V_{RM} = 200 V, I_F = 5 A, 10 A, 15 A
Fast Recovery Diode Built-in Temperature Detection

FMKS Series

Data Sheet

Description

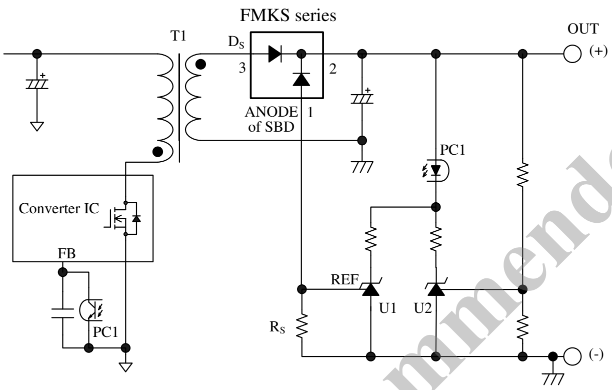
The FMKS Series is the fast recovery diode built-in temperature detection.

A fast recovery diode and a Schottky barrier diode for temperature detection are formed on the same die. Thus, the FMKS Series achieves highly accurate temperature detection that is higher than that with a thermistor, component reduction, power supply downsizing, and easy attachment.

Features

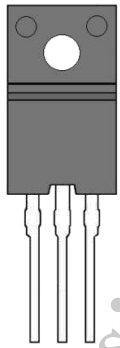
- Built-in temperature detection
- Highly accurate temperature detection of FRD
- Component reduction of temperature detection
- High speed switching
- Low forward voltage drop

Typical Application



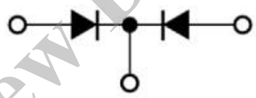
Package

TO220F-3L



(1)(2)(3)

Not to scale



(1) Anode of Schottky barrier diode, SBD, for temerature detection
(2) Cathode
(3) Anode of fast recovery diode, FRD

FMKS Series

Products	V_{RM}	I_F	V_F	t_{rr}
FMKS-2052	200 V	5 A	0.98 V	50 ns
FMKS-2102		10 A		
FMKS-2152		15 A		

where,
V_{RM} is peak reverse voltage,
I_F is average forward current,
V_F is forward voltage drop, and
t_{rr} is reverse recovery time

Application

The following with thermal protection circuit and peak power limiting circuit, and so forth

- Audio
- White goods
- Power Supplies

CONTENTS

1. Absolute Maximum Ratings

Unless specifically noted T_A = 25 °C.

Parameter	Symbol	Conditions	Rating	Unit	Note
Fast Recovery Diode (FRD)					
Transient Peak Reverse Voltage	V_{RSM}		200	V	
Peak Repetitive Reverse Voltage	V_{RM}		200	V	
Average Forward Current	$I_{F(AV)}$		5	A	FMKS-2052
			10		FMKS-2102
			15		FMKS-2152
Surge Forward Current	I_{FSM}	10 ms, half sine wave, one shot	100	A	FMKS-2052
			140		FMKS-2102
			170		FMKS-2152
I^2t Limiting Value	I^2t	1 ms ≤ t ≤10 ms	50	A^2s	FMKS-2052
			98		FMKS-2102
			144.5		FMKS-2152
Junction Temperature	T_j		−40 to 150	°C	
Storage Temperature	T_{stg}		−40 to 150	°C	
Isolation Voltage	–	Between the case and each pin, 1 minute, ac	1.0	kV	
Schottky Barrier Diode for Temperature Detection (SBD)					
Transient Peak Reverse Voltage	V_{RSM}		90	V	
Peak Repetitive Reverse Voltage	V_{RM}		90	V	
Junction Temperature	T_j		−40 to 150	°C	
Storage Temperature	T_{stg}		−40 to 150	°C	

2. Electrical Characteristics

Unless specifically noted $T_A = 25$ °C.

