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DOCUMENT COVER PAGE

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Doc Title	Product Specifications for AN8049FHN	Total no. of pages (excluding this page)		25

Revision History

Issue	Rev	Eff Date	S/N	Page	Change Details	Remarks
1	0	27-SEP-06	1	-	Added this cover page.	

FMSC-GEN-M1-01

Product Standards

Part No.	AN8049FHN
Package Code No.	*QFN024-P-0405B

Analogue LSI Business Unit
Semiconductor Company
Matsushita Electric Industrial Co., Ltd.

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2006-09-27	
Established	Revised

Contents

AN8049FHN

1.8-volt 3-channel step-up, step-down, and polarity inverting DC-DC converter control IC

■ Overview

AN8049FHN is a three-channel PWM DC-DC converter control IC that features low-voltage operation. This IC can form a power supply that provides two step-up outputs and one step-down or polarity inverted output with a minimal number of external components. Minimal operating supply voltage of this IC is as low as 1.8 V, so that it can operate from 2 dry-batteries.

■ Features

- Wide operating supply voltage range : 1.8 V to 14 V
- High-precision reference voltage circuit
  — V_{REF} pin voltage : ±1 %
  — Error amplifier : ±1.5 %
- Ultrathin surface mounting package for miniaturized and thinner power supplies
- Supports control over a wide output frequency range : 20 kHz to 1 MHz
- On/off (sequence control) pins provided for each channel for easy sequence control setup
- The negative supply error amplifier supports 0 volt input.
  Common-mode input voltage range : – 0.1 V to V_{CC} –1.4 V
  This allows the number of external components to be reduced by two resistors.
- Fixed duty factor : 86 %
  However, the duty can be adjusted to anywhere from 0 % to 100 % with an external resistor.
- Timer latch short-circuit protection circuit (charge current : 1.1 µA typical)
- Low input voltage malfunction prevention circuit (U.V.L.O.)
  (operation start voltage : 1.67 V typical)
- Standby function (active-high control input, standby mode current : 1 µA maximum)

■ Applications

- Electronic equipment that requires a power supply system

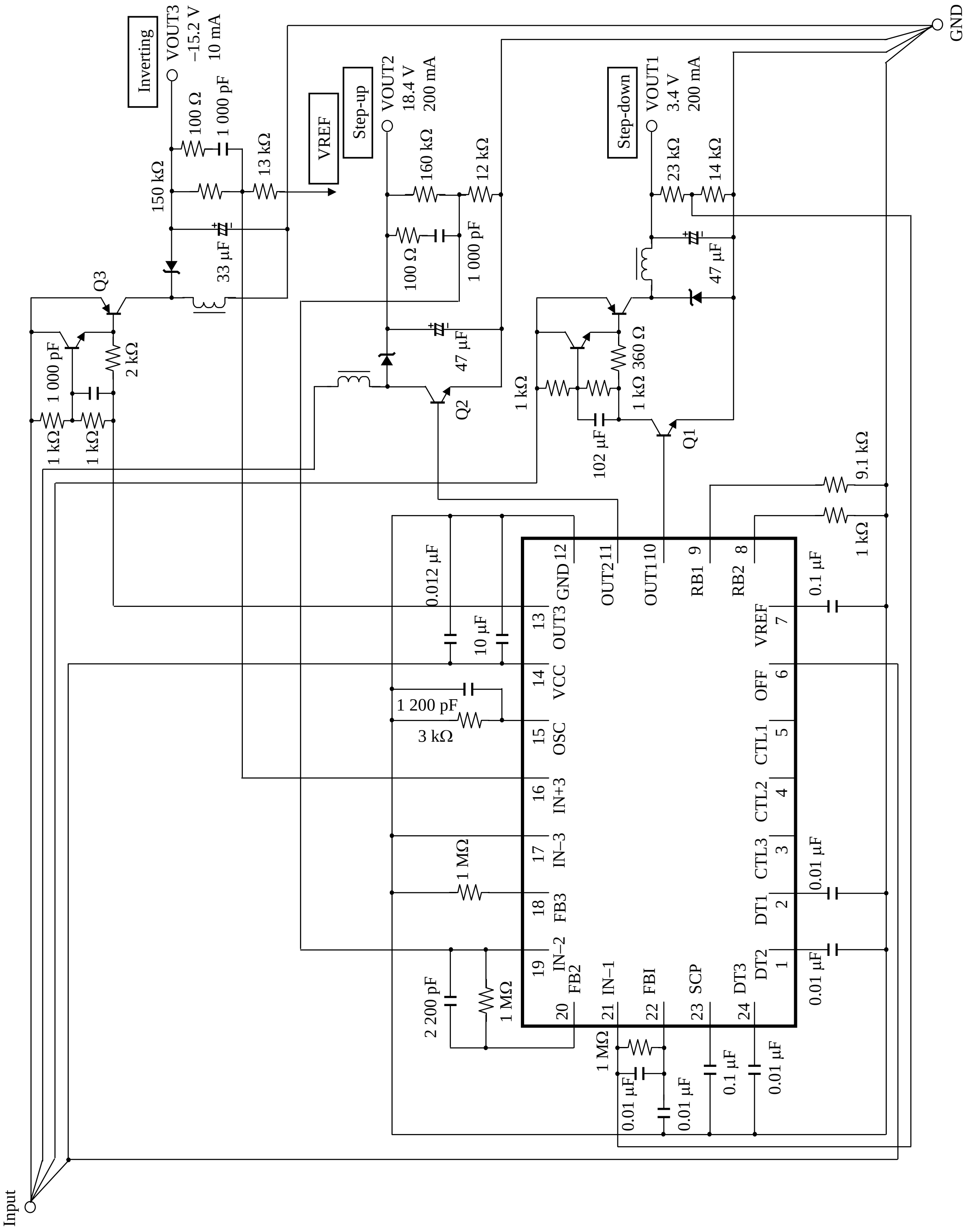
■ Package

- 24pin Plastic Quad Flat Non-leaded Package (QFN Type)

