EC2500 CDMA Cellular-Band Single Mode Phone

Phone Description for FCC Filing

Rev 1.0

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Wireless Development Division

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1.0 Phone Description

The EC2500 is a cellular-band digital CDMA phone. It has been designed by Fujitsu Network Communications, Inc. Front and rear views of the phone are shown below. The phone operates in the US AMPS band and implements IS-95B CDMA requirements. The phone does not operate in an analog mode (i.e., single mode CDMA only). It operates from a single Lithium Ion battery, at 3.6 volts nominal. The lightweight phone has an extendable antenna and meets class III mobile power output requirements of +23dBm peak.

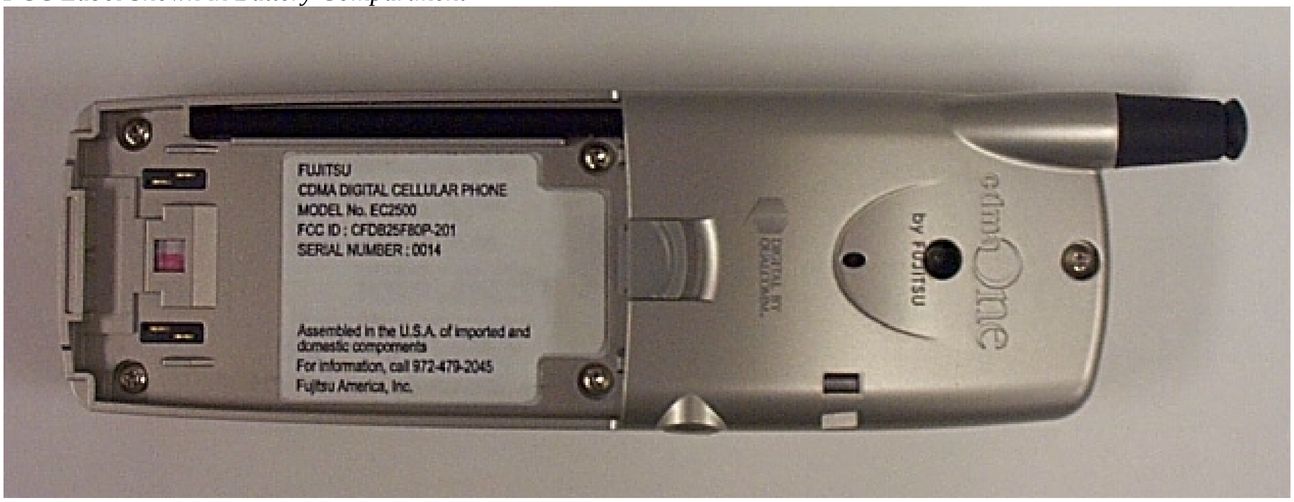
For FCC testing, prototypes of the handset are supplied with an RF test cable and a battery compartment interface for direct connection to a bench supply. See section 5.0. There are no battery chargers, car accessories, or external power amplifier boosters supplied with this phone. Only the handset itself is to be tested.

Front view of Phone

Rear view of Phone, with standard battery attached

The FCC Label is shown below, in the battery compartment of the phone. The full drawing of the FCC label has been submitted as a jpeg file.

FCC Label Shown in Battery Compartment



2.0 Phone Parameters Applicable to FCC Filing

General parameters

The general parameters for the Fujitsu EC2500 CDMA phone are given in the table below. The phone operates in the US AMPS band and implements IS-95 CDMA requirements. The phone does not operate in an analog mode (i.e., single mode CDMA mode only).

Item	***Value***
Transmitter Frequency Range	824 to 849 MHz
Receiver Frequency Range	869 to 894 MHz
Channel Bandwidth	1.23 MHz nominal
Channel Spacing	30kHz
Number of Channels	788
Duplex Separation	45 MHz
Type of Emission	G7W
Input/Output Impedance	50 ohms (RF test port interface)
Transmitter Intermediate Frequency	130.38 MHz
Receiver Intermediate Frequency	85.38MHz
Local Frequencies	
- TX RF	(F_{TX} + 130.38MHz)
- TX IF	260.76MHz
- RX RF	(F_{RX} + 85.38MHz)
- RX IF	170.76MHz
VCTCXO Frequency	19.68MHz
Frequency Stability	(F_{RX} – 45MHz) ± 300Hz
Operating Temperature	-30° to +60° C
Supply Voltage	3.6V nominal
Supply voltage range	3.2V to 4.2V
Current Consumption: Standby mode	~ 115mA (non-slot mode)
Current Consumption: Talk mode	~ 370mA (at +10dBm)
Weight with Standard Battery	125 grams
Size	140(H) x 45(W) x 26(D) mm

Transmitter parameters

The transmitter parameters are given in the table below.

