DATA SHEET

Part No.	AN18207A
Package Code No.	LQFP048-P-0707A

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AN18207A

Tuner IC for home-audio stereo set

■ Overview

AN18207A is all-in-one IC for a radio of home-audio use.
As for FM portion, FM MIX to FM MPX are integrated. As for AM portion, AM-RF to AM detector are integrated.
FM/AM PLL synthesizer with pre-scale function is also integrated.
Therefore, AN18207A can achieve the most function of radio.

■ Features

- AM : RF + MIX + L-OSC, FM : MIX + L-OSC, FM/AM : IF + DET, FM-MPX, PLL
- I^2C-bus control
- FM detector coil less
- Separation adjustment free

■ Applications

- Tuner, radio

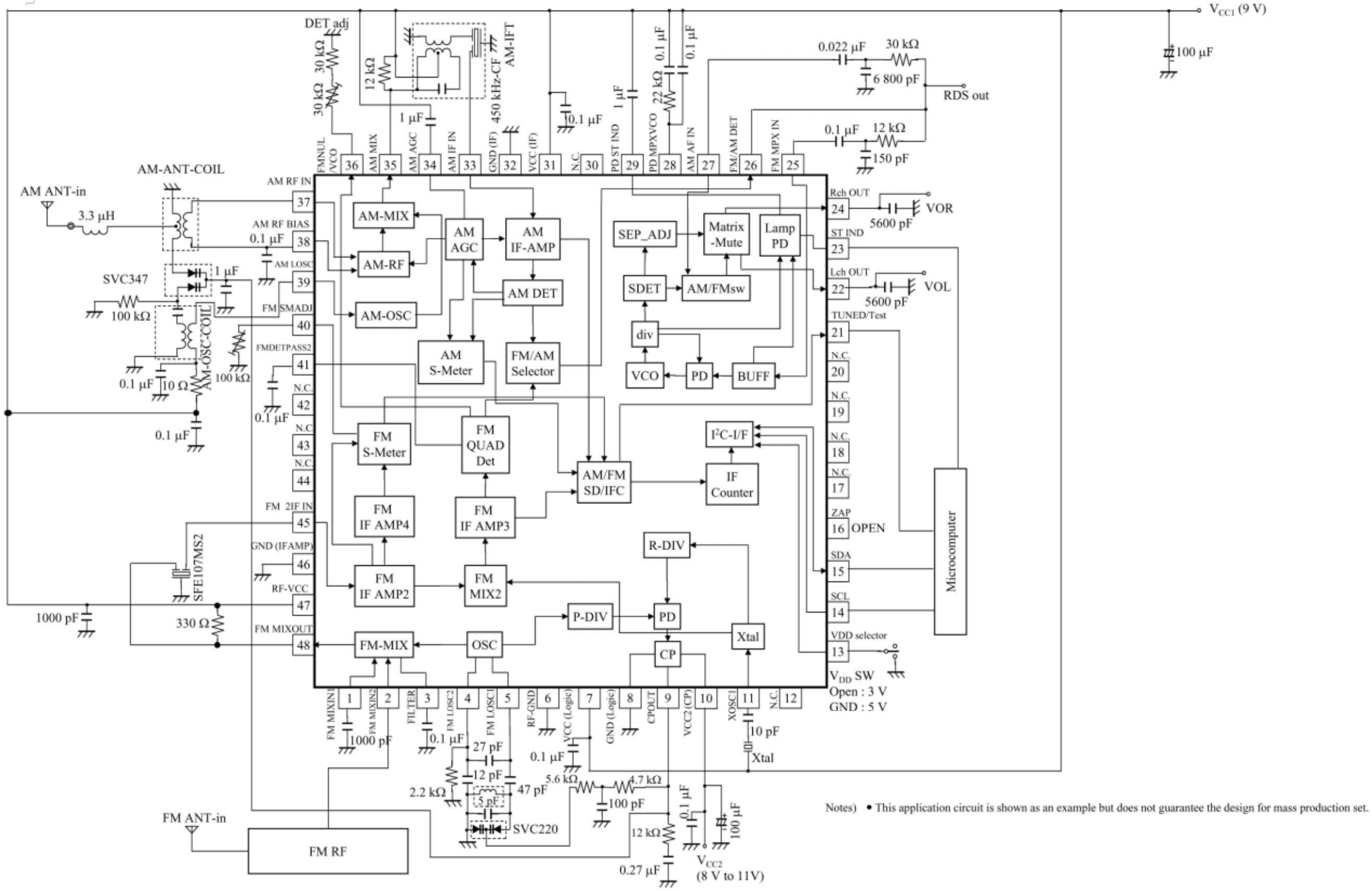
■ Package

- 48 pin Plastic Low Profile Quad Flat Package (QFP type)

■ Type

- Silicon Monolithic Bipolar IC

■ Application Circuit Example



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■ Pin Descriptions

Pin No.	Pin name	Type	Description
1	FM MIXIN1	Input	FM mixer input 1
2	FM MIXIN2	Input	FM mixer input 2
3	FILTER	Input / Output	FILTER
4	FM LOSC2	Output	FM local oscillator load 2 (Emitter side)
5	FM LOSC1	Input	FM local oscillator load 1 (Base side)
6	RF-GND	Ground	RF-GND
7	VCC (Logic)	Power supply	Logic-V_{CC}
8	GND (Logic)	Ground	Logic-GND
9	CPOUT	Output	Charge pump output
10	VCC2 (CP)	Power supply	Charge pump-V_{CC}
11	XOSC1	Input	Crystal oscillator
12	N.C.	—	N.C. (Open in IC)
13	VDD selector	Input	V_{DD} selector
14	SCL	Input	Serial clock input (SCL)
15	SDA	Input / Output	Serial data input / output (SDA)
16	ZAP	—	Pulse input for ZAP (Must be open)
17	N.C.	—	N.C. (Open in IC)
18	N.C.	—	N.C. (Open in IC)
19	N.C.	—	N.C. (Open in IC)
20	N.C.	—	N.C. (Open in IC)
21	TUNED/Test/FM S-Meter	Output	TUNED / Test monitor output / FM S-Meter
22	Lch OUT	Output	L-ch. de-emphasis output (External capacitor 0.0056 μF : Time constant = 50 μs)
23	ST IND	Output	Stereo indicator
24	Rch OUT	Output	R-ch. de-emphasis output (External capacitor 0.0056 μF : Time constant = 50 μs)
25	FM MPX IN	Input	FM MPX input
26	FM/AM DET	Output	FM/AM detector output
27	AM AF IN	Input	AM AF input
28	PD MPXVCO	Input / Output	Phase detector for MPX-VCO
29	PD ST IND	Input / Output	Phase detector for MPX stereo detector
30	N.C.	—	N.C. (Open in IC)

■ Pin Descriptions (continued)

Pin No.	Pin name	Type	Description
31	VCC	Power supply	VCC
32	GND	Ground	GND
33	AM IF IN	Input	AM IF amp. input
34	AM AGC	Input / Output	AM-AGC level detector
35	AM MIX	Output	AM mixer output
36	FMNUL/VCO	Input / Output	MPX-VCO frequency adjustment / FM detector center adjustment
37	AM RF IN	Input	AM RF input
38	AM RF BIAS	Input / Output	AM RF input reference bias
39	AM LOSC	Input / Output	AM local oscillator load
40	FM SMADJ	Input / Output	FM signal meter adjustment
41	FMDETPASS2	Input / Output	FM detector bypass 2
42	N.C.	—	N.C. (Open in IC)
43	N.C.	—	N.C. (Open in IC)
44	N.C.	—	N.C. (Open in IC)
45	FM 2IF IN	Input	FM 2nd IF amp. input
46	GND	Ground	GND for IF amp.
47	RF-VCC	Power supply	RF-V_{CC}
48	FM MIXOUT	Output	FM mixer output

■ Absolute Maximum Ratings

Note) Absolute maximum ratings are limit values which are not destructed, and are not the values to which operation is guaranteed.

A No.	Parameter	Symbol	Rating	Unit	Notes
1	Supply voltage	V_{CC1}	10.5	V	*1
		V_{CC2}	11.5		
2	Supply current	I_{CC}	60	mA	—
3	Power dissipation	P_D	294	mW	*2
4	Operating ambient temperature	T_{opr}	–20 to +85	°C	*3
5	Storage temperature	T_{stg}	–55 to +150	°C	*3

Notes) *1 : The values under the condition not exceeding the above absolute maximum ratings and the power dissipation.
V_{CC2} is VCC for charge pump.

*2 : The power dissipation shown is the value at T_a = 85°C for the independent (unmounted) IC package without a heat sink.
When using this IC, refer to the • P_D-T_a diagram in the ■ Technical Data and design the heat radiation with sufficient margin so that the allowable value might not be exceeded based on the conditions of power supply voltage, load, and ambient temperature.

*3 : Except for the power dissipation, operating ambient temperature, and storage temperature, all ratings are for T_a = 25°C.