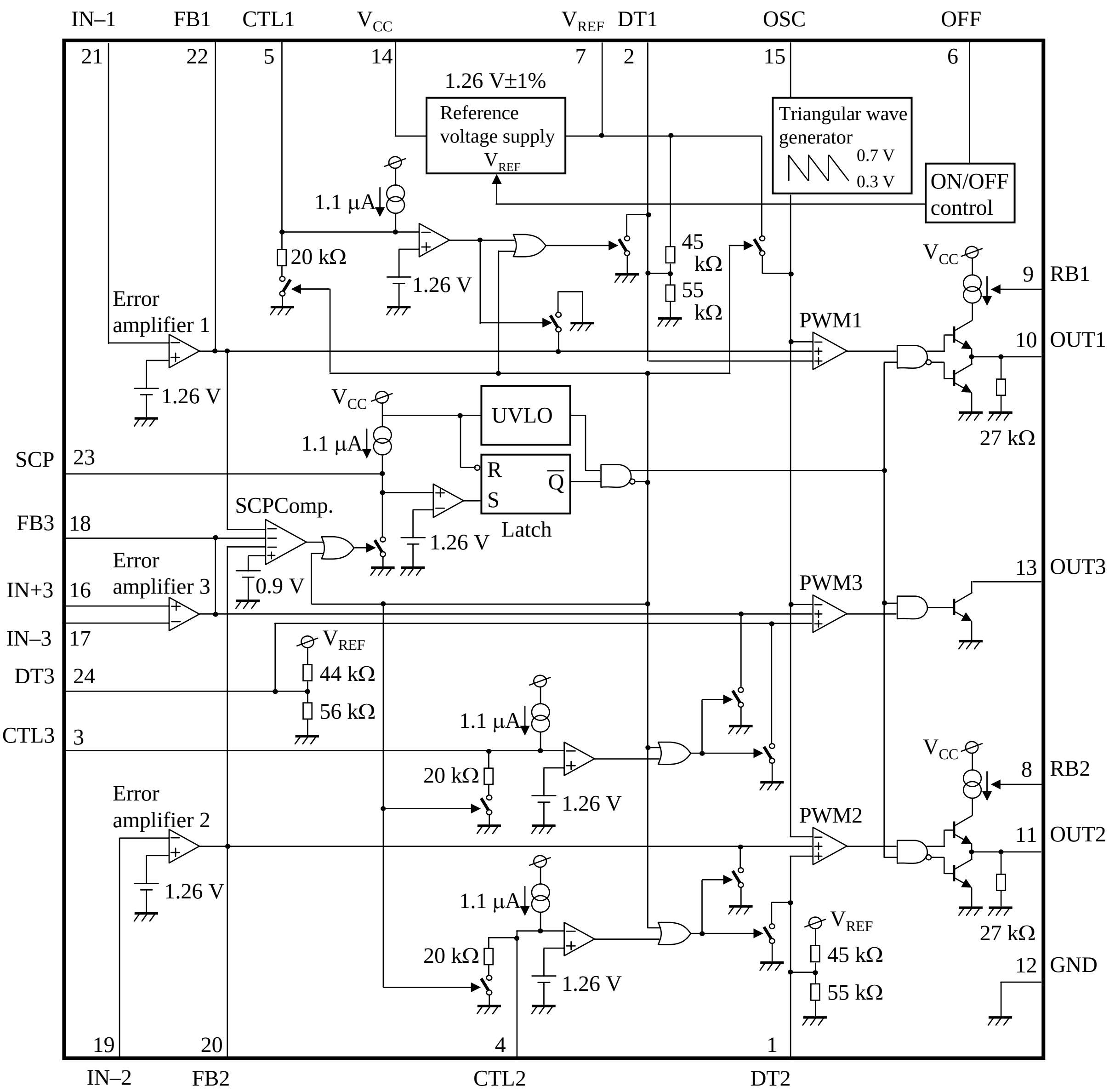
■ Type

- Silicon monolithic bipolar IC

■ Application Circuit Example



■ Block Diagram



■ Pin Descriptions

Pin No.	Pin name	Type	Description
1	DT2	—	Channel2 soft start setting
2	DT1	—	Channel1 soft start setting
3	CTL3	Input	Channel3 on/off control
4	CTL2	Input	Channel2 on/off control
5	CTL1	Input	Channel1 on/off control
6	OFF	Input	On/off control
7	VREF	Output	Reference voltage output
8	RB2	—	Output source current setting resistor connection for OUT2 block
9	RB1	—	Output source current setting resistor connection for OUT1 block
10	OUT1	Output	OUT1 block push-pull type output
11	OUT2	Output	OUT2 block push-pull type output
12	GND	Ground	Ground
13	OUT3	Output	OUT3 block open-collector type output
14	VCC	Power Supply	Voltage supply
15	OSC	—	Oscillator circuit timing resistor/capacitor connection
16	IN+3	Input	Error amplifier 3 block non-inverting input
17	IN–3	Input	Error amplifier 3 block inverting input
18	FB3	Output	Error amplifier 3 block output
19	IN–2	Input	Error amplifier 2 block inverting input
20	FB2	Output	Error amplifier 2 block output
21	IN–1	Input	Error amplifier 1 block inverting input
22	FB1	Output	Error amplifier 1 block output
23	SCP	—	Time constant setting capacitor connection for short-circuit protection
24	DT3	—	Channel 3 soft start setting

■ Absolute Maximum Ratings

A No.	Parameter	Symbol	Rating	Unit	Notes
1	Supply voltage	V_{CC}	14.2	V	*1
2	Supply current	I_{CC}	—	mA	—
3	Power dissipation	P_D	111	mW	*2
4	Operating ambient temperature	T_{opr}	–30 to +85	°C	*3
5	Storage temperature	T_{stg}	–55 to +125	°C	*3
6	OFF pin allowable applied voltage	V_{OFF}	14.2	V	—
7	CTL pin allowable applied voltage	V_{CTL}	V_{CC} – 0.2	V	—
8	Error amplifier input pin allowable applied voltage	V_{IN}	6	V	*4
9	OUT1 and OUT2 pins output source current	$I_{SO(OUT)}$	–50	mA	—
10	OUT3 pin output current	I_O	+50	mA	—

Notes) *1: The values under the condition not exceeding the above absolute maximum ratings and the power dissipation.

*2: The power dissipation shown is the value at T_a = 85°C for the independent (unmounted) IC package.
When using this IC, refer to the P_D-T_a diagram of the package standard page 4 and use under the condition not exceeding the allowable value.

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

*4: When V_{CC} < 6 V, the following condition must be satisfied : $V_{IN-1} = V_{IN+2} = V_{CC} - 0.2$ V

■ Operating Supply Voltage Range

Parameter	Symbol	Range	Unit	Notes
Supply voltage range	V_{CC}	1.8 to 14	V	*

Note) *: The values under the condition not exceeding the above absolute maximum ratings and the power dissipation.

■ Recommended Operating Conditions

A No.	Parameter	Symbol	Min	Max	Unit	Notes
1	OFF pin applied voltage	V_{OFF}	0	14	V	*
2	OUT1/OUT2 pin output source current	$I_{SO(OUT)}$	–40	–1	mA	*
3	OUT3 pin output current	I_O	—	40	mA	*
4	Timing resistance	R_T	3	33	kΩ	*
5	Timing capacitance	C_T	100	10 000	pF	*
6	Oscillator frequency	f_{OUT}	20	1 000	kHz	*
7	Time-constant setting capacitance for short-circuit protection	C_{SCP}	1 000	—	pF	*
8	Output current setting resistance	R_B	750	15 000	Ω	*

Note) *: Do not apply current or voltage from external source to any pin not listed above.
In the circuit current, (+) means the current flowing into IC and (–) means the current flowing out of IC.

■ Electrical Characteristics at V_{CC} = 2.4 V, C_{REF} = 0.1 μF

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

B No.	Parameter	Symbol	Test circuits	Conditions	Limits Min	Typ	Max	Unit	Notes
Reference Voltage Block									
1	Reference voltage	V_{REF}	1	I_{REF} = – 0.1 mA	1.247	1.26	1.273	V	
2	Line regulation	Line	1	V_{CC} = 1.8 V to 14 V	—	2	20	mV	
3	Load regulation	Load	1	I_{REF} = – 0.1 mA to –1 mA	–20	–3	—	mV	
U.V.L.O. Block									
4	U.V.L.O. start voltage	V_{UON}	2	—	1.59	1.67	1.75	V	
Error Amplifier 1 Block									
5	Input threshold voltage 1	V_{TH1}	3	—	1.241	1.26	1.279	V	
6	Input bias current 1	I_{B1}	3	—	—	0.1	0.2	μA	
7	High-level output voltage 1	V_{EH1}	3	—	1.0	1.2	1.4	V	
8	Low-level output voltage 1	V_{EL1}	3	—	—	—	0.2	V	
9	Output source current 1	$I_{SO(FB)1}$	3	—	–38	–31	–24	μA	
10	Output sink current 1	$I_{SI(FB)1}$	3	—	0.5	—	—	mA	
Error Amplifier 2 Block									
11	Input threshold voltage 2	V_{TH2}	4	—	1.241	1.26	1.279	V	
12	Input bias current 2	I_{B2}	4	—	—	0.1	0.2	μA	
13	High-level output voltage 2	V_{EH2}	4	—	1.0	1.2	1.4	V	
14	Low-level output voltage 2	V_{EL2}	4	—	—	—	0.2	V	
15	Output source current 2	$I_{SO(FB)2}$	4	—	–38	–31	–24	μA	
16	Output sink current 2	$I_{SI(FB)2}$	4	—	0.5	—	—	mA	
Error Amplifier 3 Block									
17	Input offset voltage	V_{IO}	5	—	–6	—	6	mV	
18	Common-mode input voltage range	V_{ICR}	5	—	– 0.1	—	V_{CC} –1.4	V	
19	Input bias current 3	I_{B3}	5	—	– 0.6	– 0.3	—	μA	
20	High-level output voltage 3	V_{EH3}	5	—	1.0	1.2	1.4	V	
21	Low-level output voltage 3	V_{EL3}	5	—	—	—	0.2	V	
22	Output source current 3	$I_{SO(FB)3}$	5	—	–38	–31	–24	μA	
23	Output sink current 3	$I_{SI(FB)3}$	5	—	0.5	—	—	mA	
Oscillator Block									
24	Oscillator frequency	f_{OUT}	6	R_{OSC} = 7.5 kΩ, C_{OSC} = 680 pF	170	190	210	kHz	

