# M51594AFP
OPTICAL PICKUP SERVO CONTROL

DESCRIPTION

The M51594AFP is a semiconductor integrated circuit with built-in logic control, servo amp, and switches necessary to perform servo control of CD player optical pickups.

FEATURES

■ Combination with preamplifier for optical pickup (M51595FP, M51567P, M51599FP, or M51598FP) makes it possible to form a pickup servo control system
■ Single chip containing amp, switches, and logic controller necessary for servo control of optical pickup
■ Built-in focus search circuit for automatic search up and down
■ Built-in serial-to-parallel data converter to reduce microcomputer overload
■ Adaptures for any pickup by changing gain and frequency response of amplifiers with external components
■ Built-in Vcc/2 generator to be capable of being driven by either dual or single power supply
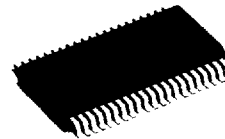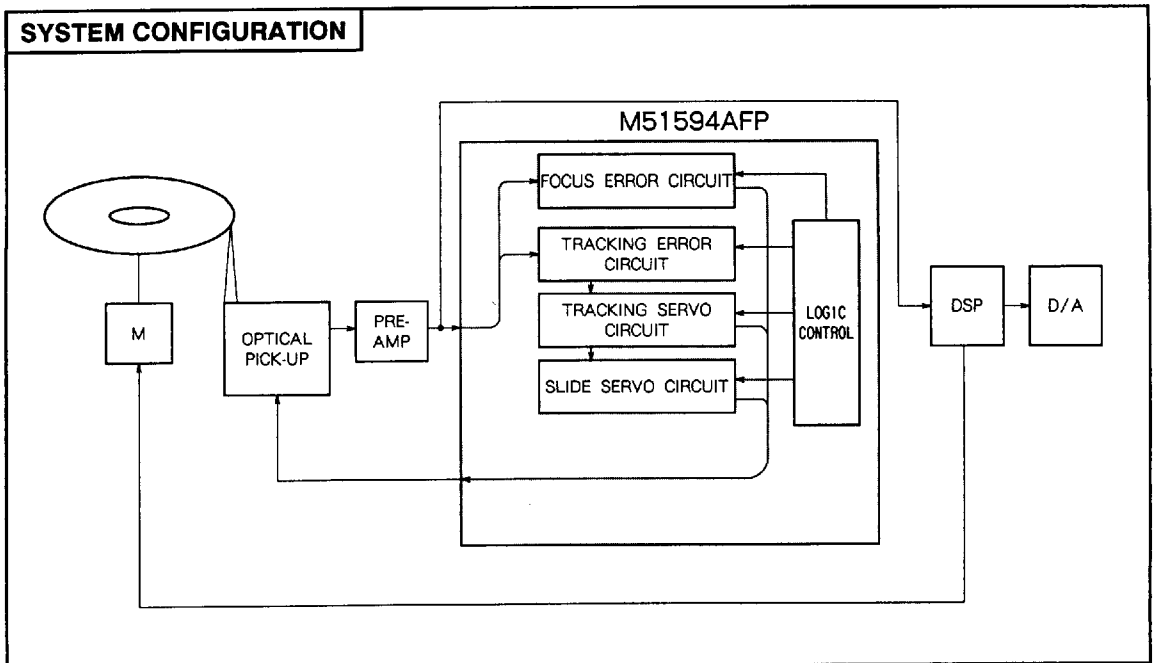
Outline 42P2R-A
0.8mm pitch 450mil SSOP
(8.4mm × 17.5mm × 2.0mm)

RECOMMENDED OPERATING CONDITIONS

Supply voltage range ··············· V_{CC}, V_{EE} = ± 4.75~± 5.25V
or V_{CC} = 4.75~5.25V

Rated supply voltage
······················· V_{CC}, V_{EE} = ± 5V(Split supply voltage)
or V_{CC} = 5V(Single supply voltage)
Rated power dissipation ····························· 70mW

SYSTEM CONFIGURATION

PIN CONFIGURATION

APC SW OUT	1	42 FE⊕
APC SW IN	2	41 FE⊖
TE IN	3	40 FE OUT
TC IN	4	39 FS⊕
MR	5	38 FS⊖
JUMP FLAG	6	37 FS OUT
HFOK	7	36 FG
HFOK IN	8	35 FSR IN
HFD	9	34 TE⊖
DATA OUT	10	33 TE OUT
JPT	11	32 TG1
MSD	12	31 TS⊕
MLA	13	30 TG2
MCK	14	29 TS⊖
ACLR	15	28 TS OUT
SYSTEM RESET1	16	27 SS⊕
SYSTEM RESET2	17	26 SS⊖
BIAS	18	25 SS OUT
COM	19	24 Vcc
GND	20	23 CURRENT REF
VEE	21	22 C-FSR

