Thick Film Hybrid IC

STK66083P

Non-Chopping Current Drive Print Head Driver

Applications

• Printers that require head drivers
• Various relay drive applications

Features

• A total of 116 devices, including drive power transistors and flyback voltage take-up diodes, are incorporated into a single package to reduce the total printed circuit board mounting area.

• A constant-current drive scheme can be implemented by setting the individual phase head current rise times to arbitrary values. Furthermore, the STK66083P's ability to handle a high supply voltage ($V_{CC}1 = 36$ V) allows the current rise times to be shortened.

• The built-in input pull-up resistors allow the STK66083P to be driven by open collector type TTL-ICs in the previous stage. Also, the provision of a base drive pin allows the STK66083P to support an enable function.

• Since the D1 to D12 flywheels for each phase are connected to the power supply, the flyback energy due to the winding inductance (L) can be returned to the power supply. This allows the power dissipation in the power supply and other circuits to be reduced.

Package Dimensions

unit: mm

4094

[STK66083P]
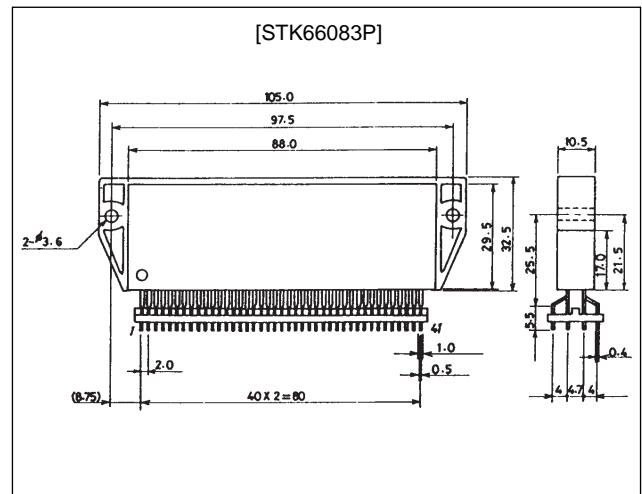
Specifications

Maximum Ratings at Ta = 25°C

Parameter	Symbol	Conditions	Ratings	Unit
Maximum supply voltage 1	V_{CC} max1	No signal	60	V
Maximum supply voltage 2	V_{CC} max2		7.0	V
Phase output current 1	Iop1 max	One pulse: 1 ms	15	A
Phase output current 2	Iop2 max	One pulse: 1 ms	6	A
Operating substrate temperature	Tc max		105	°C
Junction temperature	Tj max		150	°C
Storage temperature	Tstg		−40 to +125	°C
Transistor withstand voltages	V_{CEO}	TR1 to TR12 $I_C \leq 1$ mA	70	V

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Allowable Operating Conditions at Ta = 25°C

Parameter	Symbol	Conditions	Ratings	Unit
Supply voltage 1	$V_{CC}1$		18 to 42	V
Supply voltage 2	$V_{CC}2$		5.0 ± 10%	V
Phase output current 1	Iop1 max	For a 1 ms period and continuous operation with a duty cycle of 50% or lower while power is applied.	10	A
Phase output current 2	Iop2 max	For a 1 ms period and continuous operation with a duty cycle of 50% or lower while power is applied.	3.5	A

