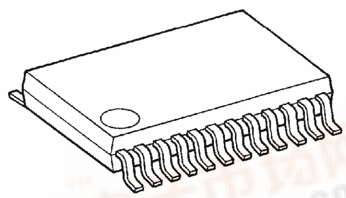
TOSHIBA Bi-CMOS INTEGRATED CIRCUIT SILICON MONOLITHIC

TB31214FNG

PLL FREQUENCY SYNTHESIZER FOR CORDLESS TELEPHONE

FEATURES

- One packaging PLL, VCO and 1st MIX
- Low operating voltage : $V_{CC} = 2.0\sim5.5V$
  ($Ta \geqq -10°C$, $V_{CC} = 1.9\sim5.5V$)
- Low current consumption : $I_{CC} = 16mA$ (Typ.)
- Charge pump is constant current type, and is able to change output current by serial data
- Reference oscillation circuit is adopted circuit of bipolar, so getting the stable X'tal oscillation circuit
- Available standby control for receiver and transmitter independent of each other
- Small package : SSOP24pin (0.65mm pitch)

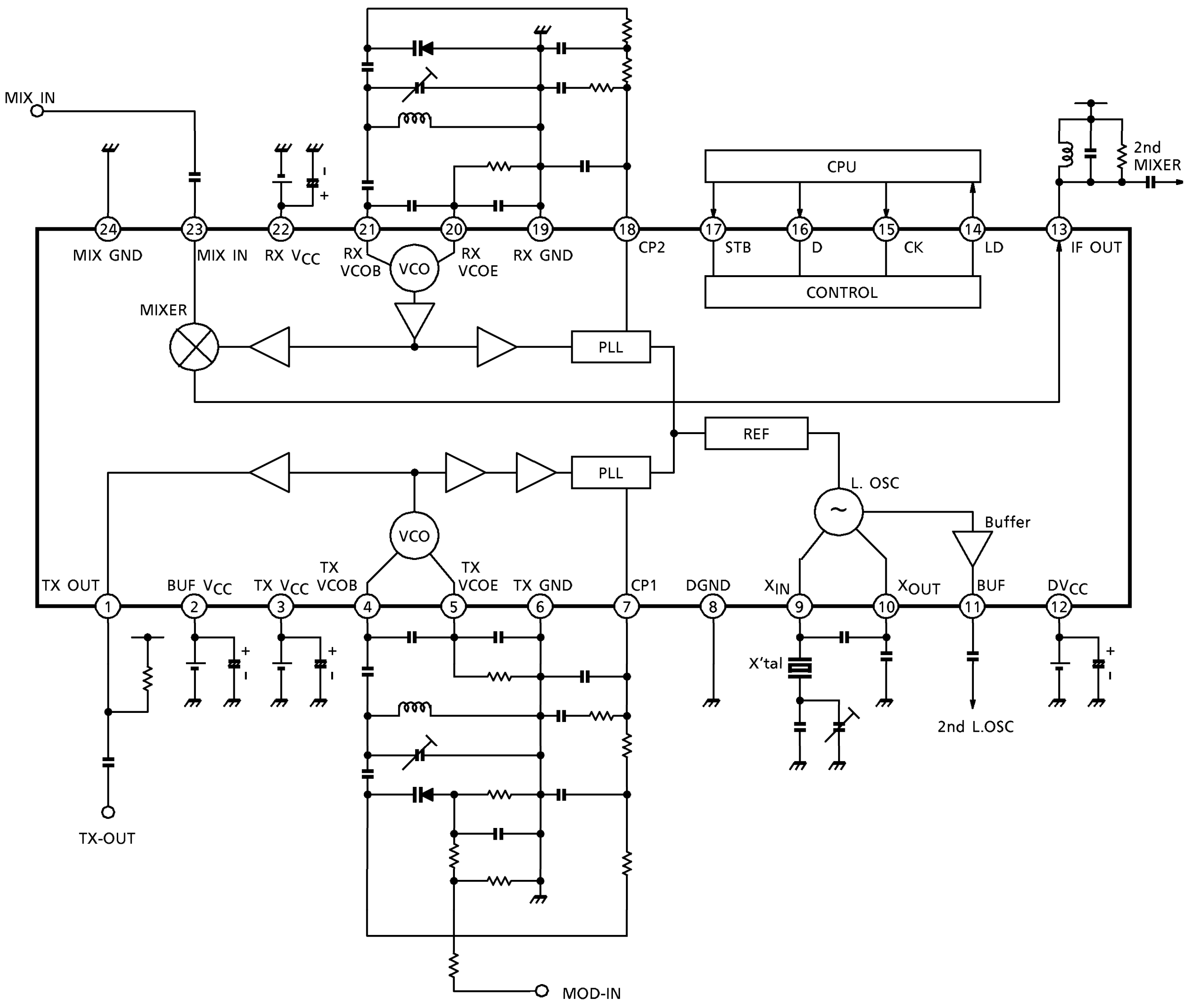


SSOP24-P-300-0.65A

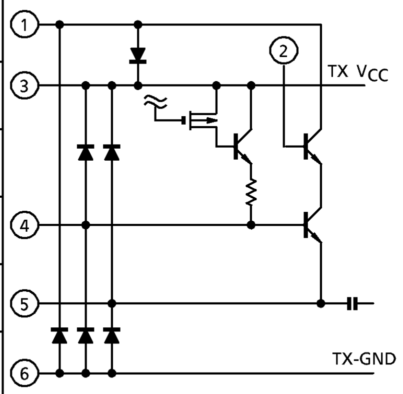
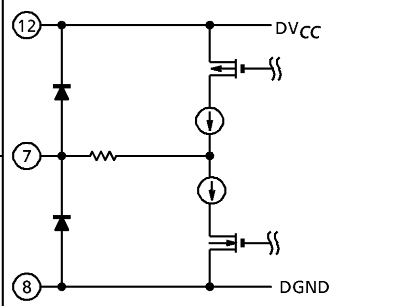
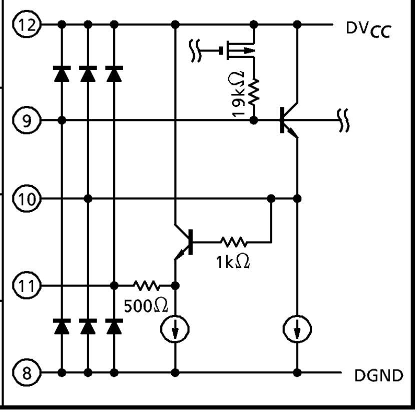
Weight : 0.14g (Typ.)

