**Before the**
**FEDERAL COMMUNICATIONS COMMISSION**
**Washington, D.C. 20554**

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| In the Matter of | ) | |
| | ) | |
| Revision of the Commission's Rules to Ensure | ) | CC Docket No. 94-102 |
| Compatibility with Enhanced 911 Emergency | ) | RM-8143 |
| Calling Systems | ) | |

**PETITION FOR WAIVER OF AT&T WIRELESS SERVICES, INC.**

AT&T Wireless Services, Inc. ("AT&T"),[1/] by its attorneys and pursuant to the Commission's November 13 Extension Order,[2/] hereby submits a petition for waiver of section 20.18(c) of the Commission's rules until October 1, 1999. Section 20.18(c) of the Commission's rules requires all covered carriers "to be capable of transmitting 9-1-1 calls from individuals with speech or hearing disabilities through means other than mobile radio handsets, e.g. through the use of Text Telephone Devices" by October 1, 1997. 47 C.F.R. § 20.18(c). AT&T currently offers analog phones that can be used with many text telephone ("TTY") devices to make wireless calls to 9-1-1. However, because digital wireless phones currently are incompatible with TTY devices, the Commission has granted several limited suspensions of the enforcement of this rule for digital wireless phones, most recently until December 31, 1998.[3/]

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1/ AT&T files this waiver request on behalf of itself and all CMRS licensees it controls.

2/ In the Matter of Revision of the Commission's Rules to Ensure Compatibility with Enhanced 911 Emergency Calling Systems, CC Docket No. 94-102, RM-8143, Order, DA 98-2323 (rel. Nov. 13, 1998) ("November 13 Extension Order").

3/ Id. See also In the Matter of Revision of the Commission's Rules to Ensure Compatibility with Enhanced 911 Emergency Calling Systems, CC Docket No. 94-102, RM-8143, Order, DA 98-1982 (rel. Sept. 30, 1998) ("September 30 Extension Order"); Memorandum Opinion and Order, 12 FCC Rcd 22665, 22695 at ¶ 59 (1997) ("E911 Reconsideration Order").

As demonstrated below, AT&T's petition satisfies the Commission's criteria for grant of a waiver of section 20.18(c). AT&T is taking steps to provide TTY users with the capability to operate such devices in conjunction with digital wireless phones. AT&T expects that phase one of its plan -- a "smart cable" that permits TTY users to avail themselves of many of the features provided by digital wireless phones while retaining the ability to access 9-1-1 over analog channels -- will be commercially available by October 1, 1999. As demonstrated below, this smart cable will address nearly all of the consumer concerns referenced in the FCC's September 30 Extension Order. Accordingly, the Commission should grant AT&T a waiver of section 20.18(c) that deems the company to be in compliance with the rule if it introduces the smart cable as soon as practicable, which it anticipates will be October 1, 1999.

## BACKGROUND

Significant technical issues impair the compatibility of TTY devices and digital wireless phones. First, current models of digital wireless phones are too small to connect acoustically with traditional TTY devices, which were designed to accommodate landline phones. Second, there are currently no commercially available "connectors" that allow a TTY user to connect his or her digital wireless phone directly to his or her TTY device. The wireless industry is developing standards for the production of such connectors, which AT&T anticipates will be generally available in late 1999. AT&T believes that carriers will be in compliance with the terms of section 20.18(c) if they offer these connectors to TTY users. However, the company is also aware that TTY user groups represented in the TTY Forum have objected to this proposed solution because initial tests suggest that the passage of TTY baudot tones through digital

wireless phone voice coders will distort the tones, producing character error rates of three to six percent.[4/]

AT&T is committed to making wireless products and services accessible to everyone, including people who use TTY devices. Since the TTY Forum was formed in 1997, AT&T has been an active participant along with other wireless service providers, wireless equipment manufacturers, TTY manufacturers, and deaf consumers. AT&T has taken the lead in notifying customers about the limitations of sending TTY tones over wireless digital phones and has also donated lab facilities for the Universal Wireless Communications Consortium ("UWCC") to conduct standardized tests of TTY performance over IS-136 TDMA wireless phones.

