

M51594AFP

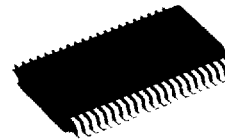
OPTICAL PICKUP SERVO CONTROL

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
- Adapts for any pickup by changing gain and frequency response of amplifiers with external components
- Built-in $V_{CC}/2$ 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)

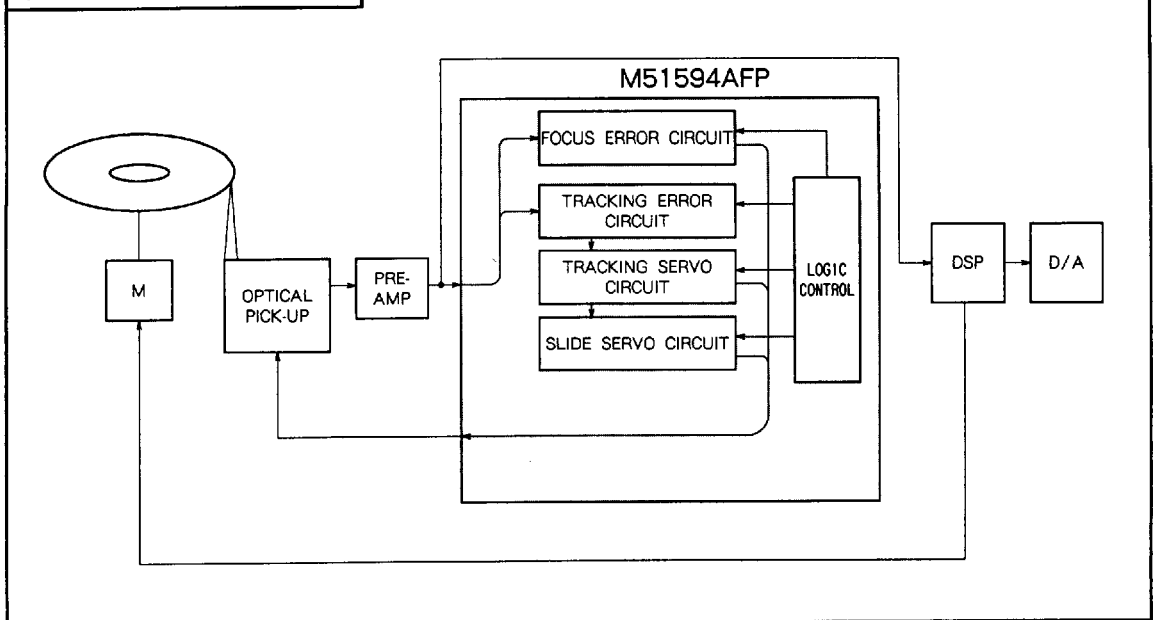
RECOMMENDED OPERATING CONDITIONS

Supply voltage range..... $V_{CC}, V_{EE} = \pm 4.75 \sim \pm 5.25V$
or $V_{CC} = 4.75 \sim 5.25V$

Rated supply voltage
..... $V_{CC}, V_{EE} = \pm 5V$ (Split supply voltage)
or $V_{CC} = 5V$ (Single supply voltage)

