M52732SP

3-CHANNEL VIDEO AMPLIFICATION

DESCRIPTION

The M52732SP is a semiconductor integrated circuit that has 3-channels of built-in amplifiers in the broad-band video amplifier having a 75MHz band. Every channel is provided with a broad-band amplifier, contrast control (main and sub), and brightness control. It accordingly has an optimal configuration for use with high resolution color display monitors.

FEATURES

- It realize low power dissipation so that 3-channels are built in. (V_{CC}=12V, I_{CC}=63mA)
- Input.....0.7V_{P-P} (typ.)
  Output.....4.5V_{P-P} (max.)
  Frequency band.....75MHz (at 3V_{P-P})
- To adjust contrast, two types of controls are provided, main and sub.
  The main controls adjusts 3-channels of contrast concurrently.
  The sub contrast controls adjusts either channel independentry.

APPLICATION

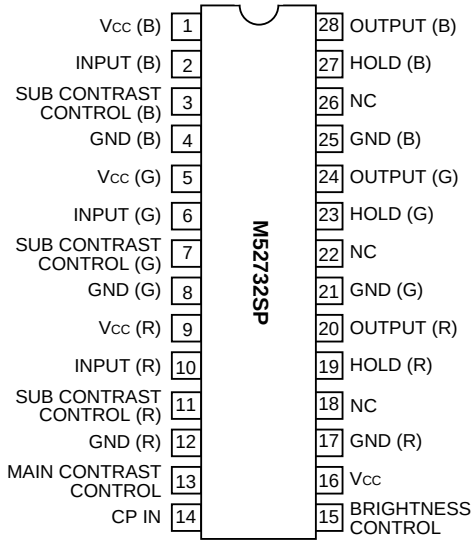
Display monitor

RECOMMENDED OPERATING CONDITION

Supply voltage range.....11.5 to 12.5V

Rated supply voltage.....12.0V

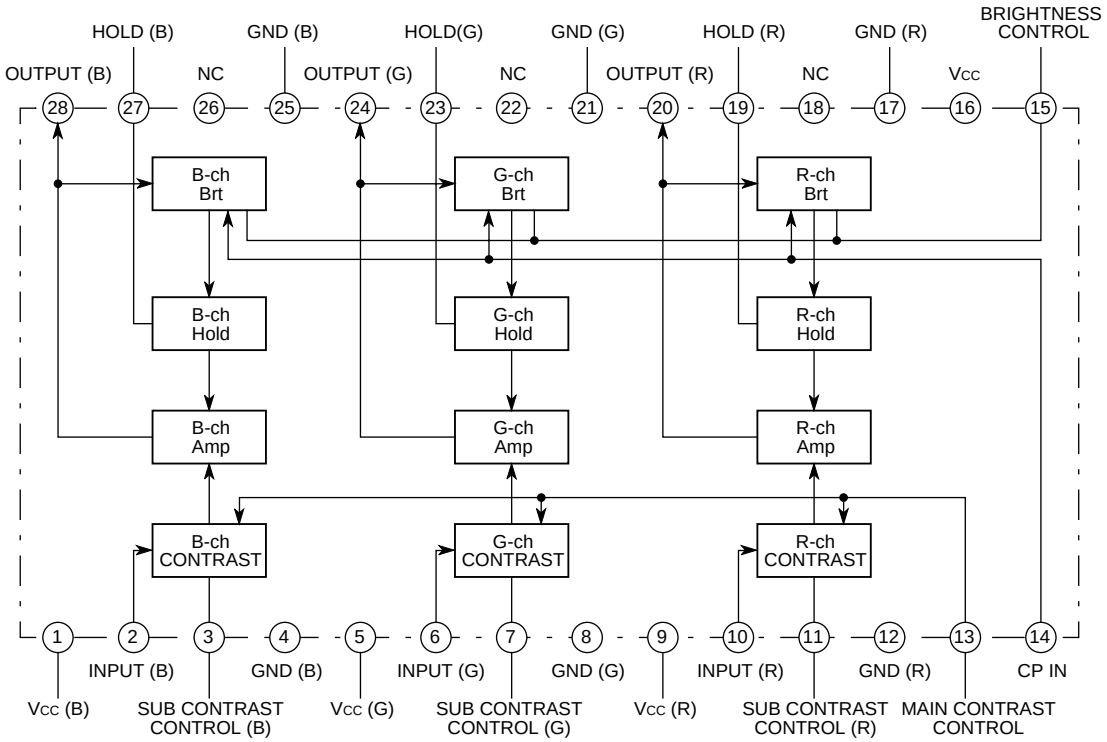
PIN CONFIGURATION (TOP VIEW)



Outline 28P4B

NC : NO CONNECTION

BLOCK DIAGRAM



ABSOLUTE MAXIMUM RATINGS (Ta=25°C)

Symbol	Parameter	Ratings	Unit
V_{CC}	Supply voltage	13.0	V
P_d	Power dissipation	1580	mW
T_{opr}	Ambient temperature	-20 to +85	°C
T_{stg}	Storage temperature	-40 to +150	°C
V_{opr}	Recommended supply voltage	12.0	V
$V_{opr'}$	Recommended supply voltage range	11.5 to 12.5	V
Surge	Electrostatic discharge	±200	V

