CVM Datasheet
Cordless Voice Module (CVM)
Version 5.27

©2003-2005 SiTel Semiconductor

1 Introduction 4
1.1 Document History 4
1.2 Document References 4
1.3 Scope 5
1.4 Order Numbers 5
1.5 Glossary and Definitions 5
2 Cordless Voice Module Description 6
2.1 Technology Platform 6
2.2 Typical Application Examples 6
3 CVM Functionality 10
4 CVM Functionality Description 11
4.1 MCU Interface 11
4.2 Eeprom 12
4.3 Audio 13
4.4 Tone/melody Handling 21
4.5 Line Interface 21
4.6 Battery Management 23
4.7 Date and Real-Time Clock 25
4.8 Protocol 25
4.9 Walkie-Talkie 27
4.10 Data Transfer 27
4.11 Registration 29
5 CVM Production Test and Product Configuration 31
5.1 Power on/off sequence 31
5.2 Sleep Mode 31
5.3 Initial Settings. 31
5.4 RF testing. 31
5.5 Handling Product Identities. 31
5.6 CVM Base Port Configuration at Start Up. 31
5.7 CVM Handset Port Configuration at Start Up. 32
6 CVM Technical Specifications 34
6.1 Absolute Maximum Ratings 34
6.2 Digital input levels 35
6.3 Digital output levels 35
6.4 General Specification 35
6.5 Baseband Specification 36
6.6 Radio Part (RF) Specification 38
6.7 CVM Power supply specification 39
7 CVM Connection Diagram 41
8 CVM Pin Description 42
8.1 GND (pin 1, 2, 5, 20, 29, 43, 44, 46, 47, 48, 50) 43
8.2 ANT1_SEL (pin 3) 43
8.3 VSUP (VSUP1 (pin 15) and VSUP2 (pin 4)) 43
8.4 RESET (pin 6) 43
8.5 CLK (pin 7) 43
8.6 SPI_DI (pin 8) 43
8.7 SPI_CLK (pin 9) 43
8.8 MIC_SENSE / LINE_SENSE (pin 10) 43
8.9 /RESET (pin 11) 43
8.10 SPI_INT (pin 12) 43
8.11 SPI_DO (pin 13) 43

8.12 POWER_ON (pin 14) 43
8.13 CHARGE_DET / CHARGE_LED (pin 16) 43
8.14 CHARGE_CONTROL / P2[6] (pin 17) 43
8.15 +2V5 (pin 18) 43
8.16 VBAT3 / RING (pin 19) 43
8.17 LRS+ / REF (pin 21) 43
8.18 LRS- / RXAF (pin 22) 43
8.19 LRS_HS / CIDIN- (pin 23) 44
8.20 VREF_HS / CIDOUT (pin 24) 44
8.21 MIC- / CID (pin 25) 44
8.22 GND_ANA (pin 26) 44
8.23 MIC+ / TXAF (pin 27) 44
8.24 VREF+ / CIDIN+ (pin 28) 44
8.25 P2[3] / POL_REV (pin 30) 44
8.26 P1[4] / HOOK_LED (pin 31) 44
8.27 P1[3] / PULSE] (pin 32) 44
8.28 P0[6] (pin 33) 44
8.29 P0[3] (pin 34) 44
8.30 P0[4] (pin 35) 44
8.31 P0[7] (pin 36) 44
8.32 P1[1]/ HOOK (pin 37) 44
8.33 P1[0] / REG_KEY (pin 38) 44
8.34 SDI+ (pin 39) 44
8.35 SERIAL_IN (pin 40) 44
8.36 SERIAL_OUT (pin 41) 44
8.37 DAC-ADC2 / CHARGE_DET (pin 42) 44
8.38 ANT2_SEL (pin 45) 44
8.39 ANT (pin 49) 44
9 CVM Design Guidelines 45
9.1 CVM MCU Software for Handset Application 45
9.2 CVM MCU Software for Base Application 45
9.3 CVM Hardware Design Guidelines 45
10 Audio level adjustment 46
10.1 Handset audio level (SLR / TOLR) and (RLR / ROLR) 46
10.2 Basestation audio level (SLR / TOLR) and (RLR / ROLR) 46
11 CVM Module Package Information 47
12 CVM Additional Information 48
12.1 CVM Demonstration Kit 48
12.2 CVM Production License 48
13 Appendix A: Battery charge algorithm 49
13.1 Battery charge states 49
13.2 Battery State Handler 49
14 Appendix B: Acoustic echo Canceller 51
14.1 Echo Canceller with mu control 51
14.2 Echo Suppressor 52
14.3 Convergence estimator description 54
14.4 Gain level diagram of the handset echo canceller 55
14.5 Echo Canceller References 56
15 Appendix C: CVM Soldering Profile 57
16 Appendix D: RFPI and IPEI Rules 58

1 Introduction

This document gives an overview of the functionalities supported by the Cordless Voice Module (CVM).

1.1 Document History

Description	Responsible	Date
.....	.....	.....
Version 5.13, CVM maximum voltages supply specification changed.	KMR	9th October 2003
Version 5.14,	KMR	9th January 2004
Version 5.15, preliminary removed	KMR	12th January 2004
Version 5.16, GAP clip note, battery doc expanded.	KMR	30th January 2004
Version 5.17,	KMR	31th January 2004
Version 5.18, Battery doc correction	SS	2th February 2004
Version 5.19, Changed sections: 4.3.1, 4.5, 4.6, 4.7, 6.5, 6.7, 13, 14	KMR, SS	23rd February 2004
Version 5.20, Changed sections: 6.1 and 6.7.2	KMR	27th February 2004
Version 5.21, Changed sections: 4.1, 4.10	KMR	15th March 2004
Version 5.22, Changed sections: 5.6, 8.37	KL	17th March 2004
Version 5.23, Changed sections: 4.3.2.11, 4.11, 5.5, 5.6, 8.5	KMR	6th April 2004
Version 5.24, Note 10 added	OM	5th January 2005
Version 5.25, Changed sections: 4.3.1.7, 5.6, Table 13, section 8, Appendix D: RFPI and IPEI rules	KMR	18th March 2005
Version 5.26, SPI clock rate vs. data flow added in 4.1.2, Limitation of simulated line mode 4.3.2.10	SS	30th August 2005
Version 5.27, Changed sections: 4.3.2.10	KMR	6th September

1.2 Document References

Number	Document:
1	CVM API Interface V0153.pdf
2	CVM eeprom FpPp V0153.pdf
3	CVM_HS_APPL_TESTSPEC_VER_1.3.pdf
4	CVM_BS_APPL_TESTSPEC_VER_1.3.pdf
5	X-tal_Spec_CVM.pdf

References made to the above documents are done in [ ].
An example is given by document reference 1, [1].

1.3 Scope

Based on the SiTel Semiconductor SC14428 base band IC and the SiTel Semiconductor LMX4168 or LMX4268 the Cordless Voice Module (CVM) is a combined RF and base band unit for cordless voice and small data applications in the DECT and 2.4 GHz ISM band.

The CVM can act both as a traditional telephony base or handset depending on one eeprom setting and the surrounding hardware. The CVM can work as a stand-alone base supporting a typically base configuration or as a high-end base by adding an external µP for handling the MMI for a typical base speakerphone application. As a handset the CVM will need an external µP for handling of the normal handset MMI.

For small data applications the CVM supports a special data transfer mode, where up to 24Kbit/s data can be transferred over the air interface.

1.4 Order Numbers

1.4.1 CVM DECT

SC14CVM1.9FL	(Flash)
SC14CVM1.9R4C1	(Rom, 4Mbit, CodeC1)

1.4.2 CVM DCT

SC14CVM2.4FL	(Flash)
SC14CVM2.4R4C1	(Rom, 4Mbit, CodeC1)

1.4.3 CVM Development Kits

SC14CVM1.9DEVKT	
SC14CVM1.9ADDPP	(Additional PP)
SC14CVM1.9ADDFP	(Additional FP)
SC14CVM2.4DEVKT	
SC14CVM2.4ADDPP	(Additional PP)
SC14CVM2.4ADDFP	(Additional FP)

1.5 Glossary and Definitions

Access Code	The customer "pincode" for registration (stored in FP eeprom and the PP should know this to be able to register)
API	Application Interface
BOM	Bill of Material
BPM	Beats Per Minute
BMC	Burst Mode Controller
CID	Caller Line ID (same as CLIP and CNIP)
CLIP	Caller Line Identification Presentation
CNIP	Caller Name Identification Presentation
Command interface	The software interface between the MCU and CVM
CPC	Calling Party Control
CPT	Call Progress Tones
CRC	Cyclic Redundancy Check
CVM	Cordless Voice Module
DCT	Digital Cordless Telephone
DECT	Digital Enhanced Cordless Telephone
EMC	Equipment Manufacturer's Code (please refer to ETSI EN 300 175-6)
ESD	Electro Static Discharge
FP	Fixed Part (base)
FSK	Frequency Shift Keying
HW	Hardware
Inband tones	Tones played by the application itself and not from external e.g. line.
IPEI	International Portable Equipment Identity (please refer to ETSI EN 300 175-6)
IPUI	International Portable User Identity (PP identification code, like a serial number, please refer to ETSI EN 300 175-6)
IWU	InterWorking Unit (please refer to ETSI EN 300 175-1)
KPN	Dutch Telecom
MCU	Micro Controller Unit (external µP in a CVM application)
MMI	Man Machine Interface
PARK	Portable Access Rights Key (FP identification code, like a serial number, please refer to ETSI EN 300 175-6)
PC	Personal Computer, IBM compatible
PCB	Printed Circuit Board without components
PLIA	Park Length Indicator (length of the mark, number of bits)
PP	Portable Part (handset)
PSTN	Public Switched Telephone Network
RF	Radio Frequency
RFPI	Radio Fixed Part Identity (please refer to ETSI EN 300 175-6)
RLR	Receive Loudness Rating
RSSI	Radio Signal Strength Indication (please refer to ETSI EN 300 175-1)
RTX	RTX Telecom A/S
SLR	Sending Loudness Rating
Subscription number	Select the PP subscription (where to store the subscription subs1 or subs2 in the PP)
SW	Software
TDD	TDD noise is 100 Hz burst noise from the DECT RF.
UAK	User authentication code (DECT term)
Uint8	A 8 bit storage
Uint16	A 16 bit storage
µP	Microprocessor
ZAP	Can be used for enhanced security (we do not use it)

2 Cordless Voice Module Description

This section describes the key functions and features supported by the CV-Module.

For detailed software interface description please see [1].

2.1 Technology Platform

The CV-Module comes in two versions, a DECT version and a 2.4 GHz version. The baseband part of both CVM DECT and CVM 2.4GHz is based on the SiTel Semiconductor SC14428 chip. The RF transceiver for the DECT is SiTel Semiconductor LMX4168, and the RF transceiver for the 2.4GHZ is SiTel Semiconductor LMX4268. The following functionality description covers both versions. The key features of the technology are listed below.

Technology features:

Encryption

Preamble Antenna diversity

2.1.1 CVM DECT Version

The CVM DECT is based on the ETSI DECT specification and is compliant with to ETSI ETS 300 444 (GAP).

The product supports up to 6 DECT GAP compliant portable units to one base station.

2.1.2 CVM 2.4GHz Version

The CVM 2.4GHz is based on proprietary frequency hopping technology developed by RTX. The additional key features of the technology are listed below.

Technology features:

- Frequency hopping
- RF channel exclusion
- Dual slot Antenna diversity

The product is featuring registration of up to 6 portable units to one base station with the possibility for 4 active handsets at the same time.

2.2 Typical Application Examples

The CVM can be used for various applications. Typical applications are the standard base and handset applications. The base can be configured as a stand-alone base with standard base features, or as a more complex base by adding an external µP (MCU). Additionally the CVM can be used for small data transfer applications. The following sections describe the four typical applications.

2.2.1 Handset Configuration (both 2.4GHz and DECT)

The handset using the CV-Module contains a baseband section and a RF section. The antennas (one or two) are located outside the module PCB area. To form a handset the module will need additionally integrated keypad, LCD, buzzer, earpiece, speaker, microphone and an MCU to implement the handset MMI functionality.

In addition to plastics, the items listed in TABLE 1 must be added to form a cordless handset.

TABLE 1. Product handset overview

Item	Handset	Remark
MCU	Required	The user MMI must be implemented in the MCU.
Battery	Supported	3 cells (NiMH or NiCD)
Microphone	Supported	
Earpiece	Supported	
Buzzer	Not supported	The buzzer must be driven by the MCU.
Headset jack	Optional	
Handsfree speaker	Optional	A speaker amplifier must be added on the handset PCB.
Keypad	Not supported	The keypad must be driven by the MCU.
Display	Not supported	The display must be driven by the MCU.

Supported: The feature is supported and needed to form a handset, and additional hw must be added.

Optional: The feature is supported, and additional hw must be added.

Not supported: The functionality must be handled by the MCU.

The below FIGURE 1 shows the usage of the module in a typical handset configuration.

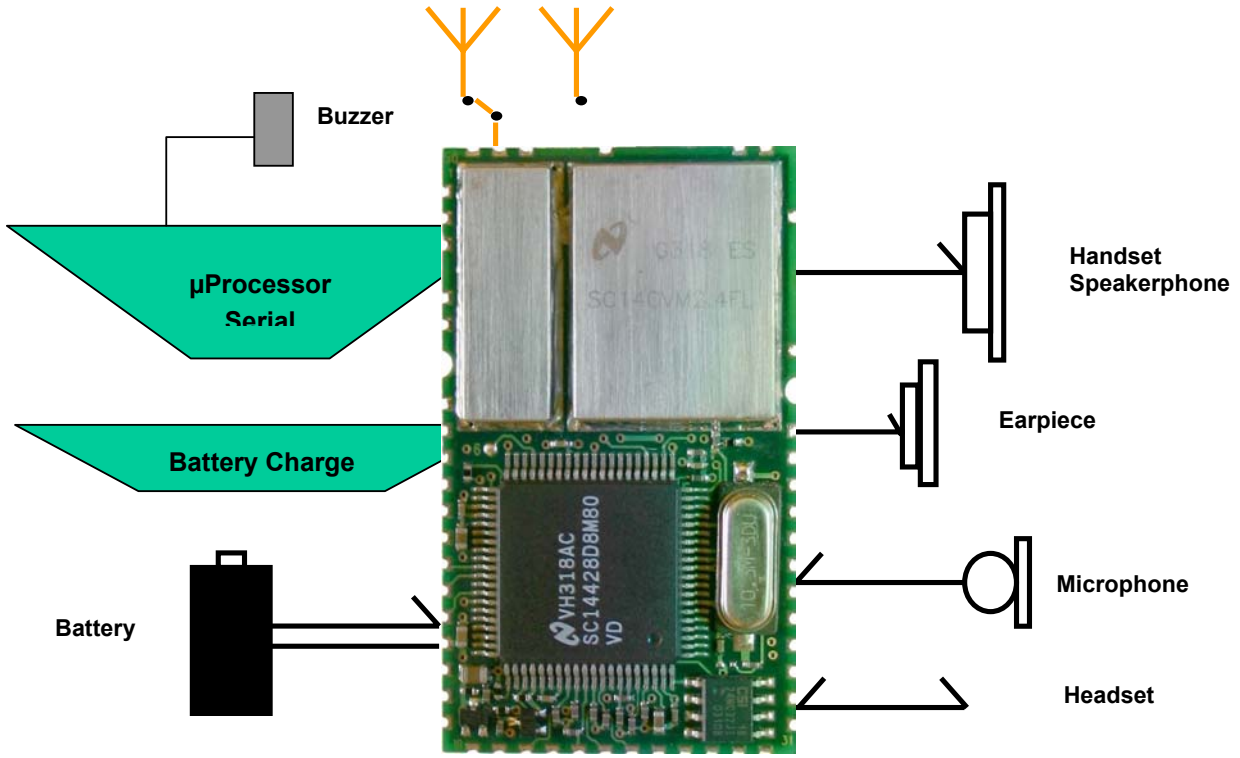


FIGURE 1. Handset Configuration Example.

2.2.2 Stand-Alone Base Station Configuration

The stand-alone base station using the CV-Module contains a standard baseband section including a minimum base configuration and RF. To make a standard base station the CV-Module will need external hardware to support line interface, mains adapter, handset charger interface, and antennas (one or two).

The items listed in TABLE 2 must be added to form a stand-alone cordless base station with CVM.

TABLE 2. Product base station overview

Item	Basestation	Remark
Line hw interface	Supported	
Power supply	Supported	
CID	Optional	CID filter circuit must be part of the line interface.
Pulse dial	Optional	Pulse dial circuit must be part of the line interface. Pulse dial software is part of the module software.

Supported: The feature is supported and needed to form a handset, and additional hw must be added.

Optional: The feature is supported, and additional hw must be added.

The FIGURE 2 shows the usage of the module in a typically stand-alone base configuration.

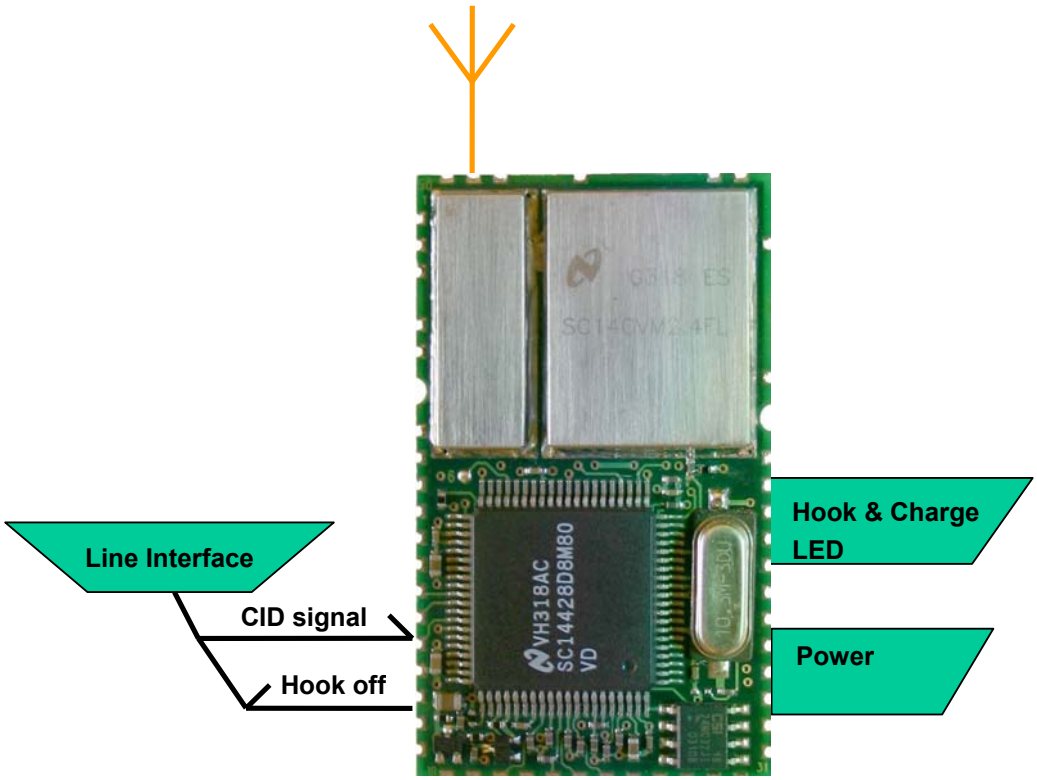


Figure 2. Stand-alone Base Station Configuration Example.

2.2.3 Base Station Configuration with MCU

The base station using the CV-Module and an MCU makes it possible to add, as with the handset, keypad, display and MMI. The CVM base station configuration also supports a basic audio routing for a PCM based speakerphone Codec (speaker and microphone). As with the handset, keypad, display and MMI must be controlled by the MCU. The base speakerphone API acts as a virtual handset. For more information about the virtual handset operation refer to section: **4.3.2**

The items listed in TABLE 3 list the possibilities by adding the MCU to form a cordless base station with CVM.

Supported:	The feature is supported and needed to form a handset, and additional hw must be added.
Optional:	The feature is supported, and additional hw must be added.
Not supported:	The functionality must be handled by the MCU.

TABLE 3. Product base station overview

Item	Basestation	Remark
MCU	Optional	
Line hw interface	Supported	
Power supply	Supported	
Base Speakerphone (microphone and loudspeaker)	Optional	MMI must be controlled by an MCU. To support audio in the Speaker/Microphone, the system needs an external codec
Keypad	Not supported	Keypad must be controlled by an MCU.
CID	Optional	CID circuit must be part of the line interface.
Pulse dial	Optional	Pulse dial circuit must be part of the line interface.
Base station LED	Not supported	LED must be controlled by an MCU.

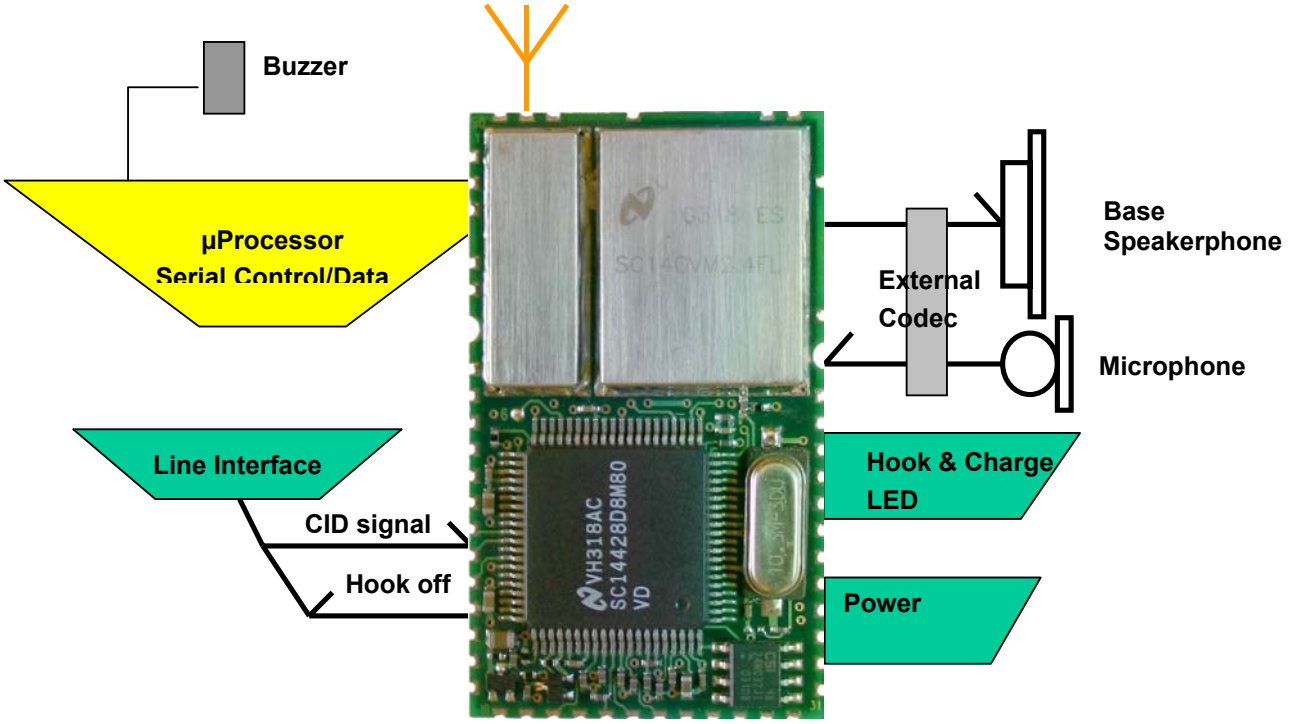


FIGURE 3. Base Station Configuration Example with MCU.

2.2.4 CVM Small Data Application

The CVM small data application can be configured as a CVM base with MCU, combined with one or more data handsets, which then by the control of the MCUs are able to send data back and forth using the up to 24 Kbit/s air interface. It is possible to establish a datalink from up to four handsets to one base and routing the data via either the SPI or UART interface. However it must be noted that the UART interface does have a limited Baudrate. If more data connections are active at the same time and exceeding the capacity of the serial bus, the bandwidth of the bus is shared equally between the data connections.

It is not possible to directly send high-speed data from one handset to another handset either via the base or between handsets. With the CVM base MCU it is possible to route data from one handset to another handset.

It is possible to send LowSpeed (1.6Kbit/s) data between two handsets in an intercom through the FP without a FP_MCU.