Rated power dissipation 70mW

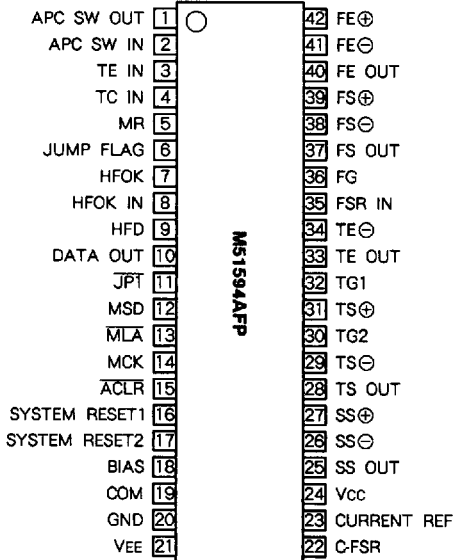
SYSTEM CONFIGURATION



M51594AFP

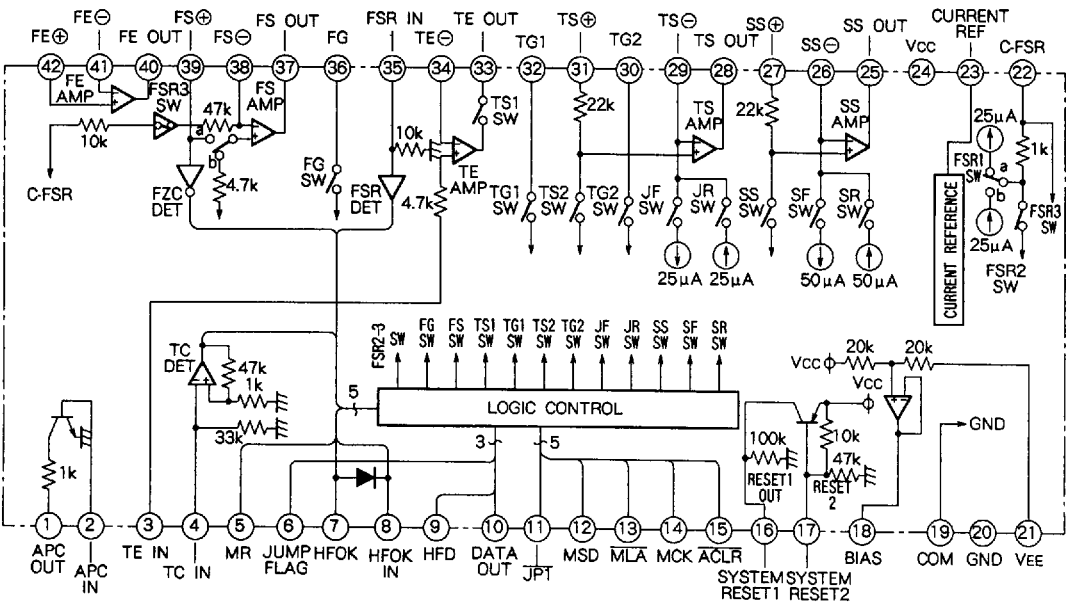
OPTICAL PICKUP SERVO CONTROL

PIN CONFIGURATION



Outline 42P2R-A

IC INTERNAL BLOCK DIAGRAM



Unit Resistance : Ω

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OPTICAL PICKUP SERVO CONTROL

PIN DESCRIPTION

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	JPT	↑	I	1 Track Jump control signal input (usually High)
⑫	MSD	↑	I	Serial data input (LSB first 8-bit data)
⑬	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	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 width
⑱	BIAS	Regulated voltage	O	Outputs reference voltage ($\approx \frac{V_{CC}}{2}$ at signal supply voltage)
⑲	COM	↑	I	COMMON connects to GND at split supply voltage : to pin ⑱ at single supply voltage
⑳	GND	↑	I	GND
㉑	VEE	↑	I	Negative supply voltage. At single supply voltage connects to GND
㉒	C-FSR	Focus servo	—	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

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OPTICAL PICKUP SERVO CONTROL

ABSOLUTE MAXIMUM RATINGS (Ta = 25 °C, 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	°C
T _{stg}	Storage temperature	-40~+125	°C

ELECTRICAL CHARACTERISTICS (V_{CC} = +5V, V_{EE} = -5V, Ta = 25 °C, unless otherwise noted)

Symbol	Parameter	Test conditions	Limits			Unit
			Min	Typ	Max	
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
ATTFS	FS SW attenuation	f=1kHz, V _i = 0dBm	-	-35	-25	dB
RONFG	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
ATTTS1	TS SW attenuation	f=1kHz, V _i = 0dBm	-	-50	-30	dB
ATTTS2			-	-50	-30	dB
RONT1	TG1 SW on resistor	f=1kHz, V _i = 0dBm	-	50	300	Ω
RONT2	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
ATTSS	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

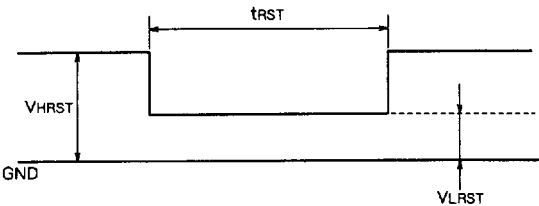
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OPTICAL PICKUP SERVO CONTROL