■ Electrical Characteristics at V_{CC} = 2.4 V, C_{REF} = 0.1 μF (continued)

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

B No.	Parameter	Symbol	Test circuits	Conditions	Limits Min	Typ	Max	Unit	Notes
Output 1 Block									
25	Output duty ratio 1	D_{U1}	6	R_{OSC} = 7.5 kΩ, C_{OSC} = 680 pF	80	86	92	%	
26	High-level output voltage 1	V_{OH1}	7	I_O = –10 mA, R_B = 1 kΩ	V_{CC} –1	—	—	V	
27	Low-level output voltage 1	V_{OL1}	7	I_O = 10 mA, R_B = 1 kΩ	—	—	0.2	V	
28	Output source current 1	$I_{SO(OUT)1}$	7	V_O = 0.7 V, R_B = 1 kΩ	–34	–29	–24	mA	
29	Output sink current 1	$I_{SI(OUT)1}$	7	V_O = 0.7 V, R_B = 1 kΩ	40	—	—	mA	
30	Pull-down resistance 1	R_{O1}	7	—	17	27	37	kΩ	
Output 2 Block									
31	Output duty ratio 2	D_{U2}	6	R_{OSC} = 7.5 kΩ, C_{OSC} = 680 pF	80	86	92	%	
32	High-level output voltage 2	V_{OH2}	8	I_O = –10 mA, R_B = 1 kΩ	V_{CC} –1	—	—	V	
33	Low-level output voltage 2	V_{OL2}	8	I_O = 10 mA, R_B = 1 kΩ	—	—	0.2	V	
34	Output source current 2	$I_{SO(OUT)2}$	8	V_O = 0.7 V, R_B = 1 kΩ	–34	–29	–24	mA	
35	Output sink current 2	$I_{SI(OUT)2}$	8	V_O = 0.7 V, R_B = 1 kΩ	40	—	—	mA	
36	Pull-down resistance 2	R_{O2}	8	—	17	27	37	kΩ	
Output 3 Block									
37	Output duty ratio 3	D_{U3}	6	R_{OSC} = 7.5 kΩ, C_{OSC} = 680 pF	80	86	92	%	
38	Output saturation voltage	$V_{O(sat)}$	9	I_O = 40 mA	—	—	0.5	V	
39	Output leakage current	I_{OLE}	9	V_{13} = 14 V	—	—	1	μA	
Short-circuit Protection Circuit Block									
40	Input standby voltage	V_{STBY}	10	—	—	—	0.1	V	
41	Input threshold voltage	V_{THPC}	10	—	0.8	0.9	1.0	V	
42	Input latch voltage	V_{IN}	10	—	—	—	0.1	V	
43	Charge current	I_{CHG}	10	V_{SCP} = 0V	–1.43	–1.1	– 0.77	μA	
ON/OFF Control Block									
44	Input threshold voltage	$V_{ON(TH)}$	12	—	0.6	0.9	1.2	V	
CTL Block									
45	Input threshold voltage	V_{THCTL}	11	—	1.07	1.26	1.45	V	
46	Charge current	I_{CTL}	11	V_{CTL} = 0 V	–1.43	–1.1	– 0.77	μA	
The Whole Circuit									
47	Average current consumption	$I_{CC(OFF)}$	13	R_B = 1 kΩ, Duty ratio = 50 %	—	7	9	mA	
48	Current consumption in standby mode	$I_{CC(SB)}$	12	—	—	—	1	μA	

■ Electrical Characteristics (Reference values for design)

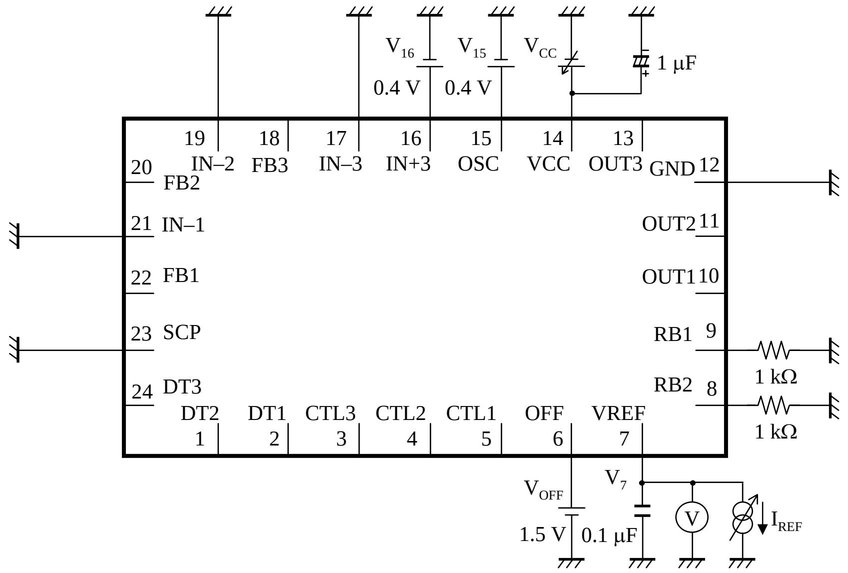
Note) T_a = 25°C±2°C unless otherwise specified.

B No.	Parameter	Symbol	Test circuits	Conditions	Reference values Min	Typ	Max	Unit	Notes
Reference Voltage Block									
49	Change of V_{REF} with ambient temperature	V_{REFdT}	1	Ta = –30°C to +85°C	—	1	—	%	*1
Error Amplifier 1 Block									
50	Change of V_{TH} with ambient temperature 1	V_{THdT1}	3	Ta = –30°C to +85°C	—	1.5	—	%	*1
51	Open-loop gain 1	A_{V1}	14	—	—	80	—	dB	*1
Error Amplifier 2 Block									
52	Change of V_{TH} with ambient temperature 2	V_{THdT2}	4	Ta = –30°C to +85°C	—	1.5	—	%	*1
53	Open-loop gain 2	A_{V2}	14	—	—	80	—	dB	*1
Error Amplifier 3 Block									
54	Open-loop gain 3	A_{V3}	14	—	—	80	—	dB	*1
Oscillator Block									
55	Change of frequency with supply voltage	f_{dV}	6	VCC = 1.8 V to 14 V R_{OSC} = 7.5 kΩ, C_{OSC} = 680 pF	—	1	—	%	*1
56	Change of frequency with ambient temperature	f_{dT}	6	Ta = –30°C to +85°C R_{OSC} = 7.5 kΩ, C_{OSC} = 680 pF	—	3	—	%	*1
Short-circuit Protection Circuit Block									
57	Comparator threshold voltage	V_{THL}	10	—	—	1.26	—	V	*1
ON/OFF Control Block									
58	OFF pin current	I_{OFF}	12	V_{OFF} = 5 V	—	38	—	μA	*1

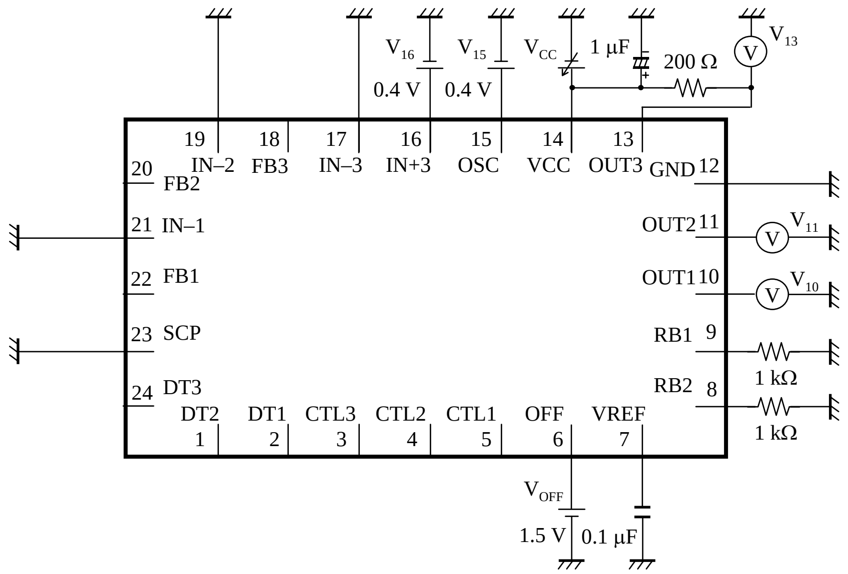
Note) *1: The above characteristics are reference values for design of the IC and are not guaranteed by inspection.
If a problem does occur related to these characteristics, Matsushita will respond in good faith to user concerns.

