FCC PART 15 Subpart C

EMI MEASUREMENT AND TEST REPORT

For

VTech Telecommunications Ltd.

23/F Tai Ping Industrial Center Block 1
57 Ting Kok Road, Tai Po NT, Hong Kong

FCC ID: EW75299-H00

February 13, 2003

This Report Concerns:	**Equipment Type:**
☒ Permissive Change Report	Cordless Phone

Test Engineer:	Jeff Lee
Report No.:	R0301132
Test Date:	January 16, 2003
Reviewed By:	Hans Mellberg
Prepared By:	Bay Area Compliance Laboratory Corporation (BACL) 230 Commercial Street Sunnyvale, CA 94085 Tel (408) 732-9162 Fax (408) 732-9164

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1 - GENERAL INFORMATION

1.1 Product Description for Equipment Under Test (EUT)

The *VTech Telecommunications Ltd.'s* product, model name: *T2406* or "EUT" as referred to in this report is a 900MHz handset of cordless telephone. The EUT measured approximately 6.5" L x 1.8" W x 1.1"H.

The EUT was supplied with VTech AC/DC adapter, M/N: U090050D01.

** The test data gathered is from typical production samples provided by the manufacturer.*

1.2 Objective

This document is a qualification tes report based on the Electromagnetic Interference (EMI) tests performed on the EUT. The EMI measurements were performed according to the measurement procedure described in ANSI C63.4: 1992.

The object of the manufacturer is to determine whether the electromagnetic emissions from the equipment under test, referred to as EUT hereafter, are within the specification limits defined by FCC Title 47, Part 15, Subpart C, section 15.205, 15.207, and 15.249.

1.3 Related Submittal(s)/Grant(s)

This Class II Permissive Change device has been tested at BACL 12/23/01, please refer to BACL report, R0212231. The new product, model: T2406, has no electronic changes. The circuitry is the same expect the layout (COB & separate module).

1.4 Test Methodology

All measurements contained in this report were conducted with ANSI C63.4 - 1992, American National Standard for Methods of Measurement of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the range of 9 kHz to 40 GHz. All radiated and conducted emissions measurement was performed at BACL. The radiated testing was performed at an antenna-to-EUT distance of 3 meters.

1.5 Test Facility

The Open Area Test site used by BACL to collect radiated and conducted emission measurement data is located in the back parking lot of the building at 230 Commercial Street, Sunnyvale, California, USA.

Test site at BACL has been fully described in reports submitted to the Federal Communication Commission (FCC) and Voluntary Control Council for Interference (VCCI). The details of these reports has been found to be in compliance with the requirements of Section 2.948 of the FCC Rules on February 11 and December 10, 1997 and Article 8 of the VCCI regulations on December 25, 1997. The facility also complies with the radiated and AC line conducted test site criteria set forth in ANSI C63.4-1992.

The Federal Communications Commission and Voluntary Control Council for Interference has the reports on file and is listed under FCC file 31040/SIT 1300F2 and VCCI Registration No.: C-1298 and R-1234. The test site has been approved by the FCC and VCCI for public use and is listed in the FCC Public Access Link (PAL) database.

Additionally, BACL is a National Institute of Standards and Technology (NIST) accredited laboratory, under the National Voluntary Laboratory Accredited Program (Lab Code 200167-0). The scope of the accreditation covers the FCC Method - 47 CFR Part 15 - Digital Devices, CISPR 22: 1997: Electromagnetic Interference - Limits and Methods of Measurement of Information Technology Equipment test methods.

1.6 Test Equipment List

Manufacturer	Description	Model	Serial Number	Cal. Due Date
HP	Spectrum Analyzer	8564E	08303	12/6/2003
HP	Spectrum Analyzer	8593B	2919A00242	12/20/2003
HP	Amplifier	8349B	2644A02662	12/20/2003
HP	Quasi-Peak Adapter	85650A	917059	12/6/2003
HP	Amplifier	8447E	1937A01046	12/6/2003
A.H. System	Horn Antenna	SAS0200/571	261	12/27/2003
Com-Power	Log Periodic Antenna	AL-100	16005	11/2/2003
Com-Power	Biconical Antenna	AB-100	14012	11/2/2003
Solar Electronics	LISN	8012-50-R-24-BNC	968447	12/28/2003
Com-Power	LISN	LI-200	12208	12/20/2003
Com-Power	LISN	LI-200	12005	12/20/2003
BACL	Data Entry Software	DES1	0001	12/20/2003

***Statement of Traceability: BACL Corp.** certifies that all calibration has been performed using suitable standards traceable to the NIST.

1.7 Local Support Equipment List and Details

Manufacturer	Description	Model	Serial Number	FCC ID
TELTONE CORP.	Simulator	TLS-3B-01	80071	DOC
Panasonic	Telephone	KX-T3175	6IBTB142741	ACJMLA-75986-MT-E

1.8 External I/O Cabling List and Details

Cable Description	Length (M)	Port/From	To
Non-Shielded telephone cable	2.0	RJ 11 Port/EUT	Telephone Simulator RJ11Port
Non-Shielded telephone cable	2.0	RJ 11 Port/Simulator	Telephone RJ11 Port/Panasonic

2 - SYSTEM TEST CONFIGURATION

2.1 Description of Test Configuration

The EUT was configured for testing in a typical fashion (as normally used by a typical user).

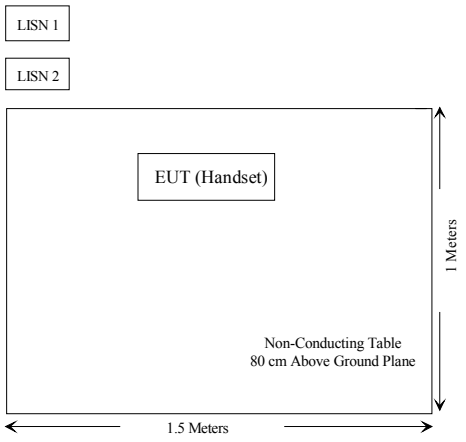
Handset being tested: The Handset unit was placed on the wooden table and tested in three orthogonal axis. The handset was connected to the headset via its headset port. The Low, middle, and high channels were tested. The handset was transmitting to and receiving from the Base unit. The EUT was investigated for emissions while off hook. The radiated data was taken in this mode of operation. All initial and final investigations were performed with the EMI receiver in manual mode scanning the frequency range continuously. The cables were bundled and routed as shown in the 2.3.

2.2 Configuration of Test System

Radiated Emission: Handset

2.3 Test Setup Block Diagram

Radiated Emission: Handset



2.4 Equipment Modifications

No modification(s) to the EUT were made by BACL to comply with the applicable limits.

3 - RADIATED EMISSION DATA

3.1 Measurement Uncertainty

All measurements involve certain levels of uncertainties, especially in field of EMC. The factors contributing to uncertainties are spectrum analyzer, cable loss, antenna factor calibration, antenna directivity, antenna factor variation with height, antenna phase center variation, antenna factor frequency interpolation, measurement distance variation, site imperfections, mismatch (average), and system repeatability.

Based on NIS 81, The Treatment of Uncertainty in EMC Measurements, the best estimate of the uncertainty of a radiation emissions measurement at BACL is $\pm$4.0 dB.

3.2 EUT Setup

The radiated emission tests were performed in the open area 3-meter test site, using the setup in accordance with the ANSI C63.4 - 1992. The specification used was the FCC 15 Subpart C limits.

The EUT was connected to 110Vac/60Hz power source and it was placed center and the back edge of the test table.

The spacing between the peripherals was 10 centimeters.

The external I/O cables were draped over edge of the test table and bundle when necessary.

3.3 Spectrum Analyzer Setup

According to FCC Rules, 47 CFR 15.33 (a) (1), the system was tested to 25GHz.

During the radiated emission test, the spectrum analyzer was set with the following configurations:

Frequency Range	***RBW***	***Video B/W***
Below 30MHz	10kHz	10kHz
30 – 1000MHz	100kHz	100kHz
Above 1000MHz	1MHz	1MHz

3.4 Test Procedure

For the radiated emissions test, the EUT was positioned and tested in 3 orthogonal axis with new battery.

Maximizing procedure was performed on the three highest emissions to ensure EUT compliance is with all installation combinations. All data was recorded in the peak detection mode. Quasi-peak readings was performed only when an emission was found to be marginal (within -4 dB of specification limit), and are distinguished with a "**Qp**" in the data table.

3.5 Corrected Amplitude & Margin Calculation

The Corrected Amplitude is calculated by adding the Antenna Factor and Cable Factor, and subtracting the Amplifier Gain from the Amplitude reading. The basic equation is as follows:

Corr. Ampl. = Indicated Reading + Antenna Factor + Cable Factor - Amplifier Gain

The "**Margin**" column of the following data tables indicates the degree of compliance with the applicable limit. For example, a margin of -7dBμV means the emission is 7dBμV below the maximum limit for applicable limits. The equation for margin calculation is as follows:

Margin = Corr. Ampl. - Applicable Limit

3.6 Summary of Test Results

According to the data in section 3.7, the EUT complied with the FCC Title 47, Part 15, Subpart C, section 15.205, 15.207, and 15.249 after tested to 10^{th} harmonics as required by FCC and had the worst margin of:

Handset, 30MHz to 25GHz, 3 Meters:

-2.0 dB at 912.75 MHz in the Vertical polarization at Low Frequency

-2.2 dB at 917.1 MHz in the Vertical polarization at High Frequency

-18.3 dB at 295.40 MHz in the Vertical polarization, Unintentional Emission

3.7 Radiated Emissions Test Result Data

3.7.1 Handset Unit, 30 MHz to 25GHz, 3 meters

INDICATED			TABLE	ANTENNA		CORRECTION FACTOR			CORRECTED AMPLITUDE	FCC 15 Subpart C	
Frequency MHz	Ampl. dBμV/m	Comments	Angle Degree	Height Meter	Polar H/ V	Antenna dBμV/m	Cable DB	Amp. dB	Corr. Ampl. dBμV/m	Limit dBμV/m	Margin dB
Low Frequency											
912.75	89.9	PEAK, FUND	30	1.8	V	23.2	3.9	25.0	92.0	94.0	-2.0
912.75	88.3	PEAK, FUND	0	1.5	H	23.2	3.9	25.0	90.4	94.0	-3.6
1825.50	50.2	AVE.	210	1.5	V	25.3	2.6	30.0	48.1	54.0	-5.9
1825.50	47.4	AVE.	180	1.5	H	25.3	2.6	30.0	45.3	54.0	-8.7
2738.25	41.5	AVE.	60	1.5	V	29.0	3.7	30.0	44.2	54.0	-9.8
2738.25	40.6	AVE.	90	1.2	H	29.0	3.7	30.0	43.3	54.0	-10.7
2409.90	40.2	AVE.	110	1.2	V	28.1	3.4	30.0	41.7	54.0	-12.4
2409.90	37.9	AVE.	130	1.5	H	28.1	3.4	30.0	39.4	54.0	-14.7
3651.00	33.7	AVE.	0	1.2	V	30.3	4.3	30.0	38.3	54.0	-15.7
3651.00	31.1	AVE.	45	1.5	H	30.3	4.3	30.0	35.7	54.0	-18.3
1825.50	57.6	PEAK	210	1.5	V	25.3	2.6	30.0	55.5	74.0	-18.5
2738.25	50.1	PEAK	60	1.5	V	29.0	3.7	30.0	52.8	74.0	-21.2
1825.50	54.8	PEAK	180	1.5	H	25.3	2.6	30.0	52.7	74.0	-21.3
2738.25	49.7	PEAK	90	1.2	H	29.0	3.7	30.0	52.4	74.0	-21.6
2409.90	49.5	PEAK	110	1.2	V	28.1	3.4	30.0	51.0	74.0	-23.1
2409.90	46.1	PEAK	130	1.5	H	28.1	3.4	30.0	47.6	74.0	-26.5
3651.00	40.3	PEAK	0	1.2	V	30.3	4.3	30.0	44.9	74.0	-29.1
3651.00	38.2	PEAK	45	1.5	H	30.3	4.3	30.0	42.8	74.0	-31.2

INDICATED			TABLE	ANTENNA		CORRECTION FACTOR			CORRECTED AMPLITUDE	FCC 15 Subpart C	
Frequency MHz	Ampl. dBμV/m	Comments	Angle Degree	Height Meter	Polar H/ V	Antenna dBμV/m	Cable DB	Amp. dB	Corr. Ampl. dBμV/m	Limit dBμV/m	Margin dB
High Frequency											
917.10	89.7	PEAK, FUND	270	1.5	V	23.2	3.9	25.0	91.8	94.0	-2.2
917.10	88.1	PEAK, FUND	30	1.5	H	23.2	3.9	25.0	90.2	94.0	-3.8
1834.20	49.8	AVE.	110	1.5	V	25.3	2.6	30.0	47.7	54.0	-6.3
1834.20	46.5	AVE.	130	1.5	H	25.3	2.6	30.0	44.4	54.0	-9.6
2751.30	41.2	AVE.	250	1.2	V	29.0	3.7	30.0	43.9	54.0	-10.1
2751.30	40.3	AVE.	270	1.2	H	29.0	3.7	30.0	43.0	54.0	-11.0
2418.60	39.1	AVE.	0	1.5	V	28.1	3.4	30.0	40.6	54.0	-13.5
2418.60	36.4	AVE.	15	1.2	H	28.1	3.4	30.0	37.9	54.0	-16.2
3668.40	32.6	AVE.	90	1.5	V	30.3	4.3	30.0	37.2	54.0	-16.8
3668.40	30.7	AVE.	120	1.5	H	30.3	4.3	30.0	35.3	54.0	-18.7
1834.20	57.2	PEAK	110	1.5	V	25.3	2.6	30.0	55.1	74.0	-18.9
1834.20	54.6	PEAK	130	1.5	H	25.3	2.6	30.0	52.5	74.0	-21.5
2751.30	49.3	PEAK	250	1.2	V	29.0	3.7	30.0	52.0	74.0	-22.0
2751.30	48.5	PEAK	270	1.2	H	29.0	3.7	30.0	51.2	74.0	-22.8
2418.60	48.8	PEAK	0	1.5	V	28.1	3.4	30.0	50.3	74.0	-23.8
2418.60	45.6	PEAK	15	1.2	H	28.1	3.4	30.0	47.1	74.0	-27.0
3668.40	39.7	PEAK	90	1.5	V	30.3	4.3	30.0	44.3	74.0	-29.7
3668.40	37.6	PEAK	120	1.5	H	30.3	4.3	30.0	42.2	74.0	-31.8
Unintentional Emission, 30MHz to 1000MHz											
295.40	36.7		15	1.5	V	13.7	2.3	25.0	27.7	46.0	-18.3
147.40	34.6		270	1.5	H	12.6	1.7	25.0	23.8	43.5	-19.7
192.75	29.8		310	1.2	H	13.7	2.1	25.0	20.6	43.5	-22.9
152.84	30.2		30	1.2	V	12.7	1.7	25.0	19.6	43.5	-23.9
83.66	30.4		90	1.5	H	9.5	1.2	25.0	16.1	40.0	-23.9

Note: The handset was positioned and tested in 3 orthogonal axis and new battery.

AVG: Average
FUND: Fundamental

4 - BAND EDGES TESTING

Requirements: FCC 15.249 (c), the emission power at the START and STOP frequencies shall be at least 50 dB below the level of the fundamental or to the general radiated emission limits in FCC 15.209, whichever is the lesser attenuation.

4.1 Test Procedure

With the EUT's antenna attached, the EUT's radiated emission power was received by the test antenna which was connected to the spectrum analyzer with the START and STOP frequencies set to the EUT's operation band.

4.2 Test Equipment

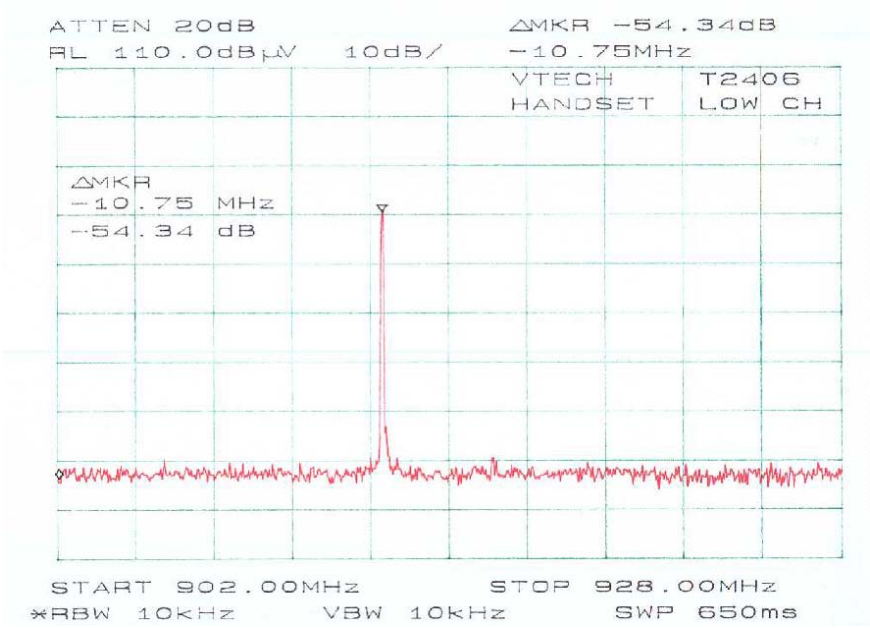
HP 8566B Spectrum Analyzer
HP 7470A Plotter

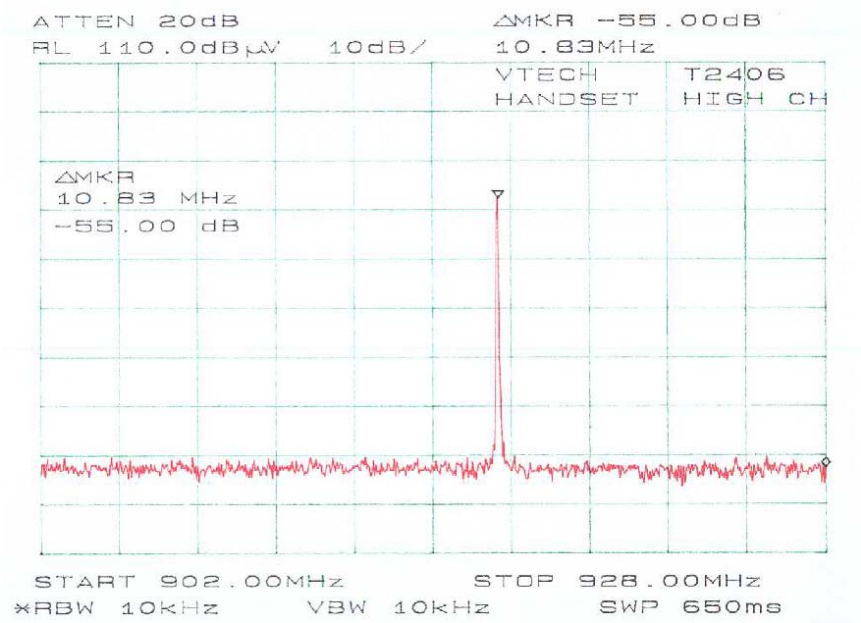
4.3 Test Results

Refer to the attached plots.