ELECTRICAL CHARACTERISTICS (V_{CC}=12V, Ta=25°C, unless otherwise noted)

Symbol	Parameter	Test conditions								Limits			Unit
		Test point (s)	Input			External power supply (V)			Pulse input				
			SW10 R-ch	SW6 G-ch	SW2 B-ch	V3	V13	V15	SW14	Min.	Typ.	Max.	
I_{CC}	Circuit current	A	a –	a –	a –	12	12	5	b SG6	45	72	110	mA
Vomax	Output dynamic range	T.P.20 T.P.24 T.P.28	b SG1	b SG1	b SG1	12	12	Variable	a –	5.8	6.8	9.0	V_{P-P}
Vimax	Maximum input	T.P.20 T.P.24 T.P.28	b SG1	b SG1	b SG1	12	6	Variable	a –	1.9	2.4	2.9	V_{P-P}
Gv	Maximum gain	T.P.20 T.P.24 T.P.28	b SG1	b SG1	b SG1	12	12	V_T	a –	13	17	20	dB
ΔGv	Relative maximum gain		Relative to measured values above							0.8	1	1.2	–
V_{CR1}	Contrast control characteristics (typical)	T.P.20 T.P.24 T.P.28	b SG1	b SG1	b SG1	12	6	V_T	a –	4.0	7.4	10.1	dB
ΔV_{CR1}	Contrast control relative characteristics (typical)		Relative to measured values above							0.8	1	1.2	–
V_{CR2}	Contrast control characteristics (minimum)	T.P.20 T.P.24 T.P.28	b SG1	b SG1	b SG1	12	3.5	V_T	a –	5	30	70	mV_{P-P}
ΔV_{CR2}	Contrast control relative characteristics (minimum)		Relative to measured values above							0.8	1	1.3	–
V_{SCR1}	Sub contrast control characteristics (typical)	T.P.20 T.P.24 T.P.28	b SG1	b SG1	b SG1	6	12	V_T	a –	9.9	14	18.1	dB
ΔV_{SCR1}	Sub contrast control relative characteristics (typical)		Relative to measured values above							0.8	1	1.2	–
V_{SCR2}	Sub contrast control characteristics (minimum)	T.P.20 T.P.24 T.P.28	b SG1	b SG1	b SG1	3	12	V_T	a –	50	300	600	mV_{P-P}
ΔV_{SCR2}	Sub contrast control relative characteristics (minimum)		Relative to measured values above							0.8	1	1.2	–
V_{CR2}	Contrast/sub contrast control characteristics (typical)	T.P.20 T.P.24 T.P.28	b SG1	b SG1	b SG1	6	6	V_T	a –	0.9	1.3	1.7	V_{P-P}
ΔV_{CR2}	Contrast/sub contrast control relative characteristics (typical)		Relative to measured values above							0.8	1	1.2	–
V_{B1}	Brightness control characteristics (maximum)	T.P.20 T.P.24 T.P.28	a –	a –	a –	12	12	5.5	b SG6	3.6	4.3	5.0	V
ΔV_{B1}	Brightness control relative characteristics (maximum)		Relative to measured values above							-100	0	100	mV

ELECTRICAL CHARACTERISTICS (cont.)

Symbol	Parameter	Test conditions								Limits			Unit
		Test point (s)	Input			External power supply (V)			Pulse input				
			SW10 R-ch	SW6 G-ch	SW2 B-ch	V3	V13	V15	SW14	Min.	Typ.	Max.	
V_{B2}	Brightness control characteristics (typical)	T.P.20 T.P.24 T.P.28	a –	a –	a –	12	12	5	b SG6	3.0	3.7	4.4	V
ΔV_{B2}	Brightness control relative characteristics (typical)		Relative to measured values above							-100	0	100	mV
V_{B3}	Brightness control characteristics (minimum)	T.P.20 T.P.24 T.P.28	a –	a –	a –	12	12	4.5	b SG6	2.5	3.2	4.0	V_{DC}
ΔV_{B3}	Brightness control relative characteristics (minimum)		Relative to measured values above							-100	0	100	mV
F_{C1}	Frequency characteristics 1 (f=50MHz;maximum)	T.P.20 T.P.24 T.P.28	b SG3	b SG3	b SG3	12	7.5	V_T	a –	-2	0	3	dB
ΔF_{C1}	Frequency relative characteristics 1 (f=50MHz;maximum)		Relative to measured values above							-1	0	1	dB
$F_{C1'}$	Frequency characteristics 1 (f=75MHz;maximum)	T.P.20 T.P.24 T.P.28	b SG4	b SG4	b SG4	12	7.5	V_T	a –	-3	0	3	dB
$\Delta F_{C1'}$	Frequency relative characteristics 1 (f=75MHz;maximum)		Relative to measured values above							-1	0	1	dB
F_{C2}	Frequency characteristics 2 (f=50MHz; maximum)	T.P.20 T.P.24 T.P.28	b SG3	b SG3	b SG3	12	5	V_T	a –	-0.5	0	3	dB
$\Delta F_{C2'}$	Frequency relative characteristics 2 (f=75MHz; maximum)	T.P.20 T.P.24 T.P.28	b SG4	b SG4	b SG4	12	5	V_T	a –	-0.5	0	3	dB
C.T.1	Crosstalk 1 (f=50MHz)	T.P.20 T.P.24 T.P.28	b SG3	a –	a –	12	12	V_T	a –	–	-36	-24	dB
C.T.1'	Crosstalk 1 (f=75MHz)	T.P.20 T.P.24 T.P.28	b SG4	a –	a –	12	12	V_T	a –	–	-28	-18	dB
C.T.2	Crosstalk 2 (f=50MHz)	T.P.20 T.P.24 T.P.28	a –	b SG3	a –	12	12	V_T	a –	–	-36	-24	dB
C.T.2'	Crosstalk 2 (f=75MHz)	T.P.20 T.P.24 T.P.28	a –	b SG4	a –	12	12	V_T	a –	–	-28	-18	dB
C.T.3	Crosstalk 3 (f=50MHz)	T.P.20 T.P.24 T.P.28	a –	a –	b SG3	12	12	V_T	a –	–	-36	-24	dB
C.T.3'	Crosstalk 3 (f=75MHz)	T.P.20 T.P.24 T.P.28	a –	a –	b SG4	12	12	V_T	a –	–	-28	-18	dB
Tr	Pulse characteristics 1	T.P.20 T.P.24 T.P.28	b SG5	b SG5	b SG5	12	7	3	b SG6	–	3	7	nsec
Tf	Pulse characteristics 2	T.P.20 T.P.24 T.P.28	b SG5	b SG5	b SG5	12	7	3	b SG6	–	6	9	nsec
V14th	Clamp pulse threshold voltage	T.P.20 T.P.24 T.P.28	a –	a –	a –	12	12	3	b SG6	0.7	1.5	2.5	V_{DC}
W14	Clamp pulse minimum width	T.P.20 T.P.24 T.P.28	a –	a –	a –	12	12	3	b SG6	–	0.3	1.5	µsec
V27	Hold voltage	T.P.20 T.P.24 T.P.28	a –	a –	a –	12	12	3	b SG6	4	5.2	6.4	V_{DC}

