Freescale Semiconductor
Product Brief

I200/D
Rev. 2, 08/2004

2G Innovative Convergence™ (i.200-20) Platform

System Overview

1 Executive Summary

Building on the success of the industry-leading 2.5G Innovative Convergence™ (i.250-20) platform for the GSM/GPRS market, Freescale Semiconductor's 2G Innovative Convergence (i.200-20) platform targets the GSM market. Leveraging the benefits of the i.250-20 platform, the i.200-20 platform offers manufacturers a solution to build products that are smaller in form factor, more cost-effective, and delivered to market quickly.

Featuring fully integrated hardware, software, and support services, the i.200-20 platform enables the rapid development and deployment of cost-effective GSM handsets. The platform is designed to be flexible and scalable. It can support the high-volume production of economical phones as well as the use of higher-tier feature sets. It also provides a smooth migration path to the i.250-21 platform and next-generation technology. The i.200-20 platform's key offerings include:

- Comprehensive platform and reference design of GSM handset for rapid time to market
- Low-tier to high-tier feature sets

Contents

- Migration path with high level of software and hardware re-use
- Highly effective tools to enable quick product derivatives

2 Platform Overview

The i.200-20 platform leverages Freescale's extensive experience in delivering world-class cellular solutions. The key platform components are as follows:

- Comprehensive reference design on handset
- Industry-proven GSM software engine
- User-friendly development tools such as man-machine interface (MMI) toolkit for rapid user interface development
- Production test planning services
- Large number of innovative third-party technologies running on the platform

Figure 1 is a system diagram of the key components of the platform.

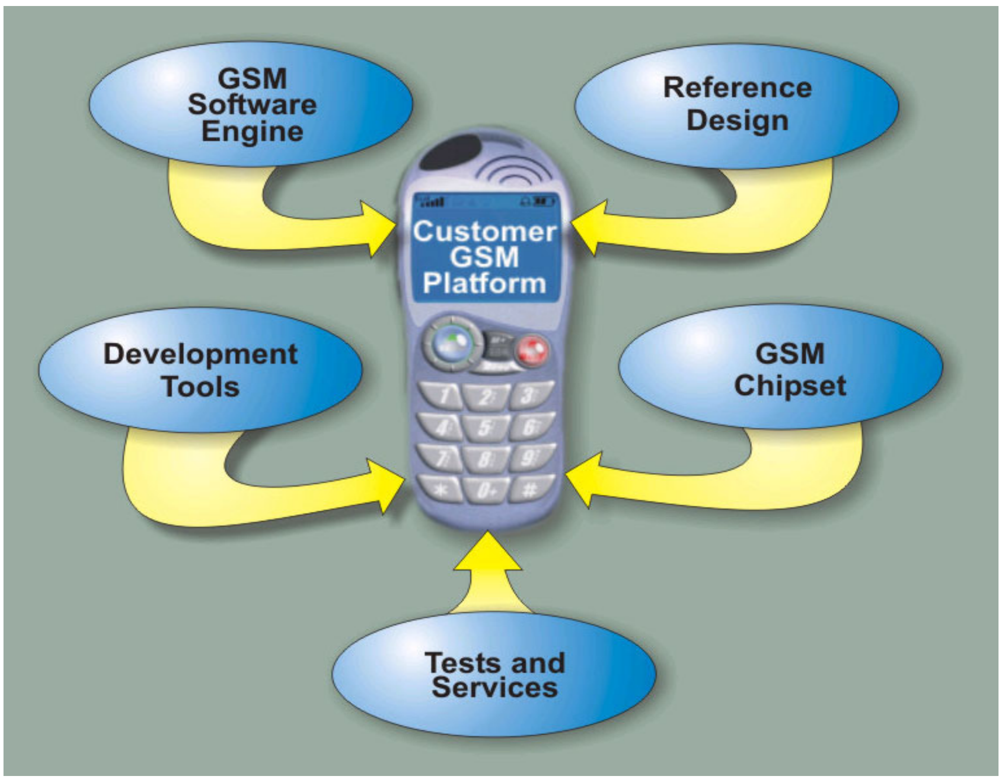

Figure 1. i.200-20 Platform Overview

3 Key Benefits

The i.200-20 platform significantly reduces both time to market and the effort to develop GSM products. Table 1 summarizes the platform's key benefits and their value.

Table 1. Key Benefits of i.200-20 Platform

Feature	Benefits	Value Proposition
Most comprehensive system solution in the industry	• Comprehensive reference design • Proven GSM software package • Comprehensive development tools • Tests and services • Integrated chipset	• Reduces time to market • Optimizes ease of system integration and interface design • Reduces qualification/certification time • Eases product customization and differentiation • Streamlines procurement
Technological expertise	• Proven system design and software • Extensive wireless experience	• Minimizes design risks and shortens development cycle • Enables design team to adopt a total solution quickly • Offers competitive size and battery life
High level of system integration	• Reduced part count • Reduced "de-sense" effect	• Decreases time to market and manufacturing cost • Saves system cost (fewer components) • Minimizes platform development time • Improves radio manufacturing cycle time and quality
Flexible, scalable architecture	• High level of software and hardware re-use when migrating to i.250-21 (2.5G) platform solution • Integration of third-party value-added technologies that enable different tiers of products • Smooth next-generation migration	• Supports different tiers of product features • Quickens time to market for derivatives • Provides path to applications like PDA phones and beyond

Another feature of the platform enabling manufacturers to quickly build GSM products is its organization into three development environments, which can simplify the design cycle from concept to production. Figure 2 on page 4 shows how the five key platform components fit into the three environments.

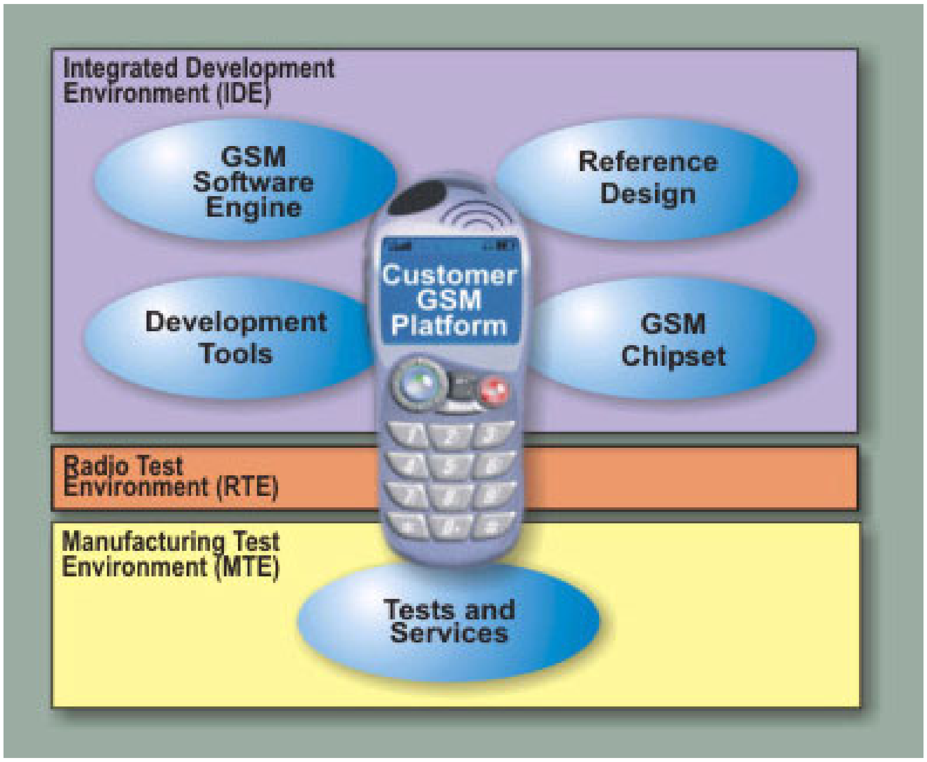

Figure 2. Integration of Five Platform Components and Three Development Environments

The Integrated Development Environment is a comprehensive hardware and software environment, integrating the GSM chipset, reference design, GSM software engine, and development tools. The Radio Test Environment provides the tools and flexibility for turning on features for testing and fine tuning the performance of the GSM products. The Manufacturing Test Environment provides the tests and services that can accelerate GSM production. For more information, see Section 5, "Platform Development Environments."

4 Platform Chipset

The core of the i.200-20 platform is a chipset that provides a high level of integration, significantly reducing component count. As a result, the chipset is able to provide the most cost-effective, feature-rich system solution for an economical GSM handset.

The five key components of the platform chipset, displayed in Figure 3 on page 6, are as follows:

- DSP56611 Baseband Processor IC
- MC13777 GSM Front End IC
- MC13717 Integrated Power Management and Audio Circuit
- MMM6022DB Dual-Band GSM Power Amplifier Module with Antenna Switch
- MC13718 Li-Ion Charge Control and Protection IC

The DSP56611 Baseband Processor IC is a dual-core processing unit that contains all the baseband functionality for the chipset, including both DSP and MCU functionality. It also features on-chip memory as well as many mixed-signal modules such as receiver analog-to-digital converters (ADCs), a receive (RX) and transmit (TX) synthesizer, TX power amplifier control, and a voice codec.

The MC13777 GSM Front End IC (RF circuit) is designed for use in GSM850/GSM900/DCS/PCS cellular radios. It can be used in dual-band, tri-band, or quad-band applications. The receiver portion of the MC13777 is designed for use in very low IF (VLIF) receivers. It integrates low noise amplifiers (LNAs), mixers, baseband filters, and RX voltage controlled oscillators (VCOs). The transmit portion of the MC13777 is designed for use in direct launch transmitters and integrates TX VCOs and buffer amplifiers.