Base - Low Frequency
Base - High Frequency

Handset - Low Frequency
Handset - High Frequency


ATTEN 20dB
RL 110.0dBμV 10dB/
ΔMKR -54.34dB
-10.75MHz
VTECH T2406
HANDSET LOW CH
ΔMKR
-10.75 MHz
-54.34 dB
START 902.00MHz
STOP 928.00MHz
*RBW 10kHz
VBW 10kHz
SWP 650ms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RL 110.0dBμV 10dB/
ΔMKR -55.00dB
10.83MHz
VTECH T2406
HANDSET HIGH CH
ΔMKR
10.83 MHz
-55.00 dB
START 902.00MHz
STOP 928.00MHz
*RBW 10kHz
VBW 10kHz
SWP 650ms

APPENDIX A - FCC PRODUCT LABELING AND WARNING STATEMENT

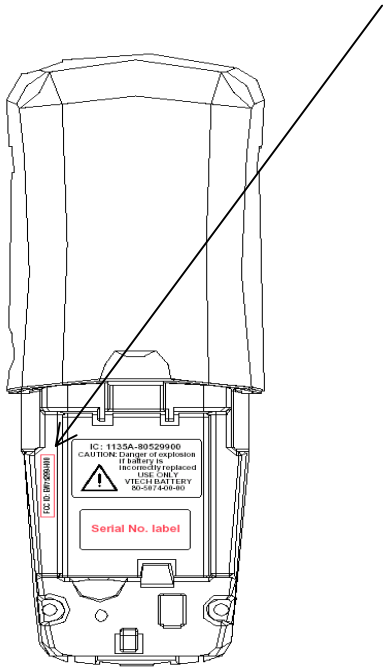
FCC ID Label

FCC ID: EW75299-H00

Specifications: Text is black or white in color and is left justified. Labels are silk-screened and shall be "permanently affixed" at a conspicuous location on the EUT.

Proposed Label Location on EUT

Rear View of Handset / Proposed FCC ID Label Location



FCC Warning Statement

A FCC Warning Statement is provided in the product manual.

APPENDIX B - TEST SETUP PHOTOGRAPHS

Handset Radiated Emission - Front View

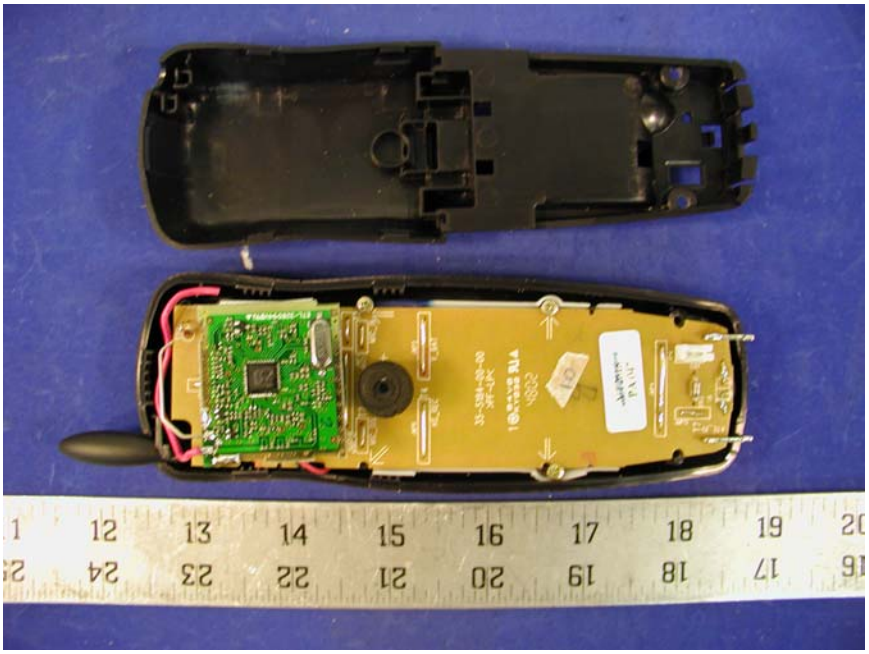
Handset Radiated Emission - Rear View

APPENDIX C - EUT EXTERNAL PHOTOGRAPHS

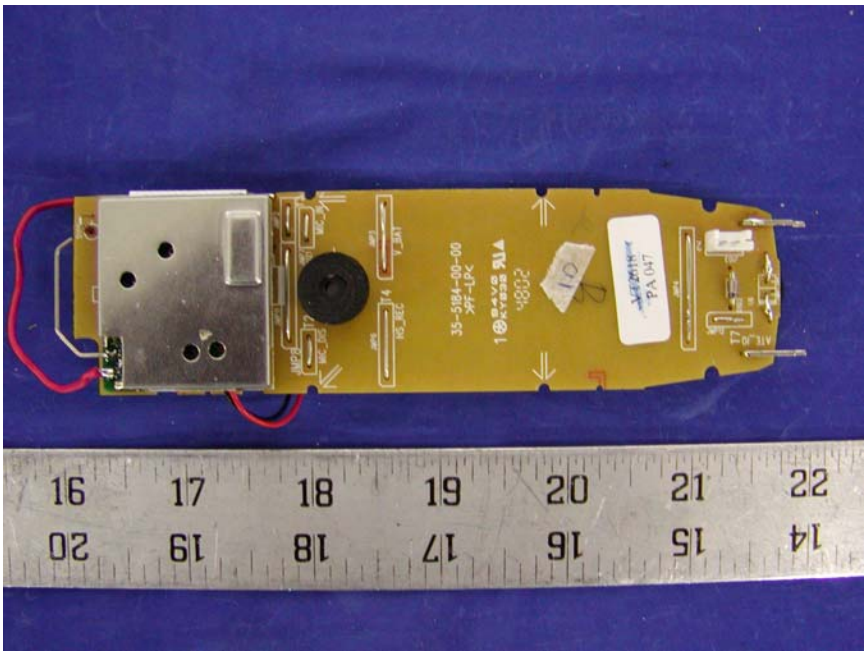
Handset – Top View

Handset – Bottom View

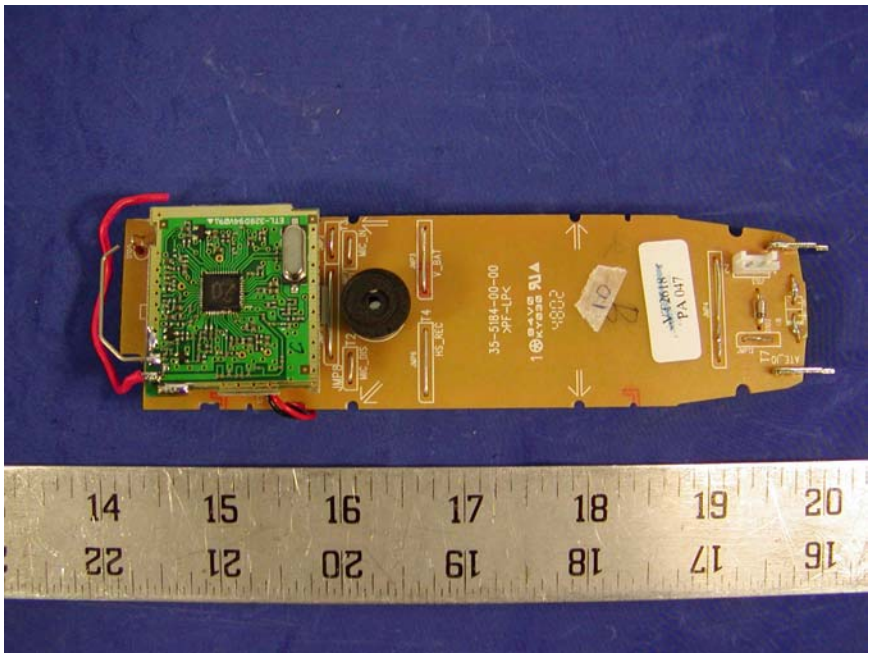
Handset – Main Board with Housing



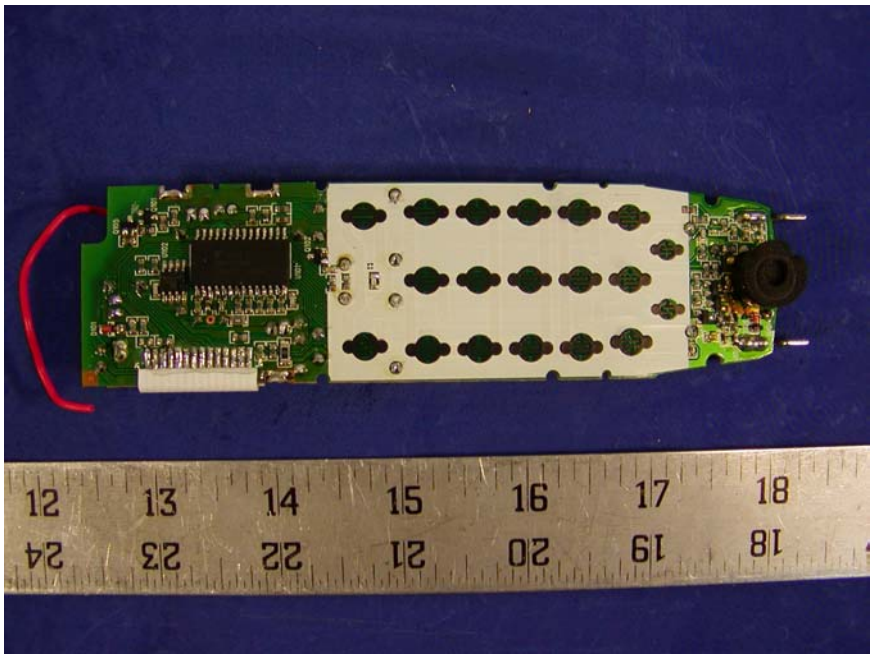
Handset – Main Board Top View



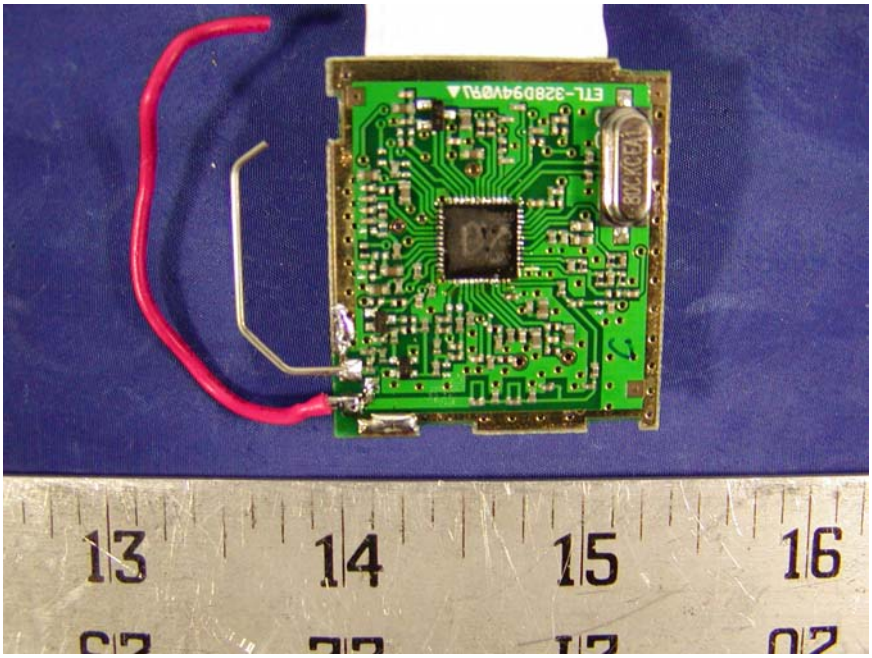
Handset – Main Board Top View without Shielding