■ Test Circuit Diagram

1. Test Circuit1

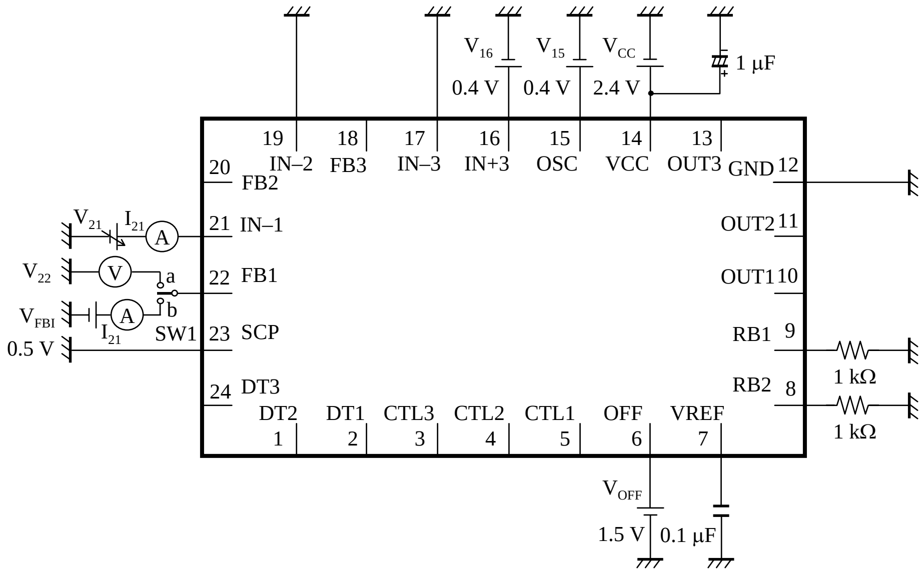


2. Test Circuit2

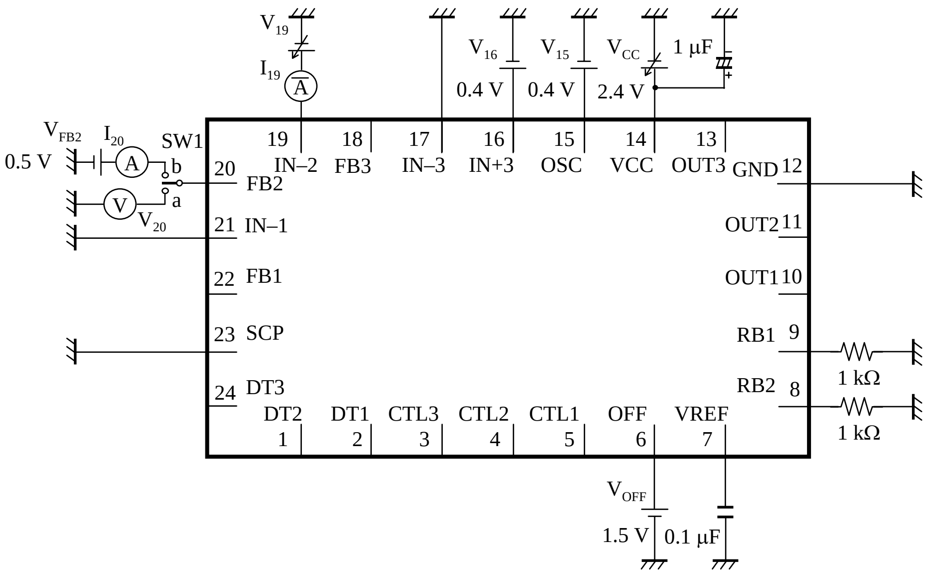


■ Test Circuit Diagram (continued)

3. Test Circuit3

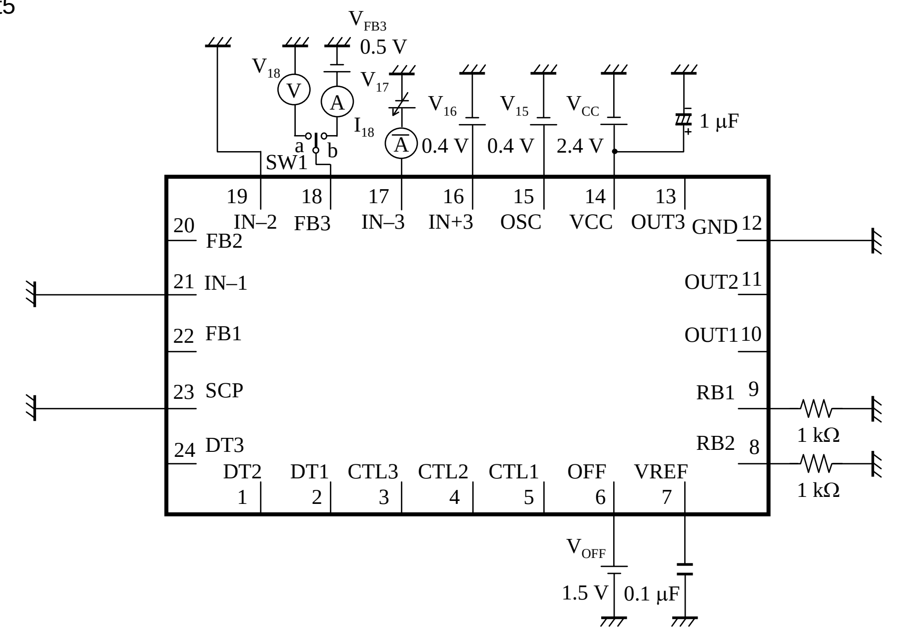


4. Test Circuit4

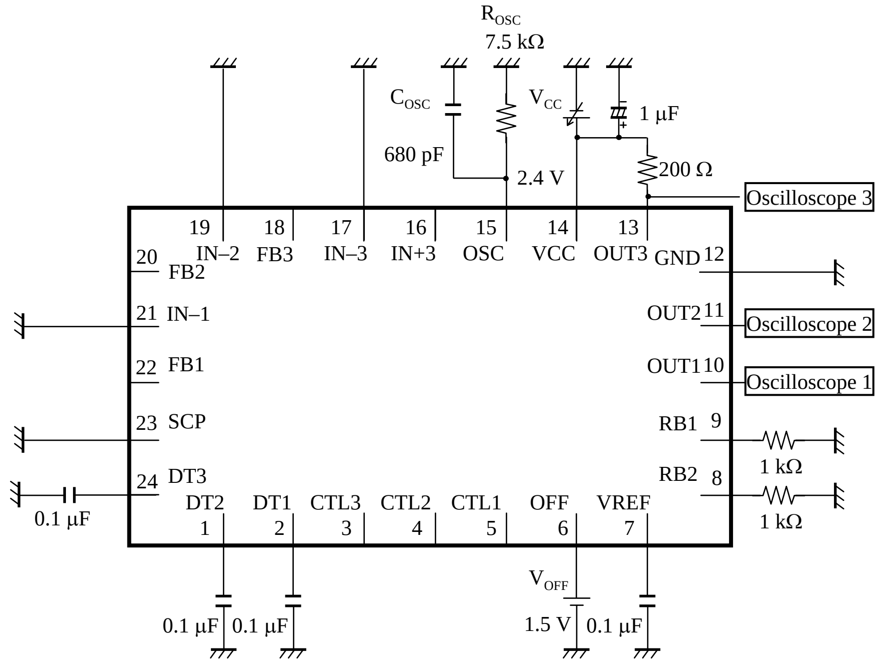


■ Test Circuit Diagram (continued)