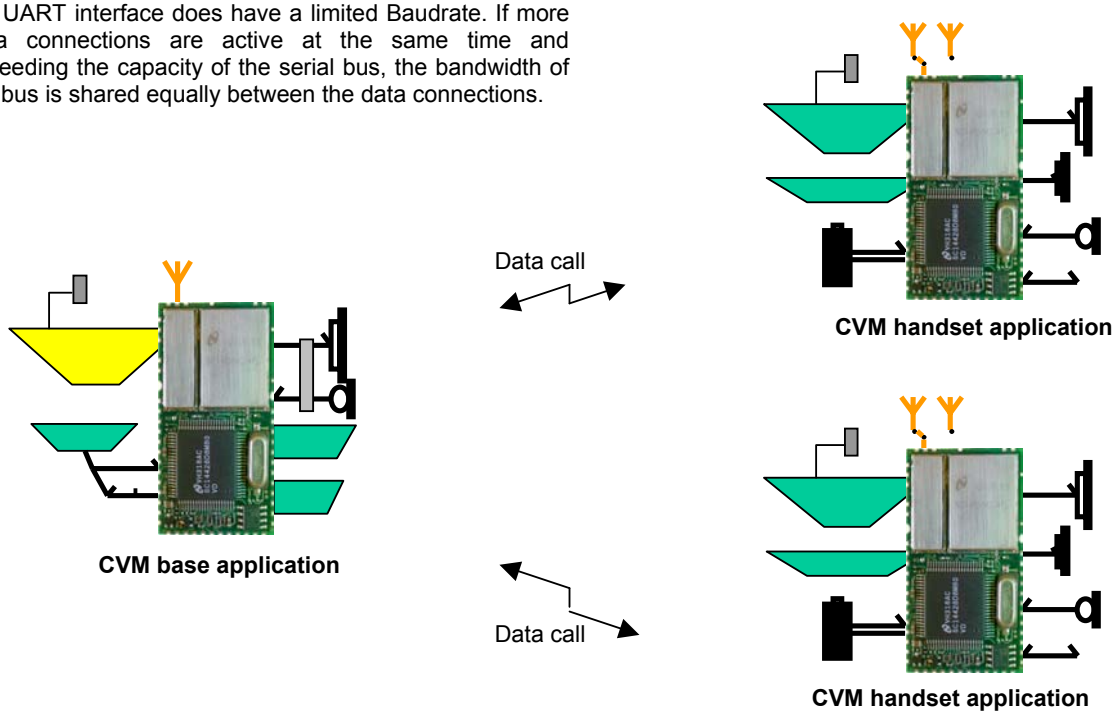


FIGURE 4. Small Data Application

3 CVM Functionality

The following tables list all the functionalities the CV-Module supports.

TABLE 4. Functionality overview

Functionality	Supported	Remark
Standard Base audio control feature: Call handling		
Incoming/outgoing call	Yes	Both DTMF and pulse dial
Intercom	Yes	Between PP's via the FP
Conference call	Yes	Up to 4 PP's, FP Speakerphone and external
Call forwarding	Yes	Transfer call between PP
Call back	Yes	If no reply on call forward
Page call	Yes	FP pages all PP's (PP locator)
Speakerphone Support	Yes	For MMI an external µP must be added.
Conference with speakerphone	Yes	Between external line, one PP and FP speakerphone
Line		
Flash (Register recall)	Yes	Optional short/long flash selection.
Dial method	DTMF/Pulse dial	
Busy tone detection	Yes	
Dial tone detection	Yes	
Parallel off hook detection	Yes	
Caller Line ID		
Call waiting at external line during intercom	Yes	Indication of incoming call during conversation.
Call waiting at external line during another external call.	Yes	Indication of incoming call during conversation. Requires that the operator and the FP application support the functionality.
Caller ID reception	Yes	Support for ETSI and Bellcore (CLIP Type 1 and type 2) and DTMF CLIP
CallWaiting Deluxe	Yes	(CLIP type 2.5)
Message Waiting reception/voice mail	Yes	
Protocol		
Manual registration	Yes	
Auto-registration	Yes	By placing PP in FP cradle.
Handsets per base station	1 to 6	Both 2.4GHz and DECT (on 2.4GHz only 4 active handsets at the same time is possible)
Low rate data transfer	Yes	1.6 Kbit/s on the air-interface using IWU to IWU messages
Data call	Yes	24 Kbit/s on the air-interface (one slot)
Dual slot diversity	Yes	32 Kbit/s voice (this is only possible with 2.4 GHz version)
Walkie Talkie	Yes	Both DECT and 2.4GHz
Broadcast from FP to PP	Yes	On FP via the external µP interface.
Audio and tone		
Microphone mute	Yes	Mute of MIC in all audio connections are possible
Tone generation	Yes	Melody generator with 3 polyphonic tones. Melodies are eeprom configurable.
Buzzer	No	Buzzer is controlled by the MCU.
Audio Volume control	Yes	10 steps are adjustable by eeprom
Tone Volume control	Yes	10 steps are adjustable by eeprom
Headset support	Yes	Needs external hw
Handsfree/Speakerphone functionality	Yes	On the handset and base

General		
Battery handling	Yes	Intelligent charging supporting NiMH + NiCD
SW eeprom access	Yes	Via the external µP interface.
FP via PP eeprom access	Yes	For base menu feature
I/O port support	Yes	Possibility to use non used CVM I/O ports.
Real time clock	Yes	Accuracy depending directly on crystal
Real time clock synchronization	Yes	All handsets clock are kept in synchronization with the base.

4 CVM Functionality Description

4.1 MCU Interface

The CVM supports both a standard UART interface and a SPI interface for the interface to the MCU. Seen from the MCU both the UART and SPI interfaces consist of a driver part and a command interface part.

Both interfaces support a re-transmission protocol, which ensures that no communication is lost during operation. The CVM only support either the UART or the SPI interface.

A detailed functional and data flow description, including an example of the startup sequence, can be found in [1].

4.1.1 UART Interface

The CVM UART is a full duplex UART with frame type: 1 start bit, 8 data bits (LSB first), 1 stop bit and no parity.

It is possible to configure the baud rate to four different speeds: 9600, 19200, 57600, 115200[1] by eeprom configuration. The CVM UART is by default set to the baud rate: 19200[2].

The UART hardware interface uses 3 wires. Please refer to FIGURE 5.

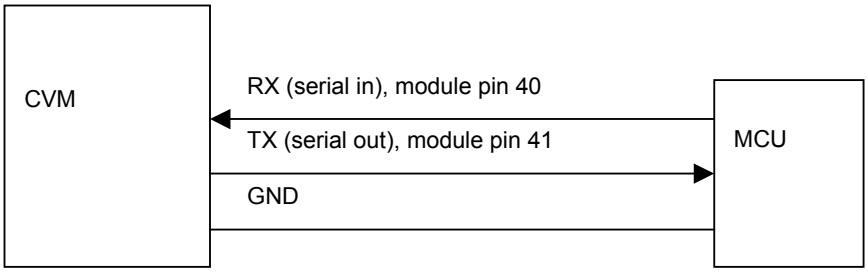


FIGURE 5. UART hardware configuration

With the CVM application boards, source code for the UART driver is included.

Caution: All signals are 2.5V. An external V.24 line driver must be provided if the module UART port is connected to a standard V.24 device. Connecting the module without a driver may damage the module.

Note [1]: At baudrate 115200 and using the pure data feature packet loss will occur.
Note [2]: It is possible to bring the CVM back to default baud rate by setting port 1.2 on the SC14428 low during power up of the CVM. The port 1.2 is available as a test pad (TP114) on the top of the CVM PCB. Please refer to section **7** for the position of the test pad.

4.1.2 SPI

The CVM always runs as a slave in a SPI configuration.

The CVM SPI slave configuration makes it possible for the MCU to run the SPI as a software simulation.

The CVM SPI uses an 8-bit wording and the SPI_CLK signal can run up to a 5.182 MHz clock.

In SPI mode the data is clocked on SDI read in negative edge, SPI_DO write in positive edge of the SPI_CLK. Please refer to FIGURE 6.

Even though the SPI clock can be set to 5.182MHz as max, it is not possible to transfer continous data on the SPI at this rate.

The actual rate is defined by the CVM processors ability to process the data. If „stuffing" the CVM with to mutch SPI data, it will overflow the bus and result in transmission errors, then forcing retransmissions.

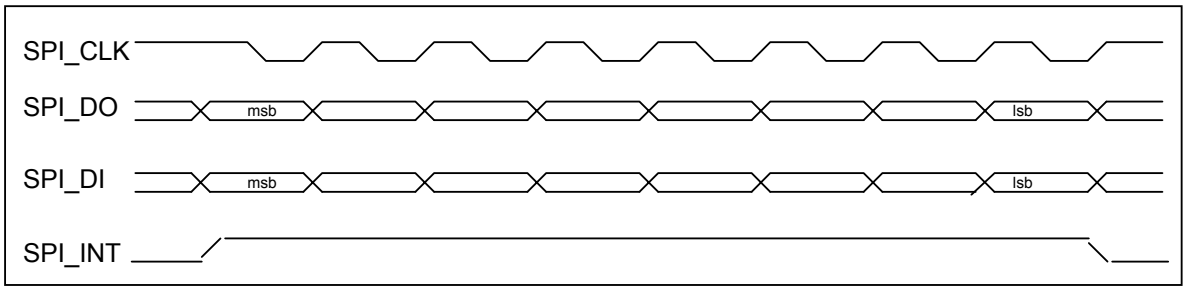


FIGURE 6. SPI Timing

The SPI_INT output pin 12 makes it possible for the CVM to inform the MCU that it wants to send new data.

When the CVM activates the SPI_INT it is an indication to the MCU that it should start clocking the SPI_CLK to receive the new data from the CVM.

The CVM will keep the SPI_INT raised until the data is delivered.

SPI_INT is active high by default and high until the last bit of the new data is read by the MCU. SPI_INT can be reconfigured to active low by an eeprom parameter.

The SPI is a 5-wire solution with a hardware configuration as shown in FIGURE 7.

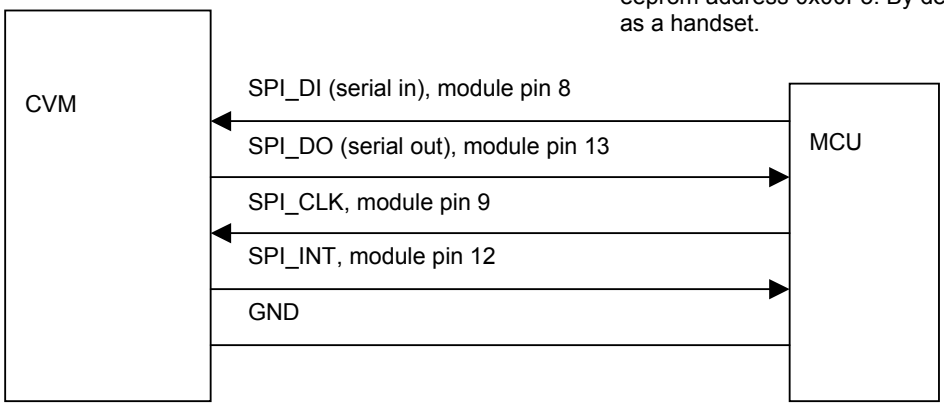


FIGURE 7. SPI hardware configuration

4.2 prom

4.2.1 Eeprom Layout

The CVM eeprom is divided into two main areas, which is showed in the table below.

TABLE 5.

CVM/customer	Size	Usage
CVM eeprom space	2 Kbyte	Used for RF, line (CLIP), audio, battery and tone setup.
µP eeprom space	2 Kbyte	Can be used for MMI applications such as phone book, CLIP list etc.

A detailed overview of the eeprom parameter is found in [2].

Parts of the eeprom parameters are read into the CVM by startup and others are used by the CVM software during execution. The specific eeprom parameters are divided into 2 types: Factory type or normal type. The factory type is specific for the CVM and should only be set by production. The factory types are either adjustments parameters used by the baseband or the radio interface, or the factory type is used to setup the CVM into special modes e.g. base or handset mode. The factory types will only be modified by a hard default (please refer to [1] for details). The other CVM parameters can be reset to default values by running a soft default (default batch file).

The CVM can be configured as either handset or base by eeprom address 0x00F3. By default the CVM is configured as a handset.

4.2.2 Eeprom access by MCU

The purpose of the eeprom access from the MCU application is to make changes in the current eeprom settings and to make use of the limited free eeprom area for other purposes.

The CVM includes a **4Kbyte** eeprom. There are two possibilities for accessing the eeprom.

Method 1: Normal eeprom access

It is possible to access the eeprom in both handset and base application via the command interface using the MCU. The eeprom can be used for storing a limited number of data from the MCU.

Method 2: Remote eeprom access

The CVM base eeprom can also be accessed via the air interface of the CVM handset application. The purpose is to support a base programming feature. This access is done using the CVM base command interface. To use this feature a connection (a call between handset and base) must be established before accessing the eeprom.

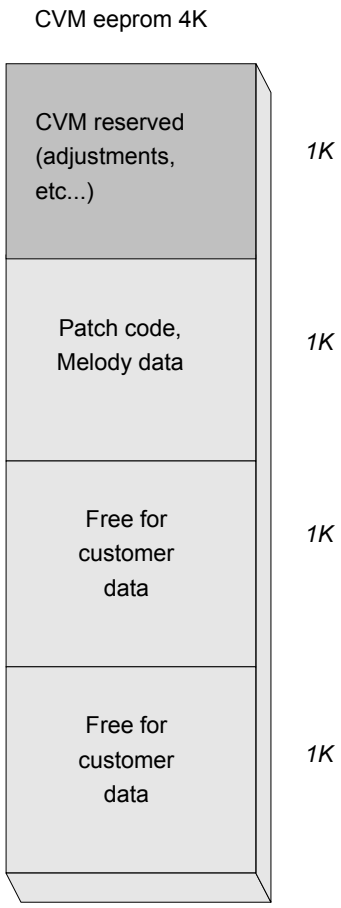


FIGURE 8. CVM eeprom layout

4.3 Audio

The CVM audio is supporting standard DECT or 2.4 GHz digital ADPCM audio qualities. The CVM audio gain and volume parameters are placed in eeprom. The CVM DECT gains are adjusted to meet the TBR38 and TBR10 audio level requirements using the CVM application reference design, and for other line and acoustic designs it is needed to adjust and tune the audio setup.

4.3.1 CVM Handset Audio Configurations

The following CVM handset audio air-interface hardware connections are possible using the CVM.

Loudspeaker Connection:

The loudspeaker can be connected either differential or single ended.

Dynamic loudspeakers as low as 30 ohm can be connected as well as ceramic loudspeakers with an equivalent resistance of 600 ohm and 30 µF capacitance can be connected without additional circuitry.

Microphone Connection:

The microphone used can be connected either differential or single ended.

Headset Connection:

The CVM supports a headset connection by configuring for two single ended microphones. Please refer to the CVM reference design kits for further information.

The CVM handset audio handling basically consists of 4 audio states and one idle mode:

1. Alert state (not relevant for mic configuration)
2. Earpiece state
3. Handsfree or Speakerphone state
4. Headset state

Selection between the modes is done by API calls, as showed on figure 5.5 [1]. The Alert mode is for tone playing and the mode is entered automatically when tones are played using the API calls.

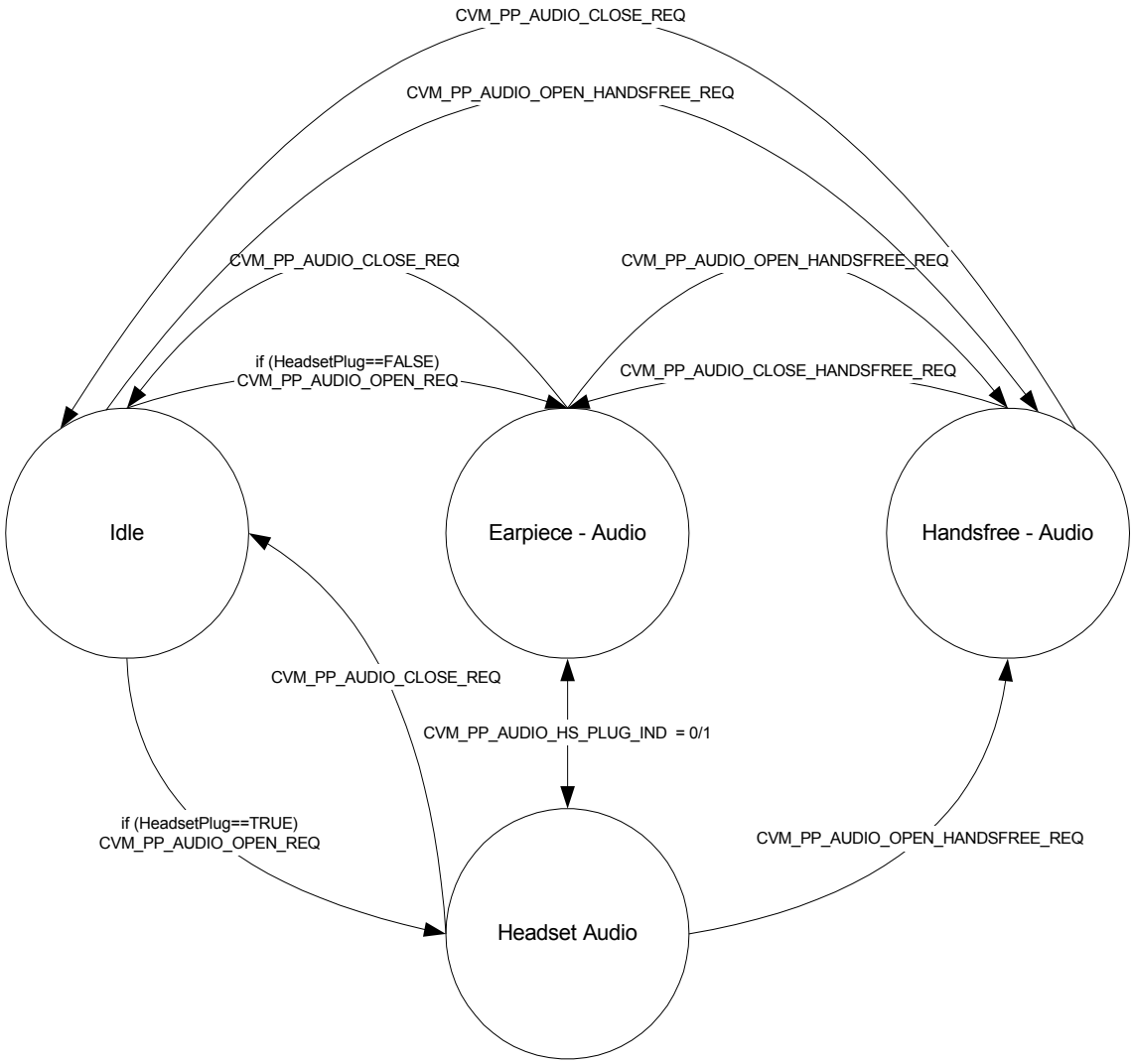


Figure 9. CVM PP Audio Modes

4.3.1.1 PP Audio Codec adjustment

The link between the hardware configuration and the 4 modes must be pre-configured by eeprom settings for each mode [2]. Because the eeprom settings is matching the SC14428 CODEC_MIC_REG and the CODEC_LSR_REG it is possible to configure the analog front end with the flexibility offered by SC14428. Please refer to the two tables below for CVM default settings and for further details to the SC14428 datasheet.

By default the CVM is configured as the CVM reference kit.

TABLE 6.

CODEC_MIC_REG			CVM default			
			Idle	1	2	3
Bit	**Symbol**	**Description**	0074	0071	00D1	0072
15-11	-	-	00000	00000	00000	00000
10	DSP_CTRL	0 = Microphone gain controlled with MIC_GAIN 1 = Microphone controlled with GenDSP	0	0	0	0
9	OFFCOM_ON	0 = Offset compensation off 1 = On	0	0	0	0
8	OFFCOM_SG	0 = Offset compensation added to MIC+ 1 = Offset compensation added to MIC-	0	0	0	0
7-4	MIC_GAIN	Microphone amplifier gain in steps of 2 dB 0000 = 0 dB, 1111 = +30 dB	0111	0111	1101	0111
3	MIC_MUTE	0 = normal operation 1 = mute MIC inputs for offset voltage measurement	0	0	0	0
2	MIC_PD	1 = Microphone amplifier powerdown, 0 = On	1	0	0	0
1-0	MIC_MODE	Microphone input configuration M[1], M[0] 00 = Normal differential or single ended AC coupled. 01 = MIC+ single ended. MIC- disabled; High impedance. 10 = MIC- single ended. MIC+ disabled; High impedance. 11 = MIC +/- disabled; High impedance. And mic amp is muted. Disabled pins are internally connected to analog ground.	00	01	01	10

TABLE 7.

CODEC_LSR_REG			CVM default				
			Idle	1	2	3	4
Bit	**Symbol**	**Description**	1D36	1912	0B33	1AF6	0333
15-14	-	-	00	00	00	00	00
13-11	LSRAT	Loudspeaker amplifier analog gain in steps of 1 dB 000 = 2dB, 111 = - 12 dB	011	011	001	011	000
10	LSR_GND_PD	1 = LSR_GND amplifier powerdown, 0 = on. Must be active if LSR+,LSR-,LSR_HS or CID amplifier is used	1	0	0	0	1
9	LSREN_SE	1 = Differential to single ended conversion enabled. 0 = Disabled	0	0	1	1	1
8	LSRHS_PD	1= LSR_HS amplifier power down, 0 = On	1	1	1	0	1
7-6	LSRHS_MODE	00 = LSR_HS output has AGND reference voltage 01 = Buzzer to LSR_HS amplifier 10 = Differential mode DA+ to LSR_HS amplifier 11 = Single ended mode to LSR_HS amplifier	01	00	01	11	01
5	LSRN_PD	1 = LSR- amplifier powerdown, 0 = On	1	0	1	1	1
4-3	LSRN_MODE	00 = LSR- output has AGND reference voltage 01 = Buzzer to LSR- amplifier 10 = Differential mode DA- to LSR- amplifier 11 = Single ended mode to LSR- amplifier	10	10	10	10	10
2	LSRP_PD	1 = LSR+ amplifier power down, 0 = On	1	0	1	1	1
1-0	LSRP_MODE	00 = LSR+ output has AGND reference voltage 01 = Buzzer to LSR+ amplifier 10 = Differential mode DA+ to LSR+ amplifier 11 = Single ended mode to LSR+ amplifier	10	10	11	10	11

4.3.1.2 General Audio adjustment

For each audio mode receive (RLR) and transmit (SLR) audio paths must be adjusted according to the external audio configuration. RLR and SLR are adjusted as described in the register tables above. The registers are mirrored in eeprom[2] for each audio mode.

4.3.1.3 Power Management

To minimize the current consumption the CODEC_VREF_REG, the CVM PP will shutdown all codec amplifiers in Idle mode. This means that all reference voltages in the front-end will be disabled. This feature can be disabled in eeprom if reference voltages for some reason are needed in idle mode.

4.3.1.4 Earpiece/headset mode

In CVM handset earpiece mode an artificial sidetone is generated. The level of the sidetone can be adjusted and setup using the eeprom [2]. In earpiece mode it is possible to adjust the volume in the earpiece via the API calls. Please refer to section 4.3.1.7 for further details.

Inearpiece mode the PP audio is routed as illustrated in FIGURE 12.

4.3.1.5 Handsfree or Speakerphone mode

In CVM handset speakerphone mode the SC14428 acoustic echo canceller algorithm is always active, and no sidetone is generated. In speakerphone mode it is possible to adjust the volume in the speaker via the API calls. In this mode audio is routed as illustrated in the FIGURE 10 below.