ELECTRICAL CHARACTERISTICS TEST METHOD

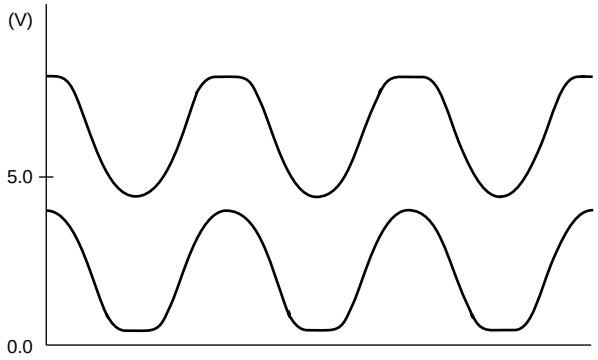
1. About switch numbers (SW Nos.) since those for the signal and pulse input pins are listed in Attached Table 1, the following notes omit them. Only SW Nos. for the external power supply will be indicated in the Notes.
2. since sub contrast voltges V3, V7, and V11, they are also set to the same value, so that V3 in attached Table 1 represents all.

I_{CC} Circuit current

Conditions shall be as indicated in Attached Table 1. Measure these conditions using ampere meter A with SW1 set to a.

Vomax Output dynamic range

1. Follow the procedure below to set V15.
   Input SG1 to pin 10 (pin 6, 2) and raise V15 slowly. Read the voltage of V15 when the higher peak of output waveform of T.P20 (T.P24, 28) begins distortion. This voltage is V_{TR1} (V_{TG1}, V_{TB1})
   Next, reduce V15 slowly. Read the voltage of V15 when the lower peak of output waveform of T.P20 (T.P24, 28) begins distortion. This voltage is V_{TR2} (V_{TG2}, V_{TB2}).



Waveform output at T.P20
(Identical to output at T.P24 and T.P28.)

From the above result, V_T (V_{TR}, V_{TG}, V_{TB}) is determined as follows:

$$V_{TR}\ (V_{TG}, V_{TB}) = \frac{V_{TR1}\ (V_{TG1}, V_{TB1}) + V_{TR2}\ (V_{TG2}, V_{TB2})}{2}$$

Change the procedure according to output pins.
Use V_{TR1} when measuring T.P20. Similarly, V_{TG1} for T.P24, V_{TB1} for T.P28.

2. Set V15 to V_{TR} (V_{TG}, V_{TB}), then slowly raise SG1 amplitude starting from 700mV. Measure the output amplitude when the higher and lower peaks of T.P20 (T.P24, T.P28) output waveform simultaneously begin distortion.

Vimax Maximum input

Under the conditions in Note 2, vary V13 to 6.7V as indicated in Attached Table 1, then slowly raise amplitude of the input signal starting from 700mV_{P-P}. Read the amplitude of the input signal when the output signal begins distortion.