5. Test Circuit5

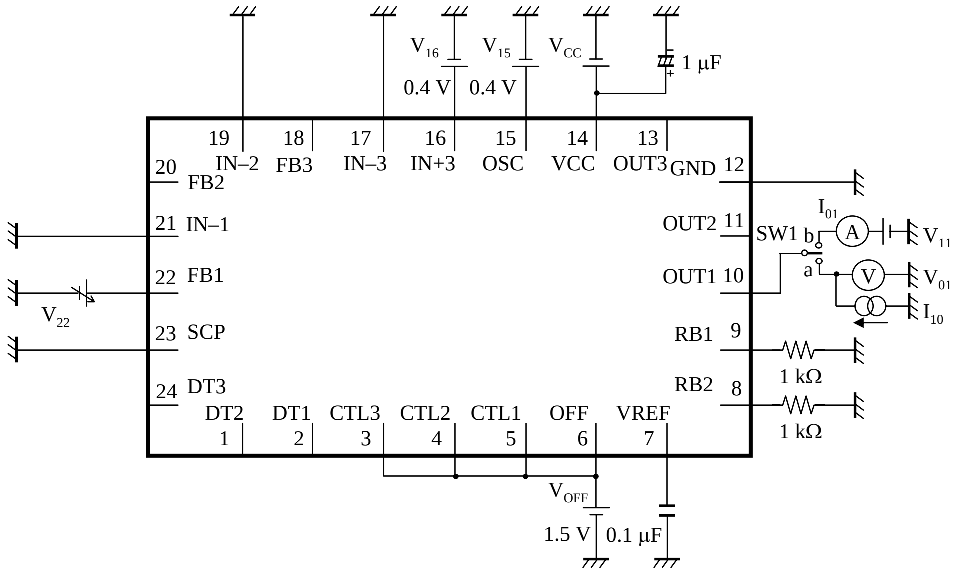


6. Test Circuit6

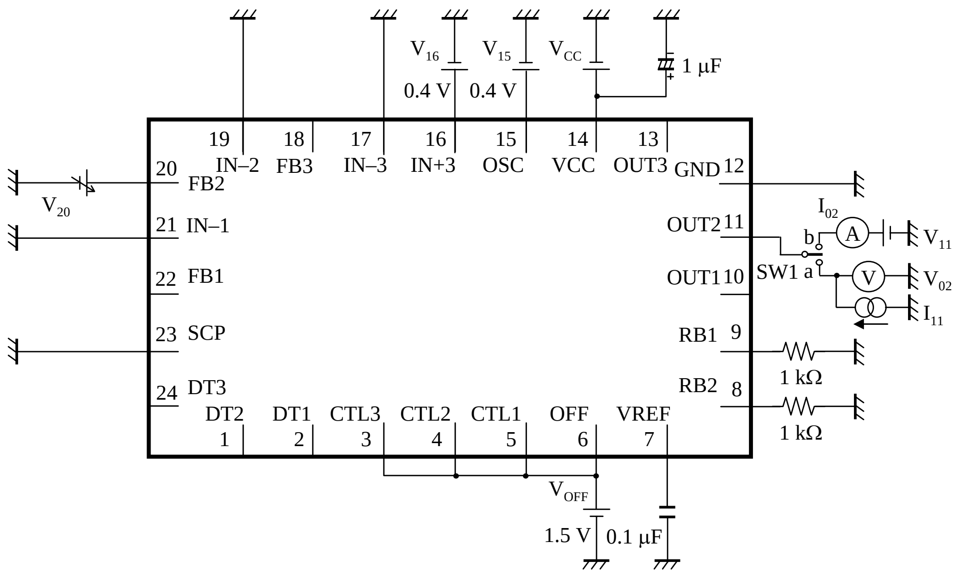


■ Test Circuit Diagram (continued)

7. Test Circuit7

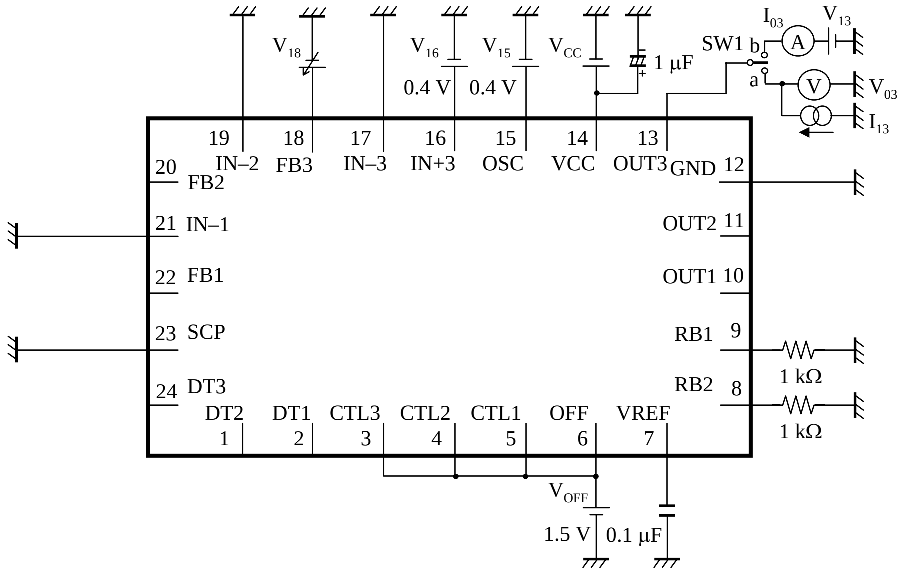


8. Test Circuit8

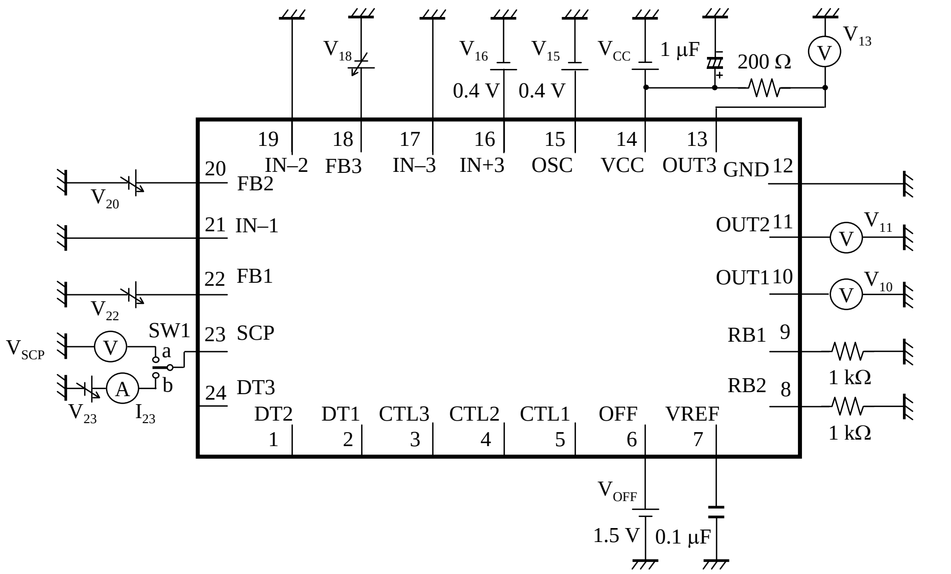


■ Test Circuit Diagram (continued)

