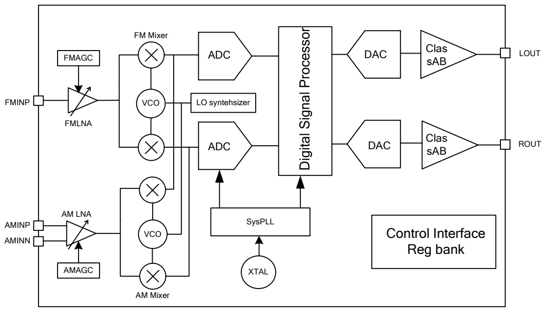
Monolithic Digital AM/FM Receiver
Radio-on-a-Chip™

KT0913



KT0913 System Diagram

▪ Features

Worldwide full band FM/AM support
- FM: 32MHz-110MHz
- AM: 500KHz-1710KHz

Fully integrated frequency synthesizer with no external components

High Sensitivity
- 1.6uVEMF for FM
- 16uVEMF for AM

High Fidelity
- SNR (FM/AM): 60dB/55dB
- THD: 0.3%

Low Supply Current
- 22mA (operating)
- <15uA (standby)

Advanced features
- Automatic antenna tuning
- Adjustable AM channel filters (2/4/6KHz)
- Automatic Frequency Control (AFC)
- Automatic Gain Control (AGC)
- Embedded FM SNR meter
- Fast seek/Tune
- Integrated stereo headphone driver
- I2C control interface for MCU

Special Features:
- Support traditional dial and digital key for frequency tuning and volume control
- Memorize channel and volume in standby mode

Low supply voltage: 2.1V to 3.6V, can be supplied by 2 AAA batteries

Support both 32.768KHz and 38KHz crystal

Support continuous reference frequency from 32.768KHz to 26MHz

Small form factor SSOP16L package

RoHS Compliant

▪ Applications

Desktop and portable radio, mini/portable audio systems, clock radio, campus radio, PMP docking station, car audio system, toy and gift.

Rev. 1.2

▪ Description

The KT0913 is a fully integrated digital AM/FM radio receiver chip with patented technologies that offer full band AM/FM functionality, high quality audio performance, simple design and low BOM cost thanks to the minimum external components required and direct frequency and volume control interface without requiring customers to modify existing exterior module.

Thanks to the patented tuning technology, the receiver maintains good signal reception even with short antennas. The chip consumes merely 22mA current and can be powered by 2 AAA batteries. Another useful feature is that the volume and channel information can be preserved in standby mode without external memories. KT0913 supports a wide range of reference clocks from 32.768KHz to 26MHz, hence can share system clocks with a varieties of MCUs further reducing the system BOM cost.

With high audio performance, fully integrated features and low BOM cost, KT0913 is ideal for various applications and products.

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1. Electrical Specification

Table 1: Operation Condition

Parameter	Symbol	Operating Condition	Min	Typ	Max	Units
Power Supply	AVDD	Relative to AVss	2.1	3.3	3.6	V
Ambient Temperature	Ta		-30	25	70	℃

Table 2: DC Characteristics

Parameter		Symbol	Test/Operating Condition	Min	Typ	Max	Units
Current Consumption	FM Mode	I_{FM}		-	21.3	-	mA
	AM Mode	I_{AM}			22		mA
Standby Current		I_{APD}			14.5		µA

Table 3: FM Receiver Characteristics

(Unless otherwise noted Ta = -30~70℃, AVDD= 2.1V to 3.6V)

Parameter	Symbol	Test/Operating Condition	Min	Typ	Max	Units
FM Frequency Range	F_{rx}		32		110	MHz
Sensitivity[1,2,3]	Sen	(S+N)/N=26dB		1.6	2	uVemf
Input referred 3rd Order Intermodulation Production[4,5]	IIP3			85		dBuVEMF
Adjacent Channel Selectivity		±200KHz	35		51	dB
Alternate Channel Selectivity		±400KHz	50		70	dB
Image Rejection Radio				35		dB
AM suppression				50		dB
RCLK frequency			32.768	32.768	26000	KHz
RCLK frequency Range[8]			-100		100	ppm
Audio Output Voltage[1,2,3,4]		32ohm load	90	100	110	mV_{RMS}
Audio Band Limits[1,2,4]		±3dB	30		15k	Hz
Audio Stereo Separation [1,4,6]			35			dB
Audio Mono S/N[1,2,3,4]			55	60		dB
Audio Stereo S/N[1,4,6,7]		DBLND=1		64		dB
Audio THD[1,2,4,6]				0.3		%
De-emphasis Time Constant		DE=0		75		µs
		DE=1		50		µs
Audio Common Mode Voltage				0.85		V
Audio Output Load Resistance	R_L	Single-ended		32		Ω
Seek/Tune Time					50	ms
Power-up Time					600	ms

Notes:
1. FMOD=1KHz, 75us de-emphasis
2. MONO=1
3. △F=22.5KHz
4. V_{EMF}=1mV, Frequency=32MHz~110MHz
5. AGCD=1
6. △F=75KHz
7. VOLUME<4:0>=11111
8. The supported RCLK frequency is not continuous. Please refer to application notes.

Table 4: AM Receiver Characteristics

(Unless otherwise noted Ta = -30~70℃, AVDD= 2.1V to 3.6V)

Parameter	**Symbol**	**Test/Operating Condition**	**Min**	**Typ**	**Max**	**Units**
AM Frequency Range	F_{rx}		500		1710	KHz
Sensitivity[1,2]	Sen	(S+N)/N=26dB		15		uVemf
Audio Output Voltage[1,2,3,4]		32ohm load		60		mV_{RMS}
Audio Mono S/N[1,2,3,4]				55		dB
Audio THD[1,2,4,6]				0.3	0.6	%
Antenna inductance	L		280	350	420	uH

Notes:
1. FMOD=1KHz
2. Modulation index is 30%
3. V_{EMF}=1mV, Frequency=500KHz~1710KHz
4. VOLUME<4:0>=11111

2. Pin List

Table 5: Pin list

Pin Num	Pin Name	Description
1	CH	Channel adjustment.
2	DVSS	Digital ground.
3	ROUT	Right channel audio output.
4	LOUT	Left channel audio output.
5	AVSS	Analog ground.
6	AVDD	Power supply.
7	XI/RCLK	Crystal input/Reference clock input.
8	XO	Crystal output.
9	ENABLE	Chip enable. Tied to an internal 600kohm pull down resistor.
10	AMINN	AM RF negative input.
11	AMINP	AM RF positive input.
12	RFINP	FM RF input.
13	RFGND	RF ground.
14	SCL	SCL of I2C interface. Tied to an internal 47kohm pull-up resistor.
15	SDA	SDA of I2C interface. Tied to an internal 47kohm pull-up resistor.
16	VOL	Volume adjustment.

