AP916B

DTS TUNING CONTROLLER

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1. OVERVIEW

The AP916B is a single chip PLL tuning controller IC for DTS type radio tuner application. It operates as a slave device and simplifies the development of DTS type radio application by providing high level control interface to the host microcontroller and handling complicated, low level control to DTS tuner IC. Host control of the AP916B can be implemented by any 4/8bit microcontroller via a simple 3-wire serial interface (host microcontroller interface). Functionalities of the AP916B include radio tuning, carrier frequency locking and runtime tuning status monitoring.

2. FEATURES

- Operating Voltage: 1.8V to 3.6V
- Operating Temperature: -20°C to 70°C
- Supports advanced system level functions, Fast-Search (pre-programmed mode), Manual-Search (single step search) and Auto-Search Mode (station seek)
- Supports FM/AM/SW/LW radio tuning
- Supports wide range of tuner ICs

3. APPLICATIONS

- Pocket Radio, Discman, Tuner Module
- Boom Box, Mini Combo

4. ORDERING INFORMATION

PART NUMBER	PINS	PACKAGE
AP916B-CB-L	24	COB
AP916B-DC-L	26	DICE

5. APPLICATION SYSTEM BLOCK DIAGRAM

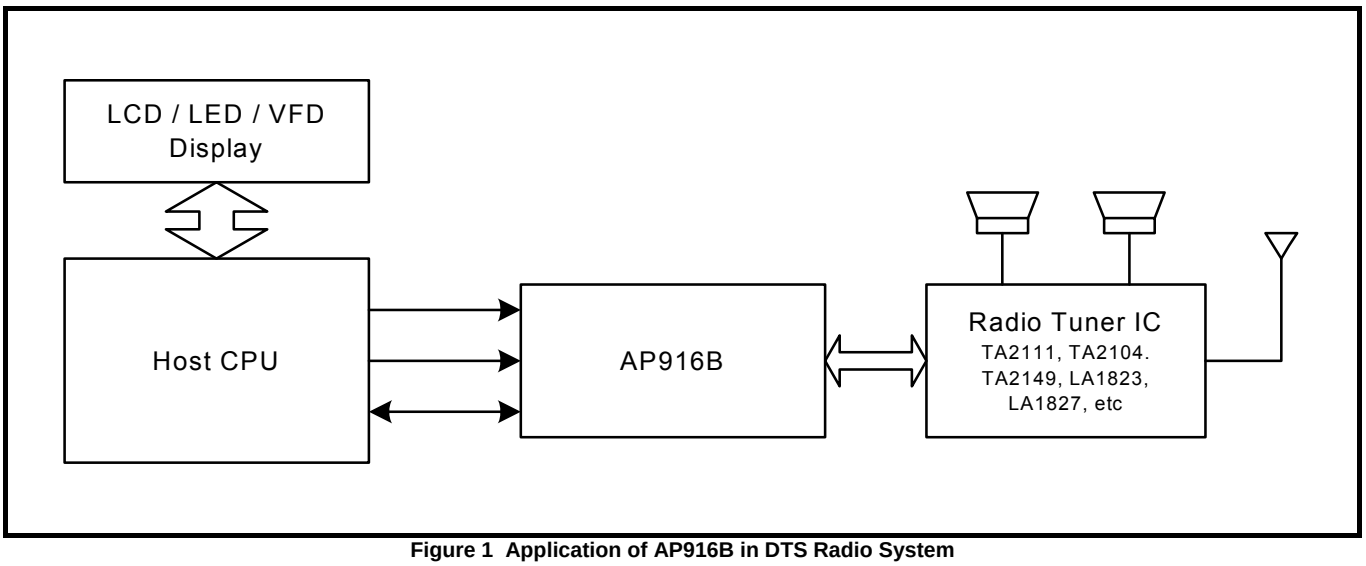


Figure 1 Application of AP916B in DTS Radio System

6. PIN CONFIGURATIONS

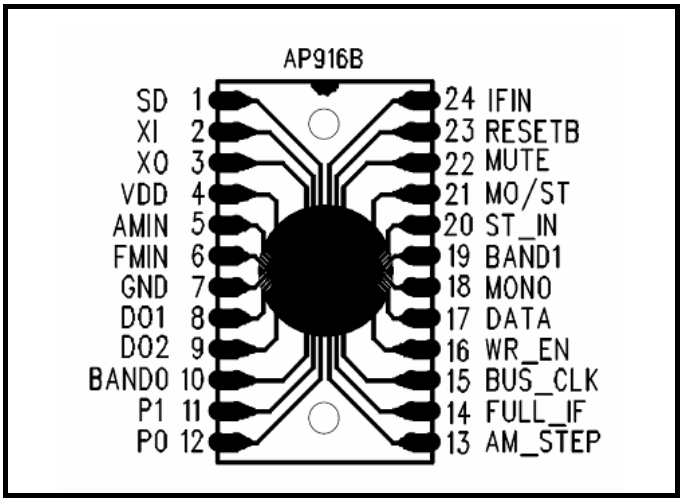


Figure 2. 24-Pin COB Package (Top View)

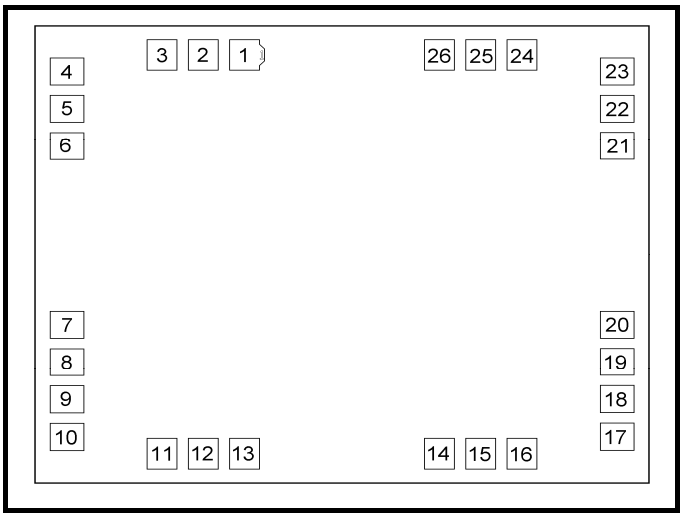


Figure 3. 26-Pin Dice Form

7. DEVICE PIN DESCRIPTION

IC/COB Pin #	Die Pad #	Pin Name	I/O	Description	Active	Initial	*Remark
1	1	SD	I	Signal detect; connect to 'Tune LED' pin of the tuner IC (see section *8.5.3 Tune Status*)	L	-	
