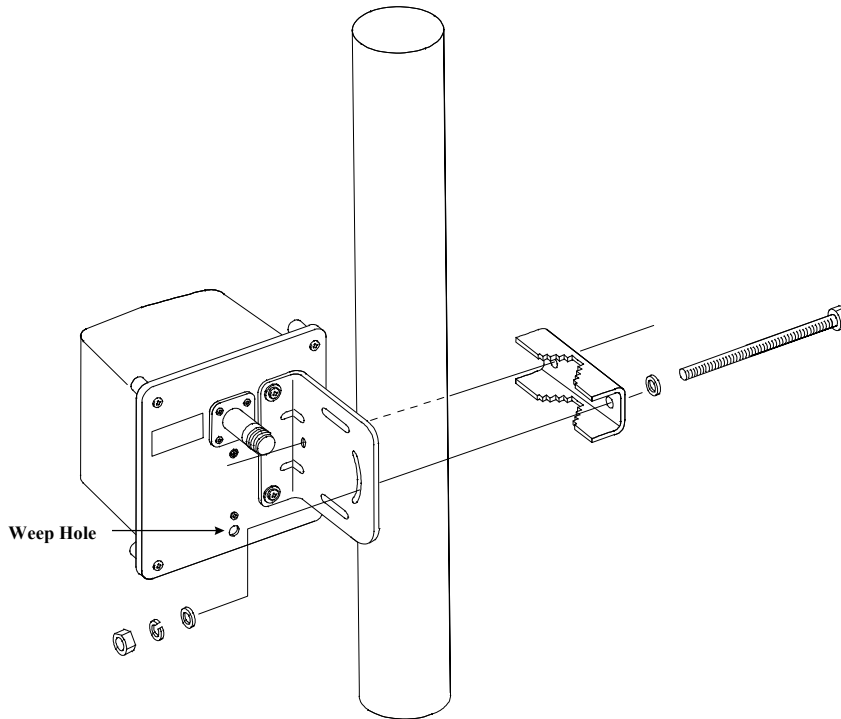
Weep Hole

Figure 4-8 : Antenna Mounted On Pole

Note : Make sure that the weep hole is positioned at the lower edge of the antenna bracket as shown in Figure 4-8.

5. After installing the antenna, use the PHS Signal Analyzer to check the receiving signal level. Measure the reception level (RX LVL) at the TNC connector on the FSU. Target values are as follows :

- RX LVL: more than -78 dBm (35 dBμV)

- Frame Error Rate: less than 2%

WARNING : DEPENDING ON LOCATION, IT MAY BE NECESSARY TO GROUND THE ANTENNA TO PREVENT DAMAGE BY LIGHTNING. REFER TO THE FIGURE BELOW FOR A DIAGRAM OF THE EARTH CABLE CONNECTION.
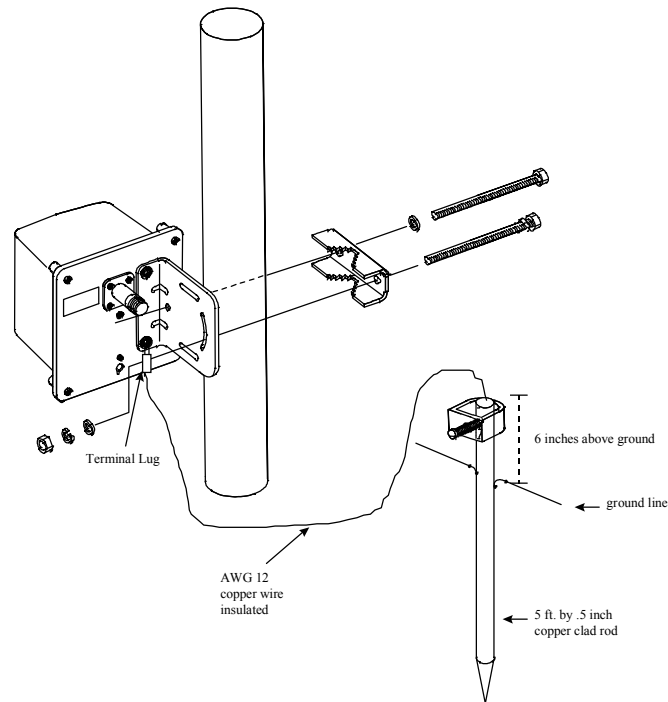
Figure 4-9 : Earth Cable Connection

6. Attach a terminal lug to the lower bracket screw and tighten screw.

7. Plug insulated copper wire into the terminal lug and use the terminal lug crimper to affix the copper wire to the terminal lug.