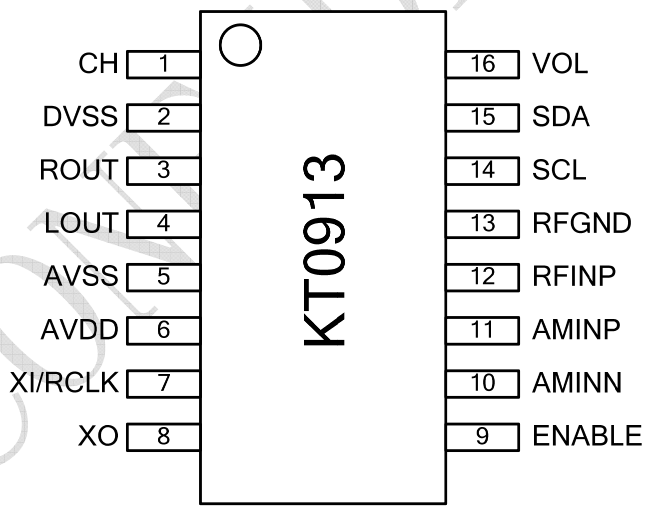


Figure 1: KT0913 Pin assignment (Top view)

3. Function Description

3.1. Overview

KT0913 offers a true single-chip, full-band FM/AM and versatile radio solution by minimizing the external components and offering a variety of configurations.

3.2. FM Receiver

KT0913 enters FM mode by setting register AM_FM to 0. The FM receiver is based on the architecture of KT Micro's latest generation FM receiver chips in mass production. There are no external filters or frequency-tuning devices thanks to a proprietary digital low-IF architecture consisting of a fully-integrated LNA, an automatic gain control (AGC), a set of high-performance ADCs, high-quality analog and digital filters, and an on-chip low-noise self-tuning VCO. The on-chip high-fidelity Class-AB driver further eliminates the need for external audio amplifiers and can drive stereo headphones directly.

3.3. AM Receiver

KT0913 enters AM mode by setting register AM_FM to 1. The AM Receiver employs a similar digital low IF architecture and share many circuits with the FM receiver. The AM receiver supports a wide band from 500KHz to 1710KHz also known as the popular AM bands. The AM channel spacing can be set to 1KHz, 9KHz or 10KHz to address different applications. The bandwidth of the channel filter can be set to 2KHz, 4KHz or 6KHz to suit various requirements.

The AM receiver in KT0913 can provide accurate and automatic AM tuning without manual alignment. It supports 350uH ferrite loop antenna with +/- 25% tolerance.

3.4. Operation Bands

KT0913 supports wide FM band and AM bands. The FM receiver covers frequencies from 32MHz to 110MHz. The 32MHz to 64MHz is defined as Campus Band in KT0913 and can be enabled by setting CAMPUSBAND_EN register to 1. The AM band is from 500KHz to 1710KHz.

3.5. Standby

KT0913 supports both Software Standby mode and Hardware Standby mode. To enter Software Standby, the STANDBT register shall be set to 1 through I2C interface. To enter Hardware Standby, the ENABLE pin is pulled down to ground. In the standby modes, the internal state (channel, volume) is preserved and can be recovered when the chip wakes up from the standby.

3.6. Crystal and reference clock

KT0913 integrates a low frequency crystal oscillator that supports 32.768KHz and 38KHz crystals. Alternatively a CMOS level external reference clock may be used by setting the RCLK_EN register to 1 and setting REFCLK<3:0> according to the frequency of the reference clock.

3.7. Digital Signal Processing

3.7.1. FM Stereo Decoder

The digitized IF signal is fed to the FM demodulator which demodulates the signal and outputs a digital multiplexed (MPX) signal consisting of L+R audio, L-R audio, 19KHz pilot tone and RDS signal. The left channel signal and the right channel signal can be extracted from the MPX signal by simply adding and subtracting the L+R signal and L-R signal. The spectrum diagram is shown in Figure 2.

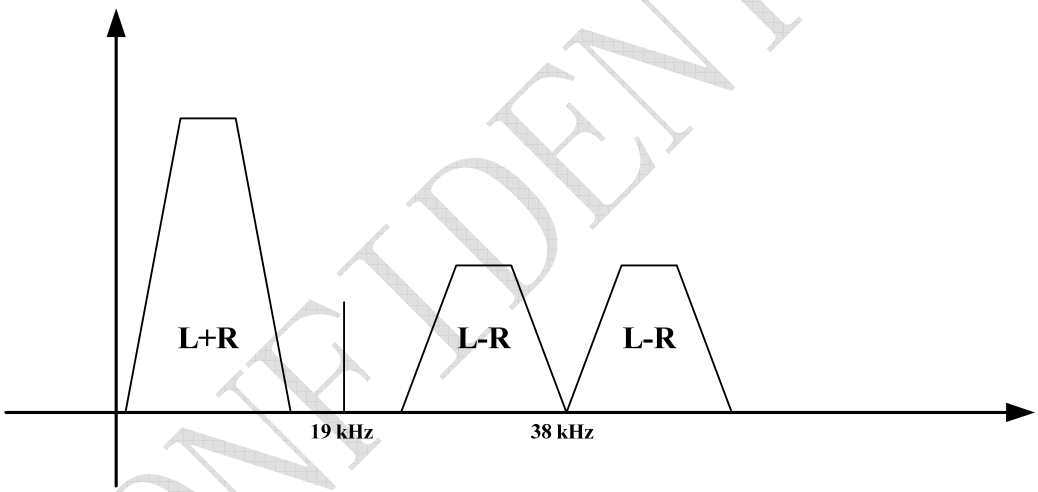


Figure 2: Spectrum diagram of the MPX signal

3.7.2. Mute / Softmute

KT0913 can be hard muted by setting DMUTE to 0 and the output of the audio signal is set to the common mode voltage.

