Functional Description
For Alpine 919
GPRS Modem

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Revision History

Date	Rev	Author	Description
10/15/2000	0.0	CSP	Preliminary

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1. GPRS Background

GPRS

General Packet Radio Services (GPRS) is a packet based wireless communication service that can deliver variable data rates as a function of assigned timeslots and maintain continuous connection to the Internet for mobile subscribers on Global System for Mobile (GSM) Network worldwide. Since GPRS is based on GSM communication, it can be single, dual or triple band depending on the area of the service, it will complement existing services such as circuit switched cellular phone connections and the Short Message Service (SMS).

In general, GPRS packet-based service should cost users less than circuit-switched services, since their communication channels are being used on a shared-use, as-packets-are-needed basis rather than dedicated only to one user at a time. Once GPRS becomes available, mobile users of a virtual private network (VPN) will be able to access their private networks continuously rather than through a dial-up connection. GPRS will also complement Bluetooth, a standard for replacing wired connections between devices with wireless radio connections. In addition to the Internet Protocol (IP), GPRS supports X.25, a packet-based protocol that is used mainly in Europe and Asia Pacific. GPRS is an evolutionary step toward Enhanced Data GSM Environment (EDGE) and Universal Mobile Telephone Service (UMTS).

The key benefit with GPRS is the ability to sustain a permanent data connection allowing a free flow of information for the mobile user. The data through put in GPRS will be significantly higher due to the ability of GPRS mobile terminals to transmit and receive more information than standard GSM terminals.

2. Theory of Operation

2.1 Introduction

The GSM communication system, in general, is standardized to operate in multiple bands, primarily, the 900 Mhz band which is assigned PGSM, EGSM, RGSM for short, 1800 Mhz band which is assigned DCS and the 1900 Mhz band which is assigned PCS. Both the GSM and DCS band are used globally for mobile voice communication. The PCS 1900 is used in North, Central and South America.

Although the GSM digital voice standard has existed for well over a decade, it wasn't until recently that the demand for wireless data capability has increased. GPRS is a protocol within the GSM standard which was developed to address the need for data only transmission. Although the GSM voice protocol does support data transmission, it is limited in data rate due to overhead within the voice protocol. What the GRPS allows is a faster data rate that is adaptive as well as being packet based.

The Enabler transceiver design is based on a proprietary chip set that complements size, cost and power consumption. Enabler-G919 is a dual band EGSM 900 MHz and PCS 1900 MHz design in a 1.7" x 2.7" x 0.2" housing. It communicates via an RF antenna port and a multiple pin digital connector. The RF and digital processors are design to operate at 3.8V. The band is selected at the front end via a high power RF Switch. This signal is then prefiltered to remove large out-of-band signals from compressing the LNA. It is then filtered again to prevent the down converter from converting unwanted signal into the IF band. An IF filter is used to set the channel BW to about 200 KHz. This high selectivity IF filter will allow the Enabler to operate through a high dynamic range. The AGC amplifier in conjunction with the DSP chip will automatically adjust the gain to maintain a constant baseband signal. The I&Q demodulator converts the RF signal into 2 baseband signals called Rx I & Q. This prefiltered I&Q signal is sent to the DSP processor where it is digitized for signal processing.

On the transmit section, the post filtered I &Q baseband signal is connected to the I&Q modulator. Using an open loop PLL, the dual band transmit VCO is modulated directly using the charge pump from the modulator section. The advantage of such methodology is an improved carrier and sideband suppression. The modulated RF signal is injected into the power amplifier where it is amplified to its respective level. An RF power detector circuit is used to control the RF level at the antenna port.

The primary function of the Enabler SDK is to allow the module to communicate with external peripherals. It provides pre-voltage regulation, serial interface and mechanical support for the Enabler module. It also allows probing and monitoring of digital signal traffic in and out of the Enabler module.

2.2 Abbreviation

GPRS	General Packet Radio Services
EGSM	Extended Global System for Mobile Communication
GSM 900	Global System for Mobile Communication
PCS 1900	Personal Communication System in 1900 Mhz band
TDMA	Time Division Multiple Access
BSC	Base Station Control Center
BTS	Base transceiver station
MS	Mobile Station
MXM	Mixed Mode Modulation
GMSK	Gaussian Minimum Shift Keying
ARFCN	Absolute Radio Frequency Channel Number
SMS	Short Message Services
VPN	Virtual Private Network
UMTS	Universal Mobile Telephone Service

2.3 Frequency Allocation (M-ES)

The following table shows the standard channel allocation for the EGSM 900 and PCS 1900 band. The EGSM transmitter transmits at exactly 45 MHz below the receive frequency. The PCS transmitter transmit at exactly 80 MHz below the its received frequency.