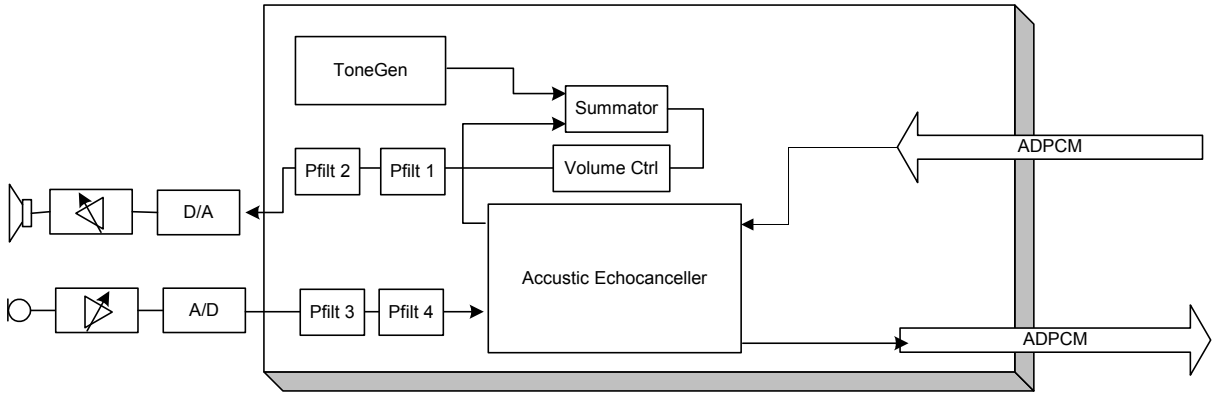


FIGURE 10. Speakerphone audio configuration

4.3.1.6 Alert mode

The alert mode is for generating tone and melodies in the speakerphone loudspeaker. In alert mode it is possible to adjust the volume in the speaker via the API calls.

4.3.1.7 Handset Volume Ctrl and DSP dataformat

The CVM PP supports ten volume steps, which are eeprom configurable. The volume steps must be set initially in the eeprom during production.

The Q15 data format is a 15-bit signed normalized fixed-point number representation.

Bit 15 is sign bit. Bit 14-0 represent steps of $2^{-(15-n)}$.

The largest positive number that can be represented is:

32767/32768 = 0.999969482421875 = 0x7fff

The smallest positive number is:

2^{-15} = 1/32768 = 0.000030517578125 = 0x0001

The Volume Control block of the CVM modules by default doubles the signal. This means that the attenuation range for the volume steps varies from 0x0000 to 0x4000.

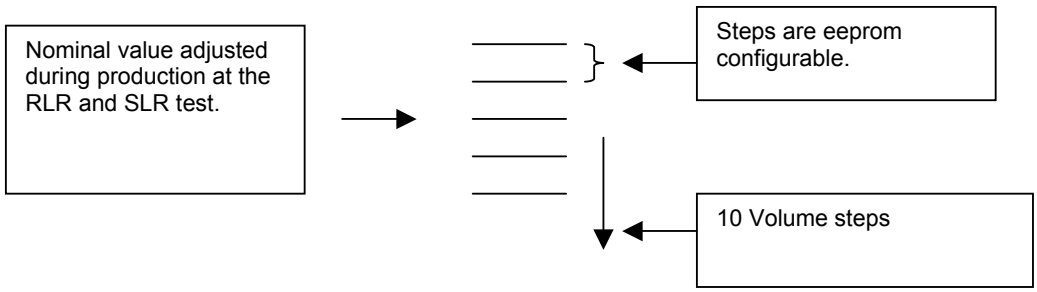


FIGURE 11. Handset volume configuration

Inband tones will be affected by the volume adjustments, since the volume control is placed after tones is added to the signal, see FIGURE 12.

CVM supports Joint Acting Volume Control (JAVC). In high volumesteps it is possible to control the microphone gain.

If JAVC is activated for a specifc volume steps the mic codec gain will be damped by 2dB

JAVC is enabled by enabling bit 15 in in specifc Volume steps.

Enabling JAVC for multiple volume steps will not result in damping more than 2dB

JAVC is enabled by enabling bit 15 in eeprom address 0x02D4 up [2]

4.3.1.8 PP Audio Equalization

To enable adjustments of the frequency response the CVM PP contain 4 programmable filters (2 in RX direction and 2 in TX direction). See FIGURE 12.

By default these filters loaded with bypass coefficients, but the API contains commands to load new coefficient for all filter.

Equaliser filters are part of the audio routes for all audio modes and are placed as illustrated in FIGURE 11.

For a detailed description of the filter functionality please refer to API documentation [1].

4.3.1.9 Acoustic Echo Canceller adjustment.

The Acoustic Echo canceller (AEC) is configured by a large number of parameters placed in DSP Parameter Ram. To access these parameters the standard API for ram access can be used.

To make adjustments of the AEC possible, a memory map describing the memory layout of the AEC parameters will be supplied together with the CVM software.

For a detailed description of the internal audio route in the AEC please refer to application note.

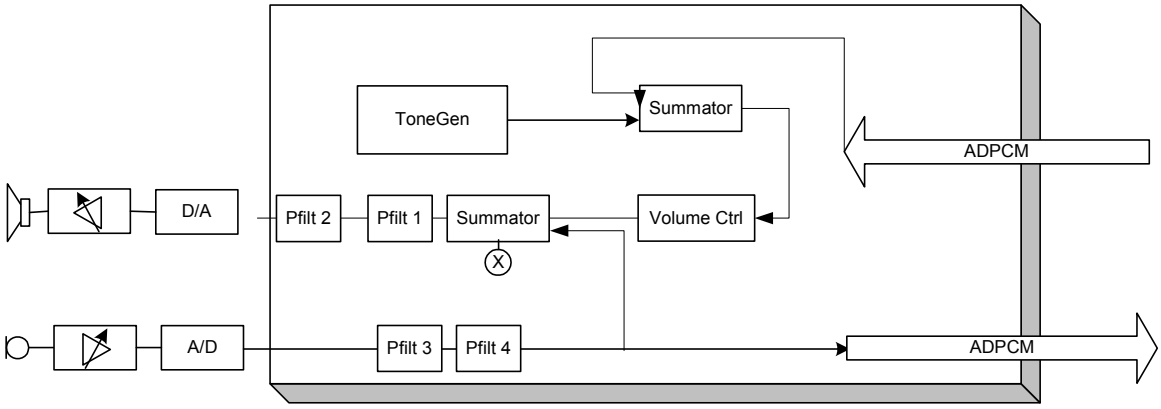


FIGURE 12. PP Audio Routing

4.3.2 Base Call Handling Using the standard Audio Control

With the CVM base audio control feature, a page and registration button on CVM pin 38 and a hook LED on CVM pin 31 is supported. A short press and release will start the base paging of all registered handsets. A key press longer than default 10 seconds (eeprom configurable [2]) will set the base into registration mode, making it possible to register handsets to the base. The hook LED will flash indication registration mode to the user.

With the CVM base audio control combined with an MCU, a full base speakerphone configuration is possible. The speakerphone codec must be connected using the PCM interface of the CVM.

4.3.2.1 Base Speakerphone

The base speakerphone requires an MCU, which handles the speakerphone MMI (keyboard and display) and call management. A base speakerphone acts in general as a virtual handset seen from the API interface used by the MCU. A similar set of API calls as the handset API calls are available for an MCU on a base configured CVM.

4.3.2.2 PCM interface[3]

The speakerphone codec must be connected using the PCM interface of the CVM.

The PCM interface is controlled by two registers which are mirrored in eeprom. Please refer to [2] for eeprom addresses.

The PCM registers are configured by default to control a PCM codec in master mode with PCM_CLK = 1.152 MHz as shown in the below tables. By changing the Pcm0CtrlReg bit 2 to 0 it is possible to get a PCM_CLK output with same frequency as the CVM crystal: 10.368 MHz.

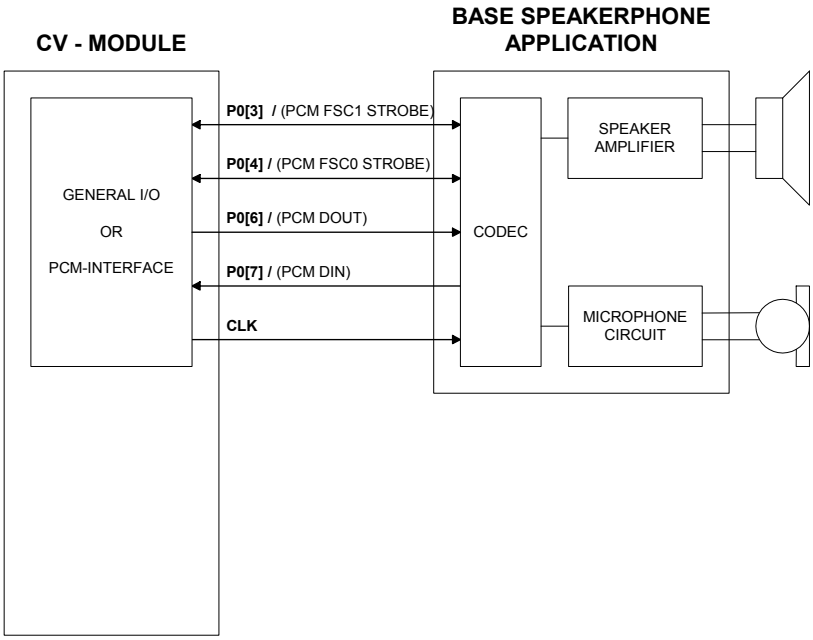


FIGURE 13. Physical PCM interface to base speakerphone application.

Place pull up resistors on the PCM Din and PCM Dout signals.

Note [3]: The PCM interface is only supported in base mode

TABLE 8.

Pcm0CtrlReg			CVM default
Bit	**Symbol**	**Description**	0007
15-4	-	-	0hex
3	PCM_CLK_BIT	Bit format (Only valid when in slave mode) 0 = 1 data bit is one PCM_CLK cycle 1 = 1 data bit consists of two PCM_CLK cycles (IOM2 format) (In mastermode 1 databit is 1 PCM_CLK cycle)	0
2	PCM_CLK_FREQ	PCM_CLK frequency (Only valid when in master mode) 0 = PCM_CLK = 10.368 MHz 1 = PCM_CLK = 1.152 MHz (FDIP/CODEC_DIV_REG)	1
1	DATA_FORM	PCM interface Date format 0 = Data interpreted as 14 bits sign extended to 16 bits 1 = Data interpreted as 16 bits (transparent)	1
0	MASTER	PCM interface master slave mode 0 = PCM interface in slave mode 1 = PCM interface in master mode	1

TABLE 9.

Pcm1CtrlReg			CVM default
Bit	**Symbol**	**Description**	9000hex
15	PCM_FSC0DEL	0 = PCM_FSC0 starts 1 databit before MSB bit (Only if PCM_CLK_BIT = 0) 1 = PCM_FSC0 starts at the same time as MSB bit	1
14-13	PCM_FSC0LEN	If MASTER = 1 00 = length of PCM_FSC0 equal to 1 data bit 01 = length of PCM_FSC0 equal to 8 data bits 10 = length of PCM_FSC0 equal to 16 data bits	00
12	PCM_FSC1DEL	0 = PCM_FSC1 starts 1 databit before MSB bit (Only if PCM_CLK_BIT = 0) 1 = PCM_FSC1 starts at the same time as MSB bit	1
11-10	PCM_FSC1LEN	If MASTER = 1 00 = length of PCM_FSC1 equal to 1 data bit 01 = length of PCM_FSC1 equal to 8 data bits 10 = length of PCM_FSC1 equal to 16 data bits	00
9-0	-	-	0hex

4.3.2.3 Incoming PSTN Call

When the CVM base detects an incoming call from the telephone line, a radio connection is set up to all the CVM handset applications making it possible for the handset MCU to receive CLIP information and indicate incoming call.

In case of a CVM 2.4GHz version it is only possible to make a radio connection for up to 4 handsets even it is possible to register up to 6 handsets. Registration of more than 4 handsets must be handled by the MCU application.

It is possible to configure the ringing indication using broadcast making all 6 handsets ringing, but then CLIP information is not included.

When receiving the call the CVM handset signals the call to the MCU via the UART/SPI interface.

4.3.2.4 Outgoing PSTN Call

When the external µP signals the CVM handset to establish a call the CVM handset opens the radio connection to the CVM base. The CVM base hooks off the line and is ready to dial. The dial procedure is then made by sending a string of dial digits from the MCU to the CVM handset, which again transmits the digits to the CVM base. The CVM dials using the chosen method (tone or pulse).

4.3.2.5 Intercom and Conference

All intercom calls goes via the base station. Intercom between two bases is made by making a connection from the first CVM handset to the CVM base requesting a call connection to the second CVM handset.

For a conference call, an additional external connection can be added to the intercom call.

The intercom and conference features are also possible with the base speakerphone acting as a virtual handset.

4.3.2.6 Call Transfer, forwarding and call back

During an external call it is possible to put the call on hold, calling another CVM handset and then perform an attended transfer of the external call to the other CVM handset.

During an external call it is also possible to perform an unattended transfer (forward) of the external call to the other CVM handset. If the receiver of the forwarded call does not answer, a call back is made to the initiating handset.

The call transfer, forwarding and call back features are also possible with the base speakerphone acting as a virtual handset.

4.3.2.7 Multiple Party Conference

It is possible to arrange a party conference by two methods:

Automatic conference initiated by another CVM handset (barge in)

When a CVM handset is in conversation with the line, it is possible for other CVM units to enter the conversation and form a conference with the already ongoing call by hook off.

In total it is possible to make the conference with 4 handsets, the BaseSpeakerphone and the PSTN line at the same time.

The first unit that connects is considered conference master by the system and is the only one that is allowed to send out digits on the line.

If the conference master releases his call, the second unit that joined the conference is pronounced master.

Manual conference initiated by the CVM handset in an active call.

During a call it is possible to put the call on hold, calling another CVM handset and then include the CVM handset in the call making a 3 party conference.

The multiple party conference feature is also possible with the base speakerphone acting as a virtual handset.

4.3.2.8 Call Waiting

During an intercom and if receiving an external call it is possible to notify the intercom callers. If provided by the telecom provider call waiting can also be received during an external call (type 2 CLIP).

4.3.2.9 Page call

The page call is a base functionality used to locate the registered handsets. In stand-alone mode the base paging does not establish a normal audio connection, and is terminated when answered by the handset. In base speakerphone mode a voice call can be established when the paging is answered.

4.3.2.10 Simulated Incoming Call

If the CVM FP is used in an application where there is no line interface or the line is managed by the external MCU it is possible to control the CVM_FP with API commands to simulate ringing. It is done by sending in a API setup command to initiate the RF connection and then followed by API commands to indicate the cadence of the ringing. In this mode PCM slave mode is not supported and there is limited or no call control features.

4.3.2.11 Connection Scenarios Using the Standard Base Audio Control Feature

The following connection scenarios are possible both in DECT and 2G4Hz versions using the stand-alone base:

TABLE 10.

PP <-> PSTN	(external call)
FP <-> PSTN	(external call with Speakerphone)
PP <-> PP	(internal call)
PP <-> FP	(internal call with Speakerphone)
PP <-> PP FP <-> PSTN	(external call with speakerphone) + (internal call)
PP <-> PP PP <-> PSTN	(external call) + (internal call)
PP <-> FP PP <-> PSTN	(external call) + (internal call with speakerphone)
PP <-> PP PP <-> PP	(more separate internal calls)
PP <-> FP PP <-> PP PP <-> PP *(3 RF connections only possible for DECT)*	(more separate internal calls, one with speakerphone)
PP <-> PP <-> PP <-> PP <-> FP <-> PSTN	(multiple part conference with Speakerphone)
PP <-> PP PP <-> PP <-> FP <-> PSTN	(multiple part conference while intercom)

FP = Speakerphone

4.3.3 Optional feature: Disabling the standard audio control

If the CVM standard audio control is not covering the needed audio and data routing possibilities, it is possible as an optional feature to disable the standard audio control. This requires that audio and connection switching is controlled by the MCU. The feature is optional and documentation for this feature must be requested from SiTel Semiconductor.

4.4 Tone/melody Handling

The tone component is a component that handles generation of various tones in the product. Both tones/melodies in a CVM base and CVM handset configuration is supported.

Main features of the tone component:

1) Ringer tones and melodies (3 tone polyfonic)

2) Alert tones (key sound, error tones, confirmation tones, etc...)

3) Inband tones (dial tone, net-congestion tone, busy tone, etc...)

4) Single tone generation

All the above tone features are generated in the earpiece, a further amplified tone requires a handsfree external circuit and functionality.

CVM comes with the following 3 predefined the patterns.

Pattern 1: Alternating between 1/32 - c6u_Tone and 1/32 - g6u_Tone at 175 BPM

Pattern 2: Alternating between 1/16 - e6_Tone and 1/16 7u_Tone at 200 BPM

Pattern 3: Alternating between 1/16- c7u_Tone and 1/16 g7u_Tone at 255 BPM

The predefined patterns are repeated 15 times before they stop.

It is possible to store the individual ringer melodies in eeprom.

When the MMI wants to play a tone/melody from CVM eeprom it simply passes the start address of the melody header in the call to the API. The CVM will then read data from eeprom and play the tone/melody.

How to activate and handle the tones/melodies is detailed described in [1].

4.4.1 Tone Envelope Algorithm

To minimize click sound during start and stop of short tones, a envelope algorithm has been added to the CVM tone generator. The envelope algorithm works by gradually increasing and decreasing the volume during start and end of tones.

See illustration below:

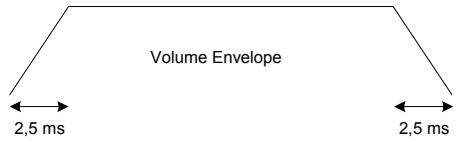


FIGURE 14. Tone Envelope

The envelope time is 2,5 ms sec. The Envelope function can be switched off by eeprom parameters.

4.4.2 Ringer Volume

The CVM supports ten eeprom configurable volume steps. Please refer to section 4.3.1.7

4.4.3 Buzzer control

The buzzer control and handling must be made via the external µP. The CVM does not supply control for a buzzer.

4.5 Line Interface

CVM can handle one single analog telephone line with pulse[4] and DTMF dialing.

The CVM DECT line interface is adjusted to meet the ETSI TBR37 line requirements using the CVM DECT base application board[5].

The CVM 2G4 line interface is adjusted to meet the FCC part 68 using the CVM 2G4 base application board[3]. All the adjustments to meet the two requirements are found in the eeprom document [1]. For each line application the line interface must be adjusted and tested against the line requirements (FCC or ETSI).

The Line interface supports Flash (Register recall). The Flash is activated via the CVM handset by sending multi keypads. By default FLASH is not enabled. For details refer to [1], and for timing setups refer to [2].

The CVM base supports the following functionalities:

- Parallel off hook detection
- Busy tone detection
- Dial tone detection.
- Line reversal (requires line AGC disabled)
- Line AGC (requires line reversal disabled)

The above functionality's will require support by proper line interface hardware.

The detection parameters are placed in eeprom and can be adjusted during development and production. The CVM base will signal to the MCU when one of the signals is detected.

Please refer to FIGURE 15 for the hardware signals available at CVM, and how they interconnect to a line interface.

Note [4]: Pulse dial for NL is not supported if CLIP impedance is used.
Note [5]: The application board is an example board and the BOM is not cost optimized.

4.5.1 CLIP

The CVM base application supports via the line interface FSK CLIP Type 1 and type 2 and DTMF CLIP.

The CVM CLIP algorithm is tested against basic ETSI and Bellcore[6] CLIP requirements. The CLIP algorithm is not adjusted and tested against country or telecom provider specific requirements. The CLIP algorithm parameters are placed in eeprom [2] to make it possible to adjust for specific country or telecom provider requirements.

Learn mode (DECT only)

At first CVM power up and by reception of the first CLIP from the line the CLIP detection algorithm automatically detects FSK or DTMF mode.

handsets, and the CLIP will be available for the CVM base MCU.

The maximum name and number lengths are defined as follows:

- Max. Name length: 16 characters.
- Max. Number length: 22 digits.

**To be able to send the entire CLIP information (Name, Number, Private/hidden info, time, etc.) the actual CLIP information is transmitted to the handset in a special none DECT GAP format. This means that CLIP info will only be available between CVM based units.*

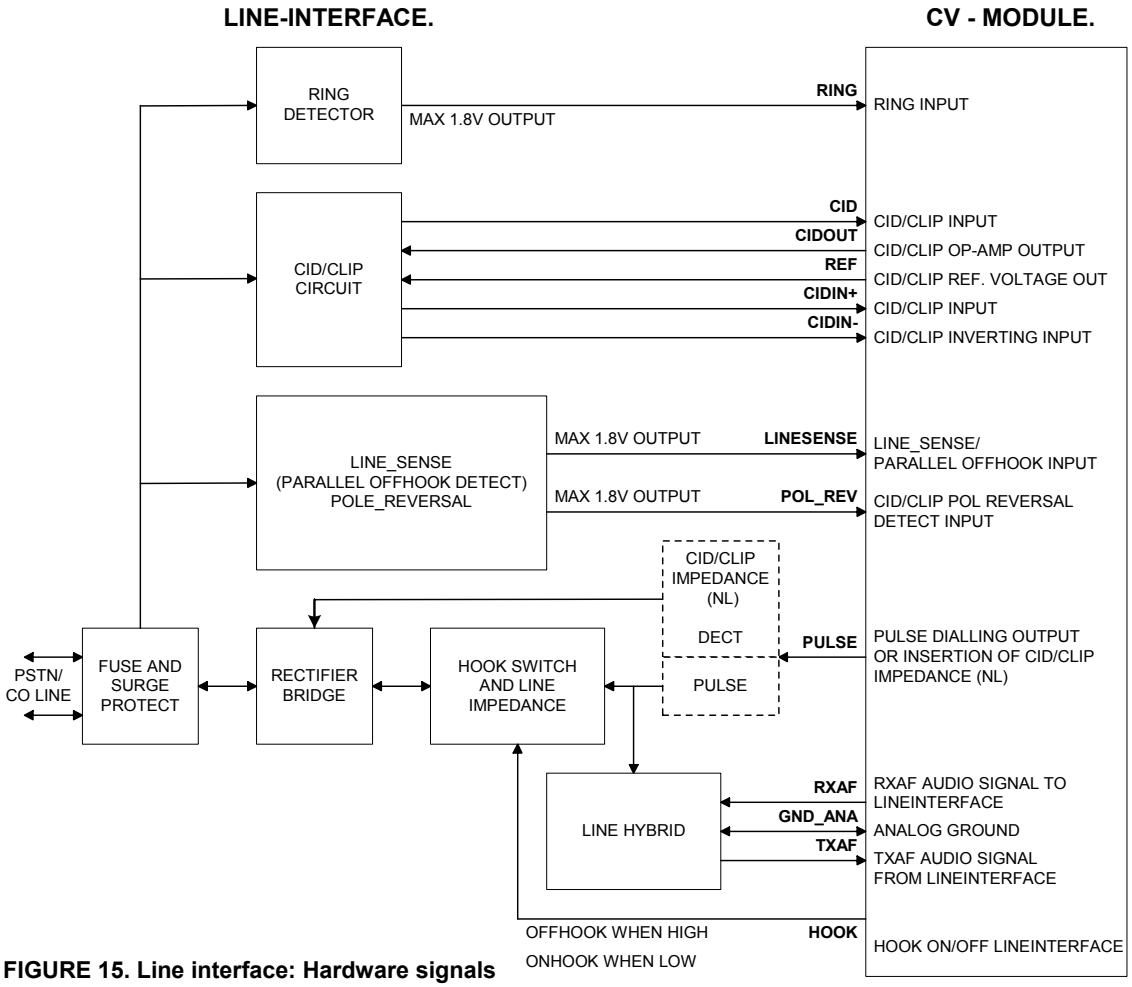


FIGURE 15. Line interface: Hardware signals

4.5.1.1 Call Waiting Deluxe

To make Call Waiting Deluxe signaling to the external PSTN, a FLASH (Calibrate break) followed by a normal DTMF digit is used.

4.5.1.2 Receive Type 1 +2 + DTMF CLIP

After reception of a Type1 or Type 2 or DTMF CLIP number in the CVM base, the CLIP number and name with timestamp is automatically send to the MCU of the ringing

4.5.1.3 Message Waiting Reception/Voice Mail

Only supported via FSK CLIP. The MCU must handle the identification of the received message-waiting signal.

Note [6]: The CVM is not approved by a Bellcore lab test. CVM is only limited tested. By practical use it will detect Bellcore.

4.6 Battery Management

The CVM battery management handles the charging of either 3 cell Ni-Mh or 3 cell Ni-Cd batteries. The battery management includes functionality for charging/ discharging and continuous capacity calculation as well as safety features to handle e.g. non-chargeable batteries.