There is also a Soft Mute feature that is enabled by setting FMDSMUTE to 0 in FM mode and AMDSMUTE to 0 in AM mode. In this mode, the audio volume is gradually attenuated when the signal reception is bad (i.e. when the RSSI is below a certain level as defined by FM_SMTH<2:0> and AM_SMTH<2:0>, respectively.) The attenuation attack rate and depth can be configured through SMUTER<1:0> and SMUTEA<1:0>, respectively. The target volume can be configured through VOLUMET<4:0>. SNR value can also be used as the judgment threshold in FM mode by setting SMMD to 1.

3.7.3. Stereo / Mono Blending

In order to provide a comfortable listening experience, KT0913 blends the stereo signal with mono signal gradually when in weak reception in FM mode. The signal level range over which the blending occurs is set by BLNDADJ<1:0>. The blending is disabled when DBLND is set to 1.
MONO playback mode can be forced by setting the MONO to 1.
If the MONO bit and the INV_LEFT_AUDIO bit are both set to 1, then a fully differential signal will be output at the LOUT and ROUT.

3.7.4. Bass

KT0913 provides bass boost feature for audio enhancement. The gain of the bass boost can be programmed through BASS<1:0>. With BASS<1:0>=00, this feature is disabled.

3.7.5. Stereo DAC, Audio Filter and Driver

Two high-quality single-bit ΔΣ audio digital-to-analog converters (DAC) are integrated along with high-fidelity analog audio filters and class AB drivers. Headphones with impedance as low as 16ohms can be directly driven without adding external audio drivers. An integrated anti-pop circuit suppresses the click-and-pop sound during power up and power down. For different load capacitor, user can set different anti-pop configuration through POP<1:0>.

3.7.6. AM Bandwidth

KT0913 provide programmable AM channel bandwidth through AM_BW<1:0>.

3.7.7. TUNE

The fully integrated LO synthesizer supports wide band operation. Channel tuning is started when the register AMTUNE/FMTUNE is set to 1.

In FM mode, the channel frequency is set by FMCHAN<11:0> and is defined as

$$\text{Freq(MHz)} = 50\text{KHz} \times \text{FMCHAN<11:0>}$$

In AM mode, the channel frequency is set by AMCHAN<10:0> and is defined as

$$\text{Freq(KHz)} = 1\text{KHz} \times \text{AMCHAN<10:0>}$$

3.7.8. SEEK

KT0913 offers an effective software based seek algorithm. Refer to application notes for more information.

3.8. User-Machine Interface

Channel and volume can be adjusted not only by setting corresponding FMCHAN, AMCHAN and VOLUME registers, but also by using built-in user-machine interface. Two types of user-machine interface, Key Mode and Dial Mode, are provided by KT0913. In these modes, the channel and volume are controlled by KT0913 itself.

3.8.1. Programmable band

KT0913 supports programmable arbitrary frequency range of the operation band by setting register USERBAND to 1. Information of the current band, such as AM/FM mode, upper and lower edge of the band, channel step and the number of guard channel used in Dial Mode, should be written to KT0913 once the band is chosen, which is sensed by MCU.

The number of channels and start channel are defined in register USER_CHAN_NUM<11:0> and USER_START_CHAN<14:0>. In FM mode, where register AM_FM is set to 0, the lower and upper bound of the current band can be express as:

$$f_{bot} = USER\_START\_CHAN < 14:0 > \times 50KHz$$

$$f_{top} = f_{bot} + USER\_CHAN\_NUM < 11:0 > \times f_{step}$$

Where f_{step} is the channel step, which can be configured by register FMSPACE<1:0>.

In AM mode, where register AM_FM is set to 1, the corresponding lower and upper bound of the band are:

$$f_{bot} = USER\_START\_CHAN < 14:0 > \times 1KHz$$

$$f_{top} = f_{bot} + USER\_CHAN\_NUM < 11:0 > \times f_{step}$$

Where f_{step} is the channel step, which can be configured by register AMSPACE<1:0>.

3.8.2. Key Mode

KT0913 allows user to control the channel and volume by using keys/buttons to send digital control signals to CH and VOL pins. Please refer to Section 4 for a typical application circuit. The key mode is enabled by setting GPIO1<1:0> and GPIO2<1:0> to 01.

Each time VOLP/VOLM key is pressed, the volume increases/decreases by 2dB. If the VOLP/VOLM key is pressed and held, the volume will continue to increase/decrease at 2dB steps until the key is released.

When configured in Key Mode, KT0913's channel selection has two working modes.

Mode A:
If KEY_MODE<1:0> is set to 00, Mode A is selected. In this mode, each time the CHP (CHM) is pressed, the channel frequency increases (decreases) by one step. The step sizes are defined by FMSPACE<1:0> and AMSPACE<1:0>. If the CHP (CHM) key is pressed for and held for a certain time (defined by TIME1<1:0>), the channel frequency will continue to increase (decrease) automatically at a certain pace (as defined by TIME2<2:0>) until the key is released.

Mode B:
If KEY_MODE<1:0> is set to 01, Mode B is selected. In this mode, each time the CHP (CHM) is pressed, the channel increases (decreases) by one step. The step sizes are defined by FMSPACE<1:0> and AMSPACE<1:0>. If the CHP (CHM) key is pressed and held for a specific time (TIME1<1:0>), the channel will continue to increase (decrease) automatically at a certain pace (TIME2<2:0>) even if the key is released. The movement is stopped when the key is pressed again.

3.8.3. Dial Mode

KT0913 supports a unique Dial Mode whose application circuit is shown in **Figure 3**.
The dial is implemented by a variable resistor with the center tap connected to the chip. KT0913 measures the divider ratio of two parts of the variable resistor and maps the result to the real control parameters, such as channel frequency, volume, etc.

The channel controller enters dial mode by setting register GPIO1<1:0> to 10. The illustration circuit is shown in **Figure 3**错误！未找到引用源。. If the center-tap of the variable resistor is located in the write area, the tuned channel could be expressed as:

$$f_{tune} = \frac{X}{X+Y}(f_{top} - f_{bot} + 2 \times N_{guard} \times f_{step}) - N_{guard} \times f_{step} + f_{bot}$$

Where f_{step} is the channel step, f_{top} and f_{bot} are the upper and lower bound of the band, as described in section 3.8.1. N_{guard} is the number of guard channel in channel step to prevent mechanical limit of the wheels, which is configured by register USER_GUARD<8:0>. When the center tap goes in the shaded guard area, the tuned channel stays at the upper or lower bound of band.