Channel Number for E-GSM 900 (0-124)	**Mobile Station Transmit Frequency = 890 MHz + 0.2(n)**	**Mobile Station Receive Frequency = 890 MHz + 0.2(n) + 45 MHz**
Channel 0	890.0MHz	935.0MHz
Channel 31	896.2 MHz	941.2 MHz
Channel 62	902.4 MHz	947.4 MHz
Channel 93	908.6 MHz	953.6 MHz
Channel 124	914.8 MHz	959.8 MHz
Channel Number for E-GSM 900 (975-1023)	**Mobile Station Transmit Frequency = 890 MHz + 0.2(n-1024)**	**Mobile Station Receive Frequency = 890 MHz + 0.2(n-1024) + 45 MHz**
Channel 975	880.2 MHz	925.2 MHz
Channel 1000	885.2 MHz	930.2 MHz
Channel 1023	889.8 MHz	934.8 MHz

MS Tx Band

Ch 955	Ch1023	Ch 0	Ch 62	Ch 124
876.2 MHz	889.8MHz	890.0 MHz	902.4 MHz	914.8 MHz

MS Rx Band

Ch 955	Ch 1023	Ch 0	Ch 62	Ch 124
921.2 MHz	934.8 MHz	935.0 MHz	947.4 MHz	959.8 MHz

Channel Number for PCS 1900 (512-810)	**Mobile Station Transmit Frequency = 1850.2MHz + 0.2(n-512)**	**Mobile Station Receive Frequency = 1850.2MHz + 0.2(n-512) + 80 MHz**
Channel 512	1850.2 MHz	1930.2 MHz
Channel 587	1865.2 MHz	1945.2 MHz
Channel 662	1880.2 MHz	1960.2 MHz
Channel 737	1895.2 MHz	1975.2 MHz
Channel 810	1909.8 MHz	1989.8 MHz

MS Tx Band

Ch 512	Ch 662	Ch 810
1850.2 MHz	1880.2 MHz	1909.8 MHz

MS Rx Band

Ch 512	Ch 699	Ch 885
1930.2 MHz	1960.2 MHz	1989.8 MHz

The primary advantage of the GSM standard is that, irregardless of the band of operation, they all share the same technical features. This specification applies to the GSM voice, voice & data, and data only (GPRS) transmission. With TDMA, one GSM RF channel can support up to 8 mobile users simultaneously. Each user is allowed to transmit once every frame period for a duration of 1 timeslot. Because of the TDMA scheme, timing accuracy in the software and hardware implementation is very critical. The Enabler has the following common specifications.

Key Technical Feature	***Specification***
Modulation Data Rate	270.833Kbit/s
Bit Period	3.692 us
TDMA Timeslot	8 timeslot / RF channel
1 Timeslot Period	576.9 us
Bits/timeslot	156.25 bits
Timeslot Composition	148 (data bits) + 8.25 (guard bits)
Timeslot Allocation	0 to 7
Frame Period	4.615 ms (8 timeslot period)
Channel Spacing	200 KHz
Modulation Scheme	0.3 GMSK

2.3.1 Power control

The Enabler design has an on-chip, high efficiency LDO voltage regulator that converts the 3.8 V supply to various isolated 2.8 Vdc. Each of these voltages is used by the digital, transmit and receive sections. This architecture allows different area of the module to power up and down to reduce power consumption. The digital section utilizes its own LDO voltage regulator to avoid digital noise from getting into the RF circuitry. The transmitter and receiver use the same LDO voltage regulator except the power amplifier. Since the PA operates in high current mode at maximum transmit level, LDO voltage regulators are not suitable. In this case, bypass capacitors are used to reduce noise from getting onto the transmitter.

2.4 Receiver Section

2.4.1 RF Switch.

The primary function of the RF switch is to pre select the RF signal into its respective band. It is capable of handling peak signal levels in excess of 2 W in burst mode. The insertion loss on the receive side of the switch it kept low, less than 2 dB, to improve sensitivity. It is encapsulated in a metal housing to reduce digital cross talk.