Operating Characteristics at Ta = 25°C, $V_{CC}1$ = 36 V, $V_{CC}2$ = 5 V

Parameter	Symbol	Conditions	min	typ	max	Unit
Input on voltage	V_{IH}		4.0			V
Input off voltage	V_{IL}	$V_{CC}2$ = 5 V, TR1 to TR18		0.8	1.0	V
Input off current 1	$I_{IL}1$	$V_{CC}2$ = 5 V, TR15 to TR18	0.25	0.35	0.45	mA
Input off current 2	$I_{IL}2$	$V_{CC}2$ = 5 V, TR1 to TR12	2.5	3.5	4.5	mA
Output saturation voltage 1	Vst1	I_O = 5.0 A, TR15 to TR18		1.2	1.9	V
Output saturation voltage 2	Vst2	I_O = 1.8 A, TR1 to TR12		1.1	1.9	V
Output leakage current 1	I_L1	V_{CE}= 60 V, TR15 to TR18			1.0	mA
Output leakage current 2	I_L2	V_{CE}= 70 V, TR1 to TR12			1.0	mA
Diode leakage current	I_L3	100 V, D1 to D16			0.1	mA
Diode forward voltage 1	Vdf1	Idf = 2.0 A, D13 to D16		1.2	1.8	V
Diode forward voltage 2	Vdf2	Idf = 0.5 A, D1 to D12		1.0	1.8	V

Note: A constant-voltage power supply must be used.
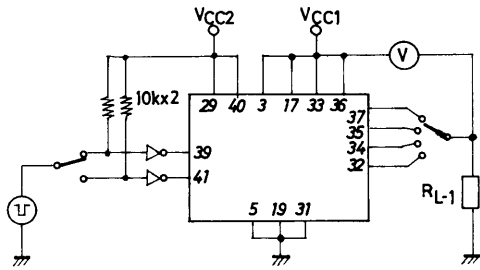
Equivalent Circuit
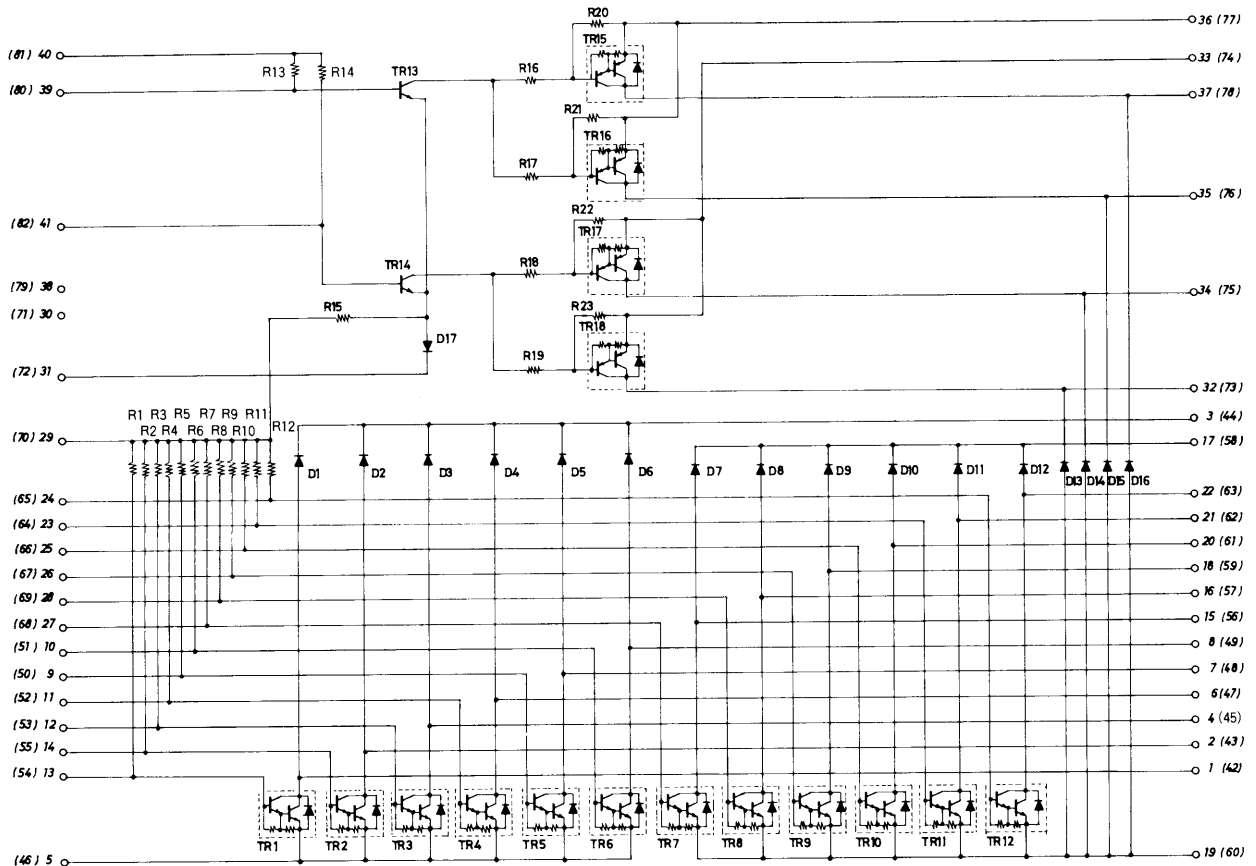
Note: Values in parentheses indicate pins 42 to 82 on the back side of the case.
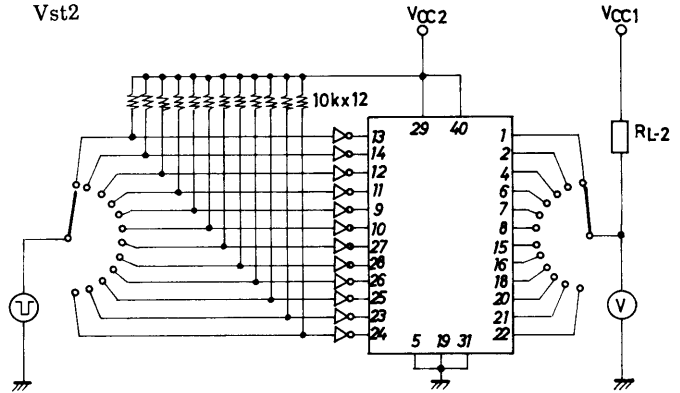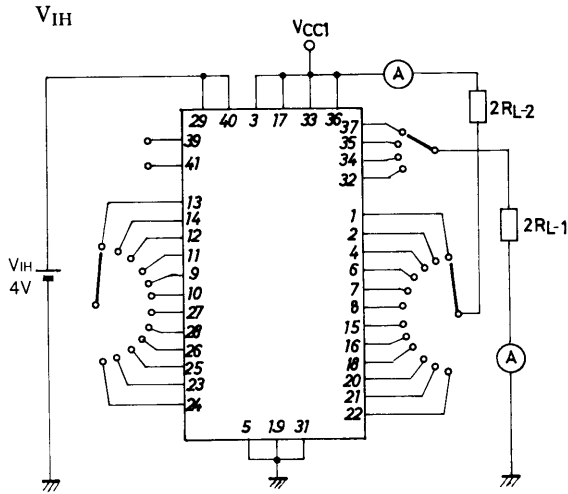
Test Circuits