■ Operating supply voltage range

Parameter	Symbol	Range	Unit	Notes
Supply voltage range	V_{CC1}	8.0 to 10.0	V	*
	V_{CC2}	8.0 to 11.0		

Note) * : The values under the condition not exceeding the above absolute maximum ratings and the power dissipation.
V_{CC2} is VCC for charge pump.

■ Allowable Voltage Range

Notes) Voltage values, unless otherwise specified, are with respect to GND.
GND is voltage for RF-GND, GND(Logic), GND(IF), GND(IF AMP). RF-GND = GND(Logic) = GND(IF) = GND(IF AMP)
Do not apply external currents or voltages to any pin not specifically mentioned. Please make Pin16 open.
For the circuit currents, "+" denotes current flowing into the IC, and "−" denotes current flowing out of the IC.

Pin No.	Pin name	Rating	Unit	Notes
1	FM MIXIN1	-0.3 to $(V_{CC1} + 0.3)$	V	—
2	FM MIXIN2	-0.3 to $(V_{CC1} + 0.3)$	V	—
3	FILTER	-0.3 to $(V_{CC1} + 0.3)$	V	—
5	FM LOSC1	-0.3 to $(V_{CC1} + 0.3)$	V	—
11	XOSC1	-0.3 to $(V_{CC1} + 0.3)$	V	—
13	VDD selector	-0.3 to $(V_{CC1} + 0.3)$	V	—
14	SCL	-0.3 to 5.3	V	—
15	SDA	-0.3 to 5.3	V	—
25	FM MPX IN	-0.3 to $(V_{CC1} + 0.3)$	V	—
27	AM AF IN	-0.3 to $(V_{CC1} + 0.3)$	V	—
28	PD MPXVCO	-0.3 to $(V_{CC1} + 0.3)$	V	—
29	PD ST IND	-0.3 to $(V_{CC1} + 0.3)$	V	—
33	AM IF IN	-0.3 to $(V_{CC1} + 0.3)$	V	—
34	AM AGC	-0.3 to $(V_{CC1} + 0.3)$	V	—
36	FMNUL/VCO	-0.3 to $(V_{CC1} + 0.3)$	V	—
37	AM RF IN	-0.3 to $(V_{CC1} + 0.3)$	V	—
38	AM RF BIAS	-0.3 to $(V_{CC1} + 0.3)$	V	—
39	AM LOSC	-0.3 to $(V_{CC1} + 0.3)$	V	—
40	FM SMADJ	-0.3 to $(V_{CC1} + 0.3)$	V	—
41	FMDETPASS2	-0.3 to $(V_{CC1} + 0.3)$	V	—
45	FM 2IF IN	-0.3 to $(V_{CC1} + 0.3)$	V	—

■ Electrical Characteristics at V_{CC1} = 9.0 V, V_{CC2} = 10 V

Note) T_a = 25°C±2°C unless otherwise specified.

B No.	Parameter	Symbol	Conditions	Limits			Unit	Notes
				Min	Typ	Max		
AM f_c = 999 kHz								
1	AM-quiescent current	amIt	No input, Current from V_{CC1}	14	28	42	mA	*1
2	AM output 1	amVo1	V_{IN3} = 30 dBμ, 1 kHz, 30% AM output	52	92	172	mV[rms]	—
3	AM output 2	amVo2	V_{IN3} = 74 dBμ, 1 kHz, 30% AM output	128	208	288	mV[rms]	—
4	AM-S/N ratio 1	amSN1	V_{IN3} = 30 dBμ, 1 kHz, 30% AM output S/N	17	23	—	dB	—
5	AM-S/N ratio 2	amSN2	V_{IN3} = 74 dBμ, 1 kHz, 30% AM output S/N	47	53	—	dB	—
6	AM THD 1	amT1	V_{IN3} = 74 dBμ, 1 kHz, 30% output distortion factor	—	0.4	1.1	%	—
7	AM THD 2	amT2	V_{IN3} = 103 dBμ, 1 kHz, 30% output distortion factor	—	0.5	2.0	%	—
8	AM-SD sensitivity	amSDS	0% mod Sens set (I^2C) = X'C'	33	43	53	dBμ	—
FM mono f_c = 10.7 MHz								
9	FM-RDS output	fmRDS	V_{IN2} = 80 dBμ, 1 kHz, 100%	320	480	640	mV[rms]	—
10	FM-quiescent current 1	fmIt1	No input, Current supplied from V_{CC1}	36	47	58	mA	*1
11	FM-quiescent current 2	fmIt2	No input, Current supplied from V_{CC2}	53	105	160	μA	*1
12	FM output	fmVo	V_{IN2} = 80 dBμ, 1 kHz, 100% output	600	800	1 000	mV[rms]	—
13	FM-S/N ratio	fmSN	V_{IN2} = 100 dBμ, 1 kHz, 100% FM output S/N	68	72	—	dB	—
14	FM-mono THD	fmTm1	V_{IN2} = 80 dBμ, 1 kHz, 100% output distortion factor	—	0.2	1.3	%	—
15	FM-SD sensitivity	fmSDS	0% mod Sens set (I^2C) = X'5'	31	41	51	dBμ	—
16	FM-mute ratio	fmMUTE	V_{IN2} = 80 dBμ, 1 kHz, 100% output ratio to fmVo (mute on)	54	74	—	dB	—

Note) *1 : No input = –10 dBμ or less.

■ Electrical Characteristics (continued) at V_{CC1} = 9.0 V, V_{CC2} = 10 V

Note) T_a = 25°C±2°C unless otherwise specified.

B No.	Parameter	Symbol	Conditions	Limits			Unit	Notes
				Min	Typ	Max		
FM stereo f_c = 10.7 MHz								
17	FM-L-ch. separation	fmSepL	V_{IN2} = 80 dBμ, 1 kHz, 90% L-ch. output separation	30	40	—	dB	—
18	FM-R-ch. separation	fmSepR	V_{IN2} = 80 dBμ, 1 kHz, 90% R-ch. output separation	30	40	—	dB	—
19	FM-stereo THD	fmTs1	V_{IN2} = 80 dBμ, 1 kHz, stereo (L + R) 90% output distortion factor	—	0.35	1.5	%	—
20	FM-carrier-leak	fmCL	pilot = 10% output level	20	—	—	dB	—
21	FM-stereo detect sensitivity	fm_{STON}	V_{IN2} = 80 dBμ, fp = 19 kHz	1.3	3.0	5.0	%	—
FM FE f_c = 98 MHz								
22	FM-FE S/N ratio	fmSN	V_{IN1} = 12 dBμ, 1 kHz, 100% mod VO_{DET}	28	39	—	dB	—
23	FM-Mixer output level	fmMIXout	V_{IN1} = 64 dBμ, IFOUT	6.4	8.2	10.0	mV[rms]	—
24	FM-LOSC level	fmOSCout	No input, 108.7 MHz	215	280	345	mV[rms]	—
FM mono f_c = 10.7 MHz								
25	FM limiting sensitivity	fmVlim	1 kHz, 100% of output –3 dB (Ref. input level V_{IN2} = 80 dBμ)	—	26	37	dBμ	—
26	AM suppression ratio	AMR	V_{IN2} = 100 dBμ, fm = 1 kHz AM : 30% mod FM : 100% mod	54	68	—	dB	—

■ Electrical Characteristics (Reference values for design) at V_{CC1} = 9.0 V , V_{CC2} = 10 V

Notes) T_a = 25°C±2°C unless otherwise specified.
The characteristics listed below are reference values derived from the design of the IC and are not guaranteed by inspection.
If a problem does occur related to these characteristics, we will respond in good faith to user concerns.

B No.	Parameter	Symbol	Conditions	Reference values			Unit	Notes
				Min	Typ	Max		
PLL								
27	Charge pump output pull-up current	Icpup	120 µA mode Pin 9 output current	90	129	170	µA	—
28	Charge pump output pull-down current	Icpdown	120 µA mode Pin 9 input current	–170	–120	–72	µA	—
I²C interface								
29	ACK Low-level output voltage	V_{ACK}	ACK Pin 15 voltage I = 3 mA	0	—	0.4	V	—
30	Low-level output voltage 1	V_{OL1}	V_{DD} > 2 V IP50 = 3 mA	0	—	0.4	V	—
31	High-level input voltage 1	V_{IHI_5}	Voltage which recognized that SDA and SCL are High-level 5 V mode Pin 13 : GND	3.5	—	5.5	V	—
32	Low-level input voltage 1	V_{ILO_5}	Voltage which recognized that SDA and SCL are Low-level 5 V mode Pin 13 : GND	– 0.5	—	1.5	V	—
33	High-level input voltage 2	V_{IHI_3}	Voltage which recognized that SDA and SCL are High-level 3 V mode Pin 13 : OPEN	2.1	—	3.5	V	—
34	Low-level input voltage 2	V_{ILO_3}	Voltage which recognized that SDA and SCL are Low-level 3 V mode Pin 13 : OPEN	– 0.5	—	0.9	V	—

■ Electrical Characteristics (Reference values for design) (continued) at V_{CC1} = 9.0 V , V_{CC2} = 10 V

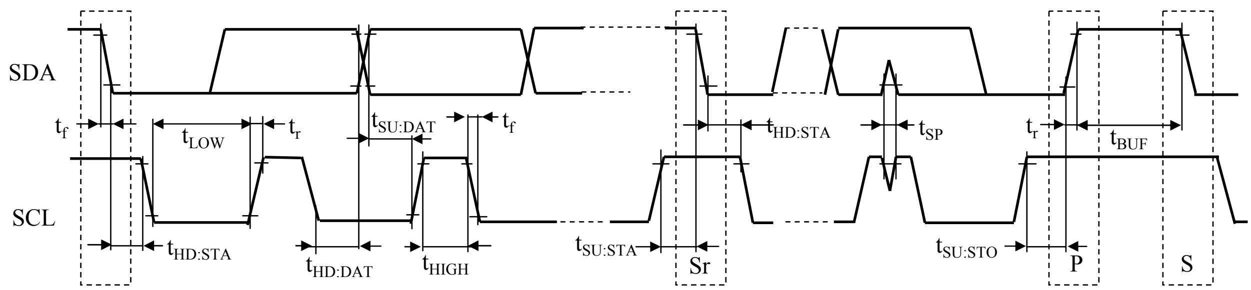
Notes) T_a = 25°C±2°C unless otherwise specified.
The characteristics listed below are reference values derived from the design of the IC and are not guaranteed by inspection.
If a problem does occur related to these characteristics, we will respond in good faith to user concerns.