Gv Maximum gain
ΔGv Relative maximum gain

1. Under conditions in attached Table.
2. Input SG1 to pin 10 (pin 6, 2). Read amplitude of the output at T.P20 (T.P24, 28), which is V_{OR1} (V_{OG1}, V_{OB1}).
3. The maximum gain G is:

$$GV=20LOG\ \frac{V_{OR1}\ (V_{OG1}, V_{OB1})\ \ [V_{P-P}]}{0.7\qquad\qquad [V_{P-P}]}$$

4. The maximum relative gain ΔG is calculated by the equation below:

$$\Delta G_V = V_{OR1}/V_{OG1},\ V_{OG1}/V_{OB1},\ V_{OB1}/V_{OR1}$$

V_{CR1} Contrast control characteristics (typical)
ΔV_{CR1} Contrast control relative characteristics (typical)

1. Conditions are identical with those in Attached Table except setting V13 to 6.0V.
2. Then read amplitude of the output at T.P20 (T.P24, 28), which is V_{OR2} (V_{OG2}, V_{OB2})
3. The contrast control characteristics V_{CR1} and relative contrast control characteristics ΔV_{CR1} are calculated by the equations below:

$$V_{CR1}=20LOG\ \frac{V_{OR2}\ (V_{OG2}, V_{OB2})\ \ [V_{P-P}]}{0.7\qquad\qquad [V_{P-P}]}$$

$$\Delta V_{CR1} = V_{OR2}/V_{OG2},\ V_{OG2}/V_{OB2},\ V_{OB2}/V_{OR2}$$

V_{CR2} Contrast control characteristics (minimum)
ΔV_{CR2} Contrast control relative characteristics (minimum)

1. Conditions are identical with those in Attached Table except setting V13 to 3.0V.
2. Then read amplitude of the output at T.P20 (T.P24, 28), which is V_{OR3} (V_{OG3}, V_{OB3}) and also V_{CR2}.
3. The relative contrast control characteristics ΔV_{CR2} is:

$$\Delta V_{CR2} = V_{OR3}/V_{OG3},\ V_{OG3}/V_{OB3},\ V_{OB3}/V_{OR3}$$

V_{SCR1} Sub contrast control characteristics (typical)
ΔV_{SCR1} Sub contrast control relative characteristics (typical)

1. Conditions are identical with those in Attached Table except setting V3, V7, and V11 to 6.0V.
2. Then read amplitude of the output at T.P20 (T.P24, 28), which is V_{OR4} (V_{OG4}, V_{OB4}).
3. The sub contrast control characteristics V_{SCR1} and relative sub contrast control characteristics ΔV_{SCR1} are:

$$V_{SCR1}=20LOG\frac{V_{OR4}\ (V_{OG4}, V_{OB4})\ \ [V_{P-P}]}{0.7\qquad\qquad [V_{P-P}]}$$

$$\Delta V_{SCR1} = V_{OR4}/V_{OG4},\ V_{OG4}/V_{OB4},\ V_{OB4}/V_{OR4}$$

V_{SCR2} Sub contrast control characteristics (minimum)
ΔV_{SCR2} Sub contrast control relative characteristics (minimum)

1. Conditions are identical with those in Attached Table expect setting V3, V7, and V11 to 3.0V.
2. Then read amplitude of the output at T.P20 (T.P24, 28), which is V_{OR5} (V_{OG5}, V_{OB5}) and also V_{SCR2}.
3. The relative sub contrast control characteristics ΔV_{SCR2} is:

$$\Delta V_{SCR2}=V_{OR5}/V_{OG5},\ V_{OG5}/V_{OB5},\ V_{OB5}/V_{OR5}$$

V_{CR2} Contrast/sub contrast control characteristics (typical)
ΔV_{CR2} Contrast/sub contrast control relative characteristics (typical)

1. Conditions are identical with those in Attached Table expect setting V13, to 6.0V and V3, V7, and V11 to 6.0V.
2. Then read amplitude of the output at T.P20 (T.P24, 28), which is V_{OR6} (V_{OG6}, V_{OB6}).
3. The gain and relative gain when the contrast and sub contrast are typical, are:

$$V_{CR3}=20\text{LOG}\ \frac{V_{OR6}\ (V_{OG6},\ V_{OB6})\ \ [V_{P\text{-}P}]}{0.7\qquad\qquad [V_{P\text{-}P}]}$$

$$\Delta V_{CR3}=V_{OR6}/V_{OG6},\ V_{OG6}/V_{OB6},\ V_{OB6}/V_{OR6}$$

V_{B1} Brightness control characteristics (maximum)
ΔV_{B1} Brightness control relative characteristics (maximum)

1. Under conditions in Attached Table.
2. Then use a voltmeter to measure the output at T.P20 (T.P24, 28), which is V_{OR7} (V_{OG7}, V_{OB7}). This value is V_{B1}.
3. In addition, the relative brightness control characteristic is determined from V_{OR7}, V_{OG7}, and V_{OB7} by calculating differences between each channel.

$$\Delta V_{B1}=V_{OR7}\text{-}V_{OG7}=V_{OG7}\text{-}V_{OB7}=V_{OB7}\text{-}V_{OR7}\quad [mV]$$

V_{B2} Brightness control characteristics (typical)
ΔV_{B2} Brightness control relative characteristics (typical)

1. Under conditions in Attached Table.
2. Then use a voltmeter to measure the output at T.P20 (T.P24, 28), which is $V_{OR7'}$ ($V_{OG7'}$, $V_{OB7'}$). This value is V_{B2}.
3. In addition, the relative brightness control characteristic is determined from $V_{OR7'}$, $V_{OG7'}$, and $V_{OB7'}$ by calculating differences between each channel.