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

Symbol	Parameter	Test conditions	Limits			Unit
			Min	Typ	Max	
VHSY	SYSTEM RESET output voltage high	RL = 20k Ω	4.0	4.9	—	V
VLSY	SYSTEM RESET output voltage low	RL = 20k Ω	—	0	0.2	V
IALON	APC SW "ON" output current		0.6	1.0	2.0	mA
IALOF	APC SW "OFF" output current		-10	0	10	μA

Note 1. Supply voltage turn on and pin ⑤ ACLR input reset pulse and next all parameter measures.



tRST : 1 μs min
VHRST : 2.5V min
VLRST : 0.4V max

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OPTICAL PICKUP SERVO CONTROL

M51594AFP LOGIC CONTROL FUNCTION DESCRIPTION

1. Serial command function

The M51594AFP has a 8-bit shift register 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 (D7~D4) are used to select the command mode. Lower 4 bits (D3~D0) 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	Data IN pin ⑫ Input								Data Out pin ⑩ Output
	MSB Mode Select				Command State LSB				
	D7	D6	D5	D4	D3	D2	D1	D0	
FOCUS	0	0	0	0	FS ON	FG	FSR EN	x	FS OK
TRACK1 { A B	0	0	0	1	x	BRAKE A	TG2	TG1	0
			1		x	BRAKE B			
TRACK2	0	0	1	0	TRACK		SLIDE		TC
SERVO OFF	0	1	x	x	x	x	x	x	0
STOP	1	1	x	x	x	x	x	x	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	D3 1 ON	Focus search start → Focus on
		0 OFF	
FG	↑	D2 1 CLOSE	FG SW for changing focus gain is opened or closed
		0 OPEN	
FSR EN	↑	D1 1 INHIBIT	Inhibit automatic re-search of focus
		0 ENABLE	
BRAKE A	TRACK1 A	D2 1 ON	Jump break action. TS2 SW is opened or closed
		0 OFF	
BRAKE B	TRACK1 B	D2 1 ON	Jump break action. TS1 SW is opened or closed
		0 OFF	
TG2	TRACK1	D1 1 OPEN	TG2 SW for changing TRACK gain is controlled
		0 CLOSE	
TG1	TRACK1	D0 1 OPEN	TG1 SW for changing TRACK gain is controlled
		0 CLOSE	
TRACK	TRACK2	D3 D2	SW states shown in Table 4
		0 0 TS OFF	
		0 1 TS ON	
		1 0 JF	
SLIDE	TRACK2	1 1 JR	SW states shown in Table 5
		D1 D0	
		0 0 SS OFF	
		0 1 SS ON	
-	SERVO OFF	1 0 SF	Forward slide
		1 1 SR	
-	STOP		Data of D0~D3 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 ② and Vcc. (Resistance value : Rx)

If the current value of a current source (FSR, TS, SS) is Ifsr, Its, Iss)

$$I_{FSR} \approx \frac{1}{8} \cdot \frac{V_{CC} - V_{(2)}}{R_x}$$

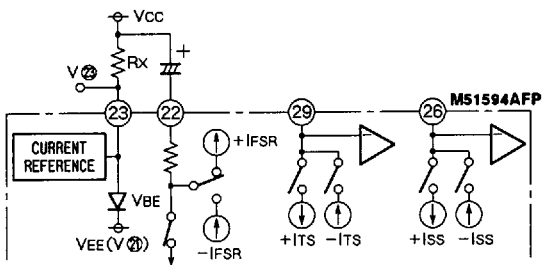
$$I_{TS} \approx \frac{1}{8} \cdot \frac{V_{CC} - V_{(2)}}{R_x}$$

$$I_{SS} \approx \frac{1}{4} \cdot \frac{V_{CC} - V_{(2)}}{R_x}$$

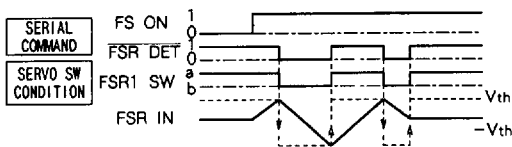
And if the voltage value of pin ② is V₍₂₎, the voltage value of pin ②,

