Ordering number : ENA1746

LV23401V

Bi-CMOS IC

1-chip Tuner IC with built-in FLL for Home Stereo System

ON Semiconductor®

http://onsemi.com

Overview

The LV23401V is a AM/FM one-chip tuner IC for home stereo system.

Functions

- AM tuner
- FM tuner
- MPX stereo decoder
- FLL tuning system

Features

- All the adjustment work of external parts is unnecessary.
- CCB control with easy command base
- External parts are reduced by LOW-IF frequency (FM=225kHz, AM=53kHz) adoption.
- The high sensitivity reception is achieved in low noise MIX input circuit.
- All bands of Japan-U.S.-Euro can be received by the soft program change (76MHz to 108MHz).
- With built-in FLL(Frequency Locked Loop) tune function
- Soft mute and stereo blend function (seven stages programmed control possible)
- With built-in adjacent channel obstruction removal function
- With built-in stereo pilot cancellation function
- For EN55020-S1 standard (European immunity)
- With built-in power save function

Specifications

Maximum Ratings at Ta = 25 °C

Parameter	Symbol	Conditions	Ratings	Unit
Maximum supply voltage	V_{CC} max	Analog block supply voltage	10.0	V
Maximum output voltage	V_O max	Digital block supply voltage	4.5	V
Maximum input voltage	$V_{IN}1$ max	CE, DI, CL	*1) Vref2+0.35	V
	$V_{IN}2$ max	CLK IN	4.5	V
Allowable power dissipation	Pd max	Ta ≤ 70 °C *2)	450	mW
Operating temperature	Topr		-20 to +70	°C
Storage temperature	Tstg		-40 to +125	°C

*1) Vref2 = 22 pin voltage

*2) When mounted on the specified printed circuit board (114.3mm × 76.1mm × 1.6mm), glass epoxy

Stresses exceeding Maximum Ratings may damage the device. Maximum Ratings are stress ratings only. Functional operation above the Recommended Operating Conditions is not implied. Extended exposure to stresses above the Recommended Operating Conditions may affect device reliability.

Operating Condition at Ta = 25 °C

Parameter	Symbol	Conditions	Ratings	Unit
Recommended supply voltage	V_{CC}	Analog block supply voltage	9.0	V
Operating supply voltage range	V_{CC} op	Resister 1Eh Bit 1(LEVSHIF)=0	4.5 to 6.5	V
		Resister 1Eh Bit 1(LEVSHIF)=1	8.5 to 9.5	V

* Stabilize the service voltage so as not to cause the voltage charge by the noise etc.

Interface block allowable operation range at Ta = -20 to +70°C, V_{SS} = 0V

Parameter	Symbol	Conditions	Ratings			Unit
			min	typ	max	
Input "H" level voltage	V_IH1	CE, DI, CL	2.3		3.435	V
	V_IH2	CLK IN	2.3		3.435	V
Input "L" level voltage	V_IL1	CE, DI, CL	0		0.5	V
	V_IL2	CLK IN	0		0.3	V
Output voltage	V_O	D0	0		4.0	V
Crystal frequency	f_{IN}	CLK IN		32.768		kHz
Crystal frequency deflection	f devi1	For the standard European immunity	-50		+50	ppm
	f devi2	When standard non-corresponds European immunity	-150		+150	ppm
Crystal vibrator load capacity	CL	*	4	12.5		pF

* The evaluation request to the crystal maker is recommended because it changes by the substrate and the circuit constant used.

Operating Characteristics at Ta = 25°C, V_{CC} = 9.0V with the designated circuit.

Parameter	Symbol	Conditions	Ratings			Unit
			min	typ	max	
Current drain (at no input)	I_{CC}FM	No input in FM mode. 15 pin supply current.	25	35	45	mA
	I_{CC}AM	No input in AM mode. 15 pin supply current.	14	24	34	mA
Power save current drain	I standby	15 pin supply current power save : Register 1Fh_bit0 = 0		0.25	0.7	mA
V_{DD} output voltage	V_{DD}	22 pin voltage (reference value)	(2.772)	3.3	(3.435)	V
V_{DD} drop-out voltage	V_{DD}_drop	22 pin voltage. Drive mode at 10mA. *Drive current maximum = 10mA		0.15		V
[FM receive characteristics] : fc = 98MHz, V_{IN} = 60dBμV, fm = 1kHz, De-emphasis = 50μs, IF = 225kHz, BW = 50% MONO : 75kHz dev. STEREO : L+R = 67.5kHz dev., Pilot = 7.5kHz dev. Volume level = 3, Soft mute = off, Soft stereo = off, Resister 1Eh Bit 1(LEVSHIF) = 1, 9 pin output, IHF-BPF						
S/N 50dB Sensitivity	SN50	Input level that becomes S/N=50dB		17	24	dBμV
S/N 30dB Sensitivity	SN30	Input level that becomes S/N=30dB		12	18	dBμV
IHF Sensitivity	IHF	Input level that becomes THD=3%		12	20	dBμV
Signal-to-noise ratio	SN	MONO	62	70		dB
	SN-ST1	STEREO	58	66		dB
Total harmonic distortion	THD1	MONO		0.5	1.5	%
	THD1-ST	STEREO		0.5	2.5	%
	THD2	MONO, 150kHz dev.		1.5	5	%
	THD3	MONO, V_{IN} = 120dBμV		0.6	2.5	%

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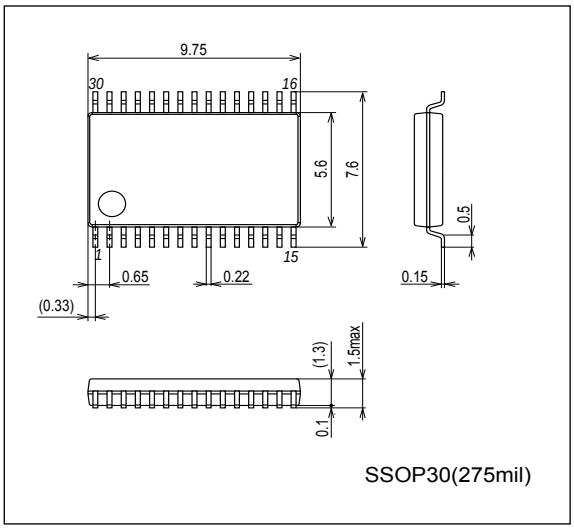
Parameter	Symbol	Conditions	Ratings			Unit
			min	typ	max	
Demodulation output	V_O0	MONO, V_OL = 0 (reference value)	(218)	(327)	(489)	mVrms
	V_O1	MONO, V_OL = 1 (reference value)	(291)	(436)	(652)	mVrms
	V_O2	MONO, V_OL = 2 (reference value)	(366)	(549)	(821)	mVrms
	V_O3	MONO, V_OL = 3 (reference value) *In-house management = Typ ± 3.0dB	518	775	1160	mVrms
MPX output	V_O_MPX	6 pin output	100	200	300	mVrms
Channel balance	CB	10 pin output / 9 pin output	-1	0	+0	dB
SD operation level	SD	FS_S = 4	17	25	33	dBµV
Stereo operation level	ST	FS_S = 4	17	25	33	dBµV
Stereo separation	Sep	Both channels of 9 pins and 10 pins are measured. *In-house management value ≥25dB	25	40		dB
De-emphasis deflection	Deemp50	fm = 10kHz, 15kHz LPF OFF	-12.5	-10	-7.5	dB
	Deemp75	fm = 10kHz, 15kHz LPF OFF		-13		dB
Carrier leakage	CL	STEREO S/N, 15kHz LPF OFF	30	40		dB
Pilot margin (Pilot lighting sensitivity)	ST-ON	L+R = 67.5kHz, Pilot-mod	0.6		5.5	%
AM suppression ratio	AMR	400Hz AM 30% mod.	40	65		dB
Mute attenuation	MUTE		60	75		dB
[AM receive characteristics] : fc = 1MHz, V_{IN} = 94dBµV, fm = 400Hz, 30% mod, IF = 53kHz, BW = 50% Volume level = 3, Soft mute = 4, Resister 1Eh Bit 1(LEVSHIF) = 1, 9 pin output, 15kHz LPF OFF						
S/N 20dB Sensitivity	SN20	Input level that becomes S/N=20dB		49	65	dBµV
	SN20-L	fc = 603kHz (reference value)		(55)	(65)	dBµV
	SN20-H	fc = 1404kHz (reference value)		(49)	(65)	dBµV
Signal-to-noise ratio	SN		42	50		dB
Total harmonic distortion	THD1			0.6	2.8	%
	THD2	V_{IN} = 104dBµV		0.8	2.8	%
Detected output	V_O0	VOL = 0 (reference value)	(55)	(78)	(109)	mVrms
	V_O1	VOL = 1 (reference value)	(69)	(98)	(138)	mVrms
	V_O2	VOL = 2 (reference value)	(87)	(123)	(173)	mVrms
	V_O3	VOL = 3	110	155	218	mVrms
Channel balance	CB	10 pin output / 9 pin output	-1	0	+1	dB
AGC response	AGC1	Input level difference that output level becomes -10dB. Soft mute = 3 (reference value)	(52)	(62)		dB
	AGC2	Soft mute = 4	47	57		dB
Frequency response	Hi-cut	fm = 4kHz	-22	-17	-12	dB
SD operation level	SD	AGC = ON, FS = 4 *In-house management =46 to 65dBµV	46	54	65	dBµV
Mute attenuation	MUTE	15kHz LPF ON	50	65		dB