2	2	XI	I	Oscillator input (75kHz)	-	-	OSC
3	3	XO	O	Oscillator output (75kHz)	-	-	OSC
4	4	VDD	-	Digital power supply	-	-	
5	5	AMIN	I	AM local oscillator signal input	-	-	AMP
6	6	FMIN	I	FM local oscillator signal input	-	-	AMP
7	7	GND	-	Digital ground	-	-	
	8			Not connected	-	-	PU
8	9	DO1	O	DO output. Connect to LPF circuit of tuner	-	-	
9	10	DO2	O	LPF control L = FM H = AM	-	-	
10	11	BAND0	O	Radio band selection of tuner IC L = FM/AM H = LW/SW	-	L	
11	12	P1	O	General purpose output pin	-	L	
12	13	P0	O	General purpose output pin	-	L	
13	14	AM_STEP	I/O	This pin has two functions. 1. Preset Mode: This pin will be in input mode for the selection of the search frequency step size. A 1MΩ resistor has to be connected from this pin to VDD or GND to indicate the search frequency step selection. (H = 9kHz step, L = 10kHz step) 2. Search Mode: This pin will become output mode. Pulse will be outputted when a search frequency step, either Upward or Downward search, is reached.	-	-	
14	15	FULL_IF	I	FM IF frequency selection L = 1/8 IF frequency H = Full IF frequency	-	-	
15	16	BUS_CLK	I	Host interface - clock pin	H	-	
16	17	WR_EN	I	Host interface - write enable pin	H	-	
17	18	DATA	I/O	Host interface – data input / output pin	-	-	OD, Ext. PU
18	19	MONO	O	Mono/Stereo control signal to tuner IC L = Stereo H = Mono	-	-	
	20			Not connected	-	-	PD
19	21	BAND1	O	Radio band selection to tuner IC BAND1 / BAND0 / MODE L / L / FM L / H / LW H / L / AM H / H / SW	-	L	
20	22	ST_IN	I	Stereo indicator input from tuner IC 0 = "Stereo LED" on 1 = "Stereo LED" off (see section *8.5.3 Tune Status*)	L	-	