M51594AFP
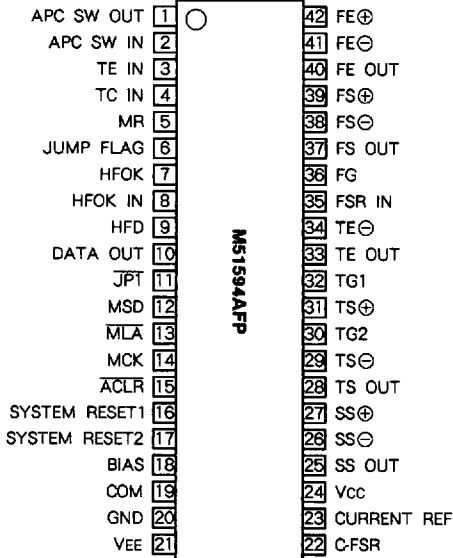
Outline 42P2R-A

IC INTERNAL BLOCK DIAGRAM
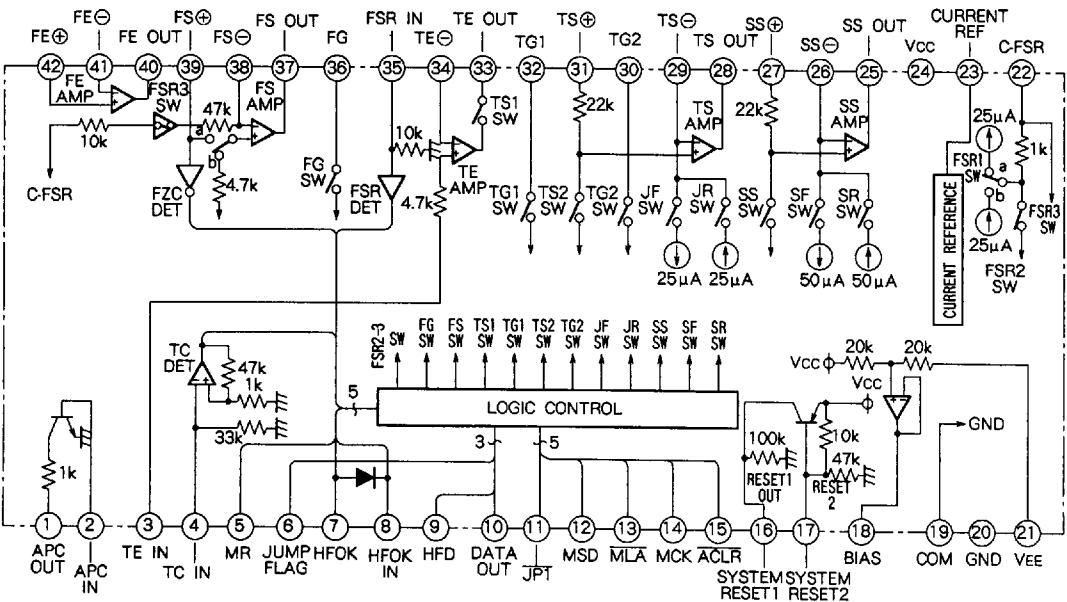
Unit Resistance : Ω

PIN DESCREPTION

Pin No.	Symbol	Block	I/O	Function
①	APC SW OUT	APC	O	APC SW control output
②	APC SW IN	APC	I	APC SW control input
③	TE IN	Pre Amp. Input	I	Tracking error signal input
④	TC IN	↑	I	Tracking cross signal input
⑤	MR	↑	I	Mirror detected signal input
⑥	JUMP FLAG	Microcomputer I/O	O	Outputs High under Jump function
⑦	HF OK	Pre Amp. Input	I	HF OK signal input
⑧	HFOK IN	Input	I	HF OK signal input
⑨	HFD	Output (DSP)	O	Outputs High, when HF OK Low
⑩	DATA OUT	↑	O	Inner condition output changed by command modes
⑪	$\overline{JP1}$	↑	I	1 Track Jump control signal input (usually High)
⑫	MSD	↑	I	Serial data input (LSB first 8-bit data)
⑬	$\overline{MLA}$	↑	I	Latch signal of serial data from microcomputer to servo IC
⑭	MCK	↑	I	Clock signal of serial data from microcomputer to the servo IC
⑮	$\overline{ACLR}$	↑	I	All clear input (clear inner registers and flip-flops by Low signal)
⑯	SYSTEM RESET	RESET	O	Reset pulse output
⑰	SYSTEM RESET	RESET	I	Reset pulse witdh
⑱	BIAS	Regulated voltage	O	Outputs reference voltage ($\simeq \frac{Vcc}{2}$ at signal supply voltage)
⑲	COM	↑	I	COMMON connects to GND at split supply voltage : to pin⑱ at single supply voltage
⑳	GND	↑	I	GND
㉑	Vᴇᴇ	↑	I	Negative supply voltage. At single supply voltage connects to GND
㉒	C-FSR	Focus serve	–	Connects the external capacitor for setting time constant of Focus search
㉓	CURRENT REF	Regulated voltage	I	Connects the external resistance for deciding value of current
㉔	Vcc	Supply voltage	I	Positive supply voltage
㉕	SS OUT	Side servo	O	SS Amp. output
㉖	SS⊖	↑	I	SS Amp. negative input
㉗	SS⊕	↑	I	SS Amp. positive input
㉘	TS OUT	Tracking servo	O	TS Amp. output
㉙	TS⊖	↑	I	TS Amp. negative input
㉚	TG2	↑	–	TG2 SW output
㉛	TS⊕	↑	I	TS Amp. positive input
㉜	TG1	↑	–	TG1 SW output
㉝	TE OUT	↑	O	TE Amp. output
㉞	TE⊖	↑	I	TE Amp. negative input
㉟	FSR IN	Focus servo	I	Focus search detector input
㊱	FG	↑	–	FG SW output
㊲	FS OUT	↑	O	FS Amp. output
㊳	FS⊖	↑	I	FS Amp. negative input
㊴	FS⊕	↑	I	FS Amp. positive input
㊵	FE OUT	↑	O	Focus error Amp. output
㊶	FE⊖	↑	I	Focus error Amp. negative input
㊷	FE⊕	↑	I	Focus error Amp. positive input

ABSOLUTE MAXIMUM RATINGS (Ta = 25℃, unless otherwise noted)

Symbol	Parameter	Ratings	Unit
V_{CC}	Supply voltage	+ 6.5	V
V_{EE}		− 6.5	V
$\|V_I\|$	Input voltage (absolute value)	Applied supply voltage+0.3	V
$\|V_O\|$	Output voltage (absolute value)	Applied supply voltage+0.3	V
P_d	Power dissipation	750	mW
T_{opr}	Operating temperature	−20~+75	℃
T_{stg}	Storage temperature	−40~+125	℃

ELECTRICAL CHARACTERISTICS (V_{CC} = + 5V, V_{EE} = − 5V, Ta = 25℃, unless otherwise noted)

