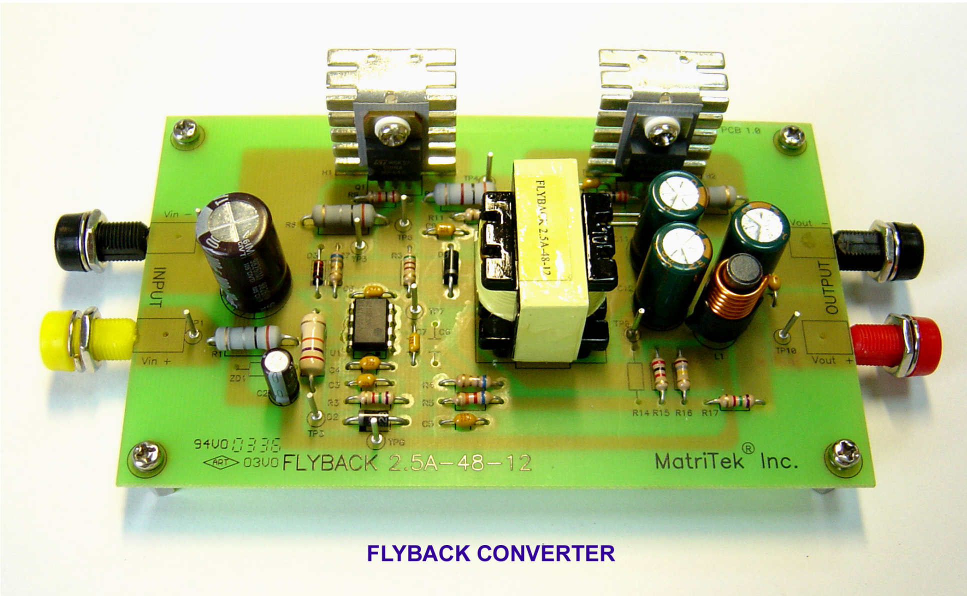
NTHU EE677000

科目：FLYBACK Switching Regulator 實作



1. 材料元器件一套
2. 簡易規格
3. 電路圖 FLYBACK SCH
4. 磁性元件繞製圖
5. 印刷電路板圖面
6. 材料表
7. 組裝步驟與注意事項
8. 參考資料
9. 評估與量測

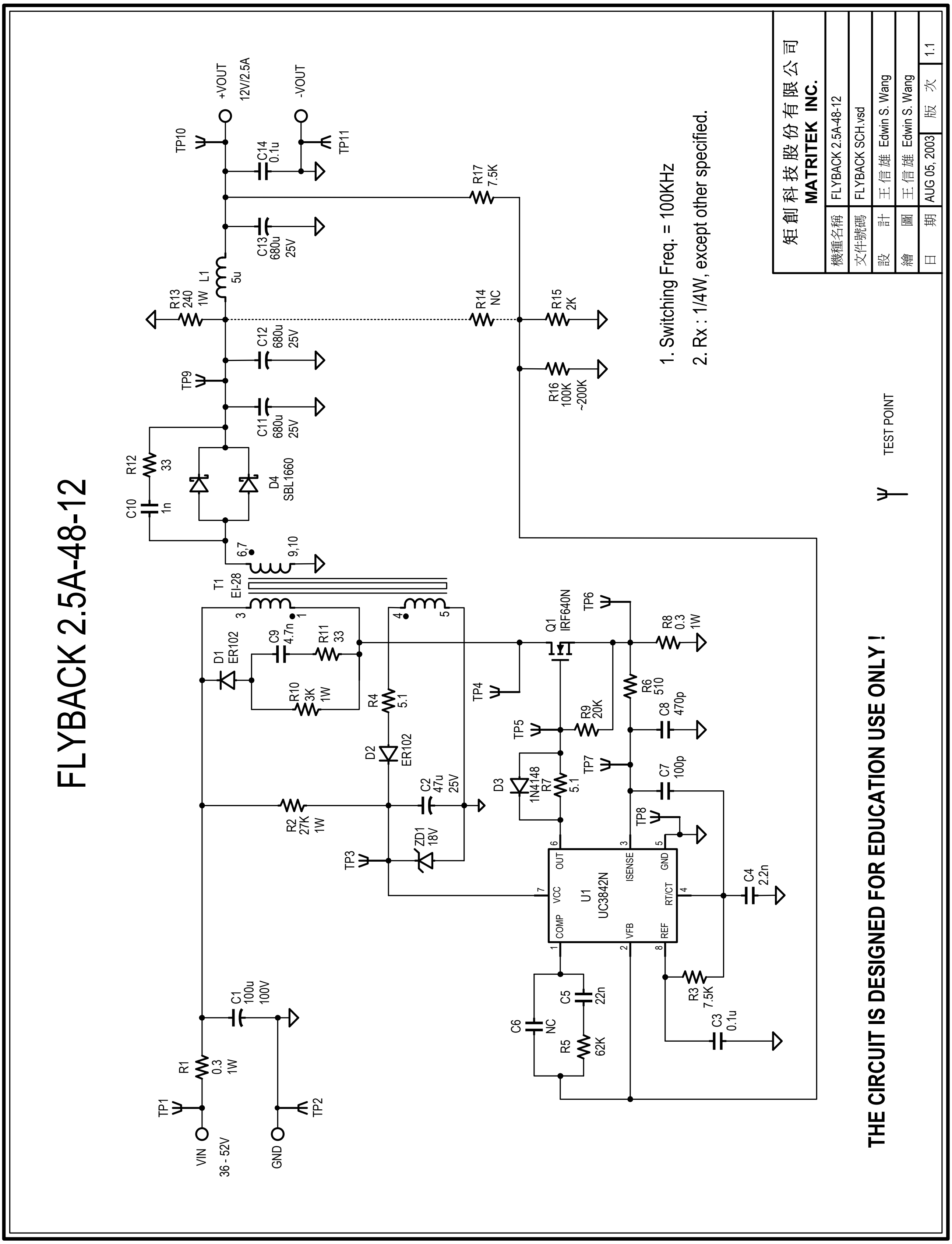
NTHU EE677000
Edwin S. Wang

Model Name : FLYBACK 2.5A-48-12

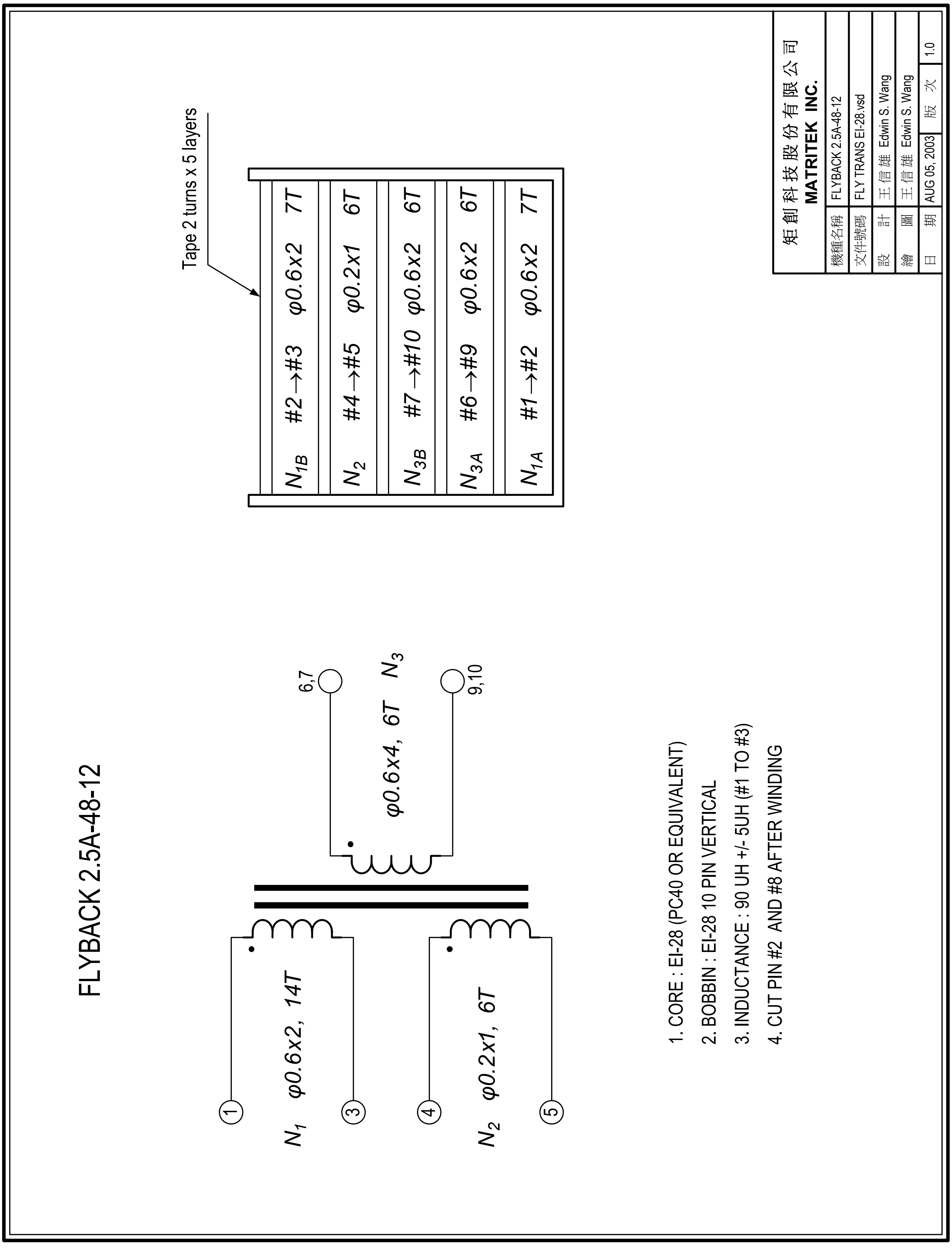
【GENERAL SPECIFICATION】

• INPUT VOLTAGE	36 VDC TO 56VDC
• OUTPUT VOLATGE	12VDC
• OUTPUT CURRENT	0.2 A TO 2.5A
• OUTPUT RIPPLE VOLTAGE	100mV
• LOAD REGULATION	+/- 1%
• LINE REGULATION	+/- 1%
• TRANSIENT RESPONSE @ 1.25A TO 2.5A, 0.1A/uS	
OVERSHOOT / UNDERSHOOT	200 mV
SETTLING TIME	5 mS
• START UP	
RISE TIME	100 mS
OVERSHORT	250 mV
DELAY TIME	1 S
• SHORT-CIRCUIT PROTECTION	Auto-recovery
• EFFICIENCY	> 83% @ I/P : 48V , O/P : 2.5A

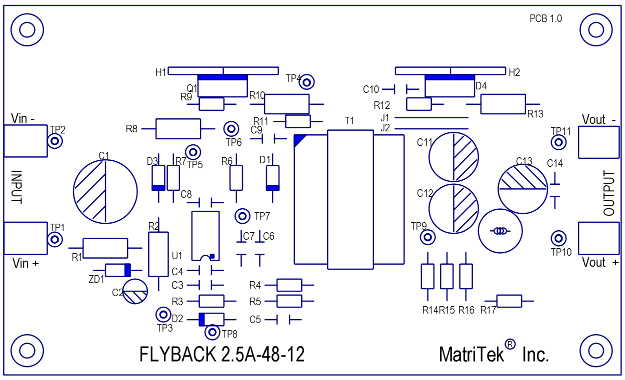
【SCHEMATICS】


FLYBACK 2.5A-48-12
1. Switching Freq. = 100KHz
2. Rx : 1/4W, except other specified.
THE CIRCUIT IS DESIGNED FOR EDUCATION USE ONLY !
TEST POINT
矩創科技股份有限公司
MATRITEK INC.
機種名稱 FLYBACK 2.5A-48-12
文件號碼 FLYBACK SCH.vsd
設 計 王信雄 Edwin S. Wang
繪 圖 王信雄 Edwin S. Wang
日 期 AUG 05, 2003
版 次 1.1
VIN 36 - 52V
GND
TP1
TP2
R1 0.3 1W
C1 100u 100V
R2 27K 1W
D1 ER102
C9 4.7n
R11 33
R10 3K 1W
T1 EI-28
R4 5.1
D2 ER102
C2 47u 25V
ZD1 18V
TP3
U1 UC3842N
COMP VFB REF RT/CT GND ISENSE OUT VCC
Q1 IRF640N
TP4
TP5
TP6
TP7
TP8
R9 20K
D3 1N4148
R7 5.1
R8 0.3 1W
R6 510
C8 470p
C7 100p
C4 2.2n
R3 7.5K
C3 0.1u
C5 22n
C6 NC
R5 62K
C10 1n
R12 33
D4 SBL1660
C11 680u 25V
TP9
C12 680u 25V
R13 240 1W
L1 5u
C13 680u 25V
C14 0.1u
TP10
TP11
+VOUT 12V/2.5A
-VOUT
R14 NC
R15 2K
R16 100K ~200K
R17 7.5K

【COUPLED-INDUCTOR】



【PCB 文字面】



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【FLYBACK 2.5A-48-12 PART LIST】

項次	PCB 位置	規格說明	數 量
1	R1	RES 0R3 +/-5% 1W	1
2	R2	RES 27K +/-5% 1W	1
3	R3	RES 7.5K +/-5% 1/4W	1
4	R4	RES 5R1 +/-5% 1/4W	1
5	R5	RES 62K +/-5% 1/4W	1
6	R6	RES 510 +/-5% 1/4W	1
7	R7	RES 5R1 +/-5% 1/4W	1
8	R8	RES 0R3 +/-5% 1W	1
9	R9	RES 20K +/-5% 1/4W	1
10	R10	RES 3K +/-5% 1W	1
11	R11	RES 33 +/-5% 1/4W	1
12	R12	RES 33 +/-5% 1/4W	1
13	R13	RES 240 +/-5% 1W	1
14	R14	RES NC +/-5% 1/4W	0
15	R15	RES 2K +/-5% 1/4W	1
16	R16	RES 180K +/-5% 1/4W	1
17	R17	RES 7K5 +/-5% 1/4W	1
18	C1	EC 100U 100V 13X20	1
19	C2	EC 47U 25V 6X11	1
20	C3	MLCC 104 50V	1
21	C4	MLCC 222 50V	1
22	C5	MLCC 223 50V	1
23	C6	MLCC NC 50V	0
24	C7	MLCC 101 50V	1
25	C8	MLCC 471 50V	1
26	C9	MLCC 472 50V	1
27	C10	MLCC 102 50V	1
28	C11	EC 680U 25V 10X20	1
29	C12	EC 680U 25V 10X20	1
30	C13	EC 680U 25V 10X20	1
31	C14	MLCC 104 50V	1
32	T1	TRANSFORMER EI-28 FLYBACK	1
33	L1	CHOKE R6X20 5U 4A	1
34	Q1	NMOS IRF640N 200V/18A	1
35	D1	FRD ER102	1
36	D2	FRD ER102	1
37	D3	DIODE 1N4148	1
38	D4	SBD SBL1660 16A/60V TO220	1
39	ZD1	ZENER DIODE 18V (NC)	0

40	U1	IC PWM CONTROLLER UC3842N	1
41	H1,H2	HEATSINK 20X30X1	2
42	SCREW	SCREW PAN HEAD M3X7	2
43	NUT	NUT M3	6
44		INSULATOR TO-220	2
45		INSULATOR SILICON TO-220	2
46	TP1~11	TEST PIN 0.8D 10mm	11
47	IN/OUT	POWER CONNECTOR	4
48		COPPER STAND	4
49	PCB	PCB 3X5 SS FLYBACK 2.5A-48-12	1

【FLYBACK 2.5A-48-12 組裝步驟與注意事項】

- 組裝工具
  (1) 溫控電烙鐵 30W，圓尖頭
  (2) 焊錫絲 0.6Φ ~ 1.0Φ
  (3) 梅花起子
  (4) 尖嘴鉗
  (6) 斜口鉗

- 量測設備
  (1) 直流電源 60V / 3A
  (2) 電子負載 60V / 60A / 300W (DYNAMIC FUNCTION)
  (3) 100MHZ 以上數位儲存式示波器 DSO (可 HARDCOPY 畫面)
  (4) 100KHZ 以上 LCR METER
  (5) DIGITAL MULTIMETER
  (6) 電流探棒 CURRENT PROBE (OPTIONAL)
  (7) GAIN-PHASE ANALYZER (OPTIONAL)

- 組裝一般注意事項
  (1) 對照料表，清點材料。必要時可用 RLC METER 確認電感、電容與電阻值。
  (2) 階層式組立步驟：先將獨立單元組立 (如功率半導體與散熱片組合)，再依零件高低由低而高依次焊錫固定。
  (3) 焊錫作業注意”三點同溫”原則，避免空焊、冷焊發生，也避免零件(特別是 IC)過熱損壞。

- 組裝步驟
  (1) 組立 MOSFET Q1 與 SBD D1 與散熱片。注意絕緣片與絕緣粒子。
  (2) 找零件腳當跳線 J1、J2 與 J3，並焊接於 PCB 上。
  (3) 將次高的零件，Zener D3 與 8 顆積層陶瓷電容(MLCC)，焊於 PCB 上。
  (4) 其次是 1/4W 的電阻，共 11 顆。
  (5) 其次 D1 與 D2。
  (6) 接著焊 IC (U1)，注意 IC 腳位標示。
  (7) 5 顆 1W 電阻。
  (8) 焊接 11 支 TEST PIN。
  (9) 依序將所有電解電容、電感及變壓器焊上。
  (10)再來是帶散熱片的 Q1 與 D1 組合。
  (11)檢查零件是否已完全裝在 PCB 上。
  (12)接著焊輸入與輸出的 PIN (或 CONNECTOR)
  (13)最後將銅柱鎖定，完成 PCB 作業。

【評估與量測】

注意： (1) 輸入電源供應器的最大輸出電流須設定在 2A 左右，如果電源串聯輸出，先確定正確電壓。

(2) 仔細查看電路圖，明確瞭解 TEST PIN 是哪一點。

(3) 輸入端與輸出端要確認再開機。

1. CONVERSION EFFICIENCY
2. LOAD REGULATION
3. LINE REGULATION
4. OUTPUT RIPPLE & NOISE (DSO)
5. DYNAMIC RESPONSE (DSO)
6. GATE SIGNAL AND MOSFET VOLTAGE (DSO)
7. START-UP (PIN 8 TO PIN 9) (DSO)
8. CURRENT SNESING VOLTAGE (U1 PIN3)
9. SECONDARY DIODE CURRENT (OPTIONAL) (DSO + CURRENT PROBE)
10. OTHERS

靜態測試記錄

輸入電壓 = 36V

輸出電流	0.5A	1A	1.5A	2A	2.5A	BOUNDARY
V_O						
I_{IN}						

輸入電壓 = 48V

輸出電流	0.5A	1A	1.5A	2A	2.5A	BOUNDARY
V_O						
I_{IN}						

輸入電壓 = 56V

輸出電流	0.5A	1A	1.5A	2A	2.5A	BOUNDARY
V_O						
I_{IN}						

注意：

(1) 輸入電壓讀值：用 DMM 量 PIN 1 TO PIN 2；輸入電流讀值：可直接於電源供應器表頭讀取；輸出電壓讀值：用 DMM 量 PIN 10 TO PIN 11；輸出電流讀值：可直接於電子負載表頭讀取。

1. CONVERSION EFFICIENCY

用量取的資料，計算出效率，並以 EXCEL 作圖。($\eta = \dfrac{V_O \cdot I_O}{V_{IN} \cdot I_{IN}}$)

2. LOAD REGULATION

定義：*Load Regulation* = $\left| \dfrac{V_{O,min\,load} - V_{O,full\,load}}{V_{O,min\,load}} \right| \times 100\%$ @ specified input voltage

用量取的資料，分別計算在三種輸入電壓下的負載穩壓率。

3. LINE REGULATION

定義：$Line\ Regulation = \left| \dfrac{V_{O,min\ input} - V_{O,max\ input}}{V_{O,min\ input}} \right| \times 100\%$ @ specified load