Vst1

Vst2

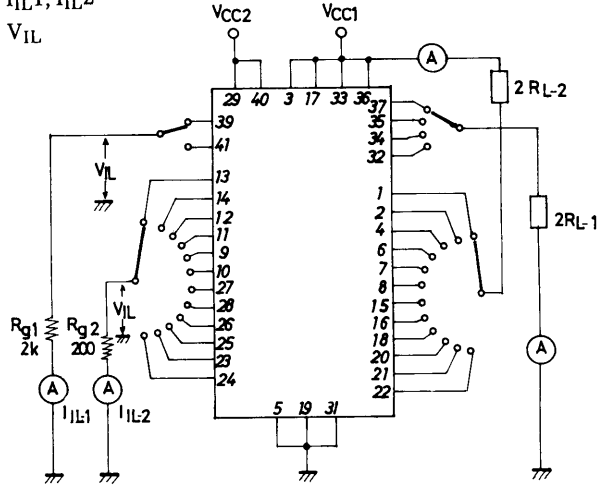Note: Pin numbers for the back side of the case are omitted.

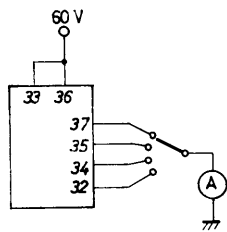Note: The input inverter IC (—▷o—) is a TTL open-collector type.
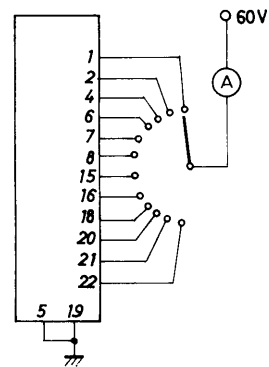(7406 equivalent)

V_{IH}

$I_{IL}1, I_{IL}2$
V_{IL}

I_L1

I_L2

I_L3 a)
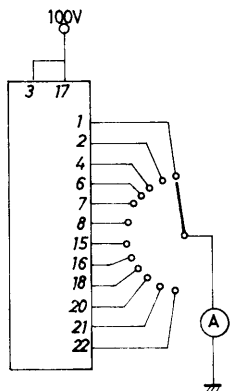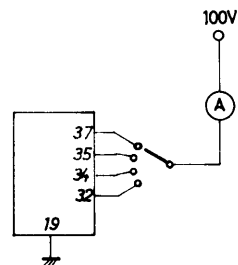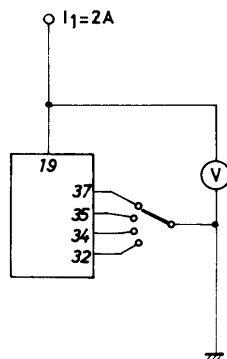
b)
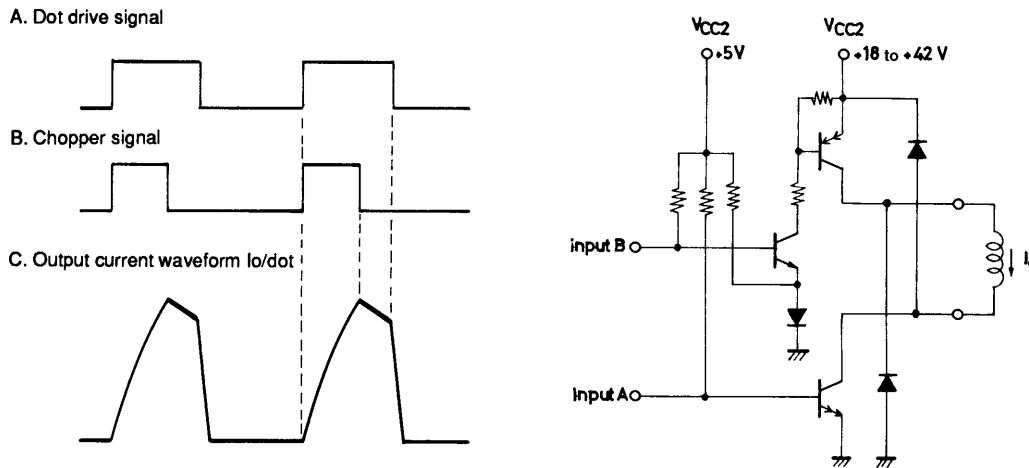
Unit (resistance: Ω)