Parameter	Symbol	Conditions	Min.	Typ.	Max.	Unit	Note
Fast Recovery Diode (FRD)							
Forward Voltage Drop	V_F	$I_F = 5$ A	−	−	0.98	V	FMKS-2052
		$I_F = 10$ A	−	−	0.98		FMKS-2102
		$I_F = 15$ A	−	−	0.98		FMKS-2152
Reverse Leakage Current	I_R	$V_R = V_{RM}$	−	−	50	µA	FMKS-2052
			−	−	100		FMKS-2102
			−	−	150		FMKS-2152
Reverse Leakage Current Under High Temperature	$H \cdot I_R$	$V_R = V_{RM}$ $T_j = 150$ °C	−	−	3	mA	FMKS-2052
			−	−	6		FMKS-2102
			−	−	10		FMKS-2152
Reverse Recovery Time	t_{rr1}	$I_F = I_{RP} = 100$ mA, $T_j = 25$ °C, 90 % recovery point	−	−	50	ns	
	t_{rr2}	$I_F = 100$ mA, $I_{RP} = 200$ mA, $T_j = 25$ °C, 75 % recovery point	−	−	35	ns	
Thermal Resistance*	$R_{th(j\text{-}C)}$		−	−	4.0	°C/W	
Schottky Barrier Diode for Temperature Detection Diode (SBD)							
Reverse Leakage Current	I_{R1}	$V_R = 15$V	−	−	50	µA	
	I_{R2}	$V_R = 90$V	−	−	2.0	mA	
Reverse Leakage Current Under High Temperature	$H \cdot I_{R1}$	$V_R = 15$V, $T_j = 130$ °C	1.20	1.90	2.60	mA	
	$H \cdot I_{R2}$	$V_R = 90$V, $T_j = 150$ °C	−	−	55	mA	

* $R_{th(j\text{-}C)}$ is thermal resistance between junction and case.

3. Performance Curves

3.1 Schottky Barrier Diode for Temperature Detection Diode Characteristics

In Figure 3-1, the reverse voltage of Schottky Barrier Diode for temperature detection (SBD), V_R, is 15V.
The temperature of fast recovery diode (FRD) can be estimated by using Figure 3-1.