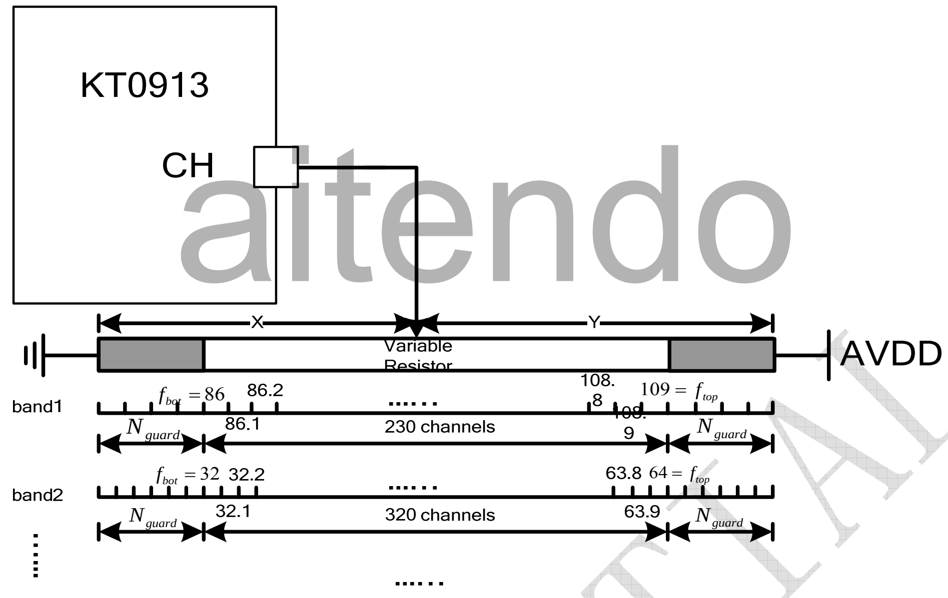


Figure 3: CH pin connection in dial-mode

The volume controller enters dial-mode by setting register GPIO2<1:0> to 10. 错误！未找到引用源。The illustration circuit is shown in **Figure 4**. The actual volume set by the dial could be expressed as:

$$VOL(dBFS)=[\frac{X}{X+Y}(64+N_{guard})]-\frac{N_{guard}}{2}-62$$

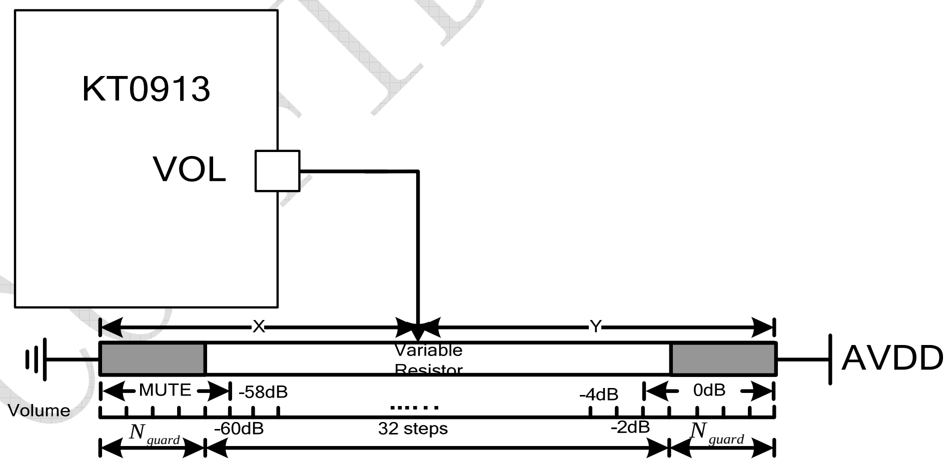


Figure 4: VOL pin connection in dial-mode

Where N_{guard} is the guard number of volume control, in 2dB step, which can be set in register VOL_GUARD<6:0>.

3.9. I2C Control Interface

The serial interface (I2C mode) is used to read and write the device registers, the external controller can directly read and write a register without going though any other registers first. There is also an internal address counter that automatically moves the pointer forward after a read/write operation so that the external controller can continuously read/write desired number of chip registers starting from any of address. The MSB of a register data is transferred first.

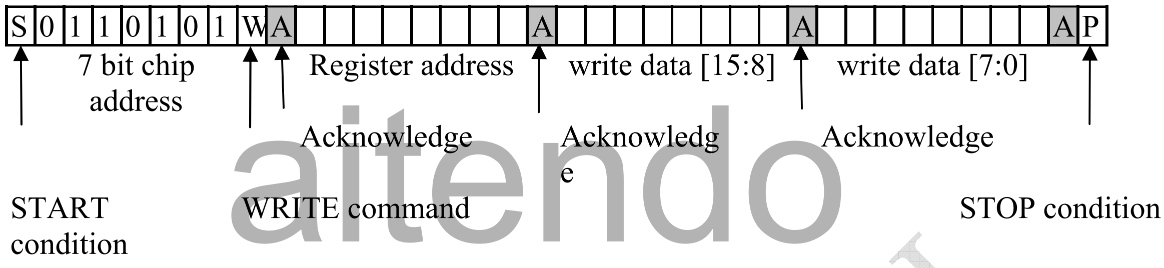
I2C bus mode uses SCL and SDA to transfer data. The device always drives data to SDA at the falling edge of SCL and captures data from SDA at the rising edge of SCL. The device acknowledges the external controller by driving SDA low at the falling edge of SCL. Data transfer always begins with START condition and ends with STOP condition. The external controller can read/write one 16-bits data at the specified address or read/write desired number of registers data continuously from the specified address till when STOP condition is occurred.

For write operations, external controller shall send command & data in the following sequence: START condition -> 7 bit chip address and Write command (“0”) -> 8 bit register address n -> write data n [15:8] -> write data n [7:0] -> write data n+1 [15:8] -> write data n+1 [7:0] -> …… -> STOP condition.