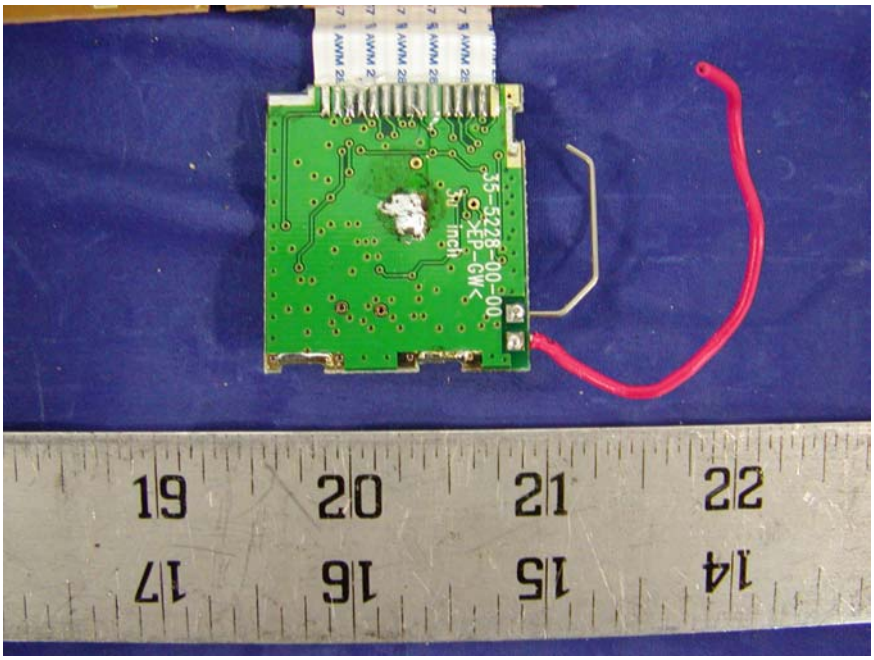
Handset – Main Board Bottom View



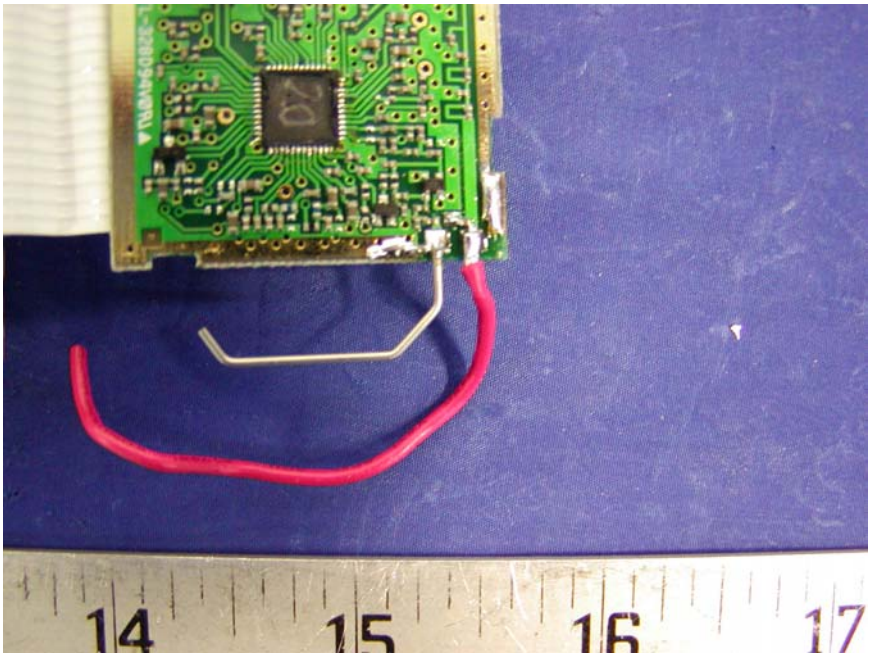
Handset – Transceiver Component View



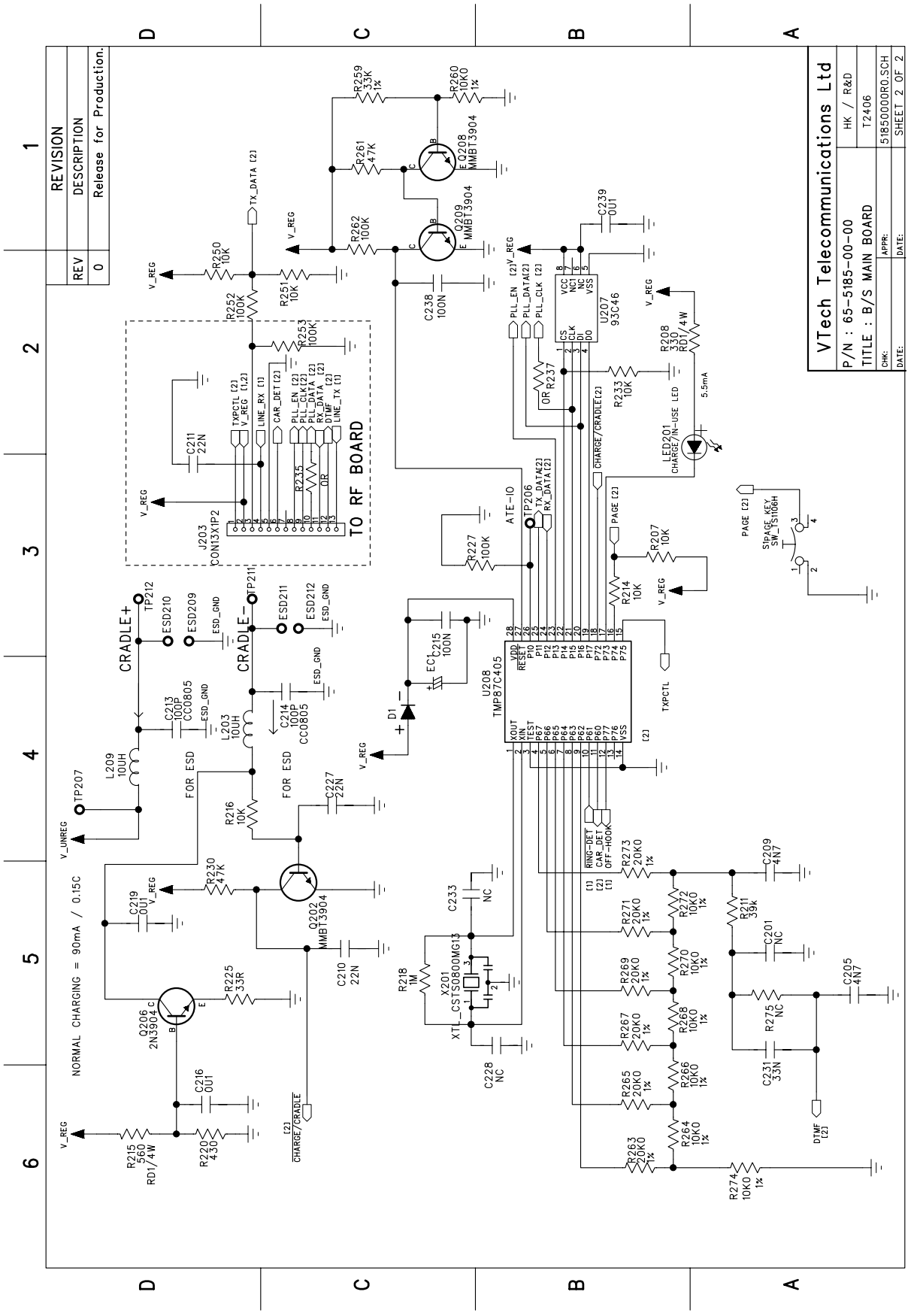
Handset – Transceiver Solder View



Antenna Connection View



APPENDIX D - BLOCK DIAGRAM /SCHEMATICS


REVISION
REV
DESCRIPTION
0
Release for Production.
VTech Telecommunications Ltd
P/N : 65-5185-00-00
TITLE : B/S MAIN BOARD
HK / R&D
T2406
CHK:
APPR:
DATE:
DATE:
51850000R0.SCH
SHEET 2 OF 2
TO RF BOARD
J203 CON13X1P2
CRADLE+
CRADLE-
NORMAL CHARGING = 90mA / 0.15C
FOR ESD
ATE-IO
U208 TMP87C405
U207 93C46
LED201 CHARGE/N-USE LED
5.5mA
X201 CSTS0800MG13
XTL
D1
Q202 MMBT3904
Q206 2N3904
Q208 MMBT3904
Q209 MMBT3904
V_REG
V_UNREG
TX_DATA [2]
PAGE [2]
DTMF [2]
CHARGE/CRADLE [2]
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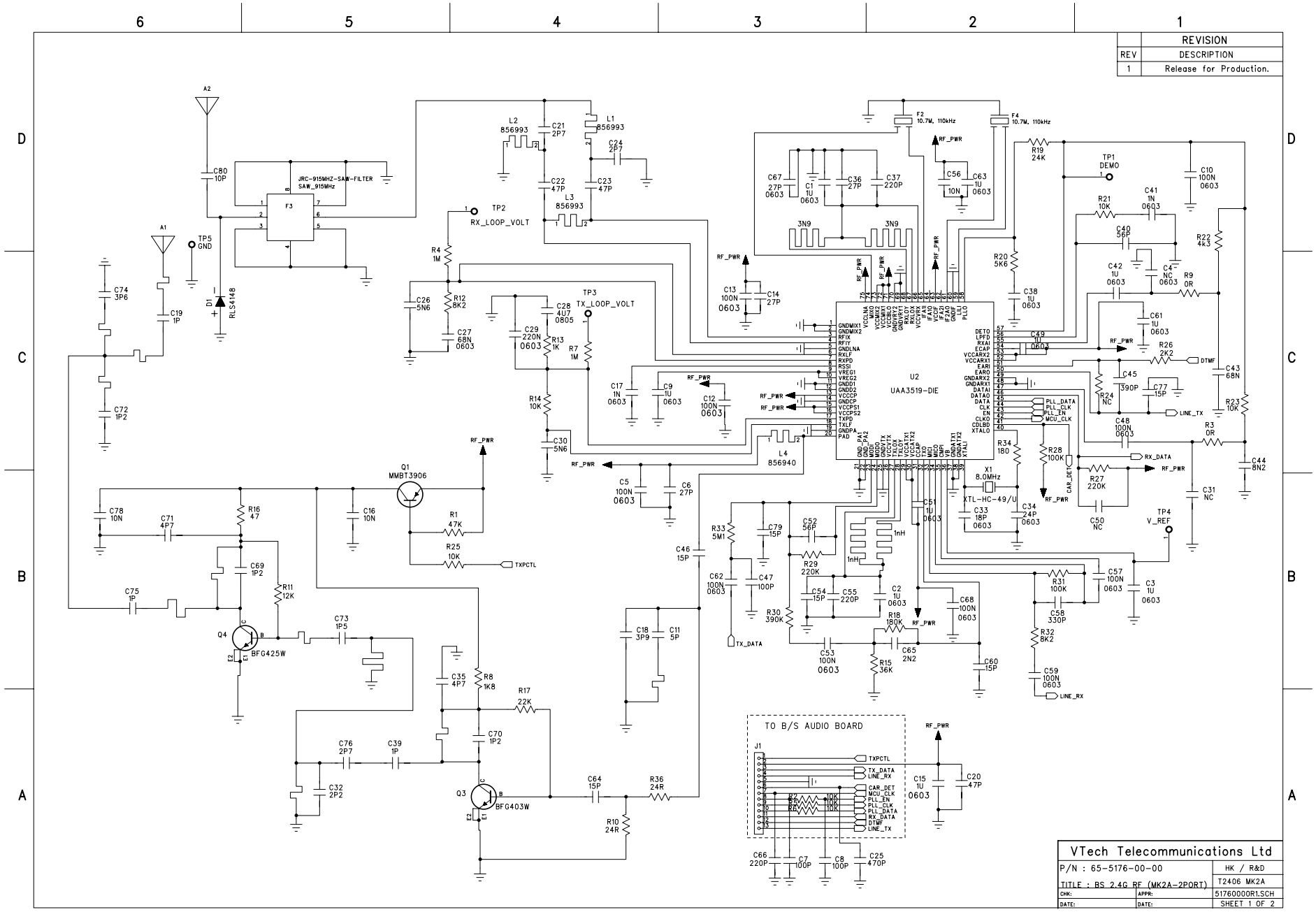
PLL_CLK [2]
RING-DET
CAR_DET
OFF-HOOK
STPAGE_KEY
SW_TS1106H


REVISION
REV
DESCRIPTION
1
Release for Production.
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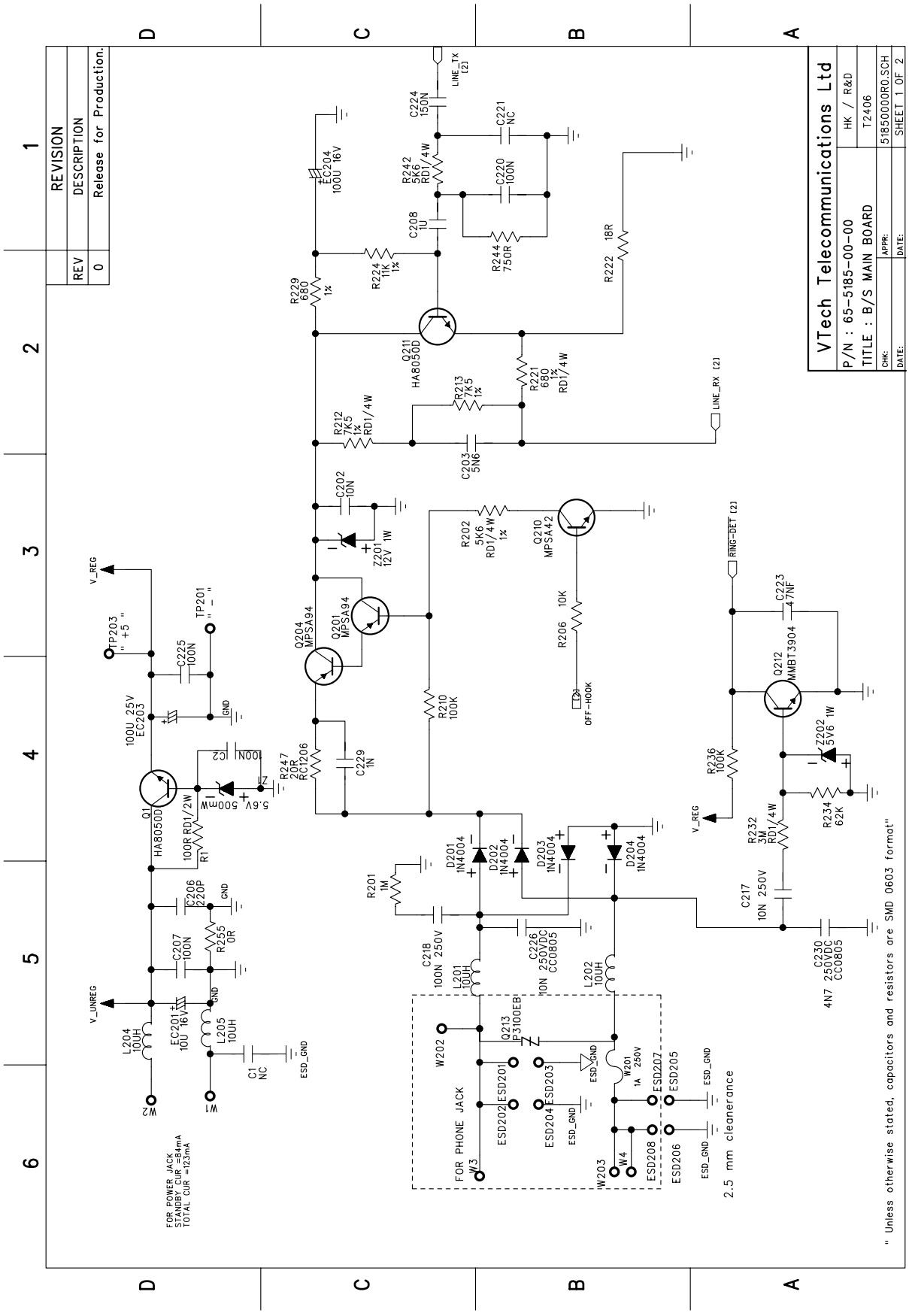
UAA3519-DIE
JRC-915MHZ-SAW-FILTER
SAW_915MHz
TO B/S AUDIO BOARD
TP1 DEMO
TP2 RX_LOOP_VOLT
TP3 TX_LOOP_VOLT
TP4 V_REF
TP5 GND
Q1 MMBT3906
Q3 BFG403W
Q4 BFG425W
D1 RLS4148
X1 8.0MHz
XTL-HC-49/U
F2 10.7M, 110kHz
F4 10.7M, 110kHz
RF_PWR
TXPCTL
TX_DATA
LINE_RX
LINE_TX
DTMF
PLL_DATA
PLL_CLK
PLL_EN
MCU_CLK
CAR_DET
RX_DATA
VTech Telecommunications Ltd
P/N : 65-5176-00-00
HK / R&D
TITLE : BS 2.4G RF (MK2A-2PORT)
T2406 MK2A
CHK:
APPR:
51760000R1.SCH
DATE:
DATE:
SHEET 1 OF 2


REVISION
REV
DESCRIPTION
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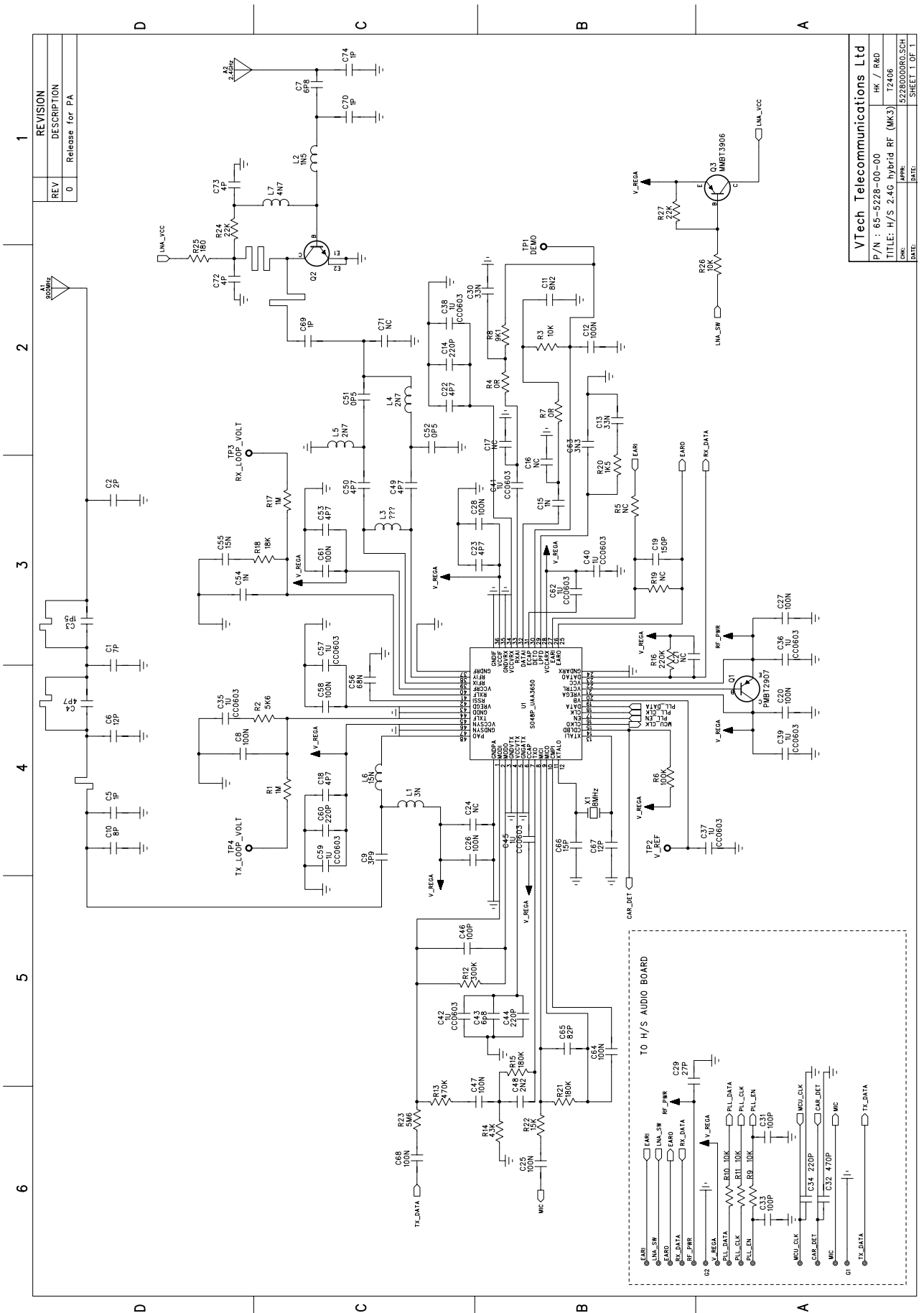
Release for Production.
VTech Telecommunications Ltd
P/N : 65-5185-00-00
TITLE : B/S MAIN BOARD
HK / R&D
T2406
51850000R0.SCH
SHEET 1 OF 2
" Unless otherwise stated, capacitors and resistors are SMD 0603 format"
FOR POWER JACK
STANDBY CUR =84mA
TOTAL CUR =123mA
FOR PHONE JACK
2.5 mm cleanerance
V_REG
V_UNREG
LINE_TX [2]
LINE_RX [2]
RING-DET [2]
OFF-HOOK
ESD_GND
GND


REVISION
REV
DESCRIPTION
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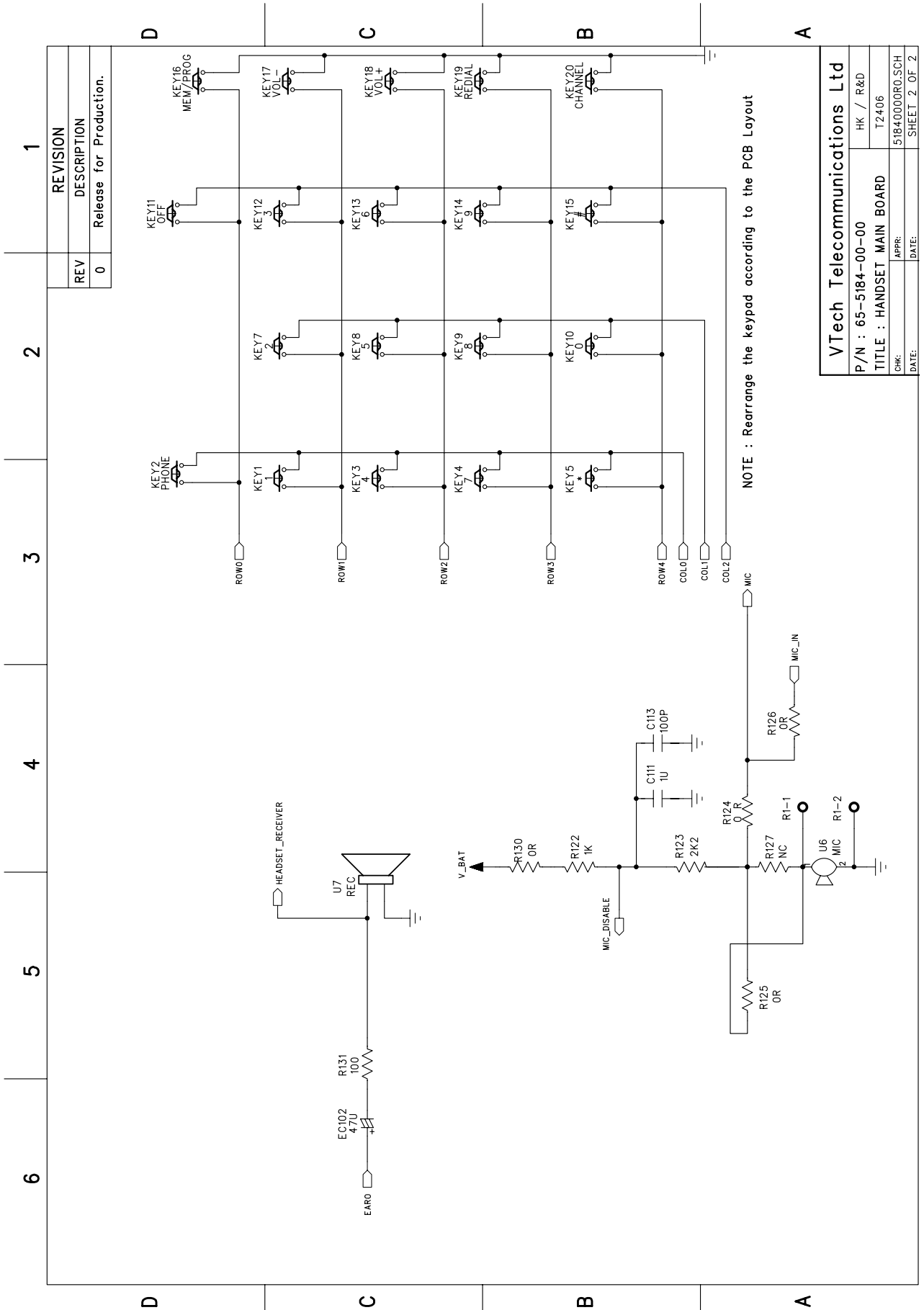
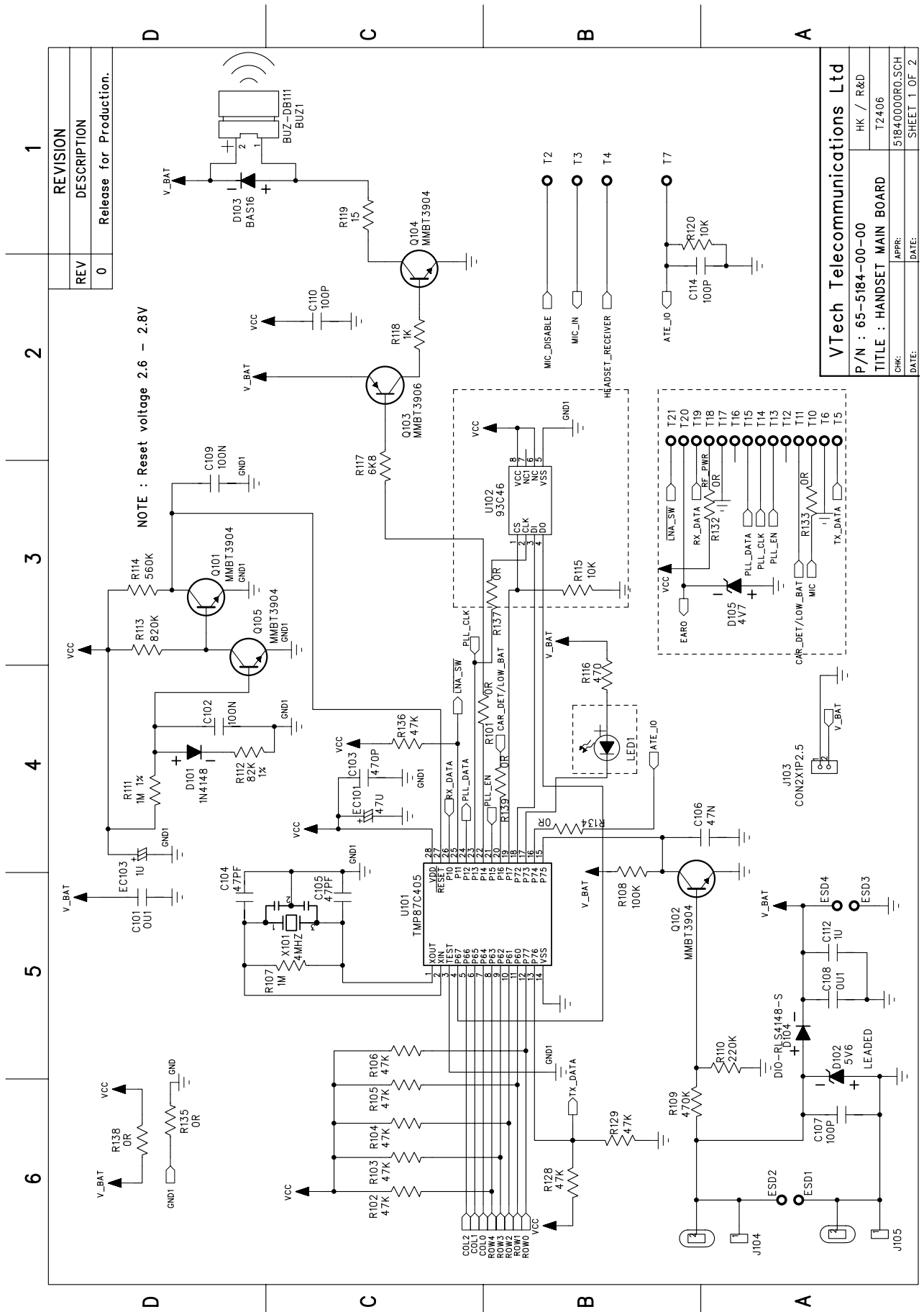
Release for PA
VTech Telecommunications Ltd
P/N : 65-5228-00-00
HK / R&D
TITLE: H/S 2.4G hybrid RF (MK3)
T2406
CHK:
APPR:
5228000R0.SCH
DATE:
DATE:
SHEET 1 OF 1
TO H/S AUDIO BOARD
U1
SO48P_UAA3650
TP1 DEMO
TP2 V_REGA
TP3 RX_LOOP_VOLT
TP4 TX_LOOP_VOLT
Q1 PMBT2907
Q2
Q3 MMBT3906
X1 8MHz
V_REGA
LNA_VCC
LNA_SW
RF_PWR
RX_DATA
TX_DATA
PLL_DATA
PLL_CLK
PLL_EN
MCU_CLK
CAR_DET
MIC
EARI
EARO