Vdf1

Vdf2
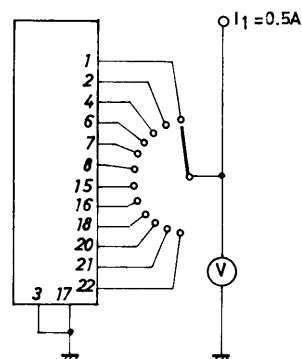
Sample Application Circuit

Chopper signal output IC
(Monostable multivibrator IC)
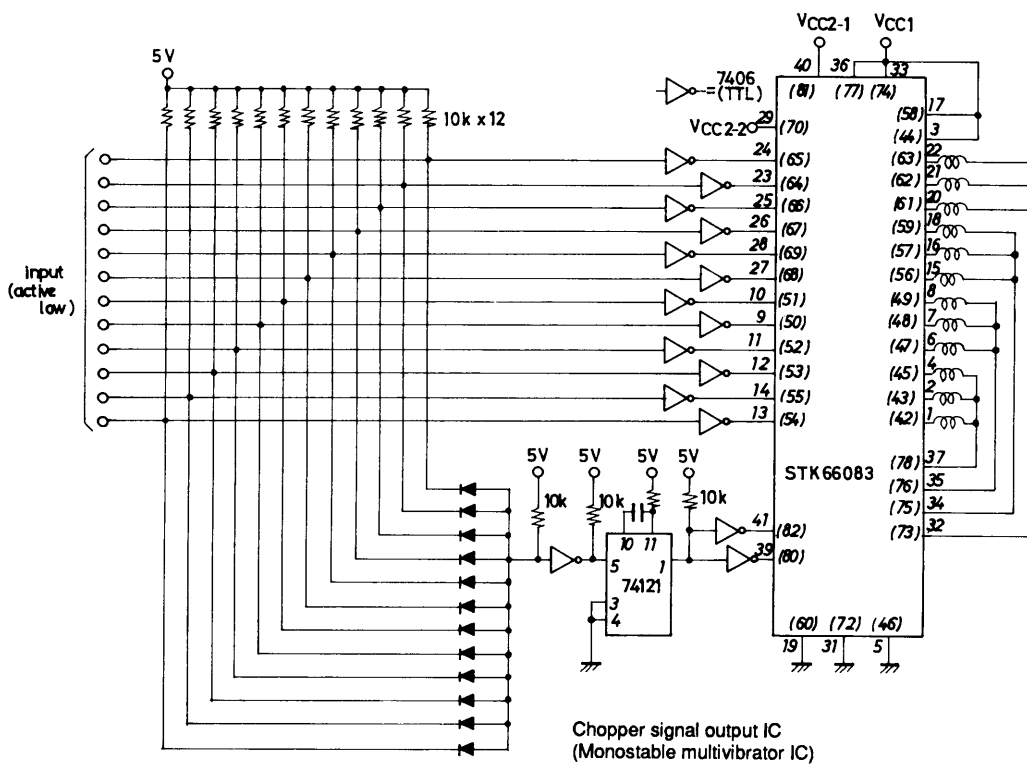
Unit (resistance: Ω)

Usage Notes

Circuit Notes

Timing Charts

Constant Current Drive

A. Dot drive signal

B. Chopper signal

C. Output current waveform Io/dot

V_{CC2} ○ +5V

V_{CC2} ○ +18 to +42 V

input B ○

Input A ○

I_o

Single Dot Constant Current Equivalent Circuit

1. Incorrect input signal operation
   If the input signals A and B shown in the figures are input incorrectly (e.g., if their timings exceed the rated time), overcurrents or DC currents can occur, and the printer head or the thick film IC itself may be destroyed. Therefore, applications must be designed with adequate consideration for this problem and must include protection and reset circuits.

2. The maximum heat dissipation in the print head and the thick film IC occurs when printing solid black (continuous printing).
   • Use a heat sink to cool the hybrid IC substrate so that the substrate temperature (Tc) remains under 105°C.
   • When the print head overheats, the heat dissipated in the head can damage the print head itself. This can lead to destruction of the hybrid IC when, for example, the overheating results in a short circuit in the head coils that results in overcurrents in the hybrid IC.

Notes on Mounting

1. Incorrect mounting, including open input pins, load shorting, pin-to-pin shorting, and pattern shorts on the printed circuit board can lead to abnormal states and destruction of the hybrid IC.

2. Clamp both the printed circuit board and the hybrid IC in place when mounting the hybrid IC on a printed circuit board.

