Benefits of Low Voltage EPROMs in Cellular Applications

National Semiconductor
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Madhusudhan Rayabhari
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INTRODUCTION

Cellular phones are rapidly moving towards the "Portable Phone" concept from their origin as vehicular mobile telephone units. The Portable phone provides the user with utmost mobility. Reduced equipment size and power consumption form the key to the design of such portable phones. The introduction of Low Voltage EPROMs by National Semiconductor addresses these requirements. The power drain on the battery in the standby and talk modes determines the duration for which the battery charge lasts. This application note discusses the critical nature of this factor and shows how the new Low Voltage EPROMs from National go a long way in satisfying the needs of cellular designers. Batteries last up to 25% longer on a single charge in designs which employ the new Low Voltage EPROMs from National.

CELLULAR CONCEPTS

The circuitry of a cellular phone consists of two sections—the Radio Section and the Digital Section. The radio section deals with the transmission and reception of voice and signaling information at the appropriate radio frequencies. The digital section is concerned with the generation and interpretation of signaling information, display functions and with manipulation of voice and users inputs. *Figure 1* gives the block diagram of a typical cellular telephone. The Radio Section *(Figure 1a)* consists of the modulator, demodulator, duplexer and the power amplifier for transmission of signals at the specified level. The frequency synthesizer is controlled by the digital section and is capable of generating the required frequencies for transmission and reception on any of the channels allocated for cellular telephony usage.

The control and digital section *(Figure 1b)* consists of a microcontroller, EPROM, RAM, E^2PROM, encoder and decoder for the setup channel (to be explained later) and an analog section consisting of tone-generators, handset interfaces, etc. The density of the EPROM used in typical cellular telephones is 512 kbit–1 Mbit. The entire microcontroller code is stored in this EPROM. The E^2PROM is used for storing frequently dialed numbers, information on radio frequencies and certain numbers related to system identification.

SIGNALING AND CALL PROCESSING

Two types of radio channels are used in Cellular Telephony—Setup Channels and Voice Channels. Setup channels transmit and receive messages consisting of binary data only. They are used only for initiating and setting up voice calls. These channels are for common use of cellular phones which are in the process of setting up a call. Voice channels are used for voice communication and for short bursts of data required for control purposes during the call or at call termination. These bursts are interleaved with voice.

When first powered up, the cellular phone enters what is called the idle state. In this state, it scans the entire group of setup frequencies to determine the strongest carrier signal and begins to monitor that channel for incoming calls. Usually, the strongest signal belongs to the base station of the cell in which the cellular phone is operating. At periodic intervals, the setup channels are scanned for the strongest signal to determine whether the movement of the cellular phone has made the use of the setup channel of another cell more appropriate.

The important point to note here is that for such an activity (i.e., monitoring the setup channel for incoming calls) the receive portion of the radio circuitry and the digital control section which includes the microcontroller, RAM, EPROM, etc., are constantly powered on. What this actually means is that the logic circuitry is always on, whether or not a voice call is in progress, and thus represents a constant drain on the battery. It is important, therefore, that this circuitry draw minimal current in view of extending battery life. The power drain of a cellular phone is a critical factor in the selection as all of them radiate the same amount of power which is determined by the relevant standard (i.e., EIA IS19B). Typical figures on power consumption for presently available cellular phones are 55 mA–60 mA in standby (Idle) mode and 550 mA–575 mA in the talk mode. The calculations for power saving that follow are based on these representative figures and a design based on a standard 5V microcontroller operating at 2 MHz–3 MHz and using a battery of 700 mAH rating.

A typical cellular phone uses an E^2PROM for storing frequently dialed numbers and electronic identification information. A separate analog IC featuring 4 analog switches (typically a CD4066) is used for switching voice, touch-tone and binary signaling on to the radio channel. An important design feature in this application note is the use of the versatile NM95C12. This device integrates, on a space saving 14-pin SO/DIP, a 1024-bit E^2PROM and 4 programmable switches which can be used in a variety of modes. In this application, the switches are used in the analog mode where they are used for connecting the touch-tone, binary and voice signals onto the transmit channel. This device replaces the use of separate ICs for the E^2PROM and analog switches. On a vehicle mounted unit, they can also be used to select between the handset and speakerphone modes. It has a serial interface to the microcontroller—MICROWIRE/PLUS™. This leads to lesser interconnect wiring on the board, giving further savings in board space.

POWER SAVING

Power consumption is reduced in two ways—by operating at a lower voltage or by using devices that consume lesser power. The NM27LV010 from National fits both categories. It is capable of operating at 3V and it consumes vastly reduced power. While standard EPROMs consume up to 100 mW (20 mA typical @ 5V and 3 MHz) National's NM27LV010 consumes about 24 mW (6 mA–8 mA typical @ 3V), thus reducing power drawn by the EPROM by 75%. Substituting these values in typical power consumption figures of a cellular phone (Box-1) shows that **the standby time of the cellular phone is extended from a typical 12 hour value to up to 15 hours**. The cellular phone consumes a very large amount of current in talk mode. Using National's Low Voltage EPROMs would extend the talk time

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by a few minutes over the typical value, permitting the user to make an extra call. Also, the device is available in the space saving TSOP package which is of great value in cellular applications as it leads to more compact equipment. Furthermore, an access time of 250 ns or greater is found to be adequate for the cellular application. Another significant point of interest to the designer is the operating frequency. The power consumption varies widely with the operating frequency. *Figure 2* depicts the relationship between the operating frequency and the typical active current for the NM27LV010. The designer may consider operating the system at an appropriately reduced frequency to achieve further savings in power.