When it became apparent that different digital technologies and wireless systems would require different approaches to resolve the incompatibilities between TTY devices and digital

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[4/] See Memorandum from Consumer Representatives to TTY Forum (Sept. 10, 1998), attached to September 30 Extension Order at Appendix ("Consumer Memorandum"). Digital wireless phones use voice coders that are optimized to carry voice calls. The baudot tones transmitted by TTY devices, however, are very different from speech tones and therefore are not reproduced well by voice coders. The low-rate voice coders used in TDMA wireless phones (TIA/IS-641 codecs) and GSM wireless phones (US1 codecs) will not transmit TTY tones without distorting characters at error rates ranging from three to six percent. See Wireless TTY Forum, Seeking Solutions to TTY Through Wireless Digital Systems, Quarterly Status Report (Oct. 13, 1998). Consumer representatives have requested that digital phones transmit TTY baudot tones with a character error rate that approximates analog transmissions, i.e., less than one percent for stationary calls. See Phillips *Aeon* TTY Interoperability Test Report, Version 1.1, Oct. 2, 1998. However, AT&T believes that the transmission of TTY tones through current digital phones satisfies the Commission's rules, which do not specify a performance measure. Consequently, the Commission would need to grant waivers to petitioning carriers only until such time as the connectors become available for sale, at which time compliance with section 20.18(c) will be feasible. AT&T intends to offer these connectors to TTY users who desire them. Nevertheless, as set forth herein, AT&T seeks a waiver on slightly different terms in order to pursue a prompt solution of the TTY/digital phone compatibility issue by means that it believes would be more satisfactory to the TTY user groups.

phones, AT&T began conducting its own research. AT&T has worked directly with its phone manufacturers to test techniques that will improve the quality of the transmission of TTY baudot tones over digital wireless phones. While such efforts continue, the lack of any immediate solution has led AT&T to adopt a two phase work plan to support TTY/digital phone compatibility for 9-1-1 calls. Phase one of its plan will utilize a "smart cable" that permits TTY users to avail themselves of many of the features provided by digital wireless phones while retaining the ability to access 9-1-1 over analog channels; phase two will utilize a third generation wireless data solution. AT&T, however, will not be able to implement phase one of its plan by January 1, 1999. AT&T therefore respectfully requests that the Commission grant it a waiver of section 20.18(c) until October 1, 1999, at which time the smart cable should be available, so that AT&T will be deemed to be in compliance with the rule if it continues to offer the smart cable solution.

**DISCUSSION**

AT&T plans to use a two-phase strategy to provide TTY users with the capability to operate such devices in conjunction with digital wireless phones. AT&T initially will provide TTY users with the ability to use current TTY technology in conjunction with current digital wireless phones ("backwards compatibility"). Because AT&T's digital multi-network ("DMN") wireless phones operate on both analog and digital networks at both cellular and PCS frequencies, AT&T will be able to provide TTY users with many of the benefits of digital phones while continuing to use the lower error rate analog channels to transmit TTY calls. AT&T will then transition TTY users to leading edge third-generation wireless data technology. AT&T will

use existing consumer education channels, including its Internet site and point of sale collateral materials, to make TTY users aware of new applications when they become commercially available.

## I. AT&T's Is Taking Steps to Allow TTY Users to Use Digital Wireless Phones in the Near Future

Cable connectors currently are used to provide an interface between certain analog wireless phones and certain TTY devices. In conjunction with its digital multi-network ("DMN") phones manufacturers, AT&T plans to develop an interface cable that will enable an audio connection between a DMN phone and a modified TTY with a 2.5mm jack.[5/] This "smart cable" will switch the DMN phone into analog mode automatically and connect the call. This will permit TTY users to access the most extensive national wireless network and also receive many of the benefits of digital technology, such as longer battery life in digital mode, eligibility for AT&T's Digital One Rate plan, Caller ID, and short messaging service.

### A. Consumer Concerns

AT&T's proposed "smart cable" also will address nearly all of the consumer concerns set forth in the Commission's September 30 Extension Order. First, it will transmit TTY tones with a character error rate of less than one percent,[6/] compared to calls transmitted over digital signals, which are subject to an average character error rate of three to six percent, depending on the type

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[5/] Many older TTY devices will need to be modified to support a 2.5 mm jack interface or connector. Newer TTYs, such as the Lober & Walsh model, may already support this feature.