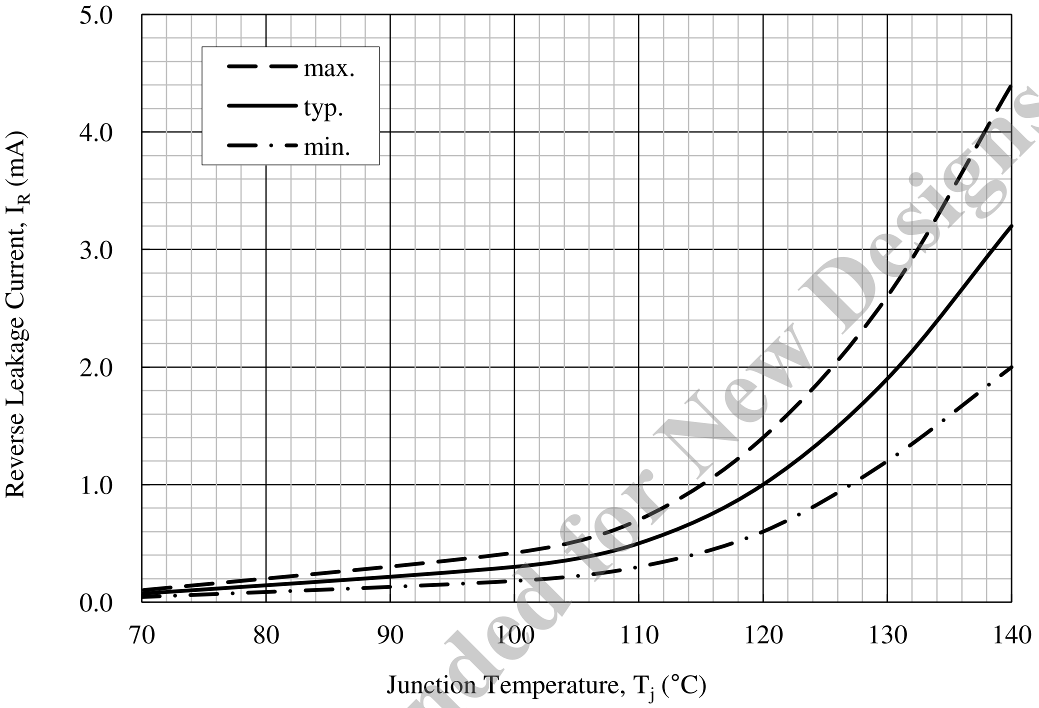


Figure 3-1 Temperature dependent of Reverse Leakage Current, I_R (SBD)

3.2 Fast Recovery Diode Characteristics

T is a pulse cycle, t is a pulse width.