The CVM battery management is controlled by EEprom parameters and by messages from the application-layer. The EEprom parameters must be setup during production and control the battery size, the charge current, the charge cycle timing for various charge states as well as voltage limits and charge state timeouts.

For at complete list of battery parameters please refer to the Battery Configuration chapter of [2]. For a complete list of battery management instructions please refer to the Battery Management chapter of [1].

The CVM handset is powered down via the software interface. If the charge detect pin is activated the CVM handset powers on and start charging. The application-layer can always ask the CVM battery management about the power-on reason (cradle, new battery or normal power on)

The CVM supports a charge LED, which can be used to indicate when the handset is inserted into the charger.

If the battery management is handled by the MCU, it is possible to disable the CVM battery management component by clearing EEprom parameter *CVMBatteryTaskEnabled* (please refer to [2]).

4.6.1 The battery charge functionality

The battery charger has five charging states: PreCharge, InitialCharge, FastCharge, TopCharge and TrickleCharge. A state change from one state to another depends on:

• Estimated capacity.

• Timeout

• Voltage thresholds.

Below is a short description of each charge state:

• PreCharge

The EEprom parameter *CVMBatteryPreCharge* enables this state and determines ist duration. It allows a charging to start with a few seconds of full charge. This is done so that a sudden current drain from the application layer does not cause the phone to power off if the batteries are critically low.

• InitialCharge

This charge state protects the battery. It is especially used on Ni-Cd batteries, which must not full-charge if the batteries are low. In the InitialCharge state, the phone charges typically 200ms on/200ms off until the voltage level exceeds the *CVMBatteryInitialChargeLevel.*

• FastCharge

This is the main charge state. It handles the charging until the estimated capacity reaches the capacity determined by the *CVMBatteryFastChargeLevel* (typically 90%).

• TopCharge

This state handles the charging while the estimated capacity is between C*VMBattery-FastCharge-Level* (typically 90%) until it reaches 100%. The on/off charge cycle in the TopCharge state is determined by *CVMBatteryTopDutyCycle*

• TrickleCharge

This state is entered when the TopCharge is completed. The charging in this state must maintain a full battery, without under- or overcharging the battery. Thus, the effective charge current in this state must approximately equal the current used by the phone. The effective charge current (i.e. the on/off charge cycle) in the TrickleCharge is determined by the *CVMBatteryTrickleCharge* parameter.

In addition to the above-mentioned charge states, the battery management has some extra safety features:

• Non-chargeable batteries

If non-chargeable batteries (i.e. Alkaline batteries) are used, the result is a very high battery voltage during the first few seconds of attempted charging. The CVM detects this and enters an error state in which case no further charging is performed. The discharge is performed as normal until LowVoltage is reached.

• Illegal current consumption reported by the application-layer.

If the handset is in TopCharge or TrickleCharge and detects a low voltage, then something is wrong and the estimated capacity can no longer be trusted. The charging algorithm sets the estimated capacity to 50% and goes to the FastCharge state. The criteria for this is that the measured voltage must be less than

(CVMBatteryMaxVoltage+CVMBatteryLowVoltage)/2.

The relation between the charge states is seen in FIGURE 16.

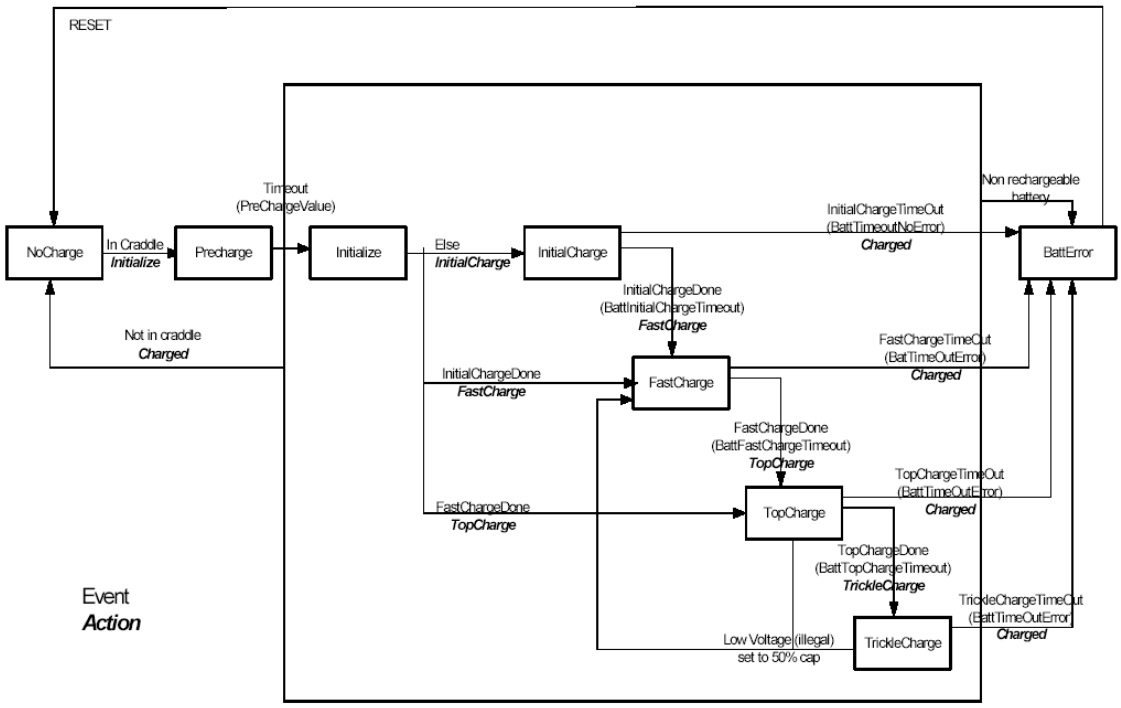


FIGURE 16. Battery Management State Handler

4.6.1.1 Typical charge up process after a period with discharge

If the handset is used outside the charger, the power consumption is calculated based on the estimate sent by the application-layer. When the handset is placed in the charger, the charge cycle starts in a state based on the calculated battery capacity and/or the measured voltage. For reference see the above FIGURE 16.

The CVM must always be informed by the MCU about the actual current consumption in order to maintain a reliable estimate for the battery capacity. For a list of commands to do this, please refer to the Battery Management chapter of [1].

If the battery voltage drops below the 'LowVoltage' limit (please refer to [2]) the calculated battery estimate is set to zero, and the CVM battery management signals the application via the command interface.

If the battery voltage drops below the 'NoVoltage' limit (please refer to [2]) the CVM battery management signals the application via the command interface. In this case the MCU should immediately request the CVM to power down. This allows the MCU a short period of time to store crucial data before the application is powered down.

If the battery voltage is below the limit where the CVM can power up, then hardwareconditioned charging is performed.

4.6.1.2 Battery change

When a new battery is inserted in the CVM, the battery application detects this and sets the estimated battery capacity to 100%. Due to internal capacities in the detection circuit, the battery has to be disconnected 10-15 seconds before the battery application is able to detect it.

For further details please refer to section: 13.

4.7 Date and Real-Time Clock

The CVM base does have a real-time clock feature, which when activated broadcasts the date and clock to the CVM handsets. Activation of the date and real-time clock is done by setting the date and clock via the CVM handset. The clock is with hours, minutes and date. The clock supports leap year. Daylight saving is not supported, and must be handled by the MMI application.

The CVM handset clock is synchronized with the CVM base every time a broadcast is received. If the CVM handset goes out of lock the CVM handset itself calculates the clock until the CVM handset again is within range of the CVM base.

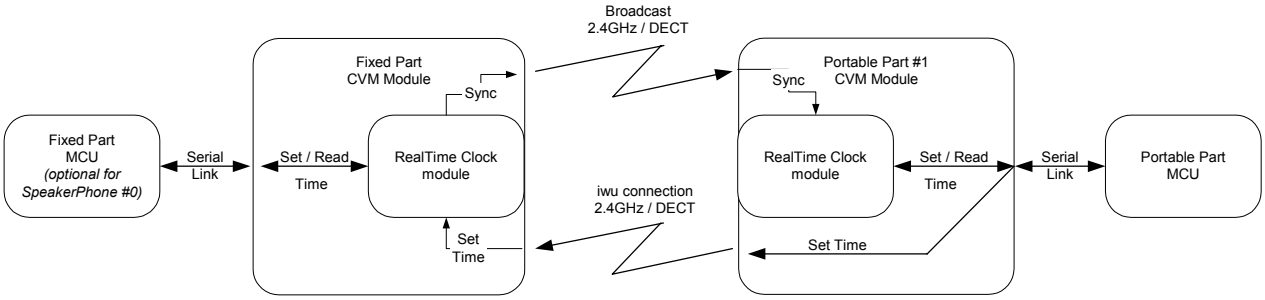


FIGURE 17. Clock Synchronization

The updated clock can then be read locally from the PP_MCU.

To adjust the clock in the basestation, a service connection can be setup and it can be set by commands from the handset.

The clock can also be read and set directly from a external MCU on the base.

The real-time clock accuracy depends directly on the CVM crystal. The clock tic is generated by RTX clock algorithm.

When CVM is configured as a CVM handset the clock has the same accuracy as the CVM base clock. But when the CVM handset synchronies with a CVM base the CVM handset crystal is synchronized with the CVM base crystal, and the CVM handset clock will change accordingly.

The accuracy is expected to be within 1 minute for up to 6 weeks[7] without being locked to a CVM base.

4.8 Protocol

The protocol handles the RF interface. For the CVM DECT the DECT TDMA is used. For the CVM 2.4GHz a RTX developed frequency-hopping algorithm is used.

The protocol features encryption within both CVM DECT and 2.4GHz version.

4.8.1 DECT TBR22

The CVM DECT protocol supports the DECT GAP standard. DECT TBR22 GAP[8] type approval is possible. To pass a GAP type approval a disable of PP authentication and encryption during conversation is needed for some TBR22 test cases (DLC test cases). This can be done via eeprom address 0x00F0 [2].

4.8.2 CVM 2G4Hz Frequency Hopping

The number of used frequencies (NUF) in the hopping algorithm is 95.

In base and handset a PrimaryHoppingIndexNumber (PHIN) exists. This number is incremented modulo NUF in the end of the normal downlink half-frame. It is broadcast in Q0 message instead of PSCN.

To a simplex or an established duplex bearer a HoppingIndexOffset (HIO) is assigned, which is an analogue to the used RF carrier in a FDMA system. This value is broadcast in place of CN in Q0 message. In the base in all unused slots in up-link direction the receiver is scanning with HIO=0. The receiver scanning doesn't exclude RF-carriers.

Different bases use different hopping sequences. The different sequences are derived from the hopping table by adding an offset, SeQuenceCode (SQC).

A hopping table maps an index I to a carrier number: CN = f (I)

The physical RF carrier is calculated by the formula:

CN = (f ((PHIN+HIO) mod NUF) + SQC) mod NUF

For 10.368000 MHz crystal the frequencies are derived as:

Frequency: 2401.056 MHz + CN * 0.864000 MHz

Note [7]: In order to achieve this clock accuracy the eeprom must be set up correctly using the batch file "patch V01.bat"

Note [8]: The CVM is not GAP compliant in its way to send clip to the handsets. Number and name will not be received by a GAP compliant handset.

TABLE 11.

I	f(I)	I	f(i)	i	f(i)	i	f(i)	i	f(i)
0	0	20	2	40	27	60	13	80	40
1	23	21	18	41	12	61	33	81	1
2	62	22	81	42	89	62	65	82	28
3	8	23	11	43	25	63	50	83	55
4	43	24	36	44	87	64	79	84	35
5	16	25	72	45	14	65	56	85	53
6	71	26	54	46	57	66	91	86	24
7	47	27	69	47	41	67	42	87	44
8	19	28	21	48	74	68	80	88	82
9	61	29	3	49	32	69	48	89	51
10	76	30	37	50	70	70	15	90	90
11	29	31	10	51	9	71	85	91	38
12	59	32	34	52	58	72	5	92	83
13	22	33	66	53	78	73	88	93	30
14	52	34	7	54	45	74	17	94	46
15	86	35	68	55	20	75	84		
16	63	36	94	56	73	76	6		
17	26	37	75	57	93	77	67		
18	77	38	4	58	64	78	49		
19	31	39	60	59	39	79	92		

It should be noted that the details regarding frequency hopping channels and sequence is not final and can be modified.

4.8.2.1 RF channel exclusion

To improve radio transmission quality the CVM base will, during the hopping procedure, measure the signal quality of the frequency when used. A noisy frequency is noted and by this method up to 20 frequencies can be excluded from the hopping procedure.

4.8.3 FP to handset Connection Types

There are three types of base to handset connections. Whenever an operation is made over the air interface one of the three connection types must be established.

1. Audio connection (max 1.6 Kbit/sec data transfer possible)
2. Service call (an audio connection without open audio)

   (max 1.6 Kbit/sec data transfer possible)
3. Pure data call. (max 24Kbit/sec data transfer possible)

During all the connection types data transfer is possible. The two data transfer modes are described more detailed in section 4.10.

4.8.4 Out of range handling

When the CVM handset goes in or out of range a signal is sent from the CVM handset to the MCU indicating whether the CVM handset is in lock or is out of lock with the CVM base.

4.8.5 Broadcast from base to handsets

By using an MCU and a CVM base it is possible to broadcast dedicated information (20 bytes at a time) from the CVM base to all the CVM handset. The broadcast is also used to broadcast line/plug-status and the real-time clock from the CVM base to the CVM handset, when the real-time clock is activated.

When broadcasting data no active connections are established.

The data is transmitted out from the basestation and received by any handset that “hears” it – the communication is only one way.

Therefore the broadcast data are not secure. There is no retransmission.

If the PP doesn’t get it right the first time, the broadcast data is lost.

4.8.6 Dual Slot Diversity Operation (only 2.4GHz version)

To optimise the audio quality during external radio frequency interruptions CVM supports an automatic controlled dual slot diversity feature. During dual slot operation the same ADPCM audio data is sent in two time slots. The two data packages are compared by CRC and the one with no or less errors are used. Because of the nature of the feature dual slot diversity operation is not active from the second active air connection, if there is more than 2 registered handsets on the base.

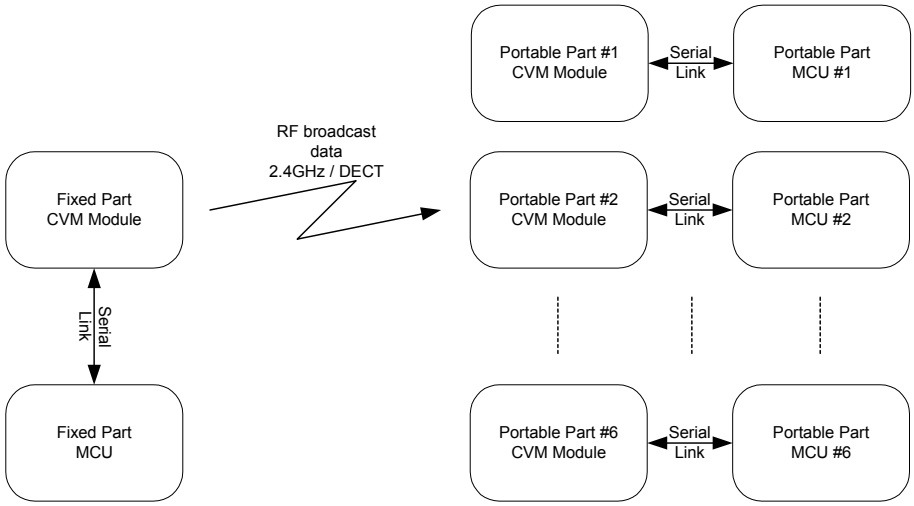


FIGURE 18. Broadcast Scenario

4.8.7 Pre-Amble Antenna Diversity

To optimise the audio quality caused by rapid changing radio paths (fading) the CVM supports pre-amble antenna diversity. The pre-amble diversity algorithm uses RSSI measurements to judge the radio signal strength on both antennas, and by this the choice of the best performing antenna is determined. The antenna will be used for receive slot and next transmit slot.

The pre-amble antenna diversity is supported by default. The pre-amble diversity can be disabled by eeprom address 0x0035 to let the CVM support a single antenna [2].

4.9 Walkie-Talkie

Via the MCU it is possible to bring a CVM handset into Walkie-Talkie mode.

In this mode all handsets are scanning. The handsets do not need to be registered to the same base. When a handset wants to establish a call, it goes into "base" mode and sets up a dummy bearer. The other handsets (also in Walkie-Talkie mode) detect the dummy bearer and start ringing. When a handset answers the call, it establishes a call. It is possible to have an infinite number of handsets, and the power consumption is high during scanning. The handsets cannot see if other handsets are within range. This mode can also be called non-synchronized mode, and is described by ETSI. For further information see: http://www.dectweb.com/News&Views/Features/0006Directmode.htm

In Walkie Talkie mode a datacall (24 Kbit/s) and low rate datacall (1.6 Kbit/s) is not possible.

4.9.1 Walkie-Talkie Identities

To be able to establish the connections the CVM will need a 16-bit value from the MCU.

The handset Walkie Talkie MMI must handle the16-bit value either as a manual entered or automatic generated value.

4.10 Data Transfer

Using the CVM there is two data rates for data transfer depending on the two connection types used.

4.10.1 Pure Data (up to 24 Kit/s)

Using a pure data setup between a CVM base and a CVM handset it is possible to transfer data with an air interface bit rate of up to 24 Kbit/s[9]. To run a data application both the CVM base and the CVM handset must be controlled by an MCU.

In FIGURE 19 is showed a pure data scenario with data connections between a base MCU and two handset MCU's.

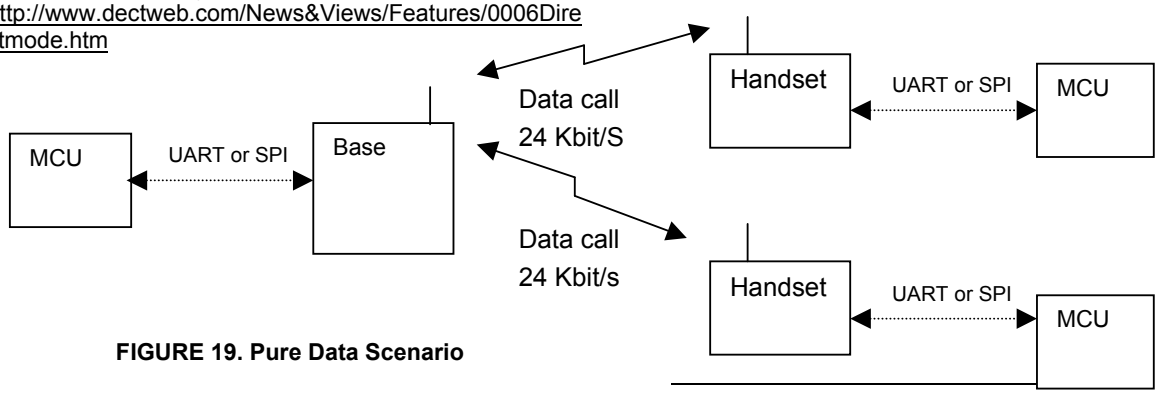


FIGURE 19. Pure Data Scenario

Note [9]: DECT protocol projected B-field is used.

The data will be transferred between the CVM handset and CVM base MCU's using either the UART or SPI interface. The maximum data speed in a system is limited by the CVM base to MCU interface, where a maximum of about 37Kbit/s can be transmitted at a maximum baudrate of 57.6KBaud. At higher baudrates data can be transmitted but packet loss will happen. The MCU interface handshakes the data packages to avoid loosing packages. The data from the MCU is transmitted in packages of up to 31 bytes.

The CVM air-interface transmits data with a bit rate of up to 24Kbit/s. The CVM FP automatically distributes the data load between uplink and downlink data, and the connected PP units. The data speed of the uplink and downlink data on the connected PP units will depend on this. The air-interface protects the data by CRC checking and retransmission in case of CRC errors. In case of errors in the airinterface the MCU to CVM interface will limit the data bandwidth by omitting a confirmation of the packages.

It is possible to establish a data transmission from up to 4 handsets to 1 base.

The overall system data rates possible are listed in the below table (UART baudrate 57.6KBaud).

TABLE 12.

	Uplink FP -> PP	Downlink PP ->FP
FP <-> PP	0 Kbit/s	24 Kbit/s
FP <-> PP	17 Kbit/s	20 Kbit/s
FP <-> 2 * PP	0 Kbit/s	16Kbit/s pr. PP
FP <-> 2 * PP	7 Kbit/s pr. PP	10Kbit/s pr. PP
FP <-> 4 * PP	0 Kbit/s	7 Kbit/s pr. PP
FP <-> 4 * PP	7 Kbit/s pr. PP	0 Kbit/s
FP <-> 4 * PP	1.2 Kbit/s pr. PP	1.2 Kbit/s pr. PP

It is only possible to establish a data call between handsets and base. A data call directly between handsets or between handsets via the base is not possible. To transfer data between handsets must be handled by the CVM base MCU.

4.10.2 Low Speed data

During a voice call or using service call data can be transferred at a rate of about: 1.6 Kbit/s using IWU to IWU messaging.

It is possible simultaneously to have a connection with a voice call on one handset and a data connection on another handset (up to 24 Kbit/s).

As with the 24 Kbit/s data connection the data transfer requires both CVM base and the CVM handset to be controlled by an MCU. However for the IWU to IWU messaging it is possible for the CVM handset to write directly to the eeprom of the CVM base, without the CVM base is controlled by an external MCU.

4.10.2.1 IWU to IWU messaging

The protocol in the CVM module is made after the DECT/GAP standard as defined in

EN 300 175 and EN 300 444. In the 2.4 GHz version the RF interface is adapted to

the 2.4 GHz frequency band, but the rest of the protocol is according to DECT/GAP.

The DECT standard defines an EMC code (see EN 300 175-5, chapter 7.7.23.). This code is unique for a DECT product and must be programmed by the DECT manufacturer to the correct manufacturer code. Within a 2.4 GHz product this code is not a requirement. The EMC code is a two-byte value set by eeprom address 0x0043 and is by default set to 00 00. Please refer to [2].

It is important that the EMC code is the same for CVM based products, which must be able to communicate together using IWU to IWU.

If products should not communicate it is important to assign a unique code, which is not used by other CVM's.

If the EMC is not changed there is a risk that two products based on CVM will interpret the IWU to IWU messaging correctly or wrongly both leading to strange operation of both CVM based applications.

IWU data is transferred in a FA format frame, see chapter 6.1 in EN 300 175-4. This frame has an information field of maximum 63 bytes, of which max. 52 bytes can be used for IWU data. With CVM it is only possible to send 5 frames in a row without pause. The following frame must be an acknowledge-frame to secure the internal buffers within CVM is emptied.

The FA frame is segmented in 5 bytes fragments and transferred over the air-interface in the A-field. The 2-bytes crc is used to determine if the data is received correct. If the data is not received correct this is signaled back to the transmitter by the Q2 bit, and the data is retransmitted.

The FA frame has a 2 bytes checksum, used to determine if the complete packet is received correct. If there is a checksum error, this is signaled back to the transmitter, and the complete packet is retransmitted. The packet will re-transmit until it is received correctly, or the link is closed.

If more packets are transmitted, it will be received in the same order, as they were transmitted. The MCU application must handle flow control if needed.

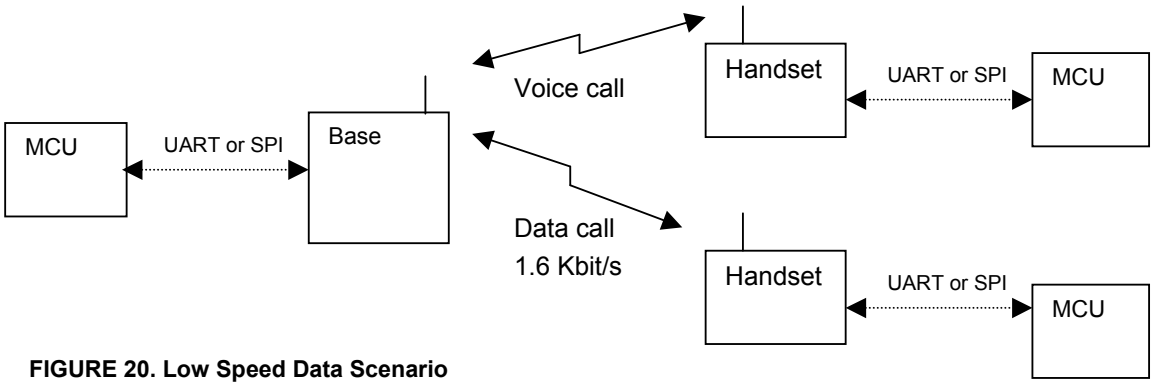


FIGURE 20. Low Speed Data Scenario

4.11 Registration

The handset and the base must be paired using a procedure called registration. Without registration the handset will be out of lock, and will not be able to establish a link to a base and then not be able to make a call. The registration is using the unique product identities described in section 4.11.3 and secures the handsets and bases not to cross communicate. To avoid cross communication it is very important that the handsets and bases all uses a unique numbering scheme.