Package Dimensions

unit : mm

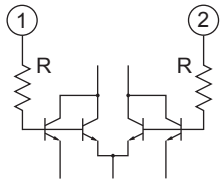
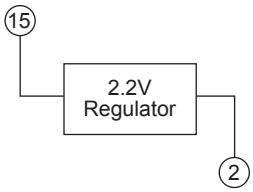
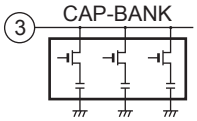
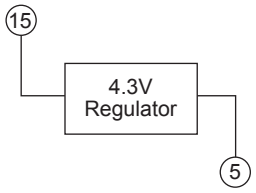
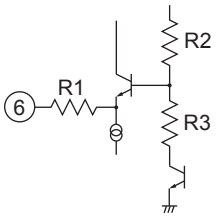
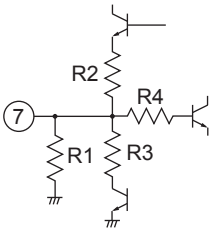
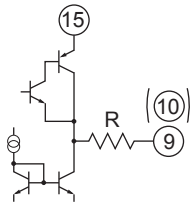
3191B



Pin function

pin	pin name	Description	Remark	DC_bias
1	AM ANT	AM antenna	It connects it to 2pin through the matching coil or the bar antenna.	
2	AM ref	AM reference voltage	It connects it to 1pin through the matching coil or the bar antenna.	2.0V
3	AM CAP	AM capacitor bank	It connects it to GND through an external inductor of recommendation 240μH.	
4	GND1	AM antenna GND	Connect to GND	
5	Vref1	Analog reference voltage	It connects it to GND through the capacitor of 1μF.	
6	MPX OUT	Detected output	LC72725 and connection when RDS is used	
7	AM AGC	AM AGC	It connects it to GND through the capacitor of 4.7μF	
8	GND2	Analog GND	Connect to GND	
9	L OUT	L-ch audio output	The DC level changes by setting Resistor 1Eh bit1 (LEVSHIF) to adjust the output level according to the V_{CC} potential.	
10	R OUT	R-ch audio output		
11	V_{CC} Low	Low voltage mode	It is short with 15pin when using it with $V_{CC} < 6.0V$ or less.	
12	AM LCF	AM low cutting filter	It connects it to GND through the capacitor of 0.047μF	
13	SD OUT	SD detecting phase output		
14	ST OUT	ST detecting phase output		
15	V_{CC}	Supply voltage		
16	CLK IN	Reference clock input	The crystal is recommended to be used. It is also possible to input directly clock signals (square wave GND standard).	
17	ST ADJ	Pilot margin adjustment pin	It connects it to GND through 180kΩ	
18	CE	address/data switching timing		
19	CL	Communication clock		
20	DI	Data input		
21	DO	Data output	It connects it to 22 pin through 10kΩ	
22	Vref2	V_{DD} voltage output	3.3V voltage output pin. It is also possible to supply the current to other IC up to 10mA.	
23	GND3	Logic GND	Connect to GND	
24	L1	Local oscillation circuit	It connects it to 25 pin through 33nF.	
25	Vref3	Reference voltage for local oscillation circuit	It connects it to GND through the capacitor of 100μF	
26	L2	Local oscillation circuit	It connects it to 25 pin through 33nF.	
27	SD ADJ	SD = ON sensitivity adjustment pin	It connects it to GND through 22kΩ	
28	FLL CAP	FLL low pass filter	It connects it to 25 pin through 0.1μF.	
29	GND4	FM antenna GND	Connect to GND	
30	FM ANT	FM antenna	Input impedance 75Ω.	

Description of Pin Functions

No.	Pin name	Voltage (V)	Internal Equivalent Circuit	Remarks
1	AM-ANT	2.2V		AM antenna input pin. The AM antenna coil is connected between 2pin. R = 100Ω
2	AM-REF	2.2V		AM standard bias pin.
3	AM-CAP	-		AM Tuning for tune pin. (AM Capacitor Bank)
4	GND1	0V		Analog (AM_FE) GND pin.
5	VREF1	4.3V		Analog (tuner area) standard bias pin. VREF = 4.3V
6	MPX-OUT	2.5V		FM demodulation output pin. R1 = 100Ω R2 = 23kΩ R3 = 1kΩ
7	AM RF-AGC	-		AGC pin for AM-RF department Gain control. R1 = 2MΩ R2 = 5kΩ R3 = 250Ω R4 = 1kΩ
8	GND2	0V		Analog (tuner) GND pin.
9 10	L-OUT R-OUT	2.5V (It is 3.3V for LEVSHIF = 1)		L-ch (R-ch) output pin. R = 100Ω R_{OUT} = 150Ω

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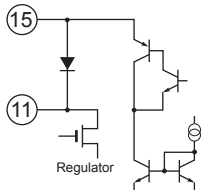
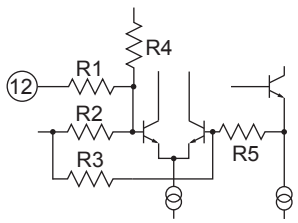
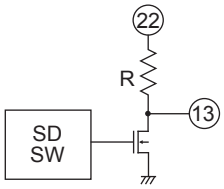
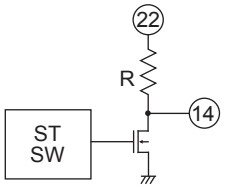
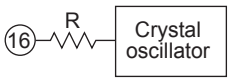
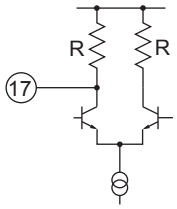
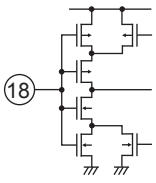
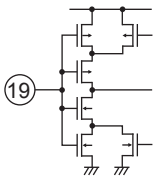
No.	Pin name	Voltage (V)	Internal Equivalent Circuit	Remarks
11	V_{CC}-Low	-		It is short 11pin with 15pin when using it with $V_{CC} < 6.0V$.
12	AM LCF	2.2V		AM Low-cut Filter pin. R1 = 250Ω R2 = 100kΩ R3 = 100kΩ R4 = 50kΩ R5 = 50kΩ
13	SD-OUT	V_{DD}		SD indicator output pin. Active Low output R = 100kΩ
14	ST-OUT	V_{DD}		FM stereo indicator output pin. Active Low output R = 100kΩ
15	V_{CC}	V_{CC}		Analog area supply voltage pin. 8.5 to 9.5V are impressed at Resister 1Eh bit 1(LEVSHIF) = 1, and it is short at “0” with V_{CC}_Low.
16	CLK_IN	2.1V		Clock connection pin for internal standard. 32.768kHz crystal is connected. R = 100Ω
17	ST-ADJ	3.7V		Stereo lighting sensitivity adjustment pin. It connects it to GND through 180kΩ. R = 24kΩ
18	CE	–		Chip enable pin. Pin assumed to be high-level when serial data input (DI) and serial data output (DO).
19	CL	–		Data clock input pin Clock that takes data and synchronization when serial data input (DI) and serial data output (DO).