Symbol	Parameter	Test conditions	Min	Typ	Max	Unit
I_{CC}	Circuit current	RESET	−	14	32	mA
I_{EE}	Circuit current	RESET	−28	−12	−	mA
G_{FE}	FE close loop voltage	f=1kHz, V_I = −10dBm	8	10	12	dB
V_{HFE}	FE output voltage high	V_I = 2V, R_L = 220 Ω	2.2	4	−	V
V_{LFE}	FE output voltage low	V_I = −2V, R_L = 220 Ω	−	−4	−2.2	V
G_{FS}	FS close loop voltage gain	f=1kHz, V_I = 10dBm	20	22	24	dB
A_{TTFS}	FS SW attenuation	f=1kHz, V_I = 0dBm	−	−35	−25	dB
R_{ONFG}	FG SW on resistor	f=1kHz, V_I = 0dBm	−	100	300	Ω
V_{HFS}	FS output voltage high	V_I = 1V, R_L = 220 Ω	2.2	4	−	V
V_{LFS}	FS output voltage low	V_I = −1V, R_L = 220 Ω	−	−4	−2.2	V
V_{FSR+}	FSR reference voltage ⊕	Note "FSR Detector Function"	0.40	0.45	0.50	V
V_{FSR-}	FSR reference voltage ⊖	Note "FSR Detector Function"	−0.54	−0.49	−0.44	V
G_{TE}	TE close loop voltage gain	f=1kHz, V_I = −10dBm	6.8	8.8	10.8	dB
G_{TS}	TS close loop voltage gain	f=1kHz, V_I = −10dBm	7.8	9.8	11.8	dB
A_{TTTS1}	TS SW attenuation	f=1kHz, V_I = 0dBm	−	−50	−30	dB
A_{TTTS2}			−	−50	−30	dB
R_{ONT1}	TG1 SW on resistor	f=1kHz, V_I = 0dBm	−	50	300	Ω
R_{ONT2}	TG2 SW on resistor	f=1kHz, V_I = 0dBm	−	50	300	Ω
V_{HTS}	TS output voltage high	V_I = 2V, R_L = 220 Ω	2.2	4	−	V
V_{LTS}	TS output voltage low	V_I = −2V, R_L = 220 Ω	−	−4	−2.2	V
G_{SS}	SS close loop voltage gain	f=1kHz, V_I = −10dBm	11.5	13.5	15.5	dB
A_{TTSS}	SS SW attenuation	f=1kHz, V_I = 0dBm	−	−54	−30	dB
V_{HSS}	SS output voltage high	V_I = 2V, R_L = 220 Ω	2.2	4	−	V
V_{LSS}	SS output voltage low	V_I = −2V, R_L = 220 Ω	−	−4	−2.2	V
V_{JF}	JF output voltage	Note "TRACK Function"	1.1	1.4	1.7	V
V_{JR}	JR output voltage	Note "TRACK Function"	−1.7	−1.4	−1.1	V
V_{SF}	SF output voltage	Note "SLIDE Function"	2.2	2.8	3.4	V
V_{SR}	SR output voltage	Note "SLIDE Function"	−3.4	−2.8	−2.2	V
V_{FCU+}	FZC⊕ reference voltage	Note "FSR Detector Function"	0.26	0.29	0.32	V
V_{FCU-}			−0.1	0	0.1	V
V_{FCD+}	FZC⊖ reference voltage	Note "FSR Detector Function"	−0.1	0	0.1	V
V_{FCD-}			−0.31	−0.28	−0.25	V
V_{TC+}	TC reference voltage	Note "BRAKE A, BRAKE B Function"	0	0.1	0.2	V
V_{TC-}			−0.2	−0.1	0	V
V_{HTE}	TE output voltage high	V_I = 2V, R_L = 47k Ω	3.5	4.2	−	V
V_{LTE}	TE output voltage low	V_I = −2V, R_L = 47k Ω	−	−4.2	−3.5	V
V_{OSFS}	FS output offset voltage	After up search	70	130	190	mV
V_{OSFE}	FE output offset voltage		−30	0	30	mV
V_{OSTE}	TE output offset voltage		−35	−10	15	mV
V_{OSTS}	TS output offset voltage		−5	20	45	mV
V_{OSSS}	SS output offset voltage		−30	0	30	mV
I_{FSRU}	FSR output current		21	29	37	μA
I_{FSRD}			−32	−25	−8	μA

* 0dBm = 775mVrms

ELECTRICAL CHARACTERISTICS (cont.) (Vcc = + 5V, VEE = – 5V, Ta = 25°C, unless otherwise noted)

Symbol	Parameter	Test conditions	Limits			Unit
			Min	Typ	Max	
V_{HSY}	SYSTEM RESET output valtage high	$R_L = 20k \, \Omega$	4.0	4.9	–	V
V_{LSY}	SYSTEM RESET output valtage low	$R_L = 20k \, \Omega$	–	0	0.2	V
I_{ALON}	APC SW "ON" output current		0.6	1.0	2.0	mA
I_{ALOF}	APC SW "OFF" output current		–10	0	10	μA

Note 1. Supply voltage turn on and pin ⑮ $\overline{ACLR}$ input reset pulse and next all parameter measures.

t_{RST}

V_{HRST}

GND
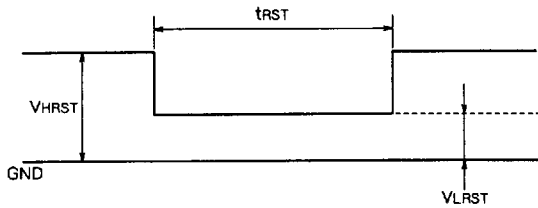
V_{LRST}

t_{RST} : 1 μs min
V_{HRST} : 2.5V min
V_{LRST} : 0.4V max

M51594AFP LOGIC CONTROL FUNCTION DESCRIPTION
1. Serial command function

The M51594AFP has a 8-bit shift resister in the logic control block to convert serial data from microcomputer input through MSD pin ⑫, to internal switch commands.

(1) Data-Input function

Higher 4 bits of the 8-bit data ($D_7 \sim D_4$) are used to select the command mode. Lower 4 bits ($D_3 \sim D_0$) set the command state.

Once a command is set, it is held until a new command of the same command mode is input. If an other command mode is selected the command state will not change.