REVISION
REV
DESCRIPTION
0
Release for Production.
VTech Telecommunications Ltd
P/N : 65-5184-00-00
TITLE : HANDSET MAIN BOARD
HK / R&D
T2406
CHK:
APPR:
DATE:
DATE:
51840000R0.SCH
SHEET 2 OF 2
NOTE : Rearrange the keypad according to the PCB Layout
KEY16 MEM/PROG
KEY17 VOL-
KEY18 VOL+
KEY19 REDIAL
KEY20 CHANNEL
KEY11 OFF
KEY12 3
KEY13 6
KEY14 9
KEY15 #
KEY7 2
KEY8 5
KEY9 8
KEY10 0
KEY2 PHONE
KEY1 1
KEY3 4
KEY4 7
KEY5 *
ROW0
ROW1
ROW2
ROW3
ROW4
COL0
COL1
COL2
MIC
MIC_IN
R126 0R
C113 100P
C111 1U
R124 0R
R130 0R
R122 1K
R123 2K2
R127 NC
U6 MIC
R1-1
R1-2
V_BAT
MIC_DISABLE
R125 0R
HEADSET_RECEIVER
U7 REC
R131 100
EC102 47U
EAR0


REVISION
REV
DESCRIPTION
0
Release for Production.
NOTE : Reset voltage 2.6 - 2.8V
VTech Telecommunications Ltd
P/N : 65-5184-00-00
TITLE : HANDSET MAIN BOARD
HK / R&D
T2406
51840000R0.SCH
SHEET 1 OF 2
U101 TMP87C405
U102 93C46
Q101 MMBT3904
Q102 MMBT3904
Q103 MMBT3906
Q104 MMBT3904
Q105 MMBT3904
D101 1N4148
D102 5V6
D103 BAS16
D104 DIO-RLS4148-S
D105 4V7
BUZ1 BUZ-DB111
X101 4MHZ
LED1
J103 CON2X1P2.5
J104
J105
MIC_DISABLE
MIC_IN
HEADSET_RECEIVER
ATE_IO
LNA_SW
RX_DATA
PLL_DATA
PLL_CLK
PLL_EN
CAR_DET/LOW_BAT
TX_DATA
RF_PWR
EARO
MIC
V_BAT
VCC
GND1
ESD1
ESD2
ESD3
ESD4
LEADED

APPENDIX E - TECHNICAL INFORMATION

1 Introduction

The manual test mode can be used for testing the RF and audio sections of the base and/or handset. This is also required for the FCC testing in which the phone is tested for interference at the first, middle, and last RF channels.

The following features are provided in the manual test mode:

- Able to set operating mode of combo chip
- Able to mute or un-mute the audio path
- Able to change the RF channels (both Tx & Rx)
- Able to transmit or receive data packet
- Able to synchronize the security code

The following sections describe how handset and base operate in the manual test mode.

2 Handset Unit

2.1 Manual Test mode

The manual test mode is entered through selecting the RINGER PROGRAMMING mode by [**PROG**][**#**] and then pressing the key sequence {[**2**], [**6**], [**1**], [**8**]}. If successful, a happy tone will be heard and the <**IN-USE**> LED will be blinking slowly.

2.2 Default Settings

- Channel set to 14 (out of 0 to 29)
- Combo set to Active mode
- TX audio path un-muted
- Rx audio path un-muted
- Data transmission disabled

2.3 Key Definition:

KEY	OPERATION	INDICATION
[1]	Set Combo to Active mode	N/A
[2]	Set Combo to Rx mode	N/A
[3]	Set Combo to Inactive mode	N/A
[4]	Increment channel by 1	N/A
[5]	Mute TX audio path	N/A
[6]	Mute RX audio path	N/A
[7]	Decrement channel by 1	N/A
[8]	Un-mute TX audio path	N/A
[9]	Un-mute RX audio path	N/A
[0]	Quit test mode	<IN-USE> LED off
[*]	Set Combo to Active mode Enable data transmission	N/A
[#]	Disable data transmission	N/A

2.4 Data Link

- Data bits are encoded in Manchester format for which bit ‘0’ is represented by (500μs high and 500μs low) while bit ‘1’ by (500μs low and 500μs high)
- If data transmission is enabled, it will transmit data packet with the following fields continuously (‘0’ = 500μs low and ‘1’ = 500μs high)
  - 8-bit Preamble 1010101010101010
  - 8-bit Word Sync 1001101100101001
  - 20-bit Security Code restored from EEPROM and inverted bit by bit
  - 4-bit reserved data 01010101

- 8-bit Command 0101010101010101
- 8-bit Data xxxxxxxxxxxxxxxx

3 Base Unit

3.1 Manual Test mode

The manual test mode is entered through pressing and holding [**PAGE**] key at power-up until the <**IN-USE**> LED is turned off; then releasing the key and pressing it again within 2 seconds. If successful, the <**IN-USE**> LED will be blinking slowly.

3.2 Default Settings

- Channel set to 14 (out of 0 to 29)
- Combo set to Active mode
- TX audio path un-muted
- RX audio path un-muted
- On-hooked

3.3 Base Test Operation

CONDITION	OPERATION	INDICATION
Press [PAGE] key while <IN-USE> LED is being on	Advance channel by 1, following {15, 16, 17, …, 29, 0, 1, 2, …}	<IN-USE> LED remains on for another 2 seconds and then blinks again
Press [PAGE] key while <IN-USE> LED is being off	Toggle Combo between Active mode and Rx mode	<IN-USE> LED remains off for another 2 seconds and then blinks again
Hold [PAGE] key over 2 second	Enable data transmission Set Combo to Active mode	LED toggles once and then remains steady
Press [PAGE] key when data transmission is enabled	Disable data transmission Set Combo to Rx mode	LED is on for 2 seconds and then blinks
Power down	Quit test mode	None

3.4 Data Link

- Data bits are encoded in Manchester format for which bit ‘0’ is represented by (500µs low and 500µ high) while bit ‘1’ by (500µs high and 500µs low)
- If data transmission is enabled, it will transmit data packet with the following fields continuously (‘0’ = 500µs low and ‘1’ = 500µs high)
  - 8-bit Preamble 0101010101010101
  - 8-bit Word Sync 0110010011010110
  - 20-bit Security Code restored from EEPROM
  - 4-bit reserved data 10101010
  - 8-bit Command 1010101010101010
  - 8-bit Data xxxxxxxxxxxxxxxx
- If data transmission is enabled, it will toggle the IN-USE LED every time when a data packet is received. (no security code would be checked)

4 Security Code Synchronization

The following procedures should be followed if the security codes of both units do not match with each other:

- Put the handset into Manual Test mode, making sure the channel is set at 14 (default) out of 0 to 29
- Press ‘*’ to start data transmission under which the C_SCCHG command is sent continuously
- Put the base into Manual Test mode
- Before the base enters the test mode, it waits 1 second for receiving C_SCCHG command from the handset. If receiving the command within the period, the base will save its accompanied security code into eeprom memory and then flash the <IN-USE> LED to indicate successful operation.

< EOF >

Theory of Operation of the

T2406 2.4G HADL MK3

2.4 GHz Hybrid Analogue Basic Phone

Revision History:

Revision	Description	Page	Effective Date
0	Initial Release	All	

Contents

1 General

T2406 2.4G HADL MK3 is a 900MHz/2.4Ghz hybrid analog basic cordless phone. The 900MHz/2.4GHz hybrid analog technology used in T2406, is a technology base on the 2.4G HADL MK3 platform.

1.1 Hardware

The T2406 2.4G HADL MK3 consists of a mobile handset and a fixed base unit. The handset contains two printed circuit boards (PCB) - the baseband audio circuit board which is single-sided and a separated radio frequency (RF) circuit board which is double-sided.

The base unit also contains two printed circuit boards (PCB) – One is the RF circuit board which is double-sided. Another one is a single-sided mainboard PCB, where line interface, power management, baseband controller, audio circuits, page key and the LED indicators are placed. The PCB is comprised of through-hole (line interface) as well as surface-mount components (rest of the circuit). The RF PCB is connected to the base main PCB via flexible ribbon cables.

1.2 Overview

This document describes the theory of operation of the T2406 2.4G HADL MK3. Section 2 provides technical description of the baseband audio module, including telephone line interface, power management circuit, audio circuit, and microcontroller unit (MCU) circuit. Though similar in some cases, there are sufficient differences that the handset and base unit baseband circuitry are described in separate subsections under each functional heading. Section 3 provides the technical description of the RF module, including the antenna circuit, receiver circuit, and transmitter circuit. Unlike the baseband, the handset and base RF circuitry are similar, any differences are highlighted within the description of each functional heading.

2 Baseband Module

The baseband audio module includes circuitry for the telephone line interface (base only), power management function, audio connection, and the microcontroller.

The following sections explain the individual blocks in the baseband module in detail.

2.1.1 Telephone Line Interface

The T2406 2.4G HADL MK3 telephone line interface couples audio and line signaling to and from the telephone lines while isolating the phone from another. The interface provides basic operation for the audio and facilitates pulse dialling and ring detection. . Isolation is achieved by electronically coupling audio through a pair of transitors. The isolation is necessary for the phone to meet the FCC 1.5 kV high-pot requirement. However, the line interface circuit used in T2406 is without Hi-Pot isolation. In other words, circuit ground has a conduction path to external T&R. Thanks to the special mechanical design to avoid accessibility of metallic parts(like charge contacts) by human fingers, the interface providing protection from high voltage transients and surge currents can be cost down and simplify.

2.1.2 Line Protection and Filtering

The audio signal from the central office or PBX is carried by the telephone line (tip and ring) to the phone jacks. These two lines are also used to carry ring signal (40 - 150 V_{rms}, 15.3 - 68 Hz) and various line signals (i.e. DTMF, dial tone, etc.)

To overcome Surge A requirement, 1A fuse is used. The fuse is installed in the telephone line loop to limit the loop current to no greater than 1A. A varistor is used to limit the voltage across the line interface should a high voltage transient appear on the telephone line (i.e., lightning strike). Further high voltage protection (1.5 kV) is afforded by high resistance high power resistors, high voltage capacitors and high voltage transistors.

2.1.3 Ring Detect

The ring signal across the tip and ring is detected by a transitor switching network. Resistors limit the current flow into the transistor and maintain the necessary ringing impedance as specified in EIA-470. The zener diode across the transitor input provides a discharge path for the coupling capacitor during negative ring cycles.

On the output side, a pull-up resistor is used to set the transistor collector current (i.e., sensitivity control) when a ring signal is detected. The output is connected to the MCU where the ring signal is analysed for validity. A typical ringing pattern from the central office is one second “on” and four seconds “off”.

2.1.4 Pulse Dialling or Off-Hook Switch

For pulse dialling (8 - 11 pps, 58 - 64% break, interval 53 - 80 ms), transitor networks are used to make and break the telephone line loop. In order for the phone to function normally irrespective of the polarity of the tip and ring, a diode bridge is used to ensure the potential on the emitter of the dialington pair with respect to its collector. One of the transitor input is connected to the MCU from which the required state of the dialington pairs is controlled. For pulse dialling, the dialington pairs are simply pulsed off and on at the appropriate rate. To set the phone off-hook, the dialington pairs are activated which closes the telephone loop.

2.1.5 Speech Circuit

To minimize cost, speech network IC is not used in the T2406 2.4G HADL MK3 design. Instead, transistors with supporting hardware are used to provide all the speech network functions. The speech circuit provides line impedance matching and sidetone cancellation.

Impendance matching (or return loss) is optimised when the termination impedance equals the source impedance. The effective impedance looking into the T2406 is a combination of all the components' impedance in the line interface. This effective impedance was derived empirically by fine-tuning the resistor across the audio transformer's secondary. The speech circuit matches a line impedance of 600 Ω (EIA-470: 4.5.2.3) while the transmit, receive and sidetone frequency responses are set with a 900 Ω line impedance (EIA-470: 4.1.1l - 4.1.3).

The telephone line to audio signal conversion (or vice versa) is accomplished by transmitting audio to dialingtons pairs via a transmit amplifier, and a receive amplifier receives audio directly from the dialington pairs output line.

Sidetone cancellation is accomplished by taking transmit audio (the sidetone) and resistively combining it with out-of-phase transmit audio. In a real-world situation, the match between the line interface and the telephone line is not perfect. This slight mismatch results in some transmit audio being enter into the receive direction. The sidetone cancellation signal in T2406 2.4G HADL MK3 is created by combining the transmit audio signal from another output of the transmit amplifier which are inherently 180° out-of-phase (i.e., the sidetone source), then feed to the receive path.

2.2 Power Management

2.2.1 Base Unit

T2406 2.4G HADL MK3 base power circuits consist of DC power regulation and charging circuits for the handset. The base unit operates on a regulated 5 VDC power supply. The power is supplied to the regulator via a UL-approved 9 VDC, 300 mA power adapter. During normal operation, the base unit draws about 115 mA of current (with an additional 60 mA when the handset is in the cradles).

2.2.1.1 Power Supply

DC power is supplied to the base via a UL-approved AC-to-DC power adapter rated at 9 VDC, 300 mA. The power from the adapter is then regulated down to 5 VDC. Filter capacitors are connected to both sides of the 5 VDC regulator to ensure AC variations are eliminated from the power lines. All circuits except for the Tx RF chain are powered at all times. The Tx RF chain is controlled by the MCU by programming the RF chip and is turned on when communications with the handset is required. The Tx_PWR is switched off when the Tx RF chain is not needed to minimise the use of the RF spectrum space during the idle state.

2.2.1.2 Handset Charge Circuit

To reduce costs by keeping circuits simple, the handset charge circuit is designed to supply a charging current to a cradled handset regardless of whether the battery is fully charged or not. This current varies with the charge on the battery and is limited to 0.1 C or 10% of the battery capacity by a limiting resistor. The charge circuit is supplied directly from the 9 VDC, 300 mA power adapter which insures that power is available to charge the handset battery.

In the T2406 2.4G HADL MK3, the handset battery has a capacity of 400mAH, thus the maximum charging current is set to approximately 40mA. The specification of 0.1 C allows a battery to be constantly charged without damaging the battery. The handset charge circuit components have been selected to withstand shorting the charge contacts on the cradle. The handset charge circuit also provides a signal to the MCU for cradle detection.

2.2.1.3 ESD Protection

The charge contacts for the handset are vulnerable to electro-static discharge (ESD) because they are exposed to the outside world. Since the contacts are connected directly to the base circuits, ESD can damage some of the base internal circuits if no protection is implemented. Therefore, a number of measures have been taken to protect internal circuits from ESD damage.

Charge contact have LC filtering on them to bypass ESD. Low voltage spare gaps (arc at ~500 V based on 1 kV/mm electric discharge through air) are also implanted in the PCB layout between charge contacts and a special ESD ground. This ESD ground channels any

ESD directly to the telephone line and AC adapter, preventing charges from entering the main circuits.

2.2.2 Handset

The T2406 2.4G HADL MK3 handset power is supplied by a three-cell battery with a nominal voltage of 3.6 VDC. This voltage will directly apply to all circuit including the RF circuit part. The variation on the performance can fall within the tolerance.

In order to achieve a long standby time, the handset conserves power by "sleeping" when not in use and occasionally "waking up". In the "sleep" condition, the handset supplies power only to those circuits deemed essential for proper operation such as the MCU and memory. The RF chip will be programmed to "Inactive" mode and all operation will stop including the oscillator circuit. In the "wake-up" condition, the handset powers the RF chip to "Rx mode" that allow it to receive data. This function is necessary to detect if the base requires the handset to act on a condition such as an incoming call. With this sleep/wake-up sequence, handset is able to achieve a six-day stand-by time. To reduce the cost, external wake-up circuit are used instead by entering "Idle mode" or "Normal mode" that under MCU control.

2.2.2.1 Battery Maintenance and Low Voltage Detection

The battery is recharged via a cradle contact on the base. The handset has a corresponding charge contact at the bottom of the handset chassis. The charge contact is protected from a short to ground by a diode placed in line with the battery connection. The diode prevents the battery from discharging from the charge contact. Protection from ESD is afforded by a bypass capacitor installed at the charge contact.