用量取的資料，分別計算在輸出電流爲 0.5A, 1.5A, 2.5A 條件下下的線電壓穩壓率。

4. OUTPUT RIPPLE AND NOISE

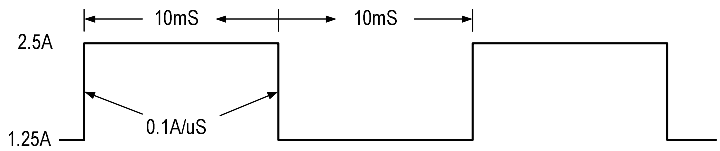
條件：輸出滿載 (2.5A)

輸入電壓 = 36V, 48V, 56V

觀察記錄：用數位示波器觀察輸出電壓(AC Coupling)，並將波形記錄存檔。注意量測技巧，以免探棒耦合雜訊。

5. DYNAMIC RESPONSE

條件：負載設定



輸入電壓 = 36V, 48V, 56V

觀察記錄：用數位示波器觀察輸出電壓動態響應(AC Coupling)，並將波形記錄存檔。注意量測技巧，以免探棒耦合雜訊。

6. GATE SIGNAL (DUTY CONTROL) 信號與 MOSFET VOLTAGE

條件：負載設定 = 0.2A, Boundary Current, 1.5A, 2.5A

輸入電壓 = 48V

觀察記錄：用數位示波器觀察 PIN 5 與 PIN 4 的電壓，並將波形記錄存檔。其中緩慢整

電子負載，使達到 CCM/DCM 界線。觀查重點：DUTY 與負載變化的關係。

7. START-UP

觀察從輸入電壓灌入到輸出電壓穩定的現象。DUAL CHANNEL 量輸入與輸出電壓，以及 SOFT START 功能。

【參考資料】

(1) UC3842 Data Sheet
(2) IRF640 Data Sheet
(3) EI-28 Ferrite Core Data Sheet

application INFO available

UC1842A/3A/4A/5A
UC2842A/3A/4A/5A
UC3842A/3A/4A/5A

Current Mode PWM Controller

FEATURES

- Optimized for Off-line and DC to DC Converters
- Low Start Up Current (<0.5mA)
- Trimmed Oscillator Discharge Current
- Automatic Feed Forward Compensation
- Pulse-by-Pulse Current Limiting
- Enhanced Load Response Characteristics
- Under-Voltage Lockout With Hysteresis
- Double Pulse Suppression
- High Current Totem Pole Output
- Internally Trimmed Bandgap Reference
- 500kHz Operation
- Low R_O Error Amp

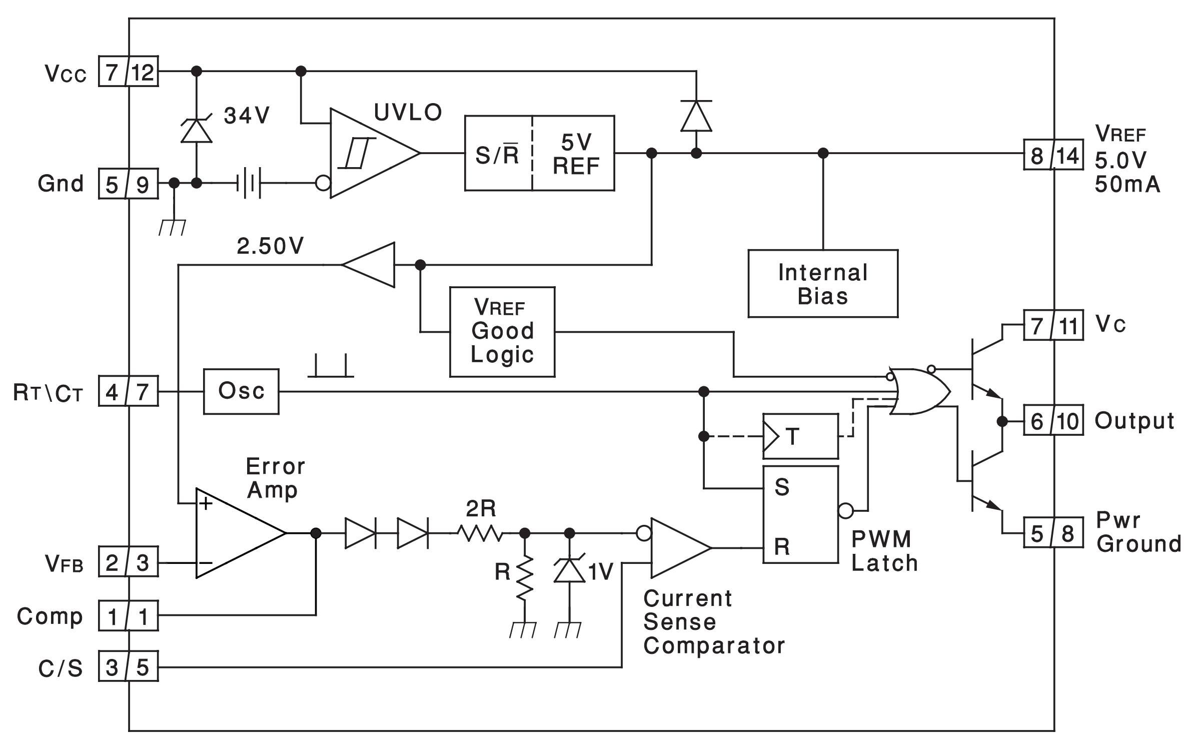
DESCRIPTION

The UC1842A/3A/4A/5A family of control ICs is a pin for pin compatible improved version of the UC3842/3/4/5 family. Providing the necessary features to control current mode switched mode power supplies, this family has the following improved features. Start up current is guaranteed to be less than 0.5mA. Oscillator discharge is trimmed to 8.3mA. During under voltage lockout, the output stage can sink at least 10mA at less than 1.2V for V_{CC} over 5V.

The difference between members of this family are shown in the table below.

Part #	UVLO On	UVLO Off	Maximum Duty Cycle
UC1842A	16.0V	10.0V	<100%
UC1843A	8.5V	7.9V	<100%
UC1844A	16.0V	10.0V	<50%
UC1845A	8.5V	7.9V	<50%

BLOCK DIAGRAM



Note 1: A/B A = DIL-8 Pin Number. B = SO-14 Pin Number.
Note 2: Toggle flip flop used only in 1844A and 1845A.

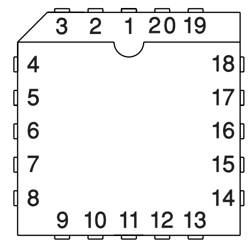
CONNECTION DIAGRAMS

ABSOLUTE MAXIMUM RATINGS (Note 1)

Supply Voltage (Low Impedance Source) 30V
Supply Voltage (I_{CC} mA) . . . . Self Limiting
Output Current. . . . . ±1A
Output Energy (Capacitive Load). 5µJ
Analog Inputs (Pins 2, 3). . . . . -0.3V to +6.3V
Error Amp Output Sink Current 10mA
Power Dissipation at $T_A \leq 25°C$ (DIL-8) 1W
Storage Temperature Range. . . . . -65°C to +150°C
Lead Temperature (Soldering, 10 Seconds) . . . . 300°C

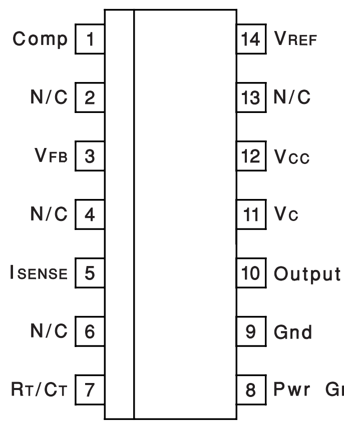
Note 1. All voltages are with respect to Ground, Pin 5. Currents are positive into, negative out of the specified terminal. Consult Packaging Section of Databook for thermal limitations and considerations of packages. Pin numbers refer to DIL package only.

PLCC-20, LCC-20
(TOP VIEW)
Q, L Packages

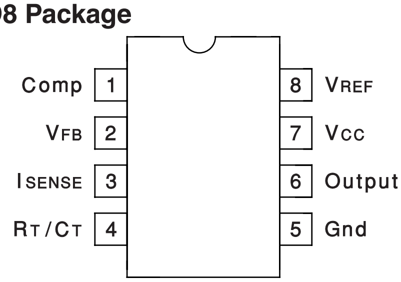


PACKAGE PIN FUNCTION	
FUNCTION	**PIN**
N/C	1
Comp	2
N/C	3-4
V_{FB}	5
N/C	6
I_{SENSE}	7
N/C	8-9
R_T/C_T	10
N/C	11
Pwr Gnd	12
Gnd	13
N/C	14
Output	15
N/C	16
V_C	17
V_{CC}	18
N/C	19
V_{REF}	20

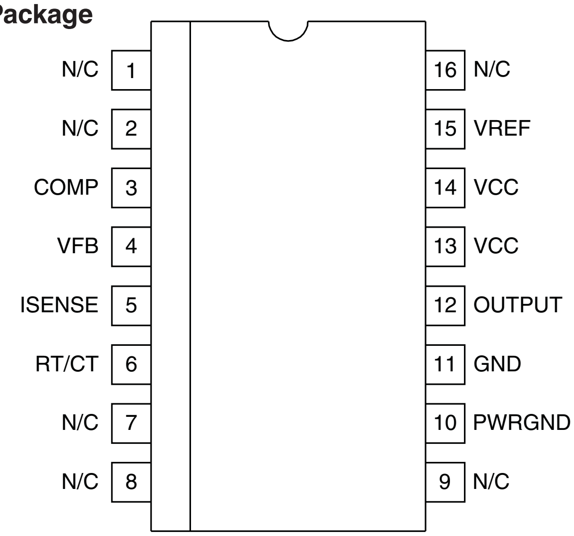
SOIC-14 (TOP VIEW)
D Package



DIL-8, SOIC-8 (TOP VIEW)
J or N, D8 Package



SOIC-WIDE16 (TOP VIEW)
DW Package



ELECTRICAL CHARACTERISTICS Unless otherwise stated, these specifications apply for –55°C ≤ T_A ≤ 125°C for the UC184xA; –40°C ≤ T_A ≤ 125°C for the UC284xAQ; –40°C ≤ T_A ≤ 85°C for the UC284xA; 0 ≤ T_A ≤ 70°C for the UC384xA; V_{CC} = 15V (Note 5); R_T = 10k; C_T = 3.3nF; T_A = T_J; Pin numbers refer to DIL-8.

PARAMETER	TEST CONDITIONS	UC184xA\UC284xA			UC384xA			UNITS
		MIN.	TYP.	MAX.	MIN.	TYP.	MAX.	
Reference Section								
Output Voltage	T_J = 25°C, I_O = 1mA	4.95	5.00	5.05	4.90	5.00	5.10	V
Line Regulation	12 ≤ V_{IN} 25V		6	20		6	20	mV
Load Regulation	1 ≤ I_O ≤ 20mA		6	25		6	25	mV
Temp. Stability	(Note 2, Note 7)		0.2	0.4		0.2	0.4	mV/°C
Total Output Variation	Line, Load, Temp.	4.9		5.1	4.82		5.18	V
Output Noise Voltage	10Hz ≤ f ≤ 10kHz T_J = 25°C (Note 2)		50			50		µV
Long Term Stability	T_A = 125°C, 1000Hrs. (Note 2)		5	25		5	25	mV
Output Short Circuit		-30	-100	-180	-30	-100	-180	mA
Oscillator Section								
Initial Accuracy	T_J = 25°C (Note 6)	47	52	57	47	52	57	kHz
Voltage Stability	12 ≤ V_{CC} ≤ 25V		0.2	1		0.2	1	%
Temp. Stability	T_{MIN} ≤ T_A ≤ T_{MAX} (Note 2)		5			5		%
Amplitude	$V_{PIN\ 4}$ peak to peak (Note 2)		1.7			1.7		V
Discharge Current	T_J = 25°C, $V_{PIN\ 4}$ = 2V (Note 8)	7.8	8.3	8.8	7.8	8.3	8.8	mA
	$V_{PIN\ 4}$ = 2V (Note 8)	7.5		8.8	7.6		8.8	mA
Error Amp Section								
Input Voltage	$V_{PIN\ 1}$ = 2.5V	2.45	2.50	2.55	2.42	2.50	2.58	V
Input Bias Current			-0.3	-1		-0.3	-2	µA
A_{VOL}	2 ≤ V_O ≤ 4V	65	90		65	90		dB
Unity Gain Bandwidth	T_J = 25°C (Note 2)	0.7	1		0.7	1		MHz
PSRR	12 ≤ V_{CC} ≤ 25V	60	70		60	70		dB
Output Sink Current	$V_{PIN\ 2}$ = 2.7V, $V_{PIN\ 1}$ = 1.1V	2	6		2	6		mA
Output Source Current	$V_{PIN\ 2}$ = 2.3V, $V_{PIN\ 1}$ = 5V	-0.5	-0.8		-0.5	-0.8		mA
V_{OUT} High	$V_{PIN\ 2}$ = 2.3V, R_L = 15k to ground	5	6		5	6		V
V_{OUT} Low	$V_{PIN\ 2}$ = 2.7V, R_L = 15k to Pin 8		0.7	1.1		0.7	1.1	V
Current Sense Section								
Gain	(Note 3, Note 4)	2.85	3	3.15	2.85	3	3.15	V/V
Maximum Input Signal	$V_{PIN\ 1}$ = 5V (Note 3)	0.9	1	1.1	0.9	1	1.1	V
PSRR	12 ≤ V_{CC} ≤ 25V (Note 3)		70			70		dB
Input Bias Current			-2	-10		-2	-10	µA
Delay to Output	$V_{PIN\ 3}$ = 0 to 2V (Note 2)		150	300		150	300	ns
Output Section								
Output Low Level	I_{SINK} = 20mA		0.1	0.4		0.1	0.4	V
	I_{SINK} = 200mA		15	2.2		15	2.2	V
Output High Level	I_{SOURCE} = 20mA	13	13.5		13	13.5		V
	I_{SOURCE} = 200mA	12	13.5		12	13.5		V
Rise Time	T_J = 25°C, C_L = 1nF (Note 2)		50	150		50	150	ns
Fall Time	T_J = 25°C, C_L = 1nF (Note 2)		50	150		50	150	ns
UVLO Saturation	V_{CC} = 5V, I_{SINK} = 10mA		0.7	1.2		0.7	1.2	V

ELECTRICAL CHARACTERISTICS Unless otherwise stated, these specifications apply for $-55°C \le T_A \le 125°C$ for the UC184xA; $-40°C \le T_A \le 125°C$ for the UC284xAQ; $-40°C \le T_A \le 85°C$ for the UC284xA; $0 \le T_A \le 70°C$ for the UC384xA; $V_{CC} = 15V$ (Note 5); $R_T = 10k$; $C_T = 3.3nF$; $T_A = T_J$; Pin numbers refer to DIL-8.

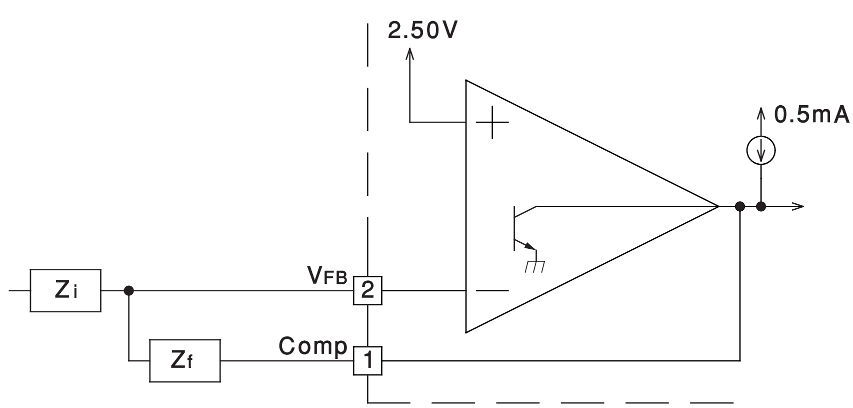
PARAMETER	TEST CONDITIONS	UC184xA\UC284xA			UC384xA			UNITS
		MIN.	TYP.	MAX.	MIN.	TYP.	MAX.	
Under-Voltage Lockout Section								
Start Threshold	x842A/4A	15	16	17	14.5	16	17.5	V
	x843A/5A	7.8	8.4	9.0	7.8	8.4	9.0	V
Min. Operation Voltage After	x842A/4A	9	10	11	8.5	10	11.5	V
Turn On	x843A/5A	7.0	7.6	8.2	7.0	7.6	8.2	V
PWM Section								
Maximum Duty Cycle	x842A/3A	94	96	100	94	96	100	%
	x844A/5A	47	48	50	47	48	50	%
Minimum Duty Cycle				0			0	%
Total Standby Current								
Start-Up Current			0.3	0.5		0.3	0.5	mA
Operating Supply Current	$V_{PIN\ 2} = V_{PIN\ 3} = 0V$		11	17		11	17	mA
V_{CC} Zener Voltage	$I_{CC} = 25mA$	30	34		30	34		V

Note 2: *Ensured by design, but not 100% production tested.*
Note 3: *Parameter measured at trip point of latch with $V_{PIN2} = 0$.*
Note 4: *Gain defined as:* $A = \frac{\Delta VPIN\ 1}{\Delta VPIN\ 3}$; $0 \le V_{PIN\ 3} \le 0.8V$.
Note 5: *Adjust V_{CC} above the start threshold before setting at 15V.*
Note 6: *Output frequency equals oscillator frequency for the UC1842A and UC1843A. Output frequency is one half oscillator frequency for the UC1844A and UC1845A.*
Note 7: *"Temperature stability, sometimes referred to as average temperature coefficient, is described by the equation:*

$$Temp\ Stability = \frac{VREF\ (max) - VREF\ (min)}{TJ\ (max) - TJ\ (min)}$$

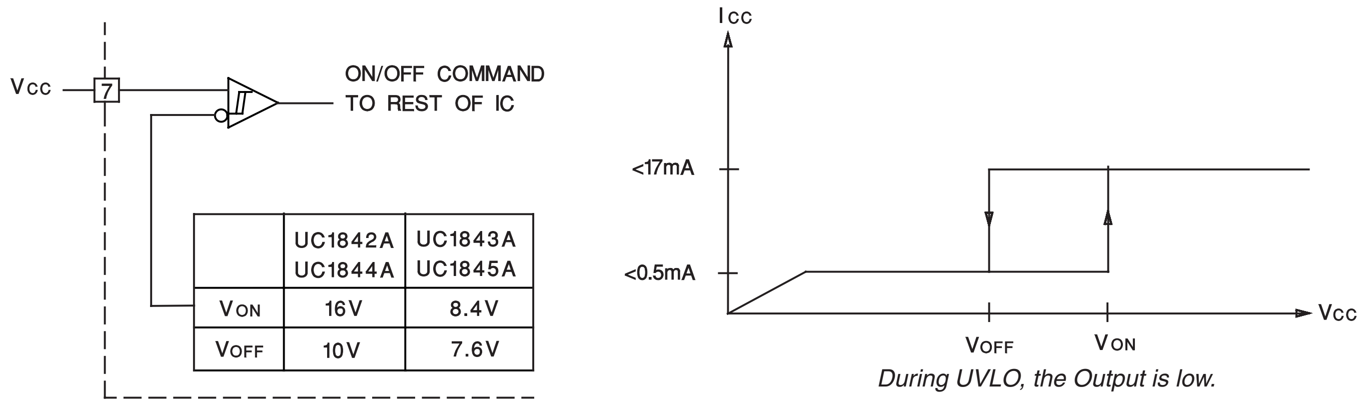
. V_{REF} (max) and V_{REF} (min) are the maximum & minimum reference voltage measured over the appropriate temperature range. Note that the extremes in voltage do not necessarily occur at the extremes in temperature."
Note 8: *This parameter is measured with $R_T = 10k\Omega$ to V_{REF}. This contributes approximately 300μA of current to the measurement. The total current flowing into the R_T/C pin will be approximately 300μA higher than the measured value.*

Error Amp Configuration



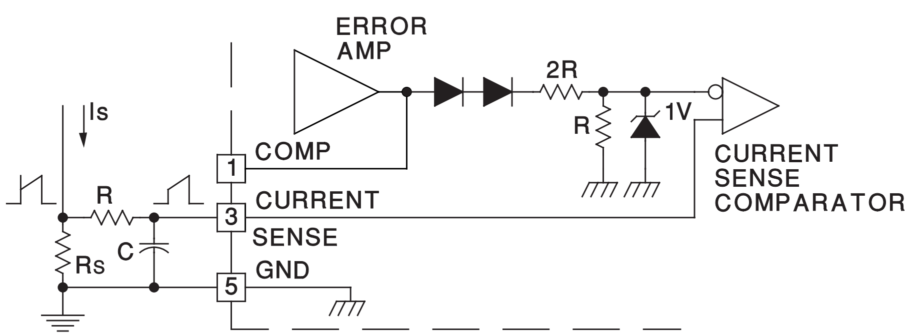
Error Amp can Source and Sink up to 0.5mA, and Sink up to 2mA.

