Technical Description

FCC ID: URNHT-580TAM
Model no: V1010

1. General Description on the Frame Structure

WDCT：Worldwide Digital Cordless Telephone(telecommunication)，uses the ISM frequency band 2400MHz - 2483.5MHz with frequency hopping technique for the transmission. The system consists of 1 base unit and maximum 4 handsets. The system use TDD, TDMA to achieve the downlink / uplink transmission and multiple handsets transmission with a 10ms respectively.

The whole frequency band 2400MHz - 2483.5MHz is divided into 95 channels, the channel bandwidth is 864kHz and the system input receiver bandwidth is 864kHz such that it matchs to the channel bandwidth of the received signal.

The frame structure is as follow:

a. 10 ms will be divided into 8 equal slots, slots 1-4 is used for the downlink and slots 5-8 is used for the uplink;
b. Slot 1 & 5, slot 2-6, slot 3-7, slot 4-8 are paired for the uplink / downlink transmission of the same base unit and handset;
c. 8 Bearer slots per frame at 0.576MBits per sec;
d. Bearers on fixed slot but frequency agile (hopping) on 95 frequencies;
e. Synchronization randomly selects frequency and tries all slots.

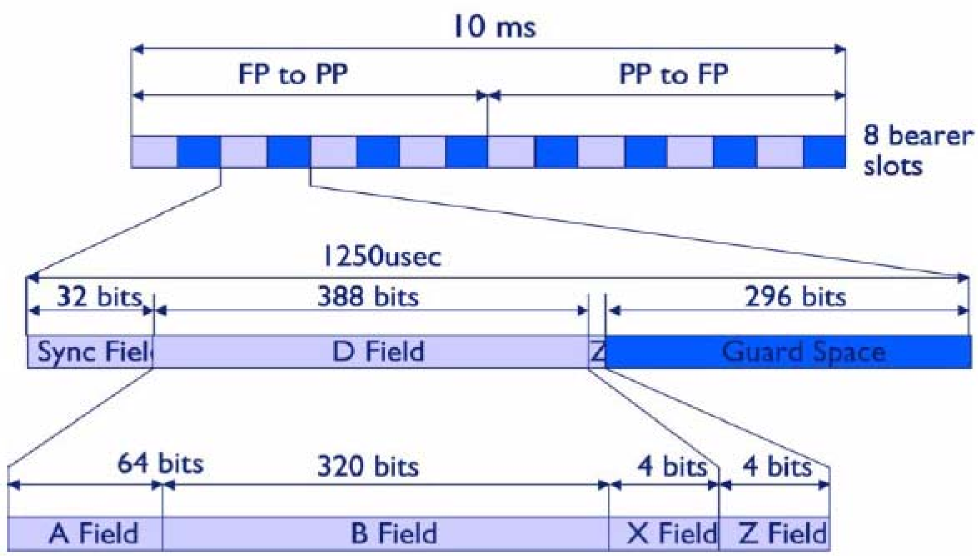

Figure 1: Frame Structure of the WDCT System.

2. RF Transcevier description

The LMX4268 is a radio transceiver integrated circuit optimized for the Digital Cordless Telecommunications (DCT) system. The transceiver, when combined with a power amplifier and a Tx/Rx switch, implements a complete 2.4GHz ISM band digital radio transceiver compliant with the FCC rules part 15. The LMX4268 integrates a complete transmitter, consisting of a phase locked loop, VCO and PA driver. The receiver contains LNA, quadrature downconverter, polyphase filter, automatic gain control and demodulator.

The channel filter in the receiver path is based on the Low-IF architecture. It is equivalent to a band-pass filter around to 864kHz IF frequency combined with image rejection architecture. In this case, the input bandwidth of this band-pass filter (system receiver) is matched to the bandwidth of the transmitted signal.

The transmitter of the radio chipset utilizes GFSK architecture. The VCO oscillates at 1.2GHz, and then pass through the integrated frequency doubler to double by 2 and amplifier to the desired RF frequency in 2.4010560GHz ~ 2.482272GHz. The VCO is directly modulated with GFSK filtered data.

