OPERATIONAL DESCRIPTION

SYSTEM DESCRIPTION

The wireless PBX uses a spread spectrum frequency hopping RF link to transfer control data and digital compressed voice at a bit rate of approximately 115Kbit/sec in each direction. PBX features such as digital voice data switching, CO lines interface control and extension controls are all done at the base module. System basic configuration is done from the handsets.

The Base unit manages the Handsets (Data and control). It acts as two CO lines interface and perform all PBX function. Other system options are two additional CO lines interface and TAD. The system consists of two major subsystems:

1. Base with upgrade capabilities, which optionally includes two extra CO lines and TAD in all combinations.
2. Wireless handsets (up to fifteen, eight of which can be operate simultaneously).

The communication method between the wireless handsets and the Base complies with the WINGs™ standard.

Following, a short description of the handset block diagram:

- RF Module – Based on the Butterfly's MMIC BFM9011J and BFM 9021J for 900MHz SSFH The RF module interfaces the handset through the BFC2203 (include controls and programming). The RF module has it's own voltage regulator.
- Base band – BFC2203 ASIC implementing of WINGS™ protocol. It communicates with handset controller using SPI protocol (with chip select option). The BFC2203 runs at 12MHz using a 12MHz crystal with 5ppm accuracy.
- BFA5220TQ – HS application controller used to communicate with the WINGS™ network, operate the DSP, LCD and keypad, monitor battery discharging, supervise battery charging and implement the higher level protocol with the Base unit.
- DSP – CT8015 TrueSpeech® DSPG VOCODER.
- CODEC and Audio Amplifier – Minus 3 volts PCM CODEC integrating the audio circuitry for microphone and earphone. The microphone is an omnidirectional condenser of the type WM-54B. The earphone is 150Ω dynamic receiver for telephone HS.
- LCD – A 2 lines of 12 characters dot matrix each, and 12 icons. Controlled by PHILIPS PCF2113x controller. Communication with HS controller is done over I^2C protocol.
- Keypad – Handset's keypad is 19 printed switches, mapped on a 7X3 matrix. Matrix coulombs are connected to the lower bits of HS controller data bus, and matrix rows are connected to the interrupt lines of HS controller.

The HS operates from three AAA cells NiMH 550mAh rechargeable battery. Voltage operation range is from 3.0 volts, and up to 4.3 volts. Two low-drop 3 volts regulators are used to maintain a constant voltage to all modules. One for the RF module with operation control ability (some parts of the RF transmitter operate directly from the battery). Second regulator (operates continuously) is used for all other components (excluding RF module). Voice channel components (DSP, CODEC and microphone) are powered through power switch controlled by HS application.

General

The transmitter and receiver in the RF module share a single antenna terminal which is switched between them on a TDD basis (time division duplex), i.e., when a data packet is received the transmitter is inactive and does not interfere with the reception, and the reception is inactive during transmissions.

The transceiver employs frequency hopping spread spectrum which is managed by the baseband processor (external to the RF module).

The transmission and reception are based on synthesized oscillators that share the same 12 MHz reference clock which is provided as an input to the module.

- **Carrier Frequencies**

The transceiver’s 50 frequencies are: 902.5MHz, 903.0MHz, 903.5MHz…927.0MHz (902.5MHz to 927.0MHz with 0.5MHz channel separation).

- **Modulation and Bandwidth**

The modulation index of the FSK modulation is set to h≅0.5, which creates a modulated signal with a 20dB bandwidth of about 500kHz (maximum allowed by the FCC in this frequency band).

Receiver

The receiver is a dual conversion heterodyne receiver with a second IF at 10.7 MHz, where the FSK demodulation is performed. Its circuitry is based on the BFM9021J incorporating a low-noise-amplifier, two frequency conversions, an FM demodulator and an RSSI output (received signal strength indication). An external baseband stage functions as a data slicer and provides a logic-level output which is interfaced with the digital logic external to the module.

The first conversion is based on a synthesized local oscillator which is set at 110.7 MHz above the received frequency (the first IF is at 110.7MHz). The second conversion is based on a fixed crystal oscillator at 100MHz which down-converts the modulated signal to the second IF of 10.7MHz.