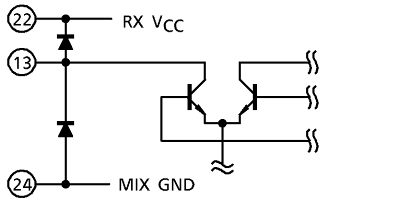
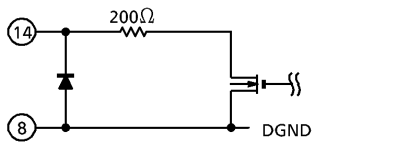
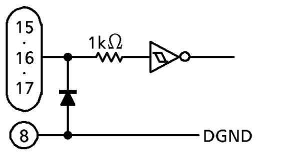
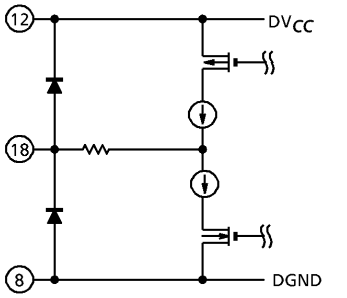
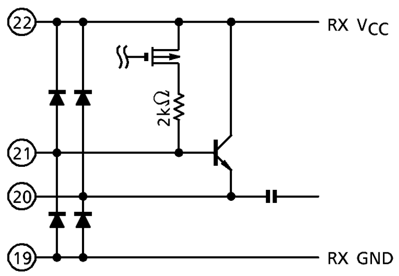
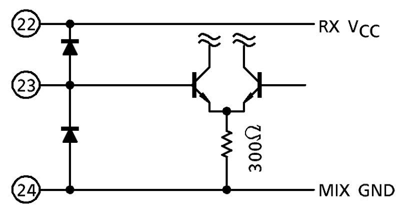
Handle with care to prevent devices deterioration by static electricity.

BLOCK DIAGRAM



PIN FUNCTION

PIN No.	PIN NAME	FUNCTION	INTERNAL EQUIVALENT CIRCUIT
1	TX OUT	Output terminal of RF.	
2	BUF V_{CC}	Power supply of transmitter output, transmitter VCO.	
3	TX V_{CC}	Power supply for transmitter PLL.	
4	TX VCOB	Base terminal of transistor for transmitter VCO.	
5	TX VCOE	Emitter terminal of transistor for transmitter VCO.	
6	TX GND	GND terminal for transmitter.	
7	CP1	Output terminal of charge pump for transmitter. It is constant current output type, and output current is varied by input serial data.	
8	DGND	GND terminal of PLL.	
9	X_{IN}	Input terminal of local oscillation. In case of external input, connecting it to this terminal.	
10	X_{OUT}	Output terminal of local oscillation.	
11	BUF	Output terminal of BUFFER AMP. The signal of local oscillation is output through BUFFER AMP.	
12	DV_{CC}	Power supply of PLL.	

PIN No.	PIN NAME	FUNCTION		INTERNAL EQUIVALENT CIRCUIT
13	IF OUT	MIX output terminal. For open collector output.		
14	LD	Output terminal of lock detector.		
15	CK	Input terminal of clock.	Input the serial data to controll this IC.	
16	D	Input terminal of data.		
17	STB	Input terminal of strobe signal.		
18	CP2	Output terminal of charge pump for receiver. It is constant current output type, and output current is varied by input serial data.		
19	RX GND	GND terminal for receiver.		
20	RX VCOE	Emitter terminal of transistor for receiver VCO.		
21	RX VCOB	Base terminal of transistor for receiver VCO.		
22	RX V_{CC}	Power supply for receiver.		
23	MIX IN	Input terminal of MIX.		
24	MIX GND	GND terminal of MIX.		

DESCRIPTION OF FUNCTION AND OPERATION

1. Entry of serial data

- Serial data used to control the IC is input through three terminals, CK, D and STB.

  ① During the rise of a clock pulse, data is fed to the shift register in the IC in order from the LSB.

  ② Upon the reception of all data, the strobe signal (STB) is made "H".

  ③ After the reception of a strobe signal (STB) of the "H" level, the data stored in the shift register is transferred to the latch in the block selected by the group code, whereby the IC is controlled.

  ④ A counters start to operate after the reception of a strobe signal (STB) of the "L" level.

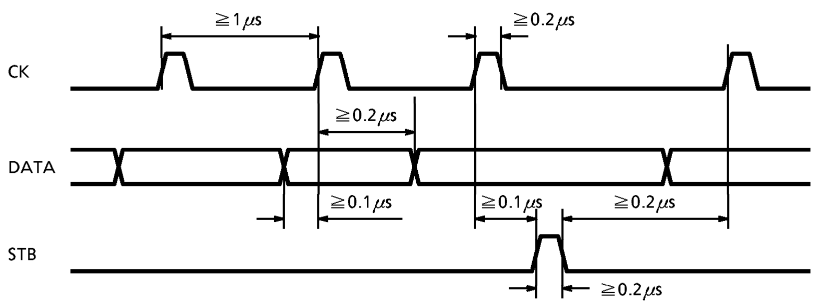
- The three terminal, CK, D and STB, contains Schmitt trigger circuits to prevent the data errors by noise, etc.

○ Serial data group and group code

- The IC has control divided into four groups so that they may be controlled independent of one another. Each group is identified by a 2bit group code attached at the data end.

CODE	ITEM
10	Number of divisions by TX programmable divider
01	Number of divisions by RX programmable divider
11	Number of divisions by reference divider (X_{IN})
00	Optional control

○ Serial data input timing



2. Programmable dividers (TX, RX)

- These programmable dividers are composed of a 5bit swallow counter (5bit programmable divider), a 10bit programmable counter, and a two-modulars prescaler providing 64 and 66 divisions.
- Swallow counter system is adopted to set high reference frequency.
- Sending certain data to the swallow counter and the programmable counter allows the setting of any of 1984 to 65534 divisions (multiple of two).
- The programmable counter and swallow counter are set by each channel. Each channel is specified by a group code.