The fully integrated VCO operates at 1.2GHz. The output of the frequency doubler will be switched to either the transmission or the receiving path. The VCO reference is a 10.368MHz crystal. It must be aligned better than +/- 2 ppm for frequency accuracy.

3. Antenna

The antenna used in handset and the base is monopole antenna with antenna gain 2.14 dBi. The base unit uses 2 antennas (Ant 0, 1) and the handset uses 1 antenna (Ant). All the antennas are permanently attached.

4. Dual Slot Operation

If only one handset or two handsets in use at the same time, the dual slot will be operated. If three or four handsets in use at the same time, the dual slot will be disabled, such as two handsets in intercom talking, and one handset in talking to telephone line at the meantime.

5. Frequency Table

Channel	Transmit frequency	Channel	Transmit frequency	Channel	Transmit frequency
1	2401.056	33	2428.704	65	2456.352
2	2401.920	34	2429.568	66	2457.216
3	2402.784	35	2430.432	67	2458.080
4	2403.648	36	2431.296	68	2458.944
5	2404.512	37	2432.160	69	2459.808
6	2405.376	38	2433.024	70	2460.672
7	2406.240	39	2433.888	71	2461.536
8	2407.104	40	2434.752	72	2462.400
9	2407.968	41	2435.616	73	2463.264
10	2408.832	42	2436.480	74	2464.128
11	2409.696	43	2437.344	75	2464.992
12	2410.560	44	2438.208	76	2465.856
13	2411.424	45	2439.072	77	2466.720
14	2412.288	46	2439.936	78	2467.584
15	2413.152	47	2440.800	79	2468.448
16	2414.016	48	2441.664	80	2469.312
17	2414.880	49	2442.528	81	2470.176
18	2415.744	50	2443.392	82	2471.040
19	2416.608	51	2444.256	83	2471.904
20	2417.472	52	2445.120	84	2472.768
21	2418.336	53	2445.984	85	2473.632
22	2419.200	54	2446.848	86	2474.496
23	2420.064	55	2447.712	87	2475.360
24	2420.928	56	2448.576	88	2476.224
25	2421.792	57	2449.440	89	2477.088
26	2422.656	58	2450.304	90	2477.952
27	2423.520	59	2451.168	91	2478.816
28	2424.384	60	2452.032	92	2479.680
29	2425.248	61	2452.896	93	2480.544
30	2426.112	62	2453.760	94	2481.408
31	2426.976	63	2454.624	95	2482.272
32	2427.840	64	2455.488		

6. Frequency Hopping Description

6.1 General description

Each system, comprising a BS and its associated HSs, is given a specific value of an identity value during manufacture, this value is specific to one system only. This value is used by the algorithm to generate hopping sequences that are used by this specific system. There is a 95 element sequence generated.

The 95 element sequence is used for all dummy bearers transmitted by the BS and for all traffic bearers between BS and HS.

The hopping sequences are generated in such a way that the elements are random and independent in both distance from each other and in the direction between each other.

When a BS transmits it uses one entry from the sequence in each frame in a cyclic manner so that once the end of the sequence is reached, the first element is taken again and so on. This means that each entry in the sequence will be used equally.

Each slot in the same frame is separated from the previous slot by one entry in the sequence.

Because the BS and the HSs in a system have the same identity value they generate identical sequences, so that once a HS has made a reception from the BS on any element in the sequence it can follow the same sequence and maintain synchronization.

Because each system only knows the identity of its own hopping sequence identity and not any other system values it cannot predict other hopping sequences and so it does not have the ability to be coordinated with other FHSS systems.

6.2 Hopping Sequences

The number of used frequencies (NUF) in the hopping algorithm is 95.
A PrimaryHoppingIndexNumber (PHIN) exists in the base and the handset,. This number is incremented modulo NUF in the end of the normal downlink half-frame. It is broadcast in Q0 message instead of PSCN.

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

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

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

The physical RF carrier is calculated by the formula:

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

For 10.368000 MHz crystal the frequencies are derived as:
Frequency: 2401.056 MHz + CN * 0.864000 MHz

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

7. Circuit Description for Base Unit

7.1 Baseband controller

The main control unit in the Base station is the Baseband controller SC14438 from National Semiconductor. This device is optimized to handle all audio, signal, data processing and answering machine features needed in a cordless base. Analog signals from the line interface are converted into digital signaling, processed and send via the radio interface to the handsets. In the opposite direction it receives data from the handsets via the radio interface, process these data and convert it into analog signals to be routed to the line interface. In addition, this baseband controller also control external blocks such as page key, battery charging, EEPROM interface and data/control to/from the 2.4GHz radio in the base.