B No.	Parameter	Symbol	Conditions	Reference values			Unit	Notes
				Min	Typ	Max		
I²C Interface (Fast-mode)								
35	SCL maximum frequency	f_{SCL}	—	—	—	400	kHz	*2
36	Hysteresis of Schmitt trigger inputs 1	Vhys1	5 V mode Pin 13 : GND	0.25	—	—	V	*2
37	Hysteresis of Schmitt trigger inputs 1	Vhys2	3 V mode Pin 13 : OPEN	0.15	—	—	V	*2
38	Output fall time from V_{IHmin} to V_{ILmax}	Tof	Bus capacitance : 10 pF to 400 pF Ip < 6 mA	20 + $0.1C_b$	—	250	ns	*2
39	Pulse width of spikes which must be suppressed by the input filter	t_{SP}	—	0	—	50	ns	*2
40	Capacitance for each I/O pin	Ci	Bus capacitance : 10 pF to 400 pF	—	—	10	pF	*2
41	Hold time (repeated)	$t_{HD:STA}$	The first clock pulse is generated after $t_{HD:STA}$	0.6	—	—	µs	*2
42	Low period of the SCL clock	t_{LOW}	—	1.3	—	—	µs	*2
43	High period of the SCL clock	t_{HIGH}	—	0.6	—	—	µs	*2
44	Set-up time for a repeat START condition	$t_{SU:STA}$	—	0.6	—	—	µs	*2
45	Data hold time	$t_{HD:DAT}$	—	0	—	0.9	µs	*2
46	Data set-up time	$t_{SU:DAT}$	—	100	—	—	ns	*2
47	Rise time of both SDA and SCL signals	t_r	—	20 + $0.1C_b$	—	300	ns	*2
48	Fall time of both SDA and SCL signals	t_f	—	20 + $0.1C_b$	—	300	ns	*2
49	Set-up time of STOP condition	$t_{SU:STO}$	—	0.6	—	—	µs	*2
50	Bus free time between a STOP and START condition	t_{BUF}	—	1.3	—	—	µs	*2
51	Capacitive load for each bus line	C_b	—	—	—	400	pF	*2

■ Electrical Characteristics(Reference values for design)(continued)at V_{CC1} = 9 V, V_{CC2} = 10 V

Notes) T_a = 25°C±2°C unless otherwise specified.
The characteristics listed below are reference values derived from the design of the IC and are not guaranteed by inspection.
If a problem does occur related to these characteristics, we will respond in good faith to user concerns.

B No.	Parameter	Symbol	Conditions	Reference values			Unit	Notes
				Min	Typ	Max		
I²C Interface (Fast-mode) (continued)								
52	Noise margin at the Low-level for each connected device	V_{aL1}	5 V mode Pin 13 : GND	0.5	—	—	V	*2
53	Noise margin at the High-level for each connected device	V_{aH1}	5 V mode Pin 13 : GND	1.0	—	—	V	*2
54	Noise margin at the Low-level for each connected device	V_{aL2}	3 V mode Pin 13 : OPEN	0.3	—	—	V	*2
55	Noise margin at the High-level for each connected device	V_{aH2}	3 V mode Pin 13 : OPEN	0.6	—	—	V	*2
56	Input current each I/O pin at 5V mode	Ii5	V_{IN} = 0.5 V to 4.5 V	–10	—	10	µA	*2
57	Input current each I/O pin at 3V mode	Ii3	V_{IN} = 0.3 V to 2.7 V	–10	—	10	µA	*2



S : START condition
Sr : Repeat START condition
P : STOP condition

Notes) *2 : The timing of Fast-mode devices in I²C-bus is specified as above.

■ Electrical Characteristics Test Procedures

C No.	Parameter	Input		Output		Pin settings					
		Pin No.	Conditions	Pin No.	Conditions	V_{CC1}	V_{CC2}	SW1	SW2	SW3	SW4
AM											
1	AM-quiescent current	—	No signal	—	—	9 V	10 V	2	1	2	2
2	AM output 1	37	f = 999 kHz, V_{IN3} = 30 dBμ fs = 1 kHz, AM : 30% mod	22	30 kHz LPF	9 V	10 V	2	1	2	2
3	AM output 2	37	f = 999 kHz, V_{IN3} = 74 dBμ fs= 1 kHz, AM : 30% mod	22	30 kHz LPF	9 V	10 V	2	1	2	2
4	AM-S/N ratio 1	37	f = 999 kHz, V_{IN3} = 30 dBμ fs = 1 kHz, AM : 30% S/N	22	30 kHz LPF	9 V	10 V	2	1	2	2
5	AM-S/N ratio 2	37	f = 999 kHz, V_{IN3} = 74 dBμ fs = 1 kHz, AM : 30% S/N	22	30 kHz LPF	9 V	10 V	2	1	2	2
6	AM THD 1	37	f = 999 kHz, V_{IN3} = 74 dBμ fs = 1 kHz, AM : 30% mod	22	30 kHz LPF	9 V	10 V	2	1	2	2
7	AM THD 2	37	f = 999 kHz, V_{IN3} = 110 dBμ, fs= 1 kHz, AM : 30% mod	22	30 kHz LPF	9 V	10 V	2	1	2	2
8	AM-SD sensitivity	37	f = 999 kHz, AM : 0% mod	21	27 kΩ pull-up	9 V	10 V	2	1	2	2
FM mono											
9	FM-RDS output	2	V_{IN2} = 80 dBμ, fs = 1 kHz FM : 100% mod	26	30 kHz LPF	9 V	10 V	2	1	2	2
10	FM-quiescent current 1	—	No signal	—	—	9 V	10 V	2	1	2	2
11	FM-quiescent current 2	—	No signal	—	—	9 V	10 V	2	1	2	2
12	FM output	2	f = 10.7 MHz, V_{IN2} = 80 dBμ, fs = 1 kHz, FM : 100% mod	24	30 kHz LPF	9 V	10 V	2	1	2	2
13	FM-S/N ratio	2	f = 10.7 MHz, V_{IN2} = 100 dBμ, FM : 100% L-ch S/N	24	30 kHz LPF	9 V	10 V	2	1	2	2
14	FM-mono THD	2	f = 10.7 MHz, V_{IN2} = 80 dBμ, fs = 1 kHz, FM : 100% mod	24	30 kHz LPF	9 V	10 V	2	1	2	2
15	FM-SD sensitivity	2	f = 10.7 MHz, 0 % mod	21	27 kΩ pull-up	9 V	10 V	2	1	2	2
16	FM-mute ratio	2	f = 10.7 MHz, V_{IN2} = 80 dBμ fs = 1 kHz, FM : 100% mod	22 24	30 kHz LPF	9 V	10 V	2	1	2	2

■ Electrical Characteristics Test Procedures (continued)