Table 1. Serial command function

X = 1 or 0

Mode Name		MSB Mode Select				Data IN pin ⑫ Input Command State			LSB	Data Out pin ⑩ Output
		D_7	D_6	D_5	D_4	D_3	D_2	D_1	D_0	
FOCUS		0	0	0	0	FS ON	FG	FSR EN	×	FS OK
TRACK1	A	0	0	0	1	×	BRAKE A	TG2	TG1	0
	B			1		×	BRAKE B			
TRACK2		0	0	1	0	TRACK		SLIDE		TC
SERVO OFF		0	1	×	×	×	×	×	×	0
STOP		1	×	×	×	×	×	×	×	0

Note 2. TRACK1 A and TRACK1 B at the same command mode.
TG2 and TG1 are set by both commands. BRAKE A or B are determined by selecting TRACK1 A or TRACK1 B.
3. Data out (pin ⑩ output) is changed automatically when the command mode is selected.
4. The serial command 10XXXXXX is available of control M50422P/M50423FP/M50427FP (DSP LSI).
   When this command input, the command state of M51594FP is not changed

Table 2. Command function

Command	Command mode	Data			Function
FS ON	FOCUS	D_3	1	ON	Focus search start→ Focus on
			0	OFF	
FG	↑	D_2	1	CLOSE	FG SW for changing focus gain is opened or closed
			0	OPEN	
FSR EN	↑	D_1	1	INHIBIT	Inhibit automatic re-search of focus
			0	ENABLE	
BRAKE A	TRACK1 A	D_2	1	ON	Jump break action. TS2 SW is opened or closed
			0	OFF	
BRAKE B	TRACK1 B	D_2	1	ON	Jump break action. TS1 SW is opened or closed
			0	OFF	
TG2	TRACK1	D_1	1	OPEN	TG2 SW for changing TRACK gain is controlled
			0	CLOSE	
TG1	TRACK1	D_0	1	OPEN	TG1 SW for changing TRACK gain is controlled
			0	CLOSE	
TRACK	TRACK2	D_3 D_2 0 0	TS OFF	Track servo off	SW states shown in Table 4
		0 1	TS ON	Track servo on	
		1 0	JF	Forward jump	
		1 1	JR	Reverse jump	
SLIDE	TRACK2	D_1 D_0 0 0	SS OFF	Slide servo off	SW states shown in Table 5
		0 1	SS ON	Slide servo on	
		1 0	SF	Forward slide	
		1 1	SR	Reverse slide	
—	SERVO OFF				Data of $D_0 \sim D_3$ is reset to 0
—	STOP				Data of $D_0 \sim D_3$ is reset to 0

SETTING CURRENT VALUE OF INTERNAL CURRENT SOURCES

(Focus search (FSR), Tracking servo (TS), Slide motor servo (SS)]

Current value of internal current sources (FSR, TS, SS) is set by an external resistor connected between pin ㉓ and Vcc. (Resistance value : Rx)

If the current value of a current source (FSR, TS, SS) is IFSR, ITS, ISS)

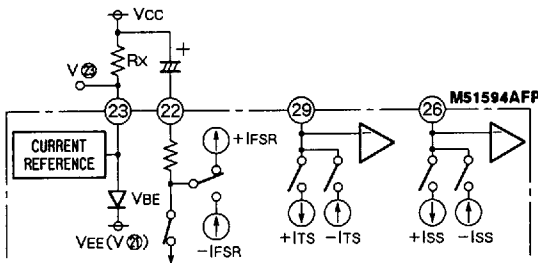$$I_{FSR} \simeq \frac{1}{8} \cdot \frac{V_{CC} - V㉓}{R_x}$$

$$I_{TS} \simeq \frac{1}{8} \cdot \frac{V_{CC} - V㉓}{R_x}$$

$$I_{SS} \simeq \frac{1}{4} \cdot \frac{V_{CC} - V㉓}{R_x}$$

And if the voltage value of pin ㉑ is V ㉑, the voltage value of pin ㉑,

$$V㉓ = V㉑ + V_{BE} \quad (V_{BE} \simeq 0.7V)$$

BLOCK DIAGRAM OF CURRENT SOURCES

Timing chart of FSR det
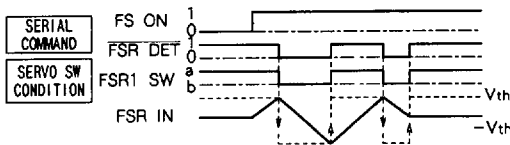
Timing chart of FZC
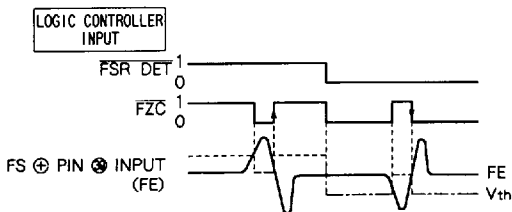
FZC reset
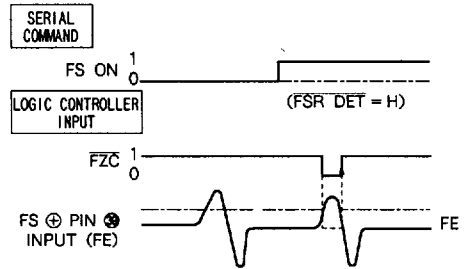
FSR detector

With external resistor (RB) connected between FS OUT (pin ㊲ output) and FSR IN (pin ㉟ input) at FSR function,

    1) FSR direction,

    2) Threshold voltage polarity of FZC detector are automatically changed.

Focus search always starts from positive voltage side. The direction of FSR is changed by FSR 1 SW controlled by FSR DET signal.