[6/] A character error rate of less than one percent was first on the list of consumer criteria in the Consumer Memorandum.

of TTY used for both sending and receiving and the conditions of the wireless connection.[7/] No reduction of throughput is necessary for successful transmission over analog signals.[8/] The interface cable also supports backward compatibility with TTYs in good working condition manufactured over the past ten years that have been modified with a 2.5mm jack, and neither the PSAP nor the landline party's TTY will require retrofitting.[9/]

In response to consumer criterion nine, voice carry-over ("VCO") and hearing carry-over ("HCO") may be included in the interface cable. DMN phones have volume control and external earphone connections,[10/] and vibrating batteries can be added to DMN phones to provide a tactile ring signal indication.[11/] DMN phones also have a visual indicator on their LCD screen that activates when a call is disconnected.[12/] As required by consumer criterion six, TTY tones may be transmitted regardless of the condition of the receiving modem. Finally, ANI and ALI will be supported wherever they are currently available to wireless customers.[13/]

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[7/] Ultratec TTYs transmit at an average CER of six percent over digital networks, whereas Lober & Walsh Mobility TTYs transmit at an average CER of three percent over digital networks. See Wireless TTY Forum, Seeking Solutions to TTY Through Wireless Digital Systems, Quarterly Status Report (Oct. 13, 1998).

[8/] Consumer memorandum, criterion #10.

[9/] Under consumer criterion #12, a solution is not required to support little-used or obsolete TTY models, but generally should support the embedded base of TTYs sold over the past ten years. Under consumer criterion #7, the landline party's TTY must not require retrofitting in order to achieve the desired error rate.

[10/] Consumer memorandum, criterion #4.

[11/] Id., criterion #5.

[12/] Id., criterion #3.

[13/] Id., criterion #11.

### B. Milestones

AT&T is currently in discussions with its DMN phone manufacturers over the production of this smart cable. AT&T plans to submit the capabilities requirements documents for its smart cable proposal to these manufacturers in December 1998. AT&T expects to test the prototype cable in June 1999, and if successful, will make the interface cable commercially available by October 1, 1999. AT&T believes that the smart cable is an improvement over other interim solutions because it will allow TTY users to avail themselves of the additional choices and features provided by digital wireless phones while providing access to 9-1-1 services over analog channels. To the extent that the Commission concludes that AT&T's proposal to transmit TTY calls to 911 over the analog channels of a DMN phone does not satisfy the requirements of section 20.18(c) of its rules, AT&T also requests a waiver of section 20.18(c) to permit it to utilize its smart cable solution until AT&T's long term solution is ready.

## II. AT&T Is Working to Provide TTY Users With a Long Term Solution to the Problem of Incompatible TTY Devices and Digital Wireless Phones

AT&T continues to investigate the source of the distortion of the TTY baudot tones and the efficacy and feasibility of modifications to the voice coder or the codec. AT&T has attached a research report generated by AT&T Labs that concludes that a voice coder or codec solution has not been found.[14/] Furthermore, AT&T has donated lab facilities to enable the UWCC to conduct standardized tests of TTY performance over IS-136 TDMA wireless networks. Once the UWCC tests are complete and the test results are analyzed, AT&T will decide whether to

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[14/] See "Binary FSK Modulated Data Transmission Via IS-641," attached hereto as Exhibit One.

continue investigating the feasibility of modifying the voice coder or codec to transmit TTY tones over digital channels with a lower character error rate.

AT&T believes that the development of a third generation data solution is the most promising solution for TTY users who want to use digital wireless phones. Third generation wireless technology will bring high-speed data transmission and fully capable Internet services to AT&T's network. High-speed data services, typically at speeds of 384 kbps, will enable real-time communications of text or text enriched with graphics. Third generation wireless capability will allow for the direct transmission of digital data from alternate entry devices, such as palm top computers or personal data assistants ("PDAs"), via a data network or the public switched telephone network, to support intercommunication with traditional TTY devices and other alternate entry devices. The devices will have the capability to "chat" back and forth and provide "virtual" real time communication.