9. Test Circuit9

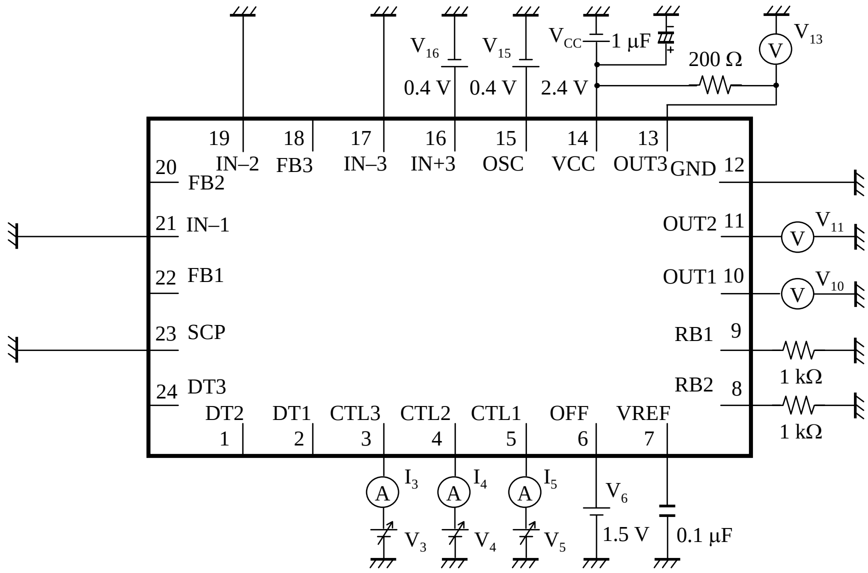


10. Test Circuit10

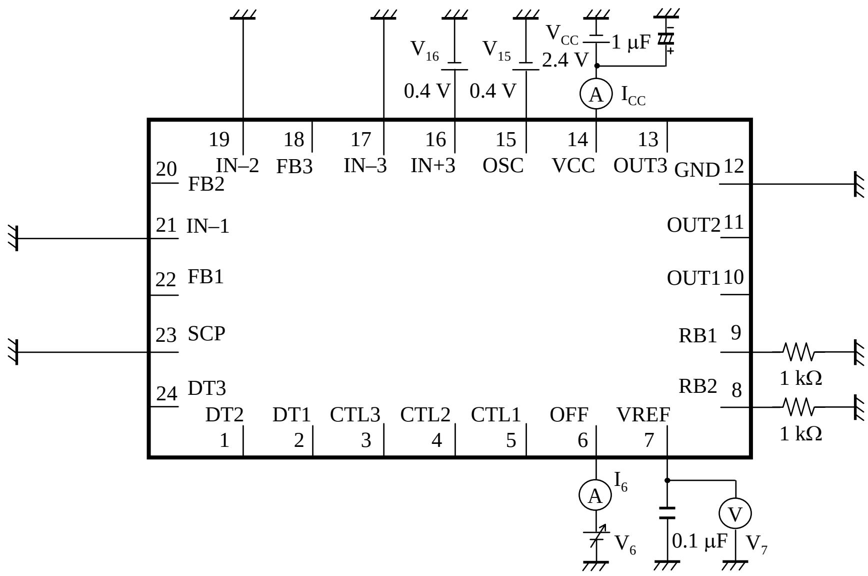


■ Test Circuit Diagram (continued)

11. Test Circuit11

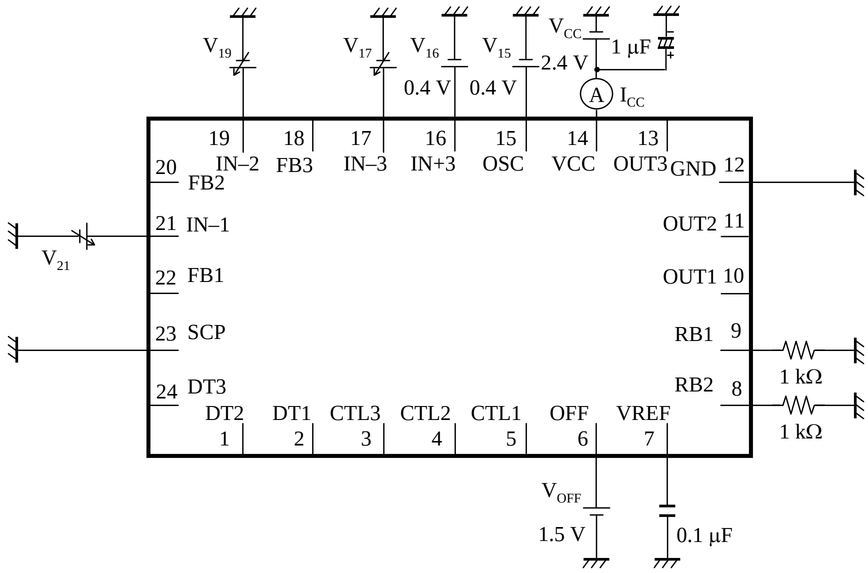


12. Test Circuit12

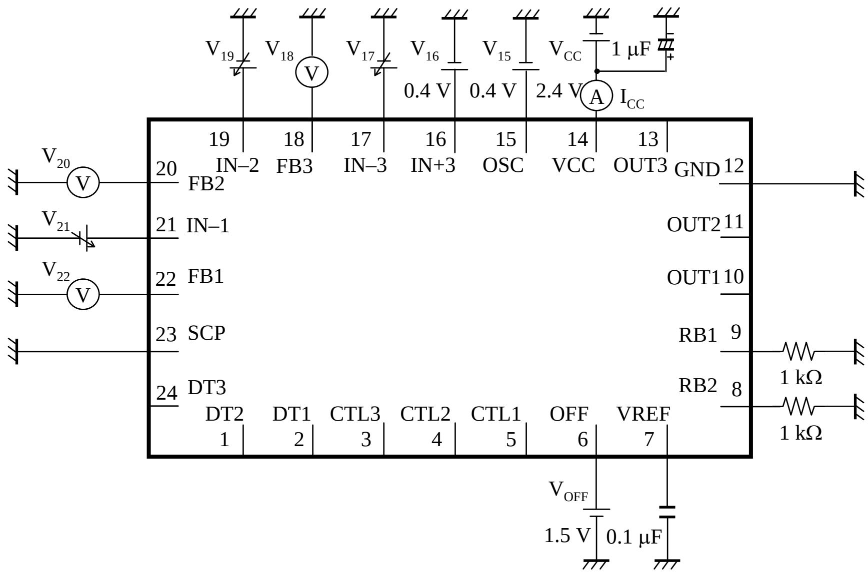


■ Test Circuit Diagram (continued)

13. Test Circuit13



14. Test Circuit14



■ Electrical Characteristics Test Procedures

1. Test Circuit1

C No.	Parameter	Conditions	Measurement Method
1	Reference voltage	V_{CC} = 2.4 V I_{REF} = 0.1 mA	Measure the voltage V_7.
2	Line regulation	V_{CC} = 1.8 V to 14 V I_{REF} = 0.1 mA	Measure the change of V_7 voltage.
3	Load regulation	V_{CC} = 2.4 V I_{REF} = 0.1 mA to 1 mA	Measure the change of V_7 voltage.
49	Change of V_{REF} with ambient temperature	V_{CC} = 2.4 V I_{REF} = 0.1 mA Ta = –30°C to +85°C	Measure the change rate of V_7 voltage.

2. Test Circuit2

C No.	Parameter	Conditions	Measurement Method
4	U.V.L.O. start voltage	V_{CC} : variable	Measure the voltage V_{CC} when V_{10} and V_{11} change from low to high level and V_{13} changes from high to low level while increasing the V_{CC} voltage gradually.

3. Test Circuit3 [Error Amplifier 1 Block]

C No.	Parameter	Conditions	Measurement Method
5	Input threshold voltage 1	V_{21} : variable SW1 : a	Measure the voltageV_{21} when V_{22} changes from low to high level while decreasing the V_{21} voltage gradually from 1.5 V.
6	Input bias current 1	V_{21} : 1.5 V SW1 : a	Measure the current I_{21} .
7	High-level output voltage 1	V_{21} : 0.5 V SW1 : a	Measure the voltage V_{22} .
8	Low-level output voltage 1	V_{21} : 1.5 V SW1 : a	
9	Output source current 1	V_{21} : 0.5 V SW1 : b	Measure the current I_{22} .
10	Output sink current 1	V_{21} : 1.5 V SW1 : b	
50	Change of V_{TH} with ambient temperature 1	V_{21} : variable, SW1 : a Ta = –30°C to +85°C	Measure the change rate of V_{TH1} voltage.