C No.	Parameter	Input		Output		Pin settings					
		Pin No.	Conditions	Pin No.	Conditions	V_{CC1}	V_{CC2}	SW1	SW2	SW3	SW4
FM stereo											
17	FM-L-ch. separation	2	f = 10.7 MHz, V_{IN2} = 80 dBμ, 1 kHz, (L = 90%, pilot = 10%)	22	15 kHz LPF	9 V	10 V	2	1	1	1
18	FM-R-ch. separation	2	f = 10.7 MHz, V_{IN2} = 80 dBμ, 1 kHz (R = 90%, pilot = 10%)	24	15 kHz LPF	9 V	10 V	2	1	1	1
19	FM-stereo THD	2	f = 10.7 MHz, V_{IN2} = 80 dBμ, 1 kHz (L + R = 90%, pilot = 10%)	22 24	15 kHz LPF	9 V	10 V	2	1	1	1
20	FM-carrier-leak	V_{IN2}	f = 10.7 MHz, V_{IN2} = 80 dBμ, fs = 19 kHz (pilot = 10%)	VOL	—	9 V	10 V	2	1	2	2
21	FM-stereo detect sensitivity	V_{IN2}	f = 10.7 MHz, V_{IN2} = 80 dBμ, fs = 19 kHz	12	27 kΩ pull-up	9 V	10 V	2	1	2	2
FM FE f_c = 98 MHz											
22	FM-FE S/N ratio	V_{IN1}	f = 98 MHz, V_{IN1} = 12 dBμ, 1 kHz, 100% mod	VO_{DET}	30 kHz LPF	9 V	10 V	1	1	2	2
23	FM-IF output level	V_{IN1}	f = 98 MHz, V_{IN3} = 64 dBμ, 0% mod	IF OUT	—	9 V	10 V	2	1	2	2
24	FM-LOSC level	—	No input, f = 108.7 MHz	VF MOS	—	9 V	10 V	2	1	2	2
FM mono f_c = 10.7 MHz											
25	FM limiting sensitivity	V_{IN2}	1 kHz, 100% of output –3 dB (Ref. input level V_{IN2} = 80 dBμ)	VOL	30 kHz LPF	9 V	10 V	2	1	2	2
26	AM suppression ratio	V_{IN2}	V_{IN2} = 100 dBμ, fm = 1 kHz, AM : 30% mod FM : 100% mod	VOL	30 kHz LPF	9 V	10 V	2	1	2	2

■ Technical Data

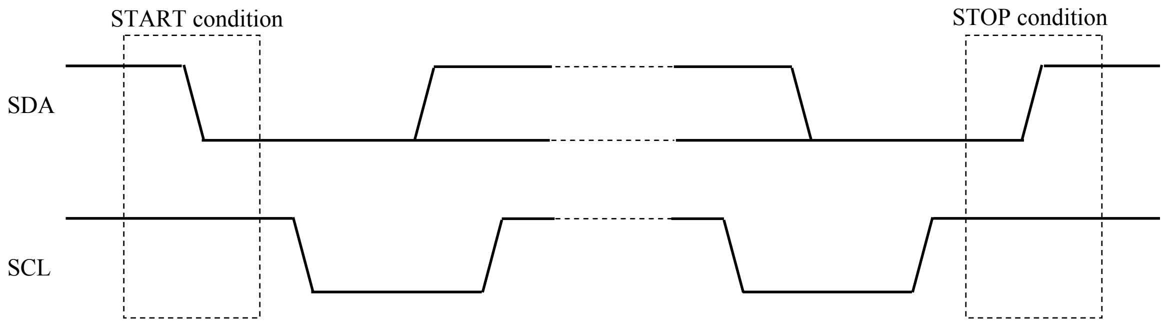
• I²C-bus interface

1. Basic Rules

- This IC, I²C-bus, is designed to correspond to the Standard-mode (100 kbps) and Fast-mode (400 kbps) devices in the version 2.1 of Philips Co.'s specification. However, it does not correspond to the H_S-mode (to 3.4 Mbps).
- This IC will be operated as a slave device in the I²C-bus system.
- The program operation check of this IC has not been conducted on the multi-master bus system and the mix-speed bus system, yet. The connected confirmation of this IC to the CBUS receiver also has not been checked. Please confirm our company if it will be used in these mode systems.
- Purchase of Panasonic I²C Components conveys a license under the Philips I²C patent right to use these components in an I²C systems, provided that the system conforms to the I²C standard specifications as defined by Philips.

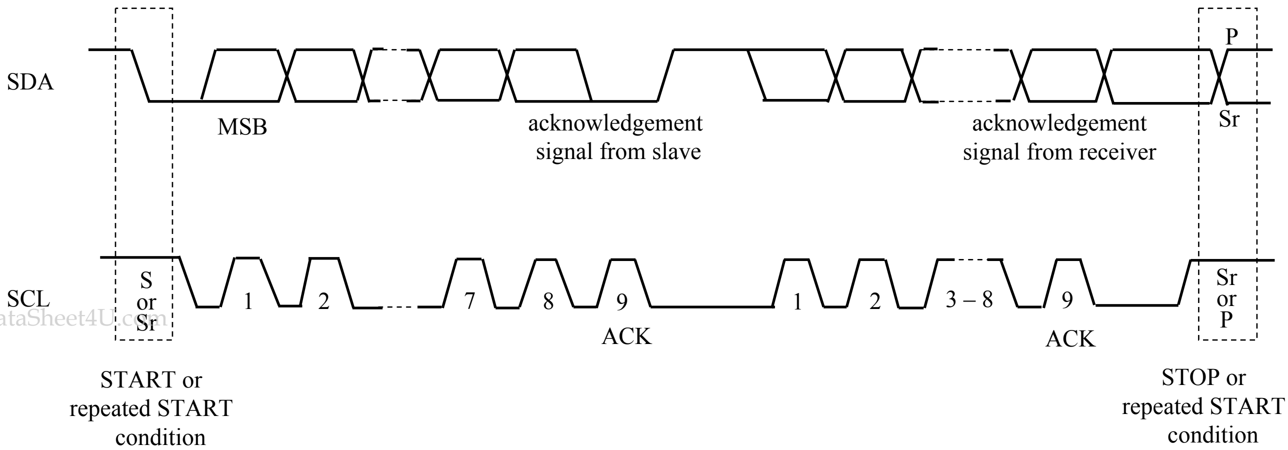
2. START and STOP conditions

A High to Low transition on the SDA line while SCL is High is one such unique case. This situation indicates a START condition. A Low to High transition on the SDA line while SCL is High defines a STOP condition.
START and STOP conditions are always generated by the master. The bus is considered to be free again a certain time after the STOP condition.



3. Transferring Data

Every byte put on the SDA line must be 8-bits long. The number of bytes that can be transmitted per transfer is unrestricted. Each byte has to be followed by an acknowledge bit. Data is transferred with the most significant bit (MSB) first. If a slave can't receive or transmit another complete byte of data until it has performed some other function, for example servicing an internal interrupt, it can hold the clock line SCL Low to force the master into a wait state. Data transfer then continues when the slave is ready for another byte of data and releases clock line SCL.



■ Technical Data (continued)

• I^2C-bus interface (continued)

4. DATA format

1) Write mode

1.1) Slave address : 1011 0110 (B6H)

1.2) Format

・Data update mode

S	Slave address	W	A	Sub address	A	Data byte	A	P

START condition

Write Mode : 0

Ack

STOP condition

・Auto-increment mode

S	Slave address	W	A	Sub address	A	Data 1	A	Data 2	A	Data n	A	P

2) Read mode

2.1) Subaddress : None

2.2) Slave address : 1011 0111 (B7H)

2.3) Format

S	Slave address	R	A	Data byte	A	P

START condition

Read Mode : 1

Ack

STOP condition

Ex.) In case data is read from Address 01h after data is written to Address 01h.

• Write

S	Slave address	0	A	Sub address 01h	A	Data byte	A	P

• Read

S	Slave address	1	A	Data byte	A	P

■ Technical Data (continued)

- I²C-bus interface (continued)

5. Register Map

Sub Address	MSB			DATA BYTE				LSB
	D7	D6	D5	D4	D3	D2	D1	D0
00	PLL-CP Current Select (ICO)	—	—	FM and SD Tuned Level Adjust (DSS4 - DSS0)				
01	AM SD Hysteresis Control (AMHIS)	PLL-Ref Frequency Select (RO)	CP Select (FCPS)	Mute ON/OFFMA TX (MUS)	Stereo Tuning Selector (TUS)	Force Monaural (FOM)	SD Mode Switch (SDS)	FM/AM Switch (DSS0)
02	PLL-N Divider (N7 - N0)							
03	—	—	PLL-N Divider (N13 - N8)					
04	FM IF AMP STOP (LIMSTOP)	L-OSC Stop (VMOS3)	Charge Pump Control (PHD1 - PHD0)		Analog/Logic Signal Monitor (DS3 - DS0)			
05	Adjustment Mode: FM Detector Adjustment / Write Mode (DE5 - DE0)						Read / Write Mode (ZRW)	Adjustment Mode (EMU)
06	—	—	—	—	—	Adjustment Mode: MPX Separation Adjustment / Write Mode (SE2 - SE1)		
07	—	—	—	—	—	Mixer AGC (MXAGC)	CIS selection (CIS)	AM IF AMP Stop (D070)

■ Technical Data (continued)

- I^2C-bus interface (continued)

6. Sub address byte and data byte format (Write mode)

Tuner-control (Group 1)
SUB-ADD 00H (Write)

Bit	Name	Function
LSB : D0	DSS0	FM and AM-SD tuned level adjust Be sure to set it when you change FM / AM. High : Sensitivity low Low : Sensitivity high This sensitivity is affected by an external RF amp. gain. Ex.) FM : X'5' AM : X'C' It is recommended to set "0" for DSS4.
D1	DSS1	
D2	DSS2	
D3	DSS3	
D4	DSS4	
D5	—	Don't care (0/1)
D6	—	
MSB : D7	ICO	PLL-charge pump current select 120 μA → Fast lock up time 30 μA → S/N improvement Normal : 120 μA