LSB ←

A0	A1	A2	A3	A4	D0	D1	D2	D3	D4	D5	D6	D7	D8	D9		
Swallow counter : A					Programmable counter : N										Group code TX : "10" RX : "01"	

$$A = A0 + A1 \times 2^1 + A2 \times 2^2 + A3 \times 2^3 + A4 \times 2^4$$

$$N = D0 + D1 \times 2^1 + D2 \times 2^2 + D3 \times 2^3 + \cdots + D9 \times 2^9$$

$$\text{Number of divisions} = 2\,(32N + A)$$

$$1984 \leqq \text{Number of divisions} \leqq 65534$$

3. Reference divider

- This block generates the reference frequency for the PLL.
- The reference divider is composed of a 11bit reference divider and a half fixed divider.
- Sending certain data to the reference divider allows the setting of any of 6 to 4094 divisions (multiple of two).

LSB ←

D0	D1	D2	D3	D4	D5	D6	D7	D8	D9	D10	1	1
Reference divider : D											Group code	

$$D = D0 + D1 \times 2^1 + D2 \times 2^2 + D3 \times 2^3 \cdots + D10 \times 2^{10}$$

$$\text{Number of divisions} = 2D$$

$$6 \leqq \text{Number of divisions} \leqq 4094$$

The example of setting number of divisions

In case of

Reference frequency : 21.25MHz
Start VCO frequency : 380.2125MHz
Channel step : 12.5KHz

○ Set up phase comparator frequency

Since a programmable divider is multiple of two, phase comparator frequency is set a half of frequency step.

Phase comparator frequency $= (12.5 \times 10^3 \div 2) = 6.25$KHz

○ Set up programmable divider divisions

$380.2125 \times 10^6 \div (12.5 \times 10^3 \div 2) = 60834$
$60834 = 2\,(32N + A)$
$N = 950 \quad A = 17$

○ Set up reference divider divisions

$21.25 \times 10^6 \div (12.5 \times 10^3 \div 2) = 3400$
$2D = 3400$
$D = 1700$

4. Optional control

- The optional control below is available.
  ① Test mode (Usually set up T1 = T2 = "0").
  ② Control of the charge pump output current for each channel.
  ③ Output terminal for Lock detector.
  ④ Standby control of each channel.

LSB ←

T1	T2	CPT1	CPT2	LD1	LD2	SBT	CPR1	CPR2	*	*	SBR	0	0
Test mode		Charge pump output current (TX)		Lock detector		Standby (TX)	Charge pump output current (RX)		Meaningless bits		Standby (RX)	Group code	

T1, T2 : Bit for test mode
CPT1, 2 : Switchover bit for charge pump output current (TX)
CPR1, 2 : Switchover bit for charge pump output current (RX)
LD1, 2 : Control bit for lock detector output
SBT, SBR : Standby control bit (TX, RX)
* : Disregard any data (Meaningless bits)

- Description of options including their control

① Test mode (T1, T2)

Bit "T1, T2" is for test mode. In other than the test mode, set this bit at "0".

② Control of charge pump output current (CPT, CPR)

This IC uses a constant current output type charge pump circuit. Output current is varied by controlling "CPT1, 2、CPR1, 2".

CHARGE PUMP OUTPUT CURRENT

CONTROL BIT		CHARGE PUMP OUTPUT CURRENT
CPT1	CPT2	
0	0	±0μA
0	1	±100μA
1	0	±200μA
1	1	±400μA

(Note) CPR is the similar way

High speed lock up is possible by switching charge pump output current.

③ Lock detector output

When phase comparator detects phase difference, LD terminal (pin 14) outputs "H". When phase comparator locks, LD terminal outputs "L". On standby, outputs "L".
LD terminal output is controlled by "SBT", "SBR", "LD1" and "LD2".
LD terminal output is open drain output.

CONTROL BIT		LOCK DETECTOR OUTPUT STATE
LD1	LD2	
0	0	H
0	1	TX Only detect
1	0	RX Only detect
1	1	TX * RX

On unlock = "H"
On lock = "L"
On Standby = "L"

→Logical multiply (AND) of TX, RX

④ Standby control (SBT, SBR)

Available standby control for receiver and transmitter independent of each other.

CONTROL BIT		STATE		
SBT	SBR	TX	RX	REF
0	0	ON	ON	ON
0	1	ON	OFF	↓
1	0	OFF	ON	↓
1	1	OFF	OFF	↓

5. Reference frequency oscillation circuit and buffer amplifier

This IC has a stable oscillation circuit composed of bipolar.
In case of inputting the external reference frequency directly, use X_{IN} terminal (pin 9).
For the common use of X'tal of the reference frequency oscillation circuit for the PLL and X'tal of local oscillation to 2'nd MIX, output terminal of local oscillation signal with buffer amplifier (pin 11) may be used.

MAXIMUM RATINGS (Ta = 25°C)

CHARACTERISTIC	SYMBOL	RATING	UNIT
Power Supply Voltage	V_{CC}	6	V
Power Dissipation	P_D	780	mW
Operating Temperature	T_{opr}	−30~85	°C
Storage Temperature	T_{stg}	−55~150	°C

ELECTRICAL CHARACTERISTICS (Unless otherwise specified, Ta = 25°C, V_{CC} = 2.2V)

CHARACTERISTIC	SYMBOL	TEST CIR-CUIT	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Operating Power Supply Voltage	V_{CC}	—	Ta = −30~+85°C	2.0	2.2	5.5	V
			Ta = −10~+85°C	1.9	2.2	5.5	
Operating Power Supply Current	I_{CCO}	1	TX, RX = ON (Open VCOE)	—	16	22	mA
Waiting Current Consumption	I_{CCS}	1	TX, RX = OFF	—	950	1300	μA