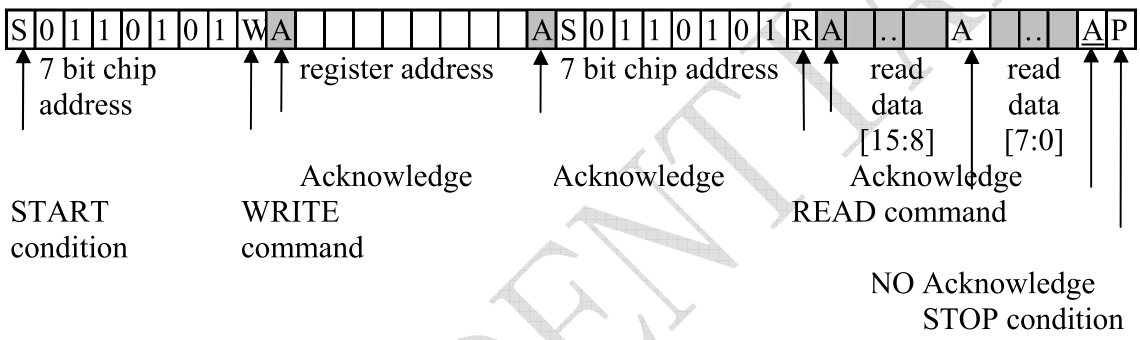
For read operations, external controller shall send command & data in the following sequence: START condition -> 7 bit chip address and Write command (“0”) -> 8 bit register address n -> 7 bit chip address and Read command (“1”) , then device will send read data n [15:8] -> read data n [7:0] -> read data n+1 [15:8] -> read data n+1 [7:0] -> …… till STOP condition.

Table 6: I2C Interface Protocol

RANDOM REGISTER WRITE PROCEDURE



RANDOM REGISTER READ PROCEDURE



Note: The data bits in gray color are sent by KT0913

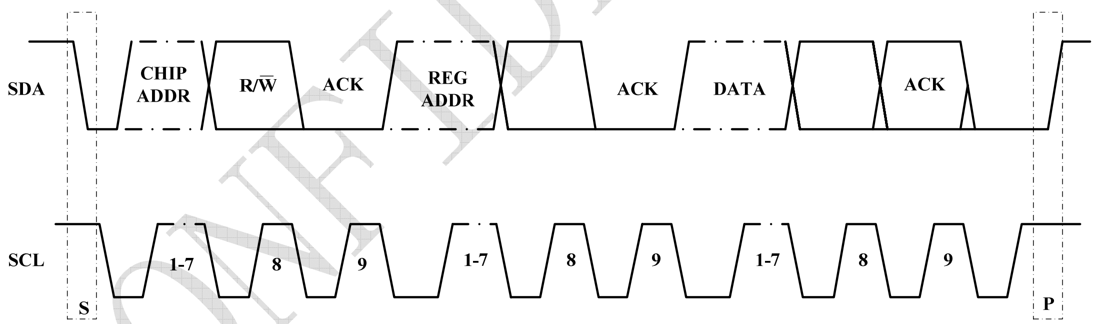


Figure 5: I2C interface timing diagram

3.10.Register Bank

Reg	Name	D15	D14	D13	D12	D11	D10	D9	D8	D7	D6	D5	D4	D3	D2	D1	D0
01h	CHIP ID	KT Mark															
02h	SEEK													FMSPACE<1:0>		DMUTER	DMUTEL
03h	TUNE	FMTUNE				FMCHAN<11:0>											
04h	VOLUME	FMDSMUTE	AMDSMUTE	DMUTE		DE		BASS<1:0>				POP<1:0>					
05h	DSPCFGA	MONO						BLNDADJ<1:0>				DBLND					
0Ah	LOCFGA								FMAFCD								
0Ch	LOCFGC													CAMPUSB AND_EN			
0Fh	RXCFG				STDBY								VOLUME<4:0>				
12h	STATUSA	XTAL_OK	STC			PLL_LOCK	LO_LOCK	ST<1:0>		FMRSSI<4:0>							
13h	STATUSB					RDCHAN<11:0>											
14h	STATUSC	PWRSTATE		CHPRDY	FMSNR<6:0>												
16h	SYSCFG	AM/FM	USERBAND		RCLK_EN	REFCLK<3:0>				AU_GAIN<1:0>							AMAFCD
17h	AMCHAN	AMTUNE					AMCHAN<10:0>										
18h	AMCALI			CAP_INDEX<13:0>													
1Dh	GPIO													GPIO2<1:0>		GPIO1<1:0>	
22h	AMDSP									AM_BW<1:0>				INV_LEFT_ AUDIO			
24h	AMSTATUSA				AMRSSI<4:0>												
25h	AMSTATUSB									AM_AFCDELTAF<7:0>							
2Eh	SOFTMUTE	SMUTERA<1:0>		SMUTER<1:0>		AM_SMTH<2:0>			VOLUMET<4:0>					SMMD	FM_SMTH<2:0>		
2Fh	USERSTARTCH		USER_START_CHAN<14:0>														
30h	USERSTARTNUM								USER_START_NUM<8:0>								
31h	USERCHANNUM					USER_CHAN_NUM<11:0>											
33h	AMCFG	AMSPACE<1:0>									KEY_MODE<1:0>						
34h	AMCFG2											TIME1<1:0>		TIME2<2:0>			
3Ah	VOLGUARD		VOL_GUARD<6:0>														
3Ch	AFC									FM_AFC_DELTAF<7:0>							

3.10.1. CHIP ID (Address 0x01)

Bit	Symbol	Access	Default	Functional Description
15:0	KT Mark	R	0x4B54	**ASCII form of string "KT"**

3.10.2. SEEK (Address 0x02)

Bit	Symbol	Access	Default	Functional Description
15:4	Reserved	RW	0000_0000_0000	**Reserved**
3:2	FMSPACE<1:0>	RW	01	**FM Channel Spacing** 00 = 200KHz 01 = 100KHz 10 = 50KHz
1	DMUTER	RW	1	**Right Channel Mute Control** 0 = Right mute enable 1 = Right mute disable
0	DMUTEL	RW	1	**Left Channel Mute Control** 0 = Left channel mute enable 1 = Left channel mute disable

3.10.3. TUNE (Address 0x03)

Bit	Symbol	Access	Default	Functional Description
15	FMTUNE	RW	0	**FM Tune Enable** 0 = Normal operation 1 = Start to tune to desired FM channel
14:12	Reserved	RW	000	**Reserved**
11:0	FMCHAN<11:0>	RW	0110_1011_1000 (0x06B8)	**FM Channel Setting** FMCHAN<11:0>=Frequency (KHz) / 50KHz. For example, if desired channel is 86MHz, then the FMCHAN<11:0> should be 0x06B8.

