

TOSHIBA Bi-CMOS INTEGRATED CIRCUIT SILICON MONOLITHIC

# T B 2 1 1 0 F N

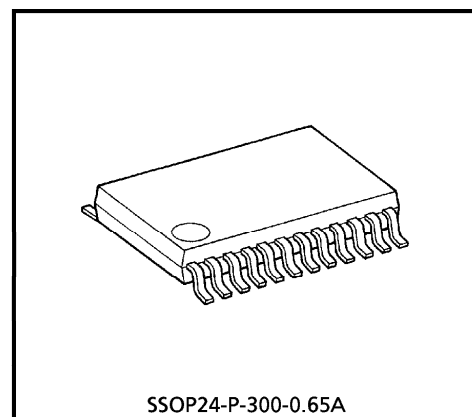
## PLL FOR DTS

The TB2110FN is a high-speed PLL LSI built in a 2 modulus prescaler that can operate with a 1.5 V power supply.

Each function is controlled via three serial bus lines, allowing you to configure a high-performance digital tuning system.

### FEATURES

- Due to a Bi-CMOS structure, the 1.5 V power supply is stepped up and stabilized by a bipolar circuit to drive the CMOS section. Therefore, this chip is best suited for digital tuning system in headphone stereos.
- Built in a prescaler, This IC can operate with TV : 50~250 MHz and FM : 40~150 MHz (2 modulus type) for the FM<sub>IN</sub> input or at 0.5~40 MHz for the AM<sub>IN</sub> input (2 modulus type or directly divided).
- Comes with a 20 bit programmable counter, two parallel output phase comparators, crystal oscillator, reference counter, and a DC/DC converter control circuit.
- The crystal oscillator (X'tal) used in this IC is a 75 kHz resonator.
- The reference frequency can be selected from seven frequencies available. (Ref = 1.0~25 kHz)
- A 20 bit general-purpose counter is built in that can measure the IF and other frequencies.
- All device operations are controlled via three serial bus lines.
- Operating voltage range :  $V_{CC} = 1.0 \sim 2.5 \text{ V}$  ( $T_a = -20 \sim 75^\circ\text{C}$ )
- Package is SSOP24pin.



Weight : 0.31 g (Typ.)

980910EBA2

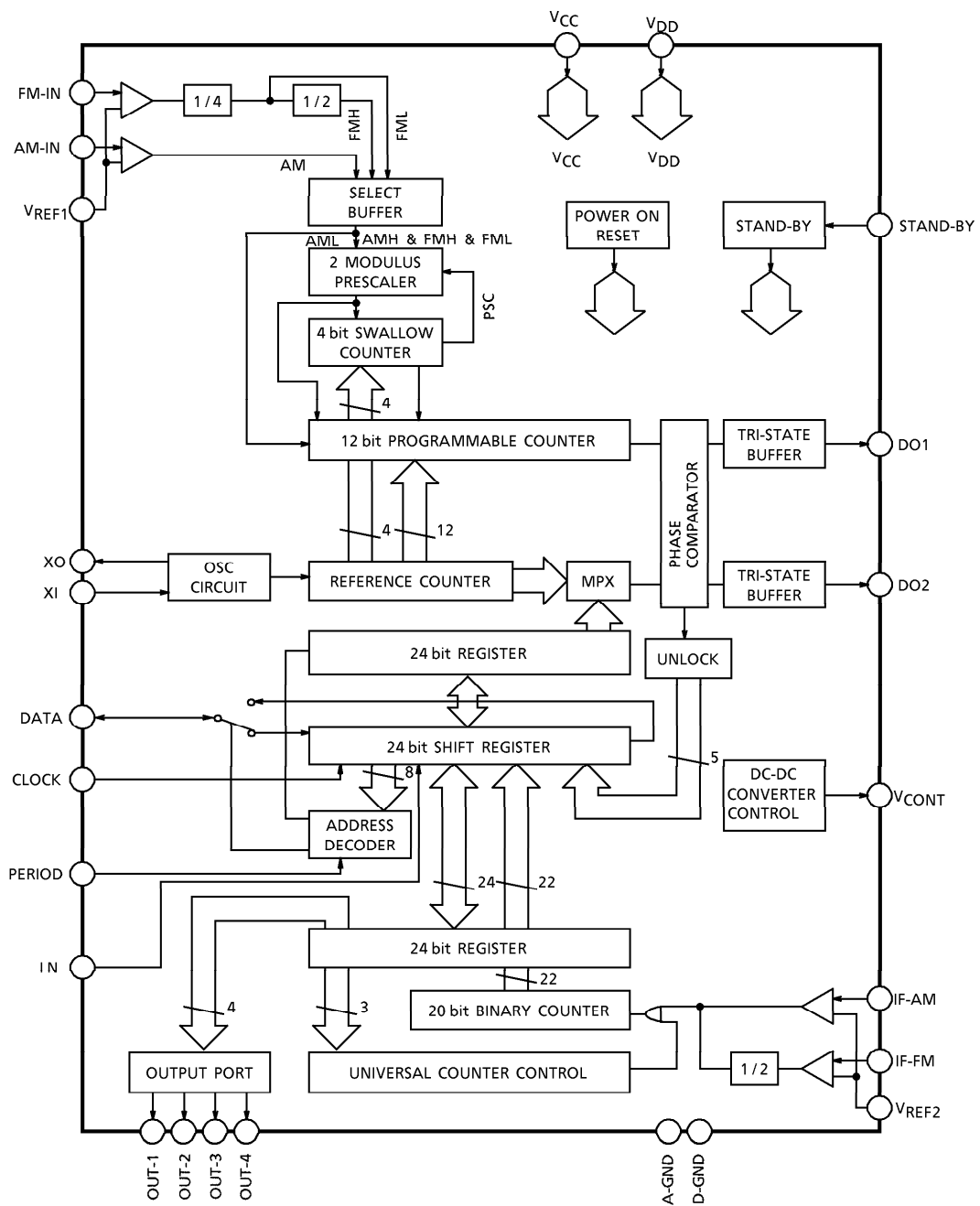
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## PIN CONNECTION