PLL

CHARACTERISTIC		SYMBOL	TEST CIR-CUIT	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Input Frequency	(RX)	FRX_{in}	4	VRX_{in} = 93dBμV *1	200	—	400	MHz
	(TX)	FTX_{in}	4	VTX_{in} = 93dBμV *1	200	—	400	
Input Sensitivity	(RX)	VRX_{in}	4	FRX_{in} = 200~400MHz *1	93	—	107	dBμV
	(TX)	VTX_{in}	4	FTX_{in} = 200~400MHz *1	93	—	107	
Charge Pump Output Current 1		I_{CP1}	2	V_{CP} = 1.1V	—	±0	—	μA
Charge Pump Output Current 2		I_{CP2}	2	V_{CP} = 1.1V	—	±100	—	μA
Charge Pump Output Current 3		I_{CP3}	2	V_{CP} = 1.1V	—	±200	—	μA
Charge Pump Output Current 4		I_{CP4}	2	V_{CP} = 1.1V	—	±400	—	μA
Charge Pump OFF Leak Current		I_{CPOFF}	2	V_{CP} = 1.1V, Standby mode	−1	—	+1	μA
CK Input Frequency		F_{CK}	—	—	—	—	1.0	MHz
Input Voltage	(H)	V_{IH}	—	CK, DATA, STB each terminal	0.8 × V_{CC}	V_{CC}	5.7	V
	(L)	V_{IL}		CK, DATA, STB each terminal	−0.2	0	0.2 × V_{CC}	
Input Current	(H)	I_{IH}	—	CK, DATA, STB each terminal V_{IH} = 6V	—	—	1	μA
	(L)	I_{IL}		CK, DATA, STB each terminal V_{IL} = 6V	—	—	1	
LD Terminal Resistance ON		R_{LD}	3	LD = "L"	—	500	—	Ω
LD Terminal OFF Leak Current		I_{LDOFF}	—	—	−1	—	+1	μA

REF

CHARACTERISTIC	SYMBOL	TEST CIR-CUIT	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
XIN Operating Frequency	FX_{in}	5	VX_{in} = 105dBμV Sin-wave	5	21.25	25	MHz
XIN Input Level	VX_{in}	5	FX_{in} = 21.25MHz	102	105	112	dBμV

1st MIX

Operating Input Frequency	FMIX	6	—	200	—	400	MHz
MIX Conversion Gain	GVMIX	6	Input 50Ω, Load : Output 750Ω	15	18	22	dB
3rd Intercept Point	IP3	—	—	—	108	—	dBμV
1dB Compression Level	1dBCP	6	—	—	99	—	dBμV

REFERENCE VALUE
Input / output resistance, input / output capacitance (Typ.)

PIN No.	PIN NAME	RESISTANCE (Ω)	CAPACITANCE (pF)
23	MIX IN	620	3.1
13	IF OUT	11K	2.5

RECEIVER VCO

Operating Frequency	FRVCO	—	—	200	—	400	MHz
C / N Characteristic	CNR	—	PLL loop shaping *2	—	72	—	dB

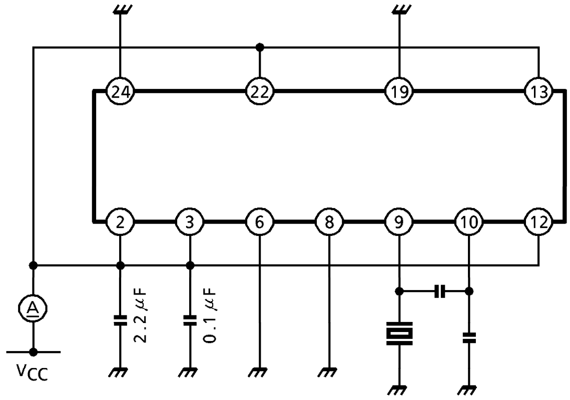
TRANSMITTER VCO

Operating Frequency	FTVCO	—	—	200	—	400	MHz
C / N Characteristic	CNT	—	PLL loop shaping *2	—	72	—	dB

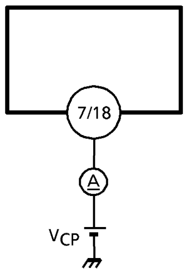
*1 : In case of input 50Ω from VCOE terminal
*2 : Detuning frequency = 12.5kHz, Band range = 8kHz
*3 : Use for operating TX V_{CC}-PLL V_{CC}, RX V_{CC}-PLL V_{CC} is within ±0.2V.