AT&T expects standards for high-speed data over digital wireless systems to be developed by October 1, 2000. Industry trials would then take place during fourth quarter 2000 and, if successful, these services would be commercially available by first quarter 2001. AT&T will do its very best to ensure that its high speed digital data services will address the consumer concerns set forth above. AT&T will provide quarterly progress reports as requested by the Commission.

## CONCLUSION

For the reasons set forth above, the Commission should grant AT&T a waiver of section 20.18(c) of the Commission's rules.

Respectfully submitted,

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# BINARY FSK MODULATED DATA TRANSMISSION VIA IS-641

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## 1. PROBLEM

A binary FSK modulated data transmission is simulated coded by the IS-641 speech coding algorithm [1]. The symbol duration is chosen to be 22 ms, the two FSK frequencies 1400 Hz and 1800 Hz. Sampled at 8 kHz, each FSK symbol contains 176 samples. The IS-641 codec works with signal frames of 160 samples (20 ms) accordingly the symbol duration is only slightly longer than one frame. To simulate realistic behaviour an offset of 3 samples is chosen to guarantee that a symbol never changes at a frame border. A random data signal after modulation is shown in Fig. 1(a), the data signal after modulation, speech coding and speech decoding is shown in Fig. 1(b).

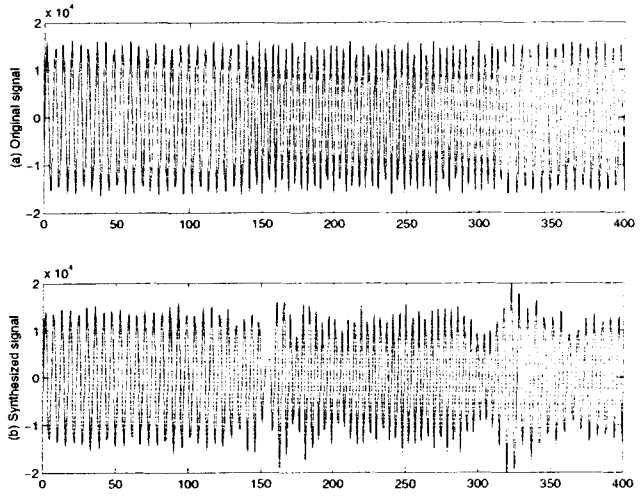


Figure 1: Part of FSK original and synthesized signal

In Fig. 1(b) two kinds of unexpected waveform behaviour can be seen: Signal muting and signal amplification. Both effects occur close to symbol changes. In the following this effect will be investigated.

## 2. INVESTIGATIONS AND EXPLANATION

The IS-641 is an analysis-by-synthesis code-excited linear predictive (CELP) coder. Four times a frame (i.e. every subframe) an adaptive codebook and a fixed codebook are searched to match a precomputed target signal in the MMSE manner. The target signal $t$ mainly consists of the speech/FSK signal filtered by a weighting filter.

### 2.1. Adaptive and fixed codebook contributions

The first question that arises is: What kind of contribution fails in subframes where the FSK symbol changes: The adaptive or the fixed one? To answer this question we defined an *adaptive codebook contribution gain* $G_a$ and a *fixed codebook contribution gain* $G_f$ according to

$$G_a = -10\log_{10}\frac{\mathrm{E}\{(t - a_a c_a * h)^2\}}{\mathrm{E}\{t^2\}} \quad [\mathrm{dB}] \qquad (1)$$

and

$$G_f = -10\log_{10}\frac{\mathrm{E}\{(t - (a_a c_a + a_f c_f) * h)^2\}}{\mathrm{E}\{(t - a_a c_a * h)^2\}} \quad [\mathrm{dB}]\,. \qquad (2)$$

The adaptive codebook search tries to minimize the term $\mathrm{E}\{(t - a_a c_a * h)^2\}$ with $a_a c_a$ being the scaled codebook entry, "$*$" meaning convolution, and $h$ being the impulse response of the weighted synthesis filter. Thus $G_a$ [dB] is a measure of quality for the adaptive codebook search. The fixed codebook search operates on the modified target signal $t' = t - a_a c_a * h$ and tries to minimize $\mathrm{E}\{(t' - a_f c_f * h)^2\}$ with $a_f c_f$ being the scaled codebook entry. Accordingly, $G_f$ [dB] is a measure of quality for the fixed codebook search.