The MC13717 Integrated Power Management and Audio Circuit contains voltage regulators, a voltage multiplier, microphone amplifiers, audio filtering and amplification, a 32 kHz oscillator, and a multiplexer that drives the general-purpose analog-to-digital converter on the Baseband Processor. It is an advanced version of the MC13713 (used in the i.250-20 platform) that incorporates additional features, such as a coin-cell backup battery charger and switch, light sensor support, and additional ADC multiplexer inputs.

The MMM6022DB is a 50-ohm Power Amplifier Module with Antenna Switch for dual-band GSM handset applications, functioning over the GSM and DCS transmit and receive frequency bands. To simplify radio front-end design requirements, power amplification, power coupling, power detection, low pass filtering, and antenna switching functions are integrated into the Power Amplifier Module. This part is reduced significantly in size by using an LTCC package, providing form-factor savings for customers.

The MC13718 Li-Ion Charge Control and Protection IC is designed to protect and control the charging of single-cell batteries employing lithium-ion cell chemistry. In addition to multi-mode charging circuitry, the MC13718 provides all of the battery cell protection circuitry normally included in stand-alone battery packs, as well as thermal and power dissipation protection for the charging electronics. The MC13718 can be used with a cost-effective wall-transformer-type supply, a vehicle adaptor supply, or a regulated power supply.

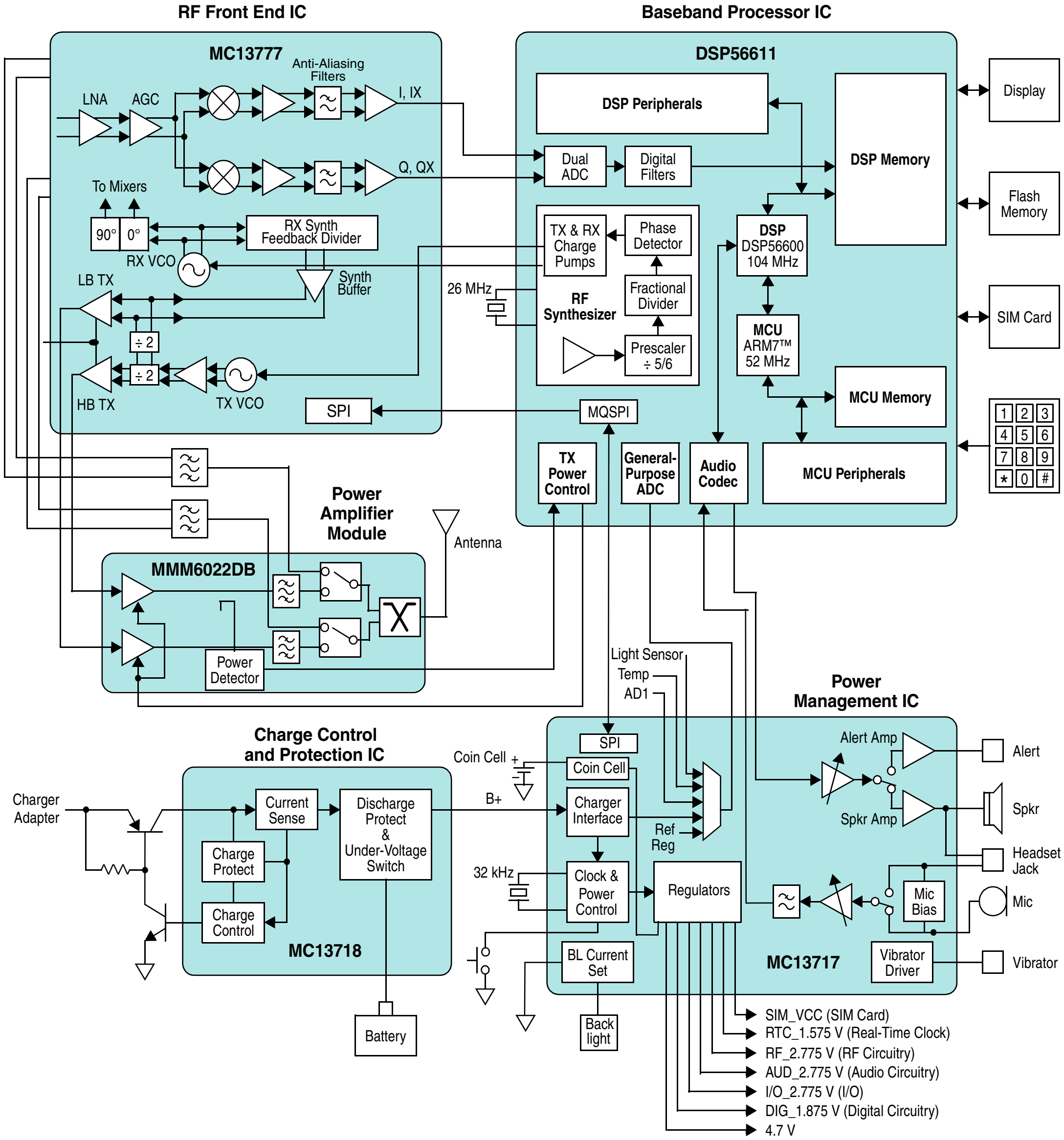

Figure 3. i.200-20 Platform Chipset Block Diagram

4.1 Chipset Key Features

The key features of the i.200-20 platform chipset are as follows:

- **DSP56611 Baseband Processor IC:**
  — Features a dual core: ARM7TDMI-S™ (52 MHz) MCU and DSP56600 (104 MHz) processor
  — Embeds 25K × 32 block of ROM and 16K × 32 block of RAM, reducing external memory size for data storage and software patches
  — Supports GSM/DCS dual-band operation

— Adds on-board bypassing to reduce electromagnetic compatibility (EMC) emissions, shrinking the need for shielding to protect the sensitivity of the RF receiver
— Features mixed-signal modules that include:
  – Voice codec
  – Receiver digital filtering
  – Transmitter dual port transmit digital-to-analog converter (DAC)
  – Transmitter power amplifier control for MMM6022DB Power Amplifier Module
  – RX/TX synthesizer with off-chip VCO on MC13777 RF Front End IC
  – Receiver analog-to-digital converters (ADCs)
  – Power supply rejection regulators
  – General-purpose ADC
  – Crystal oscillator
— Features digital modules:
  – Embedded RAM/ROM for MCU and DSP
  – 26 MHz clock for GSM time base reference
  – Real-time clock
  – MCU watchpoint module that allows for more efficient patching method and 64 unique traps
  – Display Memory Access Controller (DMAC) DMA and SPI-based display port, providing ability to use greyscale and color

- **MC13777 GSM Front End IC:**

— Separate LNAs for GSM850/GSM900/DCS/PCS operation
— Can be used for dual-band, tri-band, or quad-band applications
— LNAs with differential inputs
— RF automatic gain control (AGC) with AGC linearizer for linear dB/V transfer function
— Post-mixer amplifier (PMA) with adjustable gain
— Integrated anti-alias filters
— DC offset correction for improved dynamic range
— Tracking oscillator for calibrating integrated filter band widths
— Analog, differential I and Q outputs
— A low noise regulator to maintain a low noise supply for VCOs
— Integrated RX VCO and integrated TX VCO for direct launch transmitters
— TX buffer amplifiers
— Programmable via SPI

- **MC13717 Integrated Power Management and Audio Circuit:**

— System power up/down control logic
— Power regulator functions:
  – Eight independently controllable voltage regulators
  – Reference voltage output

- Voltage multiplier
- Programmable current regulator for backlight
- Vibrator driver

— Interface to MC13718 Li-Ion Charge Control and Protection IC
— 32 kHz oscillator on chip
— Audio functions (all are programmable):
  - Speaker and alert amplifiers
  - Microphone amplifier
  - Microphone bias
  - Headset detect

— Programmable via SPI
— LED support
— Coin-cell battery support
— A/D channel support of light sensor

- **MMM6022DB Dual-Band GSM Power Amplifier Module with Antenna Switch:**

— GSM power amplifier
— DCS power amplifier
— Integrated impedance matching
— Antenna switch with switch control logic
— Integrated harmonic filters
— Integrated couplers and power detection circuits used for closed loop power control

- **MC13718 Li-Ion Charge Control and Protection IC:**

— Multiple charge modes:
  - Low-voltage, full-rate, top-off “pulse,” trickle charge, and hibernate modes
  - Disable mode

— Multiple electronic protection features: Internal junction temperature, pass transistor power dissipation, short circuit, and under-voltage protection
— Multiple features to protect the battery cell against:
  - Over-voltage from external supply or pass transistor failure
  - Excessive charge or load current
  - Discharge at under-voltage

— Other features:
  - Wide external input voltage range
  - Minimal external components
  - Coke/graphite chemistry support
  - Logic interface directly to MC13717 Integrated Power Management and Audio Circuit

4.2 DSP56611 Baseband Processor IC

The DSP56611 Baseband Processor IC is a dual-core processor that contains Freescale's DSP56600 core, an ARM7™ MCU core, custom peripherals, and many mixed-signal modules such as receiver ADCs, an RF synthesizer, TX power amplification control, and a voice codec. This chip contains boot up ROM and sufficient embedded on-chip SRAM such that minimal external SRAM is required, reducing external memory accesses and power consumption. The DSP56611 is optimized for GSM-based applications where GPRS and circuit switched data are not needed. Figure 4 is a simplified block diagram of the DSP56611.