21	23	MO/ST	O	Mono / Stereo indicator to host microcontroller BUS_CLK / MO/ST / Indication L / L / Stereo L / H / Mono H / L / Tuned H / H / Not tuned (see section *8.5.3 Tune Status*)	-	-	
22	24	MUTE	O	Tuner output muting (active High)	H	H	
23	25	RESETB	I	Master reset of the AP916B (active Low)	L	-	PU
24	26	IFIN	I	For intermediate frequency (FM=10.7MHz /1.3375MHz, MW/LW = 450kHz) detection. Once station is locked, these IF frequencies mentioned will be fed into this pin and search will be stopped. User can read out the frequency locked at the F[14:0] register.	-	-	AMP

PD – with internal Pull Down
PU – with internal Pull Up
Ext. PU – External Pull Up
SCH – SCHmitt trigger input
OD – Open Drain
AMP – AMPlifier for small signal input
OSC – OSCillator connection

8. FUNCTIONAL DESCRIPTIONS

8.1 Bus Protocol

The operation of AP916B is controlled via a 3-wire bi-directional host microcontroller serial communication bus.

- BUS_CLK pin - Bus Clock signal from the host microcontroller.
- DATA pin - Bi-directional Data I/O pin for the host microcontroller and the AP916B.
- WR_EN pin - Read/Write control pin for the host serial communication interface.