3.2.1 FMKS-2052

3.2.1.1. Typical Characteristics

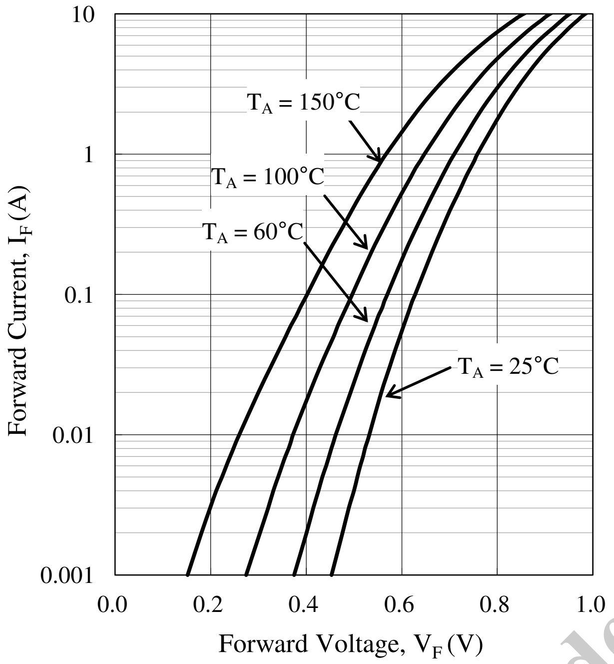


Figure 3-2 I_F − V_F Typical Characteristics

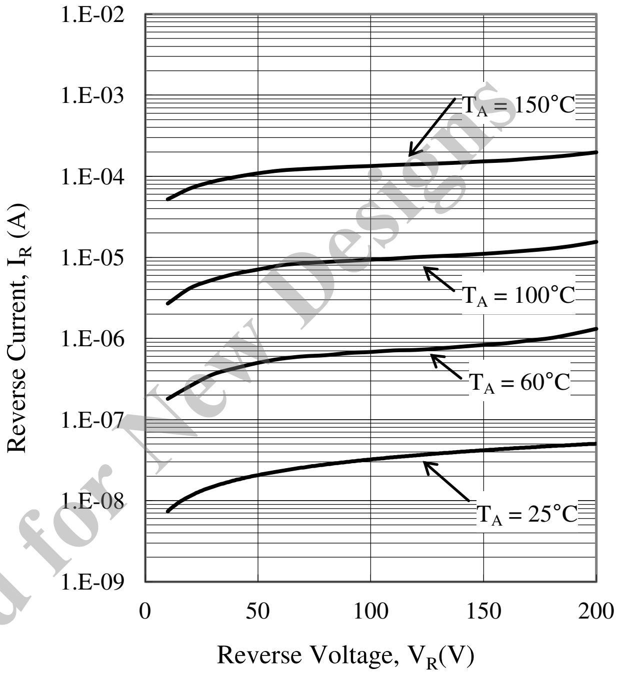


Figure 3-3 I_R − V_R Typical Characteristics

3.2.1.2. Power Dissipation Curves (T_j = 150 °C)

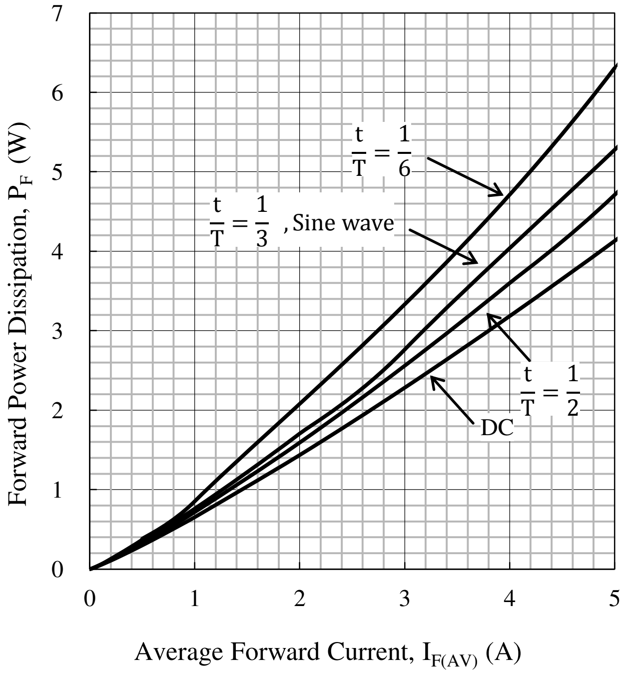


Figure 3-4 P_F − $I_{F(AV)}$

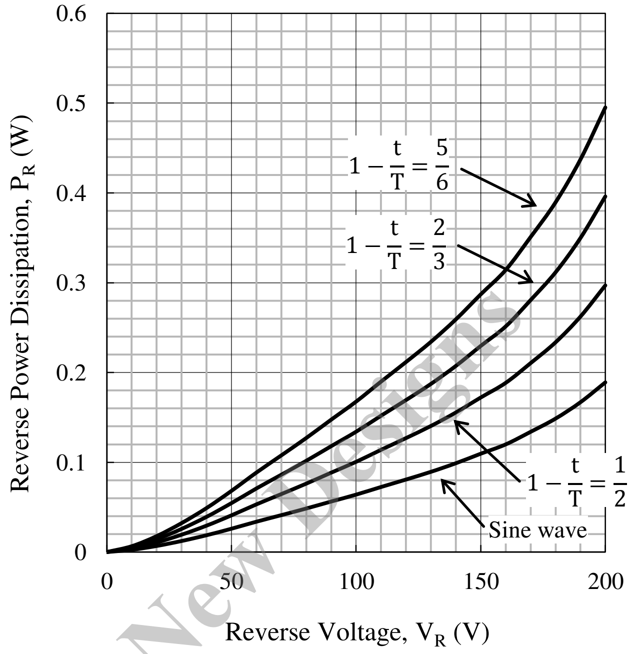


Figure 3-5 P_R − V_R

3.2.1.3. Derating Curves (T_j = 150 °C)

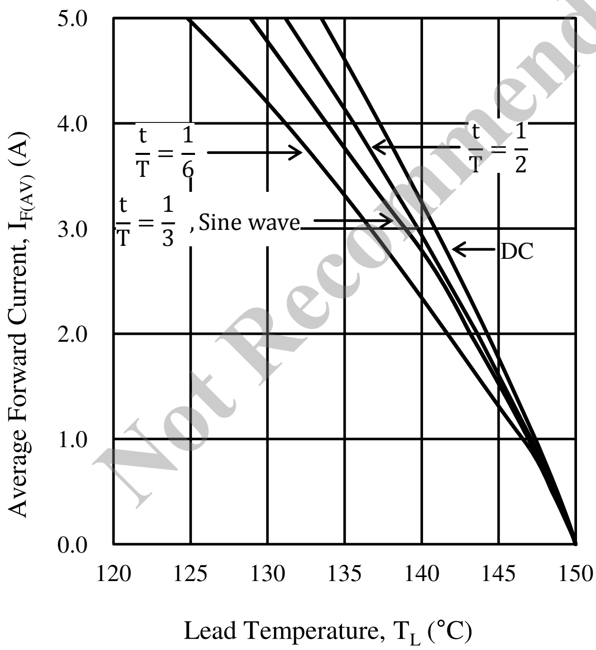


Figure 3-6 $I_{F(AV)}$ − T_L (V_R = 0 V)