SUMMARY

Using the low voltage EPROMs from National in cellular applications leads to savings in power and space. An overall power saving of up to 25% may be achieved using National's Low Voltage EPROMs. The tangible benefits are elongated battery life and more compact equipment.

Most of the components used in a cellular phone are either already available or are being designed for 3V. Table I lists the components for the digital section available from National. National has also announced an entire family of Low Voltage Logic Devices for designing systems for 3V operation. A large number of National's components come with a highly optimized serial interface—MICROWIRE/PLUS. This interface is used for device control and reduces the interconnect wiring associated with usual parallel buses leading to savings in board space. National also produces most of the analog and digital components of the cellular radio systems, giving a single source solution to the Cellular Designer's needs.

TABLE I

Functional Block	Component	Function	Features
EPROM	NM27LV512	Code Storage	Low Voltage Operation, Low Power Consumption
E^2PROM	NM95C12	Non Volatile Storage for Number, Frequencies, etc.	MICROWIRE/PLUS operation, 4 Analog switches for summing signals, selection between handset and speakerphone operations on vehicle mounted mobile phones. Replaces a separate IC for analog switching.
Display	MM58201	LCD Driver	Low Power, Serial Interface

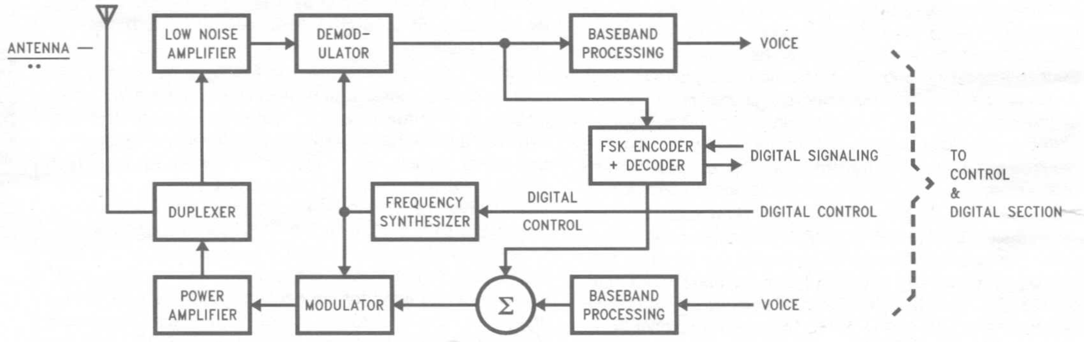

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FIGURE 1a. Radio Section of a Cellular Telephone

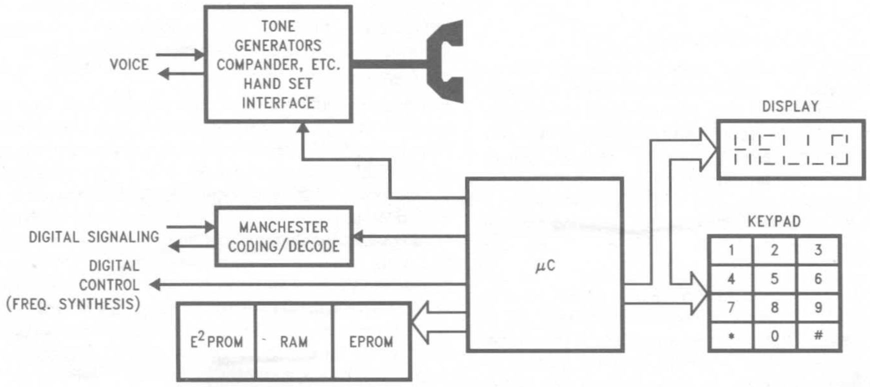

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FIGURE 1b. Control and Digital Section of a Cellular Telephone

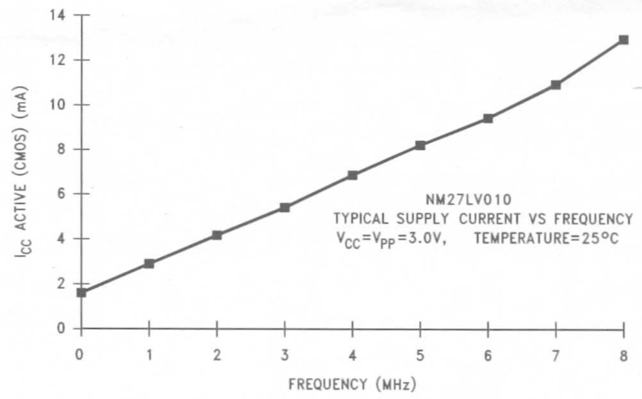

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FIGURE 2. Plot of Power Supply vs Operating Frequency

Standard EPROM Solution

Typical Cellular Phone Current Drain (in Standby Mode) — 55 mA

Typical EPROM Current @ 3 MHz and 5V — 20 mA

LV EPROM Solution

Typical Current (LV EPROM) — 8 mA

Logic ICs (for Interface) — 4 mA

Total Current → 12 mA @ 3V

Total Power → 12 * 3 = 36 mW

Using a DC-DC Converter which is 80% efficient

Current @ 5V — −36/(0.8 * 5) = 9 mA

Current Savings → 20 mA − 9 mA = 11 mA

Current drain using LV EPROM → 55 mA − 11 mA = 44 mA

Extension of Standby Time (Using a 700 mAH Battery)

(700/44) − (700/55) = 3.18 Hours

Extension of Standby Time

(Percentage) = 3/12 → 25%

Note: All above calculations assume a 3 MHz Operating Frequency

BOX-1. Power Savings Calculation