$$V_{(2)} = V_{(2)} + V_{BE} \quad (V_{BE} \approx 0.7V)$$

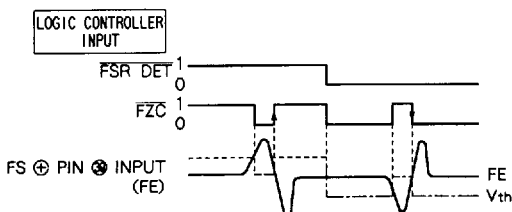
BLOCK DIAGRAM OF CURRENT SOURCES



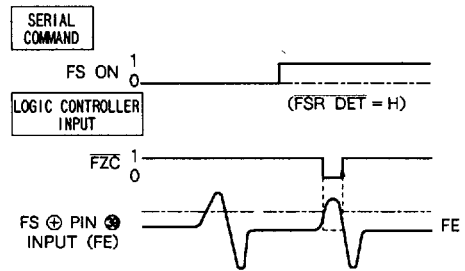
Timing chart of FSR det



Timing chart of FZC



FZC reset



FSR detector

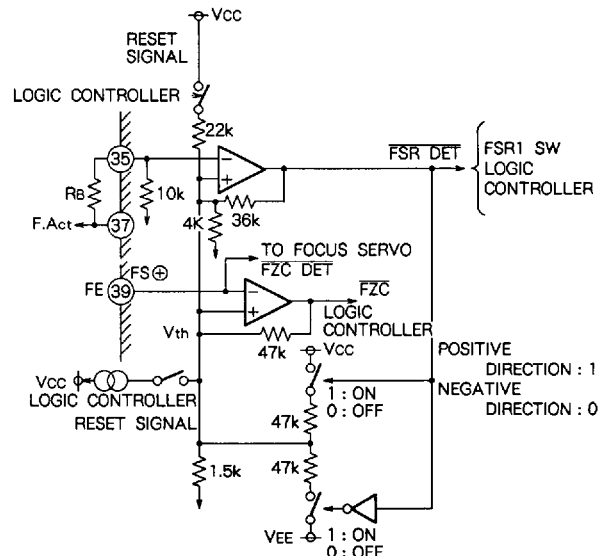
With external resistor (Ra) connected between FS OUT (pin ⑦ output) and FSR IN (pin ③ input) at FSR function,

- 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 DET	FSR1 SW	At ±5V FZC Vth
FSR IN level VIN	FSR DET	FSR1 SW	At ±5V FZC Vth
VIN > Vth	0	b: Negative direction of FSR	Min -0.30V
VIN < Vth	1	a: Positive direction of FSR	Max 0V
			0V 0.30V

Equivalent circuit



(2) How to send serial data(MSD)

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

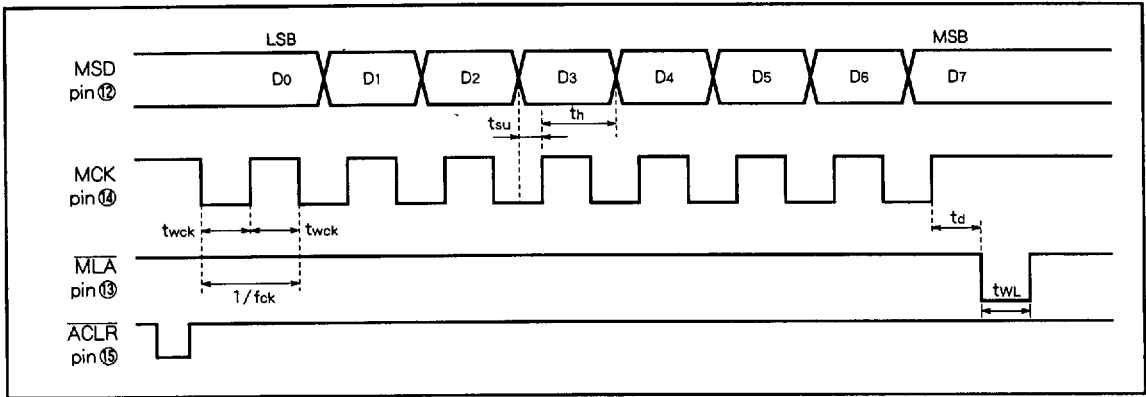


Fig. 1 Serial data input timing chart

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 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 D3 D2	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)