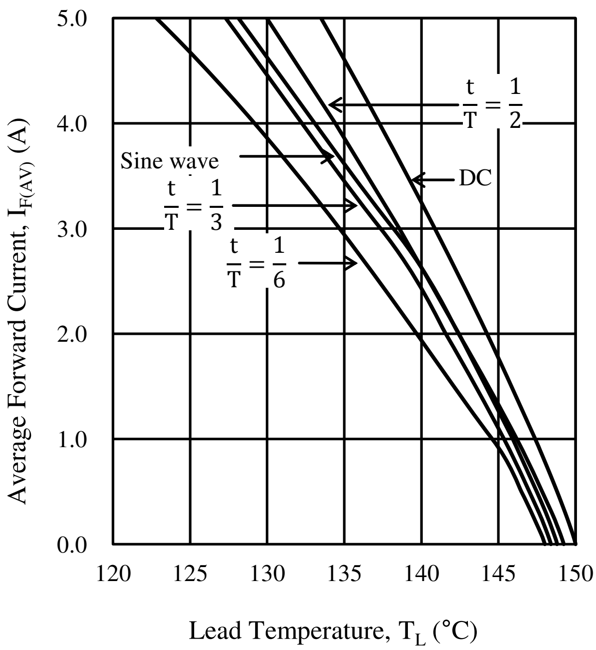


Figure 3-7 $I_{F(AV)}$ − T_L (V_R = 200 V)