Under-Voltage Lockout



During UVLO, the Output is low.

Current Sense Circuit

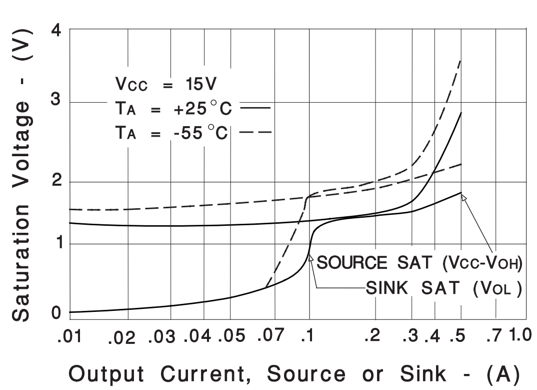


Peak Current (IS) is Determined By The Formula

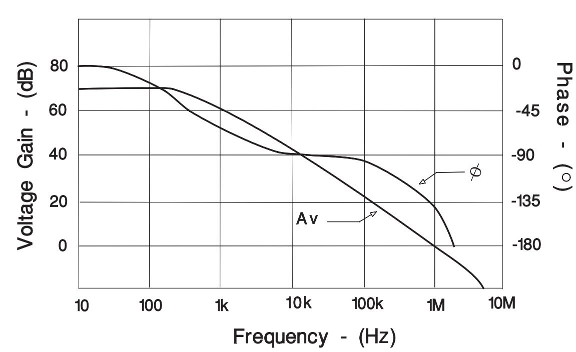
$$I_{SMAX} = \frac{1.0V}{R_S}$$

A small RC filter may be required to suppress switch transients.

Output Saturation Characteristics

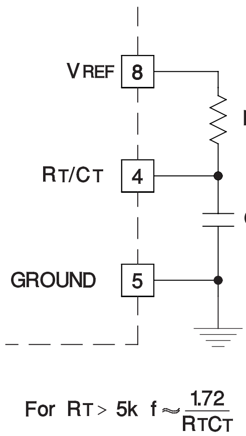


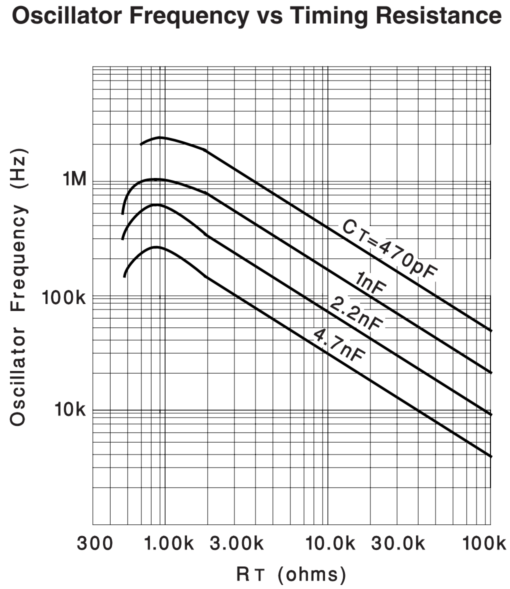
Error Amplifier Open-Loop Frequency Response

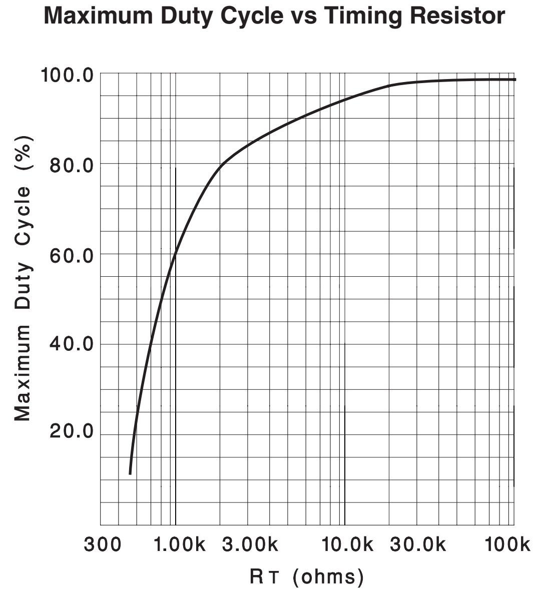


APPLICATIONS DATA (cont.)

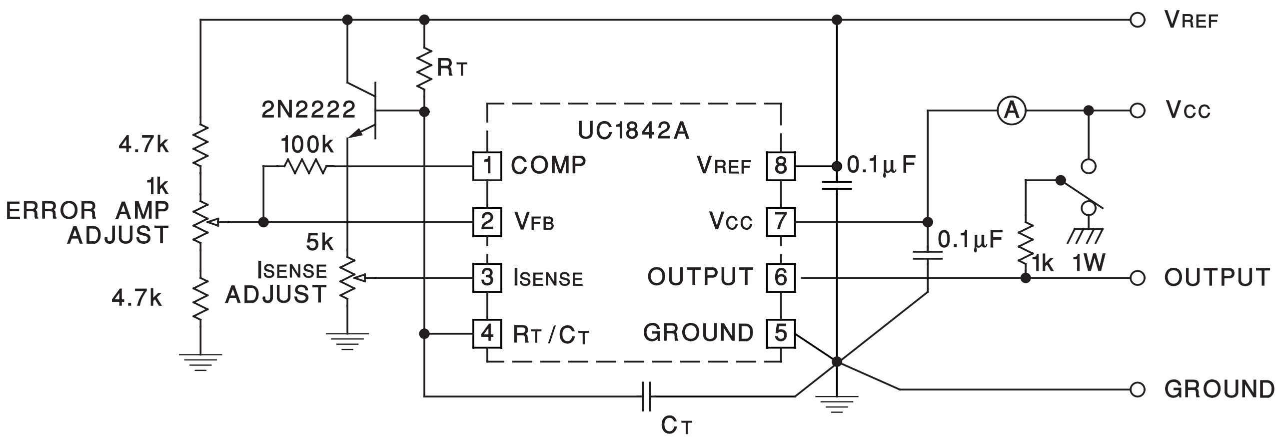
Oscillator Section





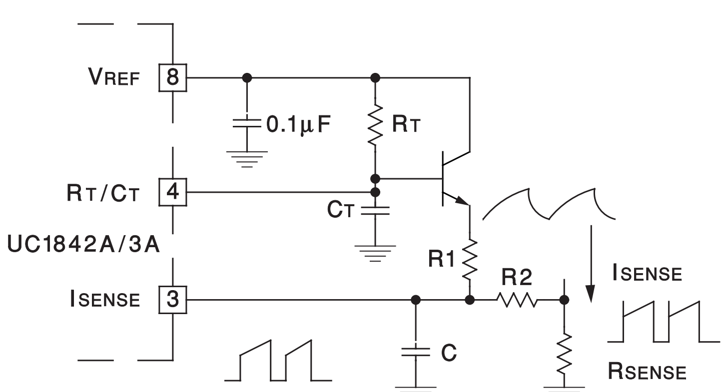


Open-Loop Laboratory Test Fixture



High peak currents associated with capacitive loads necessitate careful grounding techniques. Timing and bypass capacitors should be connected close to pin 5 in a single point ground. The transistor and 5k potentiometer are used to sample the oscillator waveform and apply an adjustable ramp to pin 3.

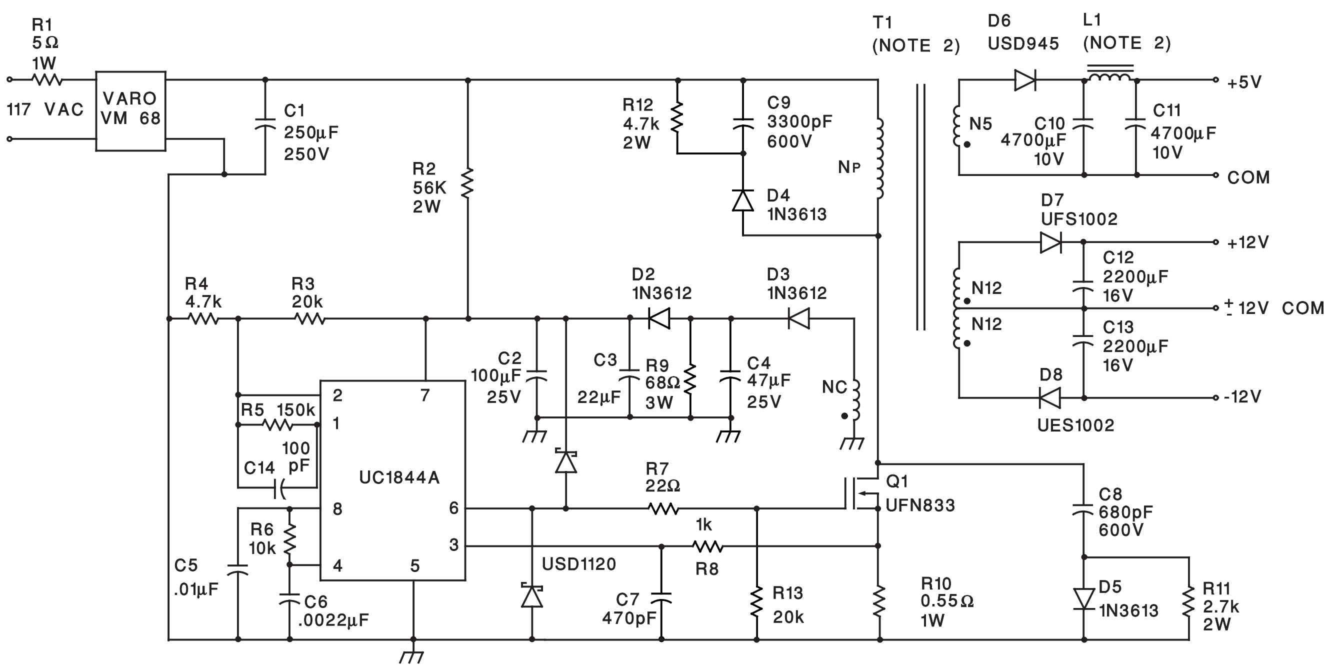
Slope Compensation



A fraction of the oscillator ramp can be resistively summed with the current sense signal to provide slope compensation for converters requiring duty cycles over 50%.
Note that capacitor, C, forms a filter with R2 to suppress the leading edge switch spikes.

APPLICATIONS DATA (cont.)

Off-line Flyback Regulator



Power Supply Specifications

1. Input Voltage *95VAC to 130VA (50 Hz/60Hz)*
2. Line Isolation *3750V*
3. Switching Frequency *40kHz*
4. Efficiency Full Load *70%*

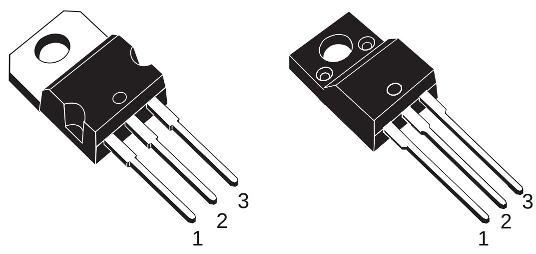
5. Output Voltage:
A. +5V, ±5%; 1A to 4A load
Ripple voltage: 50mV P-P Max
B. +12V, ±3%; 0.1A to 0.3A load
Ripple voltage: 100mV P-P Max
C. -12V ,±3%; 0.1A to 0.3A load
Ripple voltage: 100mV P-P Max

IRF640
IRF640FP

N - CHANNEL 200V - 0.150Ω - 18A TO-220/TO-220FP MESH OVERLAY™ MOSFET

TYPE	V_{DSS}	$R_{DS(on)}$	I_D
IRF640	200 V	< 0.18 Ω	18 A
IRF640FP	200 V	< 0.18 Ω	18 A

- TYPICAL $R_{DS(on)}$ = 0.150 Ω
- EXTREMELY HIGH dV/dt CAPABILITY
- VERY LOW INTRINSIC CAPACITANCES
- GATE CHARGE MINIMIZED



TO-220 TO-220FP

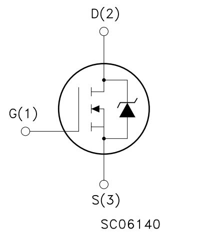
DESCRIPTION

This power MOSFET is designed using he company's consolidated strip layout-based MESH OVERLAY™ process. This technology matches and improves the performances compared with standard parts from various sources.

APPLICATIONS

- HIGH CURRENT SWITCHING
- UNINTERRUPTIBLE POWER SUPPLY (UPS)
- DC/DC COVERTERS FOR TELECOM, INDUSTRIAL, AND LIGHTING EQUIPMENT.

INTERNAL SCHEMATIC DIAGRAM



ABSOLUTE MAXIMUM RATINGS

Symbol	Parameter	Value		Unit
		IRF640	IRF640FP	
V_{DS}	Drain-source Voltage (V_{GS} = 0)	200		V
V_{DGR}	Drain- gate Voltage (R_{GS} = 20 kΩ)	200		V
V_{GS}	Gate-source Voltage	± 20		V
I_D	Drain Current (continuous) at T_c = 25 °C	18	18(**)	A
I_D	Drain Current (continuous) at T_c = 100 °C	11	11(**)	A
I_{DM}(•)	Drain Current (pulsed)	72	72	A
P_{tot}	Total Dissipation at T_c = 25 °C	125	40	W
	Derating Factor	1.0	0.32	W/°C
dv/dt(1)	Peak Diode Recovery voltage slope	5	5	V/ns
V_{ISO}	Insulation Withstand Voltage (DC)	—	2000	V
T_{stg}	Storage Temperature	-65 to 150		°C
T_j	Max. Operating Junction Temperature	150		°C

(•) Pulse width limited by safe operating area

(1) $I_{SD} \leq 18A$, di/dt ≤ 300 A/µs, $V_{DD} \leq V_{(BR)DSS}$, $T_j \leq T_{JMAX}$

First Digit of the Datecode Being Z or K Identifies Silicon Characterized in this Datasheet

(**) Limited only by Maximum Temperature Allowed

THERMAL DATA

		TO-220	TO-220FP	
$R_{thj-case}$	Thermal Resistance Junction-case Max	1.0	3.12	$^oC/W$
$R_{thj-amb}$ $R_{thc-sink}$ T_l	Thermal Resistance Junction-ambient Max Thermal Resistance Case-sink Typ Maximum Lead Temperature For Soldering Purpose	62.5 0.5 300		$^oC/W$ $^oC/W$ ^oC

AVALANCHE CHARACTERISTICS

Symbol	Parameter	Max Value	Unit
I_{AR}	Avalanche Current, Repetitive or Not-Repetitive (pulse width limited by T_j max)	18	A
E_{AS}	Single Pulse Avalanche Energy (starting T_j = 25 ^oC, $I_D = I_{AR}$, V_{DD} = 50 V)	280	mJ

ELECTRICAL CHARACTERISTICS (T_{case} = 25 ^oC unless otherwise specified)

OFF

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
$V_{(BR)DSS}$	Drain-source Breakdown Voltage	I_D = 250 µA V_{GS} = 0	200			V
I_{DSS}	Zero Gate Voltage Drain Current (V_{GS} = 0)	V_{DS} = Max Rating V_{DS} = Max Rating T_c = 125 ^oC			1 10	µA µA
I_{GSS}	Gate-body Leakage Current (V_{DS} = 0)	V_{GS} = ± 20 V			± 100	nA

ON (∗)

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
$V_{GS(th)}$	Gate Threshold Voltage	$V_{DS} = V_{GS}$ I_D = 250 µA	2	3	4	V
$R_{DS(on)}$	Static Drain-source On Resistance	V_{GS} = 10V I_D = 9 A		0.15	0.18	Ω
$I_{D(on)}$	On State Drain Current	$V_{DS} > I_{D(on)} \times R_{DS(on)max}$ V_{GS} = 10 V	18			A

DYNAMIC

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
g_{fs} (∗)	Forward Transconductance	$V_{DS} > I_{D(on)} \times R_{DS(on)max}$ I_D = 9 A	7	11		S
C_{iss} C_{oss} C_{rss}	Input Capacitance Output Capacitance Reverse Transfer Capacitance	V_{DS} = 25 V f = 1 MHz V_{GS} = 0		1200 200 60	1560 260 80	pF pF pF

ELECTRICAL CHARACTERISTICS (continued)

SWITCHING ON

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
$t_{d(on)}$ t_r	Turn-on Time Rise Time	V_{DD} = 100 V I_D = 9 A R_G = 4.7 Ω V_{GS} = 10 V (see test circuit, figure 3)		13 27	17 35	ns ns
Q_g Q_{gs} Q_{gd}	Total Gate Charge Gate-Source Charge Gate-Drain Charge	V_{DD} = 160 V I_D = 18 A V_{GS} = 10V		55 10 21	72	nC nC nC

SWITCHING OFF

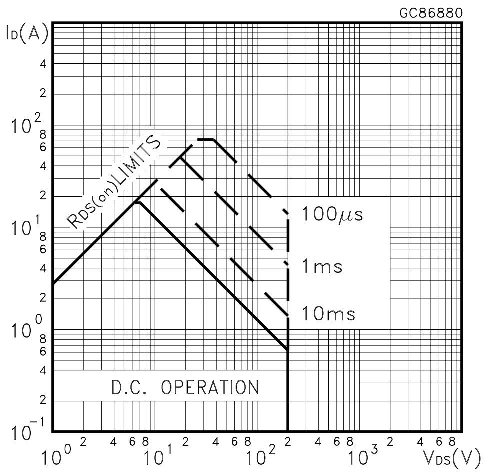
Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
$t_{r(Voff)}$ t_f t_c	Off-voltage Rise Time Fall Time Cross-over Time	V_{DD} = 160 V I_D = 18 A R_G = 4.7 Ω V_{GS} = 10 V (see test circuit, figure 5)		21 25 50	27 32 65	ns ns ns

SOURCE DRAIN DIODE

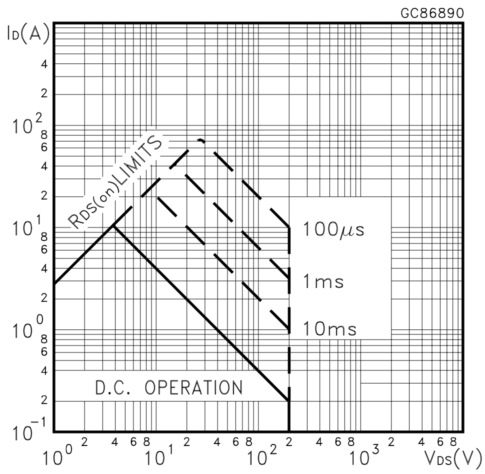
Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
I_{SD} I_{SDM}(•)	Source-drain Current Source-drain Current (pulsed)				18 72	A A
V_{SD} (∗)	Forward On Voltage	I_{SD} = 18 A V_{GS} = 0			1.5	V
t_{rr} Q_{rr} I_{RRM}	Reverse Recovery Time Reverse Recovery Charge Reverse Recovery Current	I_{SD} = 18 A di/dt = 100 A/µs V_{DD} = 50 V T_j = 150 °C (see test circuit, figure 5)		240 1.8 15		ns µC A