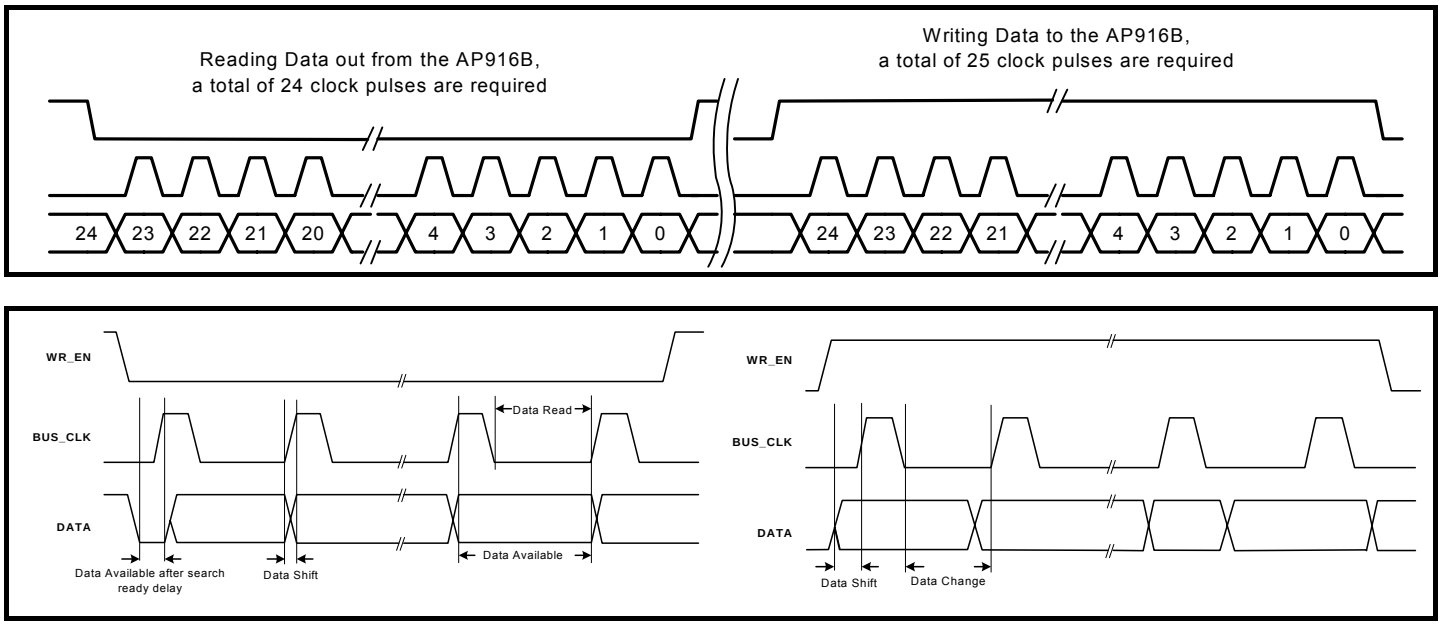


Figure 3. Host microcontroller interface data read / write format

Command word for the AP916B is 25-bit in length. Figure 3 shows the format and the waveform of the command word write into and read from the chip. Note that for command word writing, 25 BUS_CLK pulses are required. For command word reading, only 24 BUS_CLK pulses are needed.

8.2 Command Word Description

Table of the Command Word

t 8	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
F8	F7	F6	F5	F4	F3	F2	F1	F0
Bit 17	Bit 16	Bit 15	Bit 14	Bit 13	Bit 12	Bit 11	Bit 10	Bit 9
X	X	RSV	F14	F13	F12	F11	F10	F9
		Bit 24	Bit 23	Bit 22	Bit 21	Bit 20	Bit 19	Bit 18
		S	D	M	B0	B1	P0	P1

Command Word Description

F[14:0] register
F[14:0] are the register for the target tuning frequency to the tuner IC.

	Bit Value	FM Value (kHz)	AM/LW/SW Value (kHz)
F14	2^{14}	-	16384
F13	2^{13}	102400	8192
F12	2^{12}	51200	4096
F11	2^{11}	25600	2048
F10	2^{10}	12800	1024
F9	2^{9}	6400	512
F8	2^{8}	3200	256
F7	2^{7}	1600	128
F6	2^{6}	800	64
F5	2^{5}	400	32
F4	2^{4}	200	16
F3	2^{3}	100	8
F2	2^{2}	50	4
F1	2^{1}	X	2
F0	2^{0}	X	1

RSV register
Reserved. When writing command to the AP916B, it should always be “0”.

X register
X – indicates don’t care.

P1, P0 register
General purpose output pin P0 and P1 (IC/COB package pin 11 and 12) register.

B1, B0 register
Tuner IC radio mode control pins BAND0 and BAND1 (IC/COB package pin 10 and 19) output register.

B0 (BAND0)	B1 (BAND1)	Radio mode (Receiving band)
0	0	FM
0	1	AM
1	0	LW
1	1	SW

M register
Tuner mono / stereo control pin MONO (IC/COB Pin 18) output register.
0 Tuner in stereo reception mode is allowed
1 Tuner in mono reception mode only

D register
Channel search direction control register.
0 Search downward (toward lower frequency)
1 Search upward (toward higher frequency)

S register
Search Start / End Control
0 Search Stop. F[14:0] can only be loaded with this condition.
1 Search Start. Sequential search will start until a station is found. Direction of search determined by **D register** above.

8.3 Operation Frequency Range for AP916B

Band	Min. Frequency	Max. Frequency	Remark
FM	51200k	204750k	Internal operation of station search (F[14:0]) will be rounded off to the nearest 50kHz multiple.
AM	128k	32767k	Internal operation of station search (F[14:0]) will be rounded off to 1. The nearest 3k multiple if AM 9k step is being selected with the AM_STEP pin set to 'H'. 2. The nearest 5k multiple if AM 10k step is being selected with the AM_STEP pin set to 'L'.
LW	128k	32767k	Internal operation of station search (F[14:0]) will be rounded off to the nearest 1kHz multiple (same as the resolution of F[14:0] register).
SW	128k	32767k	Internal operation of channel search (F[14:0]) will be rounded off to the nearest 5kHz multiple.