It is possible to register up to 6 handsets in a CVM 2G4Hz base, and a CVM DECT base. Only 4 handsets can be active at the same time in CVM 2G4Hz. One handset can be registered to two bases. Please refer to the section 4.3.2.11 for the call handling possibilities with the handsets. Handsets numbers will be available for the MCU. For details refer to [1].

The handsets can be de-registered from a base again either via the CVM base MCU or the CVM handset MCU using the command interface. Also it is possible to de-register a handset from an extra registered handset.

There are two methods, which can be used in an application for registering the handsets to a base: Manual registration or automatic registration. Additionally it is possible to pair a handset and a base during production, using the production interface. Please refer to [3].

4.11.1 Automatic Registration

The CVM supports an automatic registration alternative, which can be enabled/disabled by eeprom (FpConfig).

If putting a handset into the base during the 2 minutes after power up, the base will automatically go into “registration enabled mode”.

The Handset should then check for cradle and automatically send a registration request if no valid registration is present.

*The handset part of this functionality should be made in the MMI of the MCU (externally)

4.11.2 Manual Registration

A registration of a handset to a base is done by first enabling the registration mode in the CVM base (by keypress on the CVM base or by command from the CVM base MCU).

Then the actual registration is started by sending the registration command request from the CVM handset MCU to the CVM handset holding the Authentication code and the SubscriptionNo.

The CVM will then search for the "registration enabled" base and when found, the registration is completed and a confirm message is returned to the CVM handset MCU.

The registration procedure must be as follows:

1. First the base registration mode is enabled
2. Secondly the handset registration mode is enabled

If a reverse order is used there is a possibility for the registration to fail. The reason is the handset search for open bases method, which will set found bases not in registration mode back in the search queue.

4.11.3 Handling Product Identities

To secure that the base and handsets do no cross communications a unique ID must be entered into the eeprom of a base or handset. For the DECT version the ID for the base is named RFPI and for the handset the ID is named IPEI. These numbers are factory settings. For the 2G4 Hz version random numbers are generated at production, and no further handling of ID's are necessary.

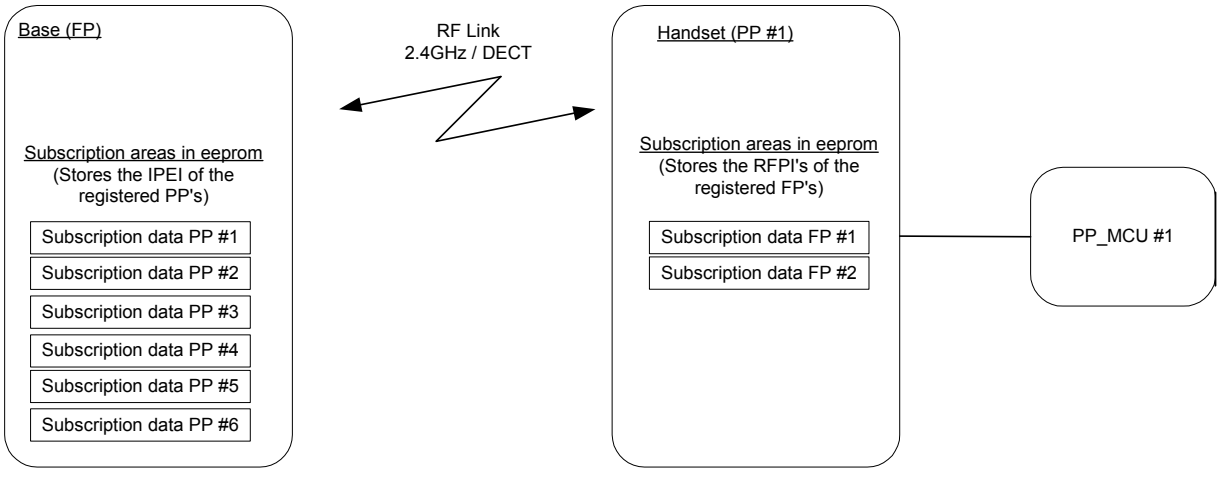


FIGURE 21. Handling Product Identities

After a successful registration, The IPEI (handsetID) is stored in the Base and the RFPI (baseID) is stored in the handset.

This way the two parts will then later know each other and allow connections.

The registration data are automatically stored in eeprom of the base/handset while making the registration.

Its possible to register the same handset to 2 base stations but it can only be inservice on one at a time.

4.11.4 Deregistration

There are 2 ways of deregistering a handset from a base:

1) Remote FP/PP deregistration

The correct way to deregister a handset from a base is to remotely deregister it in the base.

If is done over a service connection from the handset to the base.

It is then the base that actually performs the deregistration and it is then automatically signalled to the handset which will drop out of lock

Using this method it is also possible to deregister other handsets registered to the base from one handset.

2) Local PP deregistration

It is also possible to make deregistration locally in the handset only.

This could be an option if the handset should be used on another base and forget about the original registration.

4.11.5 Auto Power on Deregistration

The CVM base has a safety feature to automatically deregister its handsets after a special power up scheme.

This is implemented in case the user looses his handsets and wants to add new handsets to the base.

The auto power on deregistration is initiated by pressing the base key, then power on the base while holding the key pressed for more than 3 seconds

This procedure only deletes the registrations inside the base, - the handsets will still think that they are registered, but not be able to make calls.

It is possible to configure in eeprom which of the handsets should be deregistered by the power on deregistration.

4.11.6 Auto Power on Deregistration

The CVM base has a safety feature to automatically deregister its handsets after a special power up scheme.

This is implemented in case the user looses his handsets and wants to add new handsets to the base.

The auto power on deregistration is initiated by pressing the base key, then power on the base while holding the key pressed for more than 3 seconds

This procedure only deletes the registrations inside the base, - the handsets will still think that they are registered, but not be able to make calls.

It is possible to configure in eeprom which of the handsets should be deregistered by the power on deregistration.

5 CVM Production Test and Product Configuration

A document describing an example production test specification for a standard base and handset application is available [3].

5.1 Power on/off sequence

The CVM is ready when the ping - pong sequence described in [1] is answered from the CVM.

The CVM handset is fully powered on after 100 ms press on the power on button. The CVM handset is powered off again by software via the MCU [1].

5.2 Sleep Mode

It is possible via a command to tri-state the UART and SPI interface on the CVM. After power off and on again the CVM will return to normal mode.

5.3 Initial Settings.

The CVM is by default configured as a handset.

The CVM UART is default set to the baud rate: 19200.

Registration key: Key press length default 10 seconds.

5.4 RF testing.

For testing the CVM DECT RF the CVM is prepared for the necessary software interface to connect to test equipment such as the Rohde&Schwarz CMD60.

For testing the CVM 2G4 RF the CVM is prepared for the necessary software interface to connect to the RTX 2201 RF tester. For further information please contact RTX Telecom A/S.

5.5 Handling Product Identities.

To secure that the base and handsets do no cross communications a unique ID must be entered into the eeprom of a base or handset. These numbers are factory settings.

5.5.1 DECT Version

For the DECT version the ID for the base is named RFPI and for the handset the ID is named IPEI. These numbers must be achieved from ETSI and written correct at production.

5.5.2 2G4 Version

For the 2G4 Hz version random numbers are generated at CVM production, and no further handling of ID's are necessary.

5.6 CVM Base Port Configuration at Start Up.

TABLE 13

Pin	CVM Port	Function	Configuration
3	ANT1_SEL	Selects antenna1	RF interface
6	/RESET	/Reset signal e.g. for an MCU.	Output. Active low
7	CLK	Clock output e.g. for an MCU. Can be selected as 1.152MHz or 10.368MHz. PCM_CLK	Output. Clock Output, can be disabled for power saving.
8	SPI_DI	SPI. data in	Input
9	SPI _CLK	SPI clock Input	Input
10	LINE_SENSE	Line sense and parallel off hook detection	Analog input (ADC0)
11	RESET	Reset signal e.g. for an MCU.	Output. Active high
12	SPI_INT	SPI interrupt	Output
13	SPI_DO	SPI data out	Output
14	POWER_ ON	Turns on the CV – Module in the Basestation Application	Input
16	CHARGE_LED	Charge status LED	Output
17	P2[6]	Not used	-
19	RING	Ring input from the ring detector circuit	Input
21	REF	Reference output voltage for caller ID	Output
22	RXAF	Audio signal to line interface.	Output
23	CIDIN-	Inverting input of the CID op-amp.	Input
24	CIDOUT	Output from the CID op-amp	Output
25	CID	CID input. AC coupled signal from CID op-amp.	Input
26	GND_ANA	Ground reference for audio signals	

27	TXAF	Audio signal from line interface.	Input
28	CIDIN+	Non-inverting input of the CID op-amp.	Input
30	POL_REV	Polarity reversal detection and parallel off hook detection	Analog input (ADC1)
31	HOOK_LED	Offhook indication	Output
32	PULSE	General purpose I/O	Input/Output with selectable pull up resistor.
33	P0[6]	General purpose I/O or PCM_DOUT	Input/Output, with selectable pull up resistor. Input/Output, with open drain. PCM Data Output
34	P0[3]	General purpose I/O or PCM_FSC1 strobe	Input/Output, with selectable pull up resistor. Input/Output. PCM FSC1 strobe
35	P0[4]	General purpose I/O or PCM_FSC0	Input/Output, with selectable pull up. Input/Output. PCM 8 kHz FSC
36	P0[7]	General purpose I/O or PCM_DIN	Input/Output, with selectable pull up resistor. Input/Output, with open drain. PCM Data Input
37	HOOK	Onhook/Offhook	Output
38	REG_KEY	Registration key	Input
39	SDI+	JTAG one-wire debug interface	JTAG Input/Output (pulled up with 1 KOhm)
40	SERIAL_IN	UART RX	UART input
41	SERIAL_OUT	UART TX	UART output
42	CHARGE_DET	Indication of handset placed in charger	Input ADC2
45	ANT2_SEL	Selects antenne2	RF interface

5.7 CVM Handset Port Configuration at Start Up.

TABLE 14.

Pin	CVM Port	Function	Configuration
3	ANT1_SEL	Selects antenna1	RF interface
6	/RESET	/Reset signal e.g. for an MCU.	Output. Active low
7	P0[5]	Clock output 10.368MHz. e.g. for an MCU. PCM_CLK (The PCM_CLK cannot be used as general clock signal for an external MCU in version 1.56 of the CVM PP software. The PCM_CLK is only available in PCM mode and on FP if not in standalone mode.)	Output low by default, Clock can be activated by eeprom. Output, can be disabled for power saving.
8	SPI_DI	SPI data in	Input
9	SPI_CLK	SPI clock input	Input
10	MIC_SENSE	Headset sense/detection	Analog input
11	RESET	Reset signal e.g. for an MCU.	Output, Active high
12	SPI_INT	SPI Interrupt	Output
13	SPI_DO	SPI data out	Output
14	POWER_ ON	Turns on the CV – Module in the Handset Application	Input
16	CHARGE_DET	Detection of charge when handset is placed in charger	Input, 200KOhm internal pull down resistor.
17	CHARGE_ CONTROL	Controls charging of handset	Analog output
19	VBAT3	New battery detection	
21	LRS+	Speaker+ output / Speakerphone output	Output. Speaker+ differential Output. Speakerphone single ended
22	LRS-	Speaker- output	Output. Speaker- differential

23	LRS_HS	Headset speaker	Output. Single ended
24	VREF_HS	Reference output for headset microphone	Output
25	MIC-	Headset microphone input	Input. Single ended
26	GND_ANA	Analog ground reference for audio signals	
27	MIC+	Microphone input	Input. Single ended
28	VREF+	Reference output for Microphone	Output
30	P2[3]	General purpose I/O	Digital output
31	P1[4]	General purpose I/O	Output
32	P1[3]	General purpose I/O	Input/Output with selectable pull up resistor.
33	P0[6]	General purpose I/O or PCM_DOUT Pull up P0[6] when used as PCM_DOUT.	Input/Output, with selectable pull up resistor. Input/Output, with open drain. PCM Data Output
34	P0[3]	General purpose I/O or PCM_FSC1 strobe	Input/Output, with selectable pull up resistor. Input/Output. PCM FSC1 strobe
35	P0[4]	General purpose I/O or PCM_FSC0	Input/Output, with selectable pull up. Input/Output. PCM 8 kHz FSC
36	P0[7]	General purpose I/O or PCM_DIN. Pull up P0[7] when used as PCM_DIN.	Input/Output, with selectable pull up resistor. Input/Output, with open drain. PCM Data Input
37	P1[1]	General purpose I/O	Internal pulled up
38	P1[0]	Turn speakerphone on/off. High level = SP on	Output (Controlled from external processor)
39	SDI+	JTAG one-wire debug interface	JTAG Input/Output (pulled up with 1 KOhm)
40	SERIAL_IN	UART RX	UART input
41	SERIAL_OUT	UART TX	UART output
42	DAC / ADC2	Optional ADC input	Input ADC2
45	ANT2_SEL	Selects antenne2	RF interface

6 CVM Technical Specifications

6.1 Absolute Maximum Ratings

TABLE 15. Digital I/O level VDDIO = 2.5 V

Description	Conditions	Min	Max	Units
Supply Voltage for Baseband Vsup1	FP mode	3.3[10]*	4.2	V
Supply Voltage for RF Vsup2	FP mode	3.3*	4.2	V
Supply Voltage for Baseband Vsup1	PP mode	3.3*	4.8	V
Supply Voltage for RF Vsup2	PP mode	3.3*	4.8	V
Max total current into VDDIOs			90	mA
Max current into I/O pins			20	mA
Max I/O supply voltage for devices with flash (VDDIO-GND)	[11]		3	V
Max I/O supply voltage for devices without flash (VDDIO-GND)	[11]		3.6	V
Max voltage on pin POWER_ON		GND-0.3	2.85	V
Max voltage on pin CHARGE_DET/CHARGE_LED		GND-0.3	2.85	V
Max voltage on pin VBAT3/RING		GND-0.3	2.85	V
Max voltage on pin P2[3]/POL_REV		GND-0.3	2.85	V
Max voltage on digital input pins		GND-0.3	VDDIO+0.3	V
Max voltage on any other input (incl analog pads)		GND-0.3	2.0	V
Max current through protection diodes on any pin to VDDIO			100	µA
Max current through protection circuit of POWER_ON pin	[12]		0.6	mA
Max current through protection circuit of CHARGE_DET/CHARGE_LED pin	[12]		0.6	mA
Max current through protection circuit of VBAT3/RING pin	[12]		0.6	mA
Max current through protection circuit of P2[3]/POL_REV pin	[12]		0.6	mA
Storage temperature		-30	+80	°C
ESD voltage according to human body model			400	V

Note [10]: In order to power on the unit (e.g. PP) CVM supply voltage must be above 3.5V

Note [11]: A voltage between 2.8V and 3.0V may applied for a maximum time of 50 hours, specification are guaranteed.

Note [12]: The protection current can be calculated as follows:

In case POWER_ON, CHARGE_DET/CHARGE_LED, VBAT3/RING, P2[3] /POL_REV is input, Iprotect_max = (Vext – 2.55)/(500+Rext).Rext is an external resistor which is needed if the external voltage Vext exceeds the 2.8V.

(A lower protection current value of e.g. 100µA is recommended in case power saving is important)

In case POWER_ON, CHARGE_DET/CHARGE_LED , P2[3]/POL_REV1 is output, Iprotect_max = (VDDIO – 2.55)/(500)

6.2 Digital input levels

TABLE 16. (VDDIO = 2.5 V)

Description	Conditions	Min	Max	Units
VDDIO level	VDDIO = 2.5 V +/- 2%	2.45 V	2.55 V	V
Logic 0 input level all digital pads, except P1[6], P1[7], Vbat3	VDDIO = 2.5 V		0.35*VDDIO (0.893 V)	V
Logic 0 input level P1[6] / PON			0.6	V
Logic 0 input level P1[7] / CHARGE			0.6	V
Logic 0 input level Vbat3	"New battery" detection function		0.6	V
Logic 1 input level all digital pads, except P1[6], P1[7], Vbat3	VDDIO = 2.5 V	0.65*VDDIO (1.592 V)		V
Logic 1 input level P1[6] / PON		1		V
Logic 1 input level P1[7] / CHARGE		1		V
Logic 1 input level Vbat3	"New battery" detection function	1		V

6.3 Digital output levels

TABLE 17. (VDDIO = 2.5 V)

Description	Conditions	Min	Max	Units
Logic 0 output level	VDDIO = 2.5 V		0.2*VDDIO (0.51 V)	V
Logic 1 output level	VDDIO = 2.5 V	0.8*VDDIO (1.96 V)		V

6.4 General Specification

TABLE 18.

No	Item	CVM-Module	Specification	Comment
1	Dimension	Module	26.6 x 45.6 x 4.75 mm	
2	Weight	Module	5 gram	
3	Temperature Range	Module	From -10 to +60°C	
4	MMI		Via external micro processor or PC	
5	Frequency range	DECT	From 1880 to 1898 MHz	According to DECT Standard
6	Frequency range	DCT (2G4)	From 2400 to 2483 MHz	ISM band, RTX half rate protocol
7	Expected range[13]	DECT	Typical 350 m outdoor and 75 m indoor	
8	Expected range[13]	DCT (2G4)	Typical 350 m outdoor and 75 m indoor	
9	Data speed	Via air interface	24Kbit /sec	One way
10	Standard Compliance	DECT	ETS 300 444 (DECT GAP), former TBR22[14]	DECT version only
11	Power Supply	BS_Application	Regulated voltage from 3.3V to 4.2V	
12	Power Supply	HS_Application	3 NiCd or NiMh Battery cells	(3.6V)

Note [13]: The resulting range is very dependent of the mechanical design and the antenna design. RTX is not responsible for the design of these and as such RTX is not responsible for the resulting range performance of the final product.

Note [14]: The CVM is not GAP compliant in its way to send clip to the handsets. Number and name will not be received by a GAP compliant handset.

6.5 Baseband Specification

TABLE 19.

No	Item	Baseband	Specification	Comment
1	X-tal	Oscillator	10.386 MHz The frequency accuracy can vary up to +/- 10 PPM after 3 years	See X-tal Specification document for more information
2	Serial Interface	UART	Baud rate 19200 Kbit[15]	
3	Flash Download	Via UART	Baud rate 9600/115200 Kbit	Flash download only during development
4	SDI Interface	One wire interface	Interface for debugging	
5	SPI Interface		Interface for external processor or PC	
8	Program Memory		4Mbit / 8Mbit internal BMC flash	Later Masked ROM
9	Eeprom	Module	4 Kbyte external EEPROM	
10	Analog front end/Audio	BS_Application	Interface for line I/F,CLIP, Ring detection	
11	Analog front end/Audio	HS_Application	Interface for Microphone, Earpiece, Headset	
12	PCM Interface		For e.i. external Codec	
13	Buzzer	HS_Application	Controlled by external processor	
14	Dial modes		Both DTMF and Pulse dial	
15	Keyboard and LCD	HS_Application	Controlled by external processor	
6	Caller ID (CLIP) Detection (On Hook)	DECT	Support for ETS 300 659-1/300 778-1	
7	Caller ID (CLIP) Detection (Off Hook)	DECT	Support for ETS 300 659-2/300 778-2	
8	Caller ID (CLIP) Detection (On Hook)	DCT (2G4)	Support for Bellcore	
9a	Onhook FSK detection level	DECT/DCT (2G4)	Typically: 0dBm to –40dBm	
9b	Offhook FSK detection level	DECT/DCT (2G4)	Typically: 0dBm to –40dBm	
9c	Onhook DTMF detection level	DECT/DCT (2G4)	Typically: 0dBm to –40dBm	
9d	Offhook DTMF detection level	DECT/DCT (2G4)	Typically: 0dBm to –40dBm	
10	Busy tone detection level	DECT/DCT (2G4)	Typically: 0dBm to –40dBm	
11	Dial tone detection level	DECT/DCT (2G4)	Typically: 0dBm to –40dBm	

Note [15]: The baud rate can be changed please refer to section 4.1.1

12a	Power Consumption (stand by mode)	BS_Application DECT		Typ: 55 mA	Max: 60 mA	
12b	Power Consumption[16] (talk mode)	BS_Application DECT		Typ: 65 mA	Max: 70 mA	
12c	Power Consumption (stand by mode)	HS_Application DECT		Typ: 4.5 mA	Max: 6 mA	
12d	Power Consumption (talk mode)	HS_Application DECT		Typ: 35 mA	Max: 40 mA	
12e	Power Consumption (WT stand by mode)	HS_Application DECT		Typ: 125	Max: 140	To be optimized
12f	Power Consumption (WT talk mode)	HS_Application DECT		Typ: 65	Max: 80	To be optimized
13a	Power Consumption (stand by mode)	BS_Application DCT (2G4)		Typ: 140mA	Max: 145mA	
13b	Power Consumption[16] (talk mode)	BS_Application DCT (2G4)		Typ: 145mA	Max: 150mA	
13c	Power Consumption (stand by mode)	HS_Application DCT (2G4)		Typ: 4.5 mA	Max: 6 mA	
13d	Power Consumption (talk mode)	HS_Application DCT (2G4)		Typ: 55mA	Max: 60mA	
13e	Power Consumption (WT stand by mode)	HS_Application DCT (2G4)		Typ: 27mA	Max: 40mA	
13f	Power Consumption (WT talk mode)	HS_Application DCT (2G4)		Typ: 40mA	Max: 50mA	
14	Power Consumption (Before power on)	HS_Application DCT (2G4) and DECT		Typ: 40uA	Max: 60uA	

Note [16]: Measured with one active handset in on a base (on 2G4 with the handset in dual slot mode).

6.6 Radio Part (RF) Specification

TABLE 20.

CVM 2.4 GHz				
No	**Item**	**Radio Part**	**Specification**	**Comment**
1	Receive Sensitivity[17]	DCT (2G4)	Minimum: -89dBm Typically: -92dBm to -94dBm Maximum: -96dBm	@ BER = 0.001
2	Receive IIP3	DCT (2G4)	-21dBm to -19dBm	
3	Transmit Power (NTP)[17]	DCT (2G4)	Minimum: 20dBm Typically: 22dBm to 24dBm Maximum: 25dBm	Approx. 200mW
4	Signaling Bit-rate	DCT (2G4)	576Kbit/sec	
5	Modulation	DCT (2G4)	GFSK	Bandwidth 20dB < 0,864MHz
6	Channels	DCT (2G4)	95	Channel spacing: 0.864 MHz
7	RX/TX slots	DCT (2G4)	4/4	
8	Fast Frequency Hopping	DCT (2G4)	Up to 800 hops/sec	
9	Antenna Diversity	DCT (2G4)	Control signals are available from the module	Antenna switch has to be added externally
10	Dual Slot Diversity	DCT (2G4)		Antenna switch has to be added externally
11	Standard Compliance	DCT (2G4)	FCC part 15.247/249	

TABLE 21.

CVM DECT				
No	**Item**	**Radio Part**	**Specification**	**Comment**
1	Receive Sensitivity[17]	DECT	Minimum: -89dBm Typically: -92dBm to -93dBm Maximum: -93dBm	@ BER = 0.001
2	Receive IIP3	DECT	-21dBm to -19dBm	
3	Transmit Power (NTP)[17]	DECT	Minimum: 20dBm Typically: 23dBm to 24dBm Maximum: 25.5dBm	Approx. 200mW
4	TDMA (time division multiple access)	DECT	12 time slot pr. carrier	
5	Signaling Bit-rate	DECT	1152 Kbit/sec	
6	Modulation	DECT	GFSK	Bandwidth 20dB < 1,728MHz
7	Antenna Diversity	DECT	Control signals are available from the module	Antenna switch has to be added externally
8	Standard Compliance	DECT	ETS 301 406 (former TBR6)	

The DECT module is designed and tested to meet the EN300406 requirements, and the 2.4GHz module is tested to meet the FCC requirements. However each product using CVM will have to be tested to type approve the end application. In order to meet FCC or ETSI requirements with a safe margin, careful RF design must still be done in the application around the CVM module such as: Supply routing, antenna design, diversity switch and grounding.