Item	***Value***
Waveform Quality	0.944 or larger
Open Loop Power Control Range	
-25dBm RX input	-48dBm +/-9.5dB maximum
-65dBm RX input	-8dBm +/-9.5dB maximum
-93.5dBm RX input	+20dBm +/-9.5dB maximum
Minimum TX Power Control	- 50 dBm maximum
Closed Loop Power Control Range	+/- 24 dB minimum
RF Output Power	
Maximum RF Output Power – minimum bound	200mw (+23 dBm) minimum
Maximum RF Output Power – maximum bound	1000mw (+30 dBm) maximum
Maximum RF Output Power at 60 deg C & above	126mW (+21dBm) minimum
Occupied Bandwidth	1.23 MHz
Conducted Spurious Emissions > 900kHz offset	-42dBc/30kHz at max output
Conducted Spurious Emissions > 1.98MHz offset	-54dBc/30kHz at max output

Receiver parameters

The receiver parameters are given in the table below.

Item	***Value***
RX Sensitivity and Dynamic Range	-104dBm, FER= 0.5% or less -25dBm, FER= 0.5% or less
Conducted Spurious Emission	
TX band	-61dBm/1MHz max
RX band	-81dBm/1MHz max
all other frequencies	-47dBm/30kHz max
Single Tone Desensitization	
RX power = -101dBm, -30dBm tone @+/-900kHz	FER<1%
Two Tone Intermodulation Response Attenuation	
RX power = -101dBm, two -43dBm tones at +/-900kHz and +/-1700 kHz	FER<1%
RX power = -90dBm, two -32dBm tones at +/-900kHz and +/-1700 kHz	FER<1%
RX power = -79dBm, two -21dBm tones at +/-900kHz and +/-1700 kHz	FER<1%

2.0 Circuit Description

This section describes the receiver, transmitter, and logic portions of the phone. Brief descriptions of each of the circuit blocks are given with reference designators. The designators are referenced back to the EC2500 schematic.

2.1 Receiver section

DUPLEXER
A ceramic filter construction (FIL101) to isolate the receiver from the transmit signal, and to provide additional out-of-band filtering for both the receiver and the transmitter.

LOW NOISE AMPLIFIER (LNA)
The BFP 420 (TR101) provides the first stage amplification of the received signal with a selectable 2 gain state made possible by a switched bypass path using a PIN diode (D101) and a SPDT switch (IC101) controlled by IC605.

RF SAW BANDPASS FILTER
The RF BPF (FIL102) passes the desired RF signal from the LNA, and has a passband that matches the RX band between approximately 869MHz and 894MHz. The BPF attenuates the image frequency of the mixer (IC102), the transmit signal, and other out-of-band signals.

DOWN CONVERTER (MIXER)
The down converter (IC102) receives the wanted signal in a selected channel within the RX band and down converts it to the intermediate frequency of 85.38MHz, using the high-side RF LO (IC301) appropriately selected between 954MHz and 979MHz.

IF SAW CDMA BANDPASS FILTER
An IF BFP (FIL104) that passes the down converted signal from IC102, and has a bandwidth slightly larger than the CDMA signal bandwidth of 1.23 MHz. The BFP provides attenuation for mixer RF and LO leakage, mixer image frequency, and other out-of-band products.

IF AGC AMP AND DEMODULATOR (IFR3000)
The IFR3000 ASIC (IC502) performs IF AGC amplification having 85 dB dynamic range, IQ demodulation, baseband filtering, and A/D conversion of the analog IQ baseband signals. The IF AGC is controlled by the MSM3000 (IC605). The combination of an internal oscillator cell, an external IF PLL (IC506), and the external tank circuit supplies the RX IF LO. A three-line serial interface controls the IFR3000 via the MSM3000.

VOLTAGE REGULATION
Various regulators (IC406, IC409, and IC410) provide voltage regulation at 2.9 volts. The regulated voltage is supplied to the receive chain.

2.2 Transmitter section

IQ MODULATOR AND IF AGC AMPLIFIER (IFT3000)
The IFT3000 ASIC (IC503) performs D/A conversion of digital I and Q signals, baseband filtering, IQ modulation, and IF AGC amplification having 84dB dynamic range. The IF AGC is controlled by the MSM3000 (IC605). The combination of internal TX IF PLL, oscillator cell, and external tank circuit supplies the TX IF LO. A three-line serial bus interface controls the IFT3000 via the MSM3000.

IF BANDPASS FILTER
A multi-layer LC filter (FIL201) is used to remove replicas of the IF CDMA waveform and reduce spurious responses from the IFT3000 output.