■ Electrical Characteristics Test Procedures (continued)

4. Test Circuit4 [Error Amplifier 2 Block]

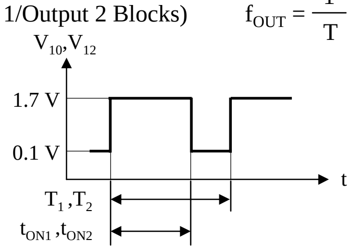
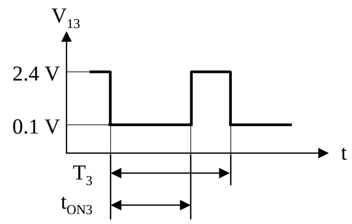
C No.	Parameter	Conditions	Measurement Method
11	Input threshold voltage 2	V_{19} : variable SW1 : a	Measure the voltage V_{19} when V_{20} changes from low to high level while decreasing the V_{19} voltage gradually from 1.5 V.
12	Input bias current 2	V_{19} : 1.5 V SW1 : a	Measure the current I_{IN2} .
13	High-level output voltage 2	V_{19} : 0.5 V SW1 : a	Measure the voltage V_{20} .
14	Low-level output voltage 2	V_{19} : 1.5 V SW1 : a	
15	Output source current 2	V_{19} : 0.5 V SW1 : b	Measure the current I_{20} .
16	Output sink current 2	V_{19} : 1.5 V SW1 : b	
52	Change of V_{TH} with ambient temperature 2	V_{19} : variable, SW1 : a Ta = –30°C to +85°C	Measure the change rate of V_{TH2} voltage.

5. Test Circuit5 [Error Amplifier 3 Block]

C No.	Parameter	Conditions	Measurement Method
17	Input offset voltage	V_{16} : 0 V V_{17} : variable SW1 : a	Measure the voltage V_{17} when V_{18} changes from low to high level while decreasing the V_{17} voltage gradually from 0.5 V.
18	Common-mode input voltage range	V_{16} : – 0.1 V V_{17} : variable, SW1 : a V_{16} : 1 V V_{17} : variable, SW1 : a	Measure the voltage V_{17} when V_{18} changes from low to high level while decreasing the V_{17} voltage gradually from 1.1 V.
19	Input bias current 3	V_{16} : 0 V V_{17} : – 0.1 V SW1 : a	Measure the current I_{17} .
20	High-level output voltage 3	V_{16} : 0 V V_{17} : – 0.1 V SW1 : a	Measure the voltage V_{18} .
21	Low-level output voltage 3	V_{16} : 0 V V_{17} : 0.1 V SW1 : a	
22	Output source current 3	V_{16} : 0 V V_{17} : – 0.1 V SW1 : b	Measure the current I_{18} .
23	Output sink current 3	V_{16} : 0 V V_{17} : 0.2 V SW1 : b	

■ Electrical Characteristics Test Procedures (continued)

6. Test Circuit6

C No.	Parameter	Conditions	Measurement Method
24	Oscillator frequency	V_{CC} = 2.4 V	Observe the waveform of oscilloscope. (Output 1/Output 2 Blocks) $f_{OUT} = \frac{1}{T}$ (Hz)  (Output 3 Block) 
25	Output duty ratio 1	V_{CC} = 2.4 V	$D_{U1} = \frac{t_{ON1}}{T_1} \times 100(\%)$
31	Output duty ratio 2	V_{CC} = 2.4 V	$D_{U2} = \frac{t_{ON2}}{T_2} \times 100(\%)$
37	Output duty ratio 3	V_{CC} = 2.4 V	$D_{U3} = \frac{t_{ON3}}{T_3} \times 100(\%)$
55	Change of frequency with supply voltage	V_{CC} = 1.8 V to 14 V	Measure the change rate of f_{OUT} frequency .
56	Change of frequency with ambient temperature	V_{CC} = 2.4 V Ta = –30°C to +85°C	Measure the change rate of f_{OUT} frequency .

■ Electrical Characteristics Test Procedures (continued)

7. Test Circuit7 [Output 1 Block]

C No.	Parameter	Conditions	Measurement Method
26	High-level output voltage 1	V_{CC} = 2.4 V, V_{22} = 0.7 V SW1 : a, I_{10} = –10 mA	Measure the voltage V_{O1}.
27	Low-level output voltage 1	V_{CC} = 2.4 V, V_{22} = 0.2 V SW1 : a, I_{10} = 10 mA	
28	Output source current 1	V_{CC} = 2.4 V, V_{22} = 0.7 V SW1 : b, V_{10} = 0.7 V	Measure the current I_{O1}.
29	Output sink current 1	V_{CC} = 2.4 V, V_{22} = 0.2 V SW1 : b, V_{10} = 0.7 V	
30	Pull-down resistance 1	V_{CC} = 0 V SW1 : a, I_{10} = 10 μA	$R_{O1} = \frac{V_{O1}}{10\ \mu A}$

8. Test Circuit8 [Output 2 Block]

C No.	Parameter	Conditions	Measurement Method
32	High-level output voltage 2	V_{CC} = 2.4 V, V_{20} = 0.7 V SW1 : a, I_{11} = –10 mA	Measure the voltage V_{O2}.
33	Low-level output voltage 2	V_{CC} = 2.4 V, V_{20} = 0.2 V SW1 : a, I_{11} = 10 mA	
34	Output source current 2	V_{CC} = 2.4 V, V_{20} = 0.7 V SW1 : b, V_{11} = 0.7 V	Measure the current I_{O2}.
35	Output sink current 2	V_{CC} = 2.4 V, V_{20} = 0.2 V SW1 : b, V_{11} = 0.7 V	
36	Pull-down resistance 2	V_{CC} = 0 V SW1 : a, I_{11} = 10 μA	$R_{O2} = \frac{V_{O2}}{10\ \mu A}$

9. Test Circuit9 [Output 3 Block]

C No.	Parameter	Conditions	Measurement Method
38	Output saturation voltage	V_{CC} = 2.4 V, V_{18} = 0.7 V I_{13} = 40 mA, SW1 : a	Measure the voltage V_{O3}.
39	Output leakage current	V_{CC} = 2.4 V, V_{18} = 0.2 V V_{13} = 14 V, SW1 : b	Measure the current I_{O3}.

■ Electrical Characteristics Test Procedures (continued)

10. Test Circuit10

C No.	Parameter	Conditions	Measurement Method
40	Input standby voltage	$V_{18} = V_{20} = V_{22} = 0.6$ V SW1 : a	Measure the voltage V_{SCP}.
41	Input threshold voltage	V_{22} : variable $V_{18} = V_{20} = 0.6$ V SW1 : a	Measure the voltage V_{22} when V_{10} and V_{11} change from high to low level and V_{13} changes from low to high level while increasing the V_{22} voltage gradually from 0.6 V.
		V_{20} : variable $V_{18} = V_{22} = 0.6$ V SW1 : a	Measure the voltage V_{20} when V_{10} and V_{11} change from high to low level and V_{13} changes from low to high level while increasing the V_{20} voltage gradually from 0.6 V.
		V_{18} : variable $V_{20} = V_{22} = 0.6$ V SW1 : a	Measure the voltage V_{18} when V_{10} and V_{11} change from high to low level and V_{13} changes from low to high level while increasing the V_{18} voltage gradually from 0.6 V.
42	Input latch voltage	Keep on hold the state when V_{10} and V_{11} are set to low level and V_{13} is set to high level under the above measurement No.41.	Measure the voltage V_{SCP}.
43	Charge current	$V_{18} = V_{20} = V_{22} = 1.2$ V SW1 : b, $V_{23} = 0$ V	Measure the current I_{23}.
57	Comparator threshold voltage	$V_{18} = V_{20} = V_{22} = 1.2$ V SW1 : b, V_{23} = variable	Measure the voltage V_{22} when V_{10} and V_{12} change from high to low level and V_{13} changes from low to high level while increasing the V_{23} voltage gradually from 0 V.

11. Test Circuit11

C No.	Parameter	Conditions	Measurement Method
45	Input threshold voltage	V_5 : variable $V_3 = V_4 = 0$ V	Measure the voltage V_5 when V_{10} changes from low to high level while increasing the V_5 voltage gradually from 0 V.
		V_4 : variable $V_3 = V_5 = 0$ V	Measure the voltage V_4 when V_{11} changes from low to high level while increasing the V_4 voltage gradually from 0 V.
		V_3 : variable $V_4 = V_5 = 0$ V	Measure the voltage V_3 when V_{13} changes from high to low level while increasing the V_3 voltage gradually from 0 V.
46	Charge current	$V_3 = V_4 = V_5 = 0$ V	Measure the current I_3, I_4, and I_5.