ICO	Icp [μA]
0	120
1	30

■ Technical Data (continued)

- I²C-bus interface (continued)

6. Sub address byte and data byte format (Write mode) (continued)

Tuner-control (Group 2)
SUB-ADD 01H (Write)

Bit	Name	Function
LSB : D0	FAS	FM / AM switch 0 : FM 1 : AM
D1	SDS	SD mode switch (FM / AM IF counter) 1 : SD mode (IF counter : ON) AM AGC-time-constant select 0 : 500 kΩ 1 : 10 kΩ IF counter is activated by setting this bit to "1" at I²C stop condition. And an inside impedance of AM-AGC is changed at AM. A time constant becomes 1/50 in the case of "1". *1)
D2	FOM	Force monaural 1 : monaural SUB detection and VCO stop. So IC is changed to monaural mode
D3	TUS	Selector to force monaural when stereo indicator is off. 0 : ON 1 : OFF
D4	MUS	Mute switch 1 : ON Output AF buffer amp. mute
D5	FCPS	FM mode & SDS OFF 0 : CP 30 μA fixed 1 : CP selectable (SUB-ADD 00H D7)
D6	RO	PLL-reference frequency selector RO 0: FM 25 kHz, AM 10 kHz RO 1: FM 50 kHz, AM 9 kHz
MSB : D7	AMHIS	AM-SD hysteresis control 1 : AM-SD hysteresis ON

PLL-reference frequency selector (D6 : RO):

RO	FM	AM
0	25 kHz	10 kHz
1	50 kHz	9 kHz

Note) *1 : When SDS mode is ON and stop condition of I²C comes, IF count is carried out .
After 70 ms of Stop condition, a result is ready to read.

■ Technical Data (continued)

- I²C-bus interface (continued)

6. Sub address byte and data byte format (Write mode) (continued)

Tuner-control (Group 2)
SUB-ADD 02H (Write)

Bit	Name	Function
LSB : D0	N0	PLL-N divider N-divider FM : $N = 2^{13} \times N13 + 2^{12} \times N12 + 2^{11} \times N11 + \cdots + 2^{0} \times N0$ AM : $N = 2^{9} \times N13 + 2^{8} \times N12 + 2^{7} \times N11 + \cdots + 2^{0} \times N4$ (Not use N0 to N3 at AM mode.)
D1	N1	
D2	N2	
D3	N3	
D4	N4	
D5	N5	
D6	N6	
MSB : D7	N7	

Tuner-control (Group 2)
SUB-ADD 03H (Write)

Bit	Name	Function
LSB : D0	N8	PLL-N divider N-divider FM : $N = 2^{13} \times N13 + 2^{12} \times N12 + 2^{11} \times N11 + \cdots + 2^{0} \times N0$ AM : $N = 2^{9} \times N13 + 2^{8} \times N12 + 2^{7} \times N11 + \cdots + 2^{0} \times N4$ (Not use N0 to N3 at AM mode.)
D1	N9	
D2	N10	
D3	N11	
D4	N12	
D5	N13	
D6	—	
MSB : D7	—	

■ Technical Data (continued)

- I²C-bus interface (continued)

6. Sub address byte and data byte format (Write mode) (continued)

<table>
<tr><td colspan="3">Tuner-control (Group 3)
SUB-ADD 04H (Write)</td></tr>
<tr><th>Bit</th><th>Name</th><th>Function</th></tr>
<tr><td>LSB : D0</td><td>DS0</td><td rowspan="4">Analog / logic signal monitor
<table>
<tr><th>DS0</th><th>DS1</th><th>DS2</th><th>DS3</th><th>Monitor point</th></tr>
<tr><td>0</td><td>0</td><td>0</td><td>0</td><td>Monitor OFF</td></tr>
<tr><td>1</td><td>0</td><td>0</td><td>0</td><td>Monitor of FM detector reference voltage</td></tr>
<tr><td>0</td><td>1</td><td>0</td><td>0</td><td>Monitor of FM detector adjustment DAC output</td></tr>
<tr><td>1</td><td>1</td><td>0</td><td>0</td><td>Monitor of FM separation adjustment DAC output</td></tr>
<tr><td>0</td><td>0</td><td>1</td><td>0</td><td>Monitor of the hysteresis DC voltage of FM-SD indicator</td></tr>
<tr><td>1</td><td>0</td><td>1</td><td>0</td><td>Monitor of the hysteresis DC voltage of stereo indicator</td></tr>
<tr><td>0</td><td>1</td><td>1</td><td>0</td><td>Monitor of SD-ON level adjustment DAC output</td></tr>
<tr><td>1</td><td>1</td><td>1</td><td>0</td><td>FM S-Meter</td></tr>
<tr><td>0</td><td>0</td><td>0</td><td>1</td><td>AM S-Meter</td></tr>
<tr><td>1</td><td>0</td><td>0</td><td>1</td><td>Monitor of MPX-VCO</td></tr>
<tr><td>0</td><td>1</td><td>0</td><td>1</td><td>PS output</td></tr>
<tr><td>1</td><td>1</td><td>0</td><td>1</td><td>ANC output</td></tr>
<tr><td>0</td><td>0</td><td>1</td><td>1</td><td>RED output</td></tr>
<tr><td>1</td><td>0</td><td>1</td><td>1</td><td>F450</td></tr>
<tr><td>0</td><td>1</td><td>1</td><td>1</td><td>NIFC</td></tr>
<tr><td>1</td><td>1</td><td>1</td><td>1</td><td>Monitor of the hysteresis DC voltage of AM-SD indicator</td></tr>
</table></td></tr>
<tr><td>D1</td><td>DS1</td></tr>
<tr><td>D2</td><td>DS2</td></tr>
<tr><td>D3</td><td>DS3</td></tr>
<tr><td>D4</td><td>PHD0</td><td rowspan="2">Charge pump control
<table>
<tr><th>PHD0</th><th>PHD1</th><th>Charge pump control</th></tr>
<tr><td>0</td><td>0</td><td>Normal mode</td></tr>
<tr><td>1</td><td>0</td><td>Force up</td></tr>
<tr><td>0</td><td>1</td><td>Force down</td></tr>
<tr><td>1</td><td>1</td><td>Hi-Z mode</td></tr>
</table></td></tr>
<tr><td>D5</td><td>PHD1</td></tr>
<tr><td>D6</td><td>VMOS3</td><td>1 : L-OSC stop</td></tr>
<tr><td>MSB : D7</td><td>LIMSTOP</td><td>0 : FM IF amp. stop (Pin 10 Low)</td></tr>
</table>

■ Technical Data (continued)

- I^{2}C-bus interface (continued)

6. Sub address byte and data byte format (Write mode) (continued)

Tuner-control (Group 3)
SUB-ADD 05H (Write)

Bit	Name	Function
LSB : D0	EMU	Adjustment mode 1 : ON
D1	ZRW	Read / write mode 0 : Read 1 : Write
D2	DE0	At adjustment mode : FM detector adjustment At write mode : 1 : Writing bit
D3	DE1	
D4	DE2	
D5	DE3	
D6	DE4	
MSB : D7	DE5	

Tuner-control (Group 3)
SUB-ADD 06H (Write)

Bit	Name	Function
LSB : D0	SE0	At adjustment mode : MPX separation adjustment At write mode : 1 : Writing bit
D1	SE1	
D2	SE2	
D3	—	Set them "0" all.
D4	—	
D5	—	
D6	—	
MSB : D7	—	

■ Technical Data (continued)

- I^2C-bus interface (continued)

6. Sub address byte and data byte format (Write mode) (continued)

Tuner-control (Group 3)
SUB-ADD 07H (Write)

Bit	Name	Function
LSB : D0	D070	1 : AM IF amp. stop
D1	CIS	0 : FM IF counter band width = 40 kHz, 1 : FM IF counter band width = 10 kHz
D2	MXAGC	0 : Mixer AGC off, 1 : Mixer AGC on
D3	—	Set them "0" all.
D4	—	
D5	—	
D6	—	
MSB : D7	—	

■ Technical Data (continued)

- I²C-bus interface (continued)

7. Data byte format (Read mode)

Tuner-control (Group 4) SUB-ADD none (Read)		
Bit	Name	Function
LSB : D0	IFC	IF counter output 0 : No signal AM IF C band width = 4 kHz, FM IFC band width = 40 kHz, or 10 kHz
D1	—	D1 to D7 = 1
D2	—	
D3	—	
D4	—	
D5	—	
D6	—	
MSB : D7	—	

■ Technical Data (continued)

- I²C-bus interface (continued)

8. Precaution in setup of I²C-bus data

1) Power on
   a) All data must be set on IC when the power supply is tuned on. (SUB ADD : 00H to 07H)
   b) IF limit amplifier must be ON at the time of the initial data transfer of I²C. (SUB ADD : 04H, D7 = "1")
   c) The power supply transition time ($V_{CC1, 2} = 0 \rightarrow 9$ V) must be more than 10 ms.
   d) Electric current flows in the power supply off condition when a power supply is connected to the TUNED terminal (Pin 21). Therefore, be careful in the case of the backup mode such as a microcomputer.