$$\Delta V_{B2}=V_{OR7'}\text{-}V_{OG7'}=V_{OG7'}\text{-}V_{OB7'}=V_{OB7'}\text{-}V_{OR7'}\quad [mV]$$

V_{B3} Brightness control characteristics (minimum)
ΔV_{B3} Brightness control relative characteristics (minimum)

1. Under conditions in Attached Table.
2. Then use a voltmeter to measure the output at T.P20 (T.P24, 28), which is $V_{OR7''}$ ($V_{OG7''}$, $V_{OB7''}$). This value is V_{B3}.
3. In addition, the relative brightness control characteristic ΔV_{B3} is determined from $V_{OR7''}$, $V_{OG7''}$, and $V_{OB7''}$ by calculating differences between each channel.

$$\Delta V_{B3}=V_{OR7''}\text{-}V_{OG7''}=V_{OG7''}\text{-}V_{OB7''}=V_{OB7''}\text{-}V_{OR7''}\quad [mV]$$

F_{C1} Frequency characteristics1 (f=50MHz; maximum)
ΔF_{C1} Frequency relative characteristics1 (f=50MHz; maximum)
$F_{C1'}$ Frequency characteristics1 (f=75MHz; maximum)
$\Delta F_{C1'}$ Frequency relative characteristics1 (f=75MHz; maximum)

1. Under conditions in Attached Table.
2. Use SG3 and SG4. Measure amplitude of the output waveform at T.P20 (T.P24, T.P28) following the procedure in G_V, ΔG_V.
3. The frequency characteristics F_{C1}, $F_{C1'}$ are calculated by the equations below:

$$F_{C1}=20\text{LOG}\ \frac{V_{OR8}\ (V_{OG8},\ V_{OB8})\ \ [V_{P\text{-}P}]}{V_{OR1}\ (V_{OG1},\ V_{OB1})\ \ [V_{P\text{-}P}]}$$

$$F_{C1'}=20\text{LOG}\ \frac{V_{OR9}\ (V_{OG9},\ V_{OB9})\ \ [V_{P\text{-}P}]}{V_{OR1}\ (V_{OG1},\ V_{OB1})\ \ [V_{P\text{-}P}]}$$

Whre, V_{OR8} (V_{OG8}, V_{OB8}) is the output amplitude when inputting SG3, and V_{OR9} (V_{OG9}, V_{OB9}), SG4, which are measured in 2 above. (V_{OR1} (V_{OG1}, V_{OB1}) is the value measured in G_V, ΔG_V.)

4. The relative frequency characteristics ΔF_{C1}, $\Delta F_{C1'}$ are determined by calculating differences between each channel's F_{C1} and $F_{C1'}$.

F_{C2} Frequency characteristics2 (f=50MHz; maximum)
$\Delta F_{C2'}$ Frequency relative characteristics2 (f=75MHz; maximum)

The procedure is identical with that in F_{C1}, ΔF_{C1}, $F_{C1'}$, $\Delta F_{C1'}$ except that the contrast (V13) is reduced to 5.0V.

C.T.1 Crosstalk1 (f=50MHz)
C.T.1' Crosstalk1 (f=75MHz)

1. Under conditions in attached Table.
2. Input SG2 (or SG4) to pin 10 (R-ch) only. Then measure amplitude of the output waveform at T.P20 (T.P24, T.P28), which are V_{OR}, V_{OG}, and V_{OB}, respectively.
3. Crosstalk C.T. is:

$$\text{C.T.}=20\text{LOG}\ \frac{V_{OG}\ \text{or}\ V_{OB}\ \ [V_{P\text{-}P}]}{V_{OR}\qquad\quad [V_{P\text{-}P}]}\ [dB]$$
(C.T. ')

C.T.2 Crosstalk2 (f=50MHz)
C.T.2' Crosstalk2 (f=75MHz)

1. Afterthe input pin from 10 (R-ch) to 6 (G-ch) and read the output following the procedure in C.T.1, C.T.1'.
2. Crosstalk C.T. is:

$$\text{C.T.} = 20\text{LOG}\frac{V_{OR} \text{ or } V_{OB}\ [V_{P\text{-}P}]}{V_{OG}\ [V_{P\text{-}P}]}\ [\text{dB}]$$
$$(\text{C.T.}') = 20\text{LOG}\frac{V_{OR} \text{ or } V_{OB}\ [V_{P\text{-}P}]}{V_{OG}\ [V_{P\text{-}P}]}\ [\text{dB}]$$

C.T.3 Crosstalk3 (f=50MHz)
C.T.3' Crosstalk3 (f=75MHz)

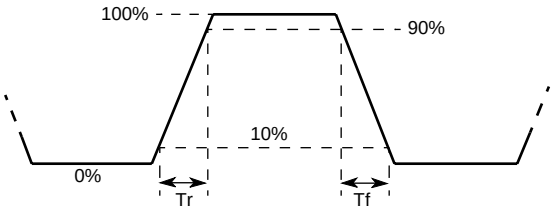
1. After the input pin from 10 (R-ch) to 2 (B-ch) and read the output following the procedure in C.T.1, C.T.1'.
2. Crosstalk C.T. is:

$$\text{C.T.} = 20\text{LOG}\frac{V_{OR} \text{ or } V_{OB}\ [V_{P\text{-}P}]}{V_{OG}\ [V_{P\text{-}P}]}\ [\text{dB}]$$
$$(\text{C.T.}') = 20\text{LOG}\frac{V_{OR} \text{ or } V_{OB}\ [V_{P\text{-}P}]}{V_{OG}\ [V_{P\text{-}P}]}\ [\text{dB}]$$