3. Apply silicone grease to the hybrid IC substrate and attach a heat sink that is adequate to dissipate the heat generated within the IC.
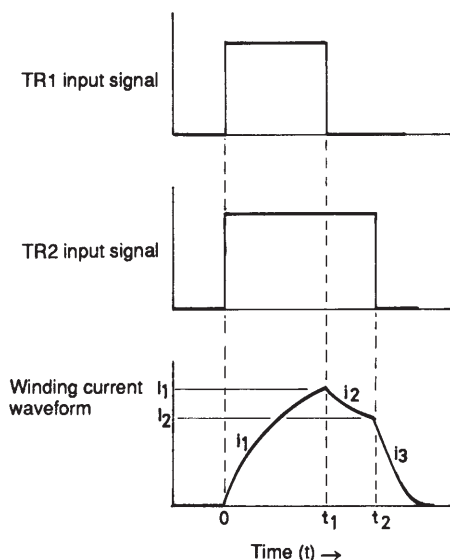
STK66083P Operation

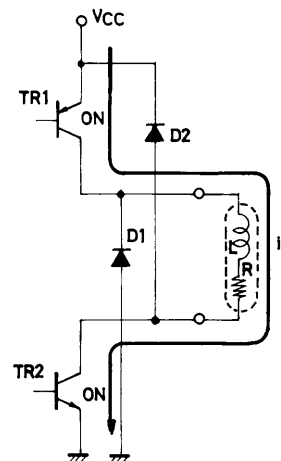Fig. 1   Input Signals and Winding Current Waveforms

Fig. 2

This section describes STK66083P operation based on the equivalent circuit for a single dot driver circuit.

As shown in Figure 1, signals are input to TR1 and TR2 so that they are turned on for the periods t_1 and t_2. The periods t_1 and t_2 are set up to have the following relationship.

$$t_1 < t_2 \ .... \ (1)$$

When both TR1 and TR2 are turned on at time t = 0, the head coil winding current i_1 (for the period $0 \le t \le t_1$) increases according to the following formula due to the time constant τ (L/R), which is determined by the head coil inductance L and the winding resistance R.

$$i_1 = \frac{V_{CC} - Vsat}{R} \ (1 - e^{-\frac{t}{\tau}}) \ .... \ (2)$$

$\tau = L/R$

L: Head coil inductance
R: Head coil winding resistance

$Vsat = Vst\,(1) + Vst\,(2)$

Vst (1): $V_{CE\,(sat)}$ for TR1
Vst (2): $V_{CE\,(sat)}$ for TR2

Therefore, the winding current value I1 at time t_1 is given by the following formula.

$$I_1 = \frac{V_{CC} - Vsat}{R} \ (1 - e^{-\frac{t_1}{\tau}}) \ .... \ (3)$$

Next, when TR1 is turned off at time t_1, V_{CC} is cut off. However, the winding current i_2 (for the period $t_1 \le t \le t_2$) continues to flow through the diode D1. This current decreases according to the following formula.

$$i_2 = I_1 e^{-\frac{t - t_1}{\tau}}) \ .... \ (4)$$

The winding current gradually decreases, and when TR2 is turned off at time t_2, the winding current I_2 is given by the following formula.

$$I_2 = I_1 e^{-\frac{t_2 - t_1}{\tau}}) \ .... \ (5)$$

After TR2 is turned off, the winding current i_3 (for the period $t_2 < t$) is returned to the power supply through the diodes D1 and D2.