8. Attach the other end of the copper wire to a copper clad rod as shown in the figure above.

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9. Connect the coaxial cable to the antenna as shown in Figure 4-10.
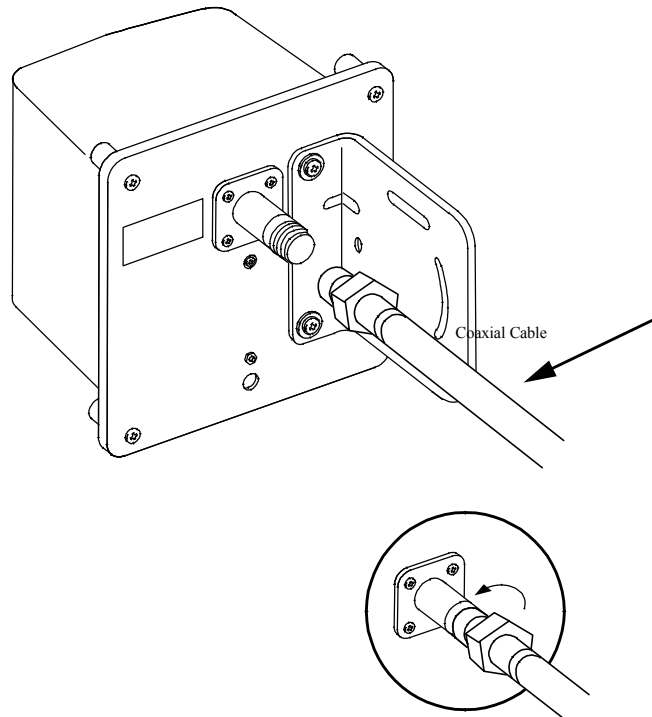
Coaxial Cable

Figure 4-10 : Coaxial Cable Connection to Antenna

10. Wrap the cable connection first with the self-adhesive rubber tape. Stretch the tape until it is ½ its original width. Then wrap the PVC tape around the rubber tape.

4.5 Main Unit Installation

Follow the steps below to install the FSU Main Unit in the subscriber's residence.

1. Unpack the FSU and accessories. Make sure all parts are in good condition. The accessories include :

   - AC Cord

   - AC/DC Adapter

   - Backup Battery Unit

   Figure 4-11 shows the FSU and its accessories.

AC/DC Adapter

Main Unit

AC Cord

Connector Cover

Backup Battery Unit
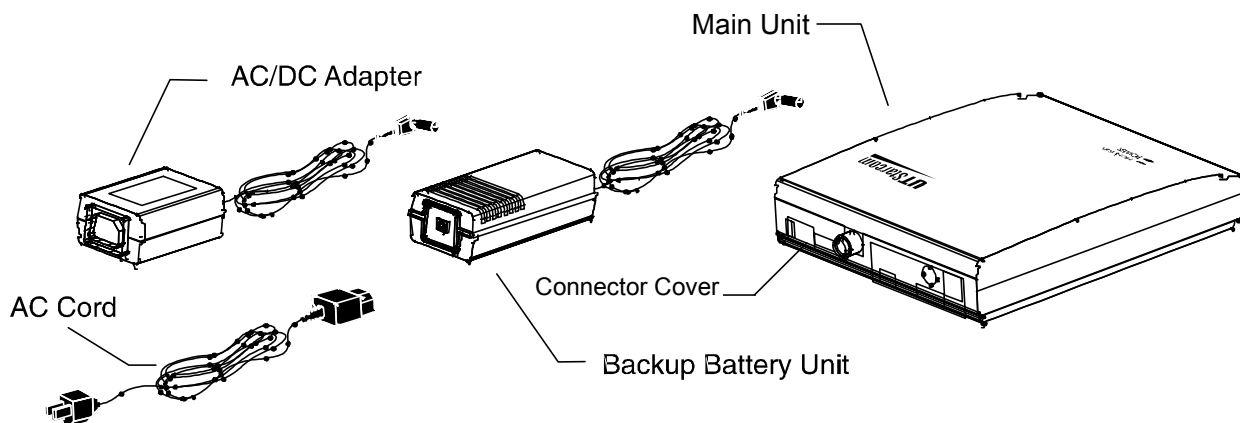
Figure 4-11 : FSU and Accessories