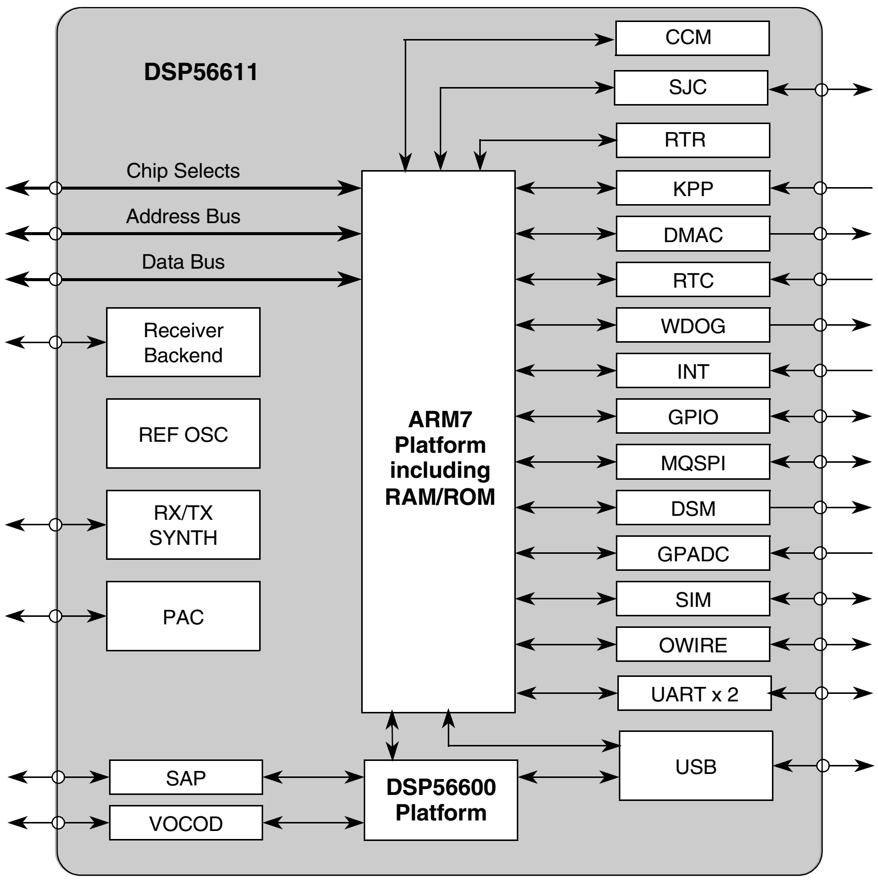

Figure 4. DSP56611 Baseband Processor IC Functional Block Diagram

Table 2 on page 10 lists on-chip peripherals, modules, and special cells that are included to support the operation of the GSM handset application.

Table 2. DSP56611 Baseband Processor IC Module List

DSP Peripherals: (SAP) Serial Audio Port (VOCOD) Voice Codec **Mixed Signal Modules:** (GPADC) General-Purpose ADC Receiver Backend (RX/TX SYNTH) RX/TX Synthesizer (PAC) Power Amplifier Control (REF OSC) Reference Oscillator	**MCU Peripherals:** (MQSPI) Multiple Queue SPI (SIM) Subscriber Interface Module (DSM) Deep Sleep Module (WDOG) Watchdog Timer (RTC) Real-Time Clock (KPP) Keypad Port (INT) External Interrupt Module (DMAC) Display Memory Access Controller (RTR) Real-Time Reference (CCM) Clock Control Module (OWIRE) One Wire Interface (UART x 2) Universal Asynchronous Receiver Transmitters
Shared Peripherals: (USB) Universal Serial Bus Module (GPIO) General-Purpose I/O	**Special Cells:** (SJC) System JTAG Controller

The Baseband Processor is packaged in a MAP BGA plastic package that is 13 mm square and has 225 pins (15 × 15 array with 0.8 mm pitch).

4.2.1 DSP Core

The DSP56600 core in the DSP56611 operates at a maximum frequency of 104 MHz. It includes sufficient program ROM (24-bit wide), data ROM, and data RAM (16-bit wide) to perform all the signal processing functions required by a GSM-centric phone, such as EFR and FR voice coding, equalization, noise suppression, and channel coding.

4.2.2 MCU Core

The ARM7TDMI-S MCU is a member of the ARM7 family of general-purpose 32-bit microprocessors. The ARM7 family offers high performance for very low power consumption and gate count. The ARM7 MCU core in the DSP56611 can operate at up to 52 MHz.

4.2.3 On-Chip Memory

The ARM7 MCU has available to it 41K × 32 of internal memory. A 25K × 32 block of internal memory is implemented as ROM, while the remaining 16K × 32 block is implemented as RAM.

4.3 MC13777 GSM Front End IC

The MC13777 RF Front End IC is designed for use in GSM850/GSM900/DCS/PCS cellular radios and can be used in dual-band, tri-band, or quad-band applications. The receiver portion of the IC is designed for use in very low IF (VLIF) receivers and integrates LNAs, mixers, baseband filters, and RX VCOs. The transmit portion of the IC is designed for use in direct launch transmitters and integrates TX VCOs and buffer amplifiers.

The Front End IC is packaged in a 48-pin (7 mm × 7 mm) EFQFN plastic package.

4.3.1 MC13777 Receiver Section

The MC13777 receiver functional block diagram appears in Figure 5. Four sets of RF inputs are provided to eliminate the need for external RF switches when using the available receiver frequency bands. Quadrature mixers convert the RF signal to baseband, quadrature I and Q. The signal then passes through baseband amplification and anti-aliasing filtering before going to an analog-to-digital converter on the Baseband Processor IC.

The LO signal is provided by a fully integrated VCO that drives either a divide-by-two or divide-by-four quadrature generator. In addition, a divide-by-five circuit is used to feed back the LO signal to the synthesizer. The divide-by-five circuit drives an output stage that provides the appropriate signal level to the synthesizer prescaler. The synthesizer feedback output stage is shared with the TX path and provides the synthesizer feedback signal in both transmit and receive.

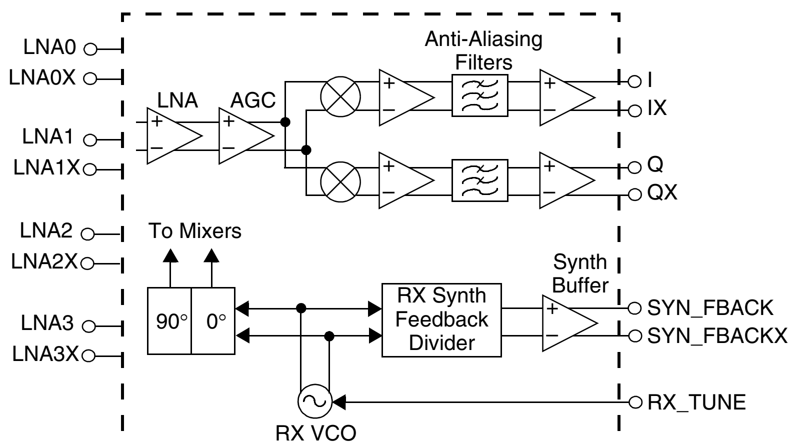

Figure 5. MC13777 Receiver Section Functional Block Diagram

4.3.2 MC13777 Transmitter Section

Figure 6 is a functional block diagram of the transmitter section of the MC13777. A single integrated VCO is used for the transmit path. A low noise floor divide-by-two stage drives the high band output. The low band output is provided through an additional divide-by-two to divide the VCO frequency by four.

Two transmit output stages are provided. Each stage has an integrated output match in order to reduce the required number of discrete components. The integrated matches are implemented as differential to single-ended transformers. The transmit signal is fed back to the synthesizer through a differential output stage that is shared with the receiver.

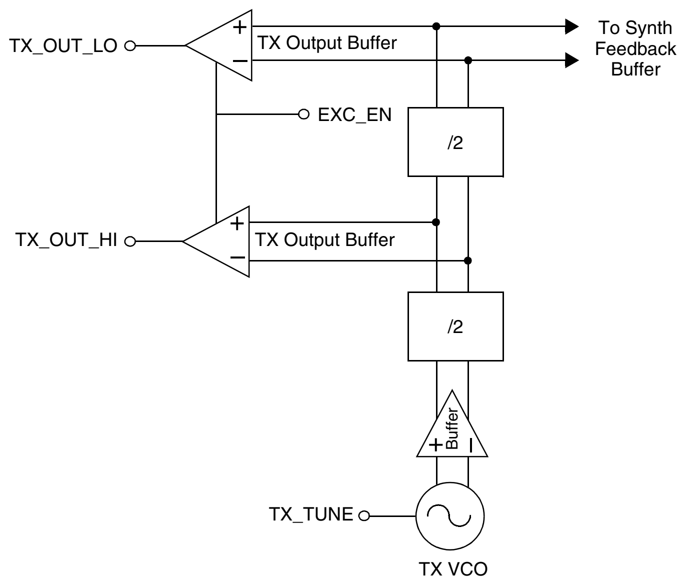

Figure 6. MC13777 Transmitter Section Functional Block Diagram

4.4 MC13717 Integrated Power Management and Audio Circuit

Figure 7 is a block diagram of the MC13717 Integrated Power Management and Audio Circuit. This IC contains all of the necessary regulators and "glue" components of a modern GSM cellular phone.

The MC13717 contains eight independently controllable linear voltage regulators and a step-up converter. This architecture incorporates dedicated regulators for various circuit blocks that allow the processor to control the powering on or off of various stages as they are needed to manage power consumption and extend standby and talk time. Also, by dedicating regulators to certain phone functions, improved isolation and noise immunity are achieved, reducing the need for passive filter components on DC lines.