Fig. 2 shows (a) the synthesized FSK signal, (b) the adaptive codebook contribution gain $G_a$, and (c) the fixed codebook contribution gain $G_f$. $G_a$ and $G_f$ are computed every subframe of 40 samples (5 ms). It can be seen that outside regions of a symbol change $G_a$ often takes relatively high values of about 10 dB or even higher. Here the adaptive codebook provides waveforms that fit to the target signal after convolution with $h$. On the other hand, if the FSK symbol changes the adaptive codebook is not able to provide a good contribution to the synthesis filter excitation: In consequence $G_a$ becomes close to zero. This was expected – so it is the task of the fixed codebook to match the target signal after convolution with $h$.

Looking at $G_f$ it turns out that in many cases during unchanged FSK symbols the fixed codebook can compensate gain losses of the adaptive codebook, and vice versa, e.g. in subframes no. 30...43 and 52. This compensation makes it possible that no degradations in the waveforms are recognizable. On the other hand, if the current subframe contains an FSK symbol transition, then the loss in $G_a$ is not (or not enough) compensated by $G_f$, the fixed codebook contribution (subframes no. 5, 9, 18, 44, 53). Why not?

A bad fixed codebook behaviour might result from too few pulses (i.e. nonzero samples of $c_f$). We checked that out by processing the FSK signal via coders with a significantly higher bit rate for the fixed excitation, i.e. more pulses. The GSM enhanced full-rate codec [2] e.g. provides a bit-rate of 7 kbit/s for the fixed codebook excitation $c_f$, whereas in IS-641 $c_f$ is coded by only 3.4 kbit/s. The muting and amplification effects using the GSM enhanced full-rate codec remained the same.

A bad fixed (and even adaptive) codebook behaviour might also be due to a mismatch of the spectral envelope of

