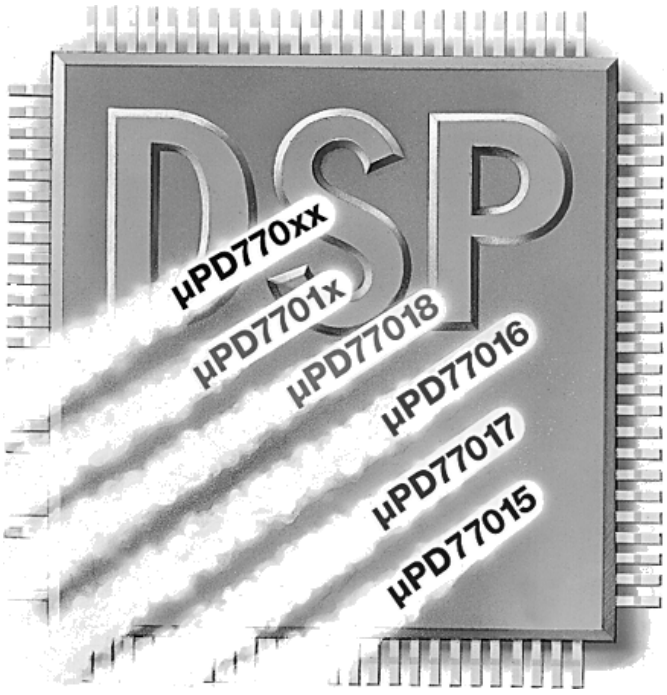
NEC



µPD7701x for DECT

The Digital European Cordless Telecommunications (DECT) standard specifies systems that combine cordless phone, PABX and cellular network functionality. Depending on the actual system environment it offers a variety of potential DSP applications.

NEC has prepared a software library for use with DECT extensions of PABXs and supplies also a couple of other software modules to support the use of the µPD7701x family in DECT systems.

Basic Characteristics of DECT

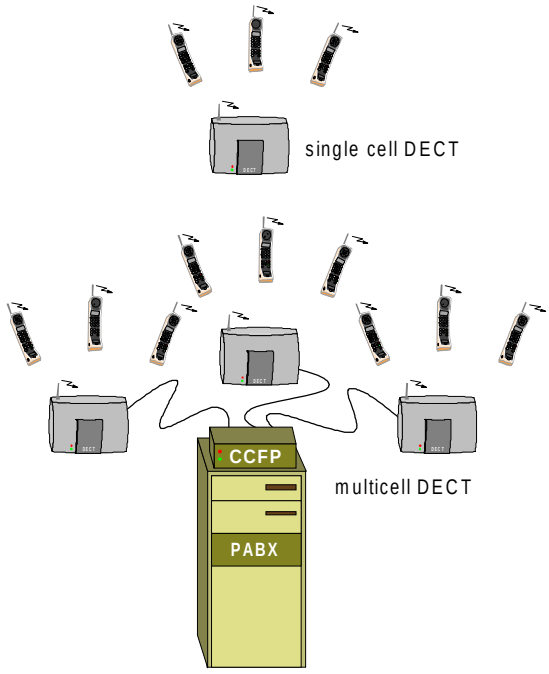
Cordless telephones according to the CT1 standard have become highly popular over the last years. They have given the people the freedom to move around while they have a telephone conversation and they can easily be reached in any room of their houses.

The digital successor of the CT1 system is the **D**igital **E**uropean **C**ordless **T**elecommunications (DECT) standard that uses digital coding techniques for the transmitted speech and data signals. The DECT standard was fixed in 1991 by ETSI, the **E**uropean **T**elecommunication **S**tandards **I**nstitute, and has meanwhile also been adopted by other countries outside Europe like Taiwan.