TEST CIRCUIT

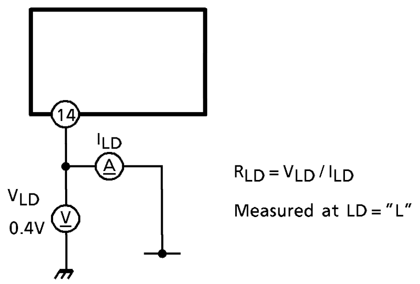
1. I_{CCO}、I_{CCS}



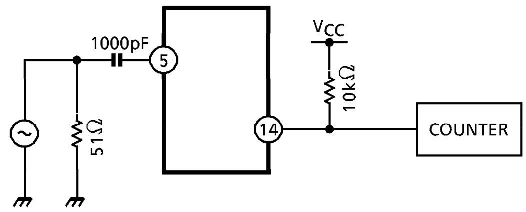
2. I_{CP}



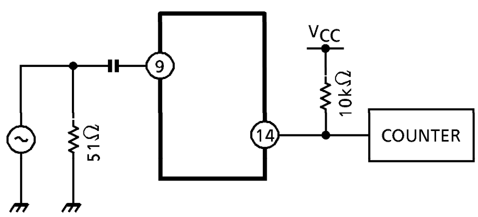
3. R_{LD}



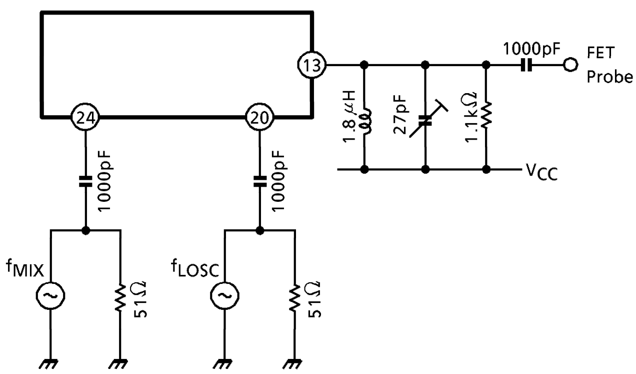
4. V_{TXIN}、V_{XIN}



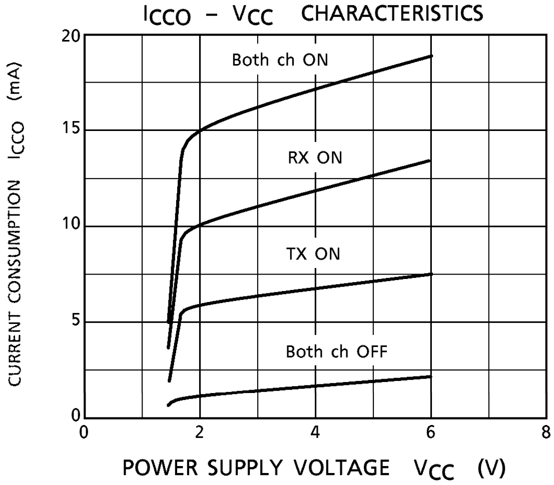
5. V_{XIN}



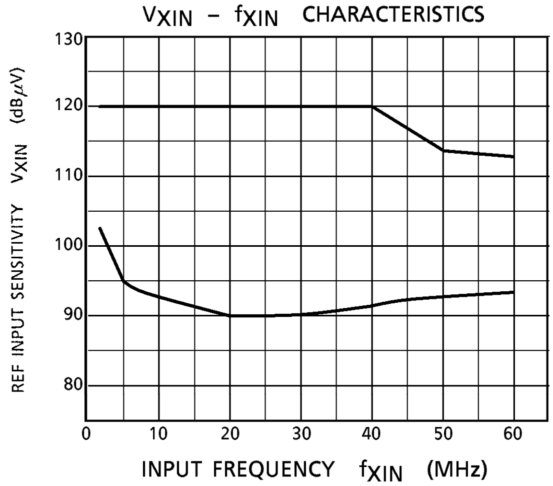
6. G_{VMIX}



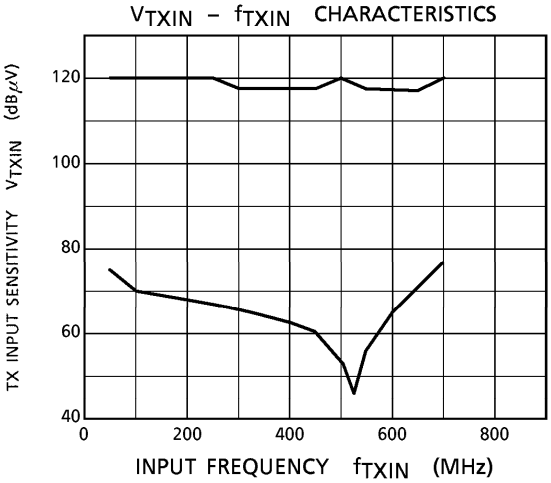
ICCO – VCC CHARACTERISTICS



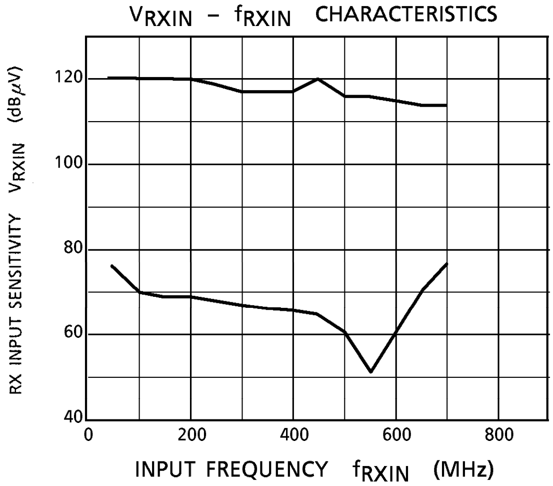
VXIN – fXIN CHARACTERISTICS



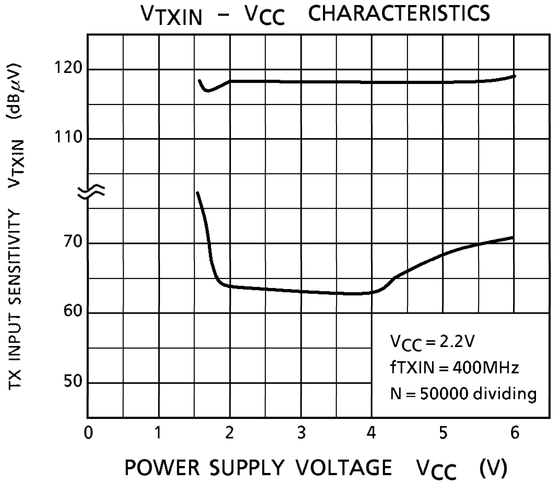
VTXIN – fTXIN CHARACTERISTICS



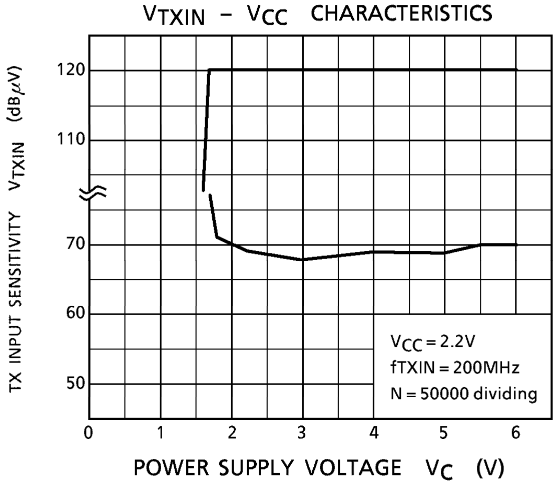
VRXIN – fRXIN CHARACTERISTICS

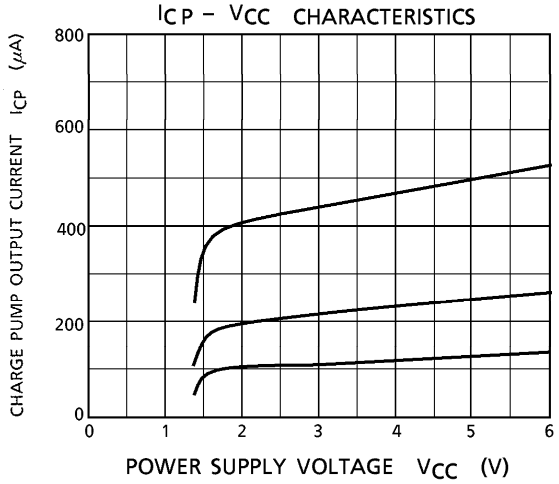


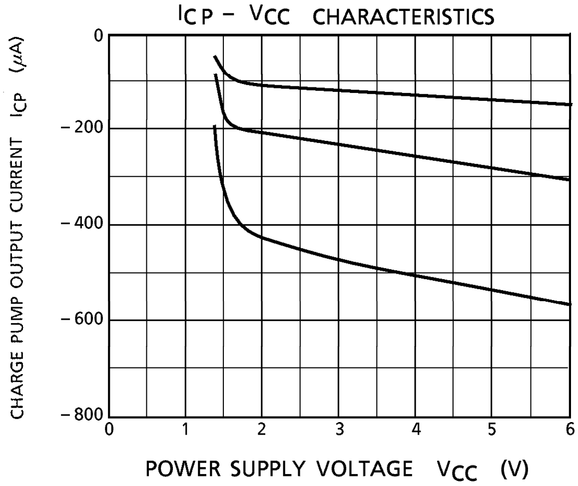
VTXIN – VCC CHARACTERISTICS