NOTE [17]: Measured in production

6.7 CVM Power supply specification

Power supply specification for the CVM module based on the SiTel Semiconductor SC14428 Baseband controller, SiTel Semiconductor LMX4168 transceiver and Macon RF Power Amplifier.

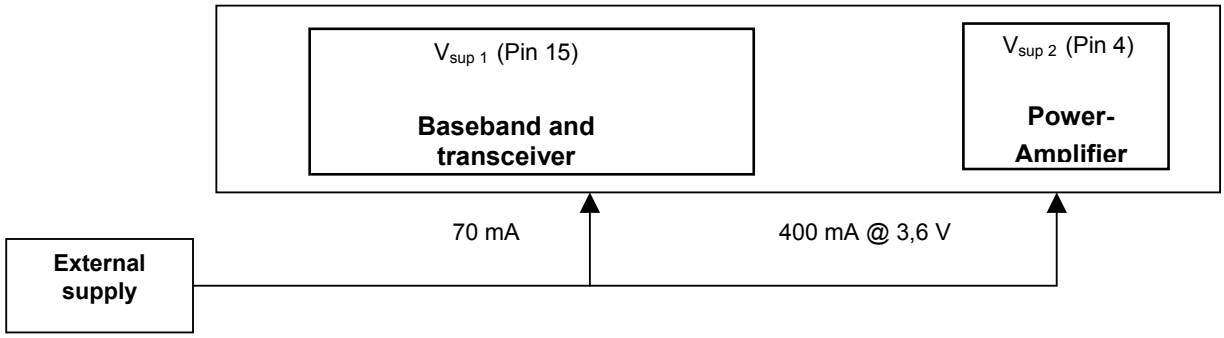


FIGURE 22. Block diagram of the power supply

6.7.1 Requirements for the Basestation Power Supply

Definition:

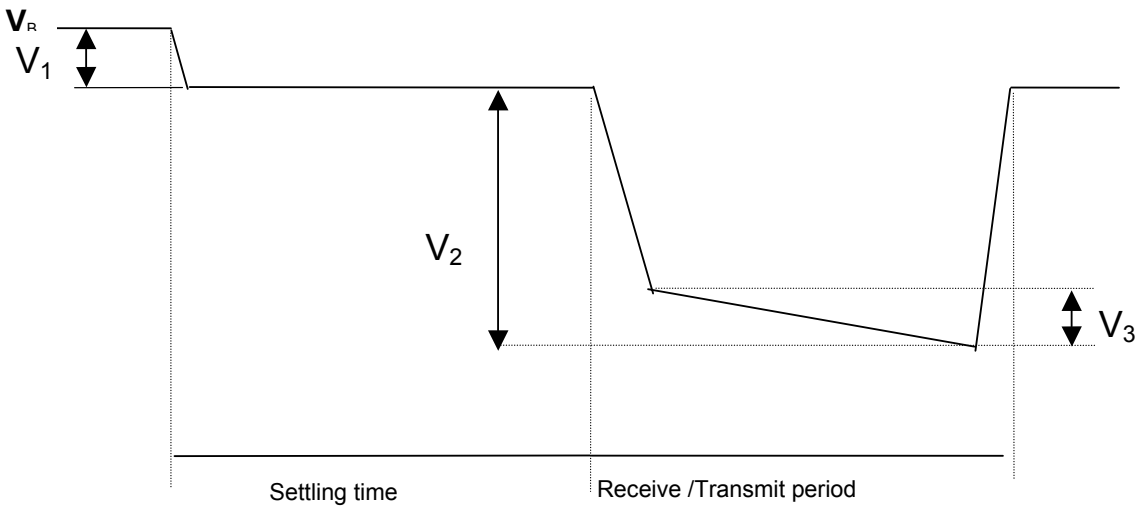


FIGURE 23.

TABLE 22.

		Requirements for the linear regulator, 3,3 V-Design
Voltage	V_B	3,6 V -0.3 / + 0.6 Volt
Settling time	V_1	< 20 mV (I= 50 mA)
Receive period	V_2	< 100 mV (I= 130 mA)
Transmit period	V_2	< 200 mV (I= 400 mA)
Drop during transmit	V_3	< 25 mV
additional ripple (DC/DC)		none

6.7.2 Time Requirement for the Handset Power Supply

To ensure correct startup of the handset the power supply voltage level must be above 3.5V within 90ms from power is suppplied to CVM. If the voltage level is below 3.5V after 90ms the CVM will power down.

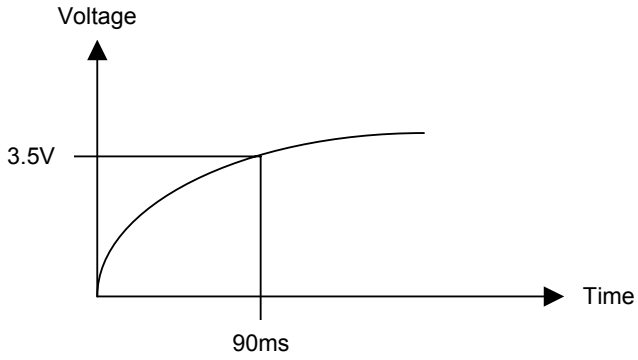


FIGURE 24.

7 CVM Connection Diagram

Connection diagram and component placement drawing.

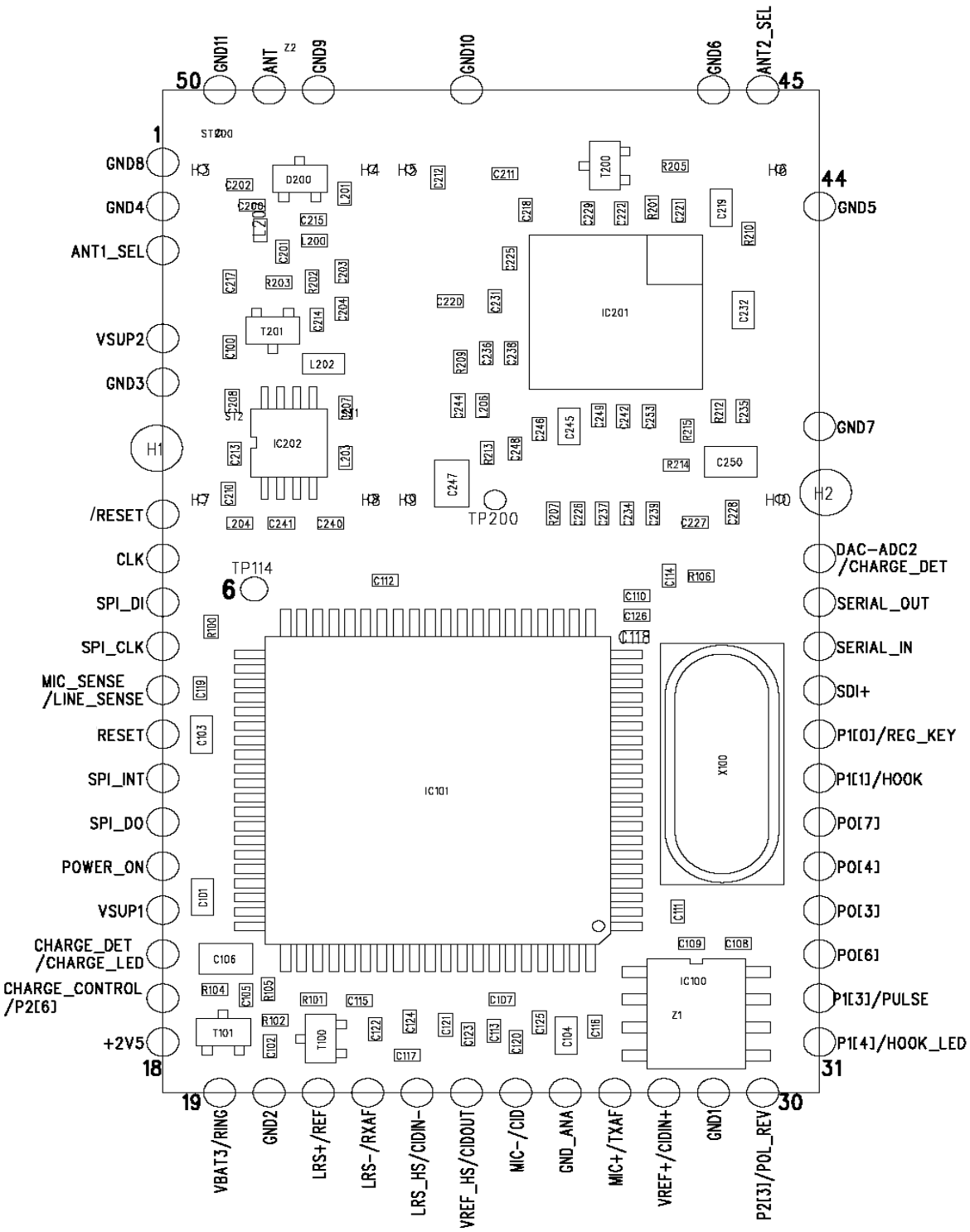


FIGURE 25.

See pin description for more information.

8 CVM Pin Description

TABLE 23.

Signal Name **Handset** / Base	IN / OUT	Handset Application	Base Application	SC14428 pin no.	CVM pin no.
GND8	I	GND	GND		1
GND4	I	GND	GND		2
ANT1_SEL	O	ANT1_SEL	ANT1_SEL	24	3
VSUP2	I	VBAT	VCC		4
GND3	I	GND	GND		5
/RESET	O	/RESET	/RESET	40	6
CLK	O	CLK	CLK	30	7
SPI_DI	I	SPI_DI	SPI_DI	45	8
SPI_CLK	I	SPI_CLK	SPI_CLK	46	9
MIC_SENSE / LINE_SENSE	I	MIC_SENSE	LINE_SENSE	47	10
RESET	O	RESET	RESET	49	11
SPI_INT	O	SPI_INT	SPI_INT	50	12
SPI_DO	O	SPI_DO	SPI_DO	51	13
POWER_ON	I	POWER_ON	POWER_ON	53	14
VSUP1	I	VBAT	VCC		15
CHARGE_DET / CHARGE_LED	I/O	CHARGE_DET	CHARGE_LED	54	16
CHARGE_CONTROL / P2[6]	O	CHARGE_CONTROL	P2[6]	55	17
+2V5	O	+2V5	+2V5		18
VBAT3 / RING	I	VBAT3	RING	56	19
GND2	I	GND	GND		20
LRS+ / REF	O	LRS+	REF	68	21
LRS- / RXAF	O	LRS-	RXAF	69	22
LRS_HS / CIDIN-	O/I	LRS_HS	CIDIN-	70	23
VREF_HS / CIDOUT	O	VREF_HS	CIDOUT	71	24
MIC- / CID	I	MIC-	CID	72	25
GND_ANA		GND_ANA	GND_ANA		26
MIC+ / TXAF	I	MIC+	TXAF	76	27
VREF+ / CIDIN+	O/I	VREF+	CIDIN+	77	28
GND1	I	GND	GND		29
P2[3] / POL_REV	I	P2[3]	POL_REV	48	30
P1[4] / HOOK_LED	O	P1[4]	HOOK_LED	39	31
P1[3] / PULSE	O	P1[3]	PULSE	38	32
P0[6]	I/O	P0[6]	P0[6]	31	33
P0[3]	I/O	P0[3]	P0[3]	28	34
P0[4]	I/O	P0[4]	P0[4]	29	35
P0[7]	I/O	P0[7]	P0[7]	32	36
P1[1] / HOOK	I/O	P1[1]	HOOK	36	37
P1[0] / REG_KEY	I	P1[0]	REG_KEY	35	38
SDI+	I/O	SDI+	SDI+	27	39
SERIAL_IN	I	SERIAL IN	SERIAL IN	26	40
SERIAL_OUT	O	SERIAL OUT	SERIAL OUT	25	41
DAC-ADC2 / CHARGE_DET	I	DAC-ADC2	CHARGE_DET	23	42
GND7	I	GND	GND		43
GND5	I	GND	GND		44

ANT2_SEL	O	ANT2_SEL	ANT2_SEL	1	45
GND6	I	GND	GND		46
GND10	I	GND	GND		47
GND9	I	GND	GND		48
ANT	I/O	ANT	ANT		49
GND11	I	GND	GND		50

8.1 GND (pin 1, 2, 5, 20, 29, 43, 44, 46, 47, 48, 50)

Ground reference for the module. There are several GND connections. All must be connected for best performance.

8.2 ANT1_SEL (pin 3)

Antenna control signal output. When high Antenna 1 will be selected.

8.3 VSUP (VSUP1 (pin 15) and VSUP2 (pin 4))

Supply voltage for the module.

Handset: In the handset this is a battery supply, using 3 Ni-Cd or Ni-MH battery cells.

Base Station: In the Base Station this is a regulated supply voltage between [3.3]V and [4.2]V.

8.4 /RESET (pin 6)

A reset signal, active low, e.g. for an MCU.

8.5 CLK (pin 7)

Clock output. Can be selected as 10.368MHz. It can also be disabled for power saving. See section 4.3.2.2 for configuration.

8.6 SPI_DI (pin 8)

SPI Data In.

8.7 SPI_CLK (pin 9)

SPI Clock Input.

8.8 MIC_SENSE / LINE_SENSE (pin 10)

Handset: Microphone Sense can detect the presence of a headset by sensing the microphone voltage. Can also sense a hook on/off command in the form of a short circuit of the microphone.

Base Station: Line Sense can detect if a parallel phone is off hook.

8.9 RESET (pin 11)

A reset signal, active high, e.g. for an MCU.

8.10 SPI_INT (pin 12)

SPI Interrupt. Output to MCU to request communication over the SPI bus.

8.11 SPI_DO (pin 13)

SPI Data Out.

8.12 POWER_ON (pin 14)

Turns on the module. A resistor divider (2 x 100k) connected to the supply voltage with the midpoint connected to POWER_ON can be used.

Handset: For the Handset a key can be inserted between the supply voltage and the resistor divider to obtain a user activated ON function. The input can be detected by the SW once the module is active, e.g. to implement a power off function via SW control.

Base Station: A resistor divider with 2 x 100k resistors connected to the supply voltage is used, with the midpoint connected to POWER_ON.

8.13 CHARGE_DET / CHARGE_LED (pin 16)

Handset: Charge Detection. If the input is above a set threshold the charger is detected as being active. If the Handset is turned OFF the Charge Detection input can turn it ON when the handset is put in the charger.

Base Station: Charge LED control. Can drive a LED with up to 8mA. A resistor must be put in series with the LED. High level = ON.

8.14 CHARGE_CONTROL / P2[6] (pin 17)

Handset: Charge control output. If the battery voltage goes above a set threshold the charge control output will go high to stop further charging, thereby protecting the battery and the SC14428 from damage due to over voltage.

Base Station: Not used.

8.15 +2V5 (pin 18)

A +2.5V regulated output voltage available for e.g. an external micro controller. Only active when the module is ON. Max power drain is [20]mA.

8.16 VBAT3 / RING (pin 19)

Handset: Should be connected to the battery supply voltage VSUP.

Base Station: Ring input from the ring detector circuit.

8.17 LRS+ / REF (pin 21)

Handset: Output for the ear-speaker.

Base Station: Reference voltage output for caller ID circuit.

8.18 LRS- / RXAF (pin 22)

Handset: Inverted output for the ear-speaker.

Base Station: RXAF audio signal to the line interface.

8.19 LRS_HS / CIDIN- (pin 23)

Handset: Speaker output for headset, single ended. Must be AC coupled to the speaker, e.g. with a 10uF capacitor.

Base Station: Inverting input of the CID op-amp.

8.20 VREF_HS / CIDOUT (pin 24)

Handset: Reference voltage, used as a supply for the headset microphone.

Base Station: Output from the CID op-amp.

8.21 MIC- / CID (pin 25)

Handset: Can be used as a differential Microphone input or as a second microphone input from headset. Must be AC coupled.

Base Station: CID input. AC coupled signal from CID op-amp output.

8.22 GND_ANA (pin 26)

Analog Ground reference for audio signals.

8.23 MIC+ / TXAF (pin 27)

Handset: Microphone input signal. Must be AC coupled.

Base Station: TXAF audio from the line interface.

8.24 VREF+ / CIDIN+ (pin 28)

Handset: Reference voltage, used as a supply for the microphone.

Base Station: Non-inverting input of the CID op-amp.

8.25 P2[3] / POL_REV (pin 30)

Handset: General purpose I/O controlled by an MCU.

Base Station: Polarity Reversal detection, used for the CID function.

8.26 P1[4] / HOOK_LED (pin 31)

Handset: General purpose I/O controlled by an MCU.

Base Station: HOOK LED control. Can drive a LED with up to 8mA. A resistor must be put in series with the LED. High level = ON.

8.27 P1[3] / PULSE] (pin 32)

Handset: General purpose I/O controlled by an MCU.

Base station: If pulse dialing is selected this signal will go high during dialing. A transistor circuit should then make sure, that the impedance of the line interface circuit is low.

For the Netherlands pulse dialing is no longer an option. Instead the port can be used to insert a 100 KOhm impedance during CID/CLIP reception.

8.28 P0[6] (pin 33)

Can be used as general input/output port or as PCM DOUT.

This port is controlled by an MCU.

8.29 P0[3] (pin 34)

Can be used as general input/output port or as input/output PCM FSC1 strobe.

This port is controlled by an MCU.

8.30 P0[4] (pin 35)

Can be used as general input/output port or as input/output PCM FSC0 strobe.

This port is controlled by an MCU.

8.31 P0[7] (pin 36)

Can be used as general input/output port or as PCM DIN.

This port is controlled by an MCU.

8.32 P1[1]/ HOOK (pin 37)

Handset: General purpose I/O controlled by an MCU.

Base Station: The HOOK signal will make the line interface go off hook when high. A max resistance of 6kohm to GND is expected, to keep it low during start-up.

8.33 P1[0] / REG_KEY (pin 38)

Handset: Turn speaker phone amplifier on/off. The on/off mode is controlled by an MCU.

Base Station: Registration and page key (optional)

8.34 SDI+ (pin 39)

SDI debug interface. Should be connected to a test point for easy access during SW debugging.

8.35 SERIAL_IN (pin 40)

Serial input for the UART of the SC14428.

8.36 SERIAL_OUT (pin 41)

Serial output from the UART of the SC14428. For normal operation this signal must be high or floating during and just after reset. For a SC14428 FLASH version to start in Flash download mode this signal must be low during power-on. Can be connected to an MCU.

8.37 DAC-ADC2 / CHARGE_DET (pin 42)

Handset: not used

Base Station: Charge indication, for Base Station use only. Can be used to detect that the charger in the Base Station is charging a Handset. If the voltage is higher than 1V the charger is assumed to be inactive. Below this voltage the charger is assumed to be active.

8.38 ANT2_SEL (pin 45)

Antenna control signal output. When high Antenna 2 will be selected.

8.39 ANT (pin 49)

Antenna connection. Must be AC coupled externally.

9 CVM Design Guidelines

Using the CVM in an application external hardware will always be needed. Using the CVM in handset or data applications MCU software to control the CVM is always required. For a base application it can be chosen to run the base in stand-alone mode or to run the base with support by a MCU. This section of the datasheet will describe what software consideration one might have, and what hardware considerations one might need to take into account, when designing the target application.

9.1 CVM MCU Software for Handset Application

In a CVM handset application the following software tasks must be handled by the MCU.

- UART/SPI communication
- Handset MMI
- Display interface
- Keyboard interface
- Battery Charge interface
- Audio handling
- Tone / Melodies handling

For control commands please refer to [1].

UART/SPI Communication:

The UART/SPI communication forms the basic of the CVM operation. It is via this interface the CVM is controlled. It is recommended to build a layered protocol to ease debug and control of the software.

Handset MMI:

The MCU must take care of the handset MMI operation. The MMI state machine must handle the call setup and call termination on the CVM.

Display Interface:

The MCU must handle the display interface including the display driver.

Keyboard Interface:

The MCU must handle the keyboard interface including the keyboard driver.

Battery Charge Handling:

If the CVM battery charge algorithm is used it must be controlled by the MCU. The MCU must handle the MMI part such as battery status for the user and the handset battery current consumption states.

Audio Handling:

The µP state machine must control when to open and close the audio.

The headset plug in detection is handled by the CVM, and a status is send to the handset MMI from the CVM. The handset MMI must handle the volume control.

Headset detection boundaries can be adjusted in eeprom. When headset indication is received from CVM headset detection logic, the MCU can decide if audio should be switched to headset and send a request to the CVM.

The handset audio handling basically consists of 4 audio states:

1. Idle (Alert) State
2. Earpiece State
3. Handsfree State (Speakerphone)
4. Headset State

Shifting between states is done through the API.

Please refer to the handset application layout for pin connections.

Tone Handling:

The MCU state machine must control when to play tones, and the volume setting.

Custom melodies can be defined in eeprom.

9.2 CVM MCU Software for Base Application

9.2.1 CVM Stand-Alone Base

In case of a stand-alone base application there is no MCU. Following the stand-alone base by configuring the CVM as a base, the CVM automatically is running as a stand-alone base with a minimum base control setup as described in section 4.3.2, and with a registration mode key configured on CVM pin 38 and a hook LED configured on CVM pin 31. The CVM software will go into registration mode if the registration key is pressed, and it is then possible to register handsets to the base.

9.2.2 CVM Non-Stand-Alone Base

By connecting an MCU to the CVM base it is possible to extend the above CVM stand-alone base implementation by a standard base speakerphone. The MCU must as with the handset application, take care of the MMI flow of the speakerphone. The CVM will do the audio routing and setup based on the MCU MMI using the software interface.

9.3 CVM Hardware Design Guidelines

Within this section general design guidelines for CVM base and handset applications are given.

9.3.1 CVM Circuit Design Guidelines

For a reference schematic refer to the CVM reference kits. With the reference kit package a non-cost optimised reference design is presented. For further information refer to section 12.1.

For a CVM base hardware design the following hardware sections will be needed besides the CVM:

- Supply voltage
- Line-Interface
- Battery Charge
- RF (antenna / antennas)
- LED and buttons
- Speakerphone (PCM Codec)

For a CVM handset design the following hardware sections will be needed besides the CVM:

- Power
- Battery Charge
- RF (antenna / antennas)
- Audio
    i. Microphone
    ii. Earpiece
    iii. Speaker
    iv. Headset

9.3.2 CVM PCB Design Guidelines

Because the digital radio frequency burst with 100 Hz time division periods (TDD noise), supply ripple and RF radiation is present it is needed to do special attention for the power supply and ground PCB layout.

Power supply considerations:

Both high and low frequency bypassing of the VSUP1 and VSUP2 connection should be provided and placed as close as possible to the CVM

In order to get the best overall performance for both base-station- and handset applications PCB a number of considerations has to be taken into account.

- Width of VSUP2 (power amplifier) supply line is recommended to be between 0.8 to 1.2 mm due to high current peaks during RF bursts.
- Angle breaks on long supply lines (VSUP1 and VSUP2) to avoid resonance frequencies in respect to DECT and 2.4 GHz frequencies. (max. 8 cm before angle break is recommended).
- Supply lines should be placed as far as possible away from sensitive audio circuits. If it is necessary to cross supply lines and audio lines it should be done with right angles between supply and audio lines/circuits (line-interface, microphone, ear-speaker, speakerphone, etc.)

Ground plane considerations:

In order to achieve the best audio performance and to avoid the influence of power supply noise, RF radiation, TDD noise and other noise sources it is important that the audio circuits on both base-station- and handset applications boards are connected to the GND_ANA (analog ground) on the CVM with separate nets in the layout.

The audio circuits, with which, it may be wise to provide separate ground nets connected to GND_ANA, are listed below.

- Microphone(s)
- Headset microphone and speaker
- Speakerphone (signal grounds)
- Line-interface (hybrid grounds)

Depending on the layout it may also be necessary to bypass a number of the audio signals listed above to avoid humming, noise from RF radiation and TDD noise with 5p6 for 2.4 GHz applications and 10pF for DECT applications. It is also important to choose a microphone of appropriate quality with a high RF immunity (with built-in capacitor).