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2. Connect the external antenna cable to the Antenna Cable Outlet located on the back of the FSU. Refer to Figure 4-12.
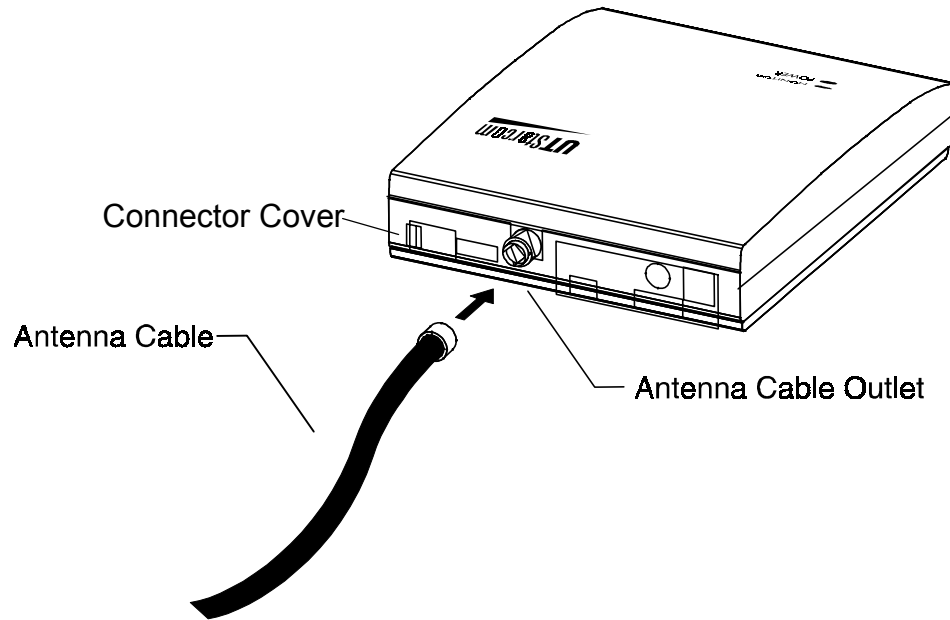
Figure 4-12 : Antenna Cable Connection

3. Connect the telephone set to the RJ-11 jack on the back of the FSU using a standard telephone cord. See Figure 4-13.
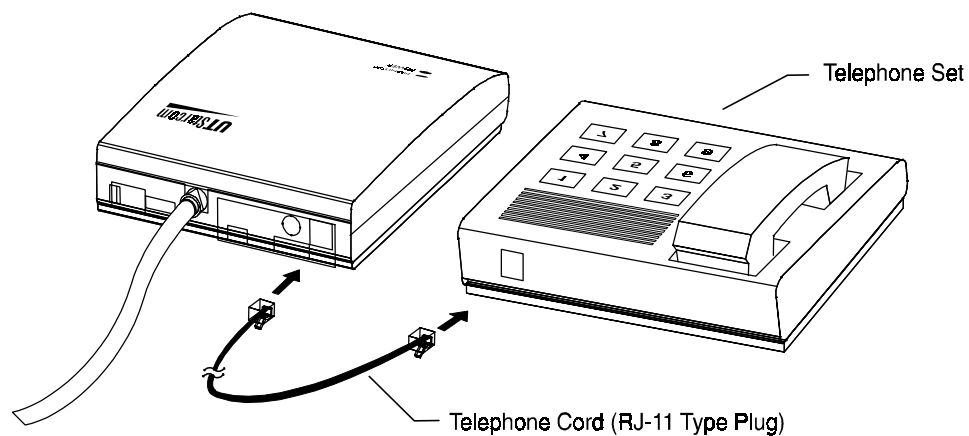

Figure 4-13 : Telephone Cord Connection

Note : The telephone cord must have an RJ-11 type plug.