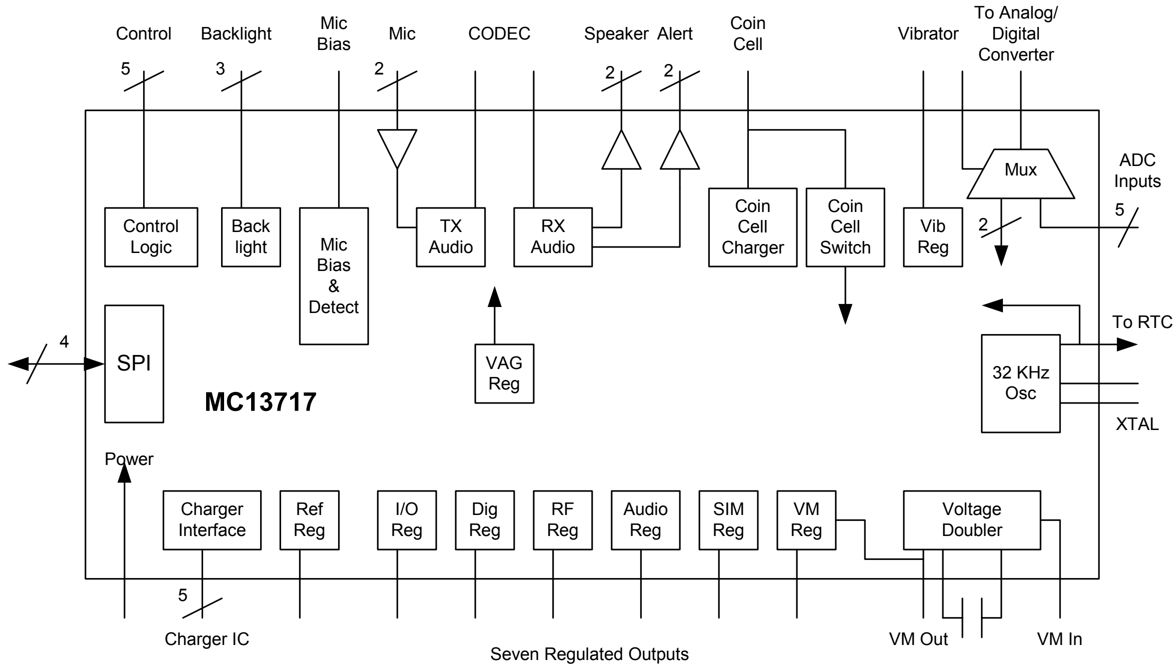

Figure 7. MC13717 Integrated Power Management and Audio Circuit Functional Block Diagram

The trimmed reference regulator provides a 1.575 V reference to all the other regulators on the chip. The RF regulator provides 2.775 V for RF circuits, mostly on the MC13777. The audio regulator provides 2.775 V for audio circuits on the MC13717 as well as the DSP56611. The I/O regulator provides 2.775 V for some of the digital circuitry on the DSP56611, external ICs, and the MC13717 itself. The digital regulator provides 1.875 V for most of the baseband logic on the DSP56611. The SIM card regulator is a selectable 1.875 V or 2.85 V regulator, with special protection for powering a 3 V SIM card.

The capacitive voltage multiplier uses an on-chip clock to double the input voltage. The multiplier is then regulated in the VM regulator to provide a 4.7 V supply to the RF synthesizer and antenna switch controller.

The vibrator regulator provides 1.3 V for the vibrator motor. A current control sinks a programmable current of up to 160 mA through the backlight.

Two programmable gain microphone amplifiers and accompanying bias generators can be selected for the main microphone or the external headset microphone. A detect circuit built into the bias circuit of microphone 2 enables the processor to determine if a headset is present. A programmable gain speaker amplifier has differential outputs, which can be operated as single-ended into a headset or as differential across the main speaker. Filtering is included in both the transmit and receive audio paths. The alert amplifier drives the alert transducer.

The MC13717 provides an oscillator using an off-chip 32.768 kHz crystal. This is used internally for control logic and debouncers and for external circuitry, such as the real-time clock on the DSP56611.

Incorporated control logic includes the ON input pin, power up/down sequencing, interrupt support, over-discharge protection, debouncing, the interface to the MC13718 Li-Ion Charge Control and Protection IC, and other functions. An analog multiplexer allows the ADC on the DSP56611 to read battery voltage, external voltage, temperature, internal reference voltage, and one other input pin. A bi-directional SPI is included for control of all functions.

The MC13717 includes drivers for LEDs, a light sensor, and a charger and switch for a coin-cell backup battery. In addition to interfacing to the MC13718 for Li-ion batteries, the MC13717 can interface to an external IC that can support direct charging of a Nickel Metal Hydride (NiMH) battery.

The MC13717 also has a very low standby current of 100 µA and additional multiplexing for a general-purpose measurement ADC (located in the Baseband Processor).

The Power Management and Audio Circuit IC is packaged in a thin MAP BGA plastic package, 10 mm × 10 mm × 1.3 mm, with 81 pins (9 × 9 array with 1 mm ball pitch).

4.5 MMM6022DB Dual-Band GSM Power Amplifier Module with Antenna Switch

The MMM6022DB is a GSM/DCS dual line-up power amplifier module that integrates two power amplifiers, antenna switching functions, harmonic filters, couplers, and power detection circuitry. It comes in a 9.9 mm x 9.0 mm x 1.5 mm LTCC package, significantly smaller than the previous generation of this module, the MMM6010A/MMM6011A. The MMM6022DB also has improved PAE.

The VAPC signal controls the Power Amplifier Module. The output matching network provides harmonic rejection for the second and third harmonics to meet the specified harmonic levels for each of the bands. The biasing for each PA stage is provided by a custom bias controller, which provides a linear output power response. Antenna switching is controlled via the LOWB_HIGH and EN_ANT_TX control signals. RF leakage to the DC supply lines or control I/Os are minimized by using appropriate RF bypass capacitors internally.

Antenna switching requires a 2.775 V supply to achieve the insertion loss and isolation required. The voltage multiplier regulator on the MC13717 Integrated Power Management and Audio Circuit provides this 2.775 V supply to the PA module.

Figure 8 is a block diagram of the MMM6022DB PA module.

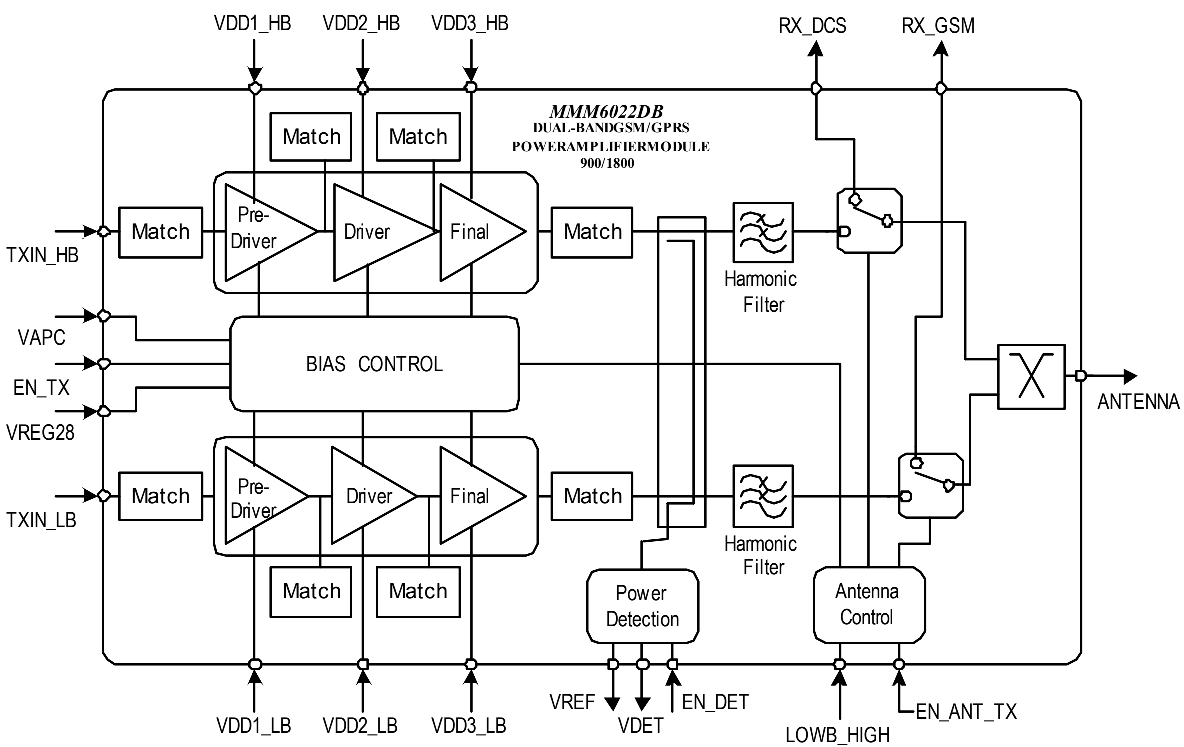

Figure 8. MMM6022DB GSM Power Amplifier Module with Antenna Switch Functional Block Diagram

The MMM6022DB Power Amplifier Module with Antenna Switch is packaged in a 34-pin LTCC (9.9 mm × 9.0 mm) package.

4.6 MC13718 Li-Ion Charge Control and Protection IC

Figure 9 is a block diagram of the MC13718 Charge Control and Protection IC. This IC is designed to protect and control the charging of single-cell batteries employing lithium-ion cell chemistry. The MC13718 interfaces directly with the MC13717 Power Management IC and performs all charging and protection functions in the phone.