When the battery voltage drops below the minimum working voltage of the MCU, the phone will not function properly again if the MCU is not properly reset. Therefore, circuits have been implemented to insure that the battery has sufficient charge for proper operation. The reset pin of MCU will be released till the battery voltage charge back to the min. operating voltage.

About the function of low voltage detection, the RF chip can provide an internal reference to which battery charge is compared and the detection voltage are programmable by MCU. In T2406 2.4G HADL MK3, two level of voltage will be detected. If the battery voltage drops below 3.4 VDC, the low battery detect pin in chip will be activated to inform the MCU and causes the MCU to notify the user by producing an audible tone and flashing the LED. Then, MCU will change the detection voltage to 2.9V to noticfy the MCU stop all the operation before the voltage drop below the operation voltage of the RF chip. The detection voltage will change back to 3.3V once the on-cradle signal detected. The typical hysteresis of the comparator is 18mV.

2.3 Audio Circuits

Audio circuits are necessary to condition speech for RF transmission and reception. The conditioning includes amplification, filtering, pre-emphasis / de-emphasis and compression / expansion, all of which ensures that the speech is received and transmitted with maximum clarity and legibility.

Pre-emphasis/de-emphasis is used to improve signal-to-noise ratio (SNR) which is, as a consequence of frequency or phase modulation, degraded at high audio frequencies. Compression/expansion is also used to improve the perceived SNR by reducing the noise vulnerability of low-level signals. The compression process amplifies low level signals more than it does for high level signals. Thus, by compressing the dynamic range of the audio before transmission, noise picked up during transmission has less of an effect on the low-level signals.

After receiving the transmission, the expansion process maintains this improved SNR while restoring the low level signals back to their original levels.

The audio circuits are implemented by using the compressor and expander inside the combo chip. It provides compression/expansion, amplification and muting all in a clean, simple way.

2.3.1 Base Audio

The audio circuits in the base provide for speech exchange between the telephone line interface and the RF module that communicates with the handset. Figure 1 shows the circuitry for audio processing in the base unit.

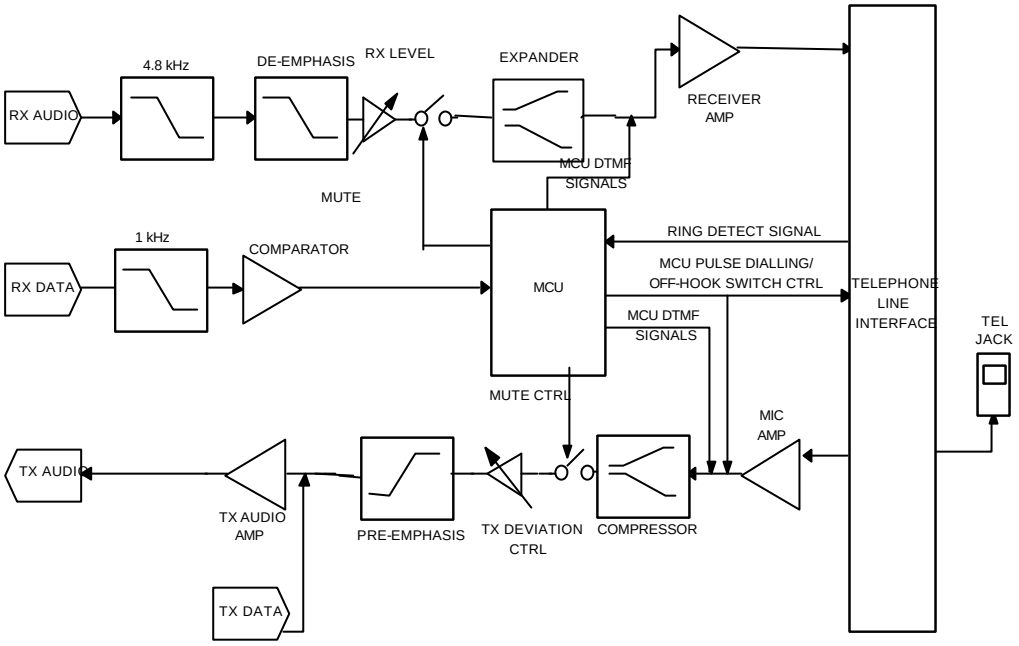


Figure 1: Audio Circuits in Base Unit (Block Diagram)

2.3.1.1 Transmit Direction (RF module to telephone line)

The transmit audio is transmitted from the handset to the base using frequency modulation (FM). The FM signal from the handset enters the base RF module, where the signal undergoes filtering, down-conversion, and finally demodulation. The baseband audio then leaves the RF module via the demodulator (for a deviation of ±25 kHz).

The DETO pin is connected to a passive low-pass filter with a -3 dB cut-off set at about 4.8 kHz. The filtered audio is then passed to an de-emphasis filter where the de-emphasis occurs across the entire audio band (300 Hz to 3400 Hz) at a rate of 6 dB/octave or 20 dB/decade. After de-emphasis, the transmit audio signal is proceeded through level control and the expansion process. The level control, which has a range of about 15 dB, is used to set the transmit audio level at the tip and ring of the telephone line, The transmit level can vary from component tolerances and variations.

After then, the audio is passed to a final stage of amplification. The output of this amplifier is connected to telephone line interface. The output of the DTMF generator circuit is also coupled in at the input to this final stage of amplification.

The transmit audio chain can be disabled at the expander amplifier on chip by a mute command from MCU. This function is used to mute the transmit audio chain when data is being received from the handset so that data noise does not enter the telephone line. When transmitting data from the base to the handset, the mute function is used to disable the receive audio circuits.

2.3.1.2 Receive Direction (telephone line to RF module)

The receive audio signal from the telephone line makes its way through the line interface and the speech circuit before reaching the receive direction audio circuits. From the speech circuit, the audio undergoes a first stage of amplification and light low-pass filtering. Following the amplifier, the receive audio is compressed and fed directly to the pre-emphasis stage. The compressor does a straight 2-to-1 conversion; the dynamic range is reduced by half. The compressor amplifier is also used to sum in DTMF feedback so that the tones can be heard from the handset earpiece. Pulse dialling feedback is accomplished similarly by summing in the hook switch signal level at the same location.

From the compressor output, the receiver audio signal enters a Tx audio level control circuit. . The level control, as in the transmit direction, has a range of about 15 dB and is used to set the level applied to the RF module. This level control thus sets the FM deviation and is necessary to compensate for component tolerances and variations in the sensitivity of the FM circuits.

Transmit data is combined resistively after the level control from which point it shares the rest of the audio circuits with the receive audio. However, either only audio or only data will

be present at any given time to prevent corruption of the signals. To further minimise the chance of data corruption, the receive audio circuits are disabled after compressor using the mute function as mentioned in above section. Muting this part of the receive audio chain ensures that any noise or signals on the telephone line do not interfere with data transmissions to the handset. The output is then coupled to the RF module's frequency modulator.

2.3.2 Handset Audio

The audio circuits in the handset provide for speech exchange between the audio transducers (ear-piece receiver and microphone) and the RF module that communicates with the base. Figure 2 shows the circuitry for audio processing in the handset.

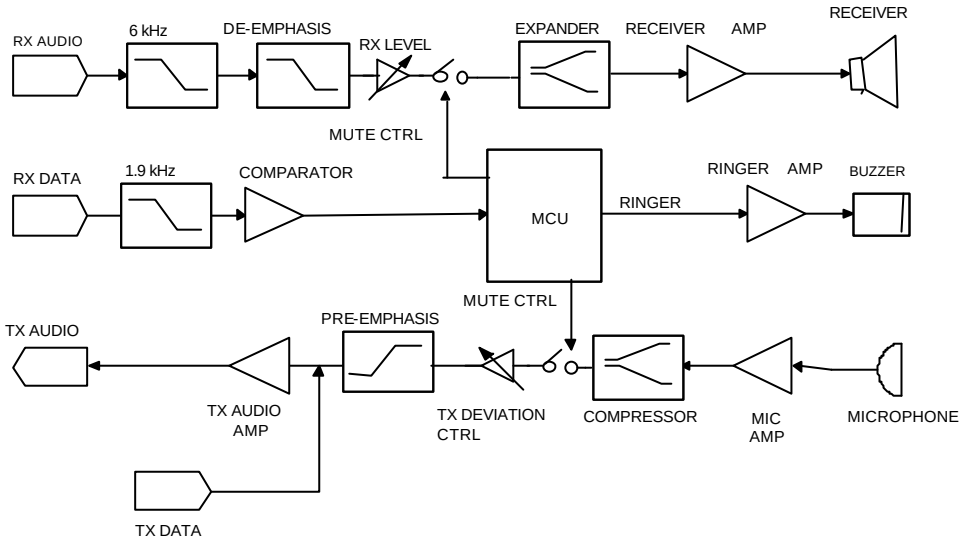


Figure 2: Audio Circuits in Handset

2.3.2.1 Receive Direction (RF module to ear-piece receiver)

The received audio is transmitted from the base to the handset using FM. The FM signal from the base enters the handset RF module where the signal undergoes filtering, down-conversion, and finally demodulation. The baseband audio then leaves the RF module via the demodulator IC (for a deviation of ±40 kHz). From the RF module, the audio is low-pass filtered and directed to both an audio channel and a data channel. The audio undergoes this split in directions because both data and audio share the same circuit.

The DETO pin is connected to a low-pass filter with a -3 dB cut-off set at about 6 kHz. The filtered audio is then passed to a de-emphasis filter where de-emphasis occurs across the entire audio band (300 Hz to 3400 Hz) at a rate of 6 dB/octave or 20 dB/decade. After de-emphasis, the audio undergoes received audio level control and the expansion process. The level control, which has a range of about 15 dB, is used to set tolerances and variations.

After the expander, the audio is passed to a final stage of amplification. A volume control (selectable to "high", "mid.", and "low" volume) can be processed through the feedback resistor of this amplifier. This process ensures the compliance of min. 12 dB volume change from the lowest to the highest (FCC Part 15: 68.317).

The receive audio chain can be disabled by a mute command from MCU. This function is used to mute the receive audio chain when data is being received from the base so that data noise is not heard at the receiver. When transmitting data from the handset to the base, the mute function is used to disable the transmit audio circuits.

2.3.2.2 Transmit Direction (microphone to RF module)

In the transmit direction, the speech is picked by an electret condenser microphone and passed into a microphone amplifier stage. The speech or transmit audio undergoes a first stage of amplification and light low-pass filtering. Following the amplifier, the transmit audio is compressed and fed directly to the pre-emphasis stage. The compressor does a straight 2-to-1 conversion; the dynamic range is reduced by half.

From the compressor output, the transmit audio signal enters a pre-emphasis circuit with an audio level control. The pre-emphasis, like the de-emphasis, is set at a rate of 6 dB/octave or 20 dB/decade throughout the entire audio band (300 Hz to 3400 Hz). The level control, as in the receive direction, has a range of about 15 dB and is used to set the level applied to the RF module. This level control thus sets the FM deviation and is necessary to compensate for component tolerances and sensitivity variations of the FM circuits. Extra range control has been implemented to compensate for microphone variations.

Transmit data is resistively combined in after the pre-amphasis from which point it shares the rest of the audio circuits with the transmit audio. However, either only audio or only data

will be present at any given time to prevent corruption of the signals. To further minimise the chance of data corruption, the transmit audio circuits are disabled at the compressor output using the mute command from MCU as mentioned in above section. Muting this part of the transmit audio chain insures that any noise or signals from the microphone do not interfere with data transmissions to the base.

Following the transmit audio level control which programmed by the MCU, the audio goes through another stage of amplification and light low-pass filtering. It is then coupled to the RF module's frequency modulator.

2.4 MCU Circuits

A CMOS 4K x 8-bit microcontroller from Toshiba (TMP87C405) is used to control all the functions in the base and handset. The B/U MCU is clocked by the 8-MHz X'tal. The H/S MCU is clocked by a separated 4-MHz resonator. The reason why not using the clock which can be provided from the RF chip CLKO pin is for current saving during "sleep" mode.

The base MCU controls functions such as DTMF generation, data communications, telephone signalling detection and ATE interfacing, while the handset MCU controls functions such as data communications, sleep/wake-up sequence, battery maintenance and ATE interfacing.

2.4.1 Base MCU

2.4.1.1 RSSI

When a communication channel is required, the handset searches for a channel that is unoccupied or has a very low-level interference. The H/S MCU does this by using the received signal strength indicator (RSSI) function of the demodulator to determine if a channel is available. The demodulator's RSSI, coupled with its carrier detect, supplies the MCU with a signal whose state indicates the status of a channel. A power threshold is set by the demodulator and when a channel's total power exceeds this threshold, the channel is declared to be occupied.

2.4.1.2 DTMF Generation

To minimise costs, power consumption, and space, the base MCU is used to generate the DTMF tones instead of a dedicated DTMF generator IC. The base MCU generates the tone waveforms by using a 1% R-2R ladder network connected to six of its ports to produce a 6-bit digital-to-analog (D/A) converter. The D/A converter's output is then passed through a

low-pass filter to clear the waveforms of high frequency ripple caused by the D/A conversion.

As mentioned in previous sections, the DTMF tones are combined in at the input of the last amplifier stage in the transmit direction for transmission onto the telephone line. The transmit audio chain is disabled before the expander during DTMF dialling to stop audio from the RF module from entering the telephone line and interfering with the dialling. Also, the DTMF tone will feedback to handset receiver through sidetone signal path.

2.4.1.3 Data Communications

The data is transmitted between the handset and base at 1000 bps using Manchester Coding format. The two frequencies used in the keying are 500 Hz and 1000 Hz. Logic 0 and logic 1 are represented by falling edge and rising edge of 1kHz data respectively. A separate modem chip is not required in the design since the MCU generates and decides all the data. The level for data transmissions is set to produce about ±80 kHz of deviation.

Received data from the handset is passed form the demodulator IC to undergoes low-pass filtering. The received data is split off to the receive data chain; as mentioned in a previous section. It is shared by both the audio and data, thus requiring a splitting junction. This received data chain consists of low-pass filtering and a comparator to restore the data to its original condition. After conditioning, the data is coupled directly to the MCU for analysis.

2.4.1.4 Reset Circuit

The reset circuit for the base MCU consists of two transistor switch and support components. The circuit is designed to reset the handset MCU when the power supply drops to about 2.8 VDC and below. This insures that if the power supply drops to a level where logic levels may become indeterminate, the MCU will be reset to a known condition, potentially preventing erroneous operation. In addition to being connected to the reset circuit, the MCU's active low reset line is connected to the power rail via an RC network. This RC network ensures that after a reset, the MCU's reset line is brought back to a logic-high cleanly and continuously.

2.4.1.5 EEPROM

An EEPROM 93C46S is used in the base to store all tuning parameters for the RF chip, the current active channel, and the security code so that the information is not lost in the event of a power failure.

2.4.1.6 ATE Interface

ATE test points are available on the base to facilitate testing using automated test equipment (ATE). The ATE uses these test points to access the signals required to complete a base alignment. Connections from the base to its ATE jig are facilitated by a bed of nails. Base to ATE communication is accomplished through a dedicated port on the MCU .

2.4.1.7 LED Indicators

The base features one LED indicator to show the base unit when the handset batteries is being charged and In-use mode.

2.4.2 Handset MCU

2.4.2.1 Data Communications

The data is transmitted between the handset and base at 1000 bps using Manchester Coding format. The two frequencies used in the keying are 500 Hz and 1000 Hz. Logic 0 and logic 1 are represented by falling edge and rising edge of 1 kHz data respectively. A separate modem chip is not required in the design since the MCU generates and decides all the data.

The level for data transmissions are set to produce about ±100 kHz of deviation. This level was determined empirically to provide optimum data sensitivity. In the idle state, the transmit data port on the MCU is set to high impedance.

Received data from the handset is passed form the demodulator output to the data comparator where it undergoes low-pass filtering. After the splitting junction at the demodulator output, this receive data chain consists of low-pass filtering and a comparator to restore the data to its original condition. After conditioning, the data is coupled directly to the MCU for analysis.

2.4.2.2 Keypad Control

The keypad is arranged as a 4 x 5 (row x column) matrix with each row pulled up to V_BAT by a pull-up resistor. When the MCU is ready to accept a key press, columns 0 to 5 are set low. As soon as a key is depressed, the MCU will detect this by sampling the rows (i.e., a row will be pulled low). To determine what column was connected to the row, identifying what key was pressed, the MCU sets all columns high and then sequentially sets them low until the previous detected row is pulled low.

2.4.2.3 Ringer

The ringer used in the handset is basically a magnetic transducer. It takes an electrical signal from the MCU and uses it to create a varying magnetic field to vibrate a metal diaphragm.

The vibrating diaphragm, in turn, produces acoustic waves forming sound energy. The ringer draws a large amount of current when it rings and is therefore powered directly from the battery. There are four different ring signals produced by the MCU to provide four distinct ringing tones. Each signal is a combination of two frequencies. The frequencies are listed in the table below.

Ring Tone Number	Frequency #1 (Hz)	Frequency #2 (Hz)
1	2500	1250
2	2500	625
3	1250	625
4	625	313

Table 1. MCU Ringer Tone Frequencies

The MCU ringing tones are coupled to the ringer via transistors. These transistors are biased to insure that ringer output is consistent from handset to handset.

2.4.2.4 ATE Interface

ATE test points are available on the handset to facilitate testing using automated test equipment (ATE). The ATE uses these test points to access the signals required to complete a handset alignment. Connections from the handset to its ATE jig use a single 8-pin header. Handset to ATE communication is accomplished through a dedicated port on the MCU.

2.4.2.5 LED Indicators

The handset has one LED, which illuminates steadily when the handset is in the PHONE mode. It will flash in cadence with an incoming ring from the PSTN line. It will flash quickly when the handset is in the PROGRAM mode. It will flash slowly when a low battery condition in the handset is detected.

3 RF Module

The basic function of the radio frequency (RF) circuits on both handset and base is to provide a full duplex wireless link between the handset and base units of the telephone. This is accomplished by setting up two simultaneous communications links between the handset and base RF modules. The RF receiver and transmitter circuitries essentially provide a link between the microphone and speaker in the handset to the telephone line in the base. In this way, the phone performs exactly as a corded phone, except without the cord.

The frequency at which the handset (operating at 3.6V) transmits to the base is centred around 914.85 MHz, and the frequency at which the base (operating at 5V) transmits to the handset is centred around 2414.4MHz. The T2406 2.4G HADL MK3 uses a wideband FM scheme to directly modulate audio signals onto the RF carriers.

The following tables outline the frequencies and corresponding channel numbers used by the RF. The handset uses a high-side local oscillator (LO) while the base uses a low-side LO to down-convert the incoming signal.