INPUT		OUTPUT		
FSR IN level VIN	FSR DET	FSR1 SW	At ±5V FZC Vth	
			Min	Max
$V_{IN} > V_{th}$	0	b : Negative direction of FSR	− 0.30V	0V
$V_{IN} < V_{th}$	1	a : Positive direction of FSR	0V	0.30V

Equivalent circuit
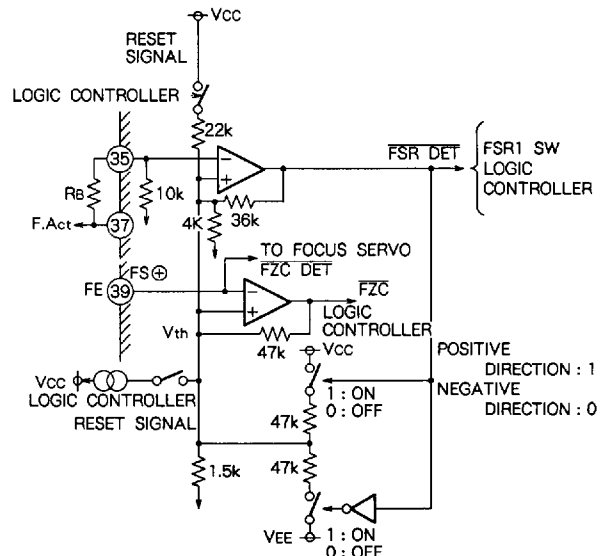
(2) How to send serial data(MSD)

The serial command is executed by sending $\overline{MLA}$ signal after sending LSB serial data.
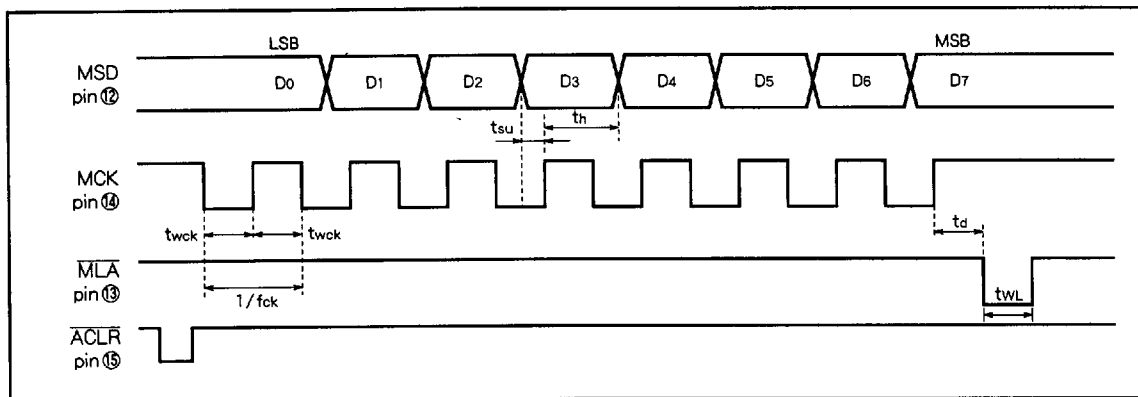

Fig. 1 Serial data input timing chart

2. BRAKE A, BRAKE B

When BRAKE A command or BRAKE B command is set to High (1), Jump brake operates.

This increases the ability to break after track jump

Jump brake action

1) When MR (pin ⑤ input) = 1, Track servo loop goes off at the edge of pulse output from TC Det.

2) When MR (pin ⑤ input) = 0, Track servo loop goes on at the edge of pulse output from TC Det.

Table 3. SW states at jump brake

INPUT	OUTPUT	
MR $\overline{TC}$	BRAKE A = 1 TS2 SW states	BRAKE B = 1 TS1 SW states
1 ⌐⌐	a (TRACK servo OFF)	b (TRACK servo OFF)
0 ⌐⌐	b (TRACK servo ON)	a (TRACK servo ON)

3. TRACK, SLIDE

Table 4. Track function

INPUT			OUTPUT (SW state)			
Command	Data D_3	D_2	TS1 SW	TS2 SW	JF SW	JR SW
TS OFF	0	0	a (servo ON)	a (servo OFF)	b	b
TS ON	0	1	a (servo ON)	b (servo ON)	b	b
JF	1	0	b (servo OFF)	b (servo ON)	a (JF ON)	b
JR	1	1	b (servo OFF)	b (servo ON)	b	a (JR ON)

6249826 0018827 359

Table 5. Slide function

INPUT			OUTPUT (SW state)		
Command	Data				
	D_1	D_0	SS SW	SF SW	SR SW
SS OFF	0	0	a (servo OFF)	b	b
SS ON	0	1	b (servo ON)	b	b
SF	1	0	a (servo OFF)	a (SF ON)	b
SR	1	1	a (servo OFF)	b	a (SR ON)

4. Direct command function

$\overline{JP1}$ Input

At one track jump, $\overline{JP1}$ signal allwes two transmissions of serial data to selected and restrains the delay time of microcomputer.

$\overline{JP1}$ is usually high. After microcomputer catches the up signal of data out output (TC singnal), if $\overline{JP1}$ goes down, the polarity of jump direction is automatically. (JF→JR, JR →JF)

After one track jump is finished (after period T3), if $\overline{JP1}$ goes up, Jump ends and the states become TS ON and SS ON.
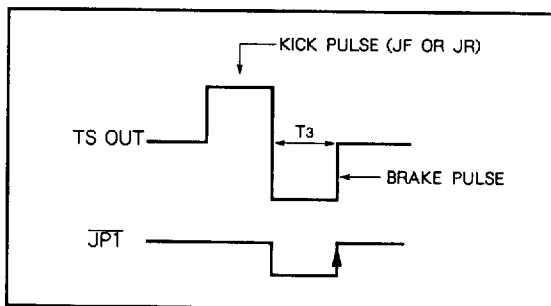

Fig. 2 $\overline{JP1}$ timing chart

Table 6. TRACK, SLIDE states by $\overline{JP1}$ Input

$\overline{JP1}$ (INPUT)	TRACK2 Mode (0010 D_3 D_2 D_1 D_0) (OUTPUT)							
	TRACK (D_3 D_2)				SLIDE (D_1 D_0)			
	00	01	10	11	00	01	10	11
1	TS OFF	TS ON	JF	JR	SS OFF	SS ON	SF	SR
0	TS OFF	TS ON	JR	JF	SS OFF	SS ON	SF	SR
↑	TS OFF	TS ON	TS ON	TS ON	SS ON	SS ON	SF	SR

Note 5. When command mode is TS OFF (001000XX, MSB first), even if $\overline{JP1}$ goes up, states do not become TS ON and SS ON.
6. Change to TS ON and SS ON after $\overline{JP1}$ goes up are held.

5. Logoc output function

(1) Data out

Data out output mode changes at each serial command mode.(shown in Table 1) It is decided by the last sent serial command.