2) Pin 16
   Don't use Pin 16 (ZAP). It must be open.

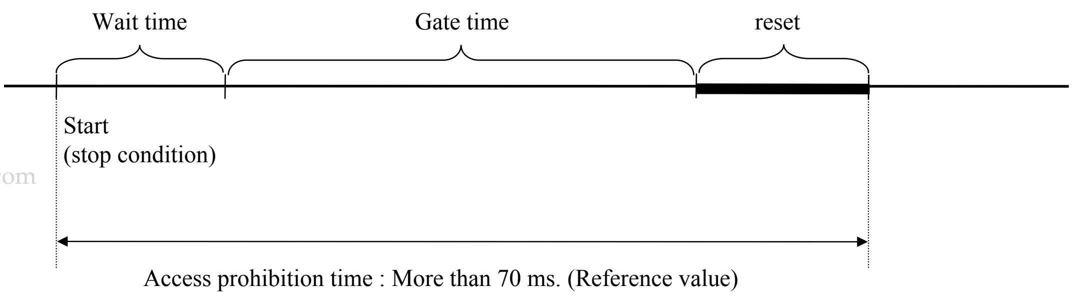
3) Monitor function
   a) Pin 21 of this IC has a function to monitor internal circuit terminals of this IC.
   The monitor point of analog signal or digital signal is set by SUBADD : 04H, D0 to D3.
   The choice of monitor point of logic signal is SUBADD : 0AH .It is chosen by D0 to D2 of 0AH.
   b) Don't choose more than one monitor point (analog, logic) at the same time.
   c) It is prohibited choosing the monitor point when IF limit amplifier is compulsory off (SUBADD : 04H, D7 = "0").
   Be sure to turn on IF limit amplifier when you use monitor function.
   d) Monitor function is a function for the test purpose only in our company, and its function is not guaranteed.
   When it is needed to send data, all data must be "0". Don't use it with the actual tuner set.

4) Charge pump test function
   a) SUBADD : 04H D4 to D5 are the bits for the function check of charge pump. For a normal use, they must be set to "0".

5) Handling unused bits
   a) All unused bits must be set to "0". When it is necessary to input Subaddress data, all unused bits must be set to "0".

6) Set number of N divider
   Don't establish N value about settlement of N divider in 271 or less.

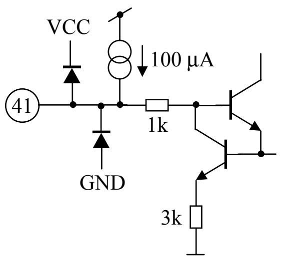
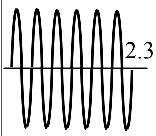
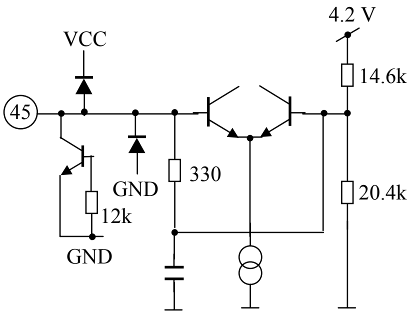
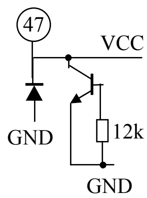
7) The timing of IF counter
   IF counter starts to count when it detects Stop condition of write mode at SDS mode (SUB ADD : 01H, D1 = "1").
   The result of the IF count can get it when it begins to read it after the progress about more than 70 ms and it is made the mode and begins to read it.
   To prevent IF counter's abnormal function, so that stop condition may not come between about 70 ms of the following. (see the figure below.) Even if this timing isn't kept, IC doesn't become uncontrollable. But the following condition are occurred by the transmitting data.
   a) When there are data which turn off SDS :
   Counter stops, and it is reset. The judgment result of IF counter isn't right. Ignore data and erase it.
   b) In the case of the dummy data:
   Stop condition is ignored, and IF counter works as it is. (It isn't reset.) If an original access prohibition time passes, the proper result of IF counter is obtained.



■ Technical Data (continued)

• I/O block circuit diagrams and pin function descriptions

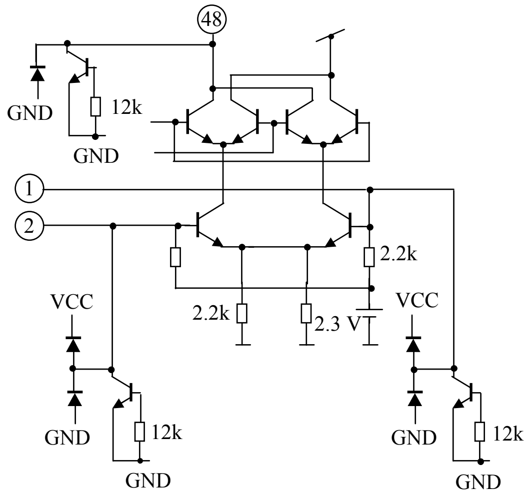
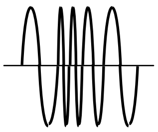
Note) The characteristics listed below are reference values derived from the design of the IC and are not guaranteed.

Pin No.	Waveform and voltage	Internal circuit	Impedance	Description
41	1.9 V		4 kΩ	FM detector bypass 2 External capacitor = 0.1 µF
42 to 44	—	OPEN	—	N.C.
45			330 Ω (AC input)	FM IF amp. input
46	—	—	—	GND (IF amp)
47	—		—	RF-VCC

■ Technical Data (continued)

• I/O block circuit diagrams and pin function descriptions (continued)

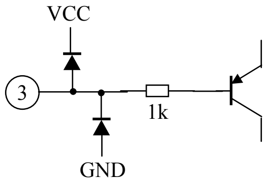
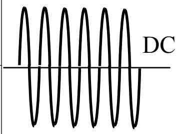
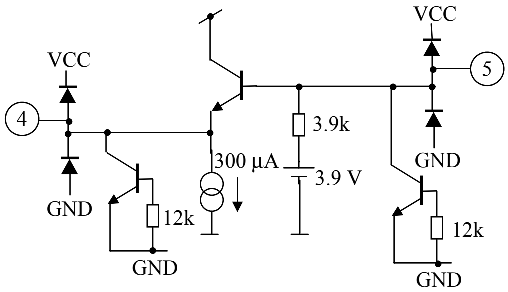
Note) The characteristics listed below are reference values derived from the design of the IC and are not guaranteed.

Pin No.	Waveform and voltage	Internal circuit	Impedance	Description
48	$f = f_{OSC} - f_{RF}$ or $f = f_{RF} - f_{OSC}$		500 Ω to High	FM mixer output
1	f = fmRF 		400 Ω (f = 100 MHz)	FM mixer input
2				

■ Technical Data (continued)

• I/O block circuit diagrams and pin function descriptions (continued)

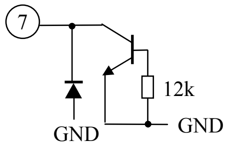
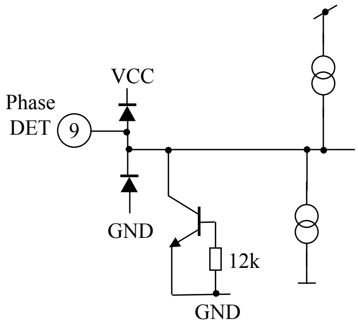
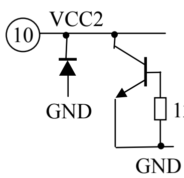
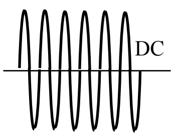
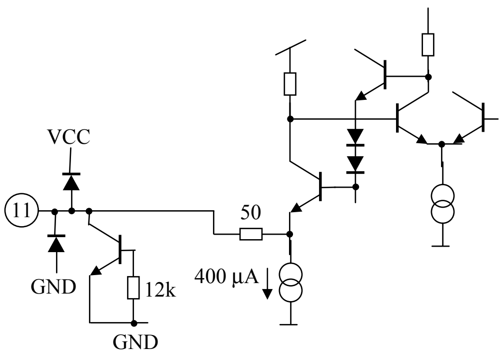
Note) The characteristics listed below are reference values derived from the design of the IC and are not guaranteed.

Pin No.	Waveform and voltage	Internal circuit	Impedance	Description
3	1.9 V		1 kΩ	FM AGC FILTER External capacitor = 0.1 μF
4			Low	FM L-OSC2 FM local oscillator load 2 (Emitter side)
5			3.9 kΩ	FM L-OSC1 FM local oscillator load 1 (Base side)
6	—	—	—	RF-GND

■ Technical Data (continued)

• I/O block circuit diagrams and pin function descriptions (continued)

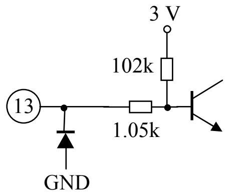
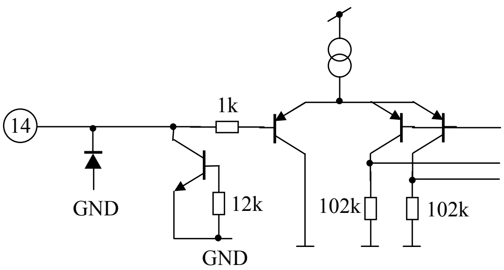
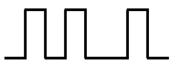
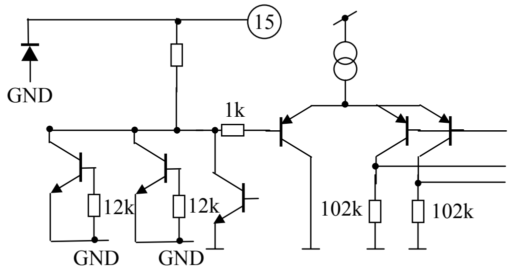
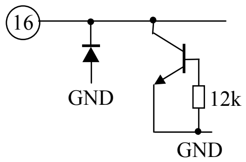
Note) The characteristics listed below are reference values derived from the design of the IC and are not guaranteed.