3.2.2 FMKS-2102

3.2.2.1. Typical Characteristics

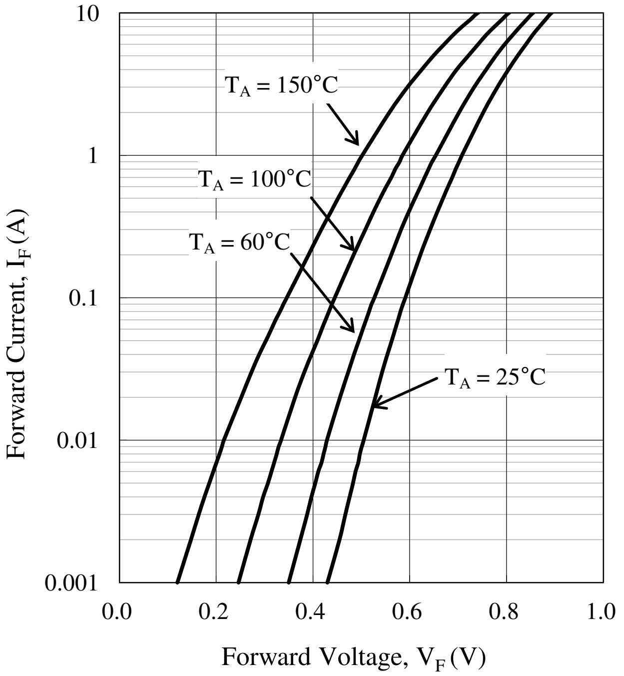


Figure 3-8 $V_F - I_F$ Typical Characteristics

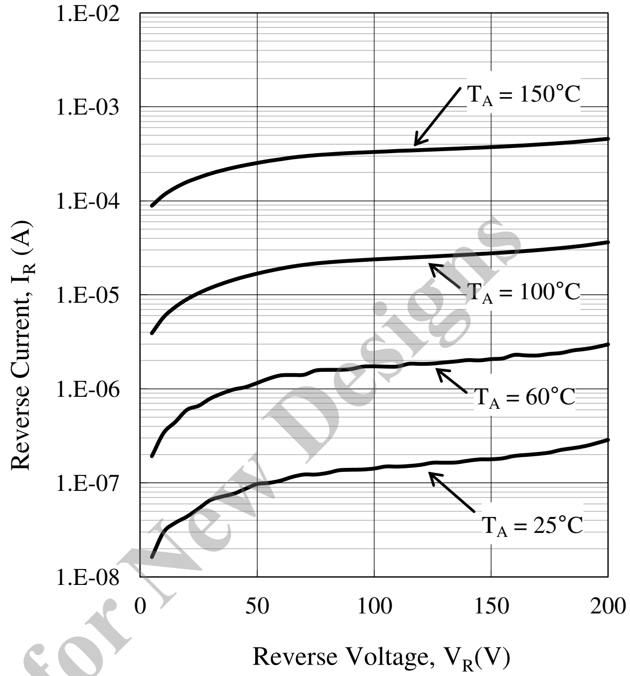


Figure 3-9 $V_R - I_R$ Typical Characteristics

3.2.2.2. Power Dissipation Curves (T_j = 150 °C)

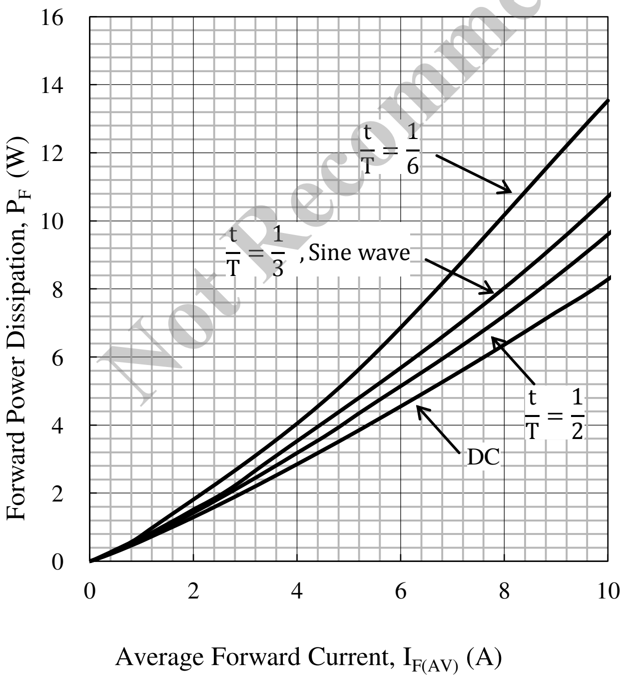