Channel #	Transmit Frequency(MHz)	Receive Frequency(GHz)	RxLO Frequency(GHz)
0	912.750	2.4102	2.4099
1	912.900	2.4105	2.4102
2	913.050	2.4108	2.4105
3	913.200	2.4111	2.4108
4	913.350	2.4114	2.4111
5	913.500	2.4117	2.4114
6	913.650	2.4120	2.4117
7	913.800	2.4123	2.4120
8	913.950	2.4126	2.4123
9	914.100	2.4129	2.4126
10	914.250	2.4132	2.4129
11	914.400	2.4135	2.4132
12	914.550	2.4138	2.4135
13	914.700	2.4141	2.4138
14	914.850	2.4144	2.4141
15	915.000	2.4147	2.4144
16	915.150	2.4150	2.4147
17	915.300	2.4153	2.4150
18	915.450	2.4156	2.4153
19	915.600	2.4159	2.4156
20	915.750	2.4162	2.4159
21	915.900	2.4165	2.4162
22	916.050	2.4168	2.4165
23	916.200	2.4171	2.4168
24	916.350	2.4174	2.4171
25	916.500	2.4177	2.4174
26	916.650	2.4180	2.4177
27	916.800	2.4183	2.4180
28	916.950	2.4186	2.4183
29	917.100	2.4189	2.4186

Table 2. Handset Frequencies

Channel #	Transmit Frequency (GHz)	Receive Frequency (MHz)	Rx LO Frequency (MHz)
0	2.4102	912.750	923.45
1	2.4105	912.900	923.60
2	2.4108	913.050	923.75
3	2.4111	913.200	923.90
4	2.4114	913.350	924.05
5	2.4117	913.500	924.20
6	2.4120	913.650	924.35
7	2.4123	913.800	924.50
8	2.4126	913.950	924.65
9	2.4129	914.100	924.80
10	2.4132	914.250	924.95
11	2.4135	914.400	925.10
12	2.4138	914.550	925.25
13	2.4141	914.700	925.40
14	2.4144	914.850	925.55
15	2.4147	915.000	925.70
16	2.4150	915.150	925.85
17	2.4153	915.300	926.00
18	2.4156	915.450	926.15
19	2.4159	915.600	926.30
20	2.4162	915.750	926.45
21	2.4165	915.900	926.60
22	2.4168	916.050	926.75
23	2.4171	916.200	926.90
24	2.4174	916.350	927.05
25	2.4177	916.500	927.20
26	2.4180	916.650	927.35
27	2.4183	916.800	927.50
28	2.4186	916.950	927.65
29	2.4189	917.100	927.80

Table 3. Base Unit Frequencies

In case of 900MHz operation, both the handset and base RF modules follow the same block with only minor changes to incorporate the different transmit and receive frequencies. The block diagram of the RF chip is shown below:

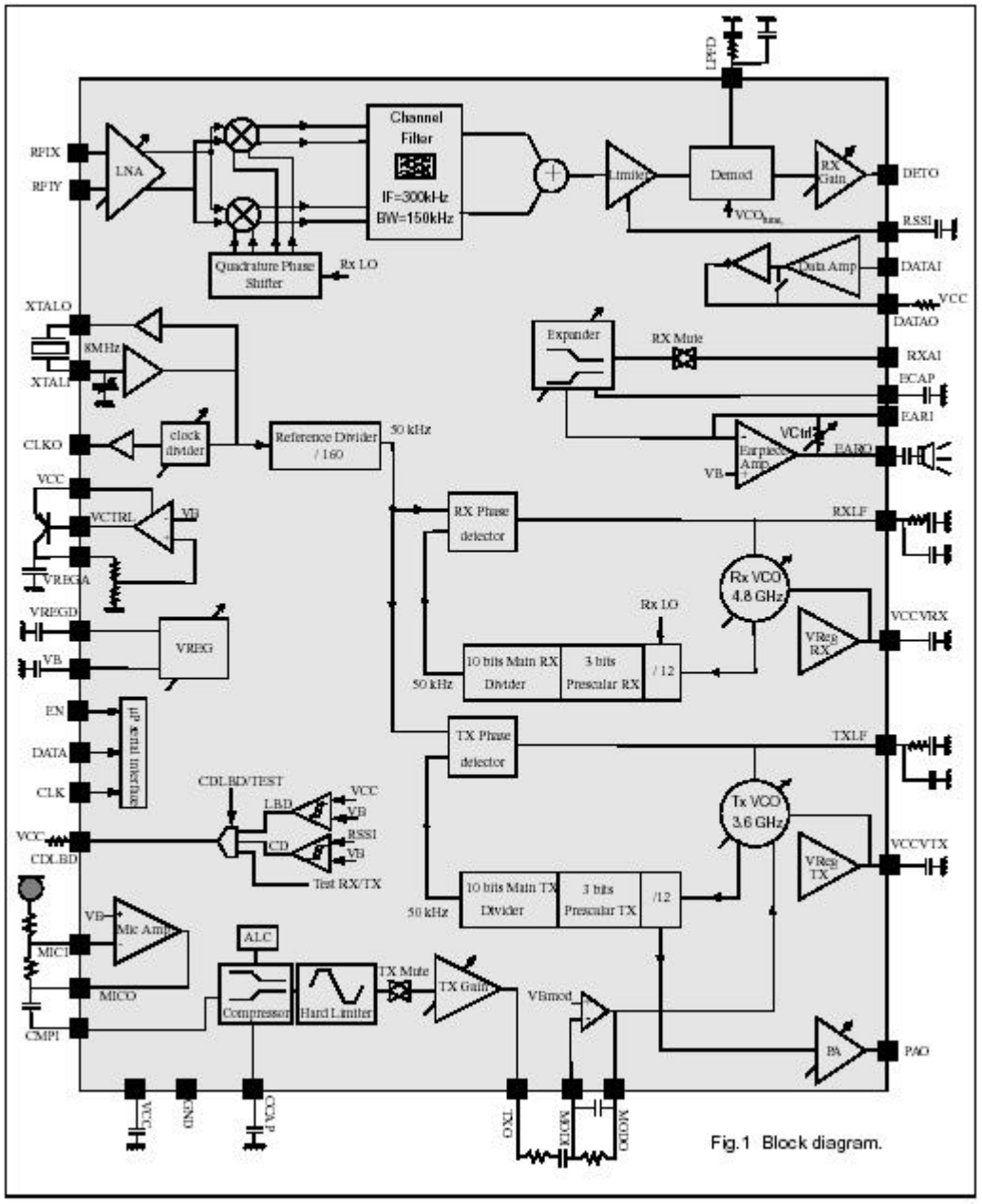


Fig.1 Block diagram.

There are seven important input/output signals that are necessary for operation of the RF section (this does not include the separate supply lines for both Tx and Rx sections). A 8.0

MHz reference is present for use in the frequency synthesisers. The accuracy of this 8.0 MHz input will affect the accuracy of the transmit and receive frequencies. In order to ensure proper operation of the RF module, the 8.0 MHz reference signal must be at least $128mV_{p-p}$ in amplitude. Also present is the three-line data (SPI) bus on which data is transferred to the synthesisers to set both the transmit and receive frequencies.

The modulation input allows analog voice and digital data (signalling) to be modulated directly onto the Tx carrier. There are three outputs from the RF module: Rx audio, Rx data and RSSI. The Rx data output is the demodulated signal which is subsequently filtered. The Rx audio output is the recovered analog voice that is sent to the audio circuits for additional processing. The RSSI output gives an indication of received signal strength. This is set to be high when the input signal is -90dBm or less at the antenna.

The RF module performs a single down-conversion of the incoming RF signal to 10.7 MHz where it is demodulated. The transmit section directly modulates the RF carrier.

In case of 2.4GHz operation, we will make use of the input port at 300KHz in the RF combo and implement the modulation. Then a new 2.4GHz to 900MHz down converter will be designed.

After studying the report from AT&T, the frequency beginning at 2.41GHz was chosen. Thanks to the attenuation of SAW filter (more than 30dB). The frequency range of 2.5GHz to 2.8GHz which the highest power of microwave oven is suppressed. This yields better selectivity at 2.4GHz.

The following sections explain the individual blocks in the RF module in detail.

3.1 Antenna Section

3.1.1 Antenna

The antenna is a device that allows effective conversion of energy from air to the RF module circuitry. The base has a 1/4-wave antenna with approximately 0-dB gain relative to an isotropic radiator, while the handset has a 1/4 wave antenna with approximately -3 dB gain. The duplexer and filters that follow the antenna require a 50 Ω match to operate properly. The antenna is approximately matched to 50 Ω and requires a simple lump-component matching network to achieve this. If a network analyser is attached to the BFA connector after disconnecting the duplexer, the antenna match may be measured. In order to achieve a good 50 Ω match, one must be careful not to obstruct the antenna, as any object near the antenna will affect its impedance.

Since large frequency separation between RX and TX, a simple duplexer was used - two discrete band pass filters for TX and RX. In addition, there will be a quart wave transformer between the each path for additional rejection.

However, because of the space limitation and design simplicity, 2 antennas are placed in handset. The 2.4GHz antenna is placed in the case.

3.2 Receive Section

The block diagram of FM receiver is shown below:

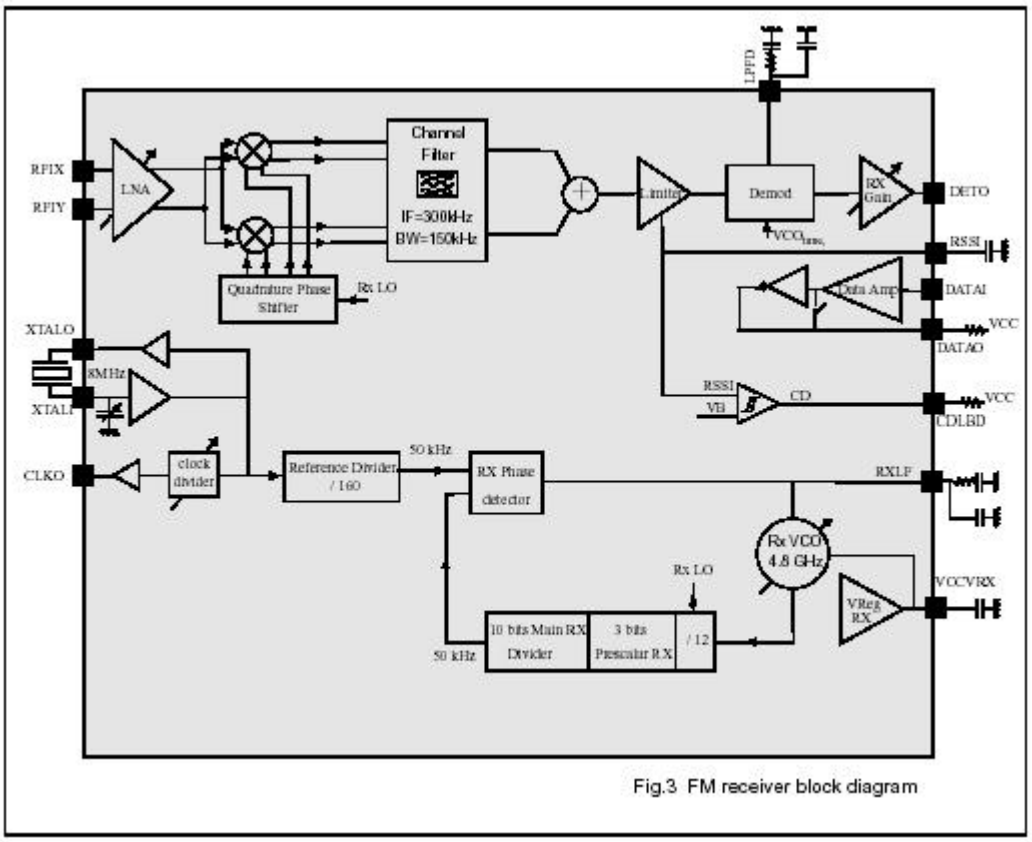


Fig.3 FM receiver block diagram

3.2.1 BALUN matching and differential low-noise amplifier

The purpose of the differential low-noise amplifier is to provide enough gain and the noise figure of the Rx section is fixed to a value as low as possible. It must provide a good 50 Ω match to both the SAW duplexer by the BALUN matching. This amplifier must also have good power handling capability due to the limited filtering which precedes it. The BALUN matching ensures the gain of this stage is not too wide-band, further improving its performance by allowing it to effectively reject signals that are far out of its passband.

3.2.2 Rx VCO and PLL

The crystal local oscillator and reference divider provide the reference frequency for the Rx PLL. The programmed divider value for the reference divider is selected based on the crystal frequency. VCOs and varicaps are integrated. Resonance inductors is shared between bonding wires, leadframe of the package and external inductors. Here, 8MHz X'tal is selected as a reference.

The Tx PLL is combined together with Rx PLL in the block "Dual PLL frequency synthesizer". The synthesiser receives channel information from the audio module through the SPI bus. It also requires a stable clock reference which is supplied from the 8MHz X'tal.

A passive loop filter is employed connecting to the VCO to improve the phase noise and to allow relatively fast lock time.

In case of handset 2.4GHz reception, with UAA3650 new RF combo chip, external PLL, LNA, mixer & LO doubler is not require. The UAA3650 internal VCO is oscillating at 2.4GHz. The mixer then compares the external 2.4GHz LO with the incoming RF, resulting the IF. The IF frequency feeding in the UAA3650 is 300kHz.

3.2.3 Rx Mixer, IF Filter & IF Amplifier

The function of the mixer is to combine the incoming signal with a LO signal in order to convert the desired signal to the 300kHz/10.7 MHz intermediate frequency (IF). The mixer output is coupled off of the combo chip to a 10.7 MHz ceramic IF filter before it is injected into IF ampilifer 1 integrated within the combo chip. The output of IF ampilifer 1 is connected to input of IF ampilifer 2 by shorting the SFS switch (software controlled). The output of IF amplifier 2 is connected to another 10.7MHz IF filter.

The limiter provide a 6dB gain for the 10.7MHz Rx signal path. It is used to limit the signal amplitude entering the demodulator.

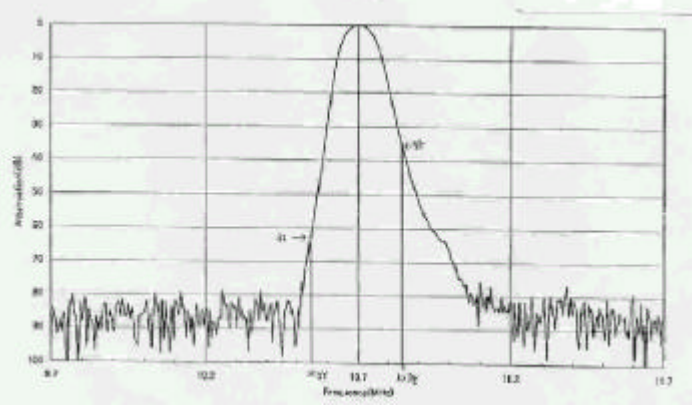


Figure 3.1 : Frequency response of 2x 10.7MHz IF filters (in series)

3.2.4 FM-PLL Demodulator

The FM-PLL demodulator is a wideband FM demodulator with programmable ability allowing to calibrate the center frequency of the VCO within the FM PLL to align the frequency as close as the norminal value (i.e.: 10.7MHz/300kHz(2.4G)). The quadrature voltage may be observed at the ATE test point connector through DETO pin. This voltage should nominally be 1.2 V for both the base and handset when a signal is centre tuned.

The recovered audio signal from the demodulator has a peak-to-peak amplitude of approximately 0.43 V (for 25 kHz peak-to-peak modulation). One path from the recovered audio port is filtered through a low-pass data filter and passed back into the baseband module.

3.2.5 Data Comparator & Data Phase Shifter

The data comparator is an inverting hysteresis comparator. The open collector output is current limited to control the output signal slew rate. An external bandpass filter is connected between DETO and DATAI (AC coupled). An external capacitor can be added to further reduce the slew rate.

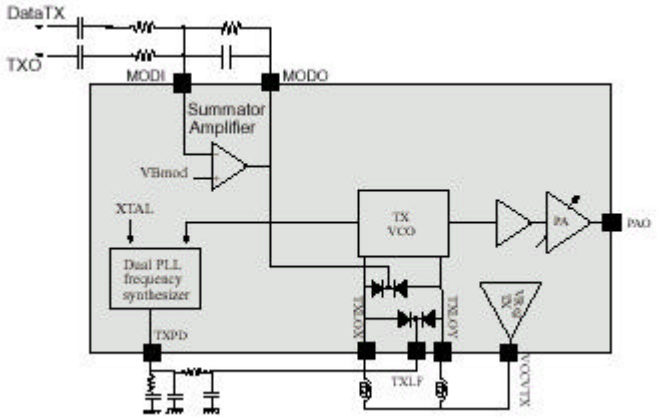
The data phase shifter allows 180 degree phase change of the received data for programming convenience.

3.2.6 RSSI Comparator

The UAA3650/ UAA3519A provides RSSI detect (i.e.: CDLBD pin) that is proportional to the input signal level, sending to the MCU in the baseband section.

3.3 Transmit Section

The block diagram of transmit section is shown below:



3.3.1 Tx Amplifiers

A programmable power amplifier is used to provide the necessary gain for the transmit section. It amplifies the signal from the Tx VCO to apply the correct output power into the antenna (-3 dBm for both handset and base).

There is a Chebyshev low-pass filter between duplexer Tx in port and PAO pin. The cutoff frequency of the filter =915MHz, 3 poles and ripple <.1dB. The source and load impedence = 50 ohms. It is used to reduce the 900 MHz harmonics power level.

In case of base 2.4GHz transmission, the internal modulator of UAA3519A is used and it will be oscillated at around 800MHz or 1.2GHz. Then an extra multiplier (x2) and a 2.4GHz power amplifier are used.

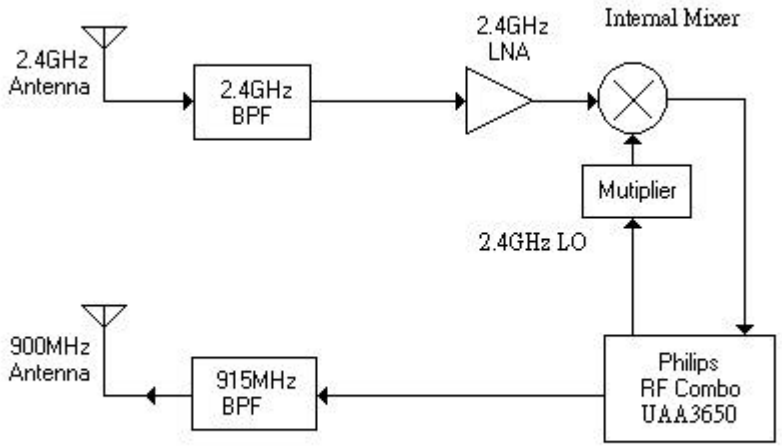
Since frequency multiplier is employed in the design. Filter is needed to suppress the fundamental frequency. (800MHz or 1.2GHz)

3.3.2 Tx VCO and PLL

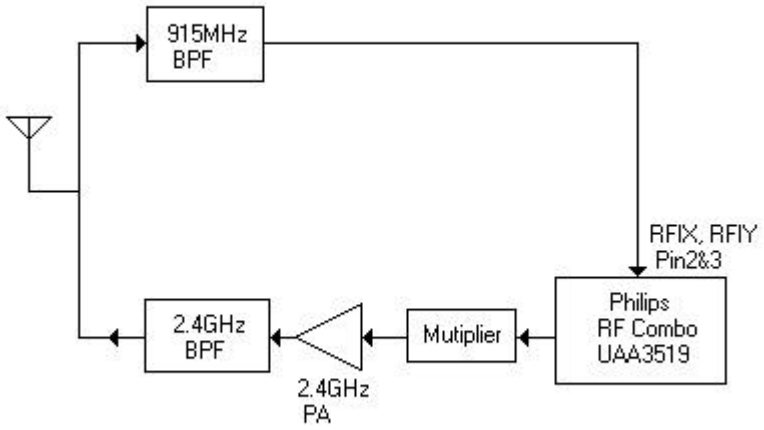
The basic operation of the Tx VCO is the same as the Rx VCO, except that the Tx VCO is modulated by the transmit voice and data. The audio deviation is adjusted to a nominal value of 25 kHz/50kHz (2.4G) by adjusting the summator amplifier gain.