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4. Connect the Backup Battery Unit to the DC Input receptacle, also on the back of the FSU.

NOTE : A fully charged backup battery allows the FSU to continue operation if power fails. The backup battery provides approximately two hours of talking time and approximately 20 hours of standby time. Recharging may take up to 30 hours. In the event of a prolonged power failure, remove the battery to avoid over discharging as this may shorten the battery's life. Backup batteries must be replaced every 2 years. The batteries' capacity decreases to 60% after 2 years , at approx. 25°C
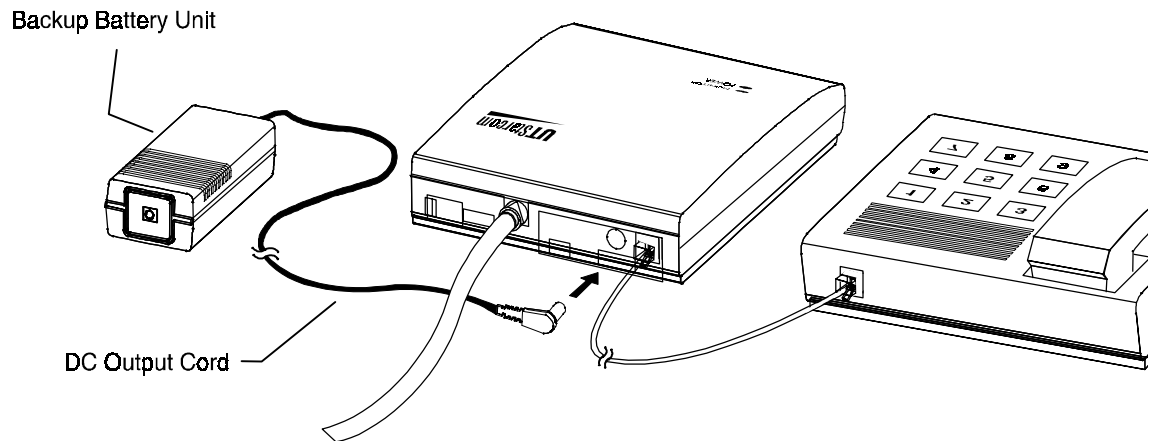
Figure 4-14 : Backup Battery Unit Connection

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5. Connect the AC/DC Adapter to the Backup Battery Unit, as shown in the figure below.
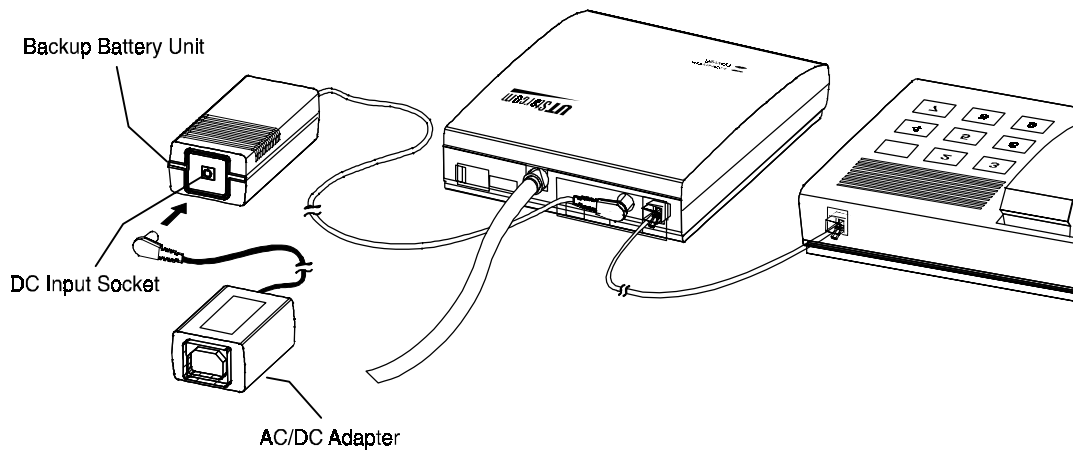
Figure 4-15 : AC/DC Adapter Connection