7.1.1 Oscillator circuit

The crystal oscillator around the SC14438 is designed only using an external quartz crystal and two optional capacitors. The oscillator frequency can be changed using an internal Software controlled capacitor array in the SC14438. The setting of the internal capacitor array is after initialization determined by an EEPROM value, trimmed during production to be as close as possible to 10.368MHz.

7.2 Program and Data Memory

The program and the voice for the answering machine feature are stored in an internal 5Mbit flash in the SC14438 and the external flash memory respectively.

7.3 Power Supply

One voltage regulators U2 LM317 is used to regulate the 9V dc power supply to 3.2V as input to two Low dropout (LDO) regulators, Q6 and Q5, which are controlled by SC14438 to give output voltage 2.5V and 1.8V respectively.

During initializing the register controlling this regulator will be set to provide a 2.5V output used as supply to the SC14438 I/O and external devices. While the 1.8V from Q5 can be trimmed by changing the internal bandgap voltage during production.

7.3.1 Power on reset

A power on, internal reset is provided using only one external capacitor connected from the RST pin to GND. Internal circuit in the SC14438 will ensure proper reset of the SC14438 after supply of the base has provided power output from the regulators.

7.4 User Interface

7.4.1 Paging Key

The paging key is connected to an interrupt input on the SC14438. The inputs have internal pull- up in the SC14438, to ensure that the inputs will be high if no key is activated.

7.4.2 LEDs

One green LED (IN_USE LED) controlled from the SC14438 are implemented as visual indication to the user. The LEDs are driven directly from a programmable current source input port on the SC14438.

7.5 Line Interface

7.5.1 Surge protection

The line interface has an over-voltage surge protector and two high voltage capacitors mounted directly after the PSTN Line connection.

7.5.2 Rectifier Bridge

The rectifier bridge ensures that the line interface can work with all polarities on the PSTN Line.

7.5.3 Ringer detection

The ringer signals are taken differentially from the PSTN Line with a resistor and capacitor circuit and interfaced to the SC14438 that makes the processing of the signals and sends it via the radio to the handset.

7.5.4 Line sense and parallel off hook detection

Since the line sense and parallel off hook detection circuit is placed after the rectifier bridge the line sense and parallel off hook detection will be work regardless of the PSTN Line polarity.The line sense and parallel off hook detection is used to detect off hook on the basestation itself or off hook on a parallel phone.

7.5.5 Hook switch and line interface impedance

The hook switch and line impedance circuit is containing a switch and a driver circuit. Between the switch and driver circuits the AC impedance is located. The AC impedance in the line interface is tuned to make the best possible match to the PSTN Line impedance.

8. Circuit Description for Handset

8.1 Baseband controller

The main control unit in the 2.4 GHz handset is the Baseband controller SC14430 from National Semiconductor. This device is optimized to handle all audio, signal, data processing and answering machine features needed in a cordless handset. Analog signals from the internal microphone or the headset microphone are converted into digital signaling, processed and send via the radio interface to the basestation. In the opposite direction it receives data from the basestation via the radio interface, process these data and convert it into analog signals to be routed to the internal receiver, handsfree speaker or to the headset speaker, based upon user setup. In addition this baseband controller also control external blocks such as keypad, backlight, LCD, battery charging, EEPROM interface and data/control to/from the 2.4 GHz radio in the Handset.

8.1.1 Oscillator circuit

The crystal oscillator around the SC14430 is designed only using an external quartz crystal and two optional capacitors. The oscillator frequency can be changed using an internal SW controlled capacitor array in the SC14430. The setting of the internal capacitor array is after initialization determined by an EEPROM value, trimmed during production to be as close as possible to 10.368 MHz.

8.2 Program and data memory

8.2.1 Program memory

The program is stored in an internal 5Mbit flash in the SC14430.