DECT uses 10 different radio frequencies in the range of 1.88 to 1.90 GHz with a channel width of 1.728 MHz each. The digital data to be transmitted consists of control and user data which are composed to data bursts of 480 bits. These data bursts are sent every 10 ms with an instantaneous data rate of 1.152 Mbits/s yielding a burst length of 417 µs. The burst structure of the data allows to divide a 10 ms frame into 2 x 12 timeslots so that 12 bidirectional communication processes can be handled with a single radio channel using TDMA principles. For transmission of speech data an ADPCM coding technique as specified in the G.721 recommendation of the ITU-S is applied.

DECT technology can be used in different applications. The most natural one is of course the direct replacement of the traditional analogue CT1 cordless phone. In this case DECT offers improved security against illegal interception.

The most amazing feature of the DECT standard is the integrated PABX functionality as shown in the picture. It allows base stations, which operate on a single radio channel, to handle up to 12 handsets - this will satisfy the needs of bigger families and smaller companies as well.
Unlimited free of charge communication is possible between handsets via a single base station.



Conventional PABXs can be extended using several base stations and a dedicated expansion equipment, usually referred to as **C**ommon **C**ontrol **F**ixed **P**art CCFP to microcellular nets with 500 handsets or more. The intelligence of the CCFP that can handover a communication from one microcell to another allows people to walk around in the whole area that is covered by the respective system while they have a telephone conversation.

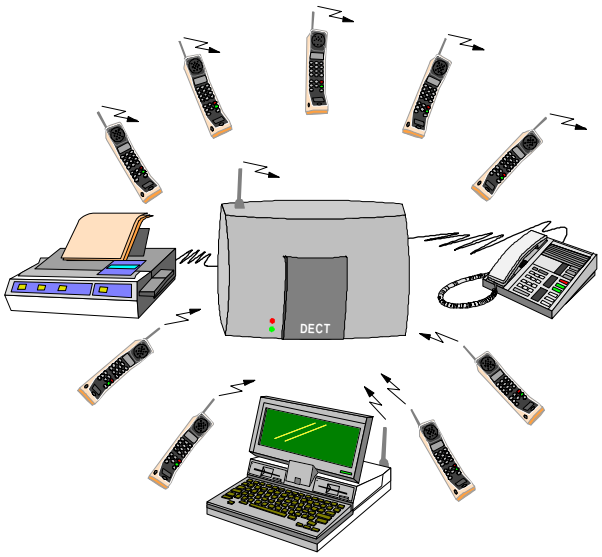
A special kind of DECT handsets will be the dual mode mobile phone for the GSM system, that operates as DECT handset as long as the owner is in the area covered by his DECT system. This provides the comfort of wireless communication at the normal and low telephone rates.

DSP Applications in DECT

The only potential DSP function in a DECT handset is the speech transcoding according to the G.721 standard, that uses ADPCM with a bitrate of 32 kbits/s for the compressed speech data. This function is nowadays integrated in dedicated chipsets and hence its implementation on a user programmable DSP is not needed and economically not advisable.

This situation looks differently for dual mode GSM handsets: The chip sets that are used today or will be used in the near future contain DSPs to realise the GSM-FR or HR speech codecs. As long as the handset is operated in DECT mode the available DSP power can be used for the G.721 speech transcoding.
The DECT base stations offer more manifold opportunities to use a DSP. The minimum DSP functions in a DECT base station are line echo cancellation and DTMF tone generation. G.721 transcoding is needed as well, but normally implemented in dedicated hardware.

As requirements grow, DSP performance has to be stepped up as well. The next figure shows that a professional base station is almost a communication centre that combines several devices in one and deals with different information streams:



- It detects incoming faxes with a specially tuned **single tone receiver** and activates an external (or internal) fax.
- It provides an answerphone service with a highly efficient **speech codec** (4...8 kbits/s).
- Remote control of the answerphone function is done via the built-in **DTMF receiver**.
- An extra **modem** function installs a wireless data connection to a PC that is equipped with a DECT extension.