Table 7. Data out output function

	Data Out output name	Serial Command Mode(INPUT)
(I)	FS OK	FOCUS (0000XXXX)
(II)	TC	TRACK2 (0010XXXX)

(I) FS OK

When HF OK (pin ⑦ input) was high and FS SW was closed (servo ON), FS OK is high.

Table 8. FS OK truth

INPUT		OUTPUT
HF OK	FS SW	FS OK
0	b (servo OFF)	0
1	b (servo OFF)	0
0	a (servo ON)	0
1	a (servo ON)	1

Note 7. While FS OK is low, TS2 SW and SS SW are opened regardless of the serial command.

(II) TC

TC pulse is producted by latching MR pulse with pulse edges of TC Det output ($\overline{TC}$). At reset, TC is low.

Table 9. TC output

INPUT		OUTPUT
MR	$\overline{TC}$	TC
1	↑ or ↓	1
0	↑ or ↓	0

(2) $\overline{HFD}$ (HF defect)

Output is High when HF OK is Low.

(3) Jump flag

Jump flag terminal outputs ; High when serial command is TS OFF or JF or JR or BRAKE. Outputs is low at other times.

6. Focus error amp

This amp is auxiliary.

7. APC switch

The APC circuit supply is controlled by this switch.

8. System reset

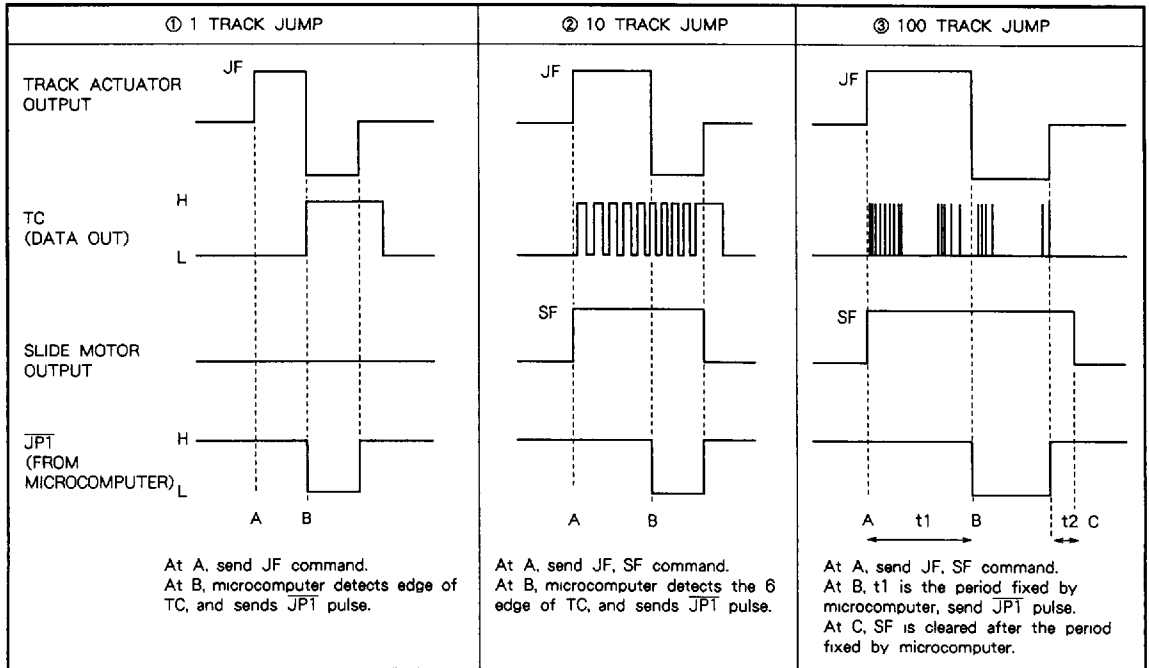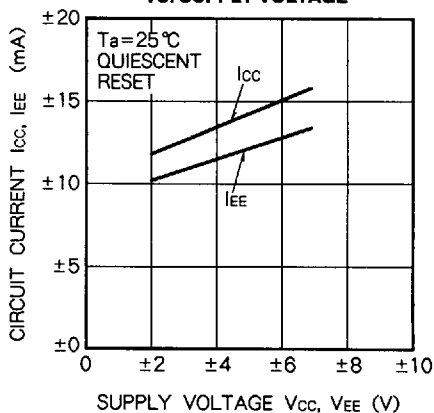This circuit generates the reset pulse at power-on.

① 1 TRACK JUMP	② 10 TRACK JUMP	③ 100 TRACK JUMP
At A, send JF command. At B, microcomputer detects edge of TC, and sends $\overline{JP1}$ pulse.	At A, send JF, SF command. At B, microcomputer detects the 6 edge of TC, and sends $\overline{JP1}$ pulse.	At A, send JF, SF command. At B, t1 is the period fixed by microcomputer, send $\overline{JP1}$ pulse. At C, SF is cleared after the period fixed by microcomputer.

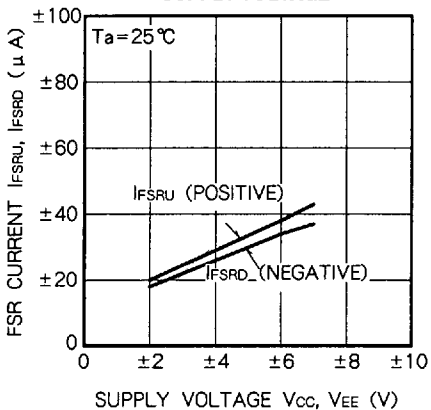Fig. 3 Example for track jump timing. (Forward jump)

TYPICAL CHARACTERISTICS

THERMAL DERATING (MAXIMUM RATING)

POWER DISSIPATION P_d (mW)