XI	1	24	D-GND
XO	2	23	DO2
DATA	3	22	DO1
CLOCK	4	21	V <sub>CC</sub>
PERIOD	5	20	FM-IN
OUT-1	6	19	VREF1
OUT-2	7	18	AM-IN
OUT-3	8	17	A-GND
OUT-4	9	16	IF-AM
IN	10	15	VREF2
V <sub>CONT</sub>	11	14	IF-FM
V <sub>DD</sub>	12	13	STAND-BY

(Note) This device is vulnerable to surge voltages. Take it into account when using this device in your system.

## BLOCK DIAGRAM



## PIN FUNCTION

PIN No.	SYMBOL	PIN NAME	FUNCTION	REMARKS
1 2	XI XO	Crystal oscillator pins	Connect a 75 kHz crystal oscillator for the reference frequency to these pins.	
3	DATA	Serial data input/output	Serial I/O port. Use this pin to set the divide ratio and divide method, as well as transfer data to and from the controller to control the general-purpose counter and general-purpose I/O port.	
4	CLOCK	Clock signal input		
5	PERIOD	Period signal input		
6 7 8 9	OUT-1 OUT-2 OUT-3 OUT-4	General-purpose output port	This is an open-collector output port. Use this port to output control signals.	
10	IN PORT	General-purpose input port	This port accepts the data to be fed to the output bit (OUT-5).	
11	VCONT	DC/DC converter control pin	This pin controls the DC/DC converter.	
12	VDD	CMOS section power supply	The VDD power supply from the DC/DC converter is applied to this pin.	—
13	STAND-BY	Standby	The device is placed in standby mode when a "L" is input. The device is in active state when a "H" is input.	
14	IF-FM	General-purpose counter input	Use this pin for IF signal input on the FM side.	
15	VREF2	Reference pin	Use this pin as the reference of the IF signal.	
16	IF-AM	General-purpose counter input	Use this pin for IF signal input on the AM side.	
17	A-GND	Bipolar section GND	—	—

PIN No.	SYMBOL	PIN NAME	FUNCTION	REMARKS
18	AM-IN	AM / SW signal input pin	Use this pin for AM / SW signal input.	
19	VREF1	Reference pin	Use this pin as the reference of the AM / FM signal.	
20	FM-IN	FM / TV signal input pin	Use this pin for FM / TV signal input.	
21	VCC	Bipolar section power supply	—	—
22 23	DO1 DO2	Phase comparator output	This is a tri-state output of the phase comparator. DO1~DO2 are parallel outputs.	
24	D-GND	MOS section GND	—	—

## OPERATION

### ○ Serial I/O port

The TB2110FN has two pairs of 24 bit registers, so it can set data to a total of 48 bits to control each function. Each data in these registers are transferred to and from the controller through a serial port using three pins : DATA, CLOCK, and PERIOD. A total of 32 bits consisting of 8 bit address and 24 data bits can be handled in one serial transfer.

Because all operations are controlled via register, this section describes mainly the function of 8 bit address and each register. The registers are configured in units of 24 bits, and are selected by an 8 bit address. The address mapping of each register is listed in the next page as "Register allocation."

REGISTER	ADDRESS	CONTENTS OF 24 BITS	No. OF BITS
Input Register 1	D0H	PLL dividend number setting	16
		Reference frequency setting	3
		PLL input and mode setting	2
		Not used	3
		Total	24
Input Register 2	D2H	General-purpose counter control	7
		Test bit	1
		Output data	4
		Not used	12
		Total	24
Output Register 1	D1H	General-purpose counter numeric data	22
		Not used	2
		Total	24
Output Register 2	D3H	Data in register D2	8
		Lock detection data	2
		Input data	1
		Not used	13
		Total	24

The input data is latched into register 1 or register 2 at the falling edge of PERIOD to put each function to work.

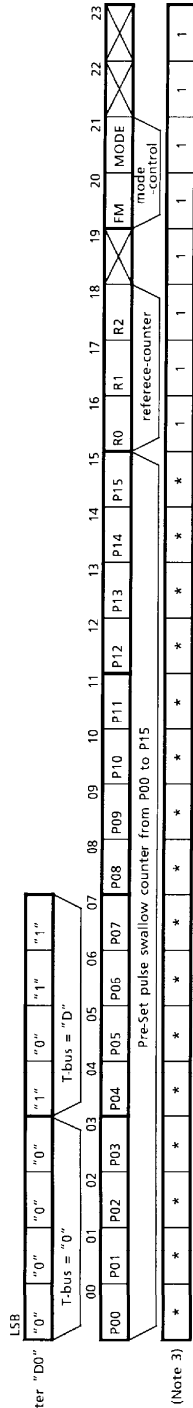
The output data that comes in parallel is latched into the output register at the 9th falling edge of CLOCK, and is serially output from the DATA pin.