6. Connect the AC/DC Adapter to an AC outlet. Refer to Figure 4-16. The Monitor Lamp on the FSU should light, indicating the line is ready for use. If the Monitor Lamp blinks or does not light, adjust the antenna until the Monitor Lamp remains lit. If the Monitor Lamp does not light after antenna adjustment, contact a qualified service technician.
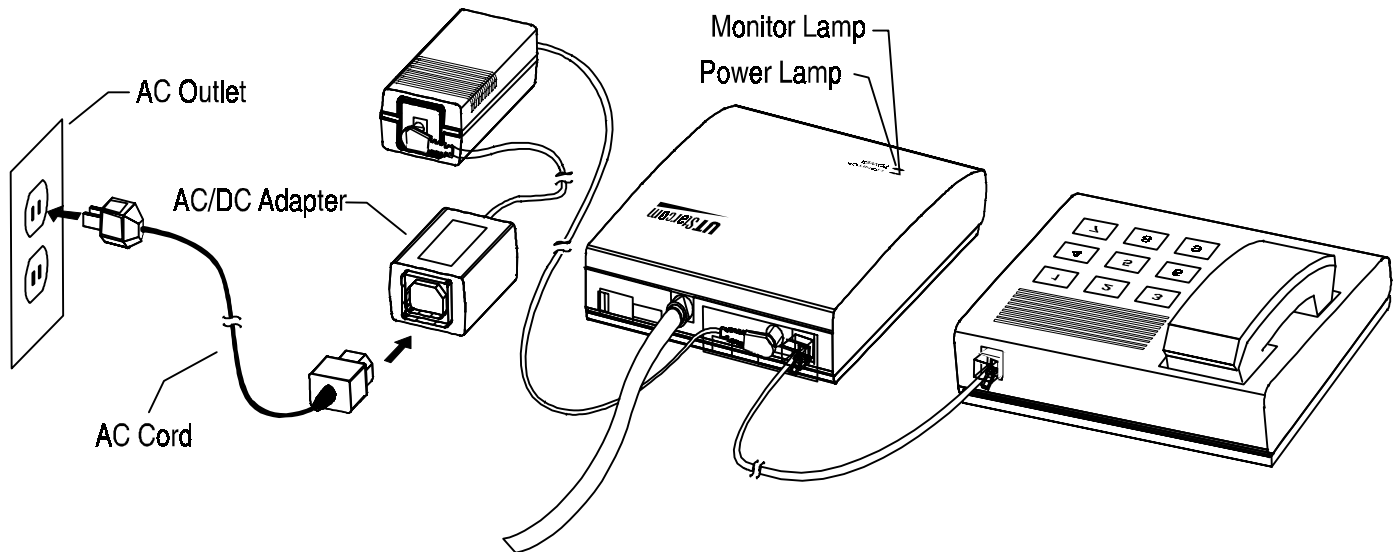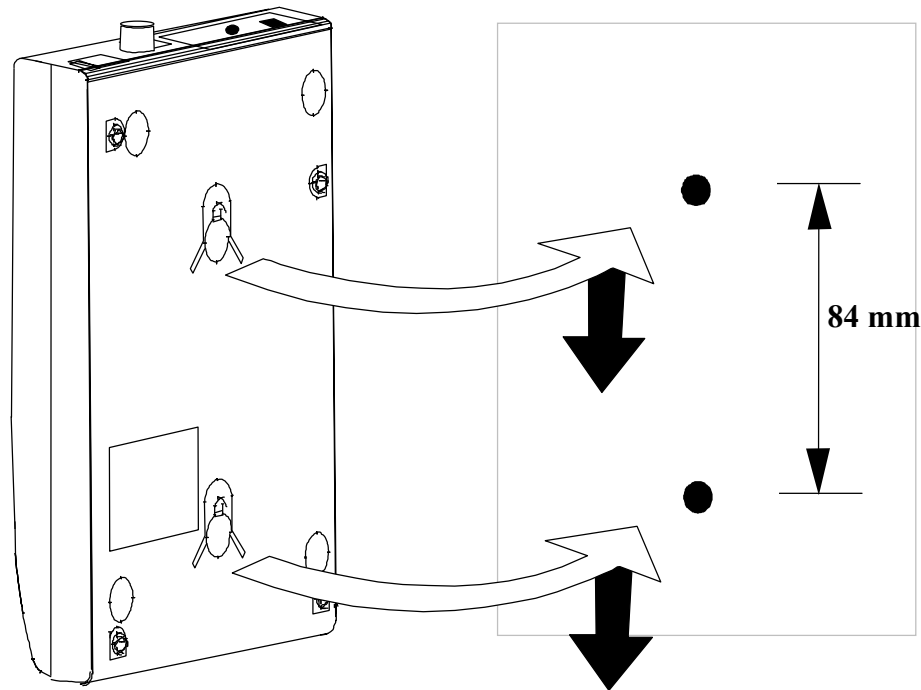
Figure 4-16 : AC Outlet Connection