(∗) Pulsed: Pulse duration = 300 µs, duty cycle 1.5 %
(•) Pulse width limited by safe operating area

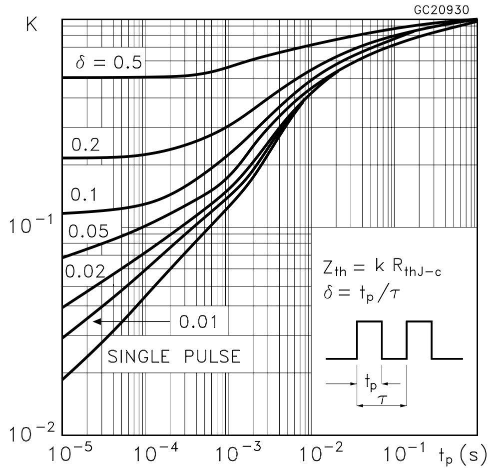
Safe Operating Area for TO-220



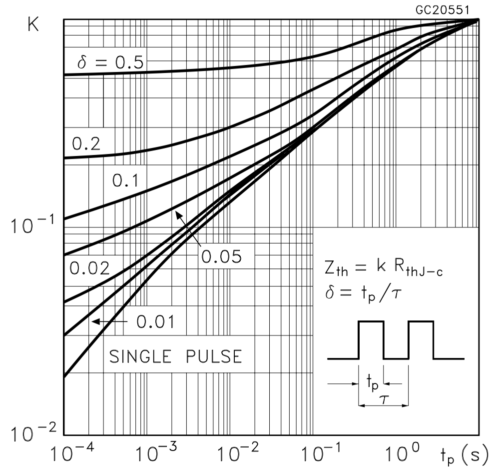
Safe Operating Area for TO-220FP



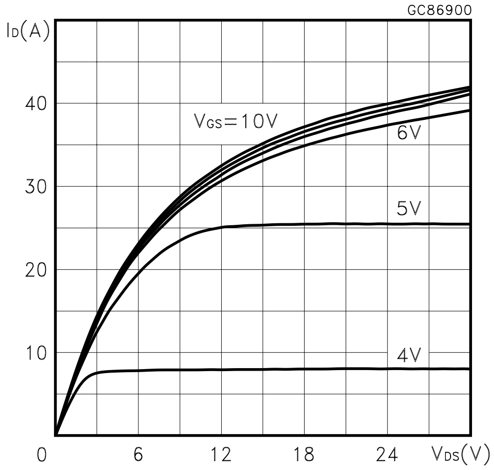
Thermal Impedance for TO-220



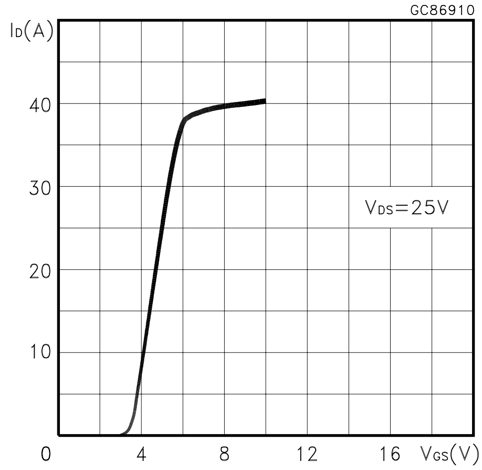
Thermal Impedance for TO-220FP



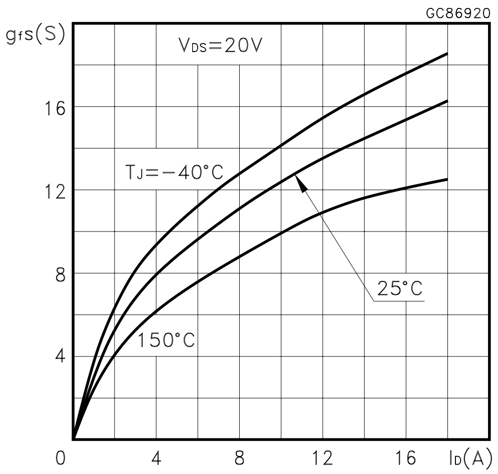
Output Characteristics



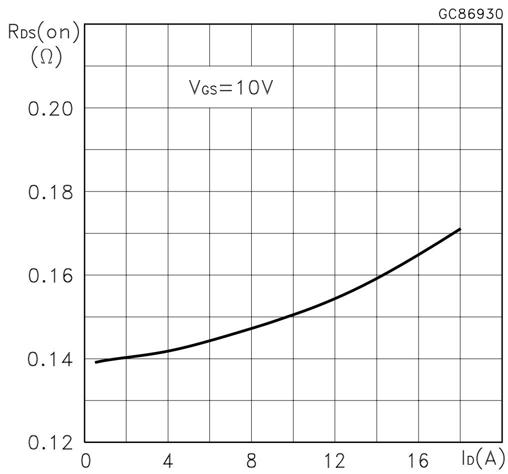
Transfer Characteristics



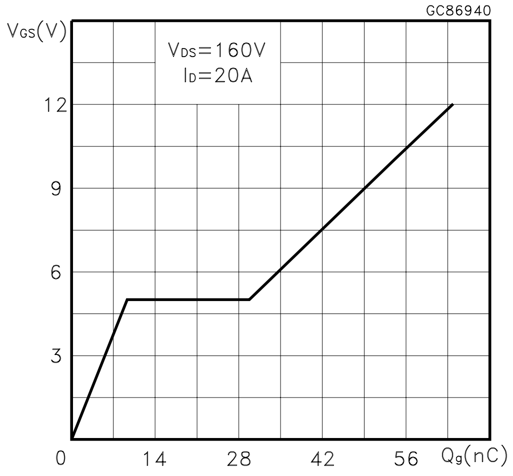
Transconductance



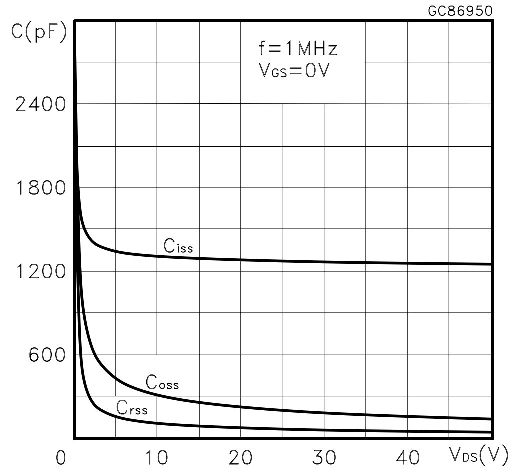
Static Drain-source On Resistance



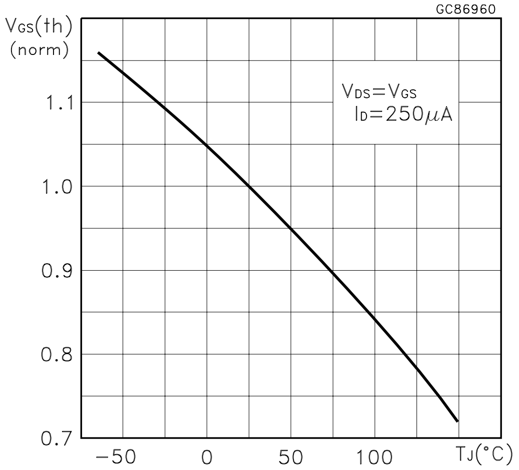
Gate Charge vs Gate-source Voltage



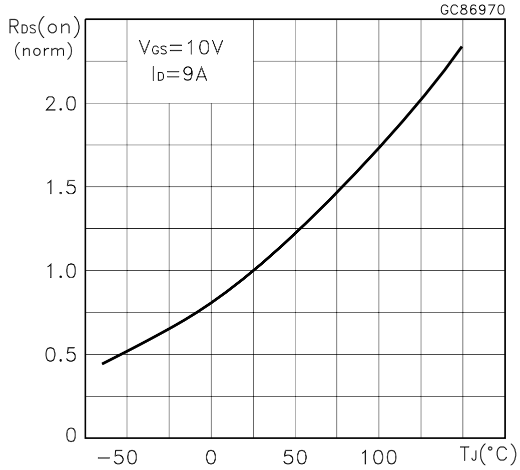
Capacitance Variations



Normalized Gate Threshold Voltage vs Temperature



Normalized On Resistance vs Temperature



Source-drain Diode Forward Characteristics

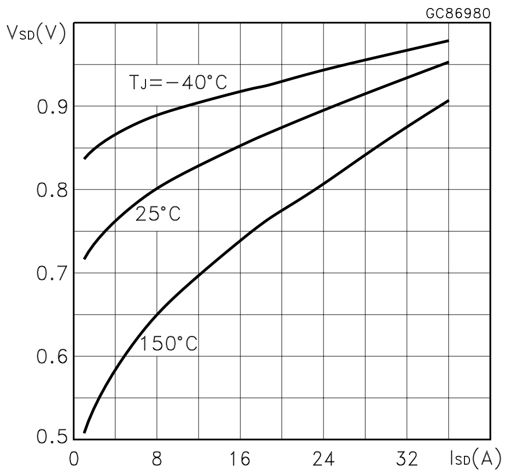


Fig. 1: Unclamped Inductive Load Test Circuit

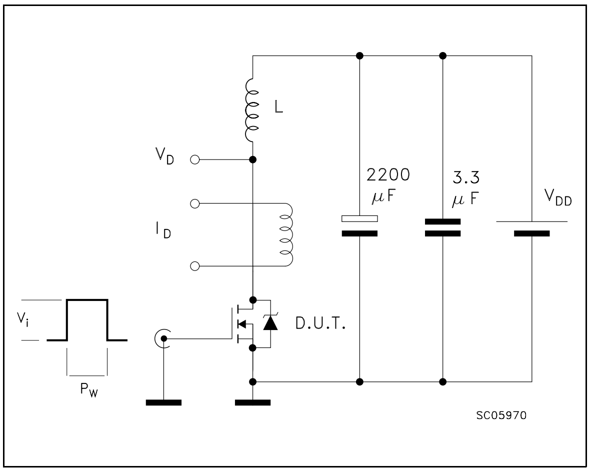


Fig. 2: Unclamped Inductive Waveform

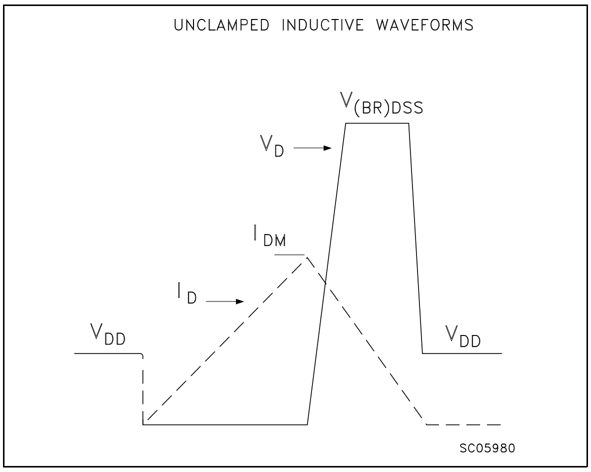


Fig. 3: Switching Times Test Circuits For Resistive Load

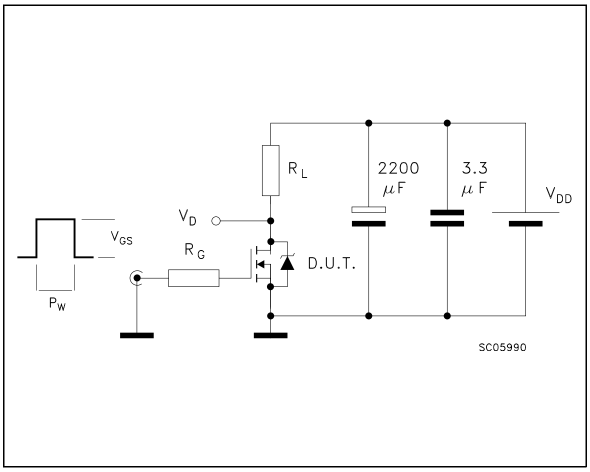


Fig. 4: Gate Charge test Circuit

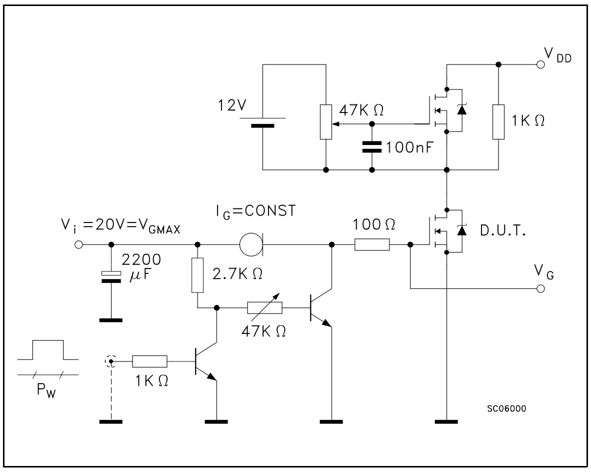
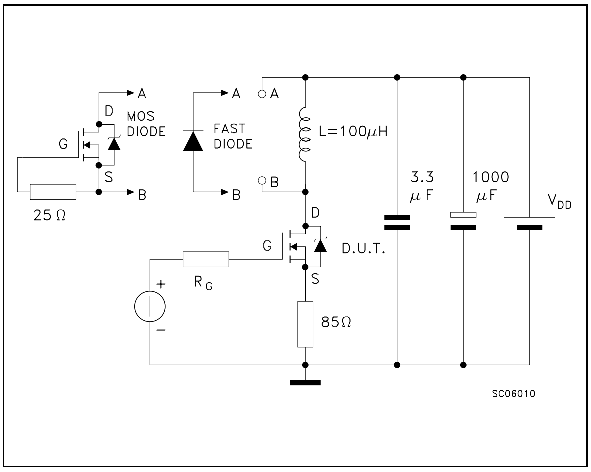
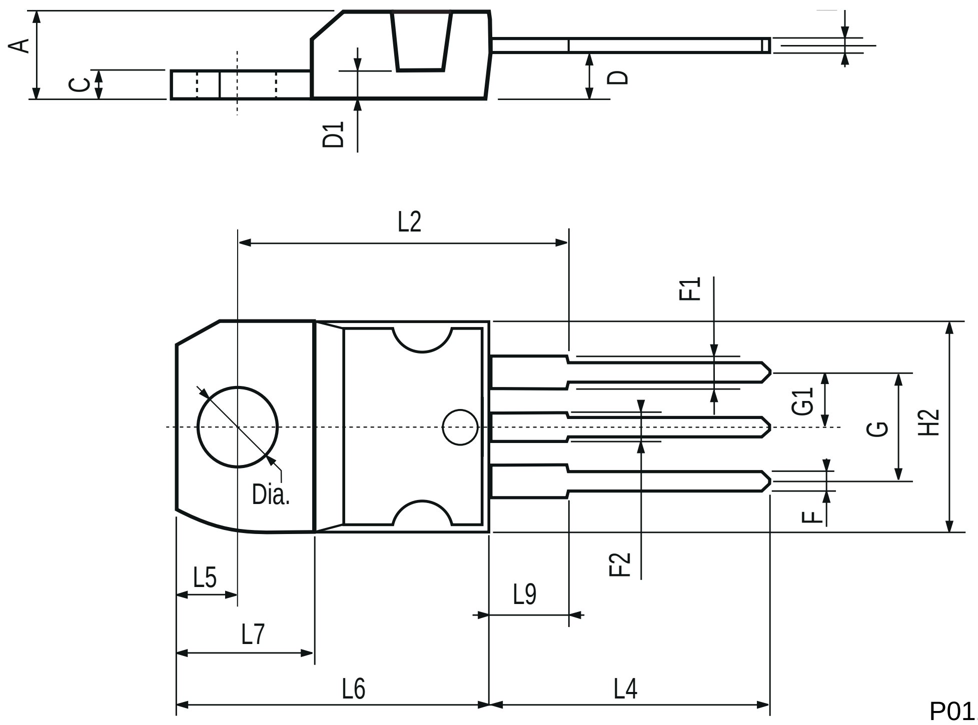


Fig. 5: Test Circuit For Inductive Load Switching And Diode Recovery Times



TO-220 MECHANICAL DATA

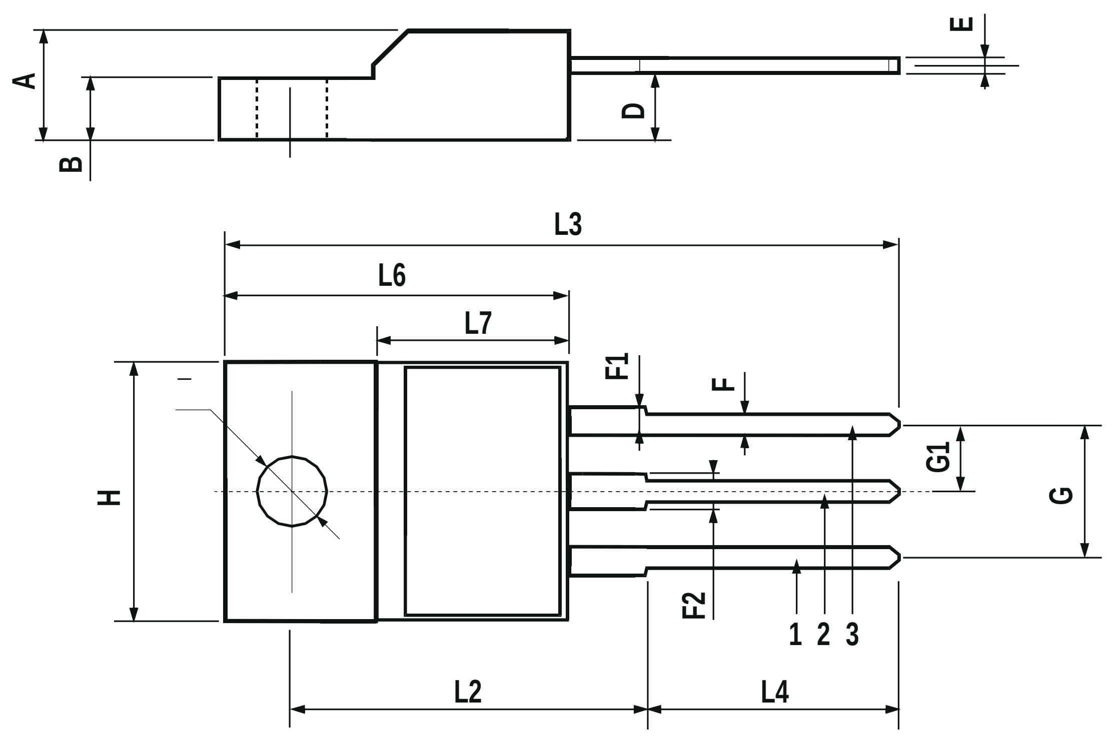
DIM.	mm			inch		
	MIN.	TYP.	MAX.	MIN.	TYP.	MAX.
A	4.40		4.60	0.173		0.181
C	1.23		1.32	0.048		0.051
D	2.40		2.72	0.094		0.107
D1		1.27			0.050	
E	0.49		0.70	0.019		0.027
F	0.61		0.88	0.024		0.034
F1	1.14		1.70	0.044		0.067
F2	1.14		1.70	0.044		0.067
G	4.95		5.15	0.194		0.203
G1	2.4		2.7	0.094		0.106
H2	10.0		10.40	0.393		0.409
L2		16.4			0.645	
L4	13.0		14.0	0.511		0.551
L5	2.65		2.95	0.104		0.116
L6	15.25		15.75	0.600		0.620
L7	6.2		6.6	0.244		0.260
L9	3.5		3.93	0.137		0.154
DIA.	3.75		3.85	0.147		0.151



P011C

TO-220FP MECHANICAL DATA

DIM.	mm			inch		
	MIN.	TYP.	MAX.	MIN.	TYP.	MAX.
A	4.4		4.6	0.173		0.181
B	2.5		2.7	0.098		0.106
D	2.5		2.75	0.098		0.108
E	0.45		0.7	0.017		0.027
F	0.75		1	0.030		0.039
F1	1.15		1.7	0.045		0.067
F2	1.15		1.7	0.045		0.067
G	4.95		5.2	0.195		0.204
G1	2.4		2.7	0.094		0.106
H	10		10.4	0.393		0.409
L2		16			0.630	
L3	28.6		30.6	1.126		1.204
L4	9.8		10.6	0.385		0.417
L6	15.9		16.4	0.626		0.645
L7	9		9.3	0.354		0.366
Ø	3		3.2	0.118		0.126



Ferrite

For Switching Power Supplies
Introduction

Since its outset in 1935, in the wake of the invention of ferrite, TDK has aimed to develop its world leading electronic technology in both material development and production. This accumulated expertise in fine structural control technology has resulted in high performance ferrite components. These components have recently been in greater demand for electronic equipment requiring reduction in size and weight.