8.4 Bus Timing

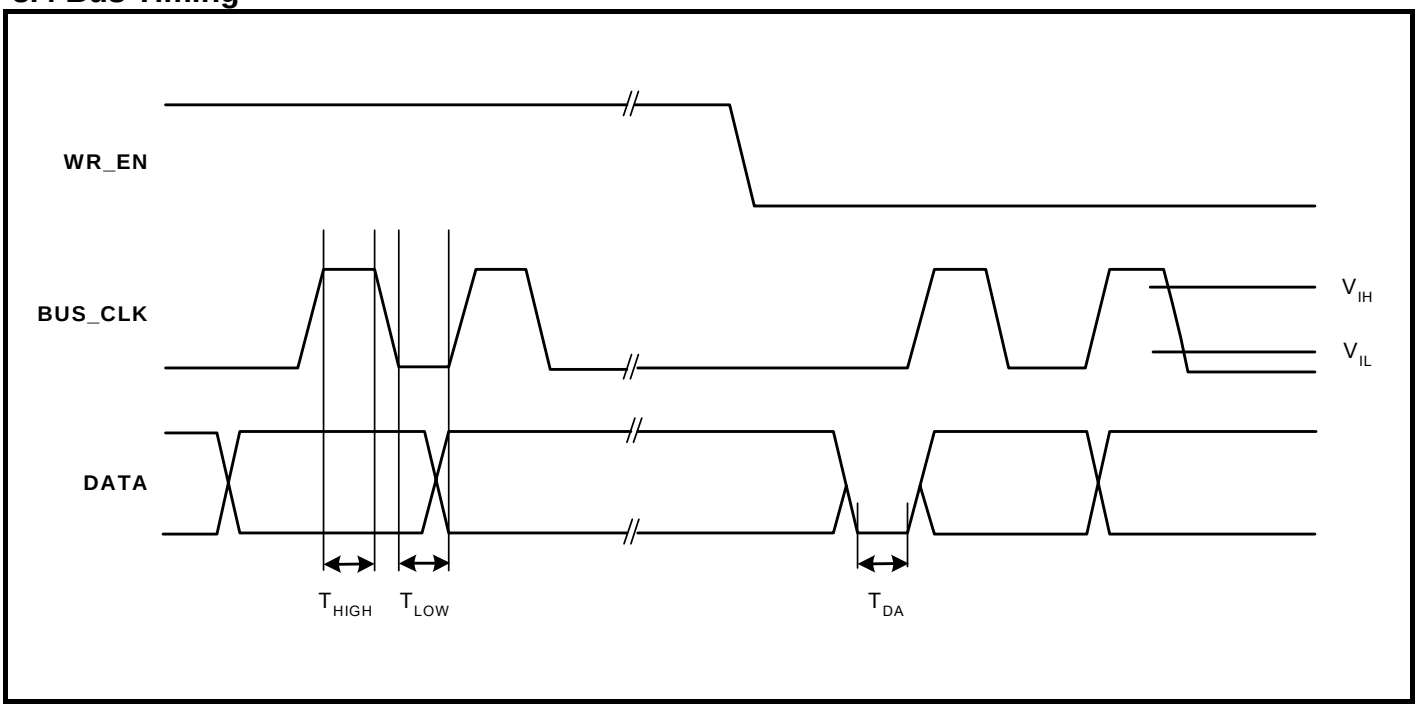


Figure 4. Timing diagram of the host microcontroller interface

Parameter	Symbol	Min	Max	Unit
High Level Input Voltage	V_{IH}	1.4		V
Low Level Input Voltage	V_{IL}		0.6	V
BUS_CLK Input Frequency	F_{clk}		300	kHz
BUS_CLK Level High Time	T_{HIGH}	1.67		µs
BUS_CLK Level Low Time	T_{LOW}	1.67		µs
Host Microcontroller Interface FIFO Latency	T_{DA}		14	µs

8.5 Chip Operation

The AP916B can operate in 2 modes: Preset mode and Search mode.

8.5.1 Preset Mode

In the Preset mode, the tuner IC will be tuned to the frequency value written in the register F[14:0] in the command word* by AP916B. When the target frequency is reached, AP916B will pull the DATA Pin from 'H' to 'L' to indicate that the station search sequence is finished.