8.2.2 Data memory

Data such as handset settings, phone book and other are stored in an external 32Kbit EEPROM.

8.3 Power Supply

Two Low dropout (LDO) regulators controlled from the SC14430 are used to power the digital and analog circuit in the handset. One LDO has a fixed output voltage of 1.8V, this voltage can be trimmed by changing the internal bandgap voltage during production. The output voltage of the other LDO is determined by the setting of an internal register in the SC14430. This regulator will before initializing and during software download provide a 1.8V output. During initializing the register controlling this regulator will be set to provide a 2.5V output used as supply to the SC14430 I/O and external devices.

A DC-DC up converter controlled by the SC14430 is used to up converter the Battery level to 3.3V.

8.3.1 Power on reset

Internal reset during initial power on is provided using only one external capacitor connected from the RST pin to GND. Internal circuit in the SC14430 will ensure proper reset of the SC14430.

8.3.2 Voltage measurement

SC14430 used the Vbat1 pin to measure the battery level. This measurement is used for both charge current measurement to the battery and also to determine the handset usage of current from the battery. The charge current measurement is used for termination of the battery charging, while the handset current usage is used for determination of the capacity of the battery (battery capacity indicator).

8.4 Charging and Battery Interface

8.4.1 Charger detection

The presence of charging voltage on the charging terminals are detected by the SC14430 via the resistor R2. Charge voltage is detected if the voltage on charge input is above 2V. The voltage on this pin should not exceed 3.45V. The diode D2 is inserted to prevent reverse voltage from the battery to trig the charge detector.

8.4.2 Ni-MH charger

The charger for the Nickel Metal Hydride battery has been implemented as a simple switch function using a NPN transistor with two 20R. resistors connected the emitter. The switch is controlled from the SC14430. This implementation requires a current limited charger.

The battery charge circuit is build around the transistor Q4, this transistor works as a switch, controlled by the SC14430 via Q3. When it is on the total charge current (around 100mA) is lead to the battery to ensure charging of the battery. The charge-current is not limited in the handset so it is vital that current limitation is provided in the base or in a charge unit if a separate charge unit is used. The resistors R37 and R38 are trickle charge resistors; their function is primary to switch on the SC14430, when a handset with a “flat” battery is put in the charger, so that the SC14430 can switch on the Q4. The charging function is after this controlled by the software.

8.5 User Interface

8.5.1 LCD interface

The display is a two line segment (one line is 7 segment and another is alphanumeric segment) with 15 icons LCD. Communication to the display is implemented using the serial bus in the SC14430. This bus is capable of running at 1MHz on the clock. A reset pin is implemented to allow reset of the display from the SC14430, this signal is used once during power-up and can be used to reset the display if communication between the SC14430 fails.

8.5.2 LCD backlight

LCD Backlight is provided using three blue LEDs, controlled by SC14430. The LEDs are driven directly from a programmable current source input port on the SC14430. The LED backlight can by this implementation be switched on and off from the SC14430, based upon user set-up.

8.5.3 Keypad

The keypad is organized as a 4 x 5 matrix, with 4 outputs and 5 inputs connected interrupt inputs on the SC14430. The inputs have internal pull-up in the SC14430, to ensure that the inputs will be high if no key is activated.

8.5.4 On/off key

The on/off (and No) key is connected to a special power on input port on the SC14430, this input will detect a key-press on this key at voltages above 1.5V. When this key is pressed the SC14430 see this as a request to power on or off the SC14430.

8.6 Audio Interface

8.6.1 Earpiece

The earpiece is coupled differentially to the loudspeaker outputs LRSP and LRSN. Two capacitors 5.6pF have been added between the outputs to GND to minimize the RF-signal coupling to the audio. The earpiece wires are soldered to the PCB via two solder pads on the 2-layer PCB.

8.6.2 Microphone

The internal condenser microphone is single-ended coupled to the MICP input on the SC14430; the negative terminal is coupled to GND via a separate routing to VREFM. This approach is made to minimize RF-signal coupling to the microphone input. A reference voltage of 1.5V is provided as biasing for the microphone from an internal voltage source in the SC14430.

8.6.3 Speakerphone

The speakerphone function has been implemented using KA8602B audio power amplifier to output PWR signal.