Table 5. Slide function

Command	INPUT		OUTPUT (SW state)		
	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

JP1 Input

At one track jump, JP1 signal allows two transmissions of serial data to selected and restrains the delay time of microcomputer.

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

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

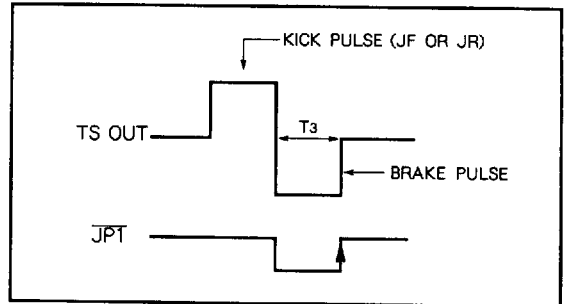


Fig. 2 JP1 timing chart

Table 6. TRACK, SLIDE states by JP1 Input

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 JP1 goes up, states do not become TS ON and SS ON.

6. Change to TS ON and SS ON after 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 produced by latching MR pulse with pulse edges of TC Det output (TC). At reset, TC is low.

Table 9. TC output

INPUT		OUTPUT
MR	TC	TC
1	↑ or ↓	1
0	↑ or ↓	0

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(2) **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.

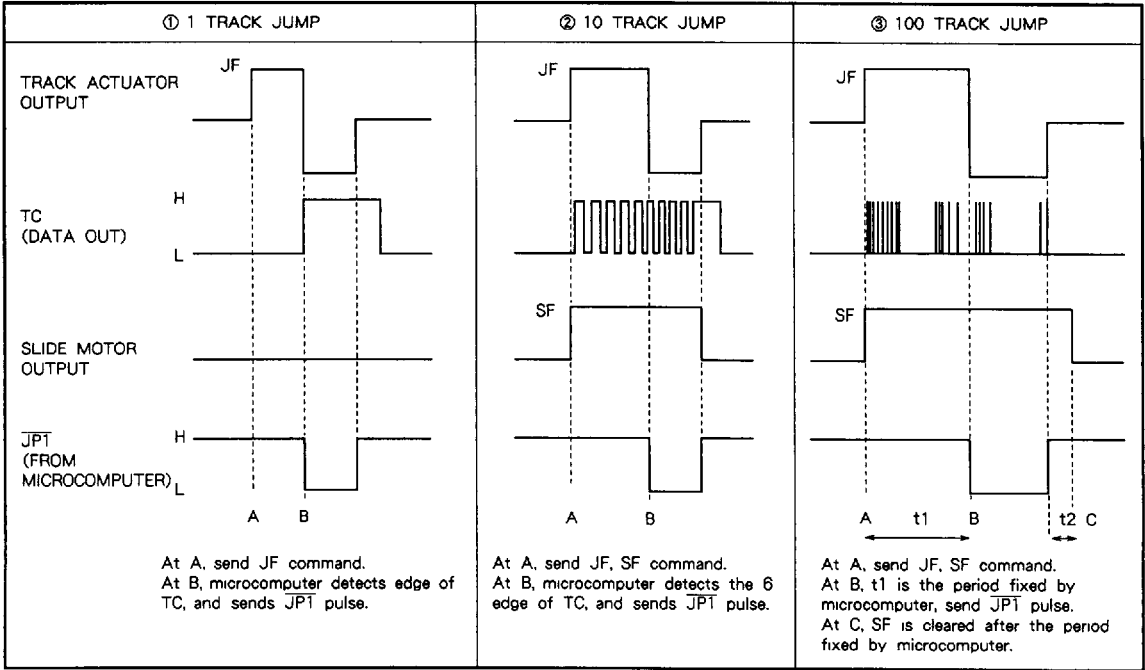
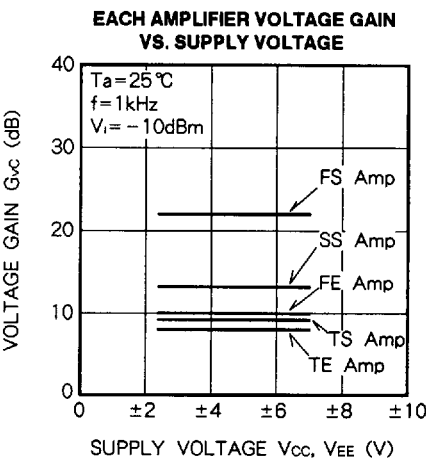
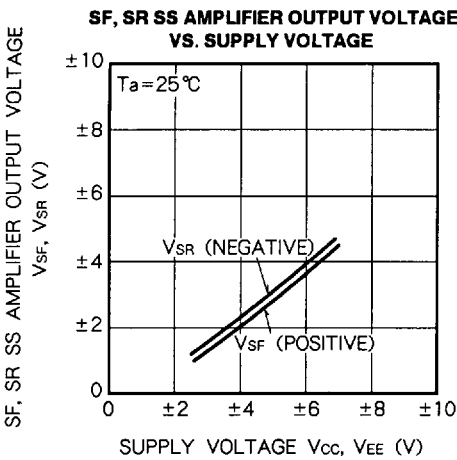
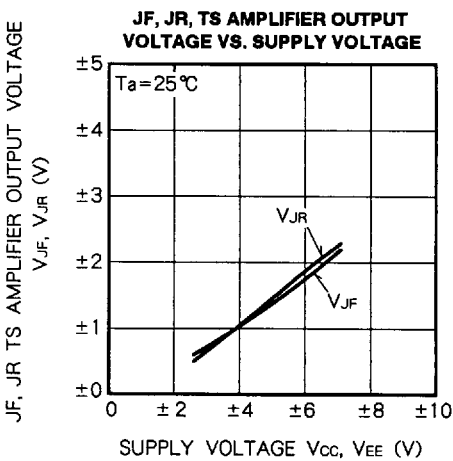
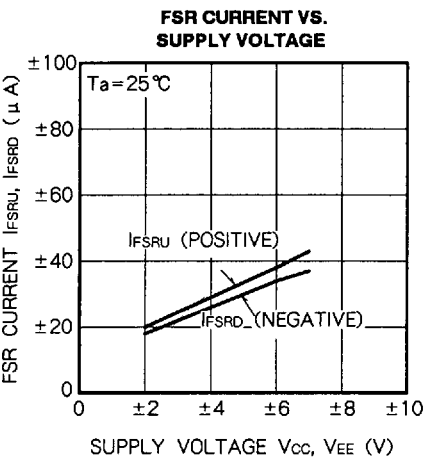
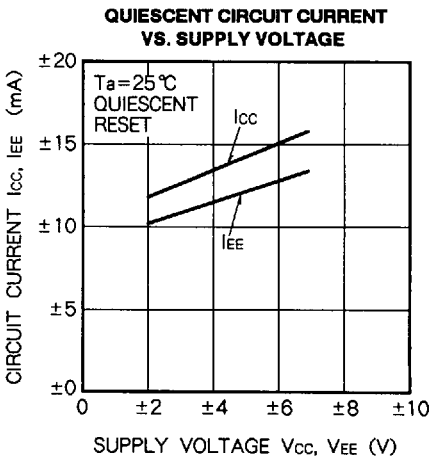
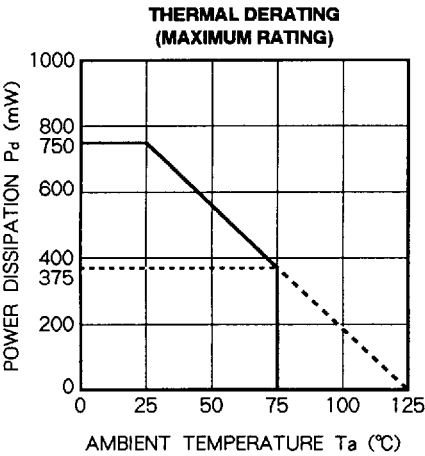