The receiver sensitivity for a bit error rate (BER) of 10^{-5} is about **–93dBm**.

Transmitter

The transmitter is based on the BFM9011 IC, which incorporates the modulator and the power amplifier.

The transmission power may be adjusted externally between a few power levels reaching a maximum of about **20 dBm** (100mW).

The RF oscillator runs at the carrier frequency and is frequency modulated directly by the data signal while the synthesizer loop is disabled.

Frequency Hopping Communications Parameters in the WPBX-9000

Scope & Purpose

This document specifies some of the frequency hopping communication parameters of the wireless PBX WPX-9000, and is intended to provide proof of its compliance with FCC Part 15.247 requirements.

The chipset on which the product is based implements the WiNGs wireless protocol (**W**ireless **I**ndoor **N**etwork – a **G**eneric **S**olution) developed by Butterfly Communications (now the Short Distance Wireless Division of Texas Instruments). The communications protocol and other technical details regarding the chipset implementing it can be found at: www.Butterfly.com.

Hopping Sequences

The frequency hopping communications in the WPBX-9000 is based on a periodic use of **25** frequencies, which are selected at system initialization according to environmental occupancy.

This is the minimal number of frequencies required for systems transmitting up to 0.25W (the transmission power in the WPBX-9000 is 100mW). The order of appearance of the selected frequencies is randomized and scrambled to obtain a pseudo-random pattern, as required in section 15.247. In addition, this ensures that other systems of this type, which might be using the same set of frequencies, have a very low probability of using them in the same order. Such orthogonality minimizes possible mutual interference between the neighboring systems.

During the operation of the system, each of the handsets which communicates with the base has an individual frequency hopping link with the base, with multiplexing performed on the time axis (TDMA). Each of these separate channels is monitored and dynamically changed according to the link failures encountered in it. Consequently, the system may end up using different frequency sequences for the various handsets in it, depending on the link conditions of each of them.

The **25** frequencies used at any given point for each of these channels are chosen out of a pool of 50 frequencies (**902.5 MHz** to **927.0 MHz** in steps of **0.5 MHz**).

Time Parameters of the FH Transmission

All frequencies are used evenly since each of them appears once in a cycle (a cycle = 25 hops), and the duration of all transmissions is equal (about **0.8 msec**). Since this synchronous system transmits every **0.0138 sec**, a cycle is completed in 0.0138 msec $\times$ 25=**0.345 seconds**.

Synchronized Reception

The receiver's IF bandwidth is in the order of that of the modulated signal (~**500 kHz**), as required. The receiver is based on two frequency conversions to a first and then second fixed intermediate frequencies.

The receiver's first local oscillator hops in synchronization with the transmitter's hopping sequence. The adaptive frequency hopping mechanism of the WiNGs protocol is supported at both ends, so that an interfered frequency is replaced by an unused one only once this is confirmed by both sides (no transmissions are "wasted"). Following such replacement initiative, a group of frequencies may be abandoned and another one will be adopted instead simultaneously at both ends of the wireless link.

Description of the antennas in the WPBX-9000

General

This document provides a basic description of the antennas used in the handsets and base of the WPBX-9000. This includes parameters such as their location, type, dimension, polarization, and maximal gain. The antennas may be viewed in the photographs provided as part of the FCC registration documentation.

Handset Antenna

Location

The handset antenna is internal to the handset's housing and is therefore not visible to the user. It is located above the earphone at the top of the handset, at a point which is typically relatively exposed electromagnetically (not obscured by the hand holding the handset).

Type & Dimensions

The antenna is a two spiral elements top-loaded monopole element with an omni-directional vertically polarized radiation.

The antenna dimensions are approx: 6.5 mm diameter, 38 mm length.

The RF transceiver module incorporates passive matching components, which serve to match the 50 Ohm output impedance of the transmitter to the impedance of the antenna element.

Gain & ERP

The maximal gain achieved by this antenna is –1 dBi.
Since the transmitter output power is limited to 20 dBm, the maximal ERP is 19 dBmi.