TDK Ferrite Division engineers have successfully explored every avenue of high performance ferrites, aiming to produce self-contained energy sources for microelectronic equipment.

To this end, TDK has developed high frequency power ferrite, such as PC33,PC40,PC44,PC45,PC46,PC47 and PC50 that are identifiable by their excellent magnetic characteristics. It is these high reliability ferrite components that have largely contributed to reducing the size of switching power supplies and DC to DC Converters for micro-electronic equipment.

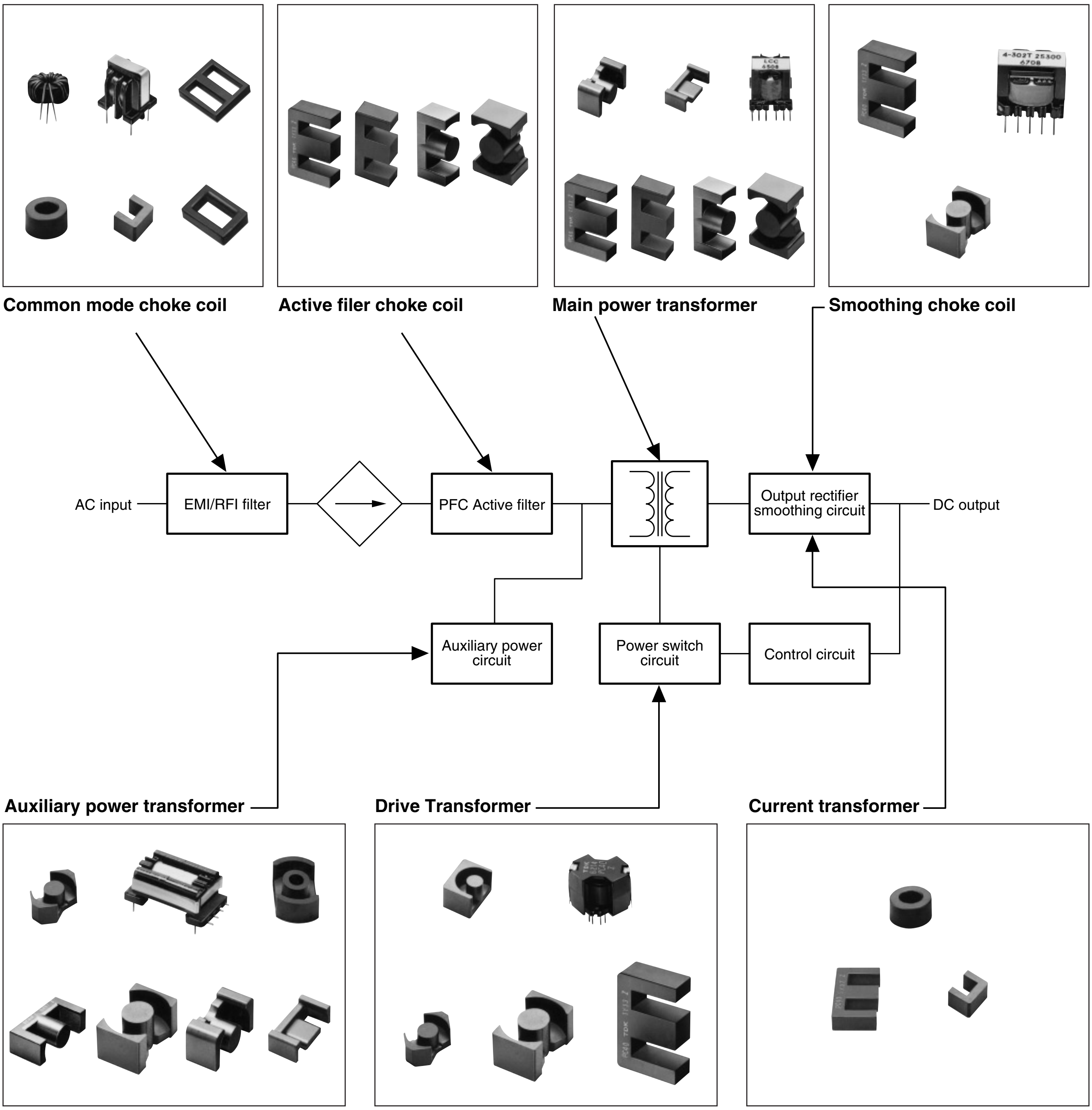
Other TDK endeavors deserving mention are ferrite for EMI filters and common mode chokes with excellent frequency characteristics. Not only have TDK's researchers overcome the theoretical limiting value of the high μ material's operating frequency, but they have also succeeded in developing new materials HS72 and HS10 those are characterized by its high impedance at high frequencies.

In order for you to take full advantage of these and other materials shown in this booklet, TDK has developed a range of cores and accessories to meet the need for miniature high performance switching power supplies and DC to DC Converters. TDK offers a comprehensive range of materials and core shapes to meet all of your power requirements.

Ferrite

For Switching Power Supplies
Circuit Example

SINGLE FORWARD CONVERTER

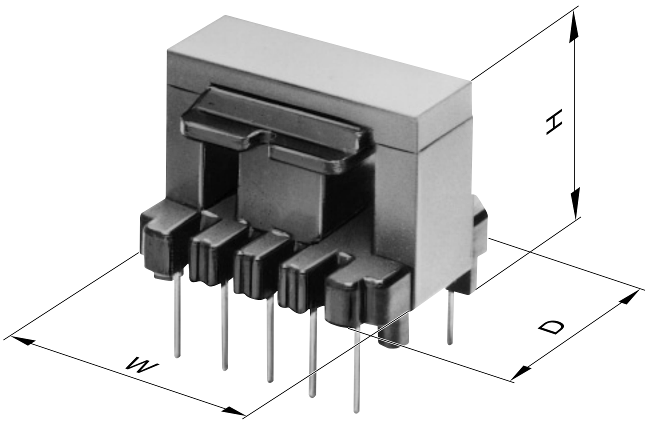


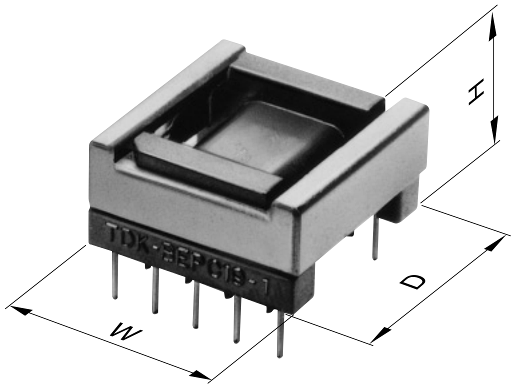
Notes:
- LP and EPC cores are ideal for use in thin transformers.
- LP cores are available in .5 and .7 inches in height (when mounted).
- EP cores are available in .5 and .65 inches in height (when mounted).

Ferrite

For Switching Power Supplies
Selected Items of Legend

$C_1 = \sum \frac{\ell}{A}$ Core constant mm^{-1}
Ae Effective cross-sectional area, mm^2
ℓe Effective magnetic path length, mm
Ve Effective core volume mm^3
Acp Cross-sectional center leg/pole area, mm^2
Acp min. Minimum cross-sectional center pole area, mm^2
Acw Cross-sectional winding area of core, mm^2
Aw Cross-sectional winding area of bobbin, mm^2
ℓw Average length of turns around bobbin, mm
t Minimum thickness of bobbin inside which core is placed, including flanges, mm
W Bobbin-core assembly dimensions
D Bobbin-core assembly dimensions
H Bobbin-core assembly dimensions





Ferrite

For Switching Power Supplies
Material Characteristics

MATERIAL CHARACTERISTICS(for Transformer and Choke)

Material					PC40	PC44	PC47	PC50
Initial permeability	μi				2300±25%	2400±25%	2500±25%	1400±25%
Amplitude permeability	μa				3000 min.	3000 min.		
Core loss volume density (Core loss)* [B=200mT]	Pcv	kW/m3	25kHz sine wave	25°C	120			
				60°C	80			
				100°C	70			
				120°C	85			
			100kHz sine wave	25°C	600	600	600	130**
				60°C	450	400	400	80**
				100°C	410	300	250	80**
				120°C	500	380	360	110**
Saturation magnetic flux density* [H=1194A/m]	Bs	mT		25°C	510	510	530	470
				60°C	450	450	480	440
				100°C	390	390	420	380
				120°C	350	350	390	350
Remanent flux density*	Br	mT		25°C	95	110	180	140
				60°C	65	70	100	110
				100°C	55	60	60	98
				120°C	50	55	60	100
Coercive force*	Hc	A/m		25°C	14.3	13	13	36.5
				60°C	10.3	9	9	31.0
				100°C	8.8	6.5	6	27.2
				120°C	8	6	7	26.0
Curie temperature	Tc	°C			>215	>215	>230	>240
Density*	db	kg/m3			4.8×10^3	4.8×10^3	4.9×10^3	4.8×10^3
Electrical resistivity*	ρv	Ω • m			6.5	6.5	4.0	30

* *Average value*
** *500kHz, 50mT*

Material					PC45	PC46	PC33
Initial permeability	μi				2500±25%	3200±25%	1400±25%
Amplitude permeability	μa						
Core loss volume density (Core loss)* [B=200mT]	Pcv	kW/m3	25kHz sine wave	25°C			
				60°C			
				100°C			
				120°C			
			100kHz sine wave	25°C	570	350	1100
				60°C	250(75°C)	250(45°C)	800
				100°C	460	660	600
				120°C	650	760	680
Saturation magnetic flux density* [H=1194A/m]	Bs	mT		25°C	530	520	520
				60°C	480	470	490
				100°C	420	410	440
				120°C	390	380	420
Remanent flux density*	Br	mT		25°C	120	80	220
				60°C	80	80	150
				100°C	80	130	100
				120°C	110	140	100
Coercive force*	Hc	A/m		25°C	12	10	23
				60°C	9	9	17
				100°C	8	10	14
				120°C	9	9	14
Curie temperature	Tc	°C			>230	>230	>290
Density*	db	kg/m3			4.8	4.8	4.8
Electrical resistivity*	ρv	Ω • m			3.0	3.0	2.5

* *Average value*

Ferrite

For Switching Power Supplies
Material Characteristics

MATERIAL CHARACTERISTICS(for Common mode Choke)

Material				**HS52**	**HS72**	**HS10**
Initial permeability	μi			5500±25%	7500±25% (2000min. at 500kHz)	10000±25%
Relative loss factor*	tanδ/μi	$\times 10^{-6}$		10(100kHz)	30(100kHz)	30(100kHz)
Saturation magnetic flux density* [H=1194A/m]	Bs	mT	25°C	410	410	380
Remanent flux density*	Br	mT	25°C	70	80	120
Coercive force*	Hc	A/m	25°C	6	6	5
Curie temperature	Tc	°C		>130	>130	>120
Density*	db	kg/m³		4.9×10^3	4.9×10^3	4.9×10^3
Electrical resistivity*	ρv	Ω • m		1	0.2	0.2

* *Average value*

MATERIAL CHARACTERISTICS(for Telecommunication)

Material				**H5A**	**H5B2**	**H5C2**	**H5C3**
Initial permeability	μi			$3300^{+40\%}_{-0\%}$	7500±25%	10000±30%	15000±30%
Relative loss factor	tanδ/μi	$\times 10^{-6}$		<2.5(10kHz) <10(100kHz)	<6.5(10kHz)	<7.0(10kHz)	<7.0(10kHz)
Temperature factor of initial permeability	αμir	$\times 10^{-6}$	–30 to +20°C	–0.5 to 2.0	0 to 1.8	–0.5 to 1.5	–0.5 to 1.5
			0 to 20°C				
			20 to 70°C	–0.5 to 2.0	0 to 1.8	–0.5 to 1.5	–0.5 to 1.5
Saturation magnetic flux density* [H=1194A/m]	Bs	mT	25°C	410	420	400	360
Remanent flux density*	Br	mT	25°C	100	40	90	105
Coercive force*	Hc	A/m	25°C	8.0	5.6	7.2	4.4
Curie temperature	Tc	°C		>130	>130	>120	>105
Hysteresis material constant	η_B	$\frac{10^{-6}}{mT}$		<0.8	<1.0	<1.4	<0.5
Disaccommodation factor	D_F	$\times 10^{-6}$		<3	<3	<2	<2
Density*	db	kg/m³		4.8×10^3	4.9×10^3	4.9×10^3	4.95×10^3
Electrical resistivity*	ρv	Ω • m		1	0.1	0.15	0.15

* *Average value*

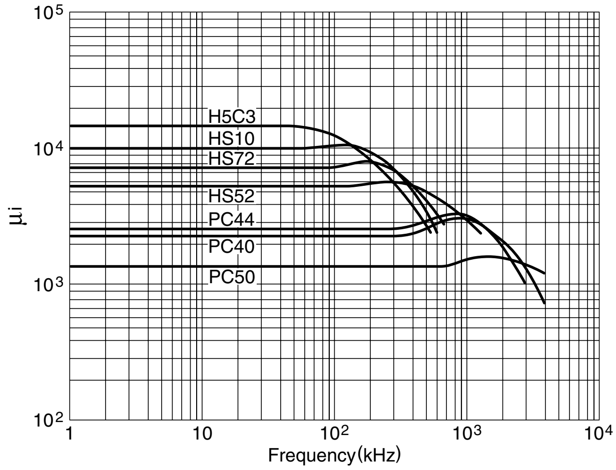
Material				**HP5**	**DN40**	**DN70**
Initial permeability	μi			5000±20%	4000±25%	7500±25%
Relative loss factor	tanδ/μi	$\times 10^{-6}$		<3.5(10kHz)	<2.5(10kHz)	<2.0(10kHz)
Temperature factor of initial permeability	αμir	$\times 10^{-6}$	–30 to +20°C		–0.5 to 2.0	–0.5 to 1.5
			0 to 20°C	±12.5%		
			20 to 70°C	±12.5%	–0.5 to 2.0	–0.5 to 1.5
Saturation magnetic flux density* [H=1194A/m]	Bs	mT	25°C	400	405	390
Remanent flux density*	Br	mT	25°C	65	95	45
Coercive force*	Hc	A/m	25°C	7.2	8.0	3.5
Curie temperature	Tc	°C		>140	>130	>105
Hysteresis material constant	η_B	$\frac{10^{-6}}{mT}$		<0.4	<0.8	<0.2
Disaccommodation factor	D_F	$\times 10^{-6}$		<3	<3	<2.5
Density*	db	kg/m³		4.8×10^3	4.8×10^3	5.0×10^3
Electrical resistivity*	ρv	Ω • m		0.15	1.0	0.3

* *Average value*

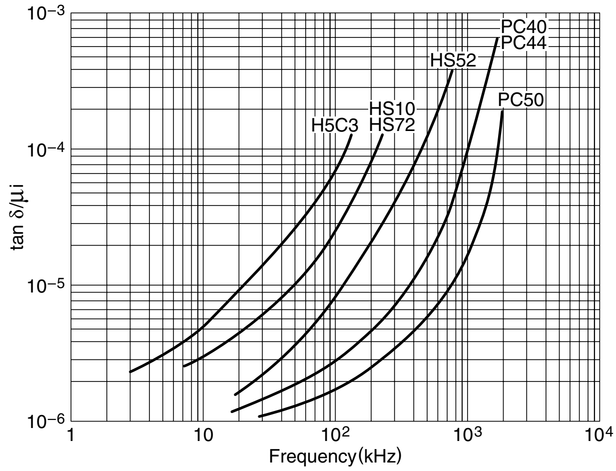
Ferrite

For Switching Power Supplies
Material Characteristics

μi vs. Frequency Characteristics

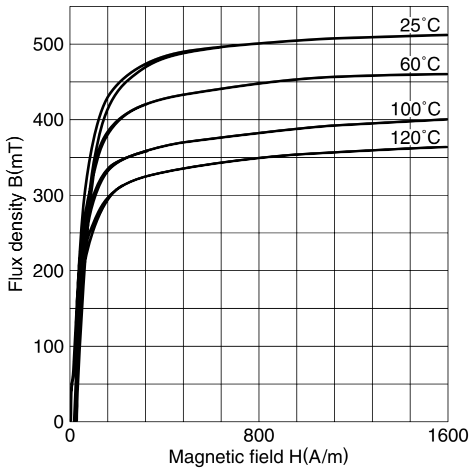


tanδ/μi vs. Frequency Characteristics

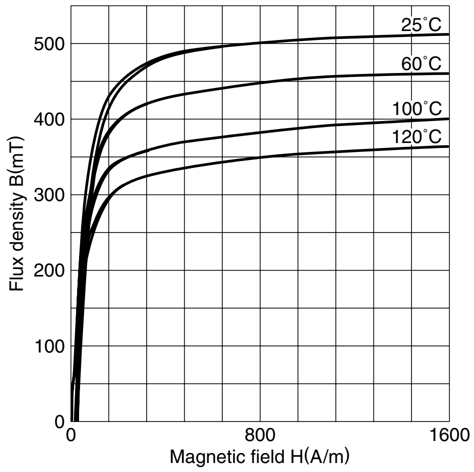


Magnetization Curves (Typical)

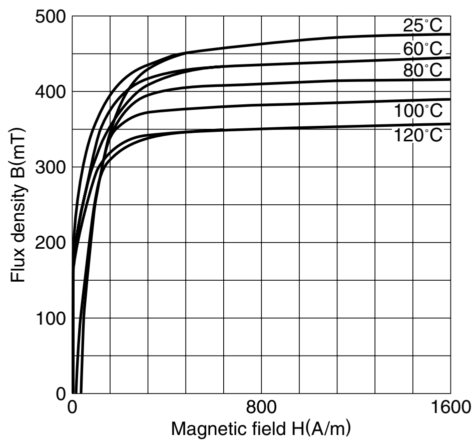
Material: PC40



Material: PC44



Material: PC50

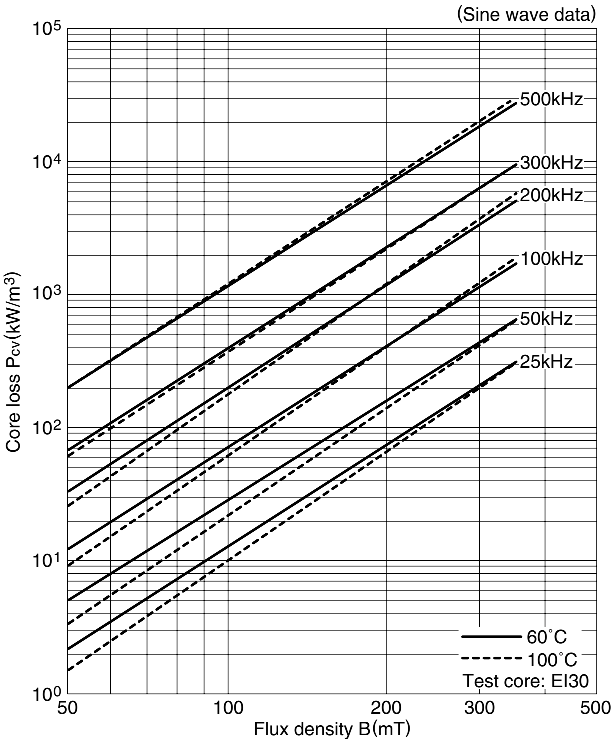


Ferrite

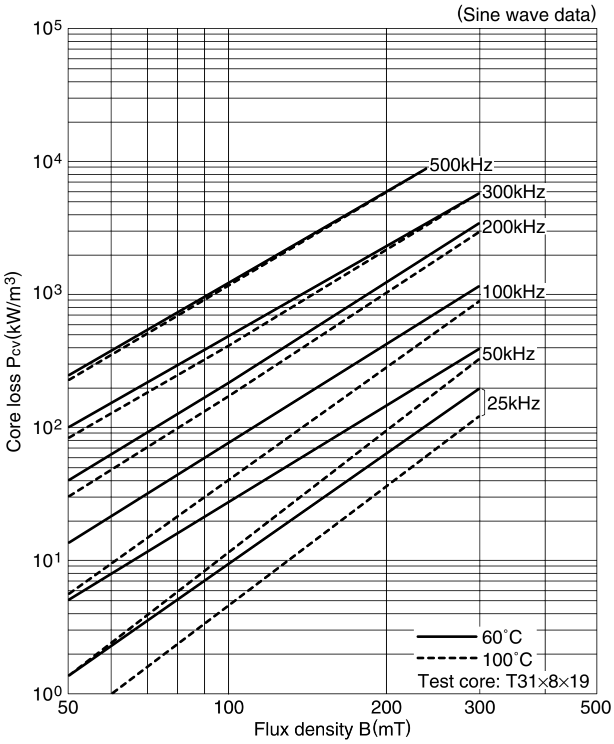
For Switching Power Supplies
Material Characteristics