(Note) Transmit dummy data at least once before transferring regular data to initialize the device's internal circuits after power-on.

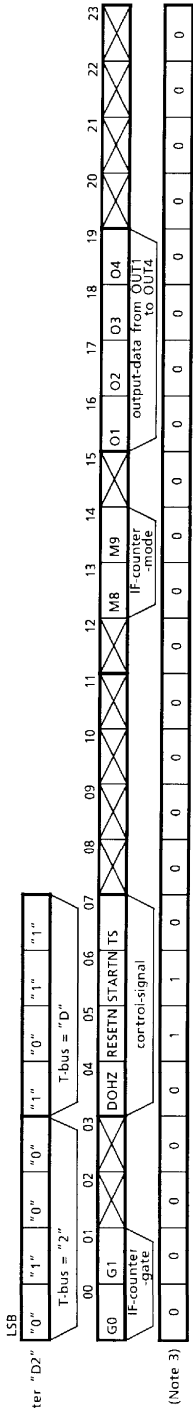
REGISTER ALLOCATION

T—BUS format

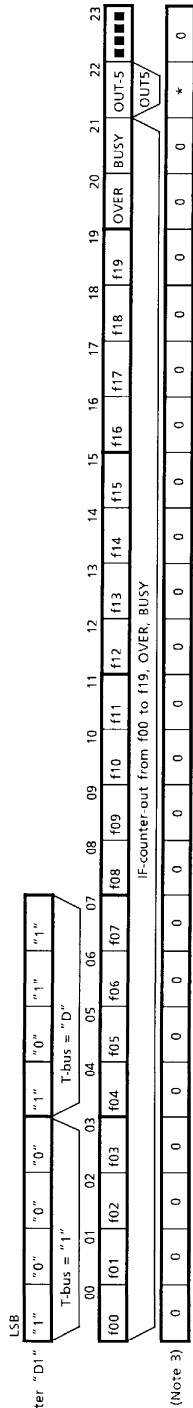
Input register "D0"



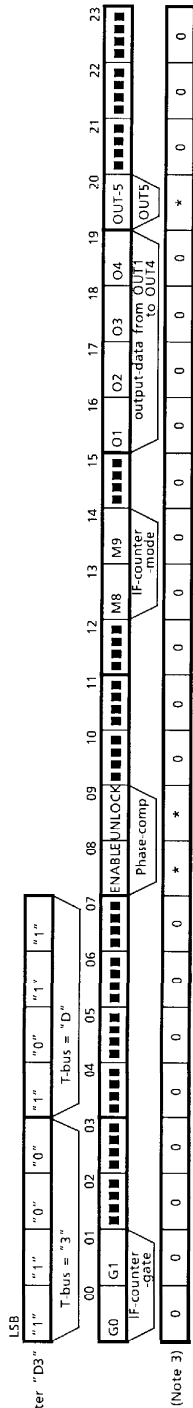
Input register "D2"



Output register "D1"

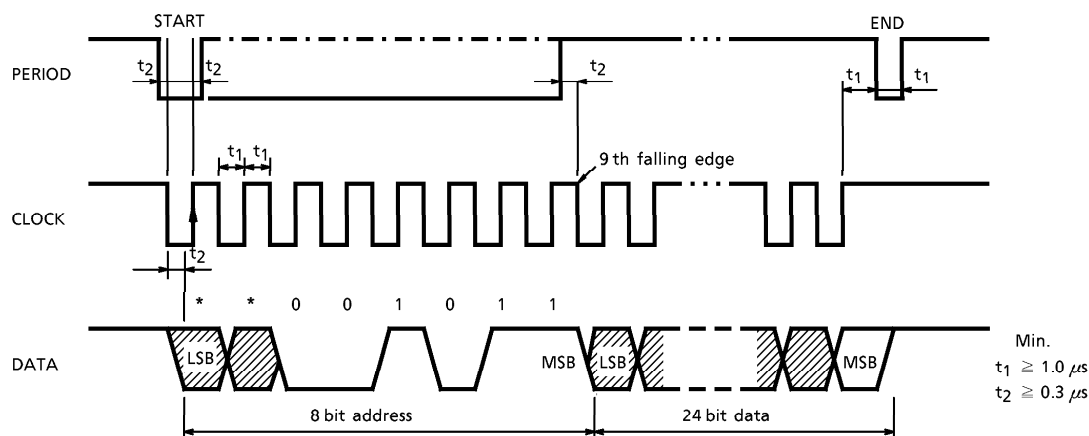


Output register "D3"



- ※ (Note 1) : GND output
- (Note 2) : Don't care
- (Note 3) \* value is undecided when power on

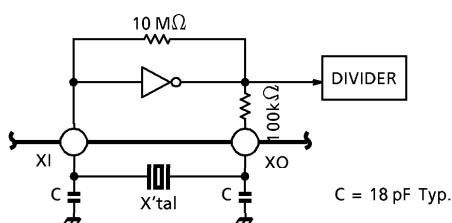
### ○ Serial transfer format



- The serial transfer format consists of 8 bit address and 24 bit data as shown above.  
The addresses used here are D0H to D3H.

### ○ Crystal oscillator connecting pins (XI, XO)

Connect a crystal oscillator and capacitors to these pins as shown in Figure 1 to generate the clock required for the device's internal operation. Use a 75 kHz crystal oscillator here.