Tr Pulse characteristics1
Tf Pulse characteristics2

1. Under conditions in attached Table.
2. Measure 10% to 90% rise Tr1 and fall Tf1 of the input pulse using an active probe.
3. Next, measure 10% to 90% rise Tr2 and fall Tf2 of the output pulse using an active probe.
4. Pulse characteristics Tr and Tf are calculated by the equations below :

$$\text{Tr (nsec)} = \sqrt{(\text{Tr2})^2 - (\text{Tr1})^2}$$
$$\text{Tf (nsec)} = \sqrt{(\text{Tf2})^2 - (\text{Tf1})^2}$$



V14th Clamp pulse threshold voltage

1. Under conditions in attached Table.
2. Then slowly reduce the level of SG6 monitoring the output (approx.2.0V_{DC}) and measure the level of SG6 when the output becomes 0V.

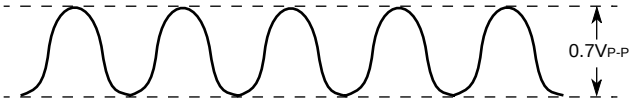
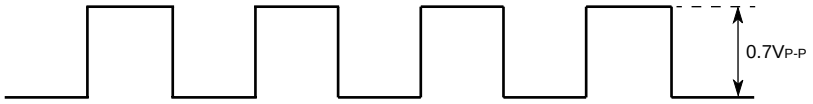
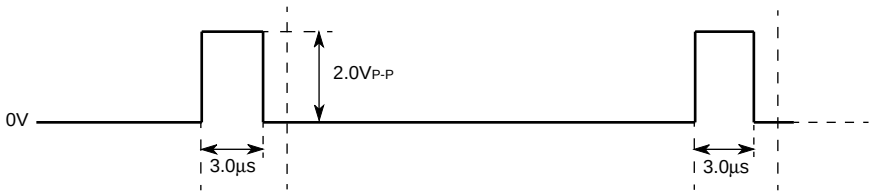
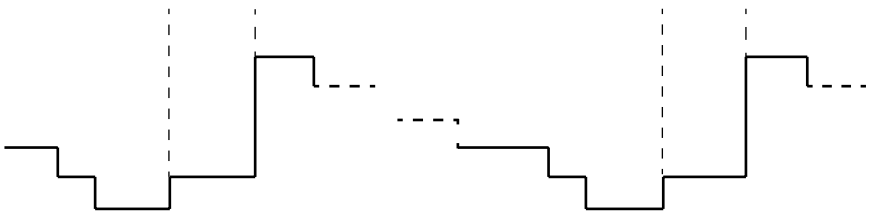
W14 Clamp pulse minimum width

Under the conditions in V14th, slowly reduce the pulse width of SG6 monitoring the output.
Then measure the pulse width of SG6 when the output becomes 0V.

V27 Hold voltage

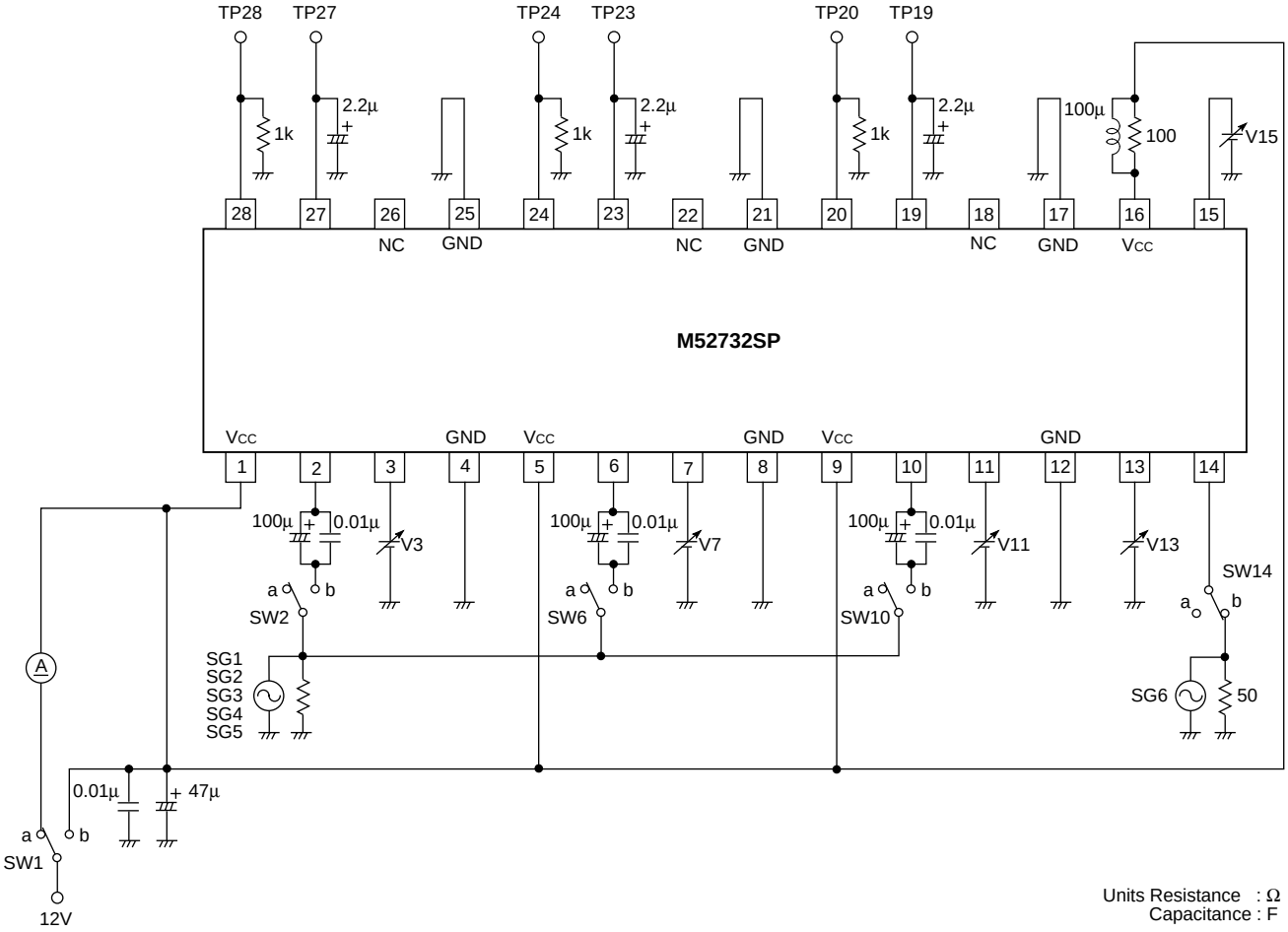
1. Under conditions in attached Table.
2. Read T.P19, 23 and 27 with a voltmeter.