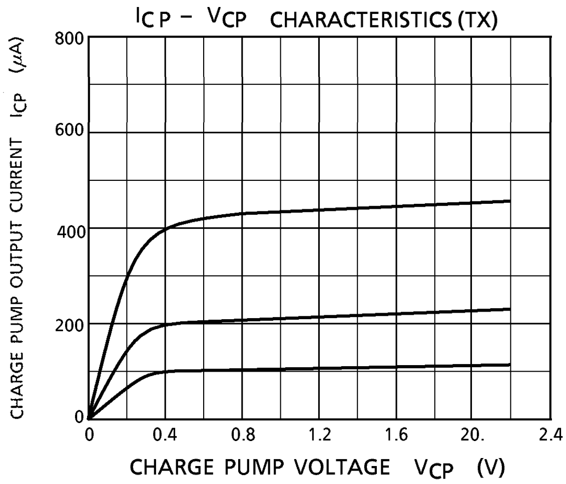


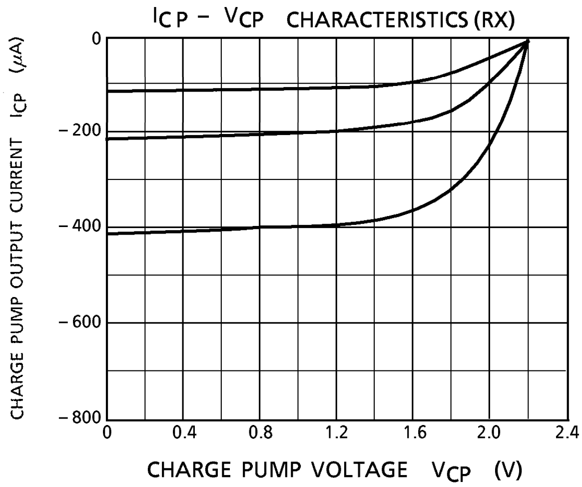
VTXIN – VCC CHARACTERISTICS

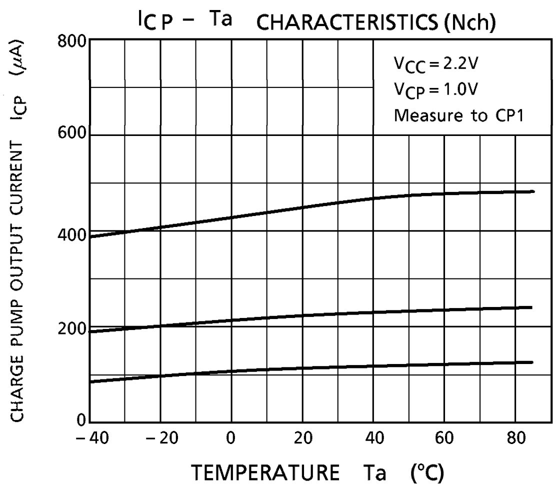


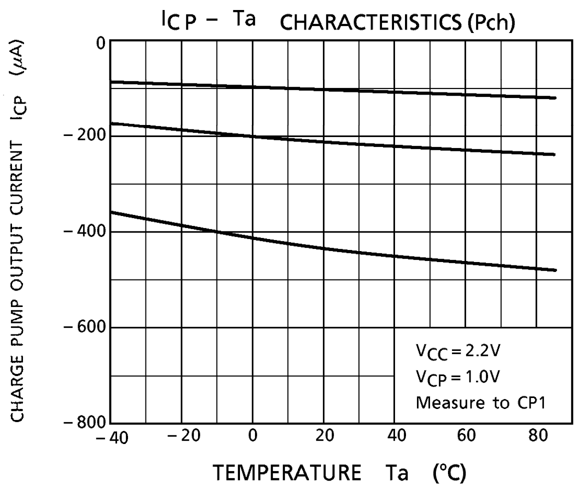

ICP – VCC CHARACTERISTICS
CHARGE PUMP OUTPUT CURRENT ICP (μA)
800
600
400
200
0
0 1 2 3 4 5 6
POWER SUPPLY VOLTAGE VCC (V)


ICP – VCC CHARACTERISTICS
CHARGE PUMP OUTPUT CURRENT ICP (μA)
0
– 200
– 400
– 600
– 800
0 1 2 3 4 5 6
POWER SUPPLY VOLTAGE VCC (V)

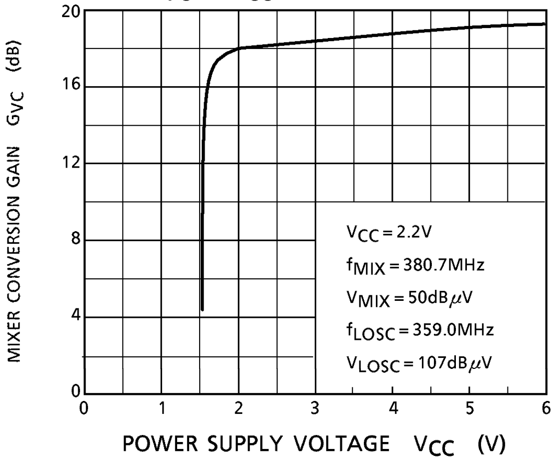

ICP – VCP CHARACTERISTICS (TX)
CHARGE PUMP OUTPUT CURRENT ICP (μA)
800
600
400
200
0
0 0.4 0.8 1.2 1.6 20. 2.4
CHARGE PUMP VOLTAGE VCP (V)


ICP – VCP CHARACTERISTICS (RX)
CHARGE PUMP OUTPUT CURRENT ICP (μA)
0
– 200
– 400
– 600
– 800
0 0.4 0.8 1.2 1.6 2.0 2.4
CHARGE PUMP VOLTAGE VCP (V)