AMBIENT TEMPERATURE Ta (℃)
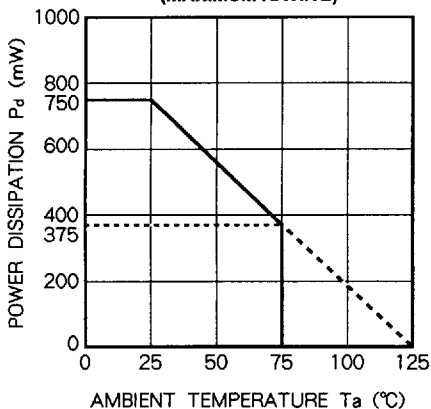
QUIESCENT CIRCUIT CURRENT VS. SUPPLY VOLTAGE

CIRCUIT CURRENT I_{CC}, I_{EE} (mA)

Ta=25℃ QUIESCENT RESET

I_{CC}

I_{EE}

SUPPLY VOLTAGE V_{CC}, V_{EE} (V)

FSR CURRENT VS. SUPPLY VOLTAGE

FSR CURRENT I_{FSRU}, I_{FSRD} (μA)

Ta=25℃

I_{FSRU} (POSITIVE)

I_{FSRD} (NEGATIVE)

SUPPLY VOLTAGE V_{CC}, V_{EE} (V)

JF, JR, TS AMPLIFIER OUTPUT VOLTAGE VS. SUPPLY VOLTAGE

JF, JR TS AMPLIFIER OUTPUT VOLTAGE V_{JF}, V_{JR} (V)

Ta=25℃

V_{JR}

V_{JF}

SUPPLY VOLTAGE V_{CC}, V_{EE} (V)

SF, SR SS AMPLIFIER OUTPUT VOLTAGE VS. SUPPLY VOLTAGE

SF, SR SS AMPLIFIER OUTPUT VOLTAGE V_{SF}, V_{SR} (V)

Ta=25℃

V_{SR} (NEGATIVE)

V_{SF} (POSITIVE)
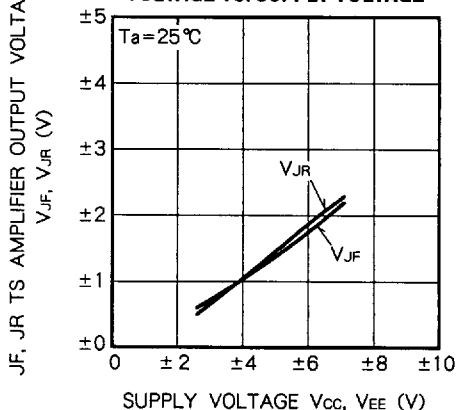
SUPPLY VOLTAGE V_{CC}, V_{EE} (V)
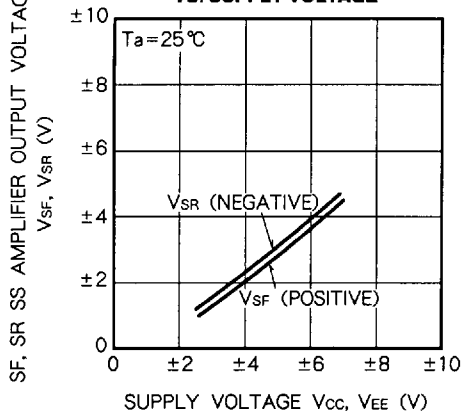
EACH AMPLIFIER VOLTAGE GAIN VS. SUPPLY VOLTAGE

VOLTAGE GAIN G_{VC} (dB)

Ta=25℃
f=1kHz
V_i=−10dBm

FS Amp

SS Amp

FE Amp

TS Amp

TE Amp

SUPPLY VOLTAGE V_{CC}, V_{EE} (V)

MITSUBISHI ELECTRIC
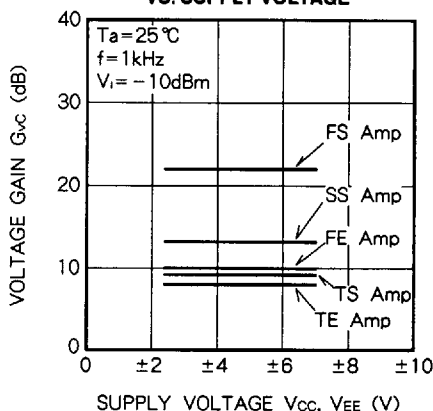
AMPLIFIER OFFSET VOLTAGES VS. AMBIENT TEMPERATURE

$V_{CC} = 5V$
$V_{EE} = -5V$

OFFSET VOLTAGE V_{offset} (mV)

AMBIENT TEMPERATURE Ta (℃)

FS
SS
FE
TS
TE
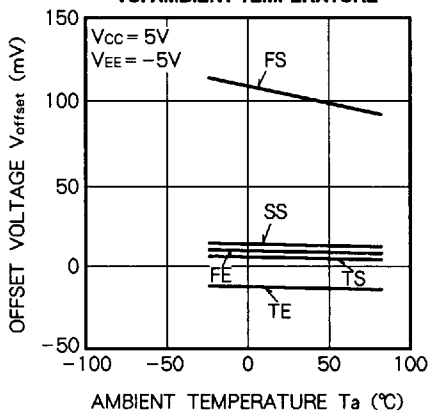
JF, JR, TS AMPLIFIER OUTPUT VOLTAGE VS. AMBIENT TEMPERATURE

$V_{CC} = 5V$
$V_{EE} = -5V$

JF, JR, TS AMPLIFIER OUTPUT VOLTAGE V_{JF}, V_{JR} (V)

AMBIENT TEMPERATURE Ta (℃)

JR
JF

SF, SR SS AMPLIFIER OUTPUT VOLTEGE VS. AMBIENT TEMPERATURE

$V_{CC} = 5V$
$V_{EE} = -5V$

SF, SR SS AMPLIFIER OUTPUT VOLTAGE V_{SF}, V_{SR} (V)

AMBIENT TEMPERATURE Ta (℃)

SF
SR
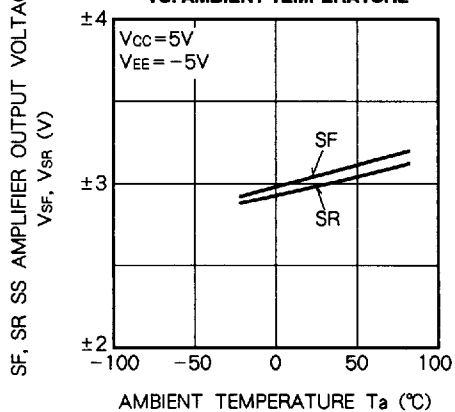
FG, TG1, TG2 CURRENT VS. AMBIENT TEMPERATURE