$$i_3 = (I_2 + \frac{V_{CC}}{R}) \ e^{-\frac{t - t_2}{\tau}} - \frac{V_{CC}}{R} \ .... \ (6)$$
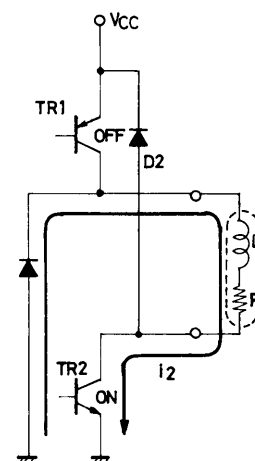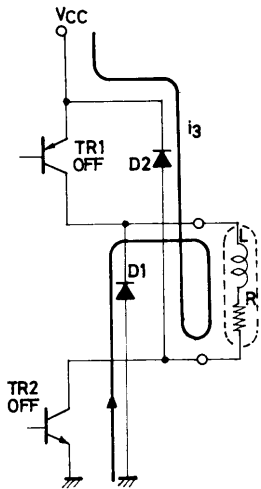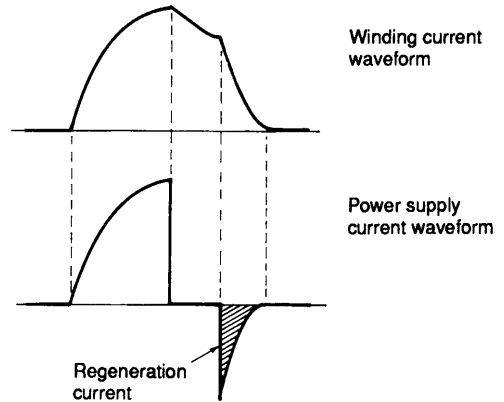

Fig. 3

Fig.4

**Fig. 5 Winding Current Waveform and
Power Supply Current Waveform**

As described above, the rated current for the head coils can be set up by setting up the input signals appropriately.
Note that mutual inductance occurs due to the structure of the head coils, and that the coil inductance is lower when all dots are printed than when only a single dot is printed. This results in increased winding currents. Therefore, the input signal timing setup must be checked with the heads actually used.

Thermal Design

1. θc-a (heat sink thermal resistance)
    The heat sink thermal resistance required due to the average power dissipation (Pd) within the hybrid IC is calculated using the following formula.

    $$\theta c\text{-}a = \frac{Tc\ max - Ta}{Pd} \quad .... (7)$$

    Tcmax: Maximum substrate temperature
    Ta: Ambient temperature

The required area for a 2 mm thick aluminum heat sink can be determined from Figure 7.
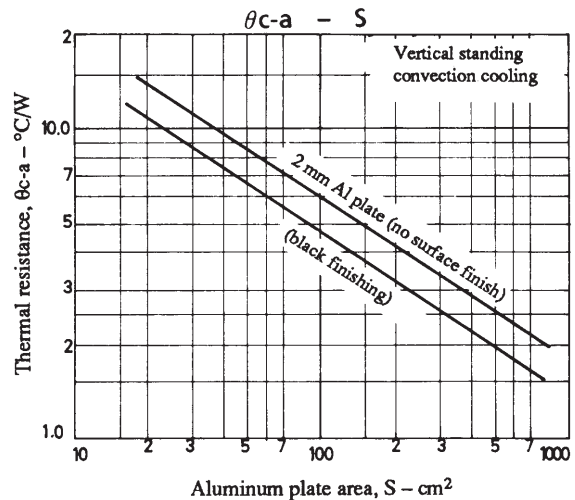

Fig. 6 θc-a vs. Pd
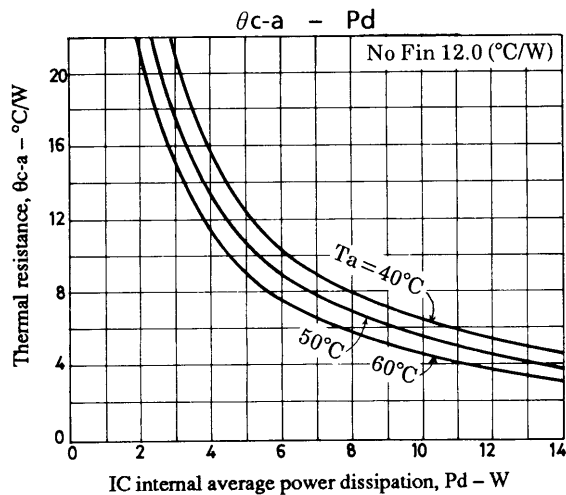
Fig. 7 θc-a vs. S

However, even for identical temperatures the required heat sink area will vary with the conditions within the final product, including the air circulation within the chassis and whether or not a cooling fan is provided. Therefore, be sure to confirm that the STK66083P's substrate temperature does not exceed 105°C in the actual end product.