The Tx PLL is combined together with Rx PLL in the block "Dual PLL frequency synthesizer". The loop filter cut-off frequency is about 60-70 Hz. This allows the data and

audio modulation to include frequencies down to about 100 Hz. The power-up time of the Tx PLL is not critical.



H/S – RF modules Block Diagram



B/S – RF modules Block Diagram

APPENDIX F - USERS MANUAL

Important Safety Instructions

When using your telephone equipment, basic safety precautions should always be followed to reduce the risk of fire, electric shock and injury, including the following:

1. Read and understand all instructions.
2. Follow all warnings and instructions marked on the product.
3. Unplug this product from the wall outlet before cleaning. Do not use liquid cleaners or aerosol cleaners. Use a damp cloth for cleaning.
4. Do not use this product near water (for example, near a bath tub, kitchen sink, or swimming pool).
5. Do not place this product on an unstable cart, stand, or table. The product may fall, causing serious damage to the product.
6. Slots and openings in the cabinet and the back or bottom are provided for ventilation. To protect it from overheating, these openings must not be blocked by placing the product on the bed, sofa, rug, or other similar surface. This product should never be placed near or over a radiator or heat register. This product should not be placed in a built-in-installation where proper ventilation is not provided.
7. This product should be operated only from the type of power source indicated on the marking label. If you are not sure of the type of power supply to your home, consult your dealer or local power company.
8. Do not allow anything to rest on the power cord. Do not locate this product where the cord will be abused by persons walking on it.
9. Never push objects of any kind into this product through cabinet slots as they may touch dangerous voltage points or short out parts that could result in a risk of fire or electric shock. Never spill liquid of any kind on the product.
10. To reduce the risk of electric shock, do not disassemble this product. If service or repair work is required, contact **VTech** Customer Service at **1-800-595-9511**. Opening or removing cabinet parts other than specified access doors may expose you to dangerous voltages or other risks. Incorrect reassembling can cause electric shock when the appliance is subsequently used.
11. Do not overload wall outlets and extension cords as this can result in the risk of fire or electric shock.
12. Unplug this product from the wall outlet:

a) When the power supply cord or plug is damaged or frayed.
b) If liquid has been spilled into the product.
c) If the product has been exposed to rain or water.
d) If the product does not operate normally by following the operating instructions. Adjust only those controls that are covered by the operating instructions because improper adjustment of other controls may result in damage and will often require extensive work to restore the product to normal operation.
e) If the product has been dropped and the cabinet has been damaged.
f) If the product exhibits a distinct change in performance.

13. Avoid using a telephone (other than a cordless type) during an electrical storm. There may be a remote risk of electric shock from lighting.
14. Do not use the telephone to report a gas leak in the vicinity of the leak.

If you have questions about this product, or if you're having difficulty with setup or operation, do not return your phone to the store. Call our Customer Support Center at:

1-800-595-9511

In Canada, call

1-800-267-7377

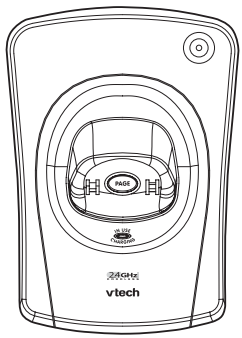
Introduction

Parts Check List:

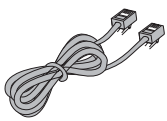
1. Handset
2. Base Unit
3. Telephone Line Cord
4. Battery Pack
5. AC Adapter
6. User's Manual

To purchase replacement battery packs, call VTech Communications at 1-800-595-9511. In Canada, call VTech Electronics at 1-800-267-7377.

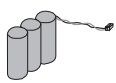
HANDSET



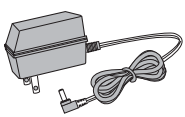
BASE UNIT



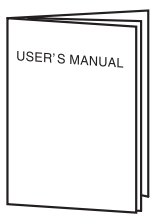
TELEPHONE LINE CORD



BATTERY PACK

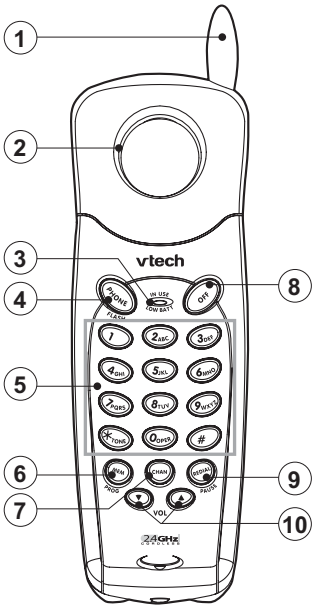


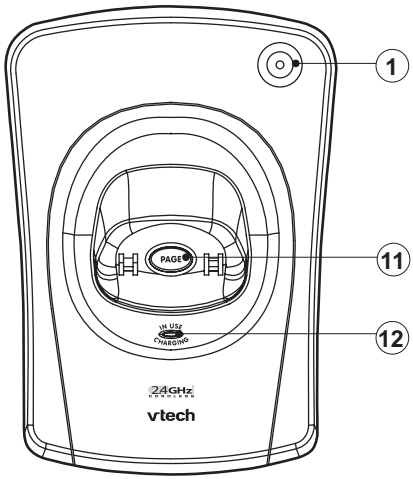
AC ADAPTER



USER'S MANUAL

Handset and Base Layout



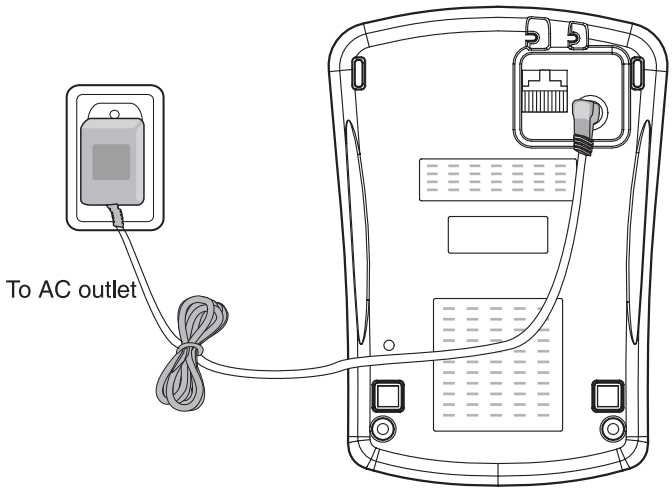


1. Antenna
2. Earpiece
3. IN USE/CHARGING LED
4. PHONE(FLASH)
5. Dialing Keys (0-9,*, #)
6. MEM(PROG)
7. Channel
8. OFF
9. REDIAL(PAUSE)
10. Volume
11. PAGE
12. IN USE/CHARGING LED

Setup

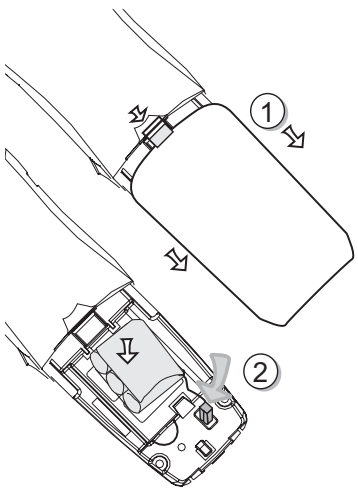
Connecting power to Base Unit

Plug the AC power adapter into an electrical outlet, and the DC connector into the bottom of the Base Unit.



Installation of Battery Pack in Handset

Follow the steps below:



1. Remove the battery cover by pressing on the indent and sliding downward.
2. With the red and black wires at the bottom of the pack, angle the top of the battery into the compartment, under the two claws. Next, press the lower end of the battery pack down, so it is held in place by the lower claw. Now, plug the connector into the socket. Slip the battery wires into the guide, located below the battery.
3. Replace the battery cover by sliding it upwards.
4. Place the Handset in the Base Unit, and allow it to charge for 12 hours. After the initial charge, a maintenance charge of 8 hours should be sufficient. Maximum talk time on a full charge is approximately 5 hours, and maximum standby time is 5 days.

Setup

CAUTION: To reduce the risk of fire or injury, read and follow these instructions:

1. Use only the **VTech** battery supplied or equivalent.
2. Do not open or mutilate the battery. Released electrolyte is corrosive and may cause damage to the eyes or skin. It may be toxic if swallowed.
3. Exercise care in handling batteries in order not to short the battery with conducting materials such as rings, bracelets, and keys. The battery or conductor may overheat and cause burns.
4. Do not dispose of the battery in a fire. The cell may explode.

Connecting to phone line

Plug one end of the telephone line cord into the jack on the bottom of the Base Unit. Plug the other end of this cord into the telephone wall jack.

Checking for dial tone

After the battery pack is charged, pick up the Handset and press the PHONE key. The **IN USE** indicator should light up, and you should hear a dial tone; if not, see **IN CASE OF DIFFICULTY**.

Tone/Pulse Selection

See **OPERATING INSTRUCTIONS** for details.

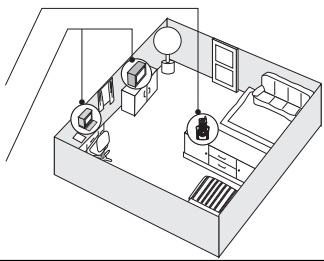
CAUTION: Use only the VTech power supply provided with your **t 2406**.

IMPORTANT:

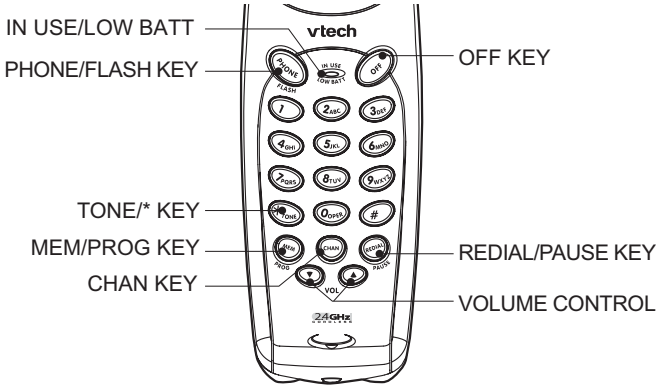
For best performance the **t 2406** should be installed as follows:

In an elevated location, in the center of the room, with no obstructions nearby.

In a location that is away from other electrical appliances such as microwave ovens, personal computers, or televisions.



Handset Features



IN USE/LOW BATT LED

- The **IN USE/LOW BATT** LED lights when the Handset is on an active call.
- It flashes in cadence with an incoming ring.
- It flashes quickly during programming mode.
- It flashes slowly when battery is low.

PHONE / FLASH KEY

- Press the **PHONE** key to make a call.
- If you are currently on a call, pressing **PHONE** flashes the line. This would be used with call waiting to answer your second call.

REDIAL / PAUSE KEY

- When you hear the dial tone, pressing the **REDIAL** key will dial out the last number that was called on your phone.
- It can also be used to store the last number dialed into the speed dial memory. See **Storing a Redial Number into Speed Dial** for details.
- You can store a **PAUSE** into your dialing number. See **Storing Pauses in Memory** for details.

TONE/ * KEY

- In **PULSE** dialing mode, this key is used to switch to Temporary **TONE** dialing mode.

PROG KEY

- Press **PROG** key to enter programming mode.

VOLUME CONTROL

- Adjust the volume of what you hear through the Handset**.**
- While on a call, press the ▲ or ▼ key to adjust the listening volume. The Handset will emit a double beep when the maximum or minimum volume level has been reached.

OFF KEY

- Press the **OFF** key to exit all modes of operation.

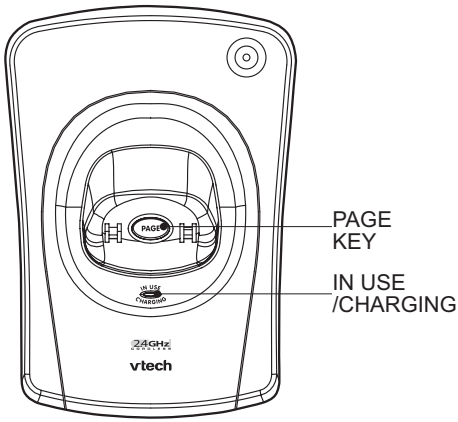
CHAN KEY

- Pressing the **CHAN** key when the Handset is in use will activate a channel change to the next free channel.
- This is used if you are experiencing noise or interference on the current channel.

MEM KEY

- Press the **MEM** key to enter memory mode.
- The sequence for dialing a speed dial number in memory is: **PHONE**, **MEM**, Number Button (**0-9**).

Base Unit Features



IN USE/CHARGING LED

- The LED illuminates steadily when the Handset is in the Base cradle to indicate that the Handset battery is being charged.
- The LED illuminates whenever the Handset is being used.
- This LED also flashes in cadence with the incoming ring.

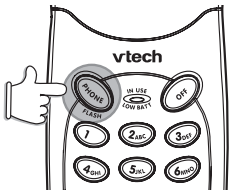
PAGE KEY

- Press the **PAGE** key to page the Handset.
- Press it second time to cancel a page.
- The Base will ring the Handset for 1 minute before ending the page automatically.
- The Handset can also cancel the page by pressing the **OFF** key.

Operating Instructions

Making Calls

- Pick up the Handset and press **PHONE**.
- When you hear a dial tone, dial the number.
- The **IN USE** LED will illuminate while the Handset is on a call. If you make a mistake when dialing, press **OFF** to hang up, then press **PHONE** to get the dial tone again.
- You must always press **PHONE** before you can dial a call on the Handset.

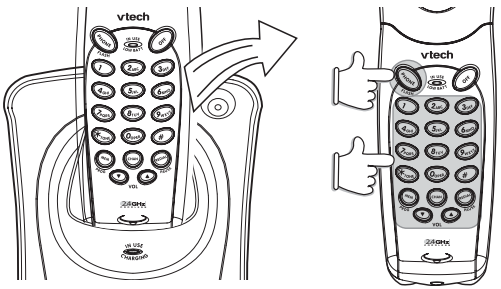


Answering Calls

- When an incoming call is ringing, the **IN USE** LED on the Base and Handset will flash.
- To answer a call when the Handset is in the Base, just pick up the Handset.

— OR —

- To answer a call when the Handset is away from the Base, press any key on the Handset (except **OFF**). This is very useful in a dark environment; you do not have to fumble around looking for the **PHONE** key to answer the call.

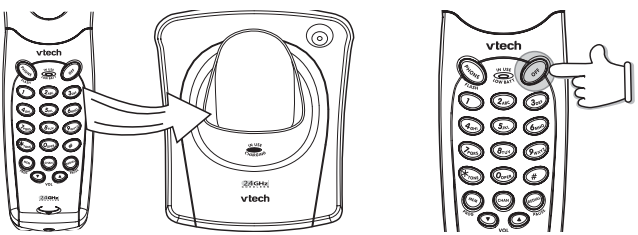


Disconnecting

- To end a call, press **OFF** on the Handset.

— OR —

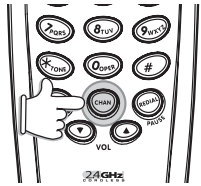
- Place the Handset back in the Base.



Operating Instructions

Changing Channels

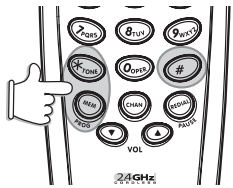
- If you notice interference when using your Handset, press **CHAN** to switch to a clear channel. This function is only available when you are on a call.



TONE/PULSE Setting

NOTE: Your t 2406 is preset at the factory for TONE dialing.

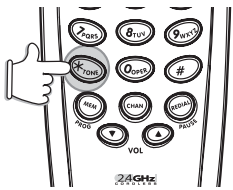
- If you have touch tone service on phone line:
- Press **MEM/PROG**, *****, *****, **MEM/PROG** to switch to **TONE** dialing.
- If you have rotary service, press **MEM/PROG**, *****, #, **MEM/PROG** to switch to **PULSE**.



Temporary Tone

If you have a rotary (dial-pulse) telephone service, (**TONE/PULSE** setting is set to **PULSE**), this feature allows you to enter special codes and tones to operate answering machines, use electronic banking services, calling cards, or other special services.

- Dial the call normally.
- Activate the Temporary Tone feature by pressing **TONE** (the ***** key).
- You can then press the numbers or symbols you need, and your phone will send the proper signals.
- To end the call, press **OFF** or place the Handset back in the Base. The phone will automatically go back to rotary (dial-pulse) service.

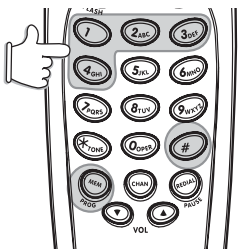


Programming the Ringer Type

The Handset ringer is capable of four different types of ringing tones. To select a different ringer type do the following:

- Press **MEM/PROG**.
- Press the # key.
- Press a key 1 - 4 to select a ringer type.
- Press the **MEM/PROG** key to confirm.

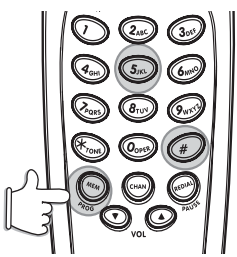
NOTE: To program, the Handset must be OFF.



Turning Off the Ringer

To turn off the ringer on the Handset, do the following:

- Press **MEM/PROG**.
- Press the # key.
- Press **5** to turn off the ringer. Press the **MEM/ PROG** key to confirm.
- To turn the ringer on again, see **Programming the Ringer Type**.

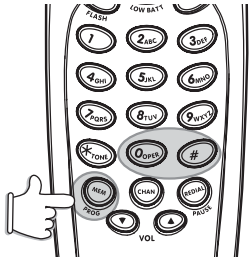


Operating Instructions

Checking the Ringer

To check the ringer which is currently programmed, do the following:

- Press **MEM/PROG**.
- Press the **#** key.
- Press **0**.
- Press the **MEM/PROG** key to confirm.



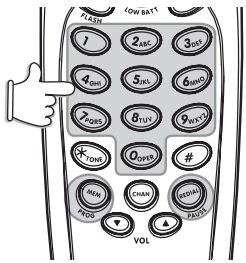
Memory Dialing

- The **t 2406** can store up to 10 different phone numbers that you can dial just by pressing **PHONE**, **MEM/ PROG** and one of the number keys (0-9)

Programming Speed Dial Numbers

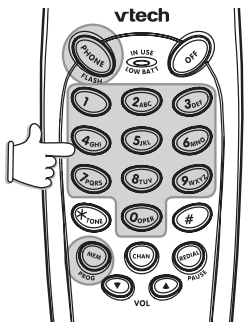
The Handset must be **OFF**.

- Press **MEM/PROG**. The **IN USE/LOW BATT** LED will blink to indicate that you are in the programming mode.
- Press the number of the memory location you wish to store the number in (0-9).
- Using the dial pad, dial the number you want to store. The number can be up to 16 digits long. The number can be entered manually or by using **REDIAL**.
- Press **MEM/PROG** to store the phone number to the key you selected. The phone exits programming mode and emits a series of beeps.