Core Loss (Typical)

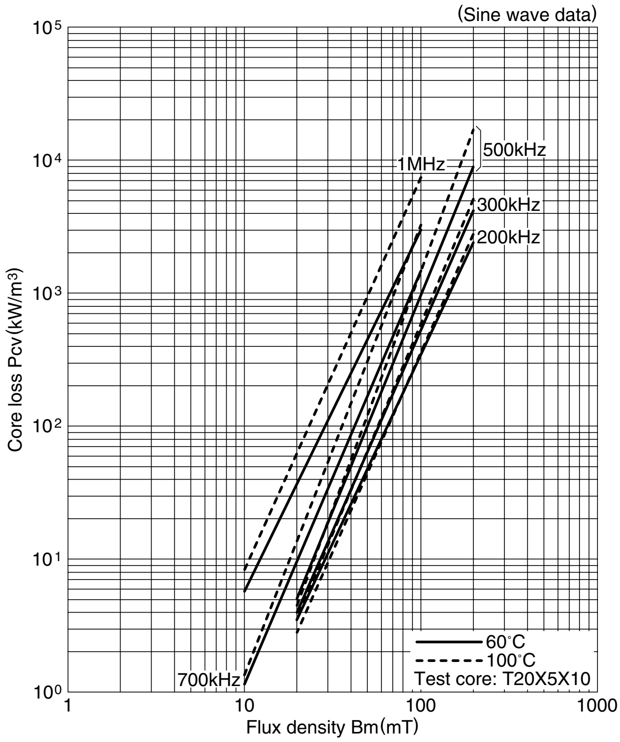
Material: PC40



Material: PC44



Material: PC50

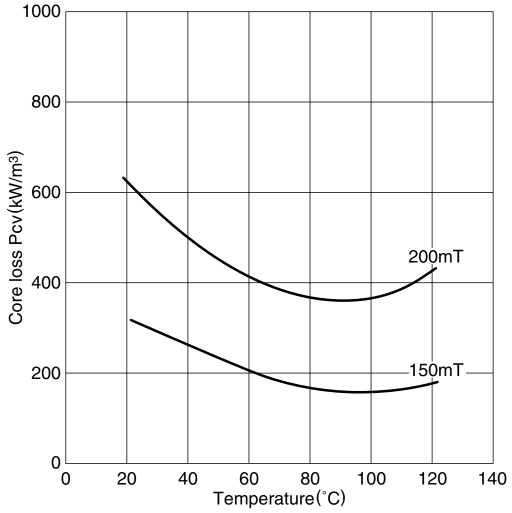


Ferrite

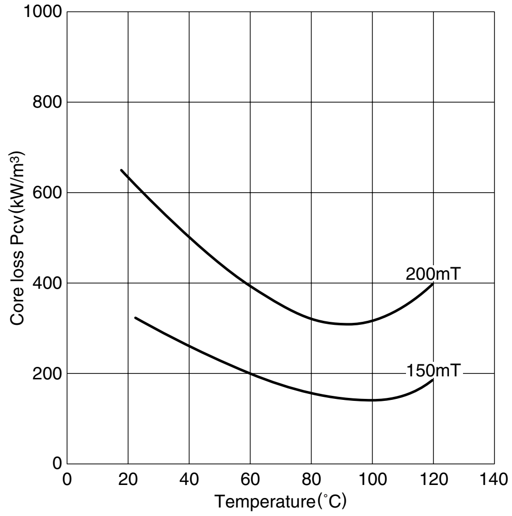
For Switching Power Supplies
Material Characteristics

Temperature Dependence of Core Loss (Typical)

Material: PC40 (Frequency: 100kHz)

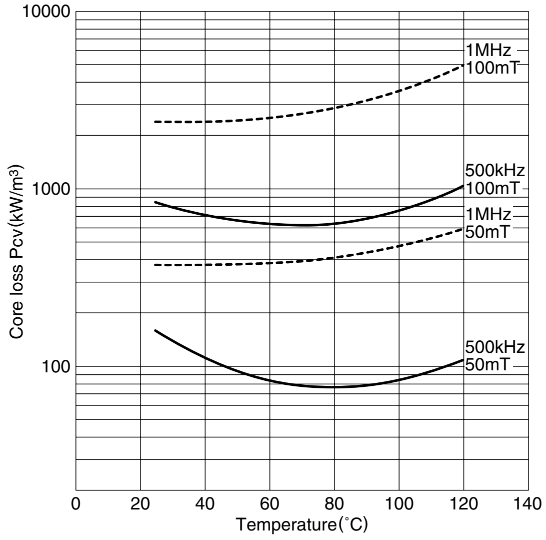


Material: PC44 (Frequency: 100kHz)



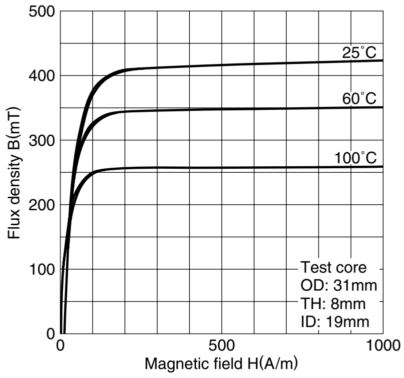
Test core: Toroidal
OD=31mm
TH=8mm
ID=19mm

Material: PC50

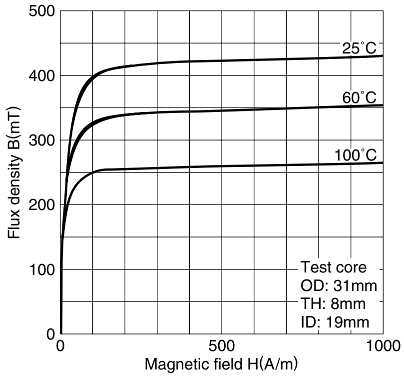


Magnetization Curves (Typical)

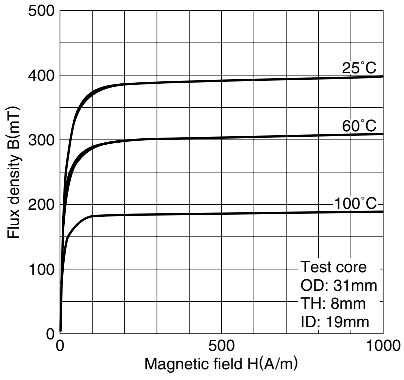
HS52



HS72



HS10

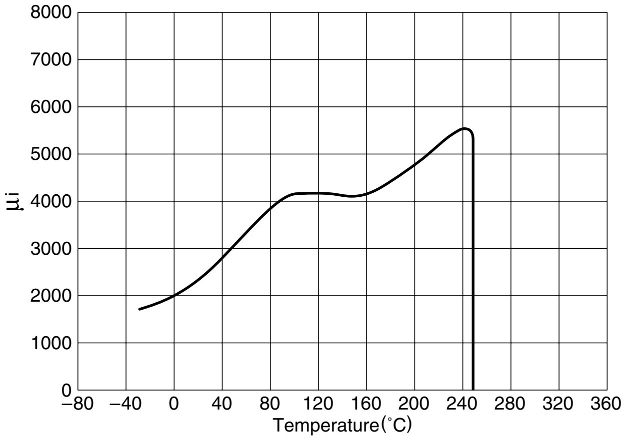


Ferrite

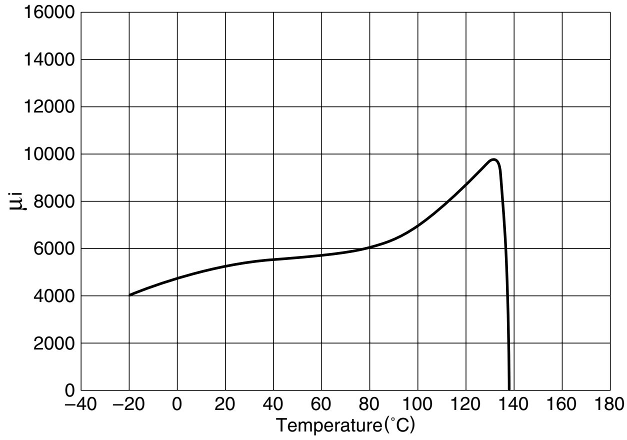
For Switching Power Supplies
Material Characteristics

µi vs. Temperature Characteristics (Typical)

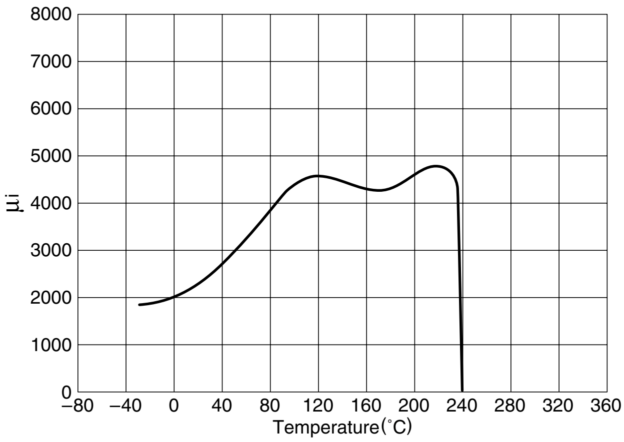
PC40



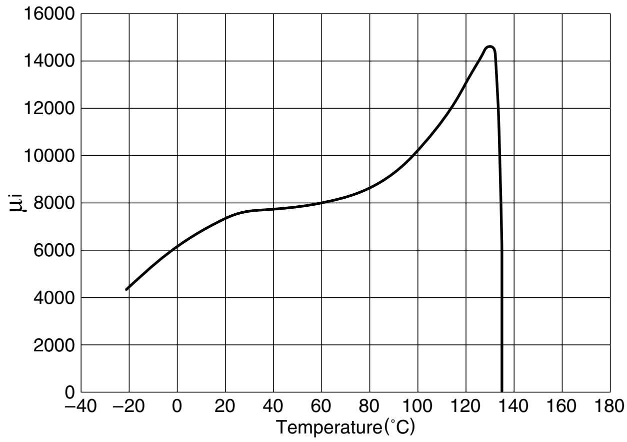
HS52



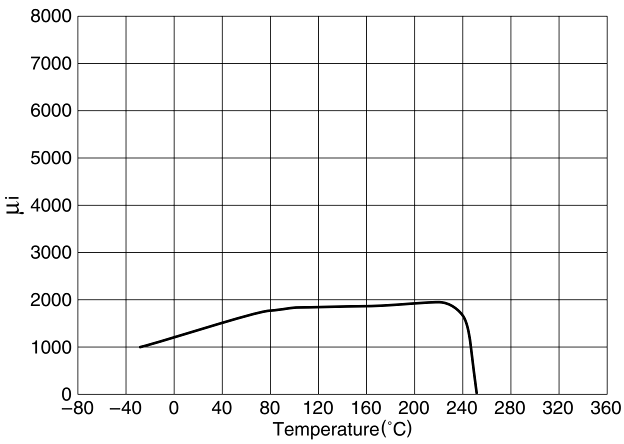
PC44



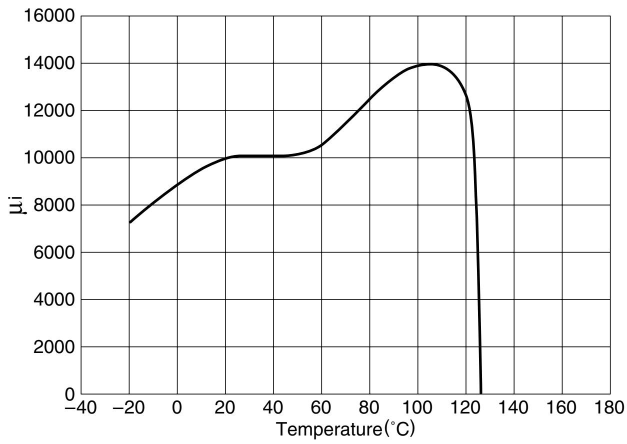
HS72



PC50



HS10



Test core: OD=31mm
TH=8mm
ID=19mm

Ferrite

PC47

For Switching Power Supplies
Low Loss Ferrite Material

PC47 has the best properties for transformers of power supplies, adapters and chargers.
The core loss and saturation magnetic flux density of PC47 are far better than PC44 and PC40 which are currently in use.

FEATURES

- Core loss: 250kW/m³ at 100kHz, 200mT, 100°C.
- Low core loss at wide frequency range 100kHz to 300kHz.
- Higher saturation flux density than PC44.

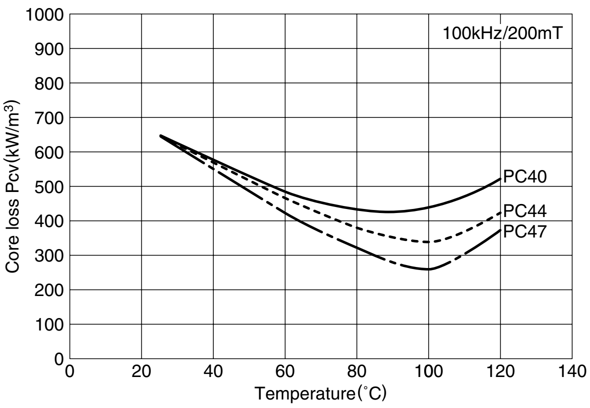
APPLICATIONS

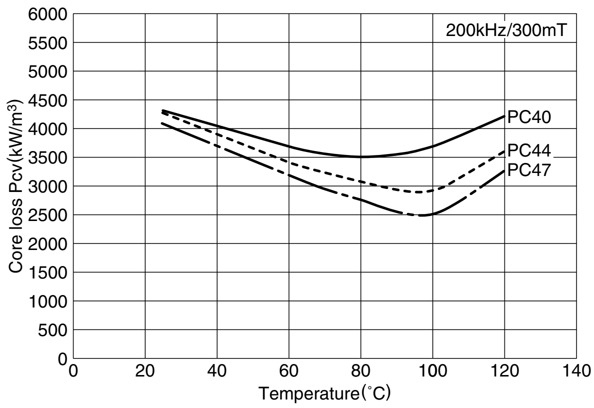
- Switching power supplies
- Adapters and chargers for notebook type pc
- CCFL LCD backlight

MATERIAL CHARACTERISTICS

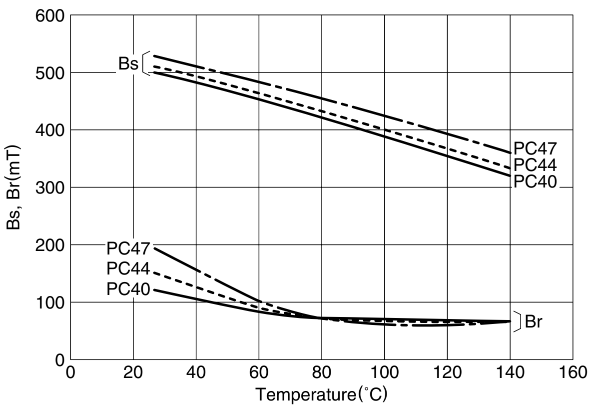
Material				**PC47(NEW)**	**PC44**	**PC40**
Initial permeability	μi		25°C	2500±25%	2400±25%	2300±25%
Core loss volume density [100kHz, 200mT]	Pcv	kW/m³	25°C	600	600	600
			60°C	400	400	450
			100°C	250	300	410
Saturation magnetic flux density [1000A/m]	Bs	mT	25°C	530	510	510
			100°C	420	390	390
Remanent flux density	Br	mT	25°C	180	110	95
			100°C	60	60	55
Curie temperature	Tc	°C	min.	230	215	215
Density	db	kg/m³		4.9×10³	4.8×10³	4.8×10³

Pcv TEMPERATURE DEPENDENCE CHARACTERISTICS (Typical)





Bs and Br TEMPERATURE DEPENDENCE CHARACTERISTICS (Typical)

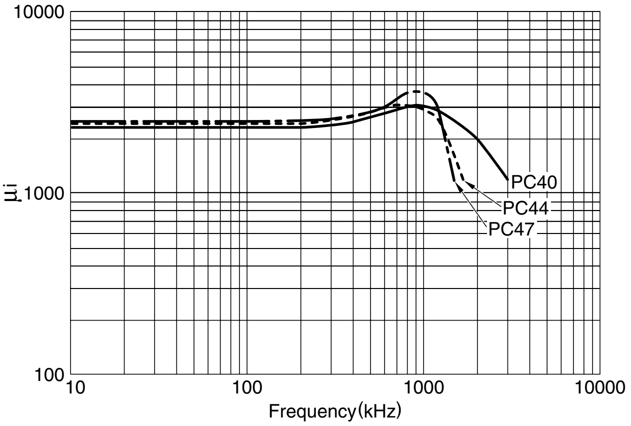


Ferrite

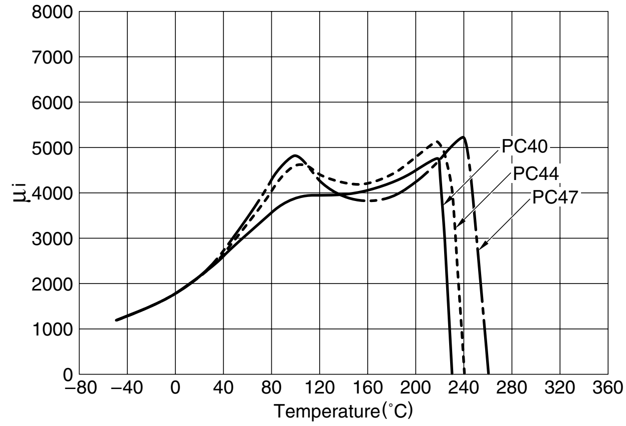
PC47

For Switching Power Supplies
Low Loss Ferrite Material

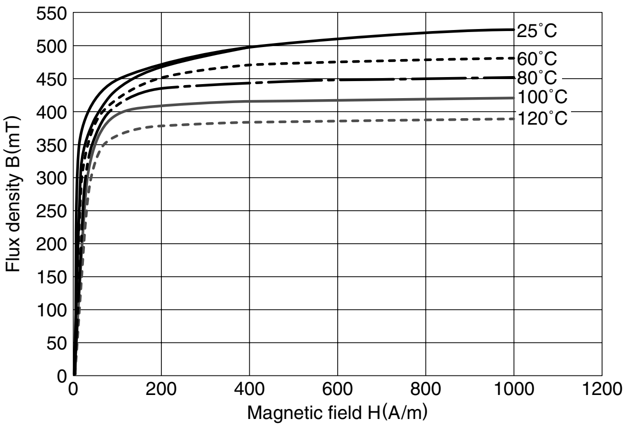
μi vs. FREQUENCY CHARACTERISTICS (Typical)



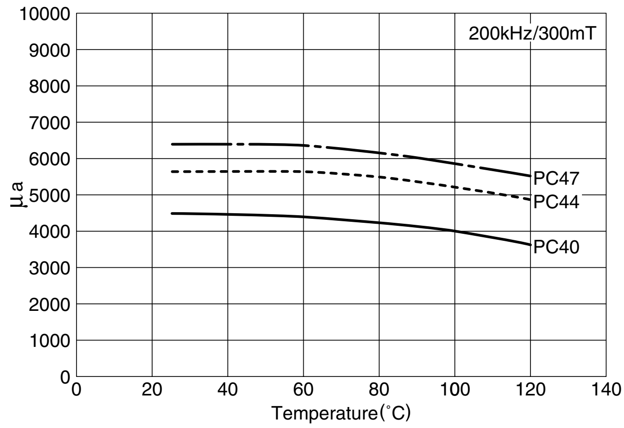
μi vs. TEMPERATURE CHARACTERISTICS (Typical)



MAGNETIZATION CURVES (Typical)
MATERIAL:PC47



μa TEMPERATURE DEPENDENCE CHARACTERISTICS (Typical)



Ferrite

For Switching Power Supplies
Low Loss Ferrite Materials

PC45 and PC46

In recent years, with the advent of notebook type pc, VCR's, digital camera's and mobile communication devices, technological demands have risen for higher performance CCFL LCD backlight units that have smaller sizes, lower profiles and higher efficiency.
The PC45 and PC46 are materials developed to achieve higher efficiency in designing minimize core loss at practical temperature ranges (PC45: 60 to 80°C and PC46: 40 to 50°C) and high saturation flux density.
They are also suitable for the transformers of DC to DC converters and adapters of notebook type pc.