* Internal operation of the AP916B will round off the frequency value written in F[14:0] into nearest integral multiple as mentioned in section 8.3.

8.5.2 Search Mode

In the Search mode, the search sequence can be started by configuring the direction of search ('D' bit) and the search start ('S' bit) in the host microcontroller command word and then download the command word to the AP916B.

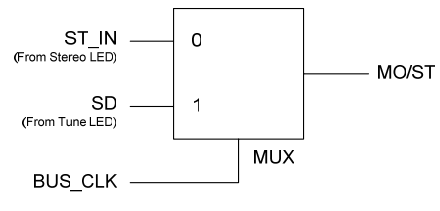
When a station is found, AP916B will toggle the DATA Pin from 'H' to 'L' to indicate that the search sequence is successful and the host microcontroller will read out the carrier frequency of the station from F[14:0] in the command word. If no station is found and the search sequence reached the radio band limits, AP916B will also set the DATA Pin from 'H' to 'L' to indicate that the search operation has been stopped. The tuning frequency read out from F[14:0] will be '0x00' for both upper and lower end of the radio band under search.

During station search, the AM_STEP pin will be changed from input mode to output mode. "H" pulses will be outputted on the AM_STEP pin when the search frequency step is reached (approximately 100ms interval).

In FM mode, the stepping for each frequency search is equal to 50kHz. In AM mode, the stepping of each frequency search can be 9kHz and 10kHz, depending on the Level of AM_STEP pin being configured. In LW mode, the stepping frequency is 1kHz. In SW mode, the stepping for each frequency search is equal to 5kHz. The host microcontroller thus can display the current searching frequency based on the radio mode and the AM_STEP pin level.

8.5.3 Tune Status

The tune status can be monitored through the MO/ST pin. It indicates whether a station is present in the current frequency, or stereo broadcasting is receiving. The BUS_CLK pin is used to select which status is showing on the MO/ST pin. Please see the following table for the relation.

BUS_CLK	MO/ST	Indication	Logical connection inside AP916B
L	L	STEREO	
L	H	MONO	
H	L	Tuned	
H	H	Not tuned	

Tune Status to Host Microcontroller

Note: In case the tuner IC does not have the Tune LED pin, simply connect the SD pin to VDD or GND. Even though the host controller will not have the tune status, AP916B can still perform auto search function since the auto search function will use IF counting method only.

9. ELECTRICAL SPECIFICATIONS

9.1 Absolute Maximum Ratings

Under no circumstances the absolute maximum ratings given below should be violated. Stresses exceeding one or more of the limiting values may cause permanent damage to the device.

PARAMETER	SYMBOL	RATING	UNIT
Power Supply Voltage (Logic)	V_{DD}	-0.5 to 7.0	V
Input Voltage	V_{in}	-0.5 to V_{DD}+0.5	V
Power Dissipation (T_A=70 °C)	P_D	100	mW
Operating Temperature	T_{opr}	-20 to 70	°C
Storage Temperature	T_{stg}	-50 to 125	°C

9.2 Recommended Operating Condition

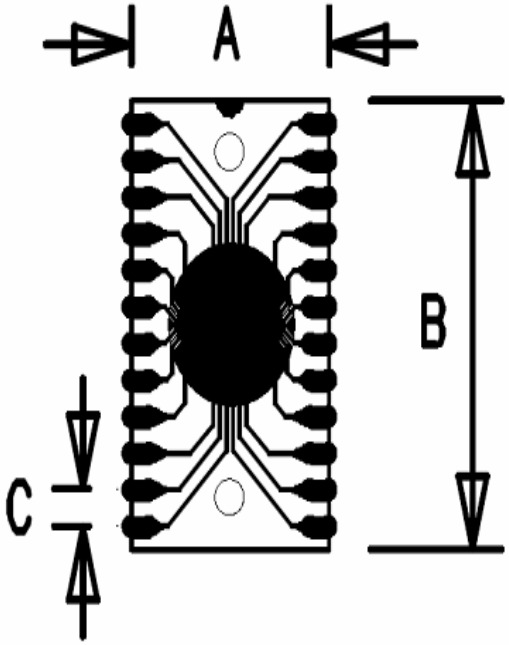
PARAMETER	SYMBOL	MIN.	TYP.	MAX.	UNIT
Power Supply Voltage	V_{DD}	1.8	-	3.6	V
Input Voltage	V_{in}	0	-	V_{DD}	V
Operating Temperature	T_{opr}	-20	-	70	°C