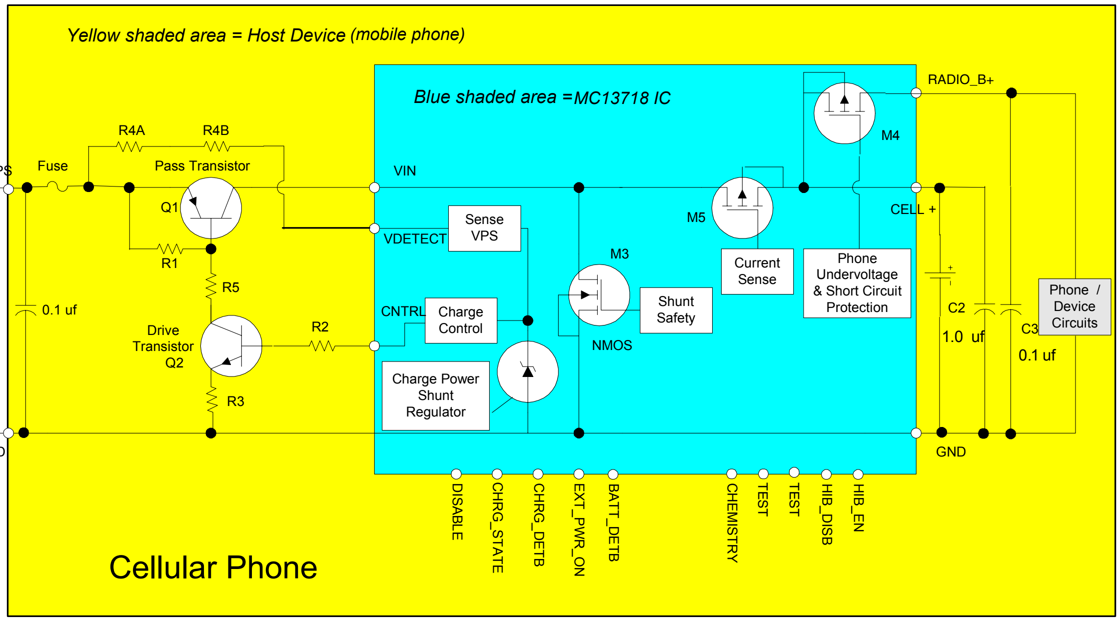

Figure 9. MC13718 Li-Ion Charge Control and Protection IC Functional Block Diagram

The MC13718 is the only connection to the lithium-ion battery cell. The IC protects the cell against short circuits, excessive charge current, excessive charge voltage, and excessive discharge. This IC replaces the protection circuitry normally included inside a removable battery pack, allowing the use of an embedded cell for a lower total cost.

When a charge supply is connected, the MC13718 controls the off-chip pass transistors Q1 and Q2 to the desired charge current. In the event of a short or failure of these devices, the MC13718 will do any or all of the following to protect the cell:

- Internally limit the charge current to the cell
- Shunt charge current to ground to limit the voltage on the cell
- Short the charge current input to blow the protection fuse

In addition to cell protection, the MC13718 performs all charge functions for the phone. The IC has five charge modes: under-voltage pre-charge, full-rate charge, top-off charge, trickle charge, and disable. Except for disable mode, which is controlled by software via the MC13717, the MC13718 automatically operates in the charge mode needed for the proper charging of lithium-ion cells based on the state of the cell.

By tolerating a wide input voltage range, and taking advantage of the current limitation in the supply, the MC13718 allows an inexpensive wall-cube-type supply to be used with the i.200-20 platform, further helping to reduce overall product costs.

The MC13718 Li-Ion Charge Control and Protection IC is provided in a 28-pin LLP plastic package.

5 Platform Development Environments

The i.200-20 platform is designed to simplify the development process for a GSM product by organizing the tools and different pieces of the solution into three major development environments. A significant advantage of using Freescale's 2G/2.5G platform portfolio for GSM and GPRS products is the maximum re-use of these tools and environments. Using the same tools as the i.250-20 and i.250-21 platforms, the i.200-20 platform is organized into the following environments:

- Integrated Development Environment (IDE) for software and MMI development
- Radio Test Environment (RTE) for radio development and performance optimization
- Manufacturing Test Environment (MTE) for meeting type approval and production line test requirements

Combining these three environments can enable customers to develop a GSM product from concept to production. Figure 10 shows the interaction of these three environments to provide a comprehensive GSM development environment.

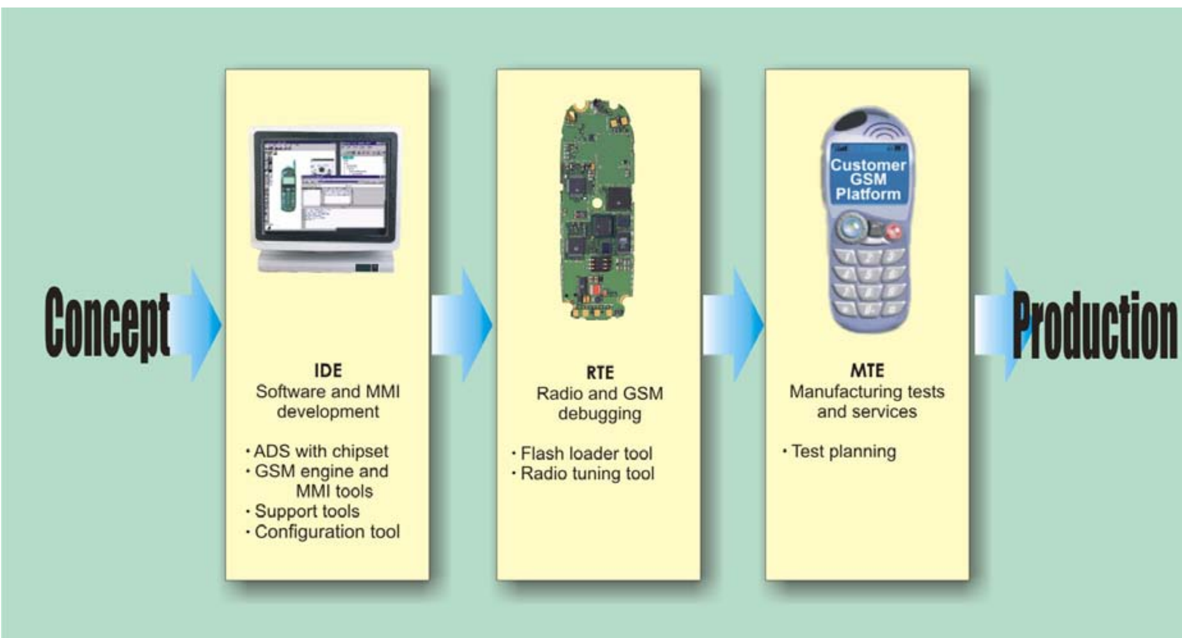

Figure 10. i.200-20 Platform Development Environments

5.1 Integrated Development Environment (IDE)

The IDE, shown in Figure 11, provides a comprehensive hardware and software environment to enable system designers to develop and test their own MMI. Figure 11 shows the flow through the major stages of the development cycle. This environment contains components such as the following:

- Application Development System (ADS)
- Software—GSM engine with MMI toolkit
- Supporting tools for handset development