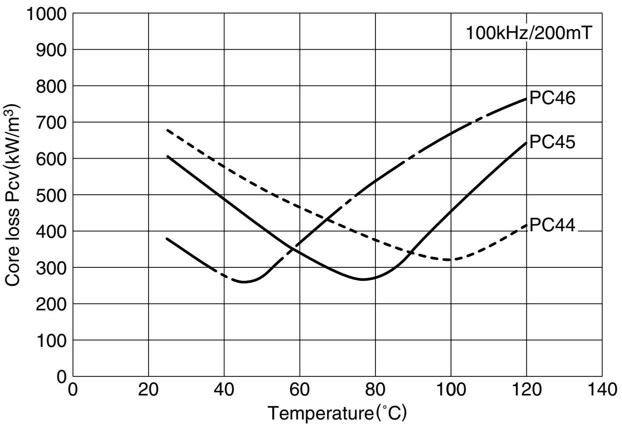
APPLICATIONS

- Switching power supplies
- Adapters and chargers for notebook type pc
- CCFL LCD backlight

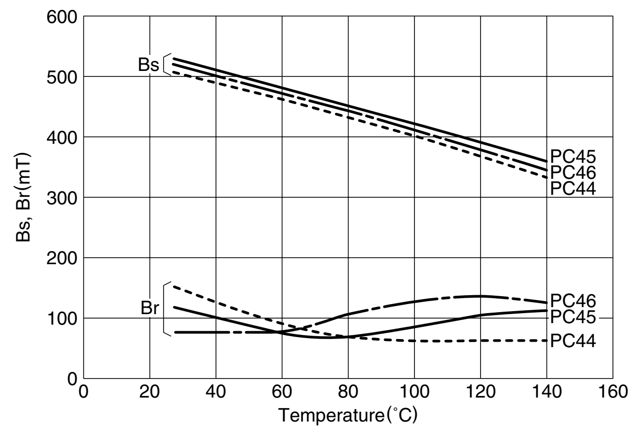
MATERIAL CHARACTERISTICS

Material				PC45(NEW)	PC46(NEW)	PC44
Initial permeability	μi		25°C	2500±25%	3200±25%	2400±25%
Core loss volume density [100kHz, 200mT]	Pcv	kW/m³	25°C	570	350	600
			60°C	250(75°C)	250(45°C)	400
			100°C	460	660	300
Saturation magnetic flux density [1000A/m]	Bs	mT	25°C	530	530	510
			100°C	420	410	390
Remanent flux density	Br	mT	25°C	120	80	110
			100°C	80	115	60
Curie temperature	Tc	°C	min.	230	230	215
Density	db	kg/m³		4.8×10^3	4.8×10^3	4.8×10^3

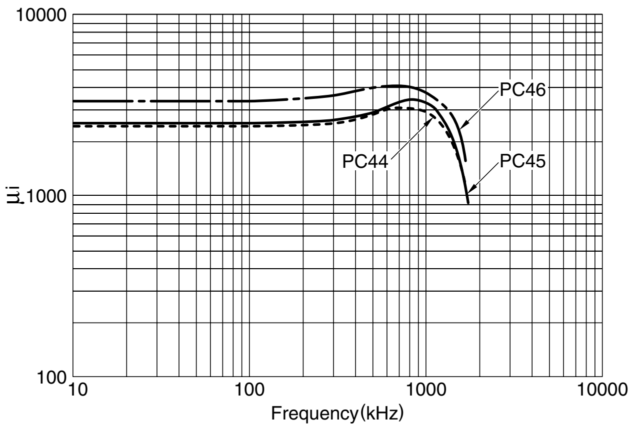
Pcv TEMPERATURE DEPENDENCE CHARACTERISTICS (Typical)



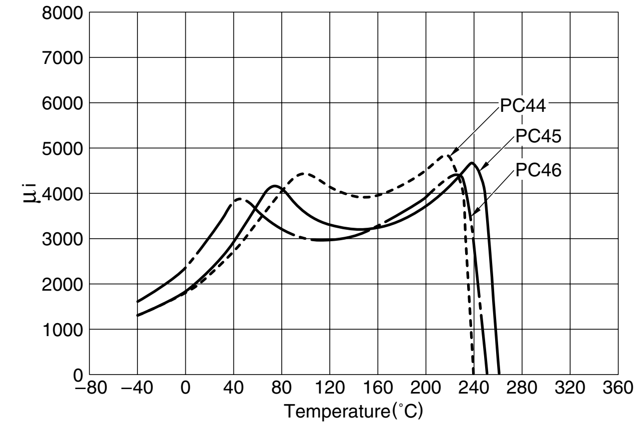
Bs and Br TEMPERATURE DEPENDENCE CHARACTERISTICS (Typical)



μi vs. FREQUENCY CHARACTERISTICS (Typical)



μi vs. TEMPERATURE CHARACTERISTICS (Typical)



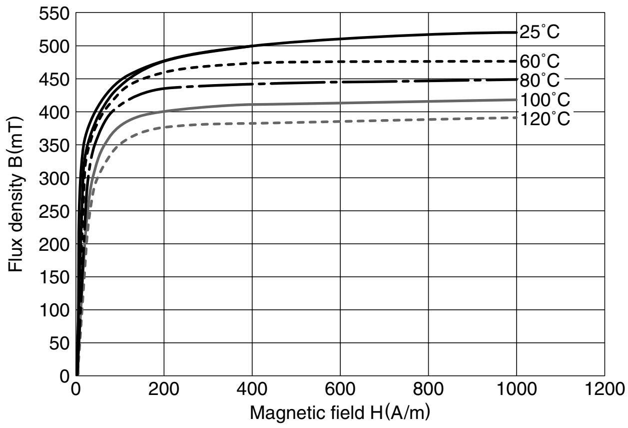
Ferrite

For Switching Power Supplies
Low Loss Ferrite Materials

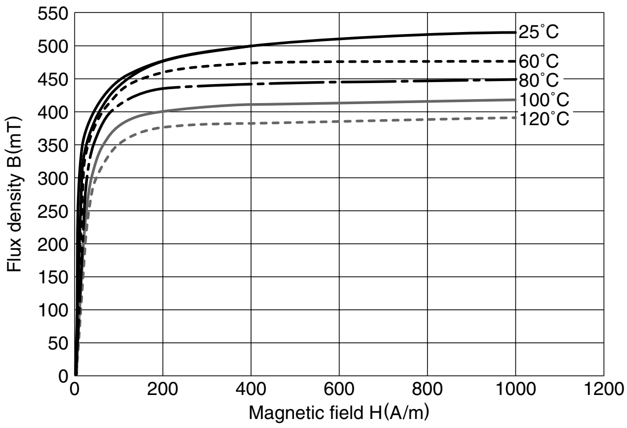
PC45 and PC46

MAGNETIZATION CURVES

MATERIAL:PC45



MATERIAL:PC46



Ferrite

PC33

For Switching Power Supplies
High Saturation Flux Density Material for Choke Coil

PC33 has the best properties for smoothing choke coil of power supplies.
The saturation magnetic flux density of PC33 is far better than PC44 and PC40 which are currently in use.

FEATURES

- Higher saturation flux density than PC44 and PC40.
- Most suitable ferrite material for choke coils.
- Maintain high saturation magnetic flux density at high temperature.

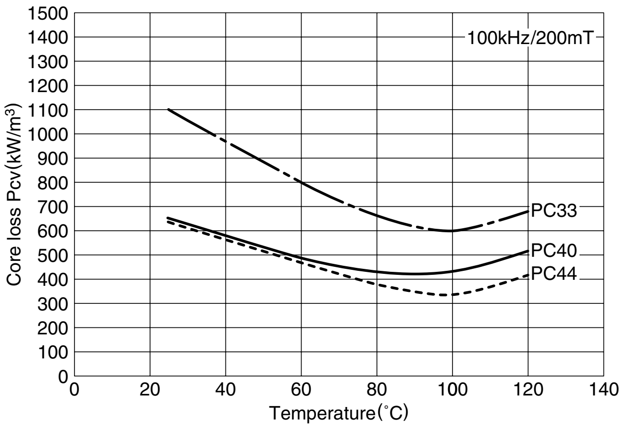
APPLICATIONS

- Power choke coils for switching power supplies
- Power choke coils for notebook type pc

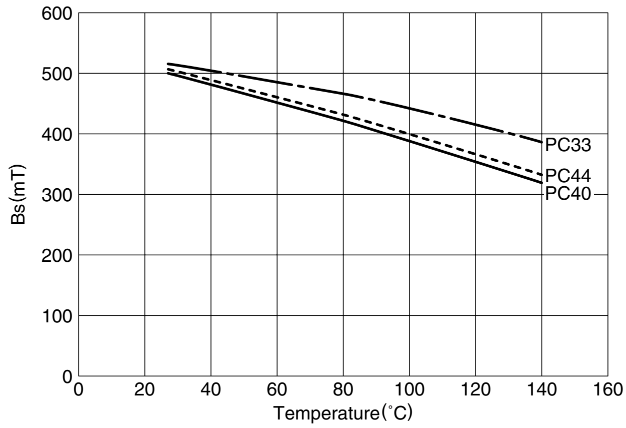
MATERIAL CHARACTERISTICS

Material				**PC33(NEW)**	**PC44**	**PC40**
Saturation magnetic flux density [1000A/m]	Bs	mT	25°C	510	510	510
			100°C	440	390	390
Initial permeability	μi		25°C	1400±25%	2400±25%	2300±25%
Core loss volume density [100kHz, 200mT]	Pcv	kW/m³	25°C	1100	600	600
			60°C	800	400	450
			100°C	600	300	410
Curie temperature	Tc	°C	min.	290	215	215
Density	db	kg/m³		4.8×10^3	4.8×10^3	4.8×10^3

Pcv TEMPERATURE DEPENDENCE CHARACTERISTICS (Typical)



Bs TEMPERATURE DEPENDENCE CHARACTERISTICS (Typical)



Ferrite

DN40 and DN70

For Switching Power Supplies
Low THD Materials for xDSL Modem Transformers

The use of xDSL technique becomes wide spread as a high broad-band access to the internet. In order to utilize such network access as sufficient as possible, low THD (Total Harmonic Distortion) of transformer for xDSL modem is quite important to transfer the significant signals.
Materials DN40 and DN70, TDK achieved such requirements recently, are developed to meet low THD over a wide temperature range(0 to 85°C) and wide frequency range(≧ 5kHz).
Therefore, They are suitable for the high performance transformer design for xDSL modem applications.
Standardization of AL-value will help you to select the optimum core at the transformer design.

FEATURES

- Meet low THD over a wide temperature range(0 to 85°C) and wide frequency range (≧ 5kHz).

APPLICATIONS

- Transformer for xDSL modem

APPLIED CORE TYPE AND AL-value

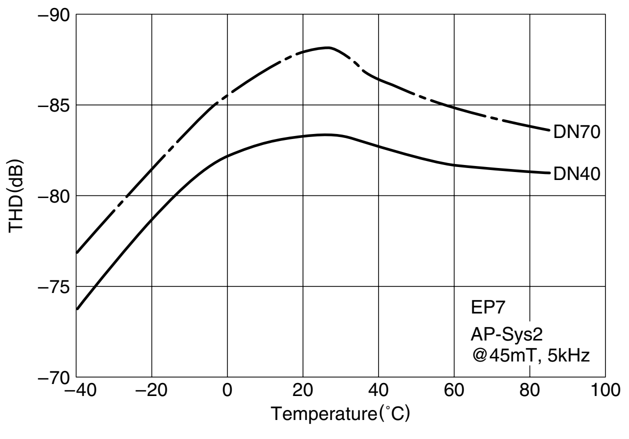
Core	Type	AL-value
EP	EP7	40, 63, 100, 160, 250
	EP10	40, 63, 100, 160, 250
	EP13	63, 100, 160, 250, 400, 500

MATERIAL CHARACTERISTICS

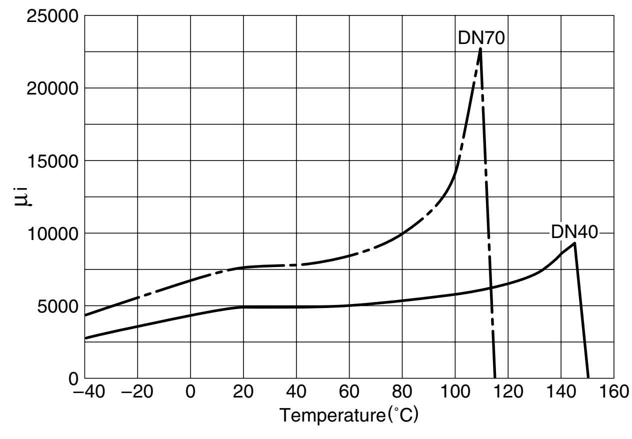
Material				DN70(NEW)	DN40
Initial permeability	μi		25°C	7500±25%	4000±25%
Relative loss factor [10kHz]	tanδ/μi	$\times10^{-6}$	25°C	<2.0	<2.5
Temperature factor of intial permeability	αμir		–30 to +20°C 20 to 70°C	–0.5 to +1.5 –0.5 to +1.5	–0.5 to 2.0 –0.5 to 2.0
Saturation magnetic flux density [1000A/m]	Bs	mT	25°C	390	405
Hysteresis material constant [25°C, 1.5 to 3.0mT, 10kMz]	η_B	$\frac{10^{-6}}{mT}$		<0.2	<0.8
Curie temperature	Tc	°C	min.	105	130
Density	db	kg/m³		5.0×10^3	4.8×10^3
Electrical resistivity	ρv	Ω • m		0.3	1.0

• Unless otherwise specify the tolerance, the values are shown as a typical.

THD TEMPERATURE DEPENDENCE CHARACTERISTICS (Typical)



μi vs. TEMPERATURE CHARACTERISTICS (Typical)



Ferrite

For Switching Power Supplies
E Cores

EI, EE, EF, EER, ETD and EC Series

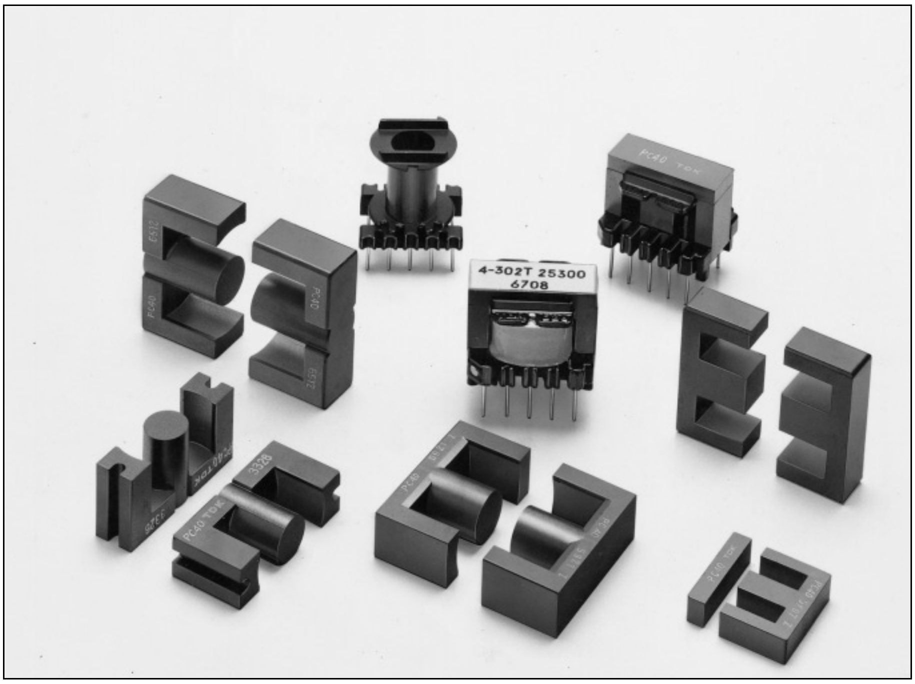
Cores

EI12.5 to EI60
EE8 to EE62.3/62/6
EF12.6 to EF32
EER25.5 to EER49
ETD19 to ETD49
EC70 to EC120

Bobbins

BE8 to BE62.3
BEER25.5 to BEER49
BETD19 to BETD24
BEC70 to BEC90

Accessories



Ordering Code System

Cores

PC40 EI 30 – Z

- Material: PC40
- Size of E core: EI 30
- AL-value Z: without air gap; G□: with air gap

Bobbins

B E30 – 1110 CPFR

- Symbol of Bobbin: B
- Size of E core: E30
- Code of Bobbin Material: 1
- Number of Section: 1
- Number of Terminal Pin: 10
- Type of Terminal Pin: CPFR

Accessories

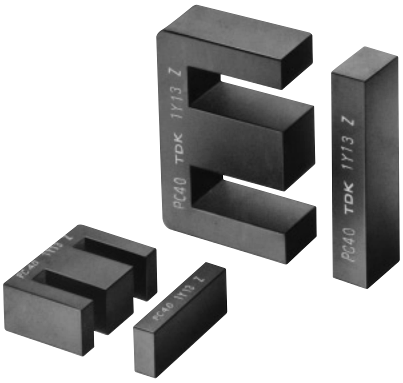
F E – 30 – F

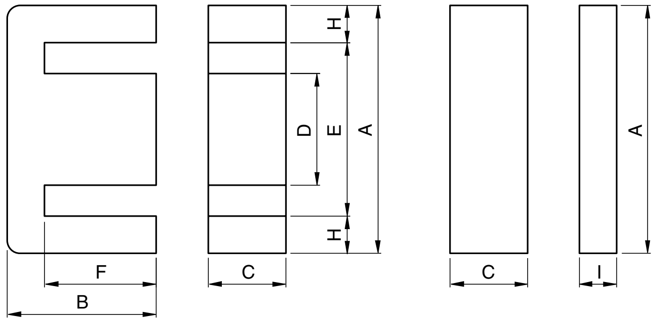
- Symbol of Accessory: F
- Size of E core: E – 30
- Type of Accessory: F