■ Electrical Characteristics Test Procedures (continued)

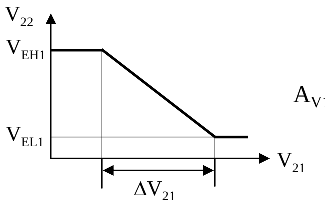
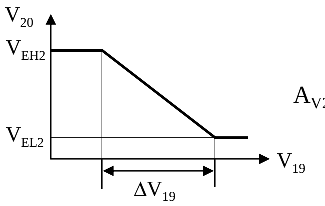
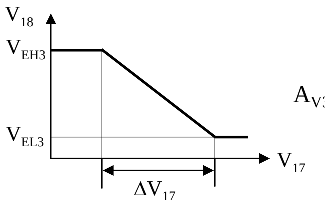
12. Test Circuit12

C No.	Parameter	Conditions	Measurement Method
44	Input threshold voltage	V_6 : variable	Measure the voltage V_6 when the voltage V_7 exceeds 1 V while increasing the V_6 voltage gradually.
59	OFF pin current	V_6 = 5 V	Measure the current I_6 .
48	Current consumption in standby mode	V_6 = 0 V	Measure the current I_{CC} .

13. Test Circuit13

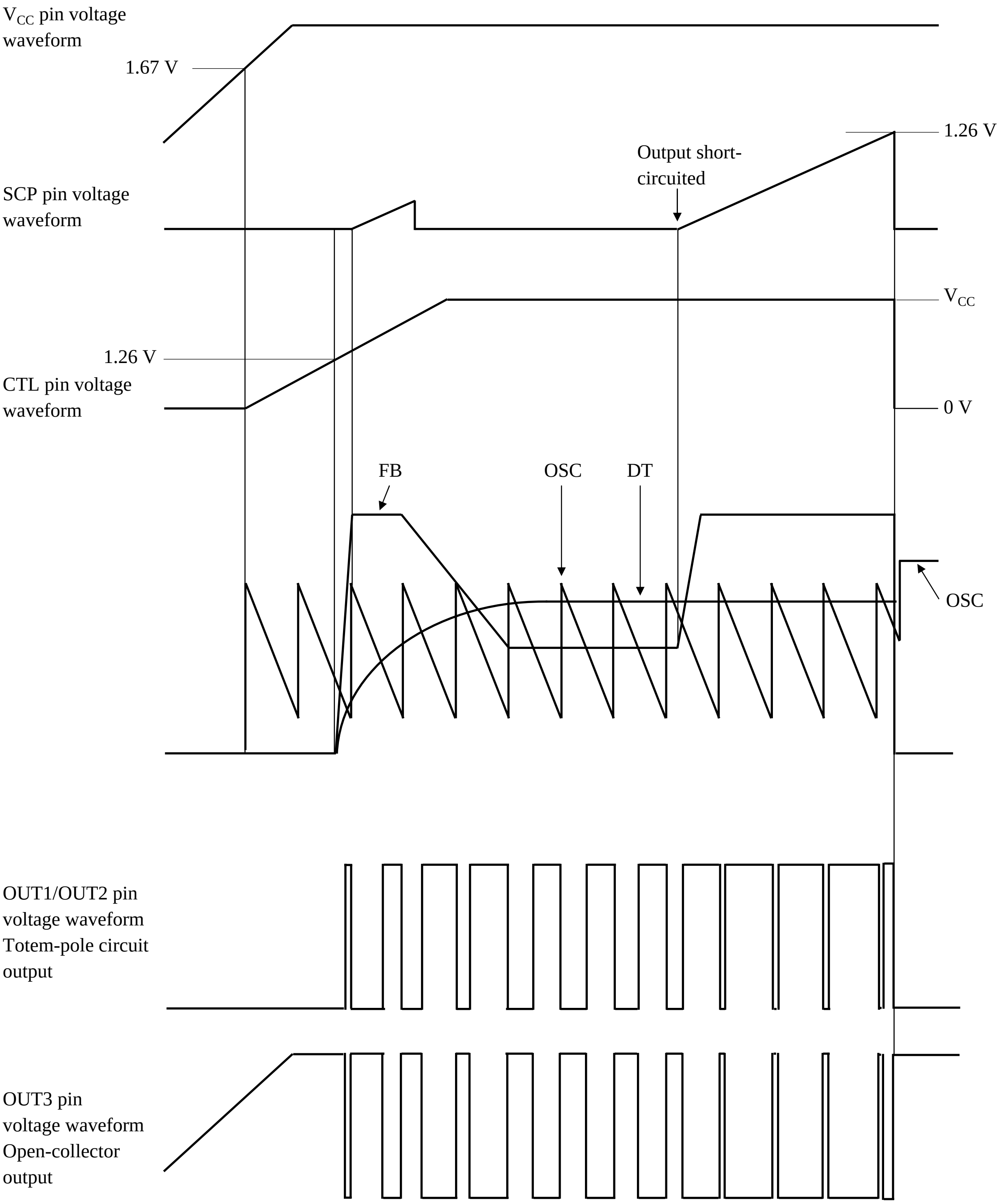
C No.	Parameter	Conditions	Measurement Method	
47	Average current consumption	$V_{17} = V_{19} = V_{21} = 1.5$ V	Measure the current $I_{CC} \rightarrow I_{CC(ON)}$.	$I_{CC(AV)} = \frac{I_{CC(ON)} + I_{CC(OFF)}}{2}$
		$V_{17} = V_{19} = V_{21} = 0$ V	Measure the current $I_{CC} \rightarrow I_{CC(OFF)}$.	

14. Test Circuit14

C No.	Parameter	Conditions	Measurement Method
51	Open-loop gain 1	V_{21} : variable $V_{17} = V_{19} = 0$ V	 $A_{V1} = 20\log_{10}\frac{V_{EH1} - V_{EL1}}{\Delta V_{21}}$ (dB)
53	Open-loop gain 2	V_{19} : variable $V_{17} = V_{21} = 0$ V	 $A_{V2} = 20\log_{10}\frac{V_{EH2} - V_{EL2}}{\Delta V_{19}}$ (dB)
54	Open-loop gain 3	V_{17} : variable $V_{19} = V_{21} = 0$ V	 $A_{V3} = 20\log_{10}\frac{V_{EH3} - V_{EL3}}{\Delta V_{17}}$ (dB)

■ Technical Data

• Timing Chart



■ Usage Notes

1) Allowable power dissipation

Since the power dissipation (P) in this IC increases proportionally with the supply voltage, application must be careful to operate so that the loss does not exceed the allowable power dissipation, P_D, for the package.

Reference formula :

$$P = (V_{CC} - V_{BEQ1}) \times I_{SO(OUT)1} \times D_{U1} + (V_{CC} - V_{BEQ2}) \times I_{SO(OUT)2} \times D_{U2} + V_{O(SAT)3} \times I_{OUT3} \times D_{U3} + V_{CC} \times I_{CC} < P_D$$

V_{BEQ1} : The voltage between the base and emitter of the channel 1 npn transistor

$I_{SO(OUT)1}$: The OUT1 pin output source current
(This is set by the resistor connected to the RB1 pin. When R_B is 1 kΩ, $I_{SO(OUT)1}$ will be 34 mA, maximum.)

D_{U1} : The output 1 ON-duty

V_{BEQ2} : The voltage between the base and emitter of the channel 2 npn transistor

$I_{SO(OUT)2}$: The OUT2 pin output source current
(This is set by the resistor connected to the RB2 pin. When R_B is 1 kΩ, $I_{SO(OUT)2}$ will be 34 mA, maximum.)

D_{U2} : The output 2 ON-duty

$V_{O(SAT)3}$: The OUT3 pin saturation voltage (0.5 V maximum when I_{OUT3} is 40 mA.)

I_{OUT3} : The OUT3 pin current (This will be $\{V_{CC} - V_{BEQ3} - V_{O(SAT)3}\} / R_{O3}$.)

D_{U3} : The output3 ON-duty

I_{CC} : The V_{CC} pin current

2) If the IC is shorted to ground, shorted to V_{CC}, or inserted incorrectly, either the device itself or peripheral components will be destroyed.

3) Electrical characteristics in pages 8 to 10 are based on the following conditions unless otherwise specified : V_{CC} = 2.4 V, Ta (ambient temperature) = 25°C±2°C.
Electrical characteristic values vary according to the change of V_{CC} or ambient temperature.