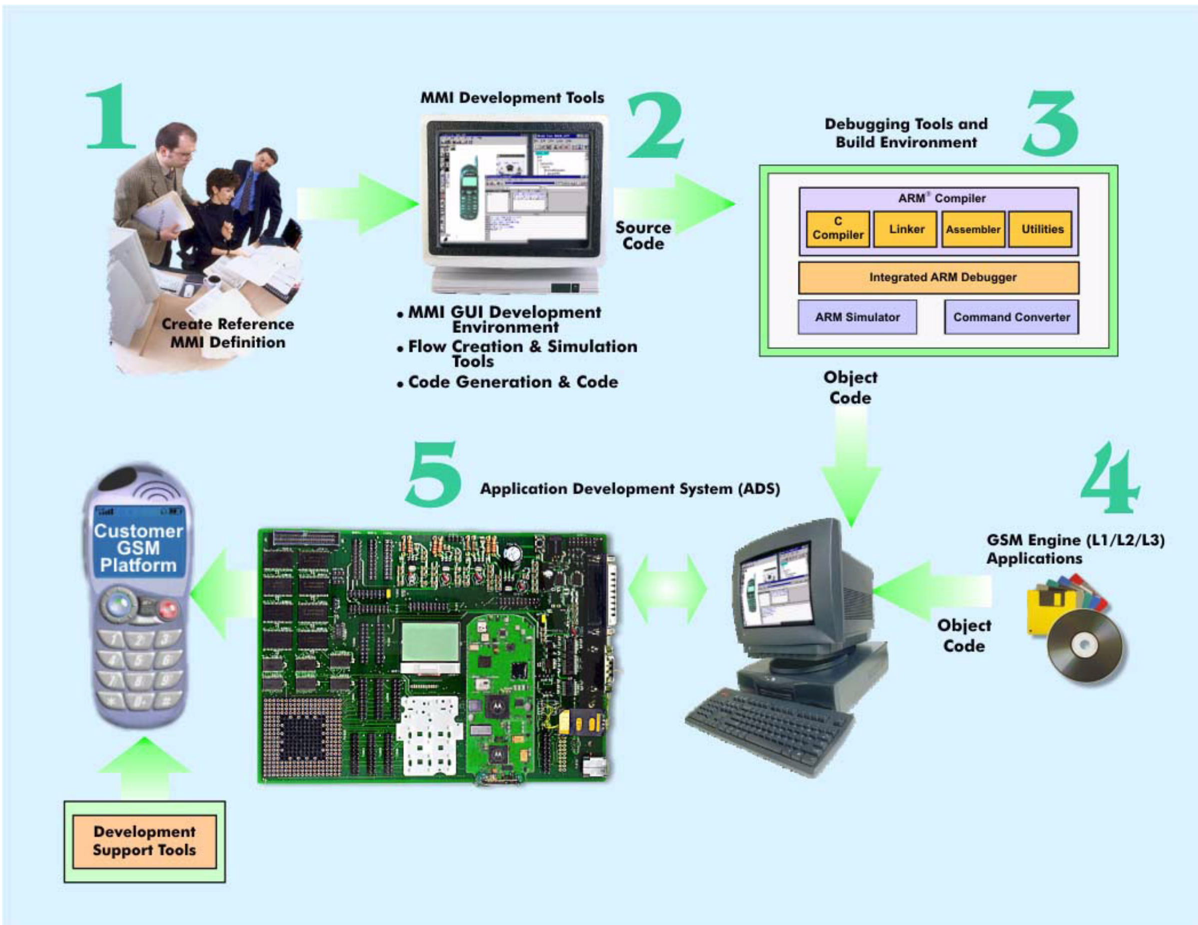

Figure 11. Integrated Development Environment Development Cycle

5.1.1 Application Development System (ADS)

The ADS board is composed of a GSM radio transceiver; monitor points for system evaluation, development, and debugging; and external interfaces such as USB, recommended standard 232 (RS-232), and Joint Test Action Group (JTAG) for communications. With this ADS board, customers can start development of their own application software before their radio hardware platform is ready.

Documentation on the ADS provided by Freescale contains all necessary information for setting up and operating the ADS board, including sections relating to the ADS functional description, setup instructions, schematics, the bill of materials (BOM), and component placement.

5.1.2 GSM Software Solution

The GSM software offering of the i.200-20 platform includes the following components:

- Phase 2 GSM Protocol Engine with seamless upgrade path to GPRS: see Section 6.1.1, "Phase 2 GSM Protocol Engine and Services."
- MMI Application Development Environment: see Section 6.2, "MMI Development Tool Suite."
- Reference MMI applications for the i.200-20 platform reference design: see Section 6.1.4, "Reference Man-Machine Interface (MMI)."

The integration of these components provides a comprehensive software development environment.

5.1.3 Configuration Tool

The configuration tool provides the ability to configure and customize each product's features and applications, allowing distinction between different tiers of products. Freescale's GSM software architecture defines certain features of the software to be configurable through a feature database, allowing a single software development to support different sets of features in a flexible manner. Security features are incorporated to protect individual customers.

The configuration tool works with the IDE and operates in a PC environment. The tool provides access to the configuration database on the flash memory of the ADS or target radio board through a USB connection.

5.1.4 Supporting Tools for Handset Development

A comprehensive suite of additional GSM product development tools is provided to cover different aspects of development needs and requirements. Freescale has partnered with third-party vendors to supply these development tools for writing software. The tools for handset development include an ARM CPU assembler, compiler, and debugger.

5.2 Radio Test Environment (RTE)

The RTE, shown in Figure 12, provides an environment that enables customers to customize and debug their radio platform design (both hardware and software), to assess RF performance and fine-tune parameters for optimum radio performance, and to perform system testing in preparation for Full Type Approval (FTA).

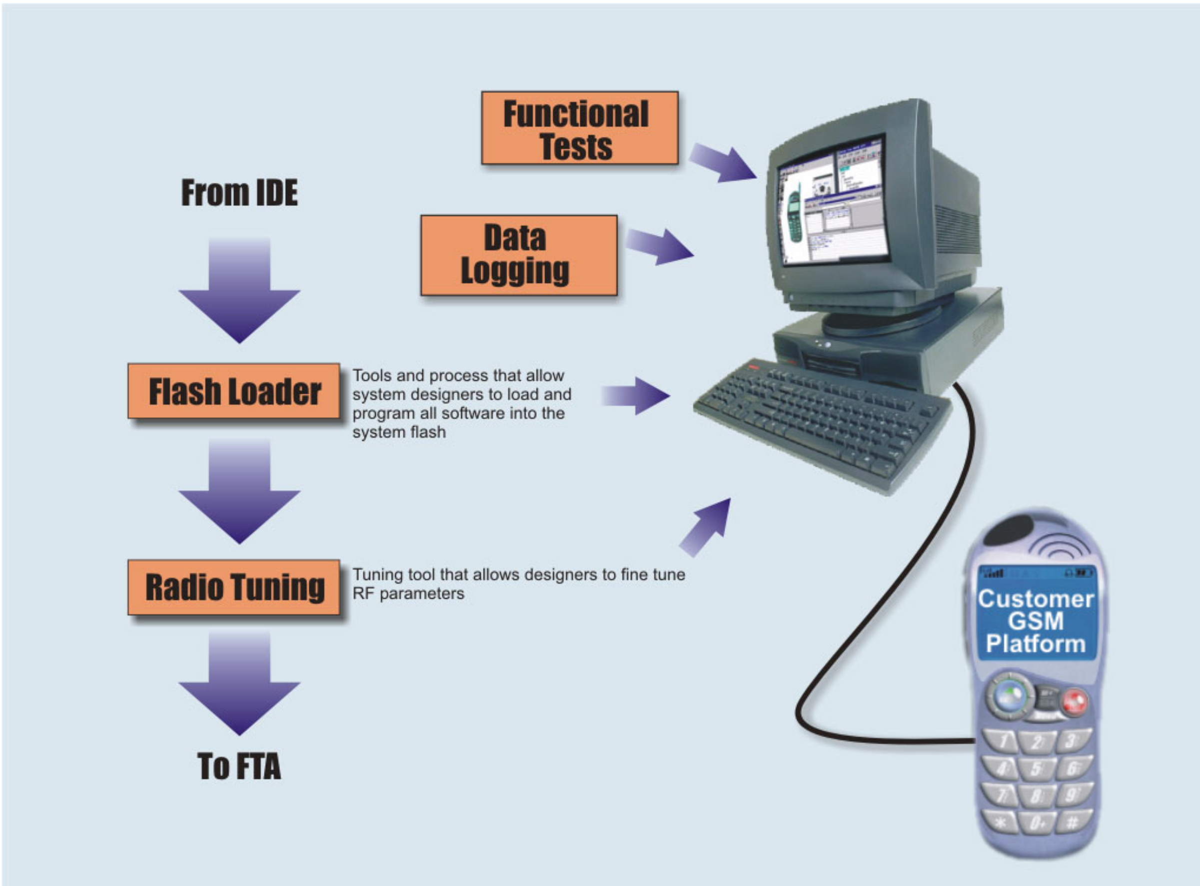

Figure 12. Radio Test Environment

When customers have system testing equipment such as a Radio Tuning Bench, performance tests, and GSM Protocol Analyzers, the i.200-20 platform provides appropriate scripts to enable test automation. The RTE package includes documentation on hardware and software setup, software scripts, and recommended hardware equipment (including accessories) with purchasing contact information.

5.2.1 Flash Loader Tool

This tool gives designers the ability to download the designed mobile radio operating software to the ADS board or target radio board. Security features are incorporated to protect individual customers.

The flash loader tool is provided with the IDE, RTE, and MTE, all of which operate in a PC environment. The tool can transfer the designed software from the PC to flash memory on the ADS or target radio board through a USB connection.

5.2.2 Radio Tuning Tool

This tool is provided to enable fine tuning of the radio performance parameters, such as gain and power. This process allows for adjustments to meet certification requirements. The radio tuning tool operates in a PC environment.

5.3 Manufacturing Test Environment (MTE)

The MTE supports multiple points in the customer's manufacturing back-end flow, as shown in Figure 13. It provides the baseline software and manufacturing adaptation tools for successful product introduction. During customer project planning, the i.200-20 platform's project management team can help to evaluate the customer's product line with regard to requirements for test planning, test software adaptation, hardware connectivity, cycle time, and line metrics. These services can help manufacturers to quickly ramp up the production line and achieve rapid time to market.