Speed Number Dialing

- Press **PHONE** to get a dial tone.
- Press **MEM/PROG** and the memory location number key (0-9).
- For example, to dial the number you assigned to key '**8**', you would press **PHONE**, **MEM/PROG**, **8**.



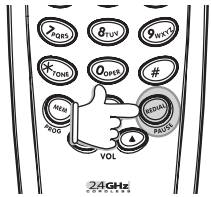
To Change or Replace a Speed Dial Number

- To change or replace a stored number in speed dial memory, simply enter the new number and store it in the memory location you wish to change.

Operating Instructions

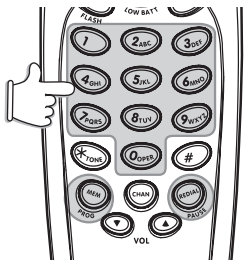
Storing Pauses in Memory

- To insert a pause in a phone number, press **REDIAL/PAUSE**. The pause is 2 seconds in length. For longer pauses, press **REDIAL/PAUSE** two or more times. Each additional press adds an additional 2 seconds pause.
- If your phone is connected to a PBX you can store the PBX access number and a pause before the phone number. For example, to store **9-PAUSE-555-1234** in memory location 8 do the following:
- Press **MEM/PROG**.
- Press **8**.
- Press **9**.
- Press **REDIAL/PAUSE**.
- Dial **555-1234**.
- Press **MEM/PROG**.



Using Redial

- To redial the last number you called, press **PHONE** then press **REDIAL/ PAUSE**. The phone will automatically dial the number.

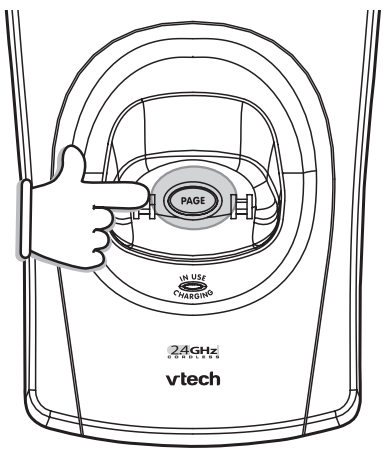


Storing a Redial Number into Speed Dial

- To store the last number you dialed as a Speed Dial number, press **MEM/ PROG**, a location number (0-9), **REDIAL/PAUSE**, **MEM/PROG**.

The Page Feature

- From the Base Unit, press **PAGE** to signal the person at the Handset.
- To end the page at the Base, press **PAGE** again.
- To end the page at the Handset, press **OFF**.
- If the Handset is in use (off-hook) when **PAGE** is pressed on the base Unit, the Handset will not emit one page alert. If the Handset is not in use (on-hook), the page alert will continue for approximately 60 seconds.
- This feature is useful in locating a misplaced Handset.



Maintenance

Taking Care Of Your Telephone

Your **t 2406** cordless telephone contains sophisticated electronic parts, so it must be treated with care.

Avoid rough treatment

Place the Handset down gently. Save the original packing materials to protect your telephone if you ever need to ship it.

Avoid water

Your telephone can be damaged if it gets wet. Do not use the Handset outdoors in the rain, or handle it with wet hands. Do not install your Base Unit near a sink, bathtub or shower.

Electrical storms

Electrical storms can sometimes cause power surges harmful to electronic equipment. For your own safety, use caution when using electric appliances during storms.

Cleaning your telephone

Your telephone has a durable plastic casing that should retain its luster for many years. Clean it only with a soft cloth slightly dampened with water or a mild soap. Do not use excess water or cleaning solvents of any kind.

Remember that electrical appliances can cause serious injury if used when you are wet or standing in water. If your Base Unit should fall into water, **DO NOT RETRIEVE IT UNTIL YOU UNPLUG THE POWER CORD AND TELEPHONE LINE CORDS FROM THE WALL**. Then pull the unit out by the unplugged cords.

In Case Of Difficulty

If you have difficulty operating your phone, the suggestions below should solve the problem. If you still have difficulty after trying these suggestions, call VTech Communications at 1-800-595-9511. In Canada, call VTech Electronics at 1-800-267-7377.

The Phone Doesn't Work At All

- Make sure the Power Cord is plugged in.
- Make sure the telephone line cord is plugged firmly into the Base Unit and the telephone wall jack.
- Make sure the batteries are properly charged. If the **LOW BATT** LED is slowly flashing, the battery pack needs charging.

No Dial Tone

- First check all the suggestions above.
- If you still don't hear a dial tone, disconnect the Base Unit from the telephone jack and connect a different phone. If there is no dial tone on that phone either, the problem is in your wiring or local service. Contact your local telephone company.

You Get Noise, Static, Or A Weak Signal Even When You're Near The Base Unit

- Household appliances plugged into the same circuit as the Base Unit can sometimes cause interference. Try moving the appliance or the Base Unit to another outlet.

You Get Noise, Static, Or A Weak Signal When You're Away From The Base Unit

- You may be out of range. Either move closer to the Base, or relocate the Base Unit.
- The layout of your home may be limiting the range. Try moving the Base Unit to another position.

The Handset Does Not Ring When You Receive A Call

- Make sure you have the Handset ringer activated. To set the ringer, see **Programming the Ringer Type**.
- Make sure the telephone line cord is plugged firmly into the Base Unit and the telephone jack. Make sure the power cord is plugged in.
- You may be too far from the Base Unit.
- You may have too many extension phones on your telephone line to allow all of them to ring. Try unplugging some of the other phones.

You Hear Other Calls While Using Your Phone

- Disconnect your Base Unit from the telephone jack, and plug in a regular telephone. If you still hear other calls, the problem is probably in your wiring or local service. Call your local telephone company.

You Hear Noise In The Handset, And None Of The Keys Or Buttons Work

- Make sure the power cord is plugged in.

In Case Of Difficulty

Common Cure For Electronic Equipment

If the unit does not seem to be responding normally, then try putting the Handset in the cradle. If it does not seem to respond, do the following(in the order listed) :

1. Disconnect the power to the Base.
2. Disconnect the Handset battery.
3. Wait a few minutes.
4. Connect power to the Base.
5. Re-install the battery pack, and return the Handset to the charge cradle.
6. After a few seconds, try using your Handset again.

Warranty Statement

What does this limited warranty cover?

- The manufacturer of this **VTech** product, **VTech Communications**, warrants to the holder of a valid proof of purchase ("Consumer" or "you") that the product and all accessories provided by **VTech** in the sales package ("Product") are free from material defects in material and workmanship, pursuant to the following terms and conditions, when installed and used normally and in accordance with operation instructions. This limited warranty extends only to the Consumer for Products purchased and used in the United States of America.

What will VTech Communications do if the Product is not free from material defects in materials and workmanship during the limited warranty period ("Materially Defective Product")?

- During the limited warranty period, VTech's authorized service representative will repair or replace at VTech's option, without charge, a Materially Defective Product. If we repair this product, we may use new or refurbished replacement parts. If we choose to replace this product, we may replace it with a new or refurbished product of the same or similar design.VTech will return repaired or replacement products to you in working condition. VTech will retain defective parts, modules, or equipment. Repair or replacement of Product, at VTech's option, is your exclusive remedy. You should expect the repair or replacement to take approximately 30 days.

How long is the limited warranty period ?

- The limited warranty period for the product extends for ONE(1)YEAR from the date of purchase if we repair or replace a Materially Defective Product under the terms of this limited warranty. This limited warranty also applies to repaired or replacement Products for a period of either (a) 90 days from the date the repaired or replacement Product is shipped to you or (b) the time remaining on the original one-year warranty; whichever is longer.

What is not covered by this limited warranty ?

This limited warranty does not cover

1. Product that has been subjected to misuse, accident, shipping or other physical damage, improper installation, abnormal operation or handling, neglect, inundation, fire, water or other liquid intrusion; or
2. Product that has been damaged due to repair, alteration or modification by anyone other than an authorized service representative of VTech; or
3. Product to the extent that the problem experienced is caused by signal conditions, network reliability or cable or antenna systems; or
4. Product to the extent that the problem is caused by use with non-VTech electrical accessories; or

Warranty Statement

5. Product whose warranty/quality stickers, Product serial numbers plates or electronic serial numbers have been removed, altered or rendered illegible; or
6. Product purchased, used, serviced, or shipped for repair from outside the United States, or used for commercial or institutional purposes (including but not limited to Products used for rental purposes); or
7. Product returned without valid proof of purchase (see 2 below); or
8. Charges for installation or set up, adjustment of customer controls, and installation or repair of systems outside the unit.

How do you get warranty service?

- To obtain warranty service in the United States of America, call 1-800-595-9511 for instructions regarding where to return the Product. Before calling for service, please check the user's manual. A check of the Product controls and features may save you a service call.
- Except as provided by applicable law, you assume the risk of loss or damage during transit and transportation and are responsible for delivery or handling charges incurred in the transport of Product(s) to the service location . VTech will return repaired or replaced product under this limited warranty to you, transportation, delivery or handling charges prepaid. VTech assumes no risk for damage or loss of the Product in transit.
- If the Product failure is not covered by this limited warranty, or proof of purchase does not meet the terms of this limited warranty, VTech will notify you and will request that you authorize the cost of repair prior to any further repair activity. You must pay for the cost of repair and return shipping costs for the repair of Products that are not covered by this limited warranty.

What must you return with the Product to get warranty service?

1. Return the entire original package and contents including the Product to the VTech service location along with a description of the malfunction or difficulty;
2. Include "valid proof of purchase" (sales receipt) identifying the Product purchased (Product model) and the date of purchase or receipt; and
3. Provide your name, complete and correct mailing address, and telephone number.

Other Limitations

- This warranty is the complete and exclusive agreement between you and VTech. It supersedes all other written or oral communications related to this Product. VTech provides no other warranties for this product. The warranty exclusively describes all of VTech's responsibilities regarding the product. There are no other express warranties. No one is authorized to make modifications to this limited warranty and you should not rely on any such modification.

  State Law Rights: This warranty gives you specific legal rights, and you may also have other rights which vary from state to state.

Warranty Statement

Limitations: Implied warranties, including those of fitness for a particular purpose and merchantability (an unwritten warranty that the product is fit for ordinary use) are limited to one year from date of purchase. Some states do not allow limitations on how long an implied warranty lasts, so the above limitation may not apply to you.

- In no event shall VTech be liable for any indirect, special, incidental, consequential, or similar damages (including, but not limited to lost profits or revenue, inability to use the product, or other associated equipment, the cost of substitute equipment, and claims by third parties) resulting from the use of this product. Some states do not allow the exclusion or limitation of incidental or consequential damages, so the above limitation or exclusion may not apply to you.

FCC, ACTA and IC Regulations

This equipment complies with Parts 15 of the Federal Communications Commission (FCC) rules for the United States. It also complies with regulations RSS210 and CS-03 of Industry and Science Canada. Operation is subject to the following two conditions: (1) this device may not cause interference, and (2) this device must accept any interference, including interference that may cause undesired operation of the device.

A label is located on the underside of the Base Unit containing either the FCC registration number and Ringer Equivalence Number (REN) or the IC registration number and Load Number. You must, upon request, provide this information to your local telephone company.

This equipment is compatible with inductively coupled hearing aids.

Should you experience trouble with this telephone equipment, please contact:

VTech Communications Inc.
CUSTOMER SERVICE at 1-800-595-9511. In Canada, call VTech Electronics at 1-800-267-7377.

For repair/warranty information. The telephone company may ask you to disconnect this equipment from the line network until the problem has been corrected.

FCC Part 15

Warning: Changes or modifications to this unit not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment.

The equipment has been tested and found to comply with part 15 of the FCC rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try and correct the interference by one or more of the following measures:

- Reorient or relocate the receiving antenna.
- Increase the separation between the equipment and receiver.
- Connect the equipment into an outlet or on a circuit different from that to which the receiver is connected.
- Consult the dealer or an experienced radio/TV technician for help.

FCC and ACTA Information

If this equipment was approved for connection to the telephone network prior to July 23, 2001, it complies with Part 68 of the Federal Communications Commission (FCC) rules. If the equipment was approved after that date, it complies with the Part 68 rules and with Technical Requirements for Connection of Equipment to the Telephone Network

adopted by the Administrative Council for Terminal Attachments (ACTA). We are required to provide you with the following information.

1. Product identifier and REN information

The label on the back or bottom of this equipment contains, among other things, an identifier indicating product approval and the Ringer Equivalence Number (REN). This information must be provided to your local telephone company upon request. For equipment approved prior to July 23, 2001, the product identifier is preceded by the phrase “FCC Reg No.” and the REN is listed separately. For equipment approved after that date, the product identifier is preceded by “US” and a colon (:), and the REN is encoded in the product identifier without a decimal point as the sixth and seventh characters following the colon. For example, the product identifier US:AAAEQ03T123XYZ would indicate an REN of 0.3.

The REN is used to determine how many devices you may connect to your telephone line and still have them ring when you are called. In most, but not all areas, the sum of all RENs should be five (5.0) or less. You may want to contact your local telephone company for more information.

2. Connection and use with the nationwide telephone network

The plug and jack used to connect this equipment to the premises wiring and the telephone network must comply with the applicable Part 68 rules and technical requirements adopted by ACTA. A compliant telephone cord and modular plug is provided with this product. It is designed to be connected to a compatible modular jack that is also compliant. An RJ11 jack should normally be used for connecting to a single line and an RJ14 jack for two lines. See Installation Instructions in the user’s manual. This equipment may not be used with Coin Telephone Lines or with Party Lines. If you have specially wired alarm dialing equipment connected to your telephone line, ensure the connection of this equipment does not disable your alarm equipment. If you have questions about what will disable alarm equipment, consult your telephone company or a qualified installer.

3. Repair instructions

If this equipment is malfunctioning, it must be unplugged from the modular jack until the problem has been corrected. Repairs to this telephone equipment can only be made by the manufacturer or its authorized agents. For repair procedures, follow the instructions outlined under the Limited Warranty.

4. Rights of the telephone company

If this equipment is causing harm to the telephone network, the telephone company may temporarily discontinue your telephone service. The telephone company is required to notify you before interrupting service. If advance notice is not practical, you will be notified as soon as possible. You will be given the opportunity to correct the problem and the telephone company is required to inform you of your right to file a complaint

with the FCC. Your telephone company may make changes in its facilities, equipment, operation, or procedures that could affect the proper functioning of this product. The telephone company is required to notify you if such changes are planned.

5. Hearing aid compatibility

If this product is equipped with a corded or cordless handset, it is hearing aid compatible.

6. Programming/testing of emergency numbers

If this product has memory dialing locations, you may choose to store police, fire department and emergency medical service telephone numbers in these locations. If you do, please keep three things in mind:

a. We recommend that you also write the telephone number on the directory card, so that you can still dial the emergency number manually if the memory dialing feature doesn't work.
b. This feature is provided only as a convenience, and the manufacturer assumes no responsibility for customer reliance upon the memory feature.
c. Testing the emergency telephone numbers you have stored is not recommended.

However, if you do make a call to an emergency number:

- You must remain on the line and briefly explain the reason for the call before hanging up.
- Programming/testing of emergency numbers should be performed during off-peak hours, such as in the early morning or late evening, when the emergency services tend to be less busy.

IC (Industry Canada)

This telephone is registered for use in Canada.

The term "IC: " before the certification/registration number only signifies that the Industry Canada technical specifications were met.

"NOTICE: This equipment meets the applicable Industry Canada Terminal Equipment Technical Specifications. This is confirmed by the registration number. The abbreviation, IC, before the registration number signifies that registration was performed based on a Declaration of Conformity indicating that Industry Canada technical specifications were met. It does not imply that Industry Canada approved the equipment."

"NOTICE: The Ringer Equivalence Number (REN) for this terminal equipment is 0.1. The REN assigned to each terminal equipment provides an indication of the maximum number of terminals allowed to be connected to a telephone interface. The termination on an interface may consist of any combination of devices subject only to the requirement that the sum of the Ringer Equivalence Numbers of all the devices does not exceed five.''

FCC, ACTA and IC Regulations

Before installing this equipment, users should ensure that it is permissible to be connected to the facilities of the local telecommunications company. The equipment must also be installed using an acceptable method of connection. The customer should be aware that compliance with the above conditions may not prevent degradation of services in some situations.
Repairs to certified equipment should be made by an authorized Canadian maintenance facility designated by the supplier. Any repairs or alterations made by the user to this equipment, or equipment malfunctions, may give the telecommunications company cause to request the user to disconnect the equipment.

Users should ensure for their own protection that the electrical ground connections of the power utility, telephone lines and internal metallic water pipe system, if present, are connected together. This precaution may be particularly important in rural areas.

Caution :
Users should not attempt to make such connections themselves, but should contact the appropriate electrical inspection authority, or electrician, as appropriate.

Your **Cordless Phone** is designed to operate at the maximum power allowed by the FCC and IC. This means your Handset and Base Unit can communicate only over a certain distance - which will depend on the location of the Base Unit and Handset, weather, and the construction and layout of your home or office.

The RBRC® Seal

The **RBRC®** Seal on the nickel-cadmium battery indicates that VTech Communications, Inc. is voluntarily participating in an industry program to collect and recycle these batteries at the end of their useful lives, when taken out of service within the United States and Canada.

The **RBRC®** program provides a convenient alternative to placing used nickel-cadmium batteries into the trash or municipal waste, which may be illegal in your area.

VTech' s participation in **RBRC®** makes it easy for you to drop off the spent battery at local retailers participating in the **RBRC®** program or at authorized VTech product service centers. Please call **1-800-8-BATTERY™** for information on Ni-Cd battery recycling and disposal bans/restrictions in your area. VTech's involvement in this program is part of its commitment to protecting our environment and conserving natural resources.

Technical Specifications

RBRC® is a registered trademark of Rechargeable Battery Recycling Corporation.

FREQUENCY CONTROL
Crystal controlled
PLL synthesizer

TRANSMIT FREQUENCY
Base: 2410.2-2418.9 MHz
Handset: 912.75-917.10 MHz

RECEIVE FREQUENCY
Base: 912.75-917.10 MHz
Handset: 2410.2-2418.9 MHz

CHANNELS
30 Channels

NOMINAL EFFECTIVE RANGE
Maximum power allowed by FCC and IC. Actual operating range may vary according to environmental conditions at the time of use.

SIZE
Handset: 173.7mmx51.5mmx31.3mm
(including antenna)

Base : 137.2mmx97.1mmx76.5mm
(including antenna)

WEIGHT
Handset: 630 grams
Base : 120 grams
(excluding battery pack)

POWER REQUIREMENTS
Handset: 3.6V 400mAh Ni-Cd
Battery Pack

Base : 9V DC @ 300mA

MEMORY
Speed Dial: 10 Memory locations
16 digits per location

SPECIFICATIONS ARE TYPICAL AND MAY CHANGE WITHOUT NOTICE.

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ANY KEY ANSWER | 30 CHANNEL OPERATION

2406

UNIQUE STAND UP DESIGN

USER'S MANUAL

HIGH FREQUENCY 2.4 GHz

To help protect the environment, this product may contain recycled or reconditioned parts and materials.

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www.vtechphones.com