UPCONVERTER (MIXER)
The upconverter (IC201) receives the 130.38MHz TX IF input and upconverts it to one of the selected RF channels in the band between approximately 824MHz and 849MHz, using the high-side RF LO (IC301) appropriately selected between 954MHz and 979MHz.

RF SAW BANDPASS FILTER
The RF BPF (FIL202) passes the desired RF signal from the upconverter, and has a passband that matches the TX band. The BPF attenuates the mixers' image frequency, harmonics, and spurious output.

RF SWITCHED GAIN AMPLIFIER
The RF switched gain amplifier (IC202) supplies either of two selectable gain levels to the RF signal. The switching control is provided by IC605.

RF DRIVER AMPLIFIER
A final driver amplifier (IC203) is used to provide the necessary RF drive level into the PA.

RF SAW BANDPASS FILTER
A second RF SAW filter (FIL203) provides additional out-of-band filtering of harmonics, spurs, and noise prior to signal injection into the PA module.

POWER AMPLIFIER MODULE
The PA module (IC204) provides sufficient linear gain to meet the CDMA specifications for output power and ACPR.

POWER SUPPLY SWITCHING
A power supply switching FET (IC206) turns on and off the transmitter power as necessary, via the PA, when the phone is in traffic mode. PA on/off control is supplied by IC605.

VOLTAGE REGULATION
Various regulators (IC402, IC403, and IC404) provide voltage regulation at 2.9 volts. The regulated voltage is supplied to the transmit chain.

ISOLATOR
An isolator (ISO201) is used to ensure proper operation of the PA, protecting the PA from possible RF reflections due to handling or removal of the antenna.

DUPLEXER
See Section 2.1 and 3.0 for duplexer description

ANTENNA
The antenna provides the 50-ohm match to the duplexer and isotropically radiates the TX RF signal to the basestation. The antenna is user-replaceable, and the phone is designed to operate with the antenna in-place.

2.3 Logic section

Power Supply

The phone utilizes a 3.6v nominal Lithium-Ion battery. Battery Voltage is supplied directly to the Power Management IC (IC650) which controls whether the rest of the phone circuitry has power applied to it or not. The Power Management IC is controlled by the “On” Key and also by the CPU itself.

CPU and Memory

CPU: The ARM7TDMI CPU is a 32 bit microprocessor that is embedded in the MSM3000 (IC605) chipset. It interfaces to external circuitry via address and data busses and general-purpose input/output pins. The MSM3000 also contains two internal UARTs that interface to the CPU. The CPU clock is derived from a 27MHz crystal oscillator (OSC600).

SRAM: 4Mbits of non-volatile memory (IC603) are used to store all variables.

FLASH Memory: 16Mbits total of FLASH Memory (IC601, 602) are used to store all of the call processing software in non-volatile memory.

Baseband

MOBILE SYSTEM MODEM (MSM3000) The MSM3000 chipset (IC605) not only contains the CPU as mentioned previously, but also contains internal glue logic which is used to provide chip selects to the SRAM, FLASH, and LCD. It contains the CDMA modem, as well as the control logic for driving all of the pulse width modulated (PWM) pins and digital logic pins to control the RF circuitry.

INPUT CLOCK: A 19.68MHz nominal frequency source (OS301) is used to drive all internal circuitry associated with the internal 1.2288MHz Chip Rate.

IO MODULE: The I/O Module contains the keypad, Liquid Crystal Display (LCD) screen, LCD driver IC, RF shields, 2mm audio jack, backlight LEDs, and Vibrator circuitry.

AUDIO CODEC: The audio codec (IC701) is used translates the analog voice signal coming in from the microphone into digital pulse code modulated (PCM) information which is then sent to the MSM3000 chipset where it is further processed. The audio codec also translates PCM data coming from the MSM3000 into an analog signal which is then sent to the speaker.

3.0 Description of Frequency Stabilization Circuit, Suppression of Spurious Radiation

Frequency Synthesizer Circuit

The frequency synthesizer circuit comprises two main parts: a VCTCXO and RF synthesizer module.

VCTCXO
The voltage-controlled temperature-compensated crystal oscillator (OSC301) is a 19.68MHz reference source for the RF synthesizer. It has a frequency stability of 19.68MHz +/- 2ppm over the phone's intended temperature range. A control voltage from IC 605 provides frequency tuning of the VCTCXO.