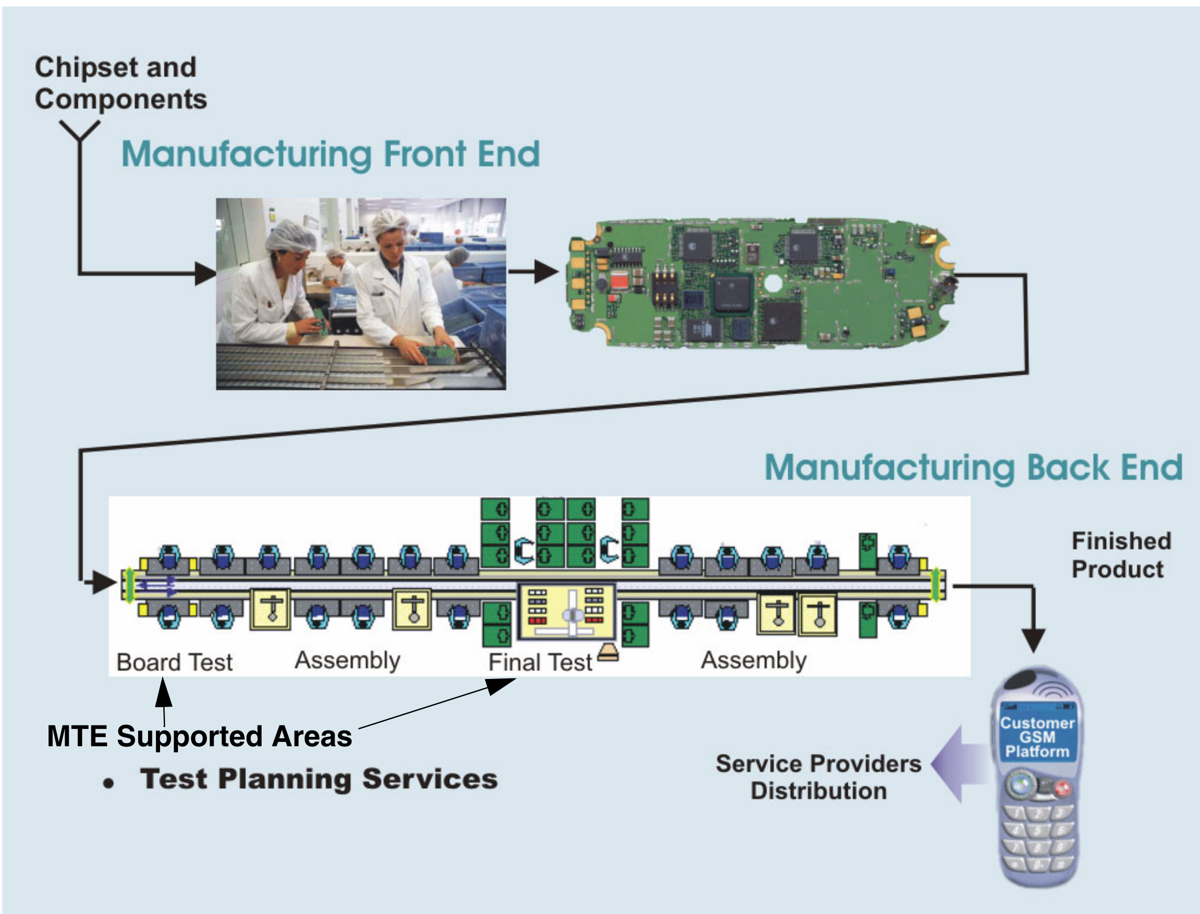

Figure 13. Manufacturing Test Environment

6 Platform Software

Freescale's i.200-20 platform software provides an end-to-end software solution for GSM handset development. The platform software solution includes:

- Proven GSM engine with support tools
- Reference design including man-machine interface (MMI)
- User-friendly MMI development tool suite

The i.200-20 platform's GSM software is partitioned in a layered architecture. There are four major components in the architecture:

- Phase 2 GSM protocol engine and services
- GSM service Application Programming Interface (API) between the GSM engine and MMI applications
- Application Service Libraries (ASLs), including the value-added applications and user-defined device drivers for external device customizing
- Reference MMI with reference design

Table 3 summarizes the features and benefits of the i.200-20 platform's GSM software solution.

Table 3. i.200-20 Platform Software Benefits

Features	Benefits	Reference
Type-approved GSM protocol engine, proven running on cellular handsets with approval from service providers	• Enables rapid and reliable GSM product development • Reduces risk	Section 6.1.1, "Phase 2 GSM Protocol Engine and Services"
Comprehensive and fully integrated GSM service and GSM protocol engine API	• Speeds development of a wide variety of GSM-based products	Section 6.1.2, "GSM Service API"
Extensive set of ASLs integrated with GSM protocol engine and MMI in reference design	• Eases development of feature-rich GSM products • Provides "one-stop shopping" for most application software	Section 6.1.3, "Application Services Libraries (ASLs)"
Reference MMI with reference design	• Provides a comprehensive starting point for customized MMI development	Section 6.1.4, "Reference Man-Machine Interface (MMI)"
Comprehensive, hardware-independent MMI development environment	• Shortens development cycle • Allows parallel development of both radio hardware and MMI software • Eases development, simulation, debugging, and testing • Allows designers to develop products without the final target hardware by simulating the "look and feel" of an actual mobile handset • Helps developers distinguish their products from those of competitors	Section 6.2, "MMI Development Tool Suite"

In addition, the i.200-20 platform's comprehensive software offering gives GSM product designers and developers the following:

- MMI micro-kernel micro state machine that facilitates the operation of the MMI applications generated by the MMI development tool. It is platform specific and should be integrated during the software build.
- Suite of additional support tools for comprehensive GSM product development that considers different aspects of development needs and requirements. These additional tools are:
  — Flash programming
  — Handset radio calibration
  — Application customization and configuration

  For more information on these tools, see Section 5, "Platform Development Environments."

Table 4 summarizes the stages in the software integration process for the i.200-20 platform.

Table 4. i.200-20 Platform Software Integration Process

Stage	Description
1	**Specification**—Designers design their own MMI specification based on Freescale's reference MMI framework.
2	**MMI Creation**—Designers create the MMI implementation according to the defined MMI specification. Designers can leverage and re-use the reference MMI, and can also build objects with GUI tools, design the MMI mode tree, create mode transitions, and define activities.
3	**Simulation and Debugging**—The customized MMI can be simulated, debugged, and verified in the development environment. The interaction between the MMI, GSM engine, and application service libraries (ASLs) can be simulated by user-defined interfaces (UDIs), which implement the same GSM service API as the actual GSM engine and ASLs on the target device.
4	**Code Generation**—After the MMI is created, designers convert the MMI objects designed in the development tools to C source code.
5	**Software Build**—Designers build the software by integrating the generated MMI code, MMI micro-kernel, GSM engine, and ASLs in a standard C development environment.
6	**Downloading**—The built software is downloaded into the ADS or target radio board with the flash loader tool. The radio board is calibrated with the radio tuning tool, and the features are configured with the application customization and configuration tool.

6.1 Platform Software Architecture Components

Figure 14 illustrates the layered architecture of the i.200-20 platform's software.

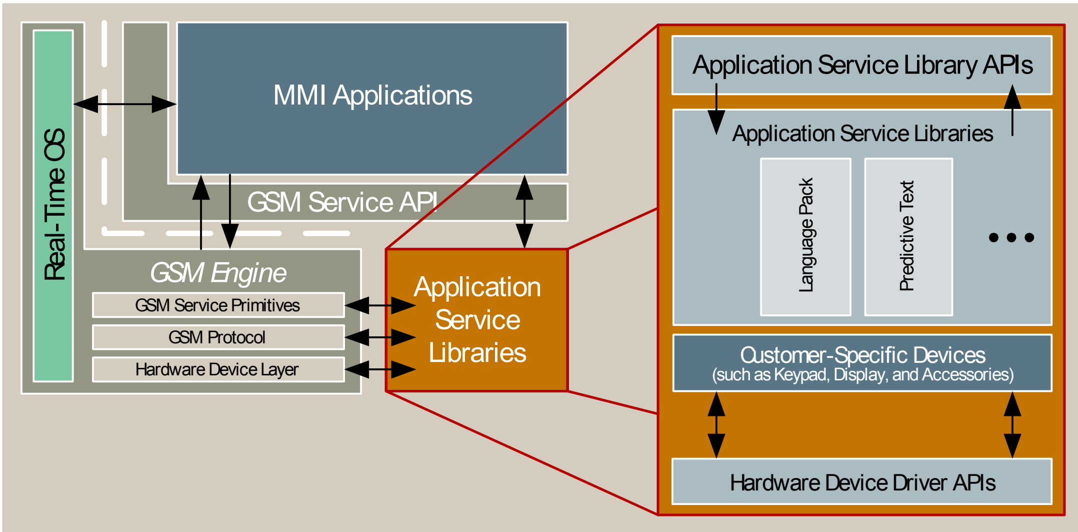

Figure 14. i.200-20 Platform Software Architecture

6.1.1 Phase 2 GSM Protocol Engine and Services

A comprehensive and type approved GSM Phase 2 compliant GSM protocol engine, together with an extensive set of GSM-related application services, are provided in object code format to enable the development of feature-rich GSM products. The GSM engine and the ASLs are accessible through the GSM service API. The features and capabilities of the GSM protocol engine and services include:

- GSM Phase 2 protocol stack that conforms to the following:
  - GSM 03.22
  - GSM 03.41
  - GSM 04.04
  - GSM 04.08
  - GSM 04.12
  - GSM 05.01
  - GSM 05.02
  - GSM 05.03
  - GSM 05.08
  - GSM 05.10
- Multiband capability: 900 MHz and 1800 MHz
- HR/FR/EFR vocoders
- State-of-the-art echo cancellation to provide excellent voice quality
- Short message service (SMS) and enhanced messaging service (EMS)
- Cell broadcast service (CBS)
- MIDI ringtones (16 channels)
- Call management that includes make call, receive call, and multi-party call
- Caller Line ID (CLD) support
- Supplementary services
- Predictive text input

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- SIM application toolkit, class 2+
- Configuration database structure
- Real-time clock
- Built-in phone book database management
- SIM manager to facilitate all SIM access functionality
- Handset security (SIM security and keypad lock)
- GSM 11.10 test function support
- System power management

The GSM protocol engine and services can support both voice-only and voice/data handsets. The availability of some software features depends on the licensed reference design. The GSM protocol capability and service continue to be enhanced to support designers in technology migration.

6.1.2 GSM Service API

The GSM service API is an interface between the GSM engine, the ASLs, and the MMI application. This comprehensive API is implemented in the form of User-Defined Interfaces (UDIs). Designers can develop their own MMI applications with user-friendly MMI development tools without knowing the functional details of the API.

The platform GSM software provides a list of GSM service API sets. Each GSM service API provides access to the functions supported by the GSM engine and the ASLs.

Sample UDIs are for call management, configuring the display and keypad, power management, phone book and other database management, and SIM management. Other UDIs serve as the interface to accessory and peripheral applications.

The i.200-20 platform's GSM service API also includes UDIs for specific ASLs. Section 6.1.3, "Application Services Libraries (ASLs)," identifies these UDIs and summarizes a typical application-development scenario using the API and an ASL.