(Note) Choose a crystal oscillator that has a small CI value and good startup characteristics.

Figure 1

## ○ Programmable counter

The programmable counter section consists of 1/4 + 1/2 prescalers, 2 modulus prescaler, and 4bit + 12bit programmable binary counters.

### 1. Setting the programmable counter section

The programmable counter need to be set for the divisor (16 bits) and the dividing mode (2 bits).

#### (1) Setting the dividing mode

Use the FM and MODE bit to choose the input setting and the dividing mode (pulse swallow mode or direct dividing mode). Four mode are available as listed below. Choose the desired one according to the frequency bands used.

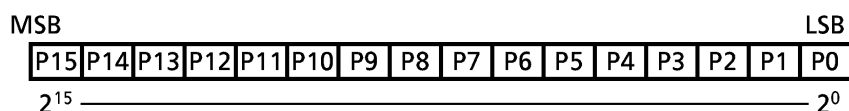
MODE	FM	MODE	DIVIDING MODE	TYPICAL RECEIVING BAND	INPUT FREQUENCY RANGE	INPUT PIN	DIVISOR
AM	0	0	Direct dividing mode	LW, MW	0.5~10 MHz	AMIN	n
SW	0	1	Pulse swallow mode	SW	3~40 MHz		n
FM	1	0	1/4 + pulse swallow mode	FM	40~150 MHz	FMIN	4·n
TV	1	1	1/8 + pulse swallow mode	TV	50~250 MHz		8·n

(Note) 'n' denotes the set value.

#### (2) Setting the divisor

To determine the programmable counter's divisor, set binary data to the P0~P15 bits.

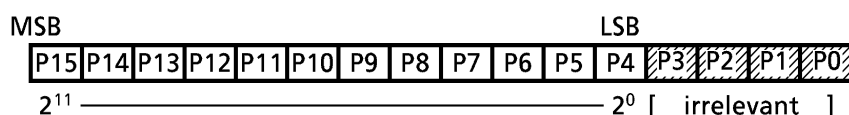
- For the pulse swallow mode (16 bits, SW, FM, and TV BAND)



Range of divisor set (pulse swallow mode) n = 210 H~FFFFH (528~65535)

(Note) The actual divisor is 4 times the programmed number for the 1/4 + pulse swallow mode, and 8 times the programmed number for the 1/8 + pulse swallow mode.

- Direct divide method (12 bits)

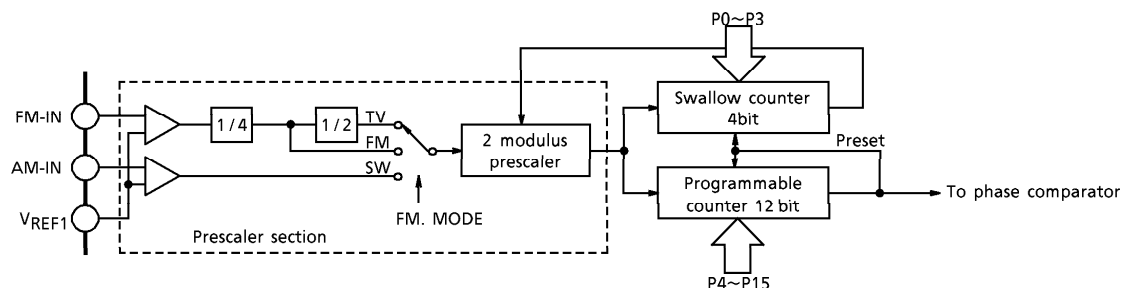


Range of divisor set (direct divide mode) n = 10 H~FFFFH (16~4095)

(Note) In the direct divide method, the data in P0~P3 becomes irrelevant and the P4 port becomes the LSB.

## 2. Circuit configuration of prescaler and programmable counter

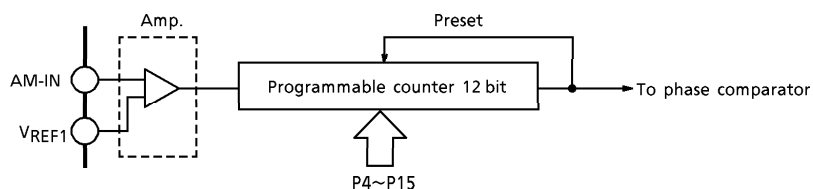
### (1) Circuit configuration in the pulse swallow mode



The circuit is configured with a 2 modulus prescaler, swallow counter (4 bits), and a programmable counter (12 bits).

In FM and TV modes, a 1/4 and a 1/8 prescaler are added in the front stage.

### (2) Circuit configuration in the direct divide method



In the direct divide method, the prescaler section is passed through and the circuit consists of only a programmable counter (12 bits).

(3) The FM-IN and AM-IN inputs each have a built-in amp, and are therefore capable of capacitor-coupled, small-amplitude operation.

### ○ Reference counter (divider to generate the reference frequency)

The reference counter section is configured with a crystal oscillator and a counter. Using a 75 kHz crystal oscillator, this circuit can generate seven types of reference frequencies.

#### 1. Setting the reference frequency

Use the R0~R2 bits to set the reference frequency.

R2	R1	R0	REFERENCE FREQUENCY
0	0	0	1 kHz
0	0	1	3 kHz
0	1	0	3.125 kHz
0	1	1	5 kHz
1	0	0	6.25 kHz
1	0	1	12.5 kHz
1	1	0	25 kHz
1	1	1	Standby mode

- When REF code = 7 H (R0~R2 = 1), the device is placed in standby mode.