$V_{CC} = 5V$
$V_{EE} = -5V$

FG, TG1, TG2, SW CURRENT I_{FG}, I_{TG1}, I_{TG2} (mA)

AMBIENT TEMPERATURE Ta (℃)

TG1, TG2
FG
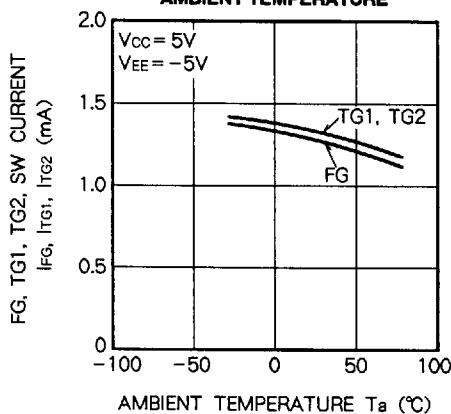
AMPLIFIER VOLTAGE GAINS VS. AMBIENT TEMPERATURE

$V_{CC} = 5V$
$V_{EE} = -5V$
$f = 1kHz$
$V_I = -10dBm$

VOLTAGE GAINS G_{VC} (dB)

AMBIENT TEMPERATURE Ta (℃)

FS
SS
FE
TS
TE
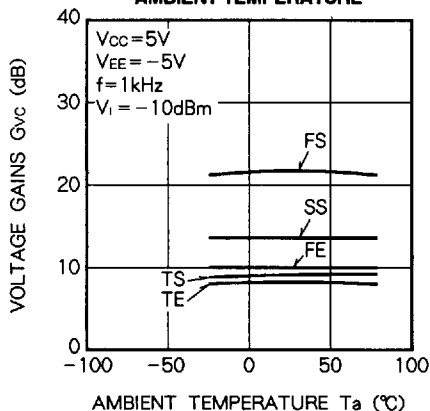
APPLICATION EXAMPLE ($V_{CC} = +5V$, $V_{EE} = -5V$)
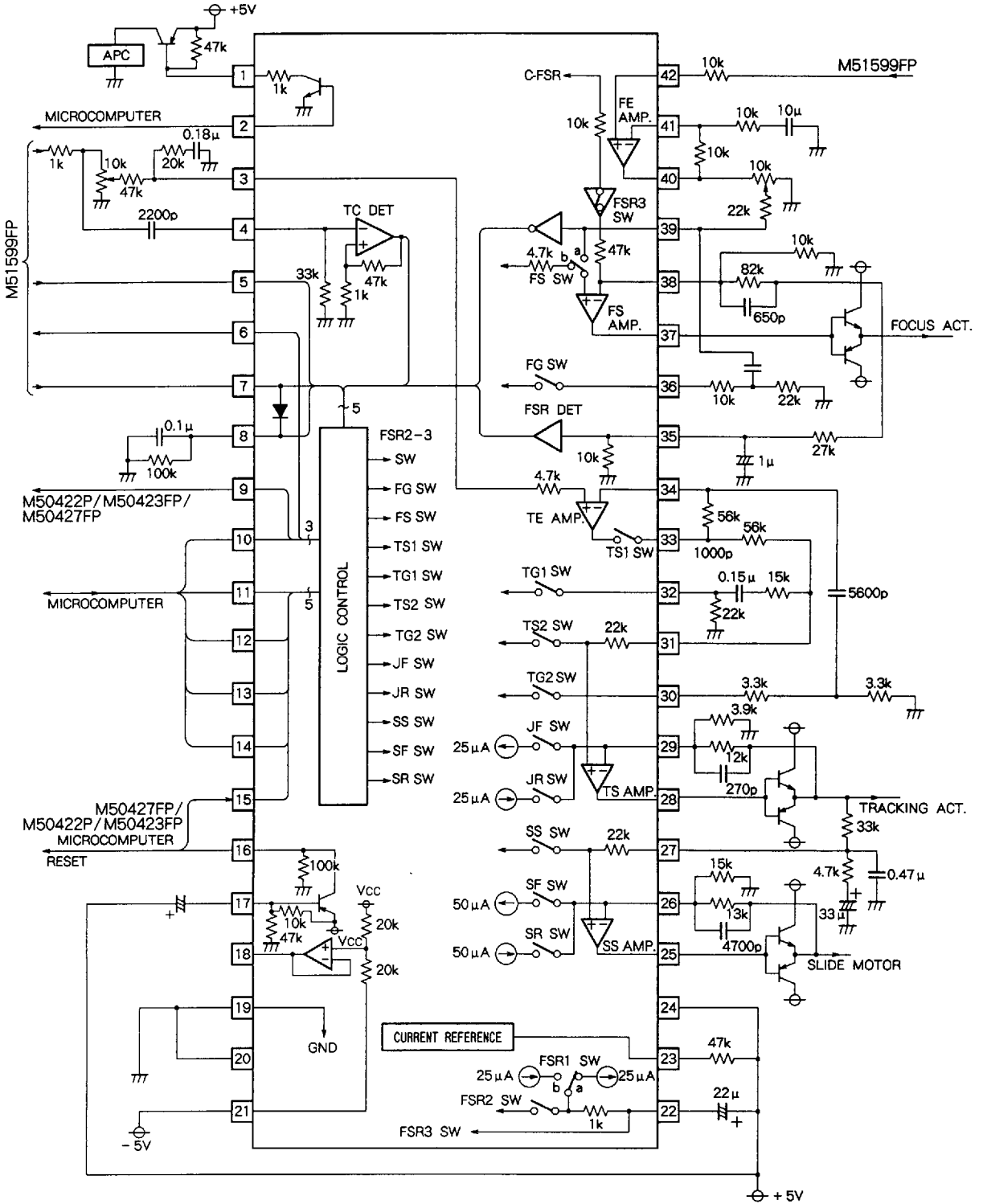
Units Resistance : Ω
Capacitance : F