INPUT SIGNAL

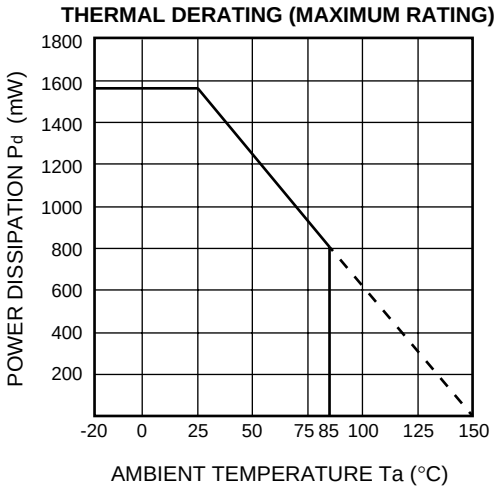
SG No.	Signals
SG1	Sine wave of amplitude 0.7V_{P-P} (75kHz, amplitude partlym variable∗) 
SG2	Sine wave with amplitude of 0.7V_{P-P} (f=10MHz)
SG3	Sine wave with amplitude of 0.7V_{P-P} (f=50MHz)
SG4	Sine wave with amplitude of 0.7V_{P-P} (f=75MHz)
SG5	Pulse with amplitude of 0.7V_{P-P} (f=1MHz, duty=50%) 
SG6	Pulses of amplitude 2.0V_{P-P} and width 3.0 synchronizing to the pedestal of the standard video staircase 
SG7 Standard video staircase	