NEC's offerings for DECT

For up to two lines base station functions can be handled by NEC's low-cost µPD77C25 DSP, which comes in several different, compact packages. A firmware package for this application is available and is successfully used in series production.

For the new µPD7701x family NEC offers a lot of ready-to-use library functions that are targeted to DECT applications. For dual mode handsets and other situations where the speech transcoding according to **G.721** should be done on a DSP, a complete implementation of this standard for the µPD7701x family is available as source code. The performance figures are listed in the table below.

	G.721 encode	G.721 decode	G.721 full duplex
Mips	6.06	6.58	12.64
Instruction memory	583	682	722
Data RAM	58	58	103
Data ROM	90		

G.726, the successor to the G.721 standard that has been expanded by higher and lower bitrates, is also available as source code.

- **Acoustic echo cancellation** (AEC) supports handsfree operation with a stationary phone.
- Music-on-hold is played **by adapted tone generators**.
- Last but not least **conferences** of a certain number of handsets and lines can be held.

Each of these functions requires DSP performance and on a device as powerful as the µPD77015 many of them can be realised on a single chip.

PABX extensions for DECT that provide a bridge between the conventional telephone system and the wireless DECT world have different requirements to the DSP. The major functions

- Echo control
- DTMF receiver/transmitter
- Single tone receiver/transmitter
- Conferencing

are the same as in the DECT base station, but they have to be performed for as many channels as possible. Due to extra delays introduced by the PABX the echo controller must be able to deal with longer echoes, i.e. 0...6 ms, than in a base station. Therefore sheer performance and data memory size are very important.

With their advanced architecture and the flexible memory configuration NEC's µPD7701x devices are the cost-effective choice for all DECT base station or CCFP related applications.

CEPT compatible **DTMF** receiver and transmitter functions have originally been prepared for switching applications, but can be used for DECT as well. Exact performance figures can be found in the brochure "DTMF on µPD7701x", a summary for an multichannel Rx/Tx configuration is given in the next table, where M corresponds to the number of channels.

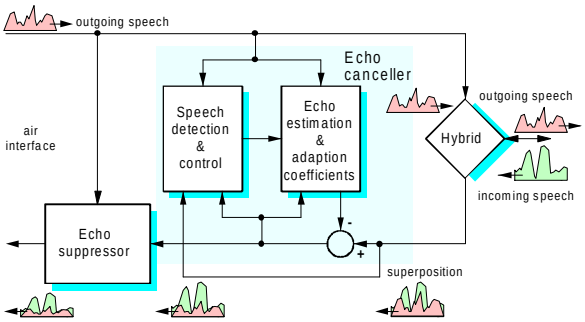
Brand-new single tone receiver/transmitter functions and conferencing have recently been prepared. Performance figures for single tone Rx/Tx are also given in the table. B is a selectable parameter which specifies the bandwidth of the receiver in multiples of 40 Hz. The echo control software that has been prepared for an 8-channel DECT extension for PABXs deserves an extra chapter.

	DTMF Rx	DTMF Tx	Tone Rx	Tone Tx
Mips	1.356·M	0.58·M	(0.5+ 0.15·B)·M	0.58·M
Instruction memory	554	52	226	52
Data RAM	16+69·M	8·M	(10+ 4·B)·M	8·M
Data ROM	84	65	(6+2·B)·M	2

Echo control for DECT

Echoes are a general problem of transmission systems that use 2/4-wire analogue line connections. So called near-end echoes are caused by an unbalanced line interface in the DECT base station. Further echoes are generated by balancing problems and/or acoustic echoes outside the DECT system. Both types of echoes are annoying due to the delay that is caused by the TDMA transmission within DECT.

Consequently the DECT standard has also fixed the countermeasures that have to be undertaken against these echoes. They have been specified under the aspect of minimum performance requirements to the echo control unit. The actual implementation is free and the performance can be improved to the user's liking.