3.10.4. VOLUME (Address 0x04)

Bit	Symbol	Access	Default	Functional Description
15	FMDSMUTE	RW	1	**FM Softmute Disable** 0 = FM softmute enable 1 = FM softmute disable

14	AMDSMUTE	RW	1	**AM Softmute Disable** 0 = AM softmute enable 1 = AM softmute disable
13	DMUTE	RW	0	**Mute Disable** 0 = Mute enable 1 = Mute disable
12	Reserved	RW	0	**Reserved**
11	DE	RW	0	De-emphasis time constant selection 0 = 75us 1 = 50us
10	Reserved	RW	0	**Reserved**
9:8	BASS<1:0>	RW	00	**Bass Boost Effect Mode Selection** 00 = Disable 01 = Low 10 = Med 11 = High
7:6	Reserved	RW	10	**Reserved**
5:4	POP<1:0>	RW	00	**Audio DAC Anti-pop Configuration** 00 : 100uF AC-coupling capacitor 01 : 60uF AC-coupling capacitor 10 : 20uF AC-coupling capacitor 11 : 10uF AC-coupling capacitor
3:0	Reserved	RW	0000	**Reserved**

3.10.5. DSPCFGA (Address 0x05)

Bit	Symbol	Access	Default	Functional Description
15	MONO	RW	0	**Mono Select** 0 = Stereo 1 = Force mono **To be noted that if both MONO bit and INV_AUDIO_LEFT are set to 1, fully differential audio signal can be obtained from LOUT and ROUT pin.**
14:10	Reserved	RW	001_00	**Reserved**
9:8	BLNDADJ<1:0>	RW	00	**Stereo/Mono Blend Level Adjustment** 00 = High 01 = Highest 10 = Lowest 11 = Low Note: Write 00 explicitly even if 00 is the default value.
7:6	Reserved	RW	0	**Reserved**

5	DBLND	RW	0	**Blend Disable** 0 = Blend enable 1 = Blend disable
4:0	Reserved	RW	0_0000	**Reserved**

3.10.6. LOCFGA (Address 0x0A)

Bit	Symbol	Access	Default	Functional Description
15:9	Reserved	RW	0000_000	**Reserved**
8	FMAFCD	RW	1	**AFC Disable Control Bit** 0 = AFC enable 1 = AFC disable
7:0	Reserved	RW	0000_0000	**Reserved**

3.10.7. LOCFGC (Address 0x0C)

Bit	Symbol	Access	Default	Functional Description
15:4	Reserved	RW	0000_0000_0010	**Reserved**
3	CAMPUSBAND_EN	RW	0	**Campus FM Band Enable** 0 = User can only use 64MHz ~ 110MHz 1 = User can extend the FM band down to 32MHz
2:0	Reserved	RW	100	**Reserved**

3.10.8. RXCFG (Address 0x0F)

Bit	Symbol	Access	Default	Functional Description
15:13	Reserved	RW	100	**Reserved**
12	STDBY	RW	0	**Standby Mode Enable** 0 = Disable 1 = Enable
11:5	Reserved	RW	1000_000	**Reserved**
4:0	VOLUME<4:0>	RW	1_1111	**Volume Control** 11111 = 0dB 11110 = -2dB 11101 = -4dB ….. 00010 = -58dB 00001 = -60dB 00000 = Mute

3.10.9. STATUSA (Address 0x12)

Bit	Symbol	Access	Default	Functional Description
15	XTAL_OK	R	NA	**Crystal ready indictor** 0 = not ready 1= crystal is ok
14	STC	RW	0	**Seek/Tune Complete** 0 = Not Complete 1 = Complete **Every time the Seek/tune process begins, the STC bit will clear to zero by hardware.**
13:10	Reserved	R	NA	**Reserved**
11	PLL_LOCK	R	NA	**System PLL Ready Indicator** 0 = Not ready 1 = System PLL ready
10	LO_LOCK	R	NA	**LO Synthesizer Ready Indicator** 0 = Not ready 1 = Ready
9:8	ST<1:0>	R	NA	**Stereo Indicator** 11 = Stereo state Other = Mono state
7:3	FMRSSI<4:0>	R	NA	**FM RSSI Value Indicator** RSSI starts from -100dBm and step is 3dB, namely RSSI(dBm) = -100 + FMRSSI<4:0> *3dB
2:0	Reserved	R	NA	**Reserved**

3.10.10. STATUSB (Address 0x13)

Bit	Symbol	Access	Default	Functional Description
15:12	Reserved	R	NA	**Reserved**
11:0	RDCHAN<11:0>	R	NA	**Current Channel Indicator**

3.10.11. STATUSC (Address 0x14)

Bit	Symbol	Access	Default	Functional Description
15	PWSTATUS	R	NA	**Power Status Indicator** 0 = Power not ready 1 = Power ready
14	Reserved	R	NA	**Reserved**
13	CHIPRDY	R	NA	**Chip Ready Indicator** 0 = Chip is not ready

				1 = Chip is ready, calibration done.
12:6	FMSNR<6:0>	R	NA	**Channel SNR value is FM mode.** 0000000 = Minimum SNR 1111111 = Maximum SNR
5:0	Reserved	R	NA	**Reserved**

3.10.12. AMSYSCFG (Address 0x16)

Bit	Symbol	Access	Default	Functional Description
15	AM_FM	RW	0	**AM/FM Mode Control** 0 = FM mode 1 = AM mode
14	USERBAND	RW	0	**User Definition Band Enable** 0 = Use internal defined band 1 = Use user-defined band which is specified in USERSTARTCH, USERSTARTNUM and USERCHANNUM
13	Reserved	RW	0	**Reserved**
12	RCLK_EN	RW	0	**Reference Clock Enable** 0 = Crystal 1 = Reference clock
11:8	REFCLK<3:0>	RW	0000	**Reference Clock Selection** 0000 = 32.768KHz 0001 = 6.5MHz 0010 = 7.6MHz 0011 = 12MHz 0100 = 13MHz 0101 = 15.2MHz 0110 = 19.2MHz 0111 = 24MHz 1000 = 26MHz 1001 = 38KHz
7:6	AU_GAIN<1:0>	RW	00	**Audio Gain Selection** 01 : 6dB 00 : 3dB 11 : 0dB 10 : -3dB
5:1	Reserved	RW	0_0001	**Reserved**
0	AMAFCD	RW	0	**AFC Disable Control in AM Mode** 0 = Enable 1 = Disable