## ○ Phase comparator

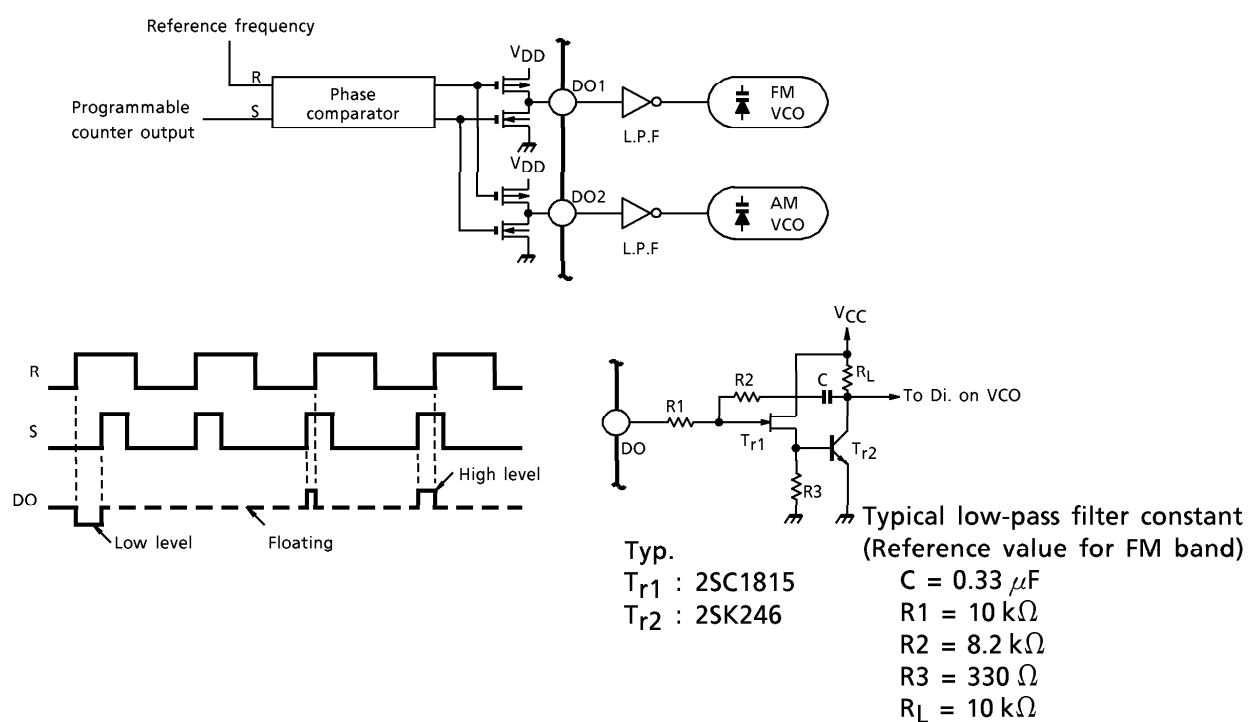
The phase comparator compares the phase difference between the reference frequency signal fed from the reference frequency divider and the divided output from the programmable counter, and outputs the difference. In this way it controls the VCO through a low-pass filter to ensure that the frequencies and the phases of these two signals are matched to each other.

Because this phase comparator has two tri-state buffers DO1 and DO2 connected in parallel as its outputs, you can design the optimum filter constant for each of the FM and AM bands.

Furthermore, you can use the DOHZ bit of register D2 to place the DO2 output in a high-impedance state as necessary.

DOHZ "1" : The DO2 pin is placed in the high-impedance state.

"0" : Nomal operation



DO output timing chart

Example of an active low-pass filter circuit

Shown above is a DO output timing chart and a typical active low-pass filter circuit based on a Darlington connection of FET and bipolar transistors.

The filter circuit shown above is just one example. When designing the actual circuit, consider the band configuration and the desired characteristics of your system.

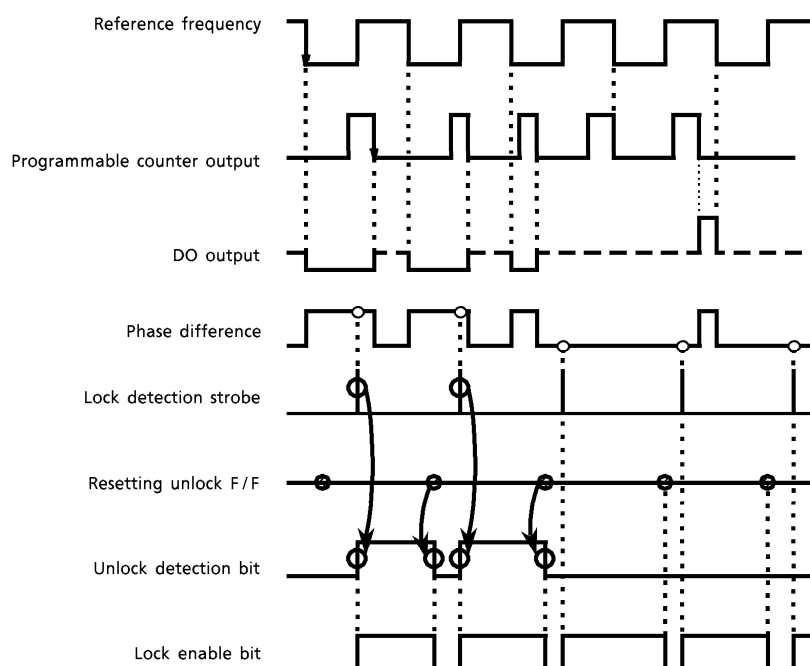
### ○ Unlock detection bit

This bit is used to detect an unlock condition of the PLL circuit. When not locked (i.e., the reference frequency and the programmable counter's divided output are not locked in phase), the phase comparator outputs a pulse to the unlock F/F synchronously with the period of the reference frequency. The unlock F/F is set by this pulse. The unlock F/F is reset each time the RESET bit of register 2 (unlock reset bit) is set to 1.