RF SYNTHESIZER MODULE
The RF synthesizer is a module (IC301). The module includes the RF VCO, an integer PLL, and loop filter. The synthesizer output frequency is programmable via IC605. The frequency span is approximately 966.5MHz +/- 12.5MHz. The PLL is a standard PLL with prescalar, dividers, and charge pump. The PLL divides the reference frequency by 656 to obtain a 30kHz comparison frequency. The VCO input to the PLL is prescaled and divided to the same comparison frequency. The phase error voltage is low pass filtered and applied back to the VCO's frequency control stage.

Spurious Radiation Suppression Circuit

Suppression of spurious radiation for both the receiver and transmitter is accomplished by internally shielding the RF sections inside the phone and by using SAW filters and a duplexer with very good out-of-band attenuation. The duplexer is a ceramic filter common to both the TX and RX paths. The duplexer specifications are shown below. The duplexer operates by passing the TX signals from TX to antenna port and passing the RX signals from antenna port to RX port. In addition, it highly attenuates the path between the TX and RX ports and by highly attenuates at the antenna port all out-of-band signals. The main TX and RX passbands are relatively low loss paths to ensure that the required receiver sensitivity and TX output power performance is met.

Duplexer specifications	***Specifications at 25 deg C***
TX Specs	
Center frequency	836.5MHz
Passband	836.5MHZ +/- 12.5MHz
Insertion loss	2.4dB maximum
VSWR in TX band	1.7 maximum
Attenuation in RX band	42 dB minimum
Input power	2 watts maximum
TX-to-Rx port isolation of TX band	56 dB minimum
TX-to-Rx port isolation of RX band	38 dB minimum
RX specs	
Center frequency	881.5MHz
Passband	881.5MHz +/- 12.5MHz
Insertion loss	4.2dB maximum
VSWR in TX band	1.8 maximum
Attenuation in RX band	56 dB minimum
Input power	1 watt maximum
General specs	
Input/output impedance	50 ohms nominal
Operating temperature range	-30 deg C to +85 deg C

4.0 Description of Power Control Circuit

Transmitter Power Detector Circuit and Limiter Operation

In general, the transmitter is calibrated over its entire dynamic range and controlled by the CPU (IC605). In addition, the transmitter has power detection and limiter circuitry that works with the CPU to adjust and, when necessary, limit the TX output at high power levels. TX control with feedback at high power levels is particularly important to reduce distortion, fix the peak output levels, and to reduce the rate of battery discharge. Output from the PA is sampled using a voltage detection circuit including 14dB directional coupler (HYB201) and rectifying diode (D201). An ADC in IC503 samples the voltage and the CPU (IC605) algorithms use the digital samples to precisely adjust and limit the TX output power.

CDMA Closed and Open Loop Power Control

The power control function described above provides closed loop feedback in the phone to control high TX output levels. CDMA networks also have closed and open loop power control functions. These loops operate between the basestation and the handheld phone to combat fast and slow fading on the links, and to optimize capacity of the network.

5.0 Information for RF testing the EC3000

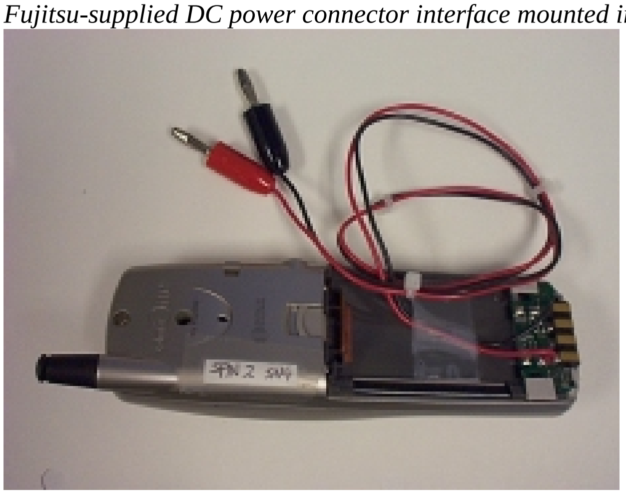
This section supplies information on how to connect to and place calls with a CMD80 basestation simulator. The section includes test interfaces, test cautions, and instructions on placing a call using the CMD80.

Test interfaces

The main interfaces to the phone are RF and DC power connections at the rear of the phone. These interfaces are shown in the photos below. Fujitsu supplies both interfaces.