Pin No.	Waveform and voltage	Internal circuit	Impedance	Description
7	DC		—	VCC for Logic
8	—	—	—	GND for Logic and Charge pump
9	DC		High	CPOUT Charge pump output
10	DC		—	VCC2 Charge pump-V_{CC}
11			120 Ω	Crystal oscillator
12	—	OPEN	—	N.C.

■ Technical Data (continued)

• I/O block circuit diagrams and pin function descriptions (continued)

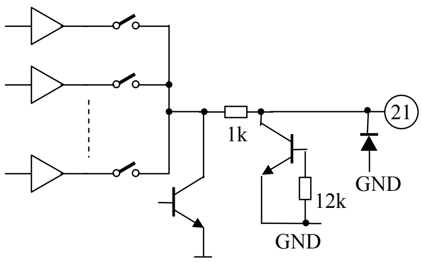
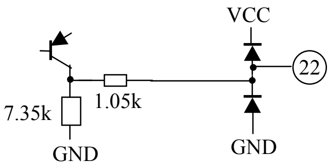
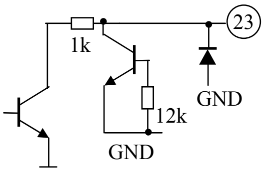
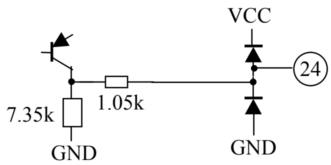
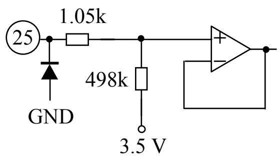
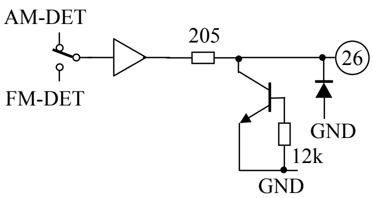
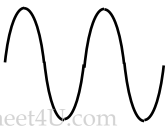
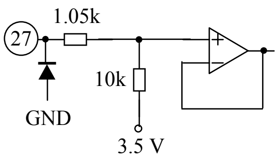
Note) The characteristics listed below are reference values derived from the design of the IC and are not guaranteed.

Pin No.	Waveform and voltage	Internal circuit	Impedance	Description
13	—		103 kΩ	V_{DD} selector
14			High	SCL Serial clock input
15			High	SDA Serial data input / output
16	—		—	ZAP (Must be open.)
17 to 20	—	OPEN	—	N.C.

■ Technical Data (continued)

• I/O block circuit diagrams and pin function descriptions (continued)

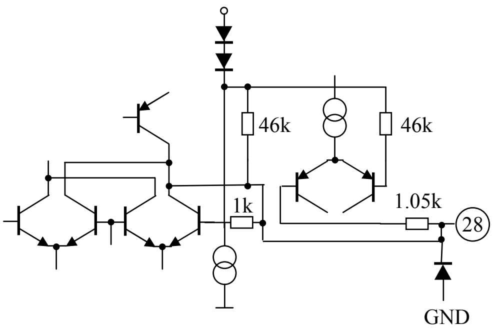
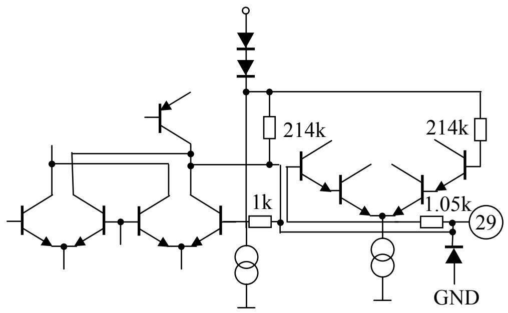
Note) The characteristics listed below are reference values derived from the design of the IC and are not guaranteed.

Pin No.	Waveform and voltage	Internal circuit	Impedance	Description
21	—		1 kΩ	TUNED/Test SD-OUT FM/AM tuning indicator Test monitor output
22	DC bias = 3.5 V		8.4 kΩ	L-ch. de-emphasis output (External capacitor 0.0056 μF Time constant = 50 μs)
23	—		1 kΩ	ST-OUT FM stereo indicator
24	DC bias = 3.5 V		8.4 kΩ	R-ch. de-emphasis output (External capacitor 0.0056 μF Time constant = 50 μs)
25	Composite signal		500 kΩ	FM MPX input
26	—		200 Ω	FM/AM detector output (Please make it to OPEN when unused.)
27	 AM-AF		11 kΩ	AM AF input

■ Technical Data (continued)

• I/O block circuit diagrams and pin function descriptions (continued)

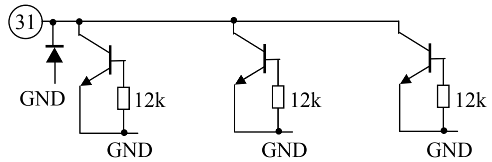
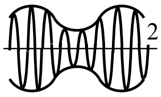
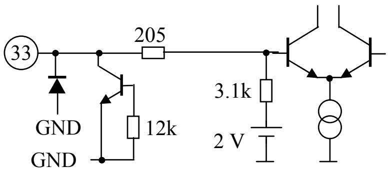
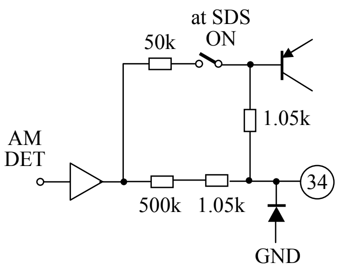
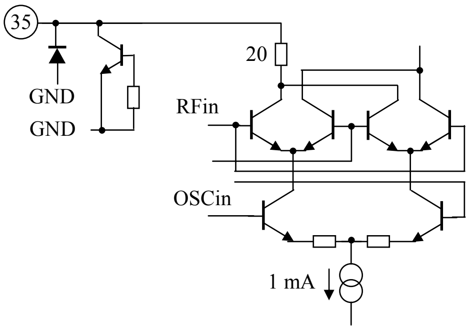
Note) The characteristics listed below are reference values derived from the design of the IC and are not guaranteed.

Pin No.	Waveform and voltage	Internal circuit	Impedance	Description
28	DC ≅ $V_{CC1} - 1.4$ V		46 kΩ	Phase detector for MPX-VCO
29	DC ≅ $V_{CC1} - 1.4$ V		214 kΩ	Stereo DET of MPX

■ Technical Data (continued)

• I/O block circuit diagrams and pin function descriptions (continued)

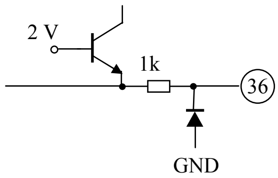
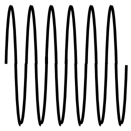
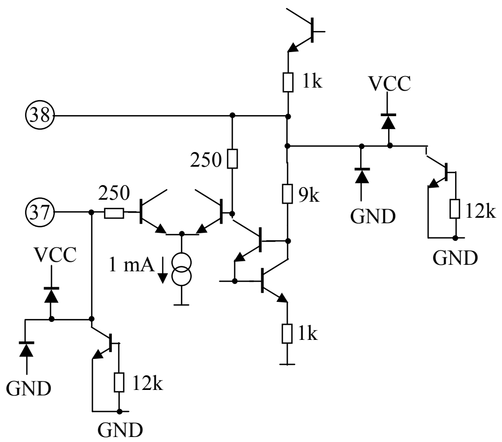
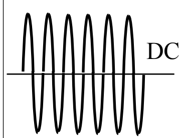
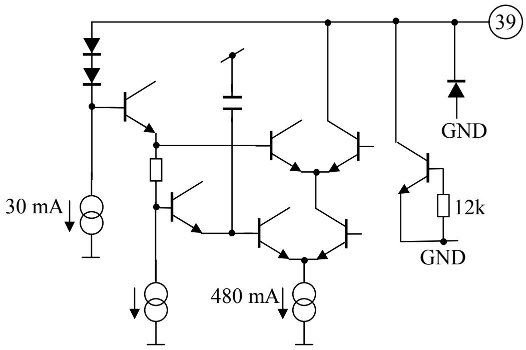
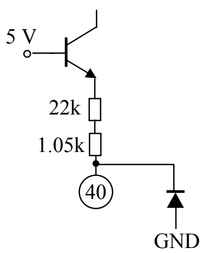
Note) The characteristics listed below are reference values derived from the design of the IC and are not guaranteed.