ESD performance:

Besides TDD noise ESD performance is important for the end application. In order to achieve a high ESD performance supply lines should be placed with a large distance from charging terminals, display, headset connector and other electrical terminals with direct contact to the ESD source.

On a two-layer PCB application it is important to keep a simulated one layer ground. With a stable ground ESD and TDD noise performance will always improve.

Migration:

When fitting the CV-Module onto the application board, considerations must be taken to avoid migration between the application board terminals on the bottom side of the CV-Module.

Migration occurs when a DC is applied to a set of electrodes. Application board ground plane and CV-Module test points / via holes will make such a pair of electrodes. These electrodes must be isolated. A method could be an increased solder stop mask, or if component printing is applied to have a silk screen mask under the CV-Module.

9.3.3 Antenna layout considerations

For antenna layout considerations please refer to separate application note found on the CVM portal.

In general schematics for base-station- and handset reference kits can be used for inspiration. Please note that these applications are not fully cost optimised.

10 Audio level adjustment

10.1 Handset audio level (SLR / TOLR) and (RLR / ROLR)

For adjusting the audio levels in the handset use the same procedure as the production test procedure, see document reference [3]

10.2 Basestation audio level (SLR / TOLR) and (RLR / ROLR)

For adjusting the audio level in the basestation use the same procedure as the production test procedure, see document reference [4]

11 CVM Module Package Information

All measurements are in millimeters.

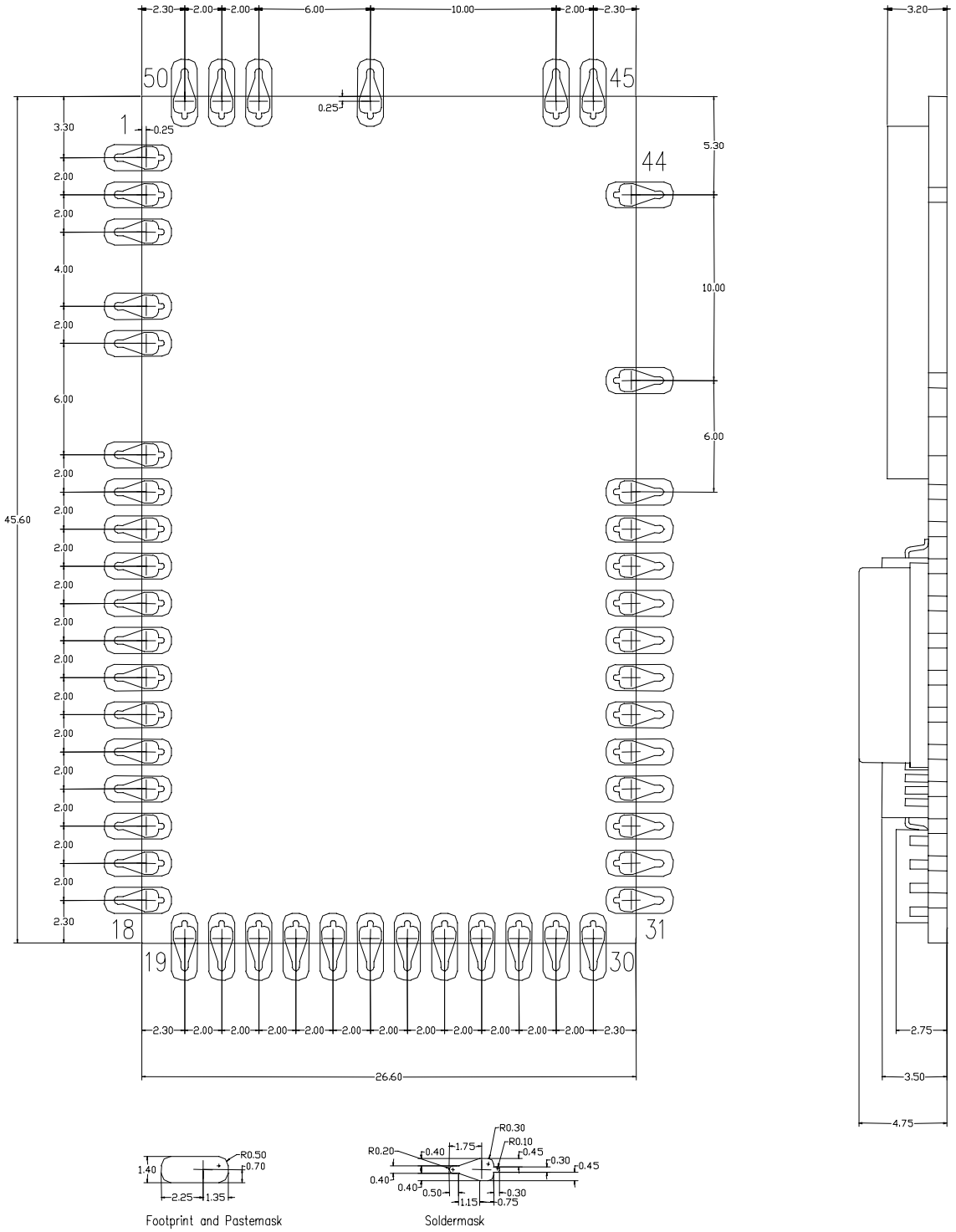


FIGURE 26.

12 CVM Additional Information

This section describes additional documentation and hardware, which is available for the application development using the CVM.

12.1 CVM Demonstration Kit

By buying a CVM demonstration kit the following will be available for the concept study and the application development:

- Hardware:
  i. Handset Application Board[18]
  ii. Base Application Board[11]
  iii. Serial PC Interface Boards
  iv. Power Supply Cables
- Software (available through SiTel Semiconductor homepage):
  i. Source Code for a simple Handset Man Machine Interface Application to be used on a PC.
  ii. Source Code for a simple Base Man Machine Interface Application to be used on a PC.
- Documentation (available through SiTel Semiconductor homepage):
  i. For the Concept Work:
    1. CVM Datasheet (this document)
  ii. For the Software Development:
    1. CVM Software Interface Description (API doc) [1]
    2. Eeprom layout document [2]
  iii. For the Reference Design:
    1. Base Application Board Schematic
    2. Handset Application Board Schematic
    3. Reference Design Test Specification [3]

12.2 CVM Production License

The following documentation will be available for a production company to start up production:

- For the Hardware:
  i. Schematic
  ii. PCB gerber data
  iii. BOM
  iv. Crystal Specification [5]
- For the production test:
  i. CVM Production Test Specification [4]

Note [18]: The application board is an example application made for demonstrating the CVM base and handset application. The boards are not cost optimized and is only for demonstration purpose.

13 Appendix A: Battery charge algorithm

13.1 Battery charge states

During battery charge of a deeply discharged Ni-MH the CVM battery charger pass through the following states

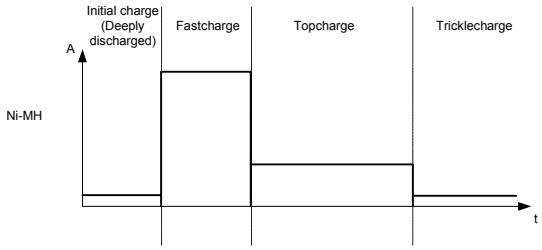


FIGURE 27.

13.2 Battery State Handler

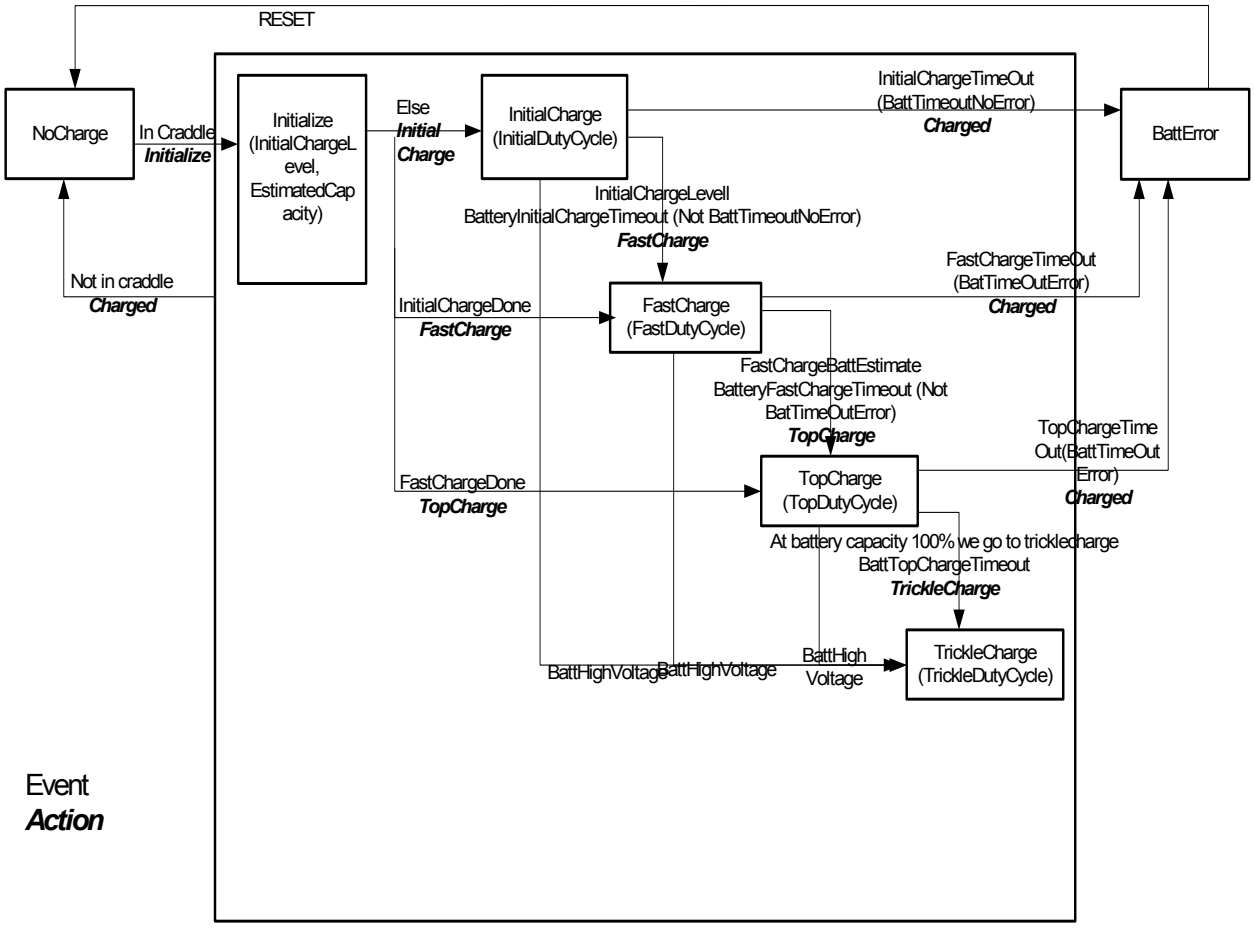


FIGURE 28.

13.2.1 Event Recognizer

TABLE 24. Event recognizer levels

Event	Ni-MH / Ni-Cd	CVM eeprom defaults
InitialChargeDone	Voltage, timeout[19](Note2	0x28 (ADC steps) InitialChargeLevel
FastChargeDone	Estimated percent, Timeout	90% of estimated capacity (eeprom parameter: EstimatedCapacity)
TopChargeDone	Estimated percent, Timeout	100% of estimated capacity (eeprom parameter: EstimatedCapacity)

TABLE 25. Timeout

13.2.2 State changes

State	CVM eeprom defaults
PreCharge	0x64*100ms=10secs (Eep: PreChargeValue)
InitialCharge	0x10*2*tick=32mins (Eep: BattInitialChargeTimeout)
FastCharge	0x5A*2*tick=3hours (Eep: BattFastChargeTimeout)
TopCharge	0x5A*2*tick=3hours (Eep: BattTopChargeTimeout)
TrickleCharge	0x00 = Disabled (Eep: BattTrickleTimeout)

Tick=1min

Change between the charge states can happen due to timeout or the specified event recognize levels.

Change to error states can happen based on timeout or too high voltage due to usage of non-chargeable batteries.

Timeout can cause state change to next charge state or to the error state. The eeprom parameter, BatTimeoutError, is a bitmask that determines whether the configured timeout should result in change to next charge state or error state.

bit0:1=statechange from **InitialCharge** to BattError allowed, 0=normal state change

bit1:1=statechange from **FastCharge** to BattError allowed, 0=normal state change

bit2:1=statechange from **TopCharge** to BattError allowed, 0=normal state change

bit3:1=statechange from **TrickleCharge** to BattError allowed, 0=normal state change

In CVM, BatTimeoutError is normally equal to 0x00, so all timeouts results in normal state changes.

Please note that the battery algorithm does not use negative delta V. The charging current is so low compared to the size of a typical battery that negative delta V does not yield reliable results. It is therefore disabled in the software.

Note[19]: Primarily used on a completely discharged battery.

14 Appendix B: Acoustic echo Canceller

The Acoustic Echo Canceller (AEC) consists basically of the following sections:

- Echo canceller with mu control (LEC block + mu control)
- Suppressor (HFREE block)
- Convergence estimator
- AGC (Softlimiter functionality)

FIGURE 28 shows the sections and the overall signal flow between

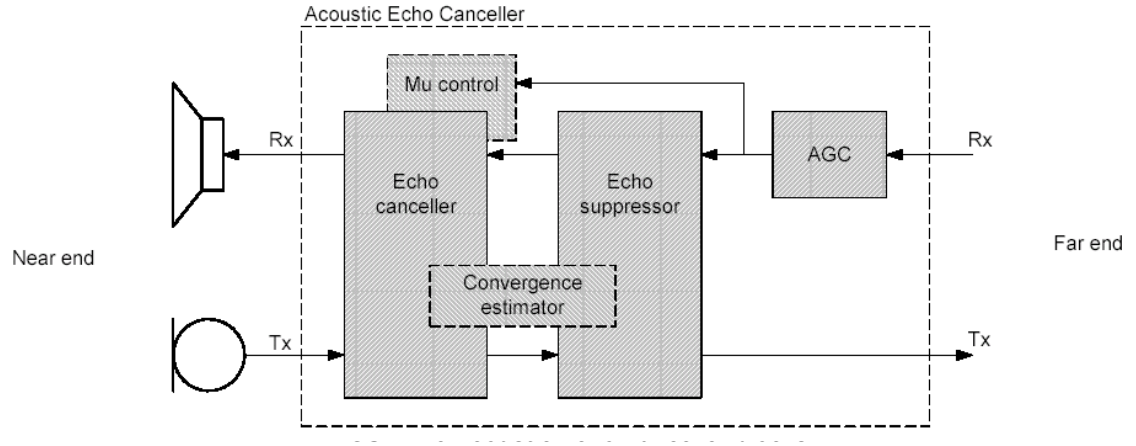


FIGURE 29.

- Clipping of the Tx signal

It is not possible to achieve a satisfactory operation of the AEC if non-linearity occurs in the acoustic paths. So for correct operation of the AEC non-linearity's MUST be avoided in all the acoustic paths. Two important design issues that make the AEC operation unsatisfactory are:

- Loudspeaker distortion (especially at lower frequencies)

14.1 Echo Canceller with mu control

The CVM echo canceller uses the standard DSP blocks that are provided by the SC14428, except for the MuCtrl. The detailed configuration of the AEC in CVM is illustrated in FIGURE 30.

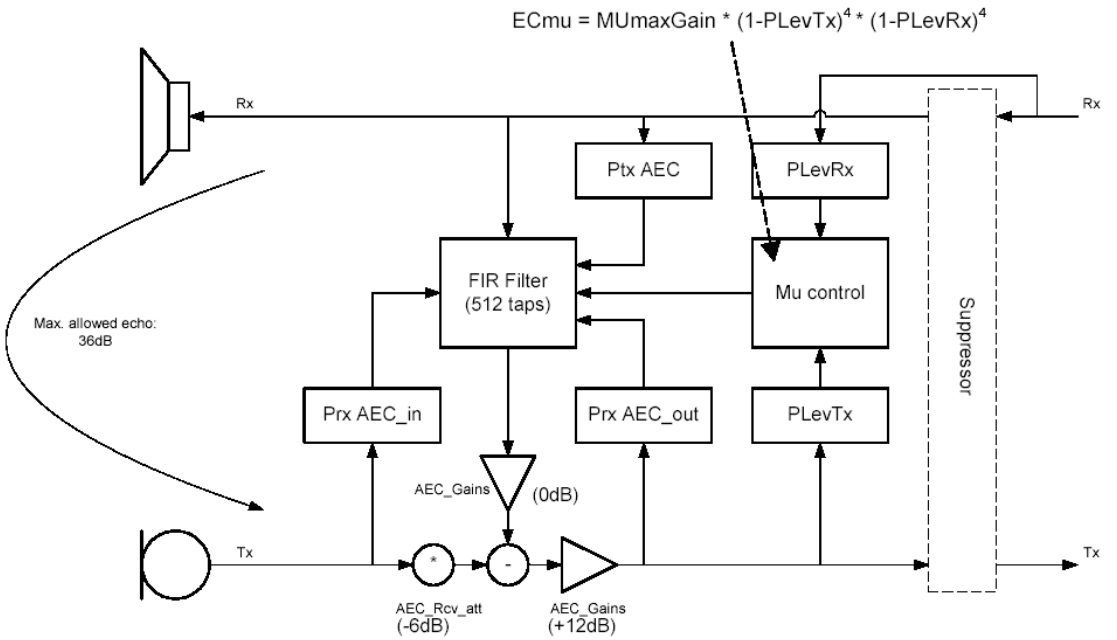


FIGURE 30. Overview of the AEC

14.1.1 MUCtrl

The MuCtrl is a block that dynamically calculates the echo-cancellation convergence speed (mu factor). The MuCtrl includes multiple summation blocks to makes the following calculation.

MUmaxGain * (1-PLevTx)^4 *(1-PLevRx)^4

The default value of MuMaxGain is 0.25.

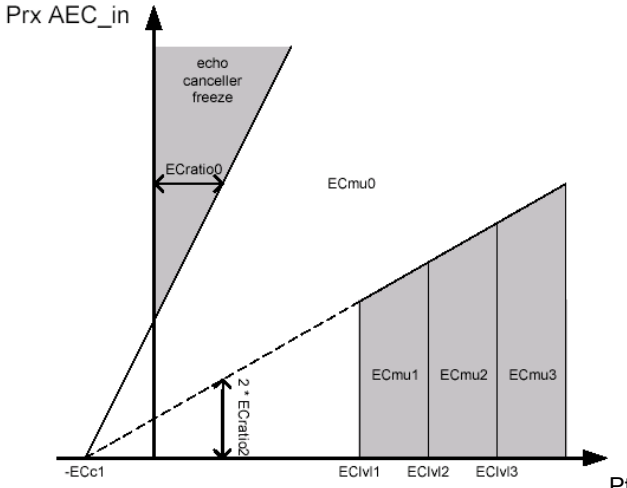


FIGURE 31.Operational area of the echo canceller Mu factor

14.1.2 Echo canceller tuning procedure

For each product and mechanical outline the echo canceller must be tuned. It is recommended to follow the below tuning procedure.

- Disable the echo suppressor (Switch_bypass = 0x8000)
- Adjust analog and digital receiving gain levels until desired performance. No clipping must occur!
- Control maximum level with AGC (AgcLvl5)
- Apply equalizer if needed
- Adjust transmit gain levels until Prx AEC_in does not saturate during

maximum receiving signal.

- Apply extra transmit gain after echo canceller until desired performance (AEC_Gains).
- Apply equalizer if needed.
- Adjust the gain of the replicated echo for best audible performance.(AEC_Gains) Not all of the echo may be cancelled.
- Fine-tune the mu control timing, mu control gain, echo canceller timing and threshold levels.
- To check whether the echo canceller is converged, monitor the FIR filter coefficients. Only the least significant byte shall be updating. (Marked by the red columns to the left.)

14.2 Echo Suppressor

The suppressor applies extra attenuation of the non-dominant party to remove the remaining echo. FIGURE 35 shows an overview of the echo suppressor.

The echo suppressor operates in three modes: Receive, Transmit and Idle mode.

The FIGURE 32 shows the relevant parameters when deciding to switch from Rx ->Tx.

Corresponding figures (FIGURE 33 and FIGURE 34) exist for the other transitions: Tx -> Rx and Idle -> Rx/Tx

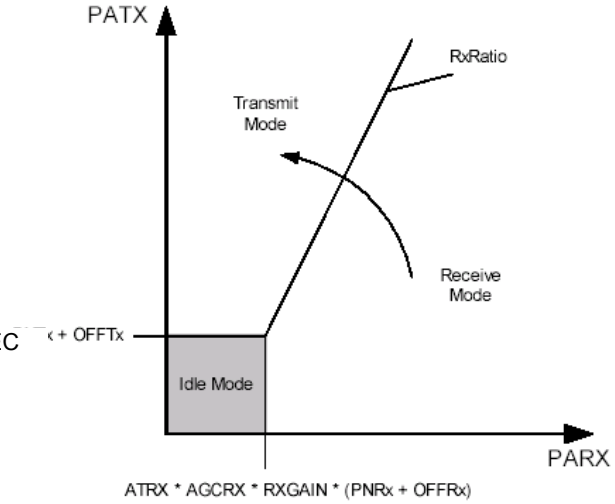


FIGURE 32.Switching from Rx -> Tx

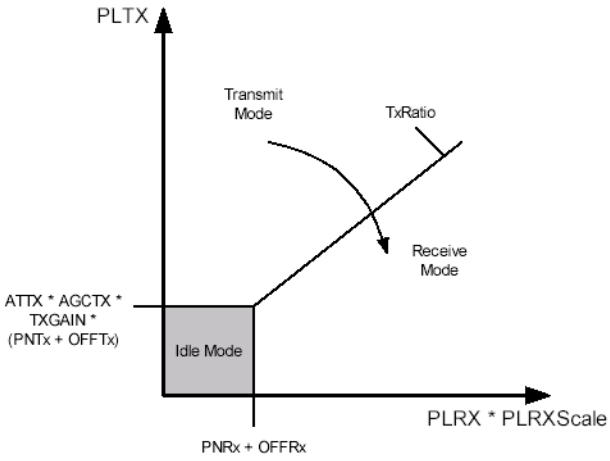


FIGURE 33. Switching from Tx -> Rx

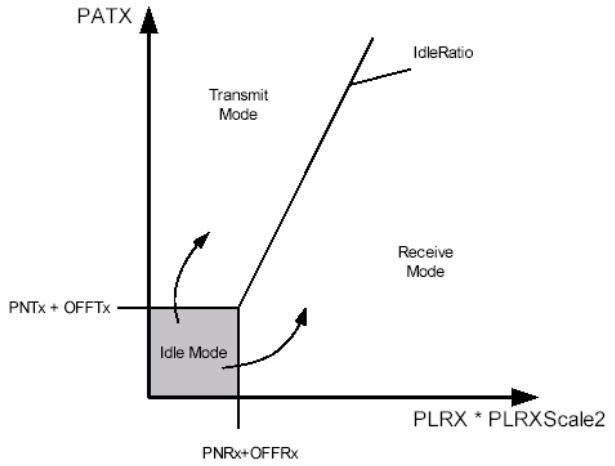


FIGURE 34.Switching from idle -> Tx/Rx

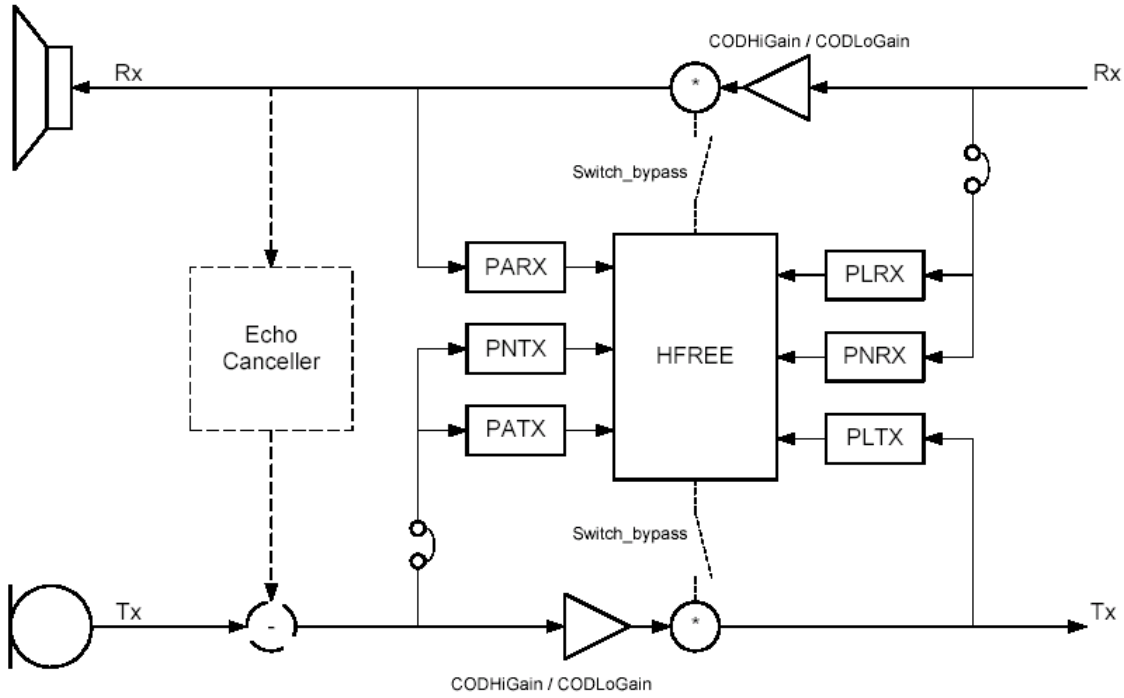


FIGURE 35. Overview of the Echo Suppressor

14.2.1 Echo suppressor tuning procedure:

Before tuning the echo suppressor it is assumed that the echo canceller is working in a stable and robust fashion. It is recommended to follow the below tuning procedure.