Figure 3-10 $P_F - I_{F(AV)}$

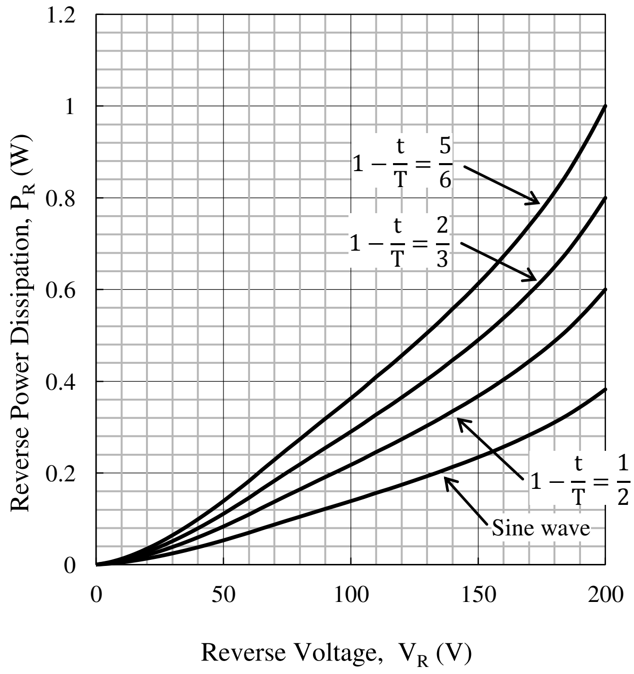


Figure 3-11 $P_R - V_R$

3.2.2.3. Derating Curves (T_j = 150 °C)

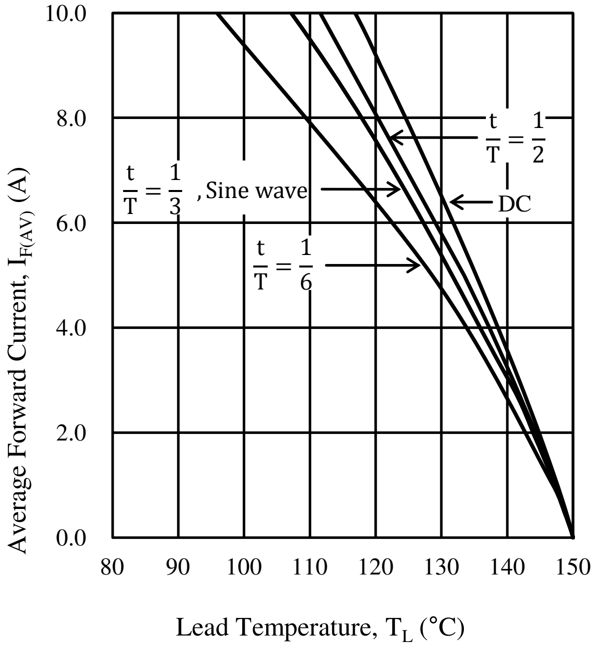


Figure 3-12 $I_{F(AV)}$ — T_L (V_R = 0 V)

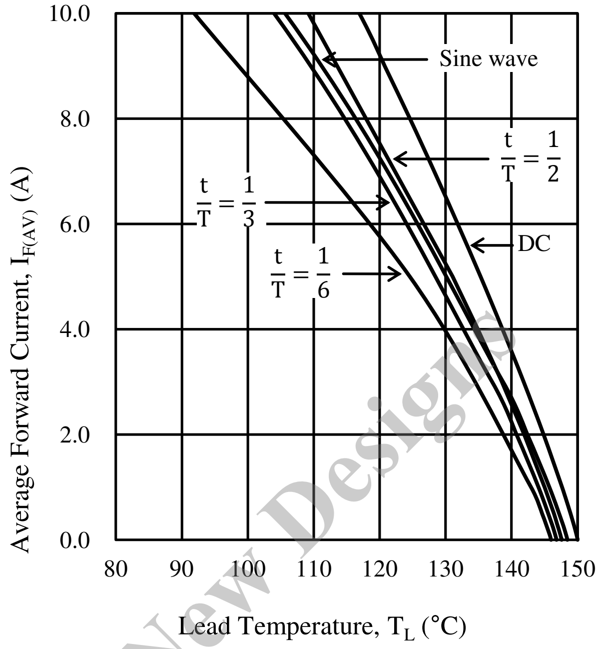


Figure 3-13 $I_{F(AV)}$ — T_L (V_R = 200 V)