After the unlock F/F is reset in this way, you can access the unlock detection bit to see if the PLL circuit is in lock condition. Because the pulse is input synchronously with the period of the reference frequency, you must wait for a duration greater than the period of the reference frequency after resetting the unlock F/F before you can access the unlock detection bit (UNLOCK).

If this duration is short, you cannot detect the correct lock condition. To solve this problem, the device has a lock enable F/F. This F/F is reset each time the unlock reset bit is set to 1, and lock enable bit is set to 1 with the unlock detection timing. This means that you can detect the correct unlock condition when the lock enable bit (ENABLE) is 1.

ENABLE	UNLOCK	STATE
0	*	—
1	0	LOCK
	1	UNLOCK



## ○ General-purpose counter

The general-purpose counter is used to count frequencies such as the FM/AM band IF frequency to detect the auto stop signal during auto search tuning.

For this frequency counting, the general-purpose counter uses a frequency measurement (IF-AM, IF-FM input) method to count the number of pulses input to the counter during a certain duration of time (gate time).

### 1. General-purpose counter control bits

- (1) G0, G1 bits ... These bits choose the general-purpose counter's gate time.

G0	G1	GATE TIME
0	0	1 ms
1	0	4 ms
0	1	16 ms
1	1	64 ms

- (2) START bit ... Each time the START bit is set to 1, measurement is restarted after resetting the general-purpose counter.

- (3) M8, M9 bits ... These bits choose the general-purpose counter's measurement mode and input pin.

M8	M9	PIN SELECTION	INPUT FREQUENCY RANGE	REMARKS
0	1	IF-AM	0.3~1.0 MHz	Direct input to IF counter
1	0	IF-FM	8~16 MHz	IF frequency divided by 2 input to IF counter

(Note) In the IF-FM mode, the general-purpose counter (20 bit binary counter) is preceded by an additionally inserted 1/2 prescaler. Therefore, the input signal from IF-FM is divided by 2 before being fed into the general-purpose counter.

### 2. General-purpose counter data output bits (f0~f19)

- (1) General-purpose counter count data bits (f0~f19)

The resulting count of the general-purpose counter can be read in binary from the output registers f0 through f19.

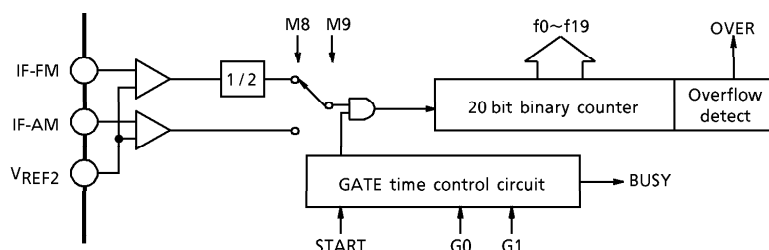
- (2) General-purpose counter operation detect bits

OVER ... General-purpose counter overflow bit	<div> <div>"1"</div> <div>"0"</div> </div>	<div> <div>General-purpose counter is in overflow condition.</div> <div>General-purpose counter data is valid.</div> </div>
BUSY ... General-purpose counter operation monitor	<div> <div>"1"</div> <div>"0"</div> </div>	<div> <div>General-purpose counter is counting.</div> <div>General-purpose counter has finished counting.</div> </div>

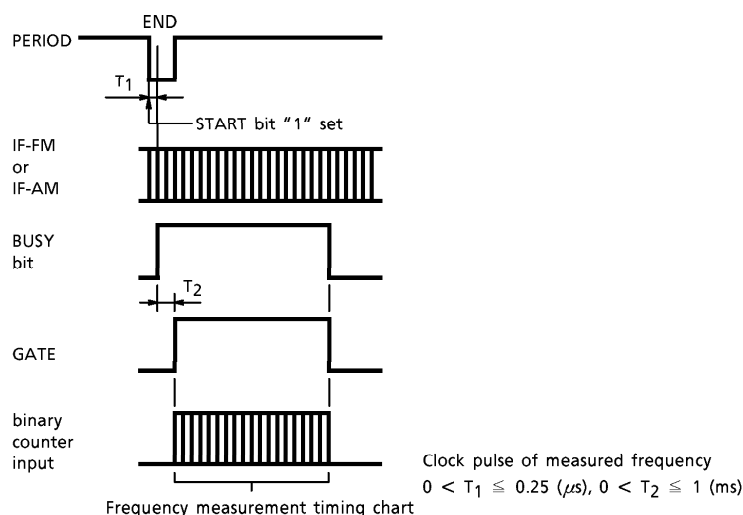
(Note) When using the general-purpose counter, check to see that the BUSY bit is 0 (finished counting) and that the OVER bit is 0 (valid data) before you reference the contents of the general-purpose counter data bits (f0~f19).