6.1.3 Application Services Libraries (ASLs)

Supplementary ASLs, shown in Figure 15, provide value-added technologies for product development. The ASLs can be reduced or expanded according to the designer's or developer's requirements.

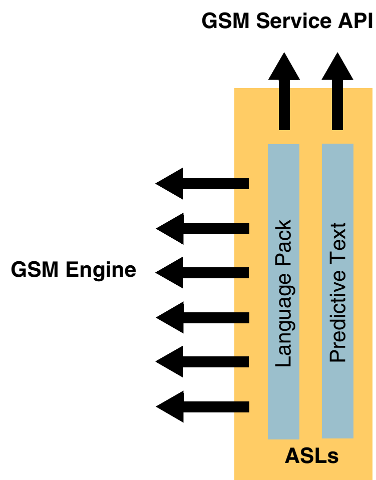

Figure 15. Sample Application Service Libraries (ASLs)

MMI applications can access the ASLs through the GSM service API. In turn, the ASLs interact seamlessly with the GSM engine.

Table 5 lists the API modules for ASLs that are available in the i.200-20 platform's reference design.

Table 5. ASL Interface Modules

ASL	Interface Module(s)
Language pack	FONT_EMB, text_emb, LPUDI
Predictive text	ITAPUDI, LPUDI

The application libraries are utilized by accessing the API provided with each ASL. For example, the development of a predictive text application might consist of the following steps:

1. Use ITAPUDI to develop the predictive text application.
2. Create a database.
3. Set up selection criteria.
4. Retrieve a predictive text list and close the database.

In this scenario, the developer is not required to have any knowledge of the predictive text algorithm, and can build the application based on the information/service provided by this engine. The set of libraries increases the capability of the system and decreases development cycle time.

For reference, particular ASLs include application objects such as a predictive text engine. The licensing of such reference technologies must be discussed separately.

6.1.4 Reference Man-Machine Interface (MMI)

The i.200-20 platform's reference MMI, provided with each reference design, is a comprehensive handset MMI application that gives designers a starting point for MMI development. It is a functional, full-feature handset application with pre-developed widgets in a working MMI framework that eases customization and shortens development time.

More specifically, the reference MMI:

- Is provided in base source code with the RapidPLUS™ MMI development tool from e-SIM Ltd.™ For more information, see Section 6.2, "MMI Development Tool Suite."
- Has a hierarchical design with a high degree of code re-usability.
- Is provided with the i.200-20 platform's reference design, i.200-20rd3. For more information, see Section 7, "Reference Designs."
- Includes applications for monochrome displays.
- Is documented extensively in Freescale publications provided to i.200-20 platform customers.

6.2 MMI Development Tool Suite

The "look and feel" of the handset is one of the strongest considerations for consumers when purchasing GSM products. The handset's MMI is the first product feature the consumer encounters, so the ability to design and build a good user interface is vital to the acceptance of the product. The i.200-20 platform therefore provides a comprehensive environment for MMI application development with the RapidPLUS prototyping tool from e-SIM Ltd.

6.2.1 Overview

To facilitate the development of MMI applications, the MMI tool provides rapid prototyping, simulation, and debugging in a PC-based environment. Figure 16 illustrates the MMI development interface.

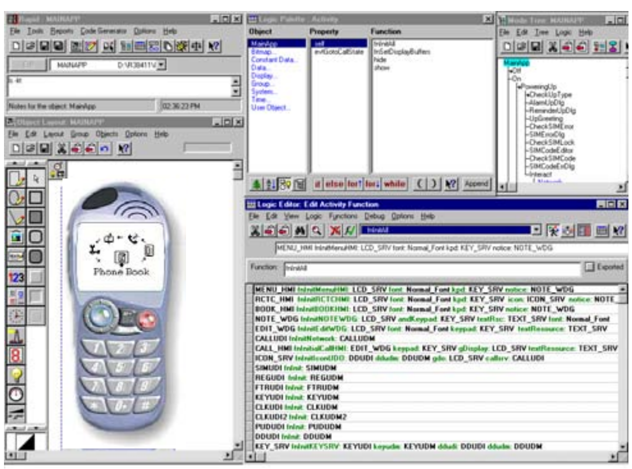

Figure 16. MMI Development Interface

As developers design a handset model, including the keypad and display, the MMI development tool emulates it. The graphical environment of RapidPLUS provides libraries of buttons, dials, gauges, and screens that resemble the phone user's actual operational experience. The MMI tool also enables developers to design the handset's hierarchical operating logic. Using the tool, they can access GSM services that interact with applications in ASLs through the GSM service API. Developers can focus on designing the "look and feel" of the target product without affecting the GSM protocol and hardware interaction.

The hardware-independent MMI development environment provides efficient MMI application development, thereby reducing time to market.

6.2.2 Features

The user-friendly MMI tool eases design, debugging, and code generation. The tool's features and capabilities include the following:

- Virtual prototyping for embedded systems
- Hierarchical and concurrent state design
- Event-driven state flow approach
- GUI object creation
- User-interface or non-user-interface object builder
- Debugger that includes step into, step over, breakpoint settings, and object inspector
- State machine activity log
- Verification test that includes unreachable modes, modes that cannot be exited, transitions without trigger, ambiguous transitions, and objects not referenced
- C source code generator
- Case recorder to record and replay a designed state transition
- Document generator with case recorder
- MMI viewer that operates on a PC for demonstration

6.2.3 Framework

The MMI development environment employs User-Defined Objects (UDOs) to simulate the target platform's components and provide corresponding interactions in the MMI simulation environment. The UDOs contain the functions that simulate the GSM service API and applications in ASLs. Designers access UDO function calls through the GSM service API. Figure 17 on page 29 illustrates this MMI development framework.

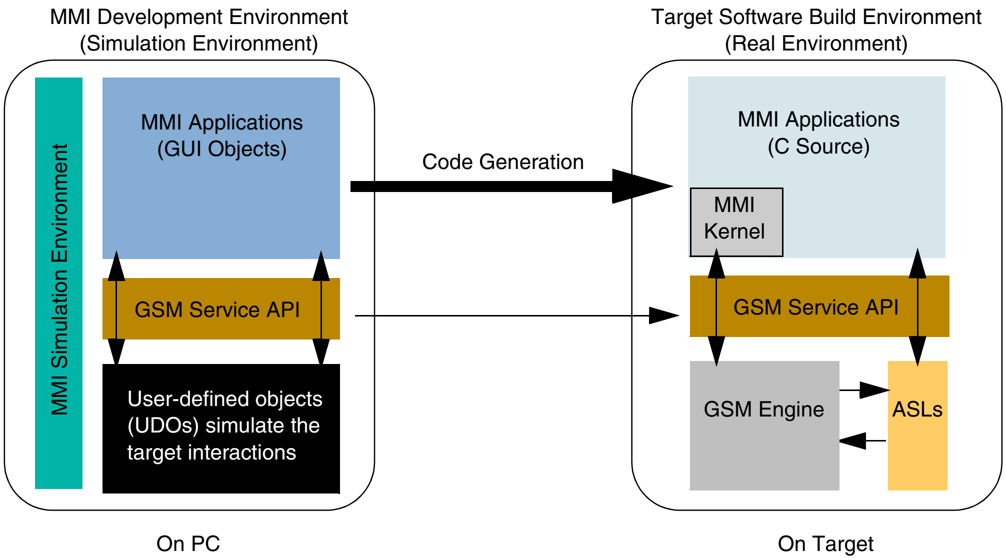

Figure 17. MMI Development Framework

After completing the MMI application design and verification in the MMI development environment, designers can begin code generation. The MMI application's objects are converted to C source code, which is then easily compiled to Superfile format to run on the platform. A pre-generated MMI micro-kernel in object code format enables the MMI application to operate on the target. Because a corresponding GSM service API is valid on the target environment, the generated MMI source code can be integrated with the MMI micro-kernel, the target GSM engine, and the ASLs.

7 Reference Designs

Reference designs for the i.200-20 platform are implementations of the platform that offer specific, value-added sets of handset features that customers demand. Each reference design integrates the hardware and software needed to support its feature set and includes the following:

- Reference phone design
- Reference bill of materials (BOM) and schematics
- Printed circuit board (PCB) layout
- Integrated reference MMI

Table 6 summarizes features of the i.200-20 platform's reference design.

Table 6. Sample Features of i.200-20 Platform's Reference Design

Feature		i.200-20rd3 Reference Design
Display module		Monochrome (96 × 64)
Sample MMI features	SMS	Provided
	EMS	EMS 5.0 (optional)
	Predictive text input	iTAP™ 5.1 (optional)
	iMelody ringtones	Provided
	MIDI	External audio IC driver (optional)

8 Summary

The comprehensive and highly integrated i.200-20 platform, consisting of chips, software, development environments, and services, provides customers with solutions that are easy to adapt to specific needs and allow rapid time to market. The platform chipset has the lowest part count in the industry. Freescale, with its broad base of digital, analog, and RF semiconductor technologies, its long-standing presence in the GSM handset market (as the Semiconductor Products Sector of Motorola prior to 2004), and its worldwide customer support, offers a total system solution unmatched by others.

9 What's New in This Document

This document's updated format reflects that the Semiconductor Products Sector of Motorola, Inc. became Freescale Semiconductor, Inc. in 2004.

Table 7 summarizes revisions made to this document since the release of the previous version (Rev. 1).

Table 7. Document Revision History

Location	Revision
Figure 8 on page 15	The MMM6022DB block diagram was updated.
Section 6.1.1, "Phase 2 GSM Protocol Engine and Services"	Details on features supported by the GSM engine were clarified.
Section 7, "Reference Designs"	Details on i.200-20rd3 were updated.

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