∗ See Notes

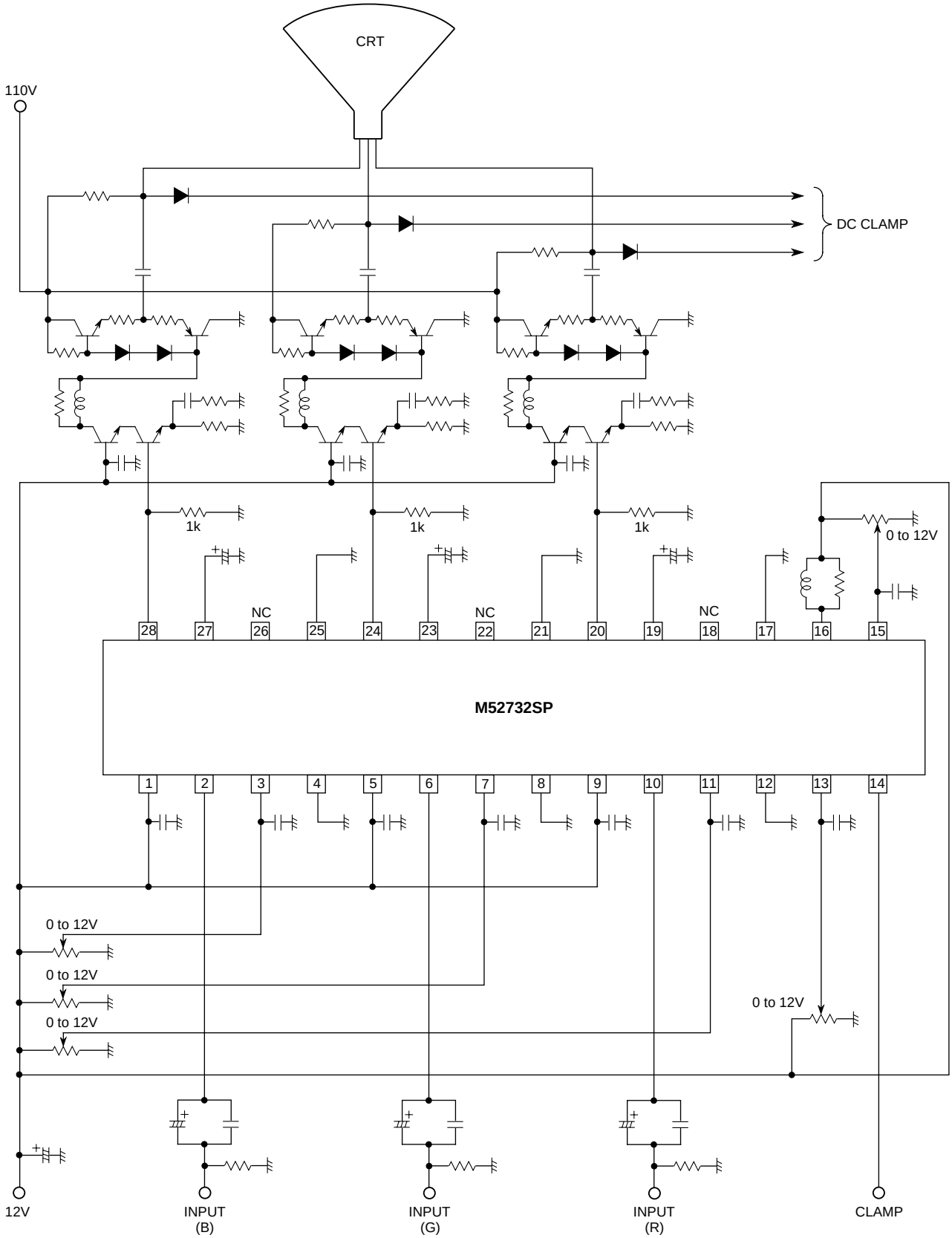
TEST CIRCUIT



TYPICAL CHARACTERISTICS

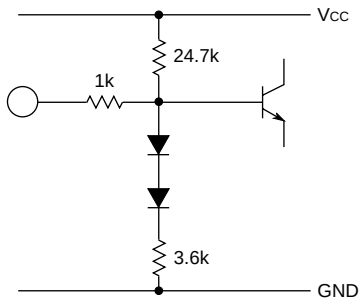
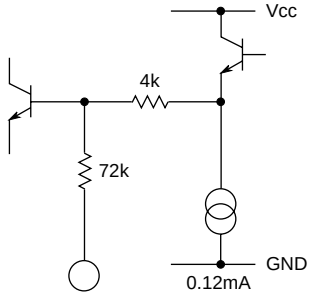
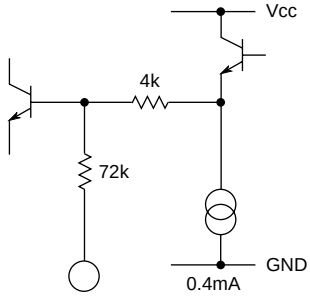
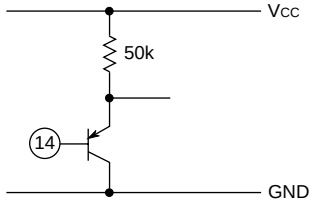


APPLICATION EXAMPLE

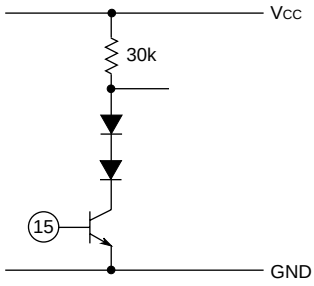
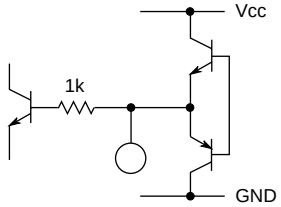
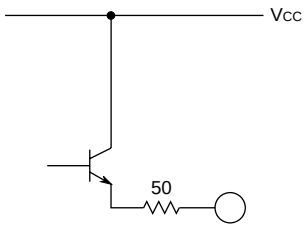


Units Resistance : Ω
Capacitance : F

DESCRIPTION OF PIN

Pin No.	Name	DC voltage (V)	Peripheral circuit of pins	Description of function
1 5 9	Vcc (B-ch) Vcc (G-ch) Vcc (R-ch)	12	–	The voltage to be applied to 3 channels shall be equal.
2 6 10	B-IN G-IN R-IN	2.9		
3 7 11	B SUB CONTRAST G SUB CONTRAST R SUB CONTRAST	4.0		
4, 25 8, 21 12, 17	GND (B-ch) GND (G-ch) GND (R-ch)	GND	–	
13	CONTRAST	6.9		
14	CLAMP PULSE			

DESCRIPTION OF PIN (cont.)

Pin No.	Name	DC voltage (V)	Peripheral circuit of pins	Description of function
15	BRIGHT			
16	Vcc	12	–	
18 22 26	NC			
19 23 27	R HOLD G HOLD B HOLD	Variable		
20 24 28	B OUT G OUT R OUT	Variable		A resistor is needed at the GND side. Choose any resistance value under 15mA according to the driving capability required.