2.4.2 LNA and First Conversion

The pre selected RF signal from the RF switch is coupled into the receive filters designated LB and HB sawfilter and dielectric filter, respectively. The insertion loss of these filters is kept to a minimum to maintain frontend noise figure. The RF switch does not provide any form of filtering, thus, this section is necessary to remove and suppress unwanted signals coming in through the antenna port. Additional filtering is provided after the LNA to prevent unwanted signals from being downconverted. The LNA provides about 15 dB of gain and noise figure of 3 dB.

2.4.3 First IF Stage

Once the RF signal is downconverted into the IF, it is immediately filtered. The primarily function of the IF sawfilter is to provide high channel selectivity and increase receiver dynamic range. The balanced input and output of this sawfilter provides additional in-phase noise cancellation, and common mode rejection. This results in better image frequency and LO frequency rejection. The downconversion gain is set at 10 dB to prevent further SNR degradation.

2.4.4. AGC IF, I&Q Demodulation

The filtered IF signal is coupled into the AGC amplifier. This section will maintain a constant level into the I & Q demodulator, independent of input RF level. The AGC amplifier has 60 dB of control range to accommodate the RF level change. The AGC signal is filtered prior to the I&Q demodulation to remove any harmonics due to non-linearity.

2.4.5. Baseband Amplifier, DC offset compensation

Before the I & Q signals are sent to the DSP processor, they are offset with a DC bias. The ADC in the DSP processor than digitized these signal before they processed through software algorithms. The baseband amplifier serves two purposes, it provides signal isolation between the A/D converter and the DC bias circuitry, it also provides the drive capability to interface with the DSP processor.

2.5 Transmit Path

2.5.1 I&Q Modulation, Tx VCO

The transmit I & Q signal connects the baseband processor to the I & Q modulator. The signal is filtered and a DC bias applied internal to the baseband processor. An open loop modulation is used to modulate the I & Q in conjunction with the Transmit VCO. The charge pump output modulates the transmit VCO while maintaining a phase lock condition. To ensure high modulation accuracy, the transmit VCO signal is fed back into the modulator. This results in superior carrier and sideband suppression for the GMSK RF signal.

2.5.2 Loop Filter

The phase lock loop filter has 3 purposes, mainly, to control the phase noise of the Transmit VCO, to control the fast loop settling time and reduce frequency overshoot during channel switching. This loop filter is a 3-pole topology to meet the stringent specification in the GSM standard.

2.5.3 PA, Directional Coupler

The modulated RF signal is coupled into the PA where its AGC provides the necessary RF level to the antenna load. To achieve level accuracy, the dual-band directional coupler tapped part of the RF signal is fed back to a power detector circuit. The power detector converts the RF level to an equivalent DC voltage that in turns, control the PA output level. The detector has 35 db of control range as required by the GSM standard.

2.6 Digital Baseband

The digital/baseband section of the Enabler consists primarily of three sections (analog baseband, digital baseband, and memory). Together these sections incorporate the ADCs and DACs for transmit and receive, voltage regulators, SIM interface, DSP and ARM processors, along with volatile and non-volatile memory.

2.6.1 Memory

The enabler has both volatile and non-volatile memory. The non-volatile memory uses FLASH technology for the executable code storage and EEPROM memory for system parameters and equipment identifiers. The keys for encryption and ciphering are stored in the SIM card and not the modem. Code is executed out of both FLASH memory and SRAM. Time critical code is executed out of the SRAM because of the faster access time.

2.6.2 Processor(s)

The Enabler uses a baseband processor which has both an ARM7 processor and a DSP. The DSP is used for realtime processing of incoming signals. The ARM is then used to run the upper layers of the protocol stack and the MMI.

2.6.3 CODEC

The analog signal conditioning is taken care of in the CODEC. This chip contains multiple voltage regulators that isolate the RF and digital supplies. It also has the SIM card reader in it. The analog-to-digital converter is within the CODEC that converts the RX I & Q signals into serial digital data that is fed into the DSP. The digital-to-analog converter do the same thing in reverse for the TX I & Q signals.

2.7 Block Diagram

Functional Block Diagram
Alpine 919 Rev. 2 GPRS Modem
By MM 10/11/01