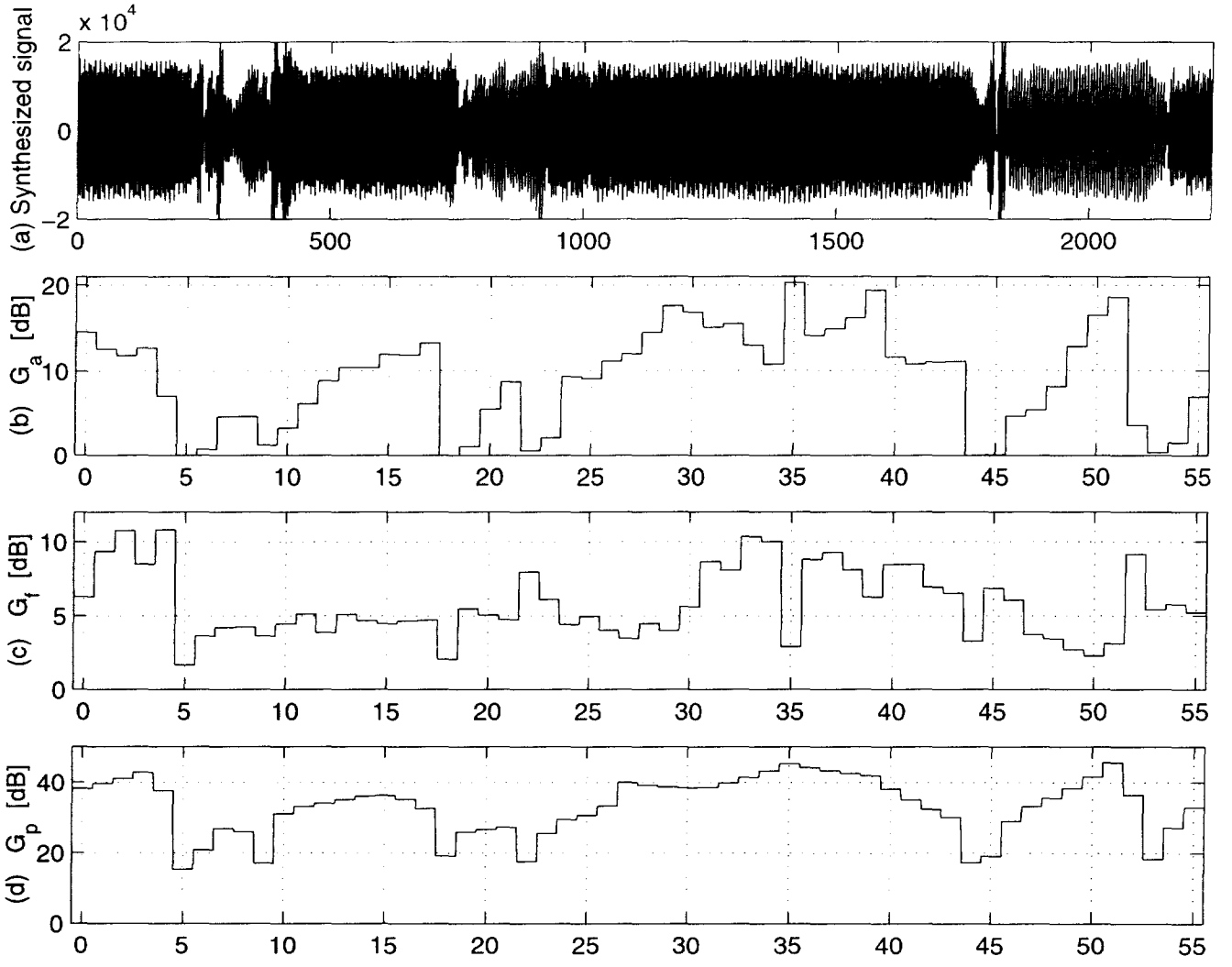


Figure 2: (a) Synthesized FSK signal, (b) adaptive codebook contribution gain $G_a$, (c) fixed codebook contribution gain $G_f$, (d) prediction gain $G_p$

the weighted synthesis filter with impulse response $h$. We investigated this by measuring the prediction gain.

### 2.2. Prediction Gain

The prediction gain is defined by

$$G_p = -10\log_{10}\frac{\mathrm{E}\{r^2\}}{\mathrm{E}\{s^2\}} \quad [\mathrm{dB}] \tag{3}$$

with $s$ being the uncoded speech or FSK signal and $r$ being the residual signal. The prediction gain is shown in Fig. 2(d). It increases and decreases in several steps due to spectral parameter interpolation for the 1st to 3rd subframe of each frame.

Every time the FSK symbol changes, the prediction gain decreases significantly, i.e. a spectral mismatch of the (weighted) synthesis filter with impulse response $h$ to at least some of the samples in the subframe. Whereas in the subframe no. 52 the $G_a$ loss was compensated by a $G_f$ gain (high $G_p$), in the following subframe no. 53 a further $G_a$ loss and a $G_f$ loss occur (low $G_p$). Thus the loss of $G_p$ appears to be the explanation for the muting and the amplification effects.

## 3. CONCLUSION

The problem addressed is inherent to framewise operating speech coders transmitting the spectral envelope of the speech/FSK signal. In subframes when FSK symbol transitions occur, all three elements of the coder fail to perform satisfactorily. The LPC filter cannot be correct for the entire subframe because of the transition. Thus, its coding gain is lost. The adaptive codebook fails because it consists of samples at one frequency while the input signal is of the other frequency. The fixed codebook fails because it simply does not have enough pulses to compensate for the incorrect LPC filter and the lack of a contribution from the adaptive codebook. Given the size of the subframe and the structure of IS-641, there is no way to overcome these shortcomings.

## References

[1] TIA Rec. IS-641, "TDMA Radio Interface, Enhanced Full-Rate Speech Codec PN-3467".

[2] ETSI TC-SMG, "Digital cellular telecommunication system; Enhanced Full Rate (EFR) Speech Transcoding (GSM 06.60)".

## CERTIFICATE OF SERVICE

I, Michelle Mundt, hereby certify that on this 4th day of December 1998, I caused copies of the foregoing "Petition for Waiver of AT&T Wireless Services, Inc." to be sent to the following by either first class mail, postage prepaid, or by hand delivery (*):

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