2. Average Internal Power Dissipation

The STK66083P incorporates the circuits for twelve print head dots within a single case. This circuit can be considered to be four identical circuits each of which drives three dots. Therefore, the total average power dissipation can be derived by calculating the average power dissipation for 1/4 of the circuits. Figure 8 shows the circuit for 1/4 of the STK66083P.
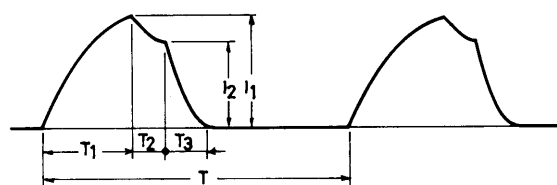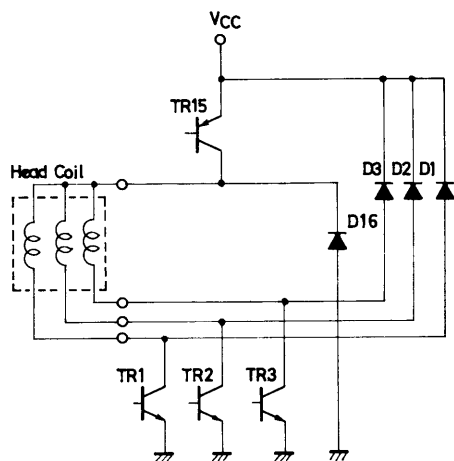
Fig. 8   Circuit for 1/4 of the STK66083P (3 dots)   **Fig. 9   Winding Current for a Single Dot**

Figure 9 shows the winding current for a single dot. Here, the average power dissipation Pd' for 1/4 of the circuits can be expressed as follows.

Pd' = the TR15 power dissipation
  + the TR1, TR2, and TR3 power dissipation
  + the D16 power dissipation
  + the D1, D2, and D3 power dissipation

Consider the case when all three dots are printed during the period T. This is solid printing and the most severe case. Here, Pd' can be approximated as follows since the winding current for three dots flows through TR15 and D16.

$$\text{Pd'} = 0.5 \times 3I_1 \times \text{Vst (1)} \times \frac{T_1}{T}$$

$$+3 \times (0.6 \times I_1 \times \text{Vst (2)} \times \frac{T_1}{T} + 0.7 \times \frac{I_1 + I_2}{2} \times \text{Vst (2)} \times \frac{T_2}{T})$$

$$+0.8 \times \frac{3I_1 + 3I_2}{2} \times V_F (1) \times \frac{T_2}{T} + 0.3 \times 3I_2 \times V_F (1) \times \frac{T_3}{T})$$

$$+3 \times (0.25 \times I_2 \times V_F (2) \times \frac{T_3}{T}) \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots \text{(8)}$$

Vst (1): $V_{CE \, (sat)}$ for the current $3I_1$ in TR15
Vst (2): $V_{CE \, (sat)}$ for the current I_1 in TR1, TR2, and TR3
V_F (1): Vdf for the current $3I_1$ in D16
V_F (2): Vdf for the current $3I_2$ in D1, D2, and D3

Multiplying by four for the whole case gives:

Pd" = 4Pd'

However, continuous solid printing (all black) does not occur in actual operation, and the situation that is actually the most severe is the printer self check operation. Therefore, it is economically advantageous to assume that the Pd for practical operation will be 10% or less of that for solid black printing. Therefore:

$$Pd = 0.1 \times Pd''$$
$$0.1 \times Pd'' = 0.1 \times 4 \, Pd'$$
$$0.1 \times 4 \, Pd' = 0.4 \, Pd'.. (9)$$

Another point is that normally the printing duty during the iteration period T should be set to be 50% or lower ($\frac{T_1 + T_2}{T} \leq 0.5$).