Usual echo control systems consist of two major blocks:

- an echo canceller for the near-end echo
- an echo suppressor for the far-end echo

The echo suppressor is a speech controlled attenuator. It works on the superposition of the incoming speech signal and the echo of the outgoing speech signal. If the level of the outgoing speech signal reached a certain threshold, i.e. if the DECT user is talking, the echo as well as the incoming speech is subjected to a programmable attenuation of typically 9...12 dB.

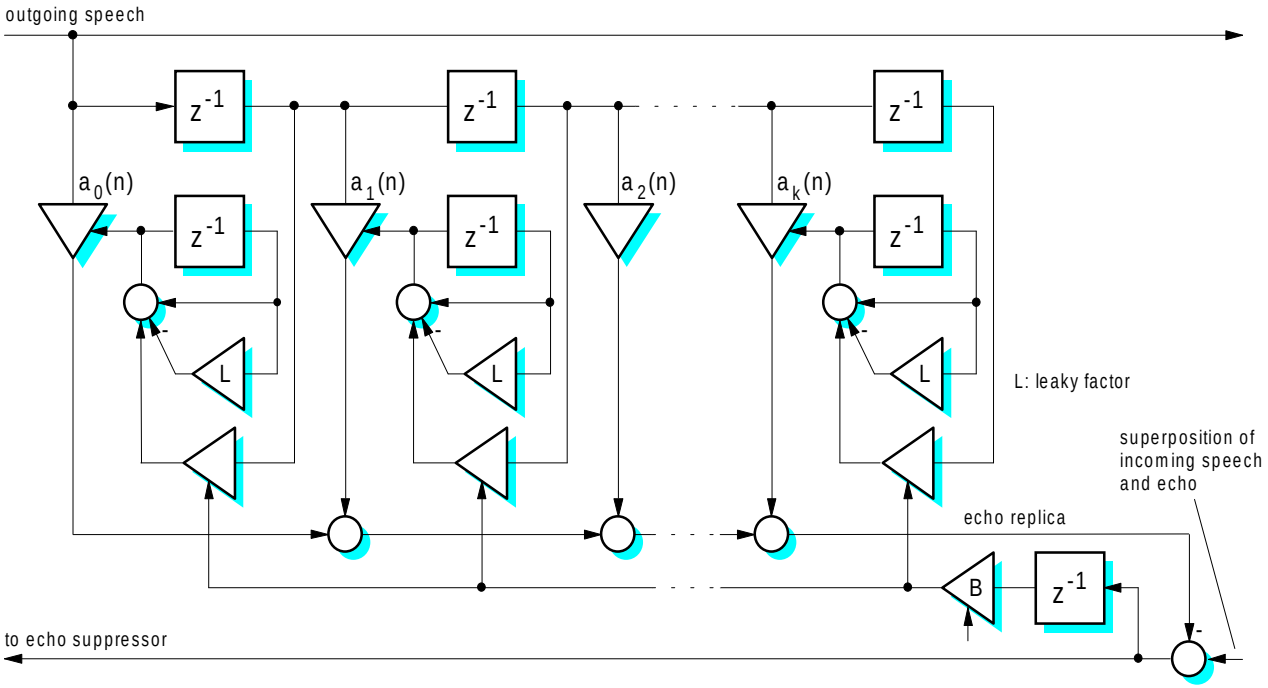
The echo canceller is the by far more critical part under the aspect of implementation. It consists mainly of an adaptive FIR filter that creates an echo replica of the outgoing speech signal which is then subtracted from the incoming superposition of speech and echo.

There are different methods for the adaptation of the filter coefficients; the most popular ones are

- least mean square (LMS) algorithm
- normalised LMS algorithm
- LMS algorithm with leaky factor

For the DECT software package NEC has implemented a combination of the normalised LMS algorithm and the LMS with leaky factor together with an optimisation strategy to deal with double talk problems. The block diagram is illustrated below.