3.10.13. AMCHAN (Address 0x17)

Bit	Symbol	Access	Default	Functional Description
15	AMTUNE	RW	0	**AM Tune Enable**
14:11	Reserved	RW	000_0	**Reserved**
10:0	AMCHAN<10:0>	RW	001_1111_1000 (0x01F8)	**AM Channel Setting** AMCHAN<10:0> = Frequency(in KHz)

3.10.14. AMCALI (Address 0x18)

Bit	Symbol	Access	Default	Functional Description
15:14	Reserved	RW	00	**Reserved**
13:0	CAP_INDEX<13:0>	R	NA	**On Chip Capacitor for AM Antenna Calibration** 0x0000:Minimum capacitor 0x3FFF:Maximum capacitor

3.10.15. GPIOCFG (Address 0x1D)

Bit	Symbol	Access	Default	Functional Description
15:4	Reserved	RW	0000_0000_0000	**Reserved**
3:2	GPIO2<1:0>	RW	00	**VOL Pin Mode Selection** 00 = High Z 01 = Key controlled volume increase/decrease 10 = Dial controlled volume increase/decrease 11 = Reserved
1:0	GPIO1<1:0>	RW	00	**CH Pin Mode Selection** 00 = High Z 01 = Key controlled channel increase / decrease 10 = Dial controlled channel increase / decrease 11 = Reserved

3.10.16. AMDSP (Address 0x22)

Bit	Symbol	Access	Default	Functional Description
15:8	Reserved	RW	1010_1111	**Reserved**
7:6	AM_BW<1:0>	RW	00	**AM Channel Bandwidth Selection**

				00 = 2KHz 01 = 2KHz 10 = 4KHz 11 = 6KHz
5:4	Reserved	RW	00	**Reserved**
3	INV_LEFT_AUDIO	RW	0	**Left Channel Inverse Control** 0 : Normal operation 1 : Inversing the left channel audio signal. **A fully differential audio signal can be got from LOUT and ROUT if both of the INV_LEFT_AUDIO bit and MONO bit are set to 1.**
2:0	Reserved	RW	100	**Reserved**

3.10.17. AMSTATUSA (Address 0x24)

Bit	Symbol	Access	Default	Functional Description
15:13	Reserved	RW	000	**Reserved**
12:8	AMRSSI<4:0>	R	NA	**AM Channel RSSI** AM RSSI starts from -90dBm and step is 3dB, namely AMRSSI(dBm) = -90 + AMRSSI<4:0> *3dB
7:0	Reserved	R	NA	**Reserved**

3.10.18. AMSTATUSB (Address 0x25)

Bit	Symbol	Access	Default	Functional Description
15:8	Reserved	R	NA	**Reserved**
7:0	AM_AFCDELTAF<7:0>	R	NA	Signed binary, max 16KHz , min -16KHz, step is 128Hz.

3.10.19. SOFTMUTE (Address 0x2Eh)

Bit	Symbol	Access	Default	Functional Description
15:14	SMUTEA<1:0>	RW	00	**Softmute Attenuation** 00 = Strong 01 = Strongest 10 = Weak 11 = Weakest
13:12	SMUTER<1:0>	RW	00	**Softmute Attack/Recover Rate**

				00 = Slowest 01 = Fastest (RSSI mode only) 10 = Fast 11 = Slow
11:9	AM_SMTH<2:0>	RW	000	**AM Softmute Start Level.** 000 = Lowest 001 = … 111 = Highest
8:4	VOLUMET<4:0>	RW	0_0001	**Sofmute Target Volume** 0000 : Minimum volume 1111 : Maximum volume
3	SMMD	RW	0	**Softmute Mode Selection** 0 = RSSI mode 1 = SNR mode (only effective in FM mode)
2:0	FM_SMTH<2:0>	RW	000	**FM Softmute Start Threshold** 000 = Lowest 001 = … 111 = Highest

3.10.20. USERSTARTCH (Address 0x2F)

Bit	Symbol	Access	Default	Functional Description
15	Reserved	RW	0	**Reserved**
14:0	USER_START _CHAN<14:0>	RW	000_1000_1111_1100 (0x08FC(2.3MHz))	User band start channel, only effect when USERBAND=1. See section 3.8.1.

3.10.21. USERGUARD (Address 0x30)

Bit	Symbol	Access	Default	Functional Description
15:9	Reserved	RW	0000_000	**Reserved**
8:0	USER_GUARD<8:0>	RW	0_0111_1000	User band guard number, only effective when USERBAND=1. See section 3.8.3.

3.10.22. USERCHANNUM (Address 0x31)

Bit	Symbol	Access	Default	Functional Description
15:12	Reserved	RW	0000	**Reserved**
11:0	USER_CHAN _NUM<11:0>	RW	0001_1111_0100 (0x01F4(500))	User band channel number, only effective when USERBAND=1. See section 3.8.1.

3.10.23. AMCFG (Address 0x33)

Bit	Symbol	Access	Default	Functional Description
15:14	AMSPACE<1:0>	RW	00	**AM Channel Space Selection** 00 : 1KHz 01 : 9KHz 10 : 10KHz 11 : 10KHz
13:7	Reserved	RW	01_0100_0	**Reserved**
6:5	KEY_MODE<1:0>	RW	00	**Working mode selection when key mode is selected.** 00 = Working mode A 01 = Working mode B Others = Reserved For detailed information about working mode A and working mode B, please refer to section 3.8.2.
4:0	Reserved	RW	0_0001	**Reserved**

3.10.24. AMCFG2 (Address 0x34h)

Bit	Symbol	Access	Default	Functional Description
15:6	Reserved	RW	0100_0000_01	**Reserved**
5:4	TIME1<1:0>	RW	01	**TIME1** 00 = Shortest …… 11 = Longest
3:1	TIME2<2:0>	RW	000	**TIME2** 000 = Fastest …… 111 = Slowest
0	Reserved	RW	0	**Reserved**

3.10.25. VOLGUARD (Address 0x3Ah)

Bit	Symbol	Access	Default	Functional Description
15	Reserved	R	NA	**Reserved**
14:8	VOL_GUARD<6:0>	RW	0x0D	**Volume Guard Number** See section 3.8.3.
7:0	Reserved	R	NA	**Reserved**