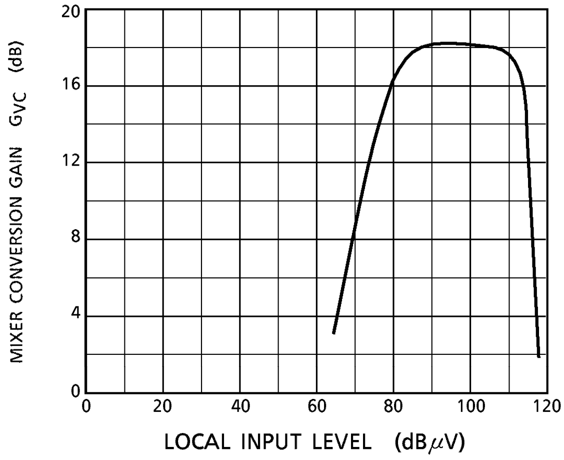

ICP – Ta CHARACTERISTICS (Nch)
CHARGE PUMP OUTPUT CURRENT ICP (μA)
VCC = 2.2V
VCP = 1.0V
Measure to CP1
800
600
400
200
0
– 40 – 20 0 20 40 60 80
TEMPERATURE Ta (°C)


ICP – Ta CHARACTERISTICS (Pch)
CHARGE PUMP OUTPUT CURRENT ICP (μA)
VCC = 2.2V
VCP = 1.0V
Measure to CP1
0
– 200
– 400
– 600
– 800
– 40 – 20 0 20 40 60 80
TEMPERATURE Ta (°C)

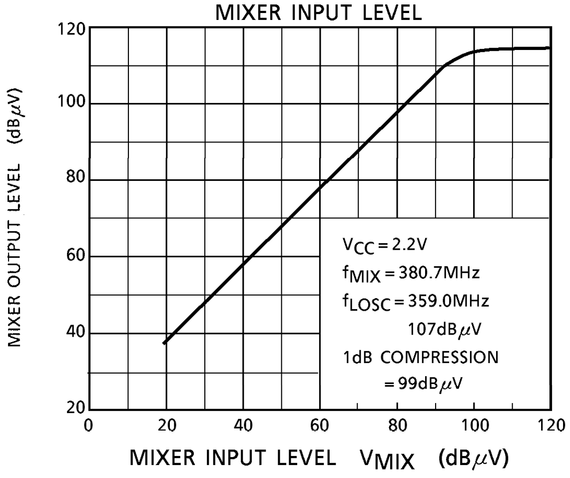
G_{VC} – V_{CC} CHARACTERISTICS



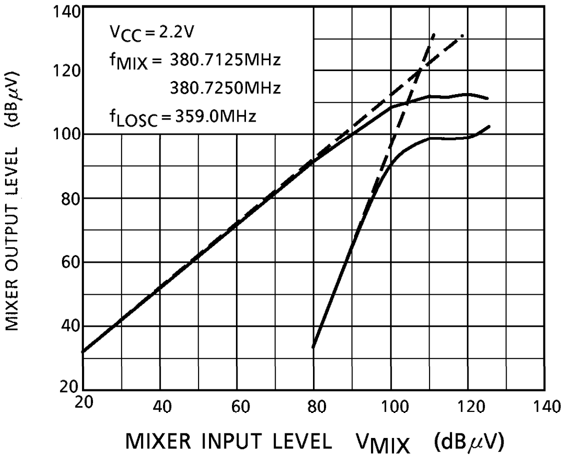
G_{VC} – LOCAL OSC LEVEL CHARACTERISTICS



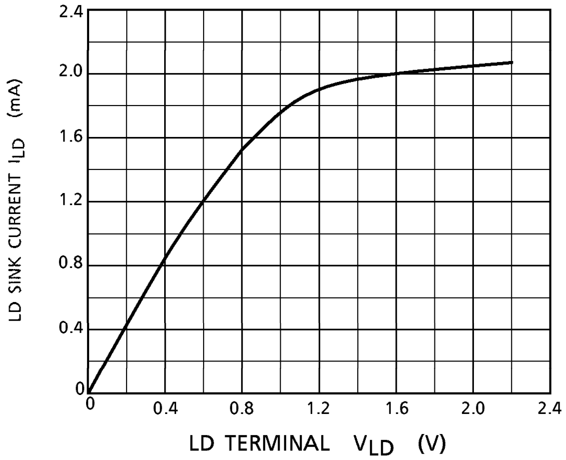
MIXER CONVERSION GAIN – MIXER INPUT LEVEL