3.2.3 FMKS-2152

3.2.3.1. Typical Characteristics

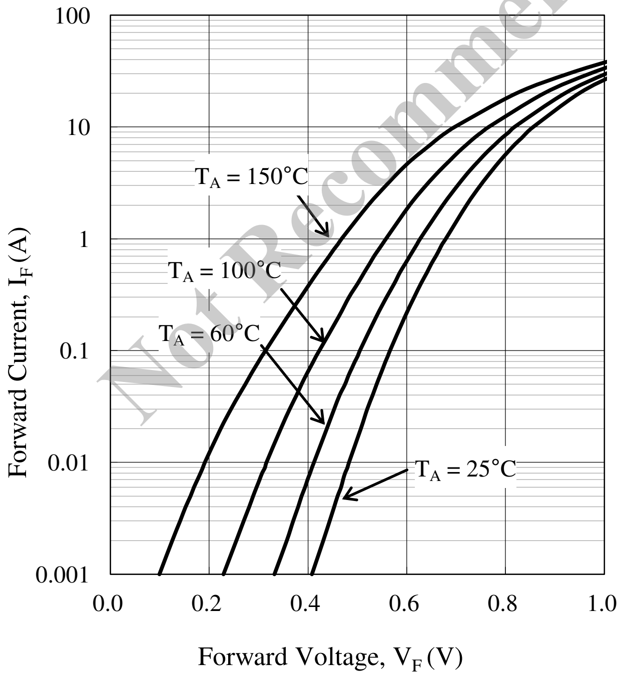


Figure 3-14 V_F — I_F Typical Characteristics

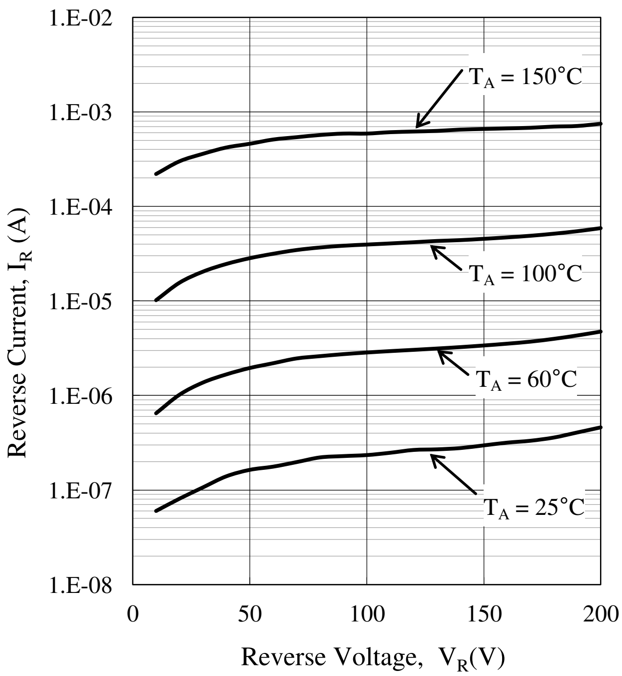


Figure 3-15 V_R — I_R Typical Characteristics

3.2.3.2. Power Dissipation Curves (T_j = 150 °C)

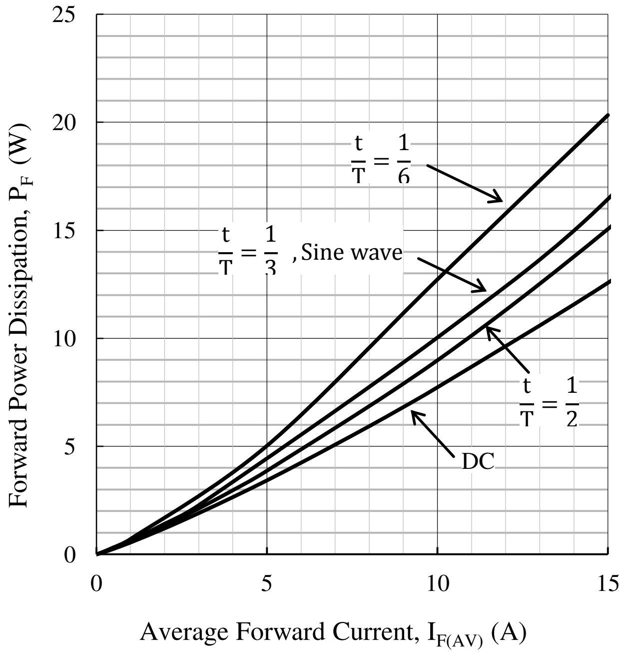


Figure 3-16 $P_F - I_{F(AV)}$