9.3 Electrical Characteristics [V_{DD}=3.0V]

PARAMETER	SYMBOL	CONDITION	MIN.	TYP.	MAX.	UNIT
Current Consumption – FM Tuning	I_{DD1}	PLL on		6		mA
Current Consumption – AM Tuning	I_{DD2}	PLL on		5		mA
Input High Voltage	V_{iH}		0.8V_{DD}			V
Input Low Voltage	V_{IL}				0.2V_{DD}	V
Pull-up Resistance	R_{PU}		100			kΩ
Pull-down Resistance	R_{PD}		100			kΩ
FMIN, AMIN and IFIN Input Voltage	V_{ina}		300			mVp-p
Output Low Current	I_{OL1}	V_{OL}=0.4V		1		mA
Output High Current	I_{OH1}	V_{OH}=V_{DD}-0.4V		1		mA

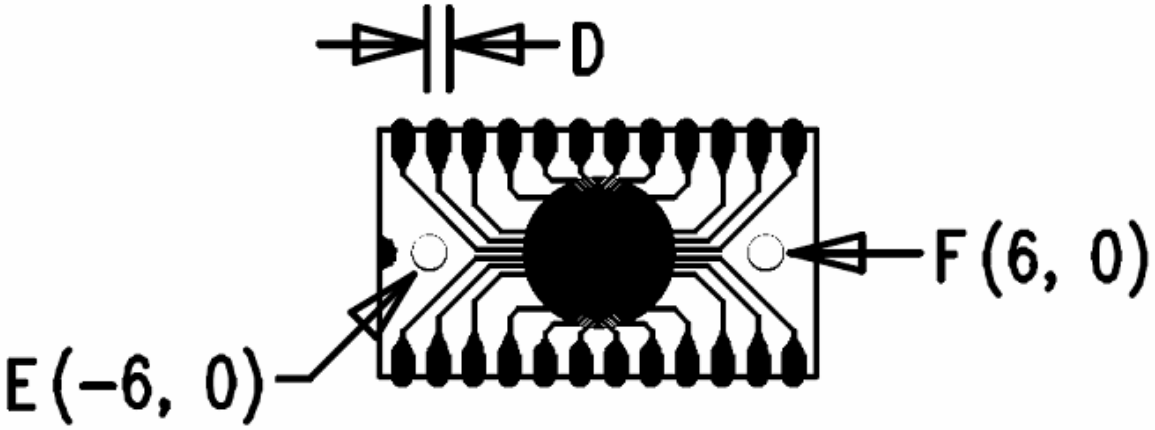
10. PACKAGE INFORMATION

10.1 COB Package



Common Dimensions
(Unit of Measure = mm)