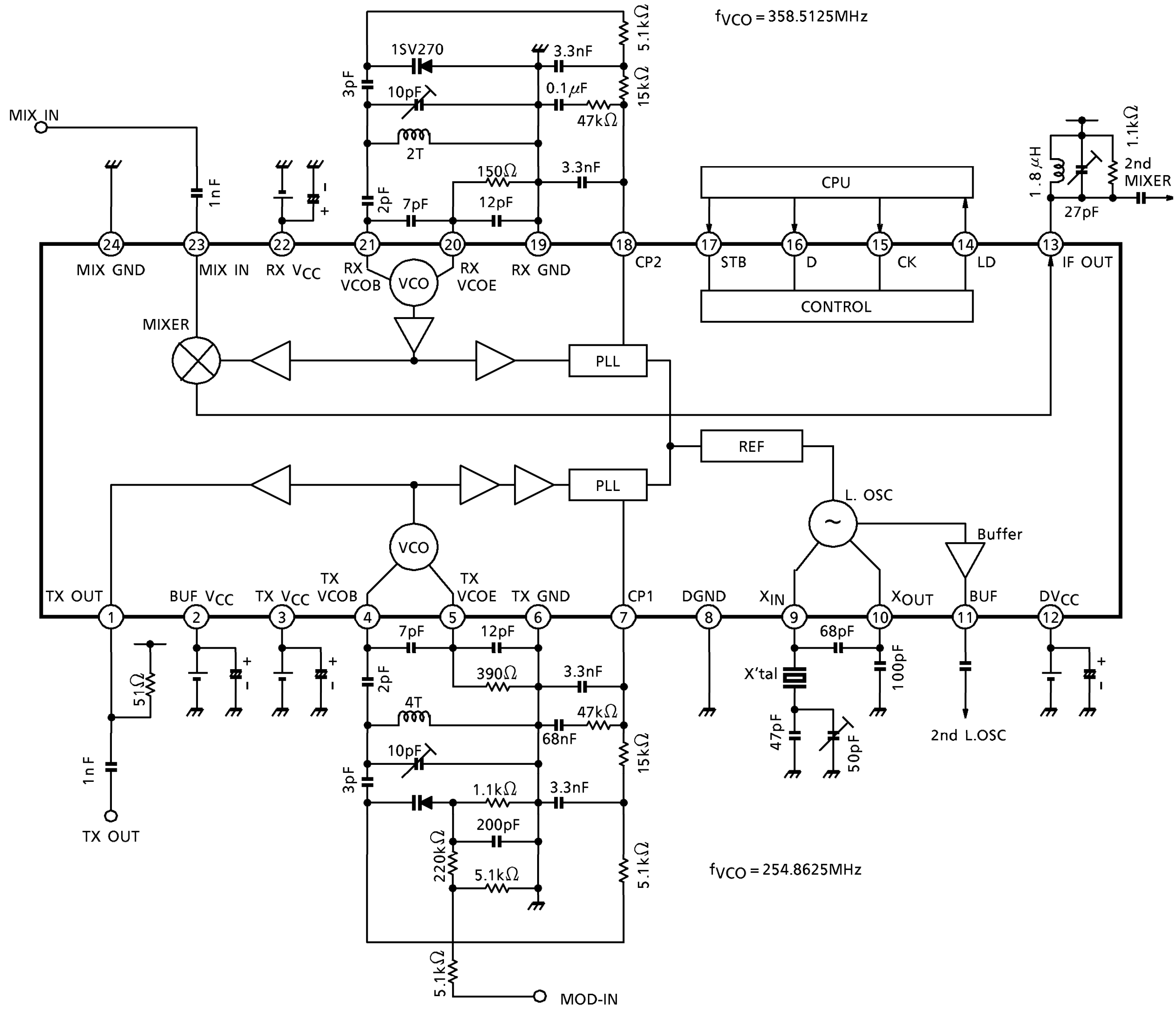
MIXER INTERCEPT POINT



LD TERMINAL OUTPUT CHARACTERISTICS



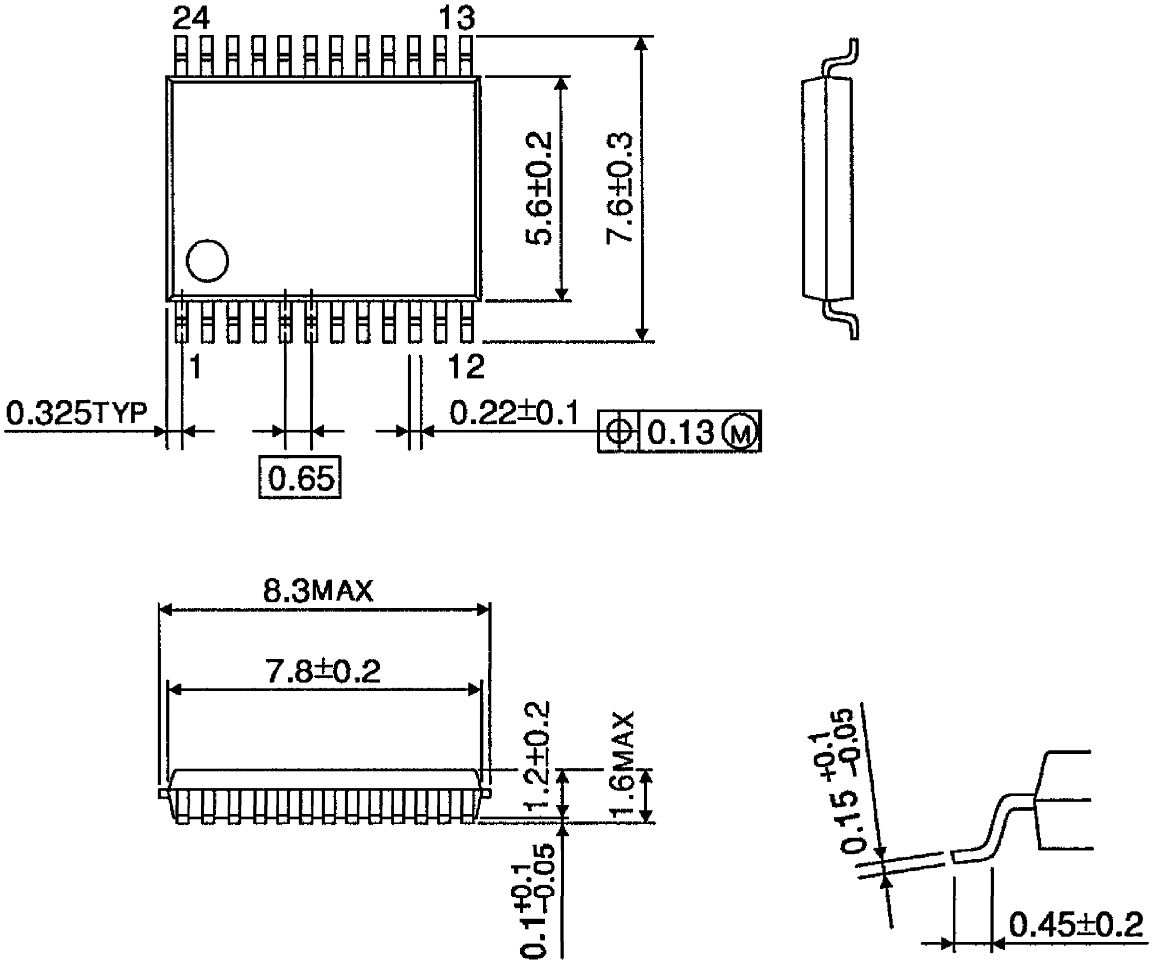
APPLICATION CIRCUIT



Hand set of coldless phone V_{CC} = 2.2 [V] constant

PACKAGE DIMENSIONS

SSOP24-P-300-0.65A UNIT : mm



Weight : 0.14g (Typ.)

About solderability, following conditions were confirmed

- Solderability

(1) Use of Sn-63Pb solder Bath
- solder bath temperature = 230°C
- dipping time = 5 seconds
- the number of times = once
- use of R-type flux

(2) Use of Sn-3.0Ag-0.5Cu solder Bath
- solder bath temperature = 245°C
- dipping time = 5 seconds
- the number of times = once
- use of R-type flux