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7. If wall mounting is desired, locate a position on the wall for the FSU. Mark the screws' locations using the enclosed mounting template. Mount the main unit on the wall using the supplied two screws. Refer to Figure 4-17.

**84 mm**

Figure 4-17 : Wall Mounting

8. If wall mounting is not desired, be sure to affix the Antenna Cable to a stable surface such as a wall, a floor, or a table to insure that the FSU does not move by force of a loose antenna cable.

4.6 Antenna Orientation Adjustment

If it is necessary to adjust the position of the antenna, follow the steps below to orient the antenna for better reception :

1. Loosen the bolts fastening the antenna to the bracket.

2. Connect the PHS Signal Analyzer to the antenna. It may be necessary to use the coaxial cable adapter (TNC-J/SMA-J).

3. Turn on the PHS Signal Analyzer's power and turn the antenna to the direction with the maximum RSS level.

4. Tighten the fastening bolts.

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Figure 4-18 depicts an FSU configuration in a subscriber's residence.
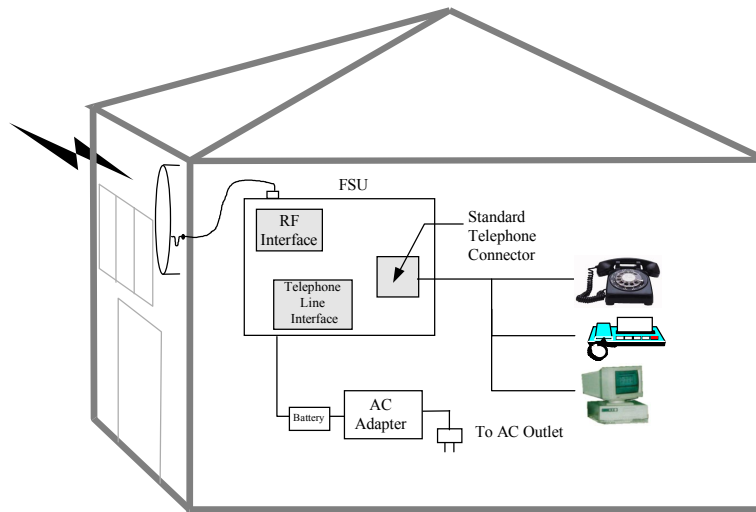
Figure 4-18 : Fixed Subscriber Unit Configuration

5. Acronym and Abbreviation List

AC	Alternating Current
ADPCM	Adaptive Differential Pulse Code Modulation
BRSH	Battery supply, Ringing Supervision, Hybrid
BT	Busy Tone
C-channel	Control Channel
CO	Central Office
CODEC	COde/DECode
COT	Central Office Terminal
DC	Direct Current
D-channel	Data channel
DT	Dial Tone
DTMF	Dual Tone Multi-Frequency
FSU	Fixed Subscriber Unit
MDF	Main Distribution Channel
PHS	Personal Handyphone System
PS	Personal Station
RF	Radio Frequency
RP	Radio Port
RSS	Received Signal Strength
RSSI	Received Signal Strength Indicator
T-channel	Traffic channel
WLL	Wireless Local Loop

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