It is important to notice that all mentioned LMS algorithms can be implemented on the µPD7701x processors with only two instruction cycles per filter tap plus a certain filter length independent overhead. This performance is possible thanks to the unrivalled efficiency of the µPD7701x family architecture.



µPD7701x Family Overview

NECs new µPD7701x 16-bit fixed point DSP family offers one of the most advanced architectures on the market. Their members are characterised by a clearly structured Harvard architecture with:

- Two identical memory banks (X, Y) with separate address computation units
- Powerful 16/40-bit arithmetic op-erat-ion unit
- Program control unit with high per-formance loop counter
- Memory-mapped peripherals
- JTAG-based on-chip debug hard-ware and boundary scan facilities

All µPD7701x devices share the same core architecture but have a couple of device specific characteristics which are summarised in the table.

Devices under development will extend this family with a DSP core and more variants in performance/speed.

		µPD77016	µPD77015	µPD77017	µPD77018	7701x core*
Internal memory	Instruction ROM	-	4k x 32 bit	12k x 32 bit	24k x 32 bit	user defined
	Instruction RAM	1.5k x 32 bit	256 x 32 bit			user defined
	Data ROM	-	2 x 2k x 16 bit	2 x 4k x 16 bit	2 x 12k x 16 bit	user defined
	Data RAM	2 x 2k x 16 bit	2 x 1k x 16 bit	2 x 2k x 16 bit	2 x 3k x 16 bit	user defined
External memory	Instr. memory	48k x 32 bit	-			-
	Data memory	2 x 48k x 16 bit	2 x 16k x 16 bit			user defined
ALU bus		40 bit				
Multiplier		16 x 16 --> 31 bit				
Barrelshifter		40 bit				
Working registers		8 x 40 bit				
Loop/repeat counter		1 repeat counter / 4 nested loop counters				
Host I/F, max. throughput		8 bit, 8.25 Mbytes/s				user defined
Serial I/F, max. throughput		2 SIOs, 8/16 bit, 16.6 Mbits/s				user defined
Interrupts		4 external, 6 internal				10
Min. instruction cycle time		30 ns				< 20 ns
Master clock for 33 Mips		66 MHz	33, 16.5, 8.25, 4.125 MHz (int. PLL)			t.b.f.
Power supply		+5 V	+3 V			
Typical power dissipation		0.7 W	90 mW	120 mW	150 mW	t.b.f.
Power down modes		0.4 W (halt)	3 mW (halt), 3 µW (stop)			t.b.f.
Packages		160 QFP	100 TQFP			user defined

**under development*

The step size B for the adaption of the filter coefficients $a_k(n)$ is calculated outgoing speech signal power. With its 48-tap FIR-filter the echo canceller can handle echoes with a maximum length of 6 ms.

The overall characteristics of the DECT echo control software are as follows:

- echo canceller 0...6 ms with adaptive control
- delay 0...2 ms for compensation of PABX internal delays
- fully programmable echo suppressor

The required processor loads for the main echo control modules are listed in the following table where N represents the number of filter taps.

	Echo canceller (normalised LMS with leaky factor)	Echo suppressor
Mips	(2·N+28)·M	32·M
Instruction memory	18	31
Data RAM	(2·N+4)·M	14·M
Data ROM	-	-

How to get the DECT software

The software modules for DECT are available in several portions:

- G.721 speech codec
- CO/PABX library including DTMF Rx/Tx and single tone Rx/Tx
- Echo control for DECT

A flexible conferencing program is in preparation. All modules are available as assembler source code and come with extensive documentation. The G.721 software can be verified versus the testsequences specified by ITU-T; supplementary programs for digital evaluation of the DTMF and single tone receivers on the PC are provided as well.

A complete µPD77015 based firmware solution for an 8 channel DECT extension for PABXs that combines all beforementioned function except the G.721 can also be supplied.

Moreover NEC guides with application support to suit the µPD7701x programs to individual S/W and H/W requirements. Please contact your local NEC sales office for the actual status.

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