### 3. Circuit configuration of general-purpose counter

The general-purpose counter section is configured with an input amp., a gate time control circuit, and a 20 bit binary counter.



### 4. Measurement timing of general-purpose counter



(Note) IF-FM and IF-AM are capable of C-coupled, small-amplitude operation using a bipolar input.

### ○ General-purpose input/output ports

The device has general-purpose input/output ports controlled by serial port.

#### 1. General-purpose output ports (OT-1~OT-4)

The data set to the O1~O4 bits of input register 2 are output in parallel from their dedicated output ports OT-1~OT-4.

#### 2. General-purpose input port (IN)

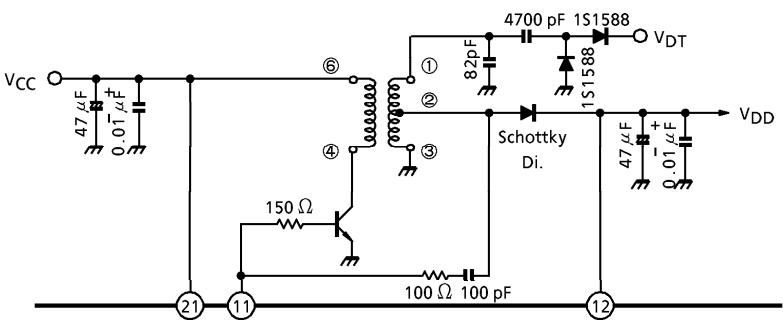
The data input from the IN pin can be read out from the DATA pin as OUT-5 of the output register.

(Note) The output ports are set to "0" when the device is powered on. (Therefore, the general-purpose output ports are held Low at power-on.)

(Note) The TS bit of input register 2 must always be set to "0".

○ DC/DC converter

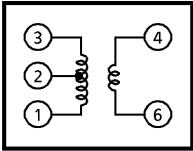
The TB2110FN uses a coil-type DC/DC converter (boosted voltage circuit) to allow for low-voltage operation.



Coil : (SUMIDA ELECTRIC CO., LTD, CP-4LB)

TEST FREQUENCY	L (μH) 1-3	CO (pF)	QO	TURNS			WIRE (mm ϕ)
				1-2	2-3	6-4	
2.52 MHz	15.6 ± 3%	—	—	18T	14T	2T	0.08 UEW

BOTTOM VIEW



**MAXIMUM RATINGS** (Ta = 25°C)

CHARACTERISTIC	SYMBOL	RATING	UNIT
Supply Voltage	V <sub>DD</sub>	- 0.3~4.5	V
Input Voltage	V <sub>IN</sub>	- 0.3~V <sub>DD</sub> + 0.3	V
Power Dissipation	P <sub>D</sub>	400	mW
Operating Temperature	T <sub>opr</sub>	- 20~75	°C
Storage Temperature	T <sub>stg</sub>	- 65~150	°C

**ELECTRICAL CHARACTERISTICS**(Unless otherwise specified, Ta = - 20~75°C, V<sub>CC</sub> = 1.0~2.5 V, V<sub>DD</sub> = 2.4 V)

CHARACTERISTIC		SYMBOL	TEST CIRCUIT	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Operating Power Supply Voltage	Bipolar Unit	V <sub>CC</sub>	—	PLL operation (Normal operating)	1.2	1.5	2.5	V
	MOS Unit	V <sub>DD</sub>		Step-up control circuit operating	2.2	2.4	3.6	
Operating Power Supply Current		I <sub>CC</sub>	—	PLL operation (Normal operating), TV mode	—	18	40	mA
		I <sub>DD</sub>	—	PLL operation (Normal operating), TV mode	—	1.5	7	

(Stand-by mode)

Operating Power Supply Current	I <sub>CS</sub>	—	V <sub>CC</sub> = 1.5 V	—	30	50	μA
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(Operating frequency)

Crystal Oscillation Frequency	f <sub>XT</sub>	—	Crystal oscillator connected to XI and XO pins.	—	75	—	kHz
TV in	f <sub>TV</sub>	—	TV mode	50	~	250	MHz
FM in	f <sub>FM</sub>	—	FM mode	40	~	150	MHz
SW in	f <sub>SW</sub>	—	SW mode	3	~	40	MHz
AM in	f <sub>AM</sub>	—	AM mode	0.5	~	10	MHz
IF-FM	f <sub>IF-FM</sub>	—	IF-FM	8	~	16	MHz
IF-AM	f <sub>IF-AM</sub>	—	IF-AM	0.3	~	1.0	MHz

(Input voltage)

TV in	V <sub>TVin</sub>	—	TV mode	25	~	300	mV <sub>rms</sub>
FM in	V <sub>FMin</sub>	—	FM mode				
SW in	V <sub>SWin</sub>	—	SW mode				
AM in	V <sub>AMin</sub>	—	AM mode				
IF-FM	V <sub>IF-FM</sub>	—	IF-FM				
IF-AM	V <sub>IF-AM</sub>	—	IF-AM				

(OT-1~OT-4 open-collector output current)

CHARACTERISTIC		SYMBOL	TEST CIR- CUIT	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Output Current	“L” Level	I <sub>OL1</sub>	—	V <sub>OL</sub> = 0.2 V	1.0	3.0	—	mA

(DATA, CLOCK, PERIOD, I/O)