- Disable the convergence estimator by setting the threshold to zero, ratios to unity and timing constants to infinitely fast.
- Disable the noise detection (PNRxMax and PNTxMax = 0x0000).
- Adjust the switching depth (SupMin and SupMin_AttAECP_min) until the echo is at an acceptable level.
- Adjust the balance between Rx and Tx with the parameters: RxRatio, TxRatio
- Adjust the balance between Rx/Tx and Idle with the parameters: OffRx, OffTx, IdleRatio and PLRXScale2.
- Adjust the switching time with the parameters: RxTxcntini, Idlecntini, SuptIdleOff, SuptIdleOn, SuptOn and SuptOff.
- Adjust the noise detection with the parameters: NoiseMargin, PNRxMax and
- If necessary, fine-tune the timing of the power level detectors.

14.3 Convergence estimator description

The convergence estimator is used to control the switching filter of the echo canceller. It makes use of two extra filters:

- The Min-Filter is designed to systematically under-estimate the echo canceller performance. This is used to make the system more robust to noise from the power level detectors.
- The Max_Filter is designed to systematically over-estimate the echo canceller performance. The Max_Filter holds the peak value of the Min_Filter + a specified threshold.

The convergence estimator constantly tries to ”track down” the Max_Filter and thereby reduce the switching depth to minimum.

In case of divergence in the Max_Filter, immediate action must be taken, so the Max_Filter is designed to decay very fast, which increases the switching depth and attenuates the echo.

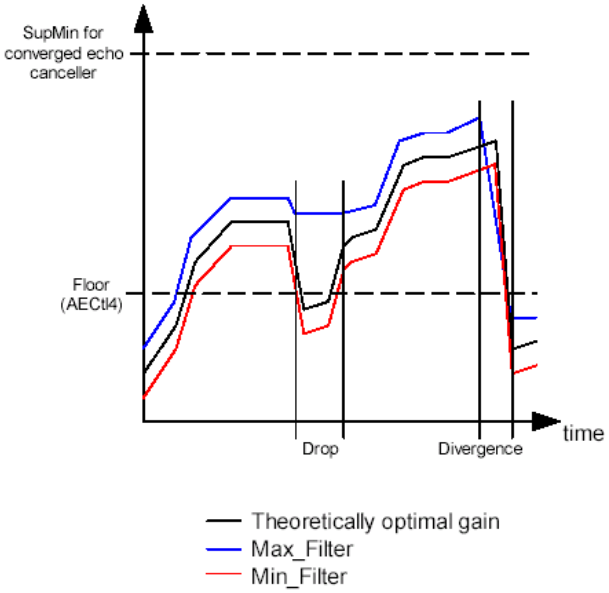


FIGURE 36.Convergence Filter Operation

14.4 Gain level diagram of the handset echo canceller

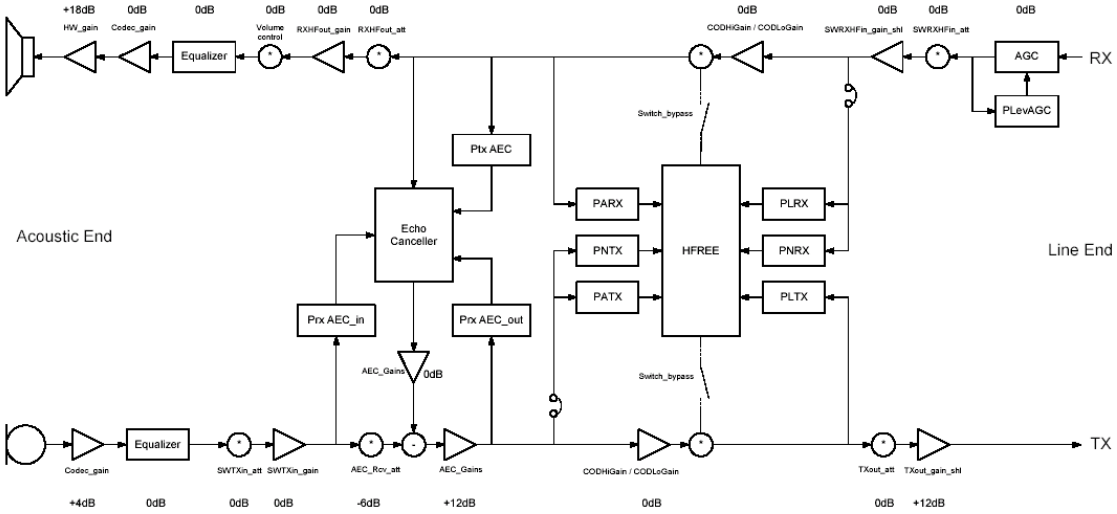


FIGURE 37. Gain level diagram of the echo canceller

14.5 Echo Canceller References

Two speakerphone specifications are mainly used:

- ***ITU-T Rec. P.342***: "Transmission characteristics for telephone band (300 -3400 Hz) digital loudspeaking and hands-free telephony terminals"
- ***I-ETS 300 245-3***: "Integrated Services Digital Network (ISDN); Technical characteristics of telephony terminals Part 3: Pulse Code Modulation (PCM) Alaw, loudspeaking and handsfree telephony"

From a subjective point of view, not all requirements are equally important, but the most relevant are:

- Sending Frequency Response
- Receiving Frequency Response (*)
- Sending Loudness Rating
- Receiving Loudness Rating (*)
- Volume Control Range
- Terminal Coupling Loss
- Stability Loss
- Harmonic Distortion Sending
- Harmonic Distortion Receiving (*)
- Out-of-Band Sending
- Out-of-Band Receiving
- Sending Noise
- Receiving Noise

(The requirements in the tests marked by (*) may be difficult to meet especially in a handset speakerphone.)

SiTel does not assume any responsibility for use of any circuitry described, no circuit patent licenses are implied and SiTel reserves the right at any time without notice to change said circuitry and specifications.

15 Appendix C: CVM Soldering Profile

The CVM should be soldered using a standard reflow soldering profile and standard solder paste as shown below. Adjustments to the profile may be necessary depending on process requirements.

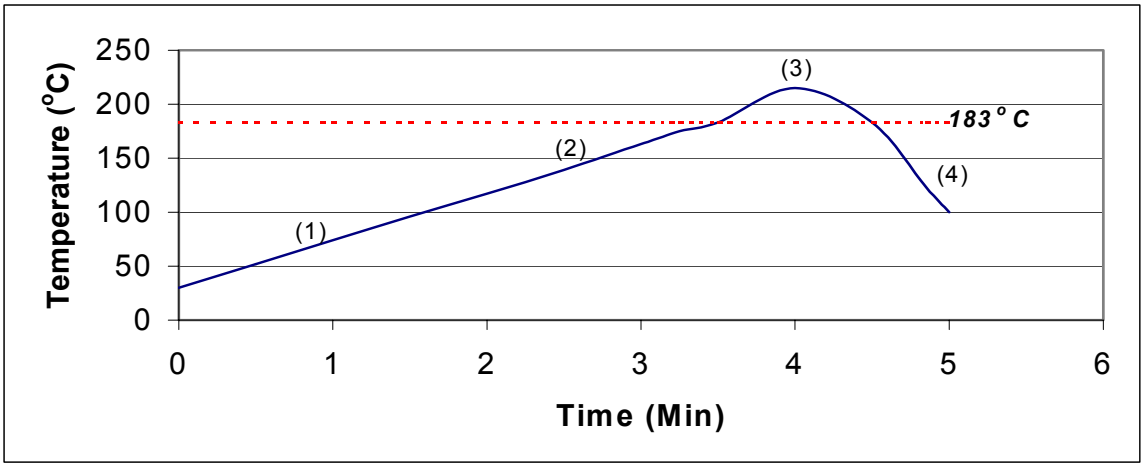


FIGURE 38. Solder Paste Composition: Sn62/Pb36/Ag2 alloy

Solder Paste supplier: Indium Corporation

1.) Preheat : The temperature rise from room temperature to 120 degrees shall be made for 30 seconds or longer. Typically 90 - 120 seconds. A linear ramp rate of 0.5º-1.0ºC/second allows gradual evaporation of volatiles.

2.) Soak or Dryout : When 120 degrees is reached, the temperature is raised to 150 degrees with a continued linear ramp of 0.5ºC - 1.0ºC/second. Typically 30 – 60 seconds. This stage serves to activate the flux and stabilize temperature across the board. The uniform heating allows a more linear ramp rate right up to liquid temperature. This eliminates the hump or conventional shoulder profile.

3.) Reflow : The linear ramp of 0.5ºC - 1.0ºC/second is continued up to the point of liquidus. When liquidus is reached the temperature should rise with about 1ºC - 2ºC/second to a spike 30 - 50 degrees above liquidus to form a quality solder joint. Time above liquidus should be 50 - 70 seconds to reduce excessive inter-metallic compound. Thermal damage and charring of the post re-flow residue can also result from excessive time above liquid and/or too high a peak temperature.

4.) Cooling : A rapid cool down of <4ºC/second is desired to form a fine grain structure. Slow cooling will form a large grain structure, which typically exhibits poor fatigue resistance. If excessive cooling > 4ºC/second is used, both the components and the solder joint can be stressed due to a high TCE mismatch.

Stencil: For the stencil a thickness of 0.127mm is recommended.

16 Appendix D: RFPI and IPEI Rules

RFPI generation:

For CVM 2G4 the CVM is born with RFPI and IPEI from manufacturing and should as such not be modified.

An RFPI consists of 40 bits (5 bytes):

1st bit: Is the SARI "On/Off" bit.

2nd - 4th bit: Defines the RFPI class.

5th - 20th bit: Is the Equipment Manufacturer's Code (EMC).

21st - 37th bit: Fixed Part Number (FPN)

38th - 40th bit: Radio fixed Part Number (RPN).

SARI:

In our system this bit **shall always be set to 0 (zero)** to disable SARI.

RFPI Class:

For residential systems class A RFPIs are always used, this means that these **3 bits must always be set to 0 (zero**).

EMC:

Equipment Manufacturer's Code, is allocated to each manufacturer by ETSI.

For the 2.4GHz system 5th bit of the RFPI must always be set in order to allow handover between a 2.4GHz system and a 2.4GHz repeater. This bit is used to synchronize the hopping sequence between the repeater and the 2.4GHz base. In the below example RFPI this bit is set.

FPN:

Fixed Part Number, shall be allocated by the manufacturer as a unique number for each EMC.

RPN:

Radio fixed Part Number, this number is allocated by the manufacturer/installer and is used to separate a maximum of 7 different cells from each other. In case of single cell FPs, RPN = 0. This indicates for a PP that this FP does not have intercell handover, since there is only one RFP. Since you don't use repeaters (multicell systems) when you test, the **RPN should always be set to 0 (zero).**

Below are examples of RFPI's:

SARI + RFPI class	EMC	FPN	RPN	Five HEX values as in CVM eeprom doc	Comments
Bit1-4	Bit5-20	Bit21-37	Bit38-40		
0000	0000 0000 0000 0001	0000 0000 0000 0000 0	000	00 00 10 00 00	First RFPI for EMC 0 00 1
0000	0000 0000 0000 0001	0000 0000 0000 0000 1	000	00 00 10 00 08	Second RFPI
0000	0000 0000 0000 0001	0000 0000 0000 0001 0	000	00 00 10 00 10	Third RFPI
0000	0000 0000 0000 0001	0000 0000 0000 0001 1	000	00 00 10 00 18	Fourth RFPI
..	..	..	..		
0000	0000 0000 0000 0001	1111 1111 1111 1111 1	000	00 00 1F FF F8	Last RFPI for EMC 0 00 1
0000	0000 0000 0000 0010	0000 0000 0000 0000 0	000	00 00 20 00 00	First RFPI for EMC 0 00 2
0000	0000 0000 0000 0010	0000 0000 0000 0000 1	000	00 00 20 00 08	Second RFPI
0000	0000 0000 0000 0010	0000 0000 0000 0001 0	000	00 00 20 00 10	Third RFPI
..	..	..	..		
0000	0000 0000 0000 0010	1111 1111 1111 1111	000	00 00 2F FF F8	Last RFPI for EMC 0 00 2
0000	0000 0000 0000 0011	0000 0000 0000 0000 0	000	00 00 30 00 00	First RFPI for EMC 0 00 3
..	..	..	..		

SiTel does not assume any responsibility for use of any circuitry described, no circuit patent licenses are implied and SiTel reserves the right at any time without notice to change said circuitry and specifications.

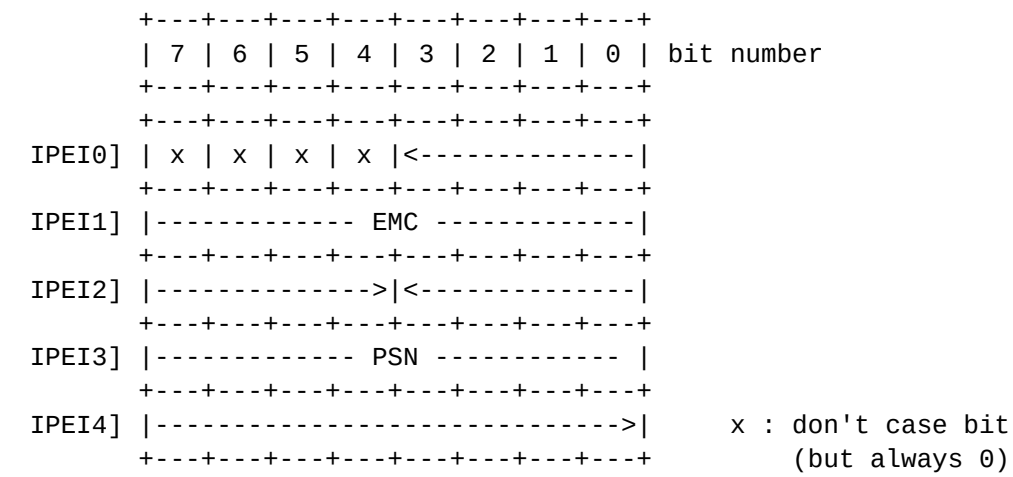
Below are examples of RFPI's for a 2.4GHz system:

SARI + RFPI class	EMC	FPN	RPN	Five HEX values as in CVM eeprom doc	Comments
Bit1-4	Bit5-20	Bit21-37	Bit38-40		
0000	1000 0000 0000 0001	0000 0000 0000 0000 0	000	01 00 10 00 00	First RFPI for EMC 0 00 1
0000	1000 0000 0000 0001	0000 0000 0000 0000 1	000	01 00 10 00 08	Second RFPI
0000	1000 0000 0000 0001	0000 0000 0000 0001 0	000	01 00 10 00 10	Third RFPI
0000	1000 0000 0000 0001	0000 0000 0000 0001 1	000	01 00 10 00 18	Fourth RFPI
..	..	..	..		
0000	1000 0000 0000 0001	1111 1111 1111 1111 1	000	01 00 1F FF F8	Last RFPI for EMC 0 00 1
0000	1000 0000 0000 0010	0000 0000 0000 0000 0	000	01 00 20 00 00	First RFPI for EMC 0 00 2
0000	1000 0000 0000 0010	0000 0000 0000 0000 1	000	01 00 20 00 08	Second RFPI
0000	1000 0000 0000 0010	0000 0000 0000 0001 0	000	01 00 20 00 10	Third RFPI
..	..	..	..		
0000	1000 0000 0000 0010	1111 1111 1111 1111	000	01 00 2F FF F8	Last RFPI for EMC 0 00 2
0000	1000 0000 0000 0011	0000 0000 0000 0000 0	000	01 00 30 00 00	First RFPI for EMC 0 00 3
..	..	..	..		

IPEI generation:

For CVM 2G4 the CVM is born with RFPI and IPEI from manufacturing and should as such not be modified.

The IPEI is the id number of the portable part.



EMC : Equipment Manufacturer's Code is allocated to each manufacturer by ETSI.

PSN : Portable equipment Serial Number, has an upper limit of over 1 million codes. PSN is the unique number for each EMC for the portable part..

In the handset we have allocated 40 bits (5 bytes) for the IPEI, these are placed in Eeprom.

As the IPEI is only 36 bits, you should always set the upper 4 bits to 0, i.e. 0x xx xx xx xx - where the x's mark the IPEI.

IPEI has no other rules besides the above and that they must not be the same. You should just start counting from e.g. 100 decimal.

Below are examples of IPEI's:

Not used	EMC	PSN	Five HEX values as in CVM eeprom doc	Comments
Bit1-4	Bit5-20	Bit21-40		
0000	0000 0000 0000 0001	0000 0000 0000 0000 0001	00 00 10 00 01	First IPEI for EMC 0 00 1
0000	0000 0000 0000 0001	0000 0000 0000 0000 0010	00 00 10 00 02	Second IPEI
..	..	..		
0000	0000 0000 0000 0001	1111 1111 1111 1111 1111	00 00 1F FF FF	Last IPEI for EMC 0 00 1
0000	0000 0000 0000 0010	0000 0000 0000 0000 0001	00 00 20 00 01	First IPEI for EMC 0 00 2
..	..	..		
0000	0000 0000 0000 0010	1111 1111 1111 1111 1111	00 00 2F FF FF	Last IPEI for EMC 0 00 2
0000	0000 0000 0000 0011	0000 0000 0000 0000 0001	00 00 30 00 01	First IPEI for EMC 0 00 3
..	..	..		

Sample code to be used in production:

```
#define WRT_RFPI        "02 3B 08 00 05 39 00
"      // Write RFPI direct from EEPROM
#define WRT_IPEI        "02 3B 08 00 05 8B 00 "
// Write IPEI direct from EEPROM
#define RD_RFPI         "02 3C 08 00 05 39 00
?"     // Read RFPI direct from EEPROM
#define RD_IPEI         "02 3C 08 00 05 8B 00 ?"
// Read IPEI direct from EEPROM
#define READ_ID         "02 5D 1C ?"            //
Read RFPI or IPEI of DUT for database
bool TMainForm::DoWriteIDs(void)  // Return write
result status
{
  BYTE RFPI[20];
  BYTE IPEI[20];

  // RFPI = 0x[0][8] 0x[SERIAL7][SERIAL6]
0x[SERIAL5][SERIAL4] 0x[SERIAL3][SERIAL2]
0x[SERIAL1][0]
  // RFPI eg . 08 12 34 56 70
  //   SERIAL1 = 7
  //   SERIAL2 = 6
  //   SERIAL3 = 5
  //   SERIAL4 = 4
  //   SERIAL5 = 3
  //   SERIAL6 = 2
  //   SERIAL7 = 1
  int  fpn = 0;
  int  psn = 0;
  bool prg_error = false; // no error
  if(CVMDect)
    fpn = Measure-
>GetSerial(DECT_RFPI_IPEI_DB);
  else
    fpn = Measure-
>GetSerial(MARS_RFPI_IPEI_DB);

  fpn=fpn*8;  // clear first three bits

  RFPI[0]=0x08;
  RFPI[1]=(fpn&0xff00000)>> 20;
  RFPI[2]=(fpn&0x00ff000)>> 12;
  RFPI[3]=(fpn&0x0000ff0)>>4;
  RFPI[4]=(fpn&0x000000f)<<4;
  AnsiString DispText = "",temp_str = "";
  DispText.sprintf("RFPI %02X %02X %02X %02X
%02X",RFPI[0],RFPI[1],RFPI[2],RFPI[3],RFPI[4]);
```

SiTel does not assume any responsibility for use of any circuitry described, no circuit patent licenses are implied and SiTel reserves the right at any time without notice to change said circuitry and specifications.

```
  Log(DispText);
  DispText.sprintf("%02X %02X %02X %02X %02X",RFPI[0],RFPI[1],RFPI[2],RFPI[3],RFPI[4]);
  SENDMAIL(WRT_RFPI + AnsiString(DispText));// RFPI
    if(SendMailForm->error){prg_error = true;}
  SENDMAIL(DUMMY_EEREAD);
  SENDMAIL(RD_RFPI);   // not checking, just reading . might be good to check !.
    if(SendMailForm->error){prg_error = true;}
  // IPEI = 0x[0][SERIAL8] 0x[SERIAL7][SERIAL6] 0x[SERIAL5][SERIAL4] 0x[SERIAL3][SERIAL2] 0x[SERIAL1][SERIAL0]
  // IPEI eg . 0B 12 34 56 78
  //   SERIAL0 = 8
  //   SERIAL1 = 7
  //   SERIAL2 = 6
  //   SERIAL3 = 5
  //   SERIAL4 = 4
  //   SERIAL5 = 3
  //   SERIAL6 = 2
  //   SERIAL7 = 1
  //   SERIAL8 = A
  psn = fpn;    // max = 268.435.455
  IPEI[0]=0|((psn&0x0f00000000)>> 32);
  IPEI[1]=(psn&0xff000000)>> 24;
  IPEI[2]=(psn&0x00ff0000)>> 16;
  IPEI[3]=(psn&0x0000ff00)>>8;
  IPEI[4]=(psn&0x000000ff);
  DispText.sprintf("IPEI %02X %02X %02X %02X %02X",IPEI[0],IPEI[1],IPEI[2],IPEI[3],IPEI[4]);
  Log(DispText);

  DispText.sprintf("%02X %02X %02X %02X %02X",IPEI[0],IPEI[1],IPEI[2],IPEI[3],IPEI[4]);
  SENDMAIL(WRT_IPEI + AnsiString(DispText));// IPEI
    if(SendMailForm->error){prg_error = true;}
  SENDMAIL(DUMMY_EEREAD);
    if(SendMailForm->error){prg_error = true;}
  SENDMAIL(RD_IPEI);
    if(SendMailForm->error){prg_error = true;}

  return(prg_error);
}
```

NOTES

LIFE SUPPORT POLICY

SiTel'S PRODUCTS ARE NOT AUTHORIZED FOR USE AS CIRTICAL COMPONENTS IN LIFE SUPPORT DEVICES OR SYSTEMS WITHOUT THE EXPRESS WRITTEN APPROVAL OF THE PRESIDENT AND GENERAL COUNSIL OF SITEL SEMICONDUCTOR CORPORATION. As used herein:

1. Life support devices or systems are devices or systems which, (a) are in for surgical implant into the body, or (b) support or sustain life, and whose failure to perform, when properly used in accordance with instructions for use provided in the labelling, can be reasonably expected to result in a significant injury to the user.

2. A critical component is any component of a life support system whose failure to perform can be reasonably expected to cause the failure of the life support device or system, or to affect it safety or effectiveness.

SiTel Semiconductor BV
Tel: +31736408822
Fax: +31736408823
cvm.support@sitelsemi.com

SiTel does not assume any responsibility for use of any circuitry described, no circuit patent licenses are implied and SiTel reserves the right at any time without notice to change said circuitry and specifications.