Fig. 3 Example for track jump timing. (Forward jump)

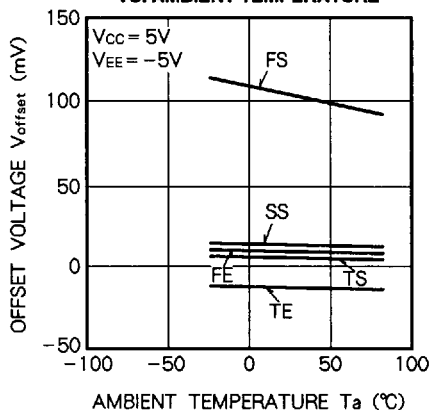
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OPTICAL PICKUP SERVO CONTROL

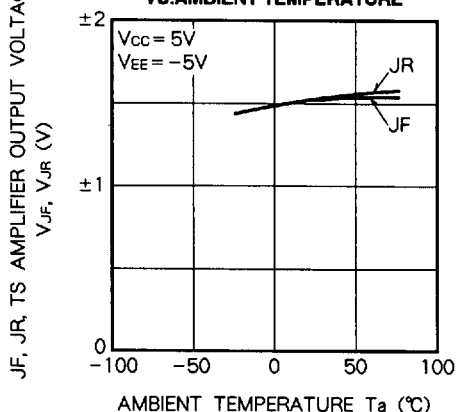
TYPICAL CHARACTERISTICS



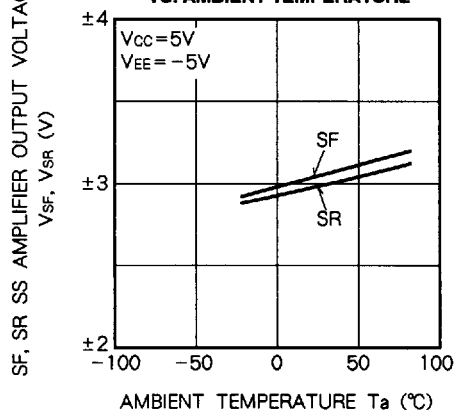
**AMPLIFIER OFFSET VOLTAGES
VS. AMBIENT TEMPERATURE**



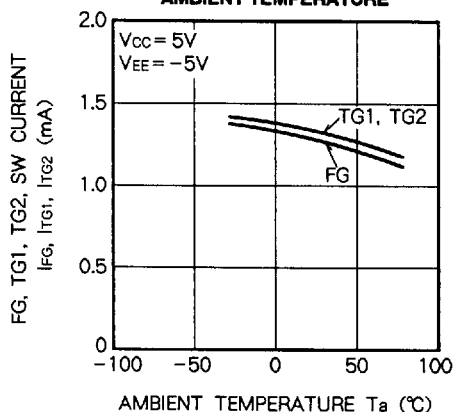
**JF, JR, TS AMPLIFIER OUTPUT VOLTAGE
VS. AMBIENT TEMPERATURE**



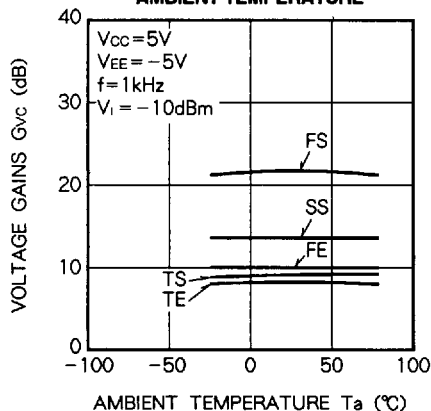
**SF, SR SS AMPLIFIER OUTPUT VOLTAGE
VS. AMBIENT TEMPERATURE**



**FG, TG1, TG2 CURRENT VS.
AMBIENT TEMPERATURE**



**AMPLIFIER VOLTAGE GAINS VS.
AMBIENT TEMPERATURE**



OPTICAL PICKUP SERVO CONTROL

APPLICATION EXAMPLE ($V_{CC} = +5V$, $V_{EE} = -5V$)