Input Voltage	"H" Level	$V_{IH}$	—	—	1.7	~	$V_{DD}$	V
	"L" Level	$V_{IL}$	—	—	0.0	~	0.5	
Input Current	"H" Level	$I_{IH}$	—	$V_{IH} = 2.4 \text{ V}$	—	—	$\pm 0.5$	$\mu\text{A}$
	"L" Level	$I_{IL}$	—	$V_{IL} = 0.0 \text{ V}$	—	—	$\pm 1.0$	
Output Current	"H" Level	$I_{OH2}$	—	$V_{OH} = 2.0 \text{ V}$ , Only DATA pin	-0.2	-1.0	—	mA
	"L" Level	$I_{OL2}$	—	$V_{OL} = 0.4 \text{ V}$ , Only DATA pin	0.2	1.0	—	

(DO1, DO2)

Input Voltage	"H" Level	$I_{OH3}$	—	$V_{OH} = 2.0 \text{ V}$	-0.2	-1.0	—	mA
	"L" Level	$I_{OL3}$	—	$V_{OL} = 0.4 \text{ V}$	0.2	1.0	—	
Tri-State Leak Current		$I_{TL}$	—	$V_{TLH} = 2.4 \text{ V}$ , $V_{TLL} = 0.0 \text{ V}$	—	—	$\pm 0.1$	$\mu\text{A}$

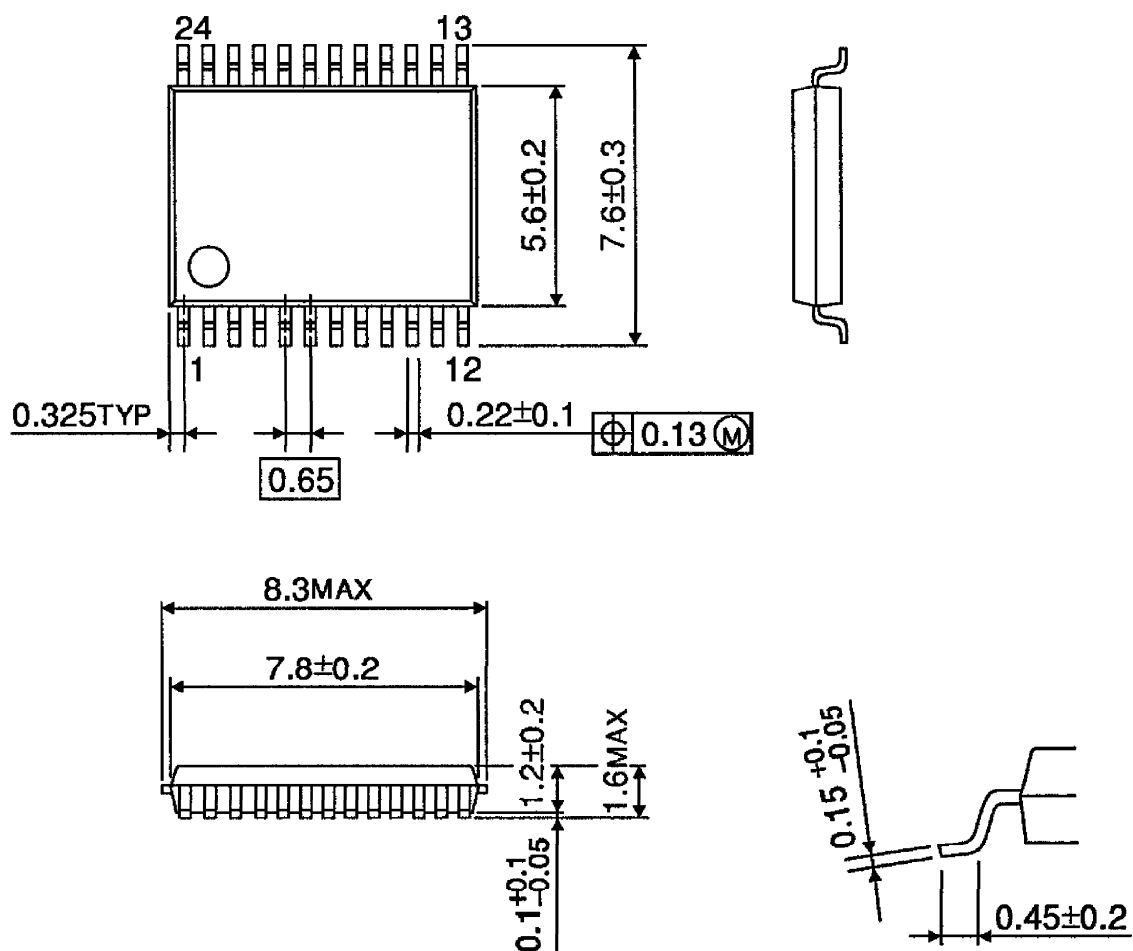
Auto Clear Voltage	$V_{CL1}$	—	Clear release voltage	—	—	1.9	V
	$V_{CL2}$	—	Clear voltage	1.4	—	—	

$V_{CONT}$ Output Current	$I_{CONT}$	—	Boosting voltage transistor drive current $V_{CONT} = 0.8 \text{ V}$	100	150	—	$\mu\text{A}$
Standby Release	$V_{STOFF}$	—	Standby mode released	0.7	~	$V_{CC}$	V
Standby Mode	$V_{STON}$	—	Placed in standby mode	0.0	~	0.6	V

**OUTLINE DRAWING**

SSOP24-P-300-0.65A

Unit : mm



Weight : 0.31 g (Typ.)