3.10.26. AFC (Address 0x3Ch)

Bit	Symbol	Access	Default	Functional Description
15:8	Reserved	R	NA	**Reserved**
7:0	FM_AFC_DELTAF <7:0>	R	NA	**Frequency difference between CHAN and received signal, calculated by AFC block in two's complement format. Range is -127 to +127. Unit is KHz. This register is valid when STC=1**

4. Typical Application Circuit

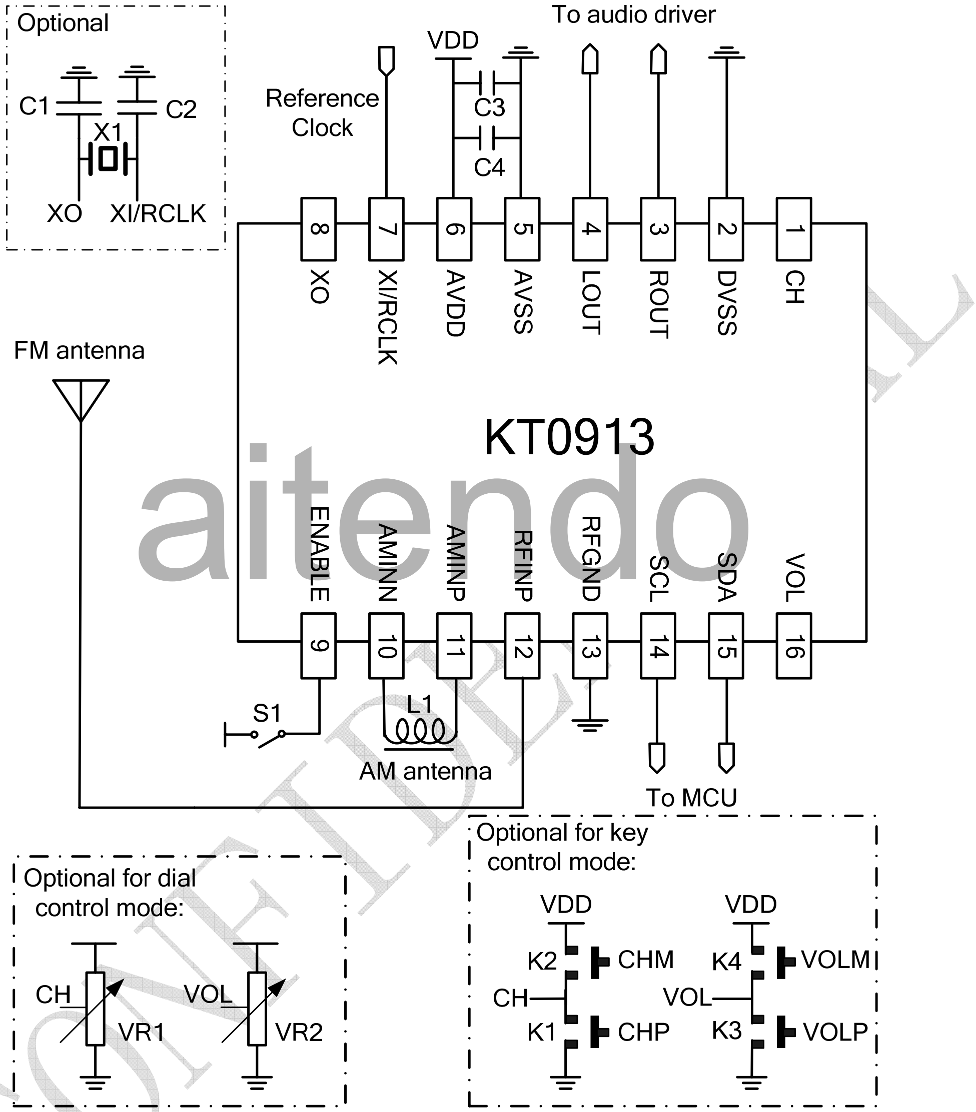
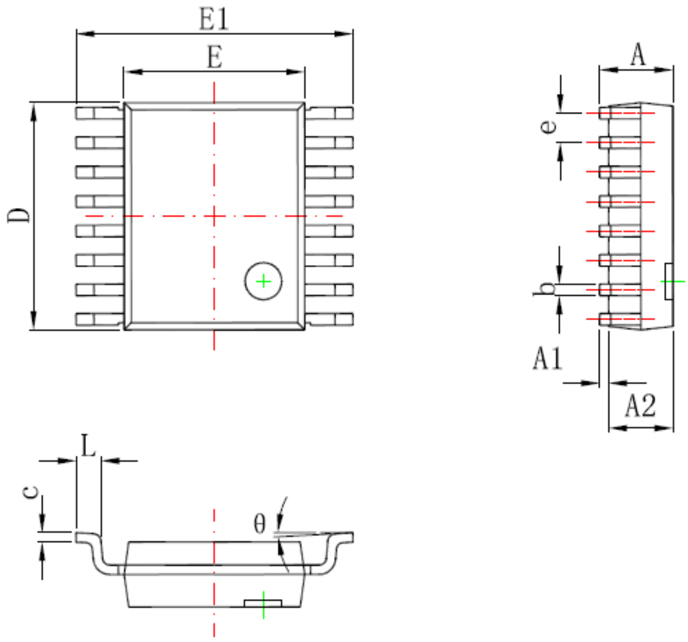


Figure 6: Typical application circuits

Components	Description	Value/Suppliers
C1,C2	Crystal load capacitor	C1=C2=24pF
C3,C4	Supply decoupling capacitor	C3=10uF C4=0.1uF
L1	AM ferrite antenna	350uH
X1	Crystal	32.768KHz
S1	Switch	
VR1,VR2	Variable resistor	10kohm
K1~K4	Key-press	

5. Package Outline



Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min	**Max**	**Min**	**Max**
A	1.350	1.750	0.053	0.069
A1	0.100	0.250	0.004	0.010
A2	1.350	1.550	0.053	0.061
b	0.200	0.300	0.008	0.012
c	0.170	0.250	0.007	0.010
D	4.700	5.100	0.185	0.200
E	3.800	4.000	0.150	0.157
E1	5.800	6.200	0.228	0.244
e	0.635 (BSC)		0.025 (BSC)	
L	0.400	1.270	0.016	0.050
θ	0°	8°	0°	8°