Ferrite

For Switching Power Supplies
E Cores

EI Series





Part No.	JIS	Dimensions in mm / inches A	B	C	D	E min.	F	H
PC40EI12.5-Z	JIS FEI 12.5	12.4±0.3 .488±.012	7.4±0.1 .291±.004	4.85±0.15 .191±.006	2.4±0.1 .094±.004	8.8 .346	5.1±0.1 .201±.004	1.6 .063
PC40EI16-Z	JIS FEI 16	16.0±0.3 .630±.012	12.2±0.2 .480±.008	4.8±0.2 .189±.008	4.0±0.2 .157±.008	11.6 .457	10.2±0.2 .402±.008	2.05 .081
PC40EI19-Z		20.0±0.3 .787±.012	13.55±0.25 .533±.010	5.0±0.2 .197±.008	4.55±0.15 .179±.006	14.3 .563	11.15±0.15 .439±.006	2.75 .108
PC40EI22-Z		22.0±0.3 .866±.012	14.55±0.25 .573±.010	5.75±0.25 .226±.010	5.75±0.25 .226±.010	13.0 .512	10.55±0.25 .415±.010	4.5 .177
PC40EI22/19/6-Z	JIS FEI 22	22.0±0.4 .866±.016	14.7±0.2 .579±.008	5.75±0.25 .226±.010	5.75±0.25 .226±.010	15.75 .620	10.7±0.2 .421±.008	3.0 .118
PC40EI25-Z		25.3±0.5 .996±.020	15.55±0.25 .612±.010	6.75±0.25 .266±.010	6.5±0.3 .256±.012	19.0 .748	12.35±0.25 .486±.010	3.0 .118
PC40EI28-Z	JIS FEI 28	28.0 $^{+0.7}_{-0.5}$ 1.102 $^{+.028}_{-.020}$	16.75±0.25 .659±.010	10.6±0.2 .417±.008 (E core) 10.7±0.3 .421±.012 (I core)	7.2±0.3 .283±.012	18.4 .724	12.25±0.25 .482±.010	4.5 .177
PC40EI30-Z	JIS FEI 30	30.0 $^{+0.7}_{-0.4}$ 1.181 $^{+.028}_{-.016}$	21.25±0.25 .837±.010	10.7±0.3 .421±.012	10.7±0.3 .421±0.12	19.7 .776	16.25±0.25 .640±.010	5.0 .197
PC40EI33/29/13-Z		33.0 $^{+0.8}_{-0.5}$ 1.299 $^{+.031}_{-.020}$	23.75±0.25 .935±.010	12.7±0.3 .500±.012	9.7±0.3 .382±.012	23.4 .921	19.25±0.25 .758±.010	4.45 .175
PC40EI35-Z	JIS FEI 35	35.0±0.5 1.378±.020	24.35±0.15 .959±.006	10.0±0.3 .394±.012	10.0±0.3 .394±.012	24.5 .965	18.25±0.15 .719±.006	5.0 .197
PC40EI40-Z	JIS FEI 40	40.0±0.5 1.575±.020	27.25±0.25 1.073±.010	11.65±0.35 .459±.014	11.65±0.35 .459±.014	27.2 1.071	20.25±0.25 .797±.010	6.2 .244
PC40EI50-Z	JIS FEI 50	50.0 $^{+1.2}_{-0.7}$ 1.969 $^{+.047}_{-.028}$	33.35±0.35 1.313±.014	14.6±0.4 .575±.016	14.6±0.4 .575±.016	33.5 1.319	24.75±0.25 .974±.010	7.7 .303
PC40EI60-Z	JIS FEI 60	60.0 $^{+1.4}_{-0.8}$ 2.362 $^{+.055}_{-.031}$	35.85±0.35 1.411±.014	15.6±0.4 .614±.016	15.6±0.4 .614±.016	43.6 1.717	27.85±0.35 1.096±.014	7.7 .303

* Please see the next page additionally.

Ferrite

For Switching Power Supplies
E Cores

EI Series

* Please see the former page additionally.

	Effective parameter				Electrical characteristics			Wt (g)	Bobbin item
l	C_1 (mm^{-1})	Ae (mm^2)	ℓe (mm)	Ve (mm^3)	A_L-value (nH/N^2)* Without air gap	With air gap	Core loss (W) max. 100kHz, 200mT, 100°C		
1.5±0.1 .059±.004	1.48	14.4	21.3	308	1200±25%	63±7% 100±10%	0.12	1.9	BE12.5-1110CPFR
2.0±0.2 .079±.008	1.75	19.8	34.6	685	1100±25%	80±7% 160±10%	0.31	3.3	BE16-116CPFR BE16-118CPHFR BE16-1110CPNFR
2.3±0.1 .091±.004	1.65	24.0	39.6	950	1400±25%	80±7% 160±10%	0.42	5.1	BE19-116CPFR BE19-118CPHFR BE-19-5116
4.5±0.2 .177±.008	0.936	42.0	39.3	1650	2400±25%	125±7% 250±10%	0.6	9.8	BE22-1110CPFR BE22-118CPFR BE-22-5116
4.0±0.2 .157±.008	1.13	37.0	41.8	1550	2000±25%	125±7% 250±10%	0.64	8.5	BE22/19/6-118CPFR
2.7±0.2 .106±.008	1.15	41.0	47.0	1930	2140±25%	125±7% 250±10%	0.79	9.8	BE25-118CPFR BE-25-5116
3.5±0.3 .138±.012	0.57	86.0	48.2	4150	4300±25%	200±5% 400±7%	1.65	22	BE28-1110CPLFR
5.5±0.2 .217±.008	0.522	111	58.0	6440	4690±25%	200±5% 400±7%	3.1	34	BE30-1110CPFR BE30-1112CPFR BE-30-5112
5.0±0.3 .197±.012	0.567	119	67.5	8030	4400±25%	200±5% 400±7%	3.5	41	BE33-1112CPLFR
4.6±0.3 .181±.012	0.664	101	67.1	6780	3800±25%	200±5% 400±7%	2.85	36	BE35-1112CPLFR
7.5±0.3 .295±.012	0.520	148	77.0	11400	4860±25%	200±5% 400±7%	4.8	60	BE40-1112CPFR BE40-1112CPNFR BE-40-5112
9.0±0.3 .354±.012	0.409	230	94.0	21620	6110±25%	250±5% 500±7%	9.2	115	BE50-1112CPFR BE-50-5112
8.5±0.3 .335±.012	0.441	247	109	26900	5670±25%	250±5% 500±7%	12.5	139	BE60-1112CPFR BE-60-5112

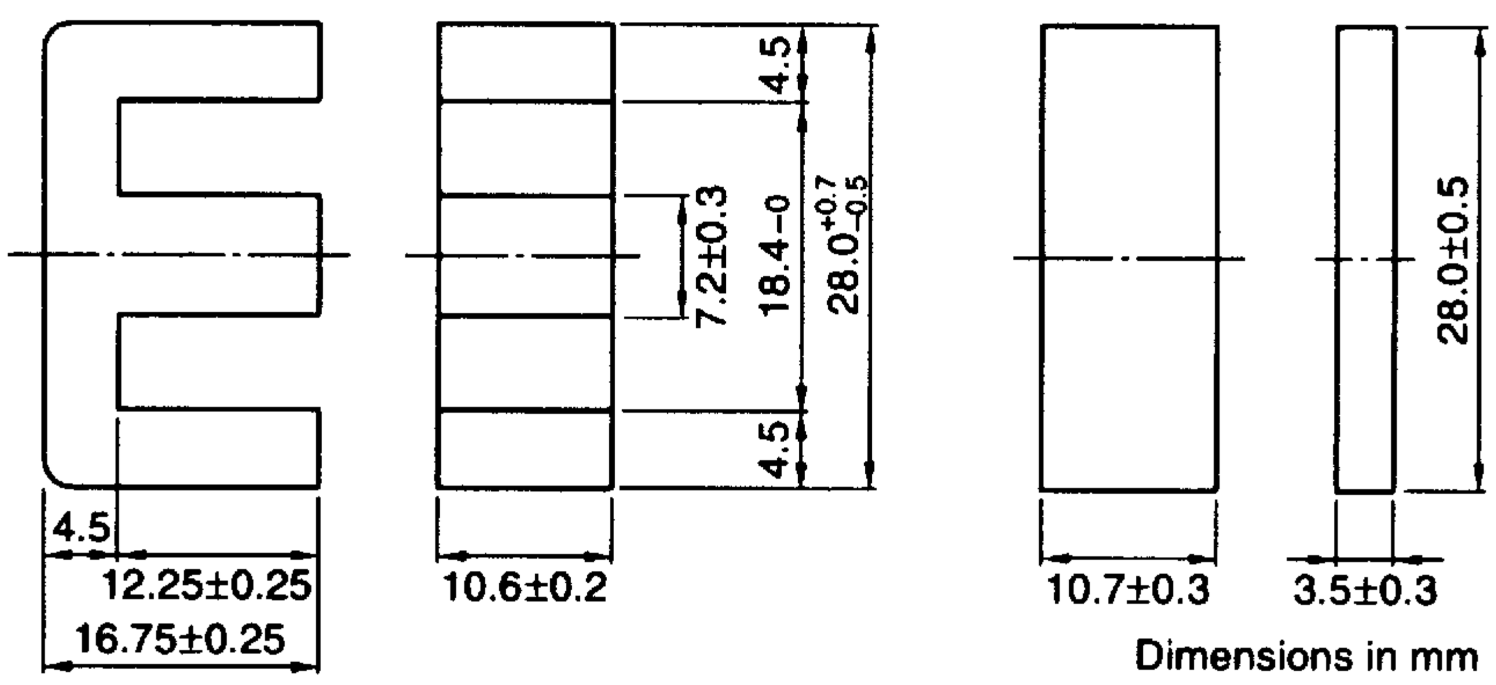
** A_L-value: 1kHz, 0.5mA, 100Ts*

Ferrite

For Switching Power Supplies Technical Data

EI Series EI28 Cores

JIS FEI 28



Dimensions in mm

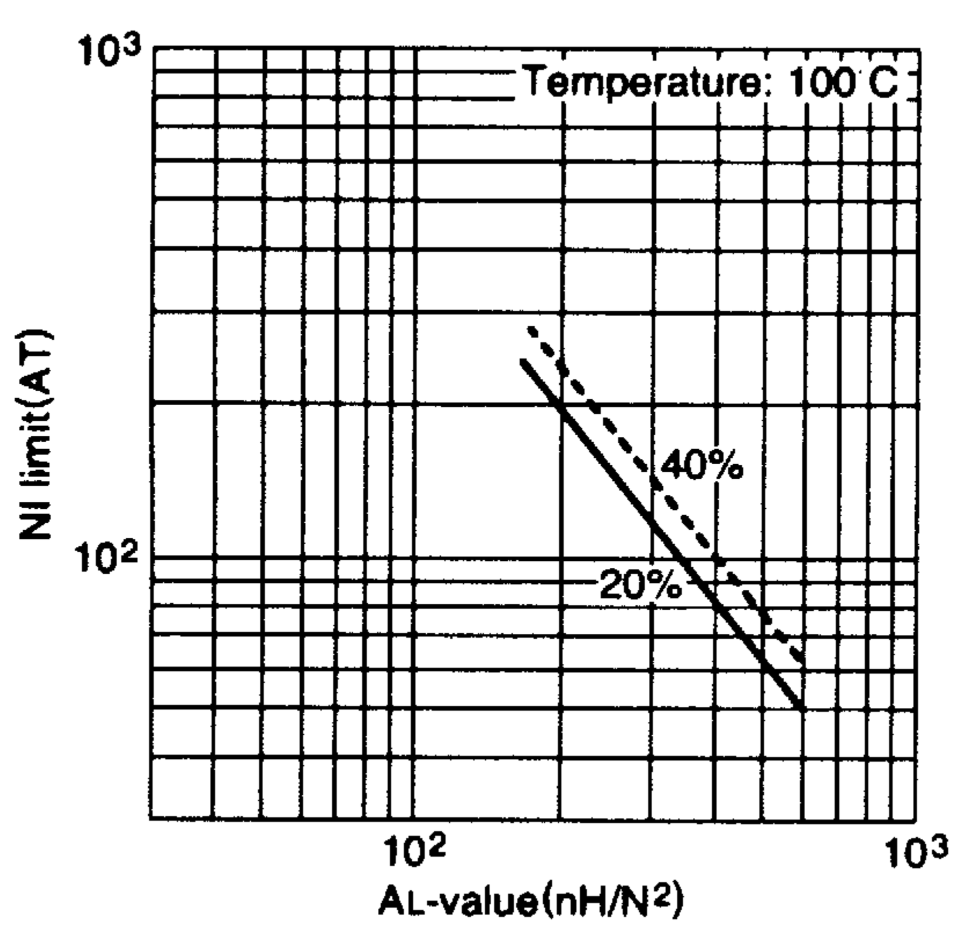
Parameter

Core factor	C1	mm^{-1}	0.560
Effective magnetic path length	ℓe	mm	48.2
Effective cross-sectional area	Ae	mm^2	86.0
Effective core volume	Ve	mm^3	4150
Cross-sectional center leg area	Acp	mm^2	76.3
Minimum cross-sectional area	Acp min.	mm^2	71.8
Cross-sectional winding area of core	Acw	mm^2	69.8
Weight (approx.)		g	22

Part No.	AL-value (nH/N^2)	Core loss (W) at 100°C 100kHz, 200mT	Calculated output power (forward converter mode)
PC40EI28-Z	4300±25% (1kHz, 0.5mA)* 6060 min. (100kHz, 200mT)	1.65 max.	107W (100kHz)

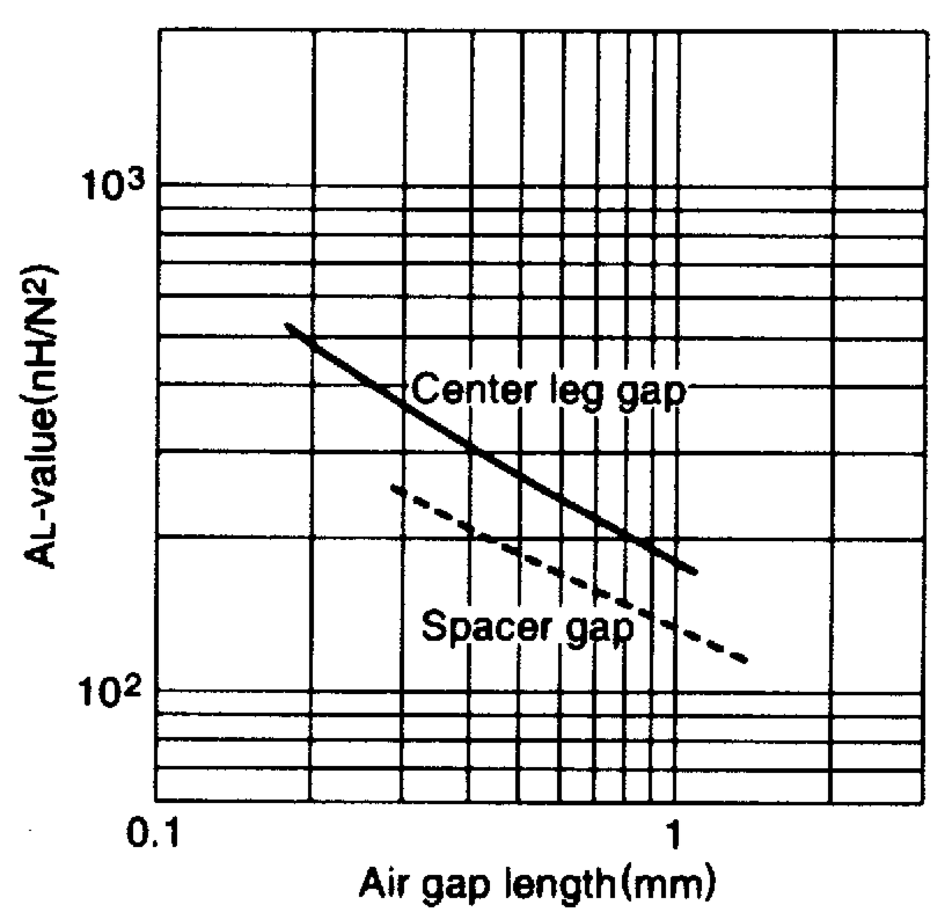
* *Coil: ø0.35 2UEW 100Ts*

NI limit vs. AL-value for PC40EI28 gapped core (Typical)



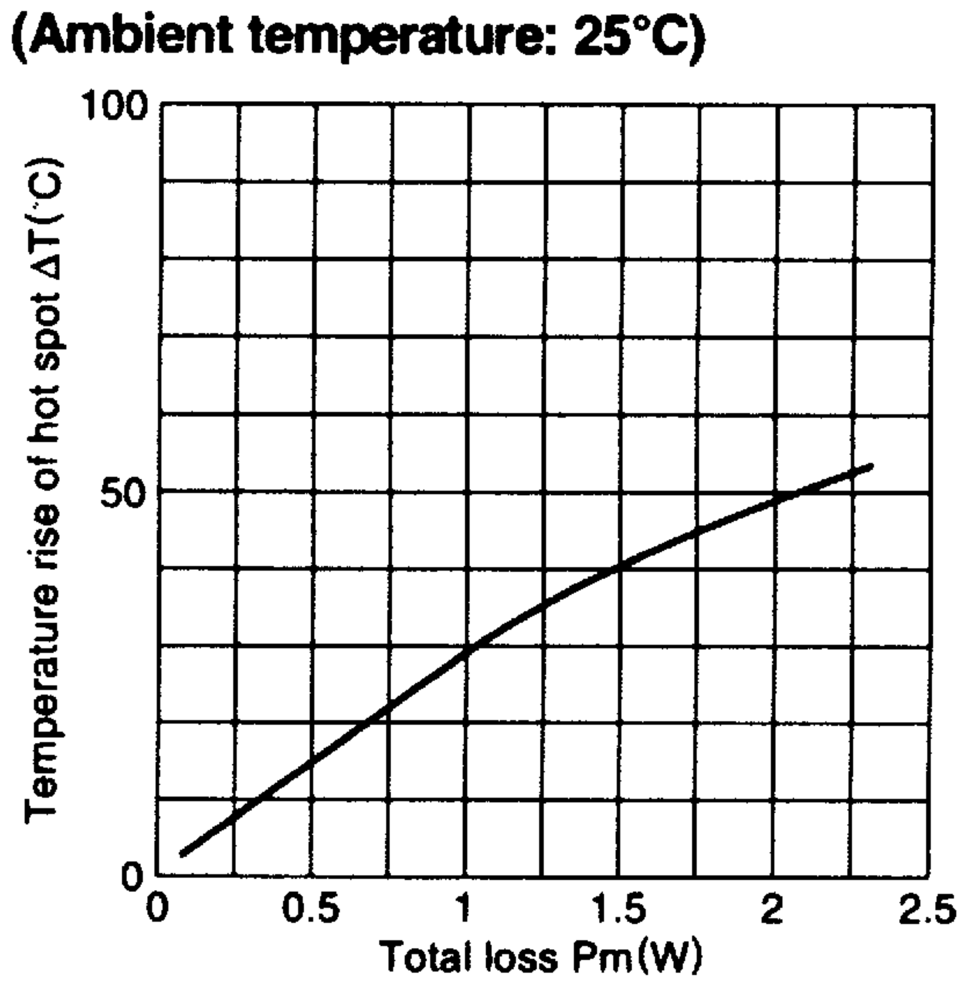
Note: NI limit shows the point where the exciting current is 20% and 40% away from its extended linear part.

AL-value vs. Air gap length for PC40EI28 core (Typical)



Measuring conditions • Coil: ø0.35 2UEW 100Ts
• Frequency: 1kHz
• Level: 0.5mA

Temperature rise vs. Total loss for EI28 core (Typical) (Ambient temperature: 25°C)



Note: The temperature rise is measured in the room whose temperature and humidity are fixed to 25°C and 45(%)RH. respectively. (approx. 400×300×300cm)