Fujitsu-supplied RF test cable for RF interface

Fujitsu-supplied DC power connector interface mounted in the phone's battery compartment



Testing cautions

The phone has been loaded with operational code, with added features to accommodate RF testing. In particular, features are added to accommodate automate testing in temperature chambers. Please observe the following cautions while testing:

1. The phone will power on by itself when DC voltages are supplied. The phone will also automatically answer a call when initiated by the CMD80 or HP8924C. Do not press the keys or use the menus or scrolls to perform these functions, and do not use the keys while testing.
2. Check the seating of the RF connector into the back of the phone. It should be inserted straight (i.e. perpendicular to phone) and inserted firmly. The connector is for low usage applications. If the connector is bumped, it mis-aligns, and will not pass RF efficiently. Erroneous test results would occur.
3. Secure the phone in a vice while testing. This ensures the phone will not rest on the RF test cable.
4. The phone will shut off with DC supply voltages below 3.2 to 3.25 volts. If the supply voltage displayed is 3.3 volts or lower, the phone may shutoff because of resistive losses in the supply cables. A DC supply is recommended that has closed loop sampling and feedback capability. This supply will ensure that a 3.2 volt displayed value results in 3.2 volts measurable at the battery terminals.
5. The phone needs no tuning. Calibration data is already loaded into the phone. The CMD80 is used to control the phone's operation. By key presses, the CMD80 adjusts channel frequency, RX input, and TX output, and initiates and terminates calls.

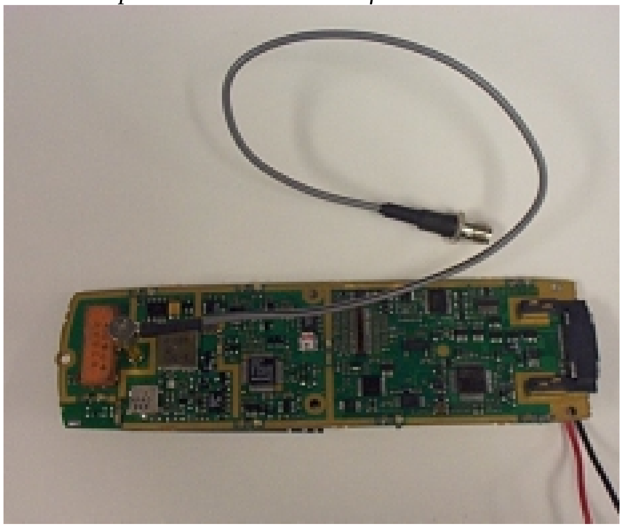
Instructions on placing phone into traffic channel mode using "loopback mode" of the CMD80.

1. Set current limit on DC supply to 2 amps maximum. Connect DC supply to battery interface on phone using supply cables. Set supply to 3.6 volts nominal to power up the phone.
2. Connect RF adapter cable into access port in back of phone.
3. Configure a calibrated, powered up CMD80 into the cellular CDMA network mode, system B, & channel 383 or 358.
4. Set CMD80 RF loss offsets to account for RF losses between phone and CMD80. The Fujitsu-supplied RF test cable has 0.5dB of loss in the TX and RX bands. Include this loss and other cable losses into the total loss. Enter this total antenna-port-to-CMD80 loss into the CMD80's configuration menu.
5. Connect phone to CMD80 via your own RF test cable connected to Fujitsu-supplied RF test cable. Use the CMD80's duplexed port to interface to phone.
6. Set CMD80 on either channel 383 or 358.
7. If desired, insert a directional coupler for measuring frequency spectrum, and include additional loss offsets in both CMD80 and spectrum analyzer.
8. Wait for the phone to automatically register itself to the CMD80. The phone will register to either channel 383 or 358.
9. After registration, place phone into the digital traffic channel mode from a key press on CMD80. The CMD80 will operate as a basestation simulator.
10. Adjust basestation power output (same as RX input to phone) as necessary to set the desired transmitter level.
11. Adjustment of channel number can be made after the phone begins ringing or any time the phone is in the traffic channel mode.

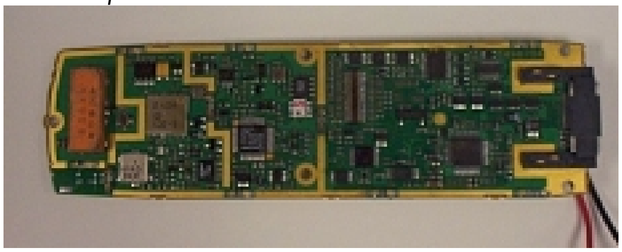
RF power output at RF port similar to power output at antenna

The RF test cable connects directly to an RF connector on the RF board located very close to the antenna interface. This direct connection to the board is shown in the photo below. Although the RF board is hidden inside the phone, this photo is included here to show the proximity of the RF test port to the antenna. The RF access port at the back of the phone therefore gives a good indication of actual power levels available at the antenna. The last two pictures below show the TX and RX side of the main circuit board.

RF access port near antenna interface



TX Side of the main circuit board



RX Side of the main circuit board