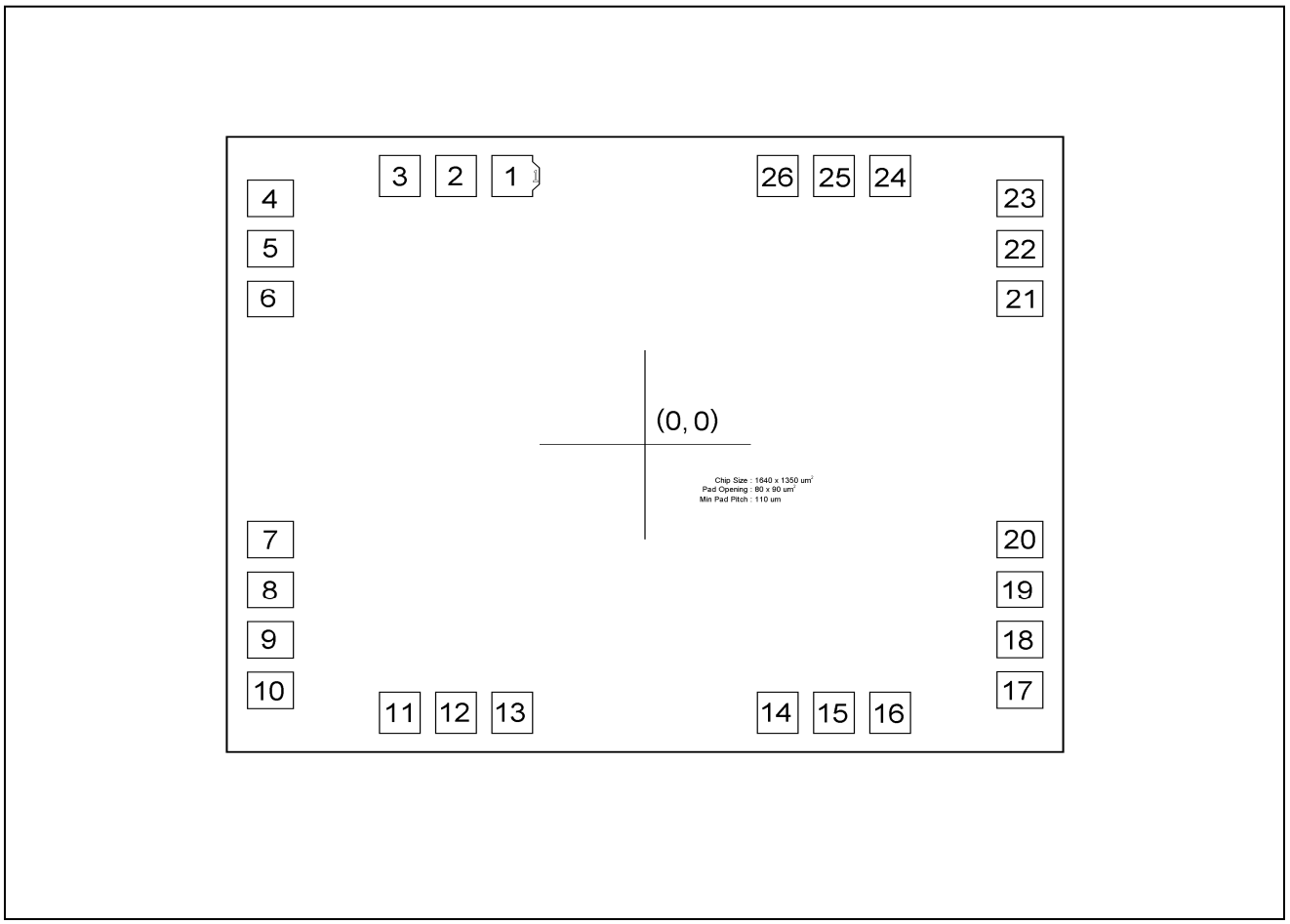
SYMBOL	VALUE
A	8.80
B	15.60
C	1.27
D	0.80
E	1.20
F	1.20



10.2 Dice Package

Dice Size : 1640 x 1350μm^2 (Excluding Scribe Line)
Origin : Center of Dice
Minimum Pad Pitch : 110μm
Pad Opening : 80 x 90μm^2

PAD NO.	PAD NAME.	X-coordinate	Y-coordinate	PAD NO.	PAD NAME.	X-coordinate	Y-coordinate
1	SD	-260.4	591	14	AM_STEP	260.4	-591
2	XI	-371.2	591	15	FULL_IF	371.2	-591
3	XO	-482	591	16	BUS_CLK	482	-591
4	VDD	-736	542.2	17	WR_EN	736	-542.2
5	AMIN	-736	431.4	18	DATA	736	-431.4
6	FMIN	-736	320.6	19	MONO	736	-320.6
7	GND	-736	-209.8	20	N.C.	736	-209.8
8	N.C.	-736	-320.6	21	BAND0	736	320.6
9	DO1	-736	-431.4	22	ST_IN	736	431.4
10	DO2	-736	-542.2	23	MO / ST	736	542.2
11	BAND1	-482	-591	24	MUTE	482	591
12	P1	-371.2	-591	25	RESETB	371.2	591
13	P0	-260.4	-591	26	IFIN	260.4	591



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