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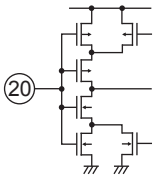
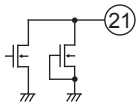
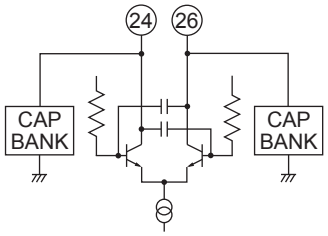
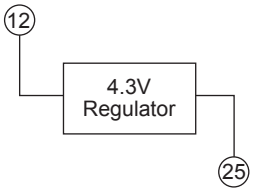
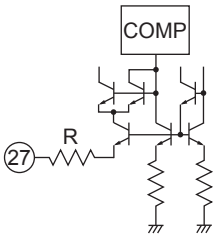
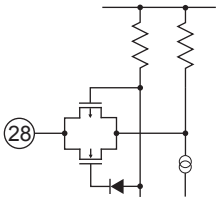
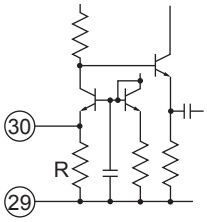
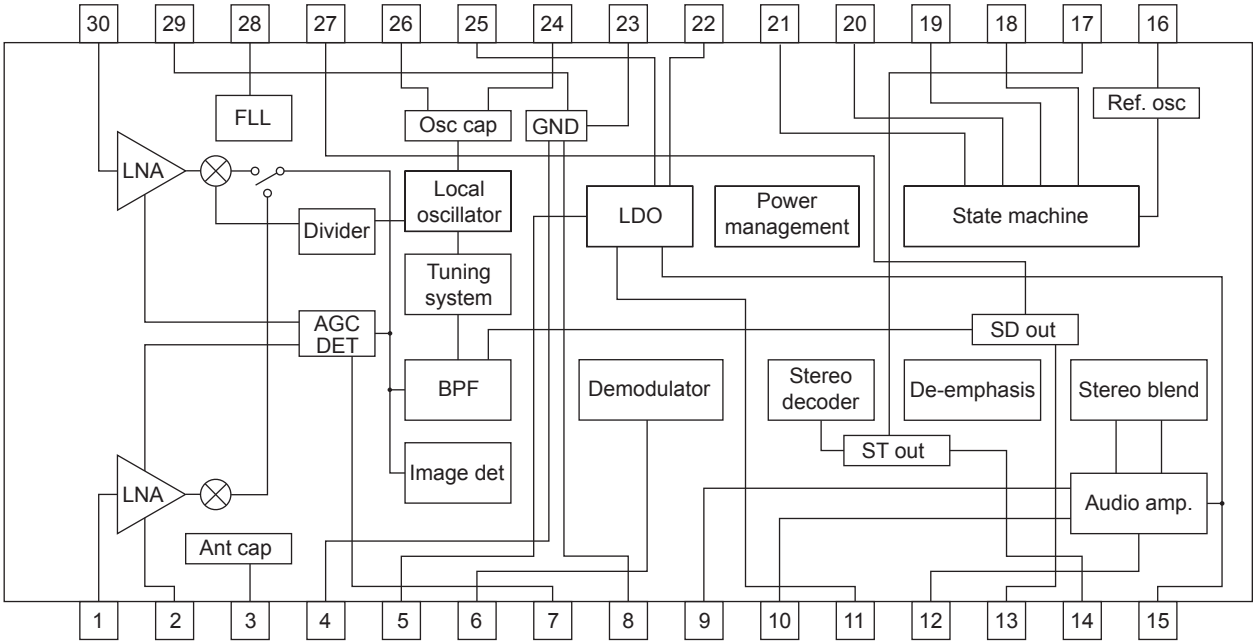
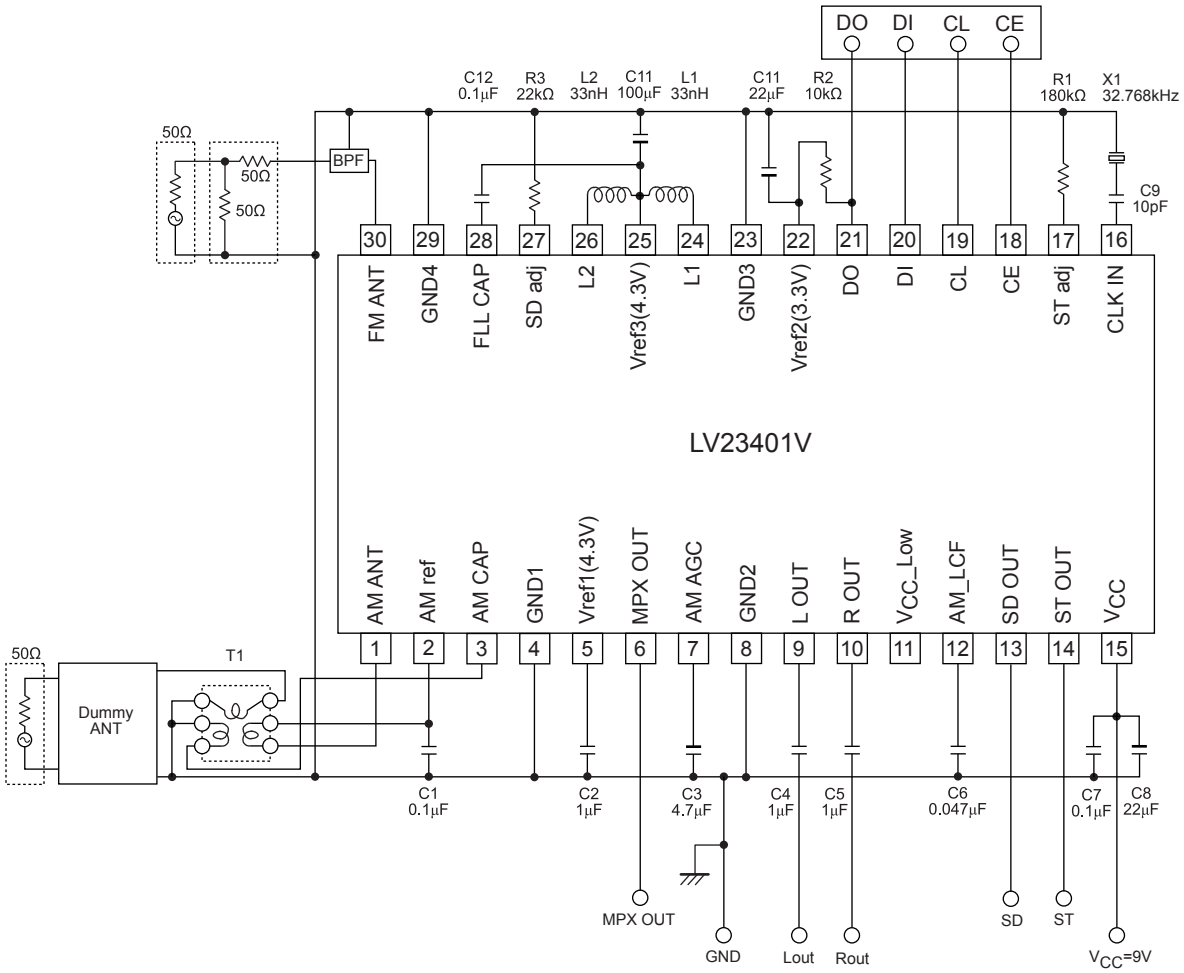
No.	Pin name	Voltage (V)	Internal Equivalent Circuit	Remarks
20	DI	–		Serial data input pin. Input pin of the serial data transmitted by controller.
21	DO	–		Serial data output pin. Serial data output pin to controller.
22	V_{DD}	3.3V		Logic area standard bias pin. V_{DD} = 3.3V
23	GND3	0V		Digital area (control block) GND pin.
24 26	L1 L2	4.3V		OSC coil connect pin. 33nH is connected between 25pin.
25	VREF2	4.3V		OSC area standard bias pin. VREF2 = 4.3V
27	SD-ADJ	0.1V		SD lighting sensitivity adjustment pin. It connects it to GND through 22kΩ. R = 100Ω
28	FLL-CAP	–		LPF pin for internal FLL control. R = 80kΩ
29	GND4	0V		Analog (FMRF) GND pin.
30	FM-ANT	0.9V		FM antenna input pin. R = 1.5kΩ R_{IN} = 75Ω

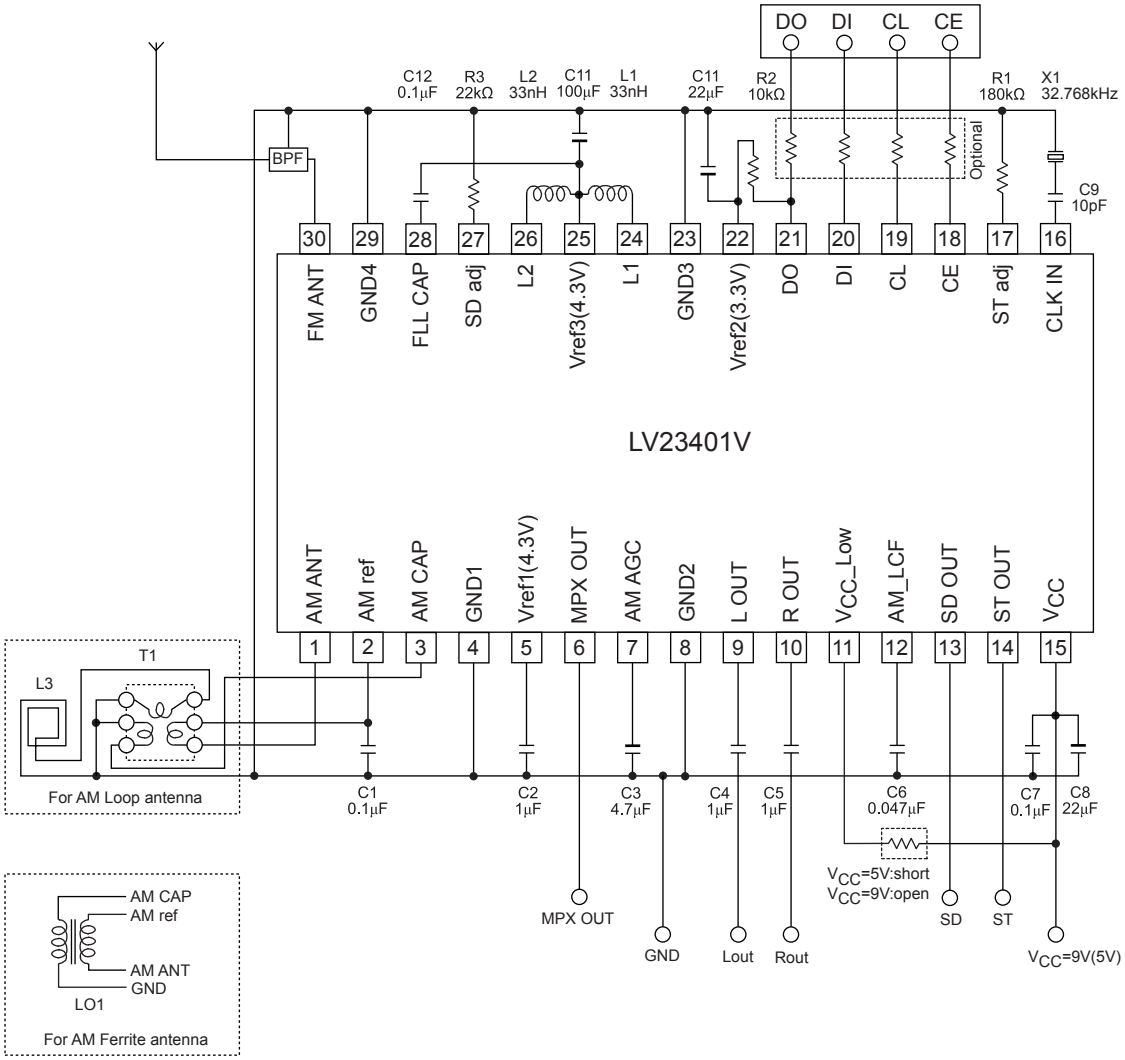
Block Diagram



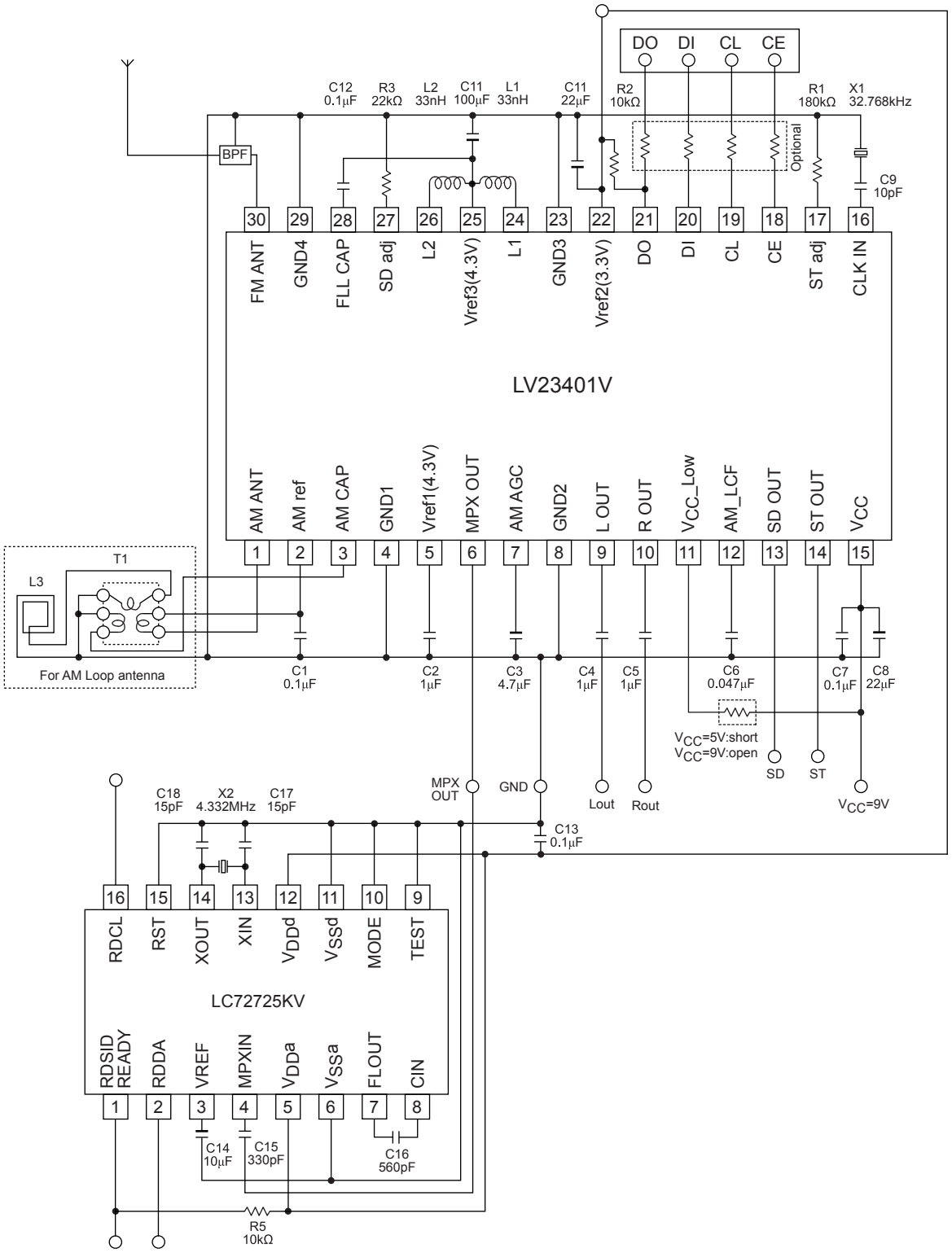
Measurement circuit



Example of applied circuit 1



Example of applied circuit 2



Used parts

Component	Parameter	Value	Tolerance	Type	Supplier
L1	Local Osc Coil	33nH	5%	LL2012-FHL33NJ	TOKO
L2	Local Osc Coil	33nH	5%	LL2012-FHL33NJ	TOKO
L3	AM Loop antenna	18.1μH	5%	4910-CSL18R1JN1	SAGAMI
T1	AM RF matching	-	-	A90326057	COILS
				#7003RNS-A1109YZS	TOKO
C1	Ripple Filter	0.1μF			
C2	Ripple Filter	1μF			
C3	AM RF AGC Capacitor	4.7μF			
C4	Coupling Capacitor	1μF			
C5	Coupling Capacitor	1μF			
C6	AM Low-cut Filter	0.047μF			
C7	Supply Bypass Capacitor	0.1μF			
C8	Supply Bypass Capacitor	22μF			
C9	Correction Capacitor	10pF			
C10	Supply Bypass Capacitor	22μF			
C11	Ripple Filter	0.1μF			
C12	Osc Filter	0.1μF			
C13	Ripple Filter	0.1μF			
C14	Ripple Filter	10μF			
C15	Coupling Capacitor	330pF			
C16	Coupling Capacitor	560pF			
C17	Correction Capacitor	15pF			
C18	Correction Capacitor	15pF			
R1	Reference Resistor	180Ω			
R2	Pulled-up Resistor	10kΩ			
R3	Reference Resistor	22kΩ			
R4	Reference Resistor	33kΩ			
R5	Pulled-up Resistor	10kΩ			
BPF	FM ANT BPF	-	-	GFMB7	SOSHIN
X1	Crystal	32.768kHz	100ppm	VT-200-F(12.5pF)	SEIKO
X2	Crystal	4.332MHz	100ppm	AT-49	DAISHINKI
LO1	AM Ferrite antenna	260μH	TBD	-	-

* L1 must be used when you receive an Eastern European band (65MHz to 75MHz) and L2 must use 39nH.

* Inquire match (C9, C17, C18) of X1 and the X2 crystal of the crystal maker together with the substrate used.

Interface specification

1) LV23401 Interface specification

LV23401 is controlled by the C^2B (Computer Control Bus) cereal bus format.

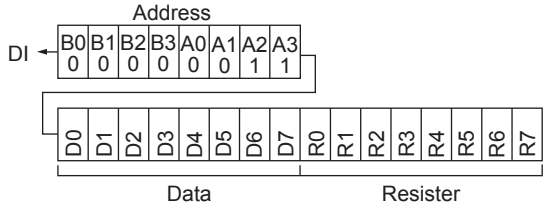
C^2B is a bus to achieve it economically surely format as for the communications between LSI in the system with two or more LSI. Because it is single master's system, the processing of a complex arbitration is unnecessary. Therefore, the load of hardware is reduced, and the system configuration that is economically abundant becomes possible.

Moreover, neither a lot of kinds of controller and interface doing nor special hardware is easily needed by serial I/O with software. C^2B is thought between LSI in the equipment, and the communications between equipment that need a long line are not targeted.

2) C2B data composition

DI control data (cereal data input) composition

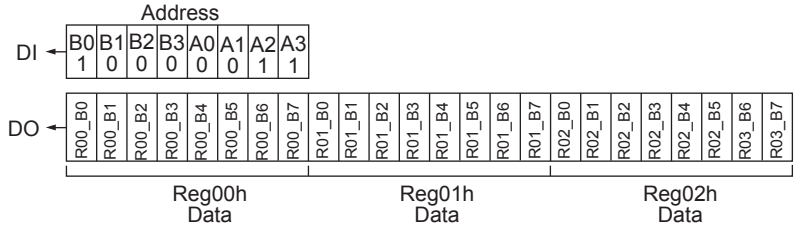
IN mode



LV23401V is controlled by the bus format composed of the sub-address (register) that stores the data of the device address of 8bit (address) and each 8bit. "C0" is input from LSB to the start as an address when the serial data is input to LV23401V, the device that controls is specified, and the mode as the data input is fixed. It inputs from LSB in order of data (bit setting) → register synchronizing with data clock (CL) after the address is input and the data input can be concluded.

Composition of the DO control data (serial data output)

OUT mode



"C1" is input from LSB to the start as an address when the serial data is output from LV23401V, the controlled device is specified, and the mode as the data output is fixed. The subsequent data is output from DO pin synchronizing with lock (CL) after the address is input LSB from one with small register number. The output of data is ended by setting CE pin to Low.

3) Description of the Register of LV23401

Register 00h – CHIP_ID – Chip identify register (Read-Only)

7	6	5	4	3	2	1	0
ID[7:0]							

Bit 7-0 : ID[7:0] : 8-bit CHIP ID.
LV23400 : 18h

Note : To abort the command, write any value in this register.

Register 01h – CHIP_REV – Chip Revision identify resister (Read-Only)

7	6	5	4	3	2	1	0
Revision[7:0]							

Bit 7-0 : ID[7:0] : 8-bit Chip revision
ES1 : 00h

Note : To abort the command, write any value in this register.

Register 02h – RADIO_STAT – Radio station status (Read-Only)

7	6	5	4	3	2	1	0
IM_STAT	IM_FS[1:0]		MO_ST	FS[2:0]			TUNED

Bit 7 : IM_STAT : State of image evasion code
0 = Eternal operation (It is possible to write it.)
1 = The image evasion is being processed. (Writing is improper.)

Note : This bit operates only when Resister 14h_bit7 (IM_EVAS) is set to "1". The data writing processing to LV23401 when this bit is "1" is prohibited.

Bit 6 - 5 : IM_FS : Image bureau electric field strength
0 : Image bureau none
1 : 0
2 : 0dB to 10dB compared with the hope bureau.
3 : The level of the image bureau is +10dB or more stronger than that of the hope bureau.

Bit 4 : MO_ST : MONAURAL/STEREO display
0 = Stereo reception (Compelling the monaural setting is also the same.)
1 = Receiving in stereo mode.

Bit 3 - 1 : FS[2:0] : Field strength
0 : Field strength < 10dBμV
1 : Field strength 10 to 20dBμV
2 : Field strength 20 to 30dBμV
• • •
3 : Field strength > 70dBμV

Bit 0 : TUNED : Radio-tuning flag
0 = No tuning.
1 = The tuning.

Note : When the frequency tuning succeeds, this bit is set. This flag is cleared under the following three conditions.
1. PW_RAD = 0
2. Do the tuning of the frequency.
3. When FLL becomes outside the correction range

Only when the TUNED flag is changed from one into 0, the RAD_IF interrupt flag is set.
When the status of TUNED changes from 0 into one, the interrupt is not generated.

Register 04h – TNPL – Tune position low (Read-Only)

7	6	5	4	3	2	1	0
TUNEPOS[7:0]							

Bit 7-0 : TUNEPOS[7:0] : Current RF frequency (Low 8bit)

Register 05h – TNPH_STAT – Tune position high / status (Read-Only)

7	6	5	4	3	2	1	0
ERROR[1:0]		TUNEPOS[12:8]					

Bit 7 - 6 : ERROR[1:0] : Error code

ERROR[1:0]	Remark
0	OK, Command end (No Error)
1	DAC Limit Error
2	Command forced End
3	Command busy (executing it)

Bit 5 – 0 : TUNEPOS[13:8] : Current RF frequency (High 5 bit)

Register 06h – COUNT_L – Counter low (Read-Only)

7	6	5	4	3	2	1	0
COUNT[7:0]							

Bit 7 – 0 : COUNT[7:0] : Counter value (Low 8bit)

Register 07h – COUNT_H – Counter High (Read Only)

7	6	5	4	3	2	1	0
COUNT[15:8]							

Bit 7 – 0 : COUNT[15:8] : Counter value (High 8bit)

Register 08h – IF_OSC – DAC for IF OSC (Read/Write)

7	6	5	4	3	2	1	0
IFOSC[7:0]							

Bit 7 – 0 : IFOSC[7:0] : IF Oscillator DAC

Register 09h – IFBW – DAC for IF – Filter Band width (Read/Write)

7	6	5	4	3	2	1	0
IFBW[7:0]							

Bit 7 – 0 : IFBW[7:0] : IF Band-pass Filter Band DAC

Register 0Bh – STEREO_OSC – DAC for Stereo Decoder OSC (Read/Write)

7	6	5	4	3	2	1	0
SDOSC[7:0]							

Bit 7 – 0 : SDOSC[7:0] : Stereo Decoder Oscillator DAC

Register 0Ch – RF_OSC – DAC for RF OSC (Read/Write)

7	6	5	4	3	2	1	0
RFCAP[7:0]							

Bit 7 – 0 : RFOSC[7:0] : RF Oscillator DAC

Register 0Dh – RFCAP – RF Cap bank (Read/Write)

7	6	5	4	3	2	1	0
RFCAP[7:0]							

Bit 7 – 0 : RFCAP[7:0] : RF Oscillator Capacitor bank

Register 0Eh – AMCAP1 – AM-ANT Cap bank1 (Read/Write)

7	6	5	4	3	2	1	0
AMCAP[7:0]							

Bit 7 – 0 : AMCAP[7:0] : AM Antenna Capacitor bank

Note : The AM antenna capacitor bank is composed of 12 bits.
High 4 bits are arranged in AMCTRL resister.

Register 0Fh – AMCTRL – AM Station Control (Read/Write)

7	6	5	4	3	2	1	0
AMDIV[2:0]			AM_CAL	ACAP11	ACAP10	ACAP9	ACAP8

Bit 7 – 5 : AMDIV[2:0] : AM Clock Divider
Bit 7 : AM_CD2 : AM Clock Divider bit 2.
Bit 6 : AM_CD1 : AM Clock Divider bit 1.
Bit 5 : AM_CD0 : AM Clock Divider bit 0.

Note : AMCD[2:0] uses the frequency of FM belt even for the AM belt to lower.
Set the machine of the AM dividing frequency to turning off at FM mode.

AM_CD[2:0]	Rate of dividing frequency	Rough estimate AM-RF frequency (In kHz)
0,1	Divider OFF	0 (FM mode)
2	224	338 – 483
3	160	474 – 676
4	112	676 – 966
5	80	947 – 1353
6	64	1183 – 1692
7	48	1578 - 2256

Bit 4 : NA (0 Fixation)
Bit 3 – 0 : AMCAP[11:8] : AM antenna capacitor bank.
Bit 3 : AMCAP_bit11
Bit 2 : AMCAP_bit10
Bit 1 : AMCAP_bit9
Bit 0 : AMCAP_bit8

Register 10h – DO_REF_CLK_CNF – Do output mode and reference clock configuration (Read/Write)

7	6	5	4	3	2	1	0
IPOL	DO_SEL[1:0]		EXT_CLK_CFG[1:0]		FS_S[2:0]		

Bit 7 : IPOL : Indicator (DO pin _SD/ST mode) polarity
0 = SD/ST Active Low (The same state change as 13pin – SD pin / 14pin – ST pin)
1 = SD/ST Active High (State change opposite to 13pin – SD pin / 14pin – ST pin)
Note : This bit doesn't influence the polarity of the serial data.

Bit 6 -5 : DO_SEL : DO pin select (DO pin output mode select)

DO_SEL[1:0]	DO pin
00	Serial data output mode
01	ST pin mode
10	SD pin mode
11	Local position confirmation mode

DO pin is used by observing the position (Upper heterodyne / Lower heterodyne) of a state of SD pin/ST pin besides the serial data output and local OSC.
* The state of DO pin changes synchronizing with SD pin / ST pin when DO_SEL is set to (01b) or (10b).
* The state of DO pin changes by the position of Local OSC when DO is set to (11b). Lower heterodyne = 0, Upper heterodyne = 1
* Set DO_SEL to (00b) when you output the serial data.

Bit 4 – 3 : EXT_CLK_CFG[1:0] : External clock setting

EXT_CLK_CFG[1:0]	Reference clock
00	Off
01	The external clock is supplied.
10	32768Hz Crystal oscillation
11	Unused

Bit 2 – 0 : FS_S[2:0] : SD(Station Detector) operate level setting (distinguishes at the FS level)

Register 11h – IF_SEL – IF frequency selection (Read/Write)

7	6	5	4	3	2	1	0
FLL_MOD	AMIF[2:0]			FMIF[3:0]			

Bit 7 : FLL_MOD : FLL operation mode
0 : Smoothing filter = OFF
1 : Smoothing filter = ON

Bit 6 -4 : AMIF[2:0] : IF frequency setting when AM mode is selected

AMIF[2:0]							
0	1	2	3	4	5	6	7
20kHz	31kHz	42kHz	53kHz	64kHz	75kHz	86kHz	97kHz

Bit 3 – 0 : FMIF[3:0] : IF frequency setting when FM mode is selected (kHz)

SE_	RF_	FMIF[3:0]														
AM	SEL	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
0	0	112.5	125	137.5	150	162.5	175	187.5	212.5	225	237.5	250	262.5	275	287.5	312.5	325
0	1	112.5	127.5	142.5	157.5	157.5	172.5	187.5	202.5	217.5	232.5	247.5	262.5	277.5	292.5	307.5	322.5

Register 12h – REF_CLK_MOD – Slope correction (Read/Write)

7	6	5	4	3	2	1	0
REFMOD[7:0]							

Bit 7 – 0 : REFMOD[7:0] : Reference clock correction

Note : As for this register, a set value is different according to the crystal connected with 16pin and the input clock. Inform of a set value of this register when you adopt the applications other than an example of applied circuit and recommended parts of this specifications.

Register 13h – SM_CTRL – Statemachine control (Read/Write)

7	6	5	4	3	2	1	0
FLL_ON	CLKS_SE[2:0]			nSD_PM	nIF_PM	DM_SE[1:0]	

Bit 7 : FLL_ON : FLL control
0 = FLL OFF
1 = FLL ON

Bit 6 – 4 : CLKS_SE : Clock course select
0 = No select
1 = The source of the stereo decoder oscillator is effective.
2 = The source of the IF oscillator is effective.
3 = The source of the AM antenna oscillator is effective.
4 = The source of the FM-RF oscillator is effective.
5 = The source of the AM-RF oscillator is effective.
6 – 7 = no select

Note : Bit[6-4] selects the source of the oscillator. Select the arbitrary source that to be adjusted and to be measured.

Bit 3 : nSD_PM : Stereo decoder clock PLL mute
0 = SD PLL OFF (Adjustment)
1 = SD PLL ON (Operation usually)

Bit 2 : nIF_PM : IF PLL mute
0 = IF PLL OFF (Adjustment)
1 = IF PLL ON (Operation usually)

Bit 1 – 0 : CM_SE : Command mode select
0 = Command no select
1 = Measurement mode
2 = Adjustment mode
3 = Radio tuning (reception frequency adjustment) mode

Note : This bit is used to select the command mode. Select the arbitrary command to be executed. The command is executed by setting TARGET_VAL_L/H.

Command execution time :
SD calibration = 540ms
IF calibration = 134ms
RF(FM) tuning = 105ms
RF(AM) tuning = 158ms
* Stand-by at time to have provided for the above-mentioned before all processing including reading the register value after having executed the command.

Register 14h – REF_CLK_PRS – Reference clock pre-scalar (Read/Write)

7	6	5	4	3	2	1	0
IM_EVAS	Reserved	WAIT_SEL	A<_FINE	REFPRE[3:0]			

Bit 7 : IM_EVAS : Image evasion function ON/OFF
0 = The image bureau is not evaded.
1 = The image bureau is evaded. (recommendation)

Bit 6 : Reserved : 0 fixation

Bit 5 : WAIT_SEL : Selection after tuning at mute release standby time
0 = 8ms standby
1 = 4ms standby

Bit 4 : AM_FINE : Selection at AM_ANT adjustment standby time
0 = No standby after switch of DAC
1 = 2ms standby after switch of DAC

Bit 3 – 0 : REFPRE[3:0] : Standard Clock Pre-scalar
0 = 1:1
1 = 1:2
2 = 1:4
• • •
15 = 1:32768

Register 15h – REF_CLK_DIV – Reference clock divider (Read/Write)

7	6	5	4	3	2	1	0
REFDIV[7:0]							

Bit 7 – 0 : REFDIV[7:0] : Standard clock divider
0 : Rate of dividing frequency = 1
1 : Rate of dividing frequency = 2
• • •
255 : Rate of dividing frequency =256

Register 16h – TARGET_VAL_L – Target Value Low Register (Read/Write)

7	6	5	4	3	2	1	0
TARGET[7:0]							

Bit 7 – 0 : TARGET[7:0] : Target Frequency Low 8bit : Targeted value of radio tuning and oscillator adjustment : Low byte

Register 17h – TARGET_VAL_H – Target Value High Register (Read/Write)

7	6	5	4	3	2	1	0
TARGET[15:8]							

Bit 7 – 0 : TARGET[15:8] : Target Frequency High 8 bit : Targeted value of radio tuning and oscillator adjustment : High byte
Note : When subordinate position 8bit of the frequency of the target is set when it is on, and high rank of the frequency of the target 8bit is set to this register afterwards, the command is executed as for the radio power.

TUNEPOS and TARGET :
- 1kHz interval at AM
- 10kHz interval at FM

Register 18h – RADIO_CTRL1 – Radio control 1 (Read/Write)

7	6	5	4	3	2	1	0
IQC_CTR	IFPOL	OSC_LEV[1:0]		DEEM	VOL[1:0]		EN_AMHC

Bit 7 : IQC_CTR : I/Q phase conversion
0 = Operational mode usually (Upper heterodyne)
1 = I/Q phase conversion : Image measures (Lower heterodyne)
Note : When the local is switched as an image measures, it uses it.

Bit 6 : IF polarity conversion in State Machine.
0 = The IF frequency is added to a local frequency. (Operational usually)
1 = The IF frequency is subtracted by a local frequency. (Image measures)

Bit 5 – 4 : OSC_LEV[1:0] : RF-OSC oscillation level setting
0 = Minimum oscillation level
3 = Maximum oscillation level
* A possible level adjustment and "2" are assumed to be a recommended value at each interval of 3dB.

Bit 3 : DEEN : De-emphasis time constant switch
0 = 50μs : Japan, South Korea, China, and Europe
1 = 75μs : The United States

Bit 2 – 1 : VOL[1:0] : Volume setting
0 = Minimum (VOL0)
• • •
3 = Maximum (VOL3)

Bit 0 : EN_AMHC : AM high cut filter ON/OFF
0 = AM hi-cut filter function OFF
1 = AM hi-cut filter function ON

Register 19h – RADIO_CTRL 2 – Radio control 2 (Read/Write)

7	6	5	4	3	2	1	0
Reserved	Reserved	EN_AMM	Reserved	IF_AGC_LEV	RF_AGC_LEV[1:0]		EN_RFAGC

Bit 7 : Reserved : 0 fixation

Bit 6 : Reserved : 1 fixation

Bit 5 : EN_AMM : AM mute ON/OFF
0 = AM mute function OFF
1 = AM mute function ON

Bit 4 : Reserved : 0 fixation

Bit 3 : IF_AGC_LEV : IF-AGC level control
0 = AGC slow mode
1 = AGC first mode

Bit 2 – 1 : RF_AGC_LEV[1:0] : RF-AGC level control
0 = AGC slow mode
1 = AGC normal mode
3 = AGC first mode

Bit 0 : EN_RFAGC : RF-AGC ON/OFF
0 = AGC OFF
1 = AGC ON (Operational usually)

Register 1Ah – RADIO_CTRL3 – Radio control 3 (Read/Write)

7	6	5	4	3	2	1	0
AMOSC_GA[2:0]			AMOSC_DL[2:0]			AMAGC_SP[1:0]	

Bit 7 – 5 : AMOSC_GA[2:0] : AM antenna oscillator gain control
0 = Minimum level
7 = Maximum level

Bit 4 – 2 : AMOSC_DL[2:0] : AM oscillator detection level
0 = Minimum level
7 = Maximum level

Bit 1 – 0 : AMSGC_SP[1:0] : AM oscillator AGC speed
0 = Slow mode
3 = First mode

Register 1Ch – STEREO_CTRL1 – Stereo control 1 (Read/Write)

7	6	5	4	3	2	1	0
CRC[1:0]		SS_SP2	SS_SP1	NA	PICAN_EN	FOSTEREO	ST_M

Bit 7 – 6 : CRC[1:0] : Capture range control
0 = Narrowband mode
1 = Recommended value
3 = Wideband mode

Bit 5 : SS_SP2 : STEREO sensitivity speed 2 (First mode)
0 : First mode = OFF
1 : First mode = ON - Recommended value

Bit 4 : SS_SP1 : STEREO sensitivity speed 1 (Slow mode)
0 : Slow mode = OFF - Recommended value
1 : Slow mode = ON

Bit 3 : NA

Bit 2 : PICAN_EN : Pilot cancel function ON/OFF
0 = OFF
1 = ON

Bit 1 : FOSTEREO : Compulsion stereo
0 = Operational usually
1 = Compulsion stereo mode

Bit 0 : ST_M : STEREO/MONAURAL setting
0 = Stereo function ON (Operational usually)
1 = Stereo function OFF (Compulsion monaural)

Register 1Dh – STEREO_CTRL2 – Stereo control 2 (Read/Write)

7	6	5	4	3	2	1	0
NA			FOAMAGC	Reserved	NA	CPAJ[1:0]	

Bit 7 – 5 : NA

Bit 4 : FOAMAGC
0 : Compulsion AGC = OFF
1 : Compulsion AGC = ON

Bit 3 : Reserved : 0 fixation

Bit 2 : NA

Bit 1 – 0 : CPAJ[1:0] : Channel separation adjustment
0 = Sub career level minimum
7 = Sub career level maximum

Register 1Eh – RADIO_CTRL4 – Radio control 4 (Read/Write)

7	6	5	4	3	2	1	0
SOFTST[2:0]			SOFTMU[2:0]			LEVSHIF	FO_SOFTT

Bit 7 – 5 : SOFTST[2:0] : Soft stereo function setting
0 : Soft stereo function = OFF
7 : Soft stereo function = Lev7 (Max)

Bit 4 – 2 : SOFTMU[2:0] : Soft audio mute function setting
0 : Soft mute function = OFF
7 : Soft mute function = Lev7 (Max)

Bit 1 : LEVSHIF : Audio line DC level shift
0 = Normal DC level (V_{CC}=5.0V supply)
1 = DC level shift (V_{CC}=9.0V supply)

Bit 0 : FO_SOFTST : Compulsion soft stereo function setting
0 : Compulsion soft stereo function = ON
1 : Compulsion soft stereo function = OFF
* Set it to "0" when corresponding to European immunity standard.

Register 1Fh – RADIO_XTRL5 – Radio control 5 (Read/Write)

7	6	5	4	3	2	1	0
RF_SEL	IFRIM	nAGC_SPD	SE_FM/AM	AMP_CTR	MUTE	NA	PW_RAD

Bit 7 : RF_SEL : RF frequency range setting
0 = Normal (Japan / USA / Europe)
1 = Eastern Europe (65MHz to 74MHz)

Bit 6 : IFRIM : IF oscillator limit setting
0 : Max = 350kHz (FM mode)
1 : Max =150kHz (AM mode)

Bit 5 : nAGC_SPD : IF AGC speed setting
0 = Hi speed (FM mode)
1 = Normal (AM mode)

Bit 4 : SE_FM/AM : AM/FM mode select
0 = FM mode
1 = AM mode

Bit 3 : AMP_CTR : Audio amplifier ON/OFF
0 = OFF
1 = ON

Bit 2 : MUTE : Audio mute function ON/OFF
0 = Mute ON
1 = Mute OFF

Bit 1 : AM_CAL : AM calibration (Oscillation mode)
0 = AM calibration impropriety (Operational usually)
1 = AM calibration mode (AM antenna frequency setting time)
Note : Set this bit to "1" when you measure the frequency of the AM antenna.

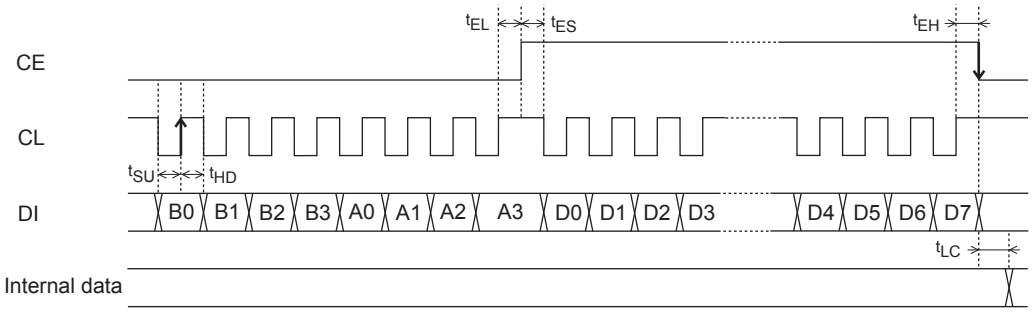
Bit 0 : PW_RAD : Radio circuit power
0 = Power OFF (Power save)
1 = Power ON

* 1 : After the V_{CC} voltage is impressed, PW_RAD of Register 1Fh_bit0 is automatically set to "0" in 50ms.
* 2 : When the V_{CC} voltage is dropped once, content of registers other than PW_RAD becomes irregular.
* 3 : The content of the register change set at the power save becomes effective, and any command processing cannot be executed.
* 4 : The standby time of 1200ms is necessary, the circuit with stability (PW_RAD = 0 → 1) after the power save returns.
* 5 : Tune RF again after the power save returns.
* 6 : A built-in each oscillator including the RF bureau departure and all other analogue part circuit operation stop at the power save.
* 7 : The standby time of 200ms is necessary after the switch of the band to AM before counting IF after adjusting the first RF.

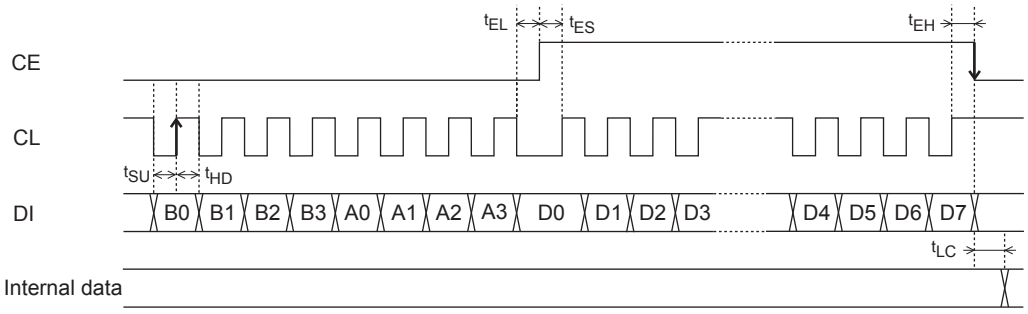
4) C^2B communication timing specification

Serial data input (IN1/IN2) tSU, tHD, tEL, tES, tEH≥0.75μs tLC<0.75μs

CL : Normally Hi

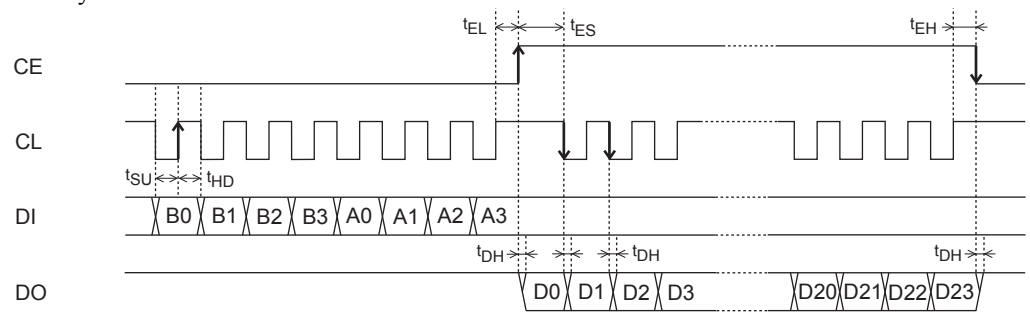


CL : Normally Low

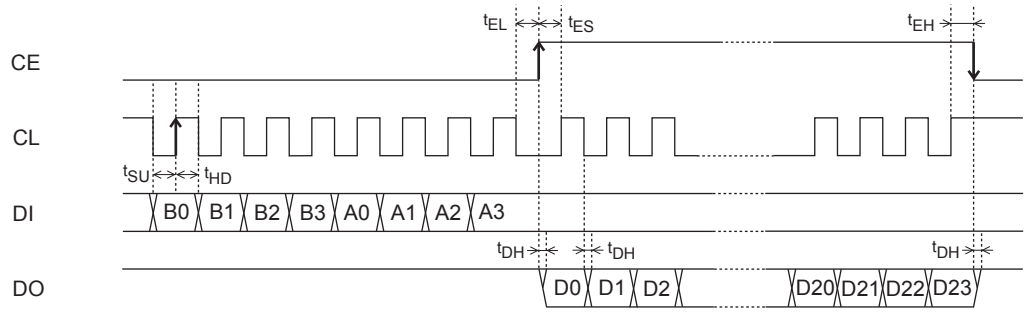


Serial data output (OUT) tSU, tHD, tEL, tES, tEH≥0.75μs tDC, tDH<0.35μs

CL : Normally Hi

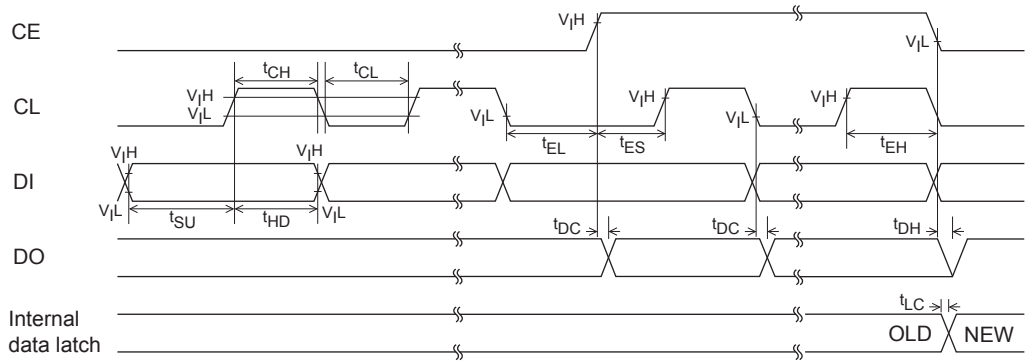


CL : Normally Hi

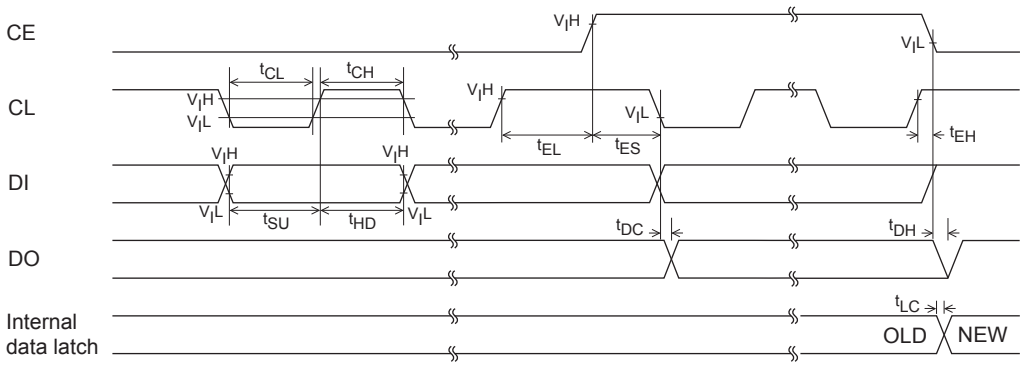


(Note) DO pin is an Nch open drain pin, so that the data varying time (tDC and tDH) differs depending on the pull-up resistance and substrate capacity.

Serial data timing



<< When CL stops at the “L” level >>



<< When CL stops at the “H” level >>

Parameter	Symbol	Pin	Conditions	Min	Typ	Max	Unit
Data setup time	tSU	DI, CL		0.75			μs
Data hold time	tHD	DI, CL		0.75			μs
Clock “L” level time	tCL	CL		0.75			μs
Clock “H” level time	tCH	CL		0.75			μs
CE wait time	tEL	CE, CL		0.75			μs
CE setup time	tES	CE, CL		0.75			μs
CE hold time	tEH	CE, CL		0.75			μs
Data latch change time	tLC					0.75	μs
Data output time	tDC	DO, CL	Differs depending on the pull-up resistance and substrate capacity			0.35	μs
	tDH	DO, CE					