Pin No.	Waveform and voltage	Internal circuit	Impedance	Description
30	—	OPEN	—	N.C.
31	—		—	VCC
32	—	—	—	GND
33	 2 V f = 450 kHz		3.3 kΩ	AM IF amp. input
34	DC		51 kΩ / 501 kΩ	AM-AGC level detector
35	$f = f_{OSC} - f_{RF}$		High	AM mixer output

■ Technical Data (continued)

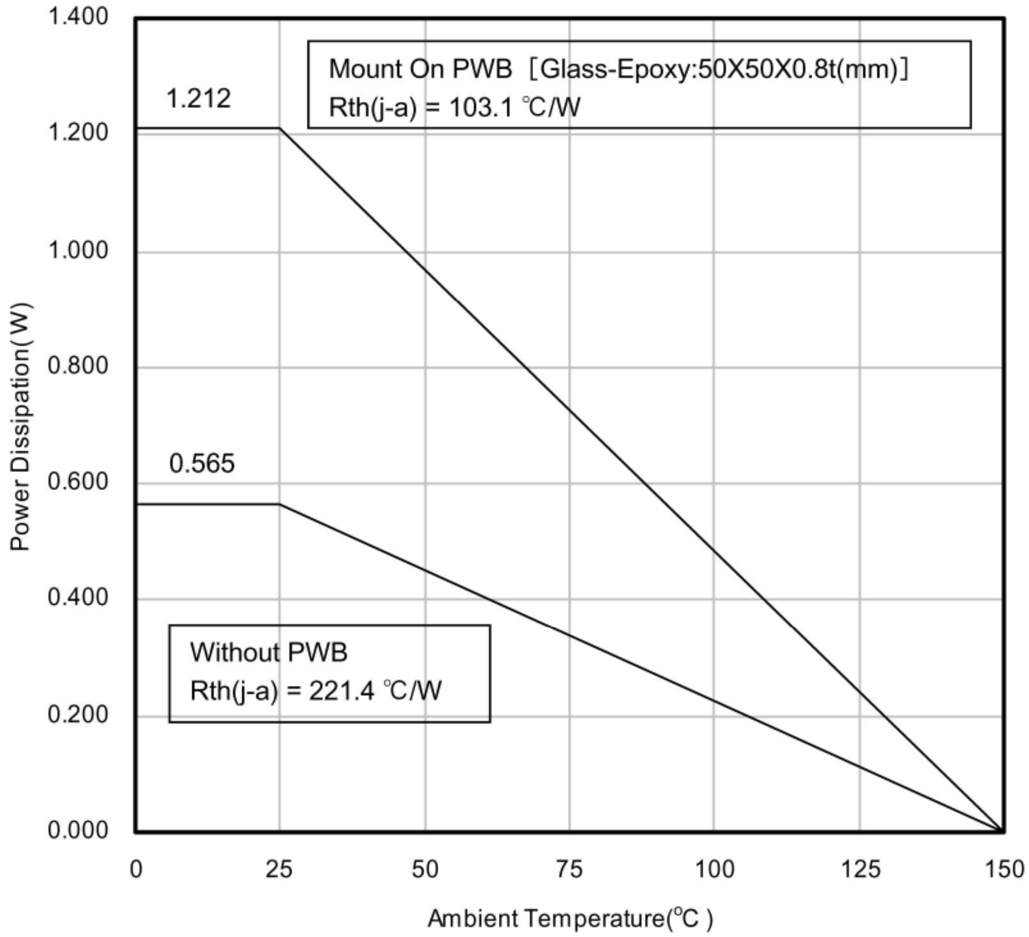
• I/O block circuit diagrams and pin function descriptions (continued)

Note) The characteristics listed below are reference values derived from the design of the IC and are not guaranteed.

Pin No.	Waveform and voltage	Internal circuit	Impedance	Description
36	—		1 kΩ	FM DET-NULL and MPX-VCO adjustment
37	 522 kHz – 1 720 kHz		High	AM RF input
38	—		1 kΩ	AM RF reference
39			—	AM L-OSC AM local oscillator load
40	—		23 kΩ	FM signal meter adjustment

■ Technical Data (continued)

- P_D — T_a diagram



■ Usage Notes

• Special attention and precaution in using

1. This IC is intended to be used for general electronic equipment [Home audio tuner].
   Consult our sales staff in advance for information on the following applications:
   ・Special applications in which exceptional quality and reliability are required, or if the failure or malfunction of this IC may directly jeopardize life or harm the human body.
   ・Any applications other than the standard applications intended.
   (1) Space appliance (such as artificial satellite, and rocket)
   (2) Traffic control equipment (such as for automobile, airplane, train, and ship)
   (3) Medical equipment for life support
   (4) Submarine transponder
   (5) Control equipment for power plant
   (6) Disaster prevention and security device
   (7) Weapon
   (8) Others : Applications of which reliability equivalent to (1) to (7) is required
2. Pay attention to the direction of LSI. When mounting it in the wrong direction onto the PCB (printed-circuit-board), it might smoke or ignite.
3. Pay attention in the PCB (printed-circuit-board) pattern layout in order to prevent damage due to short circuit between pins. In addition, refer to the Pin Description for the pin configuration.
4. Perform a visual inspection on the PCB before applying power, otherwise damage might happen due to problems such as a solder-bridge between the pins of the semiconductor device. Also, perform a full technical verification on the assembly quality, because the same damage possibly can happen due to conductive substances, such as solder ball, that adhere to the LSI during transportation.
5. Take notice in the use of this product that it might break or occasionally smoke when an abnormal state occurs such as output pin-V_{CC} short (Power supply fault), output pin-GND short (Ground fault), or output-to-output-pin short (load short) .
   And, safety measures such as an installation of fuses are recommended because the extent of the above-mentioned damage and smoke emission will depend on the current capability of the power supply.
   And IC is destroyed under the conditions listed below,
   (1) V_{CC2} and Pin5 are shorted.
   (2) V_{CC2} and Pin22 are shorted.
   (3) V_{CC2} and Pin45 are shorted.
6. When designing your equipment, comply with the range of absolute maximum rating and the guaranteed operating conditions (operating power supply voltage and operating environment etc.). Especially, please be careful not to exceed the range of absolute maximum rating on the transient state, such as power-on, power-off and mode-switching. Otherwise, we will not be liable for any defect which may arise later in your equipment.
   Even when the products are used within the guaranteed values, take into the consideration of incidence of break down and failure mode, possible to occur to semiconductor products. Measures on the systems such as redundant design, arresting the spread of fire or preventing glitch are recommended in order to prevent physical injury, fire, social damages, for example, by using the products.
7. When using the LSI for new models, verify the safety including the long-term reliability for each product.
8. When the application system is designed by using this LSI, be sure to confirm notes in this book.
   Be sure to read the notes to descriptions and the usage notes in the book.

Request for your special attention and precautions in using the technical information and semiconductors described in this book

(1) If any of the products or technical information described in this book is to be exported or provided to non-residents, the laws and regulations of the exporting country, especially, those with regard to security export control, must be observed.

(2) The technical information described in this book is intended only to show the main characteristics and application circuit examples of the products. No license is granted in and to any intellectual property right or other right owned by Panasonic Corporation or any other company. Therefore, no responsibility is assumed by our company as to the infringement upon any such right owned by any other company which may arise as a result of the use of technical information described in this book.

(3) The products described in this book are intended to be used for standard applications or general electronic equipment (such as office equipment, communications equipment, measuring instruments and household appliances).
Consult our sales staff in advance for information on the following applications:
- Special applications (such as for airplanes, aerospace, automobiles, traffic control equipment, combustion equipment, life support systems and safety devices) in which exceptional quality and reliability are required, or if the failure or malfunction of the products may directly jeopardize life or harm the human body.
- Any applications other than the standard applications intended.

(4) The products and product specifications described in this book are subject to change without notice for modification and/or improvement. At the final stage of your design, purchasing, or use of the products, therefore, ask for the most up-to-date Product Standards in advance to make sure that the latest specifications satisfy your requirements.

(5) When designing your equipment, comply with the range of absolute maximum rating and the guaranteed operating conditions (operating power supply voltage and operating environment etc.). Especially, please be careful not to exceed the range of absolute maximum rating on the transient state, such as power-on, power-off and mode-switching. Otherwise, we will not be liable for any defect which may arise later in your equipment.
Even when the products are used within the guaranteed values, take into the consideration of incidence of break down and failure mode, possible to occur to semiconductor products. Measures on the systems such as redundant design, arresting the spread of fire or preventing glitch are recommended in order to prevent physical injury, fire, social damages, for example, by using the products.

(6) Comply with the instructions for use in order to prevent breakdown and characteristics change due to external factors (ESD, EOS, thermal stress and mechanical stress) at the time of handling, mounting or at customer's process. When using products for which damp-proof packing is required, satisfy the conditions, such as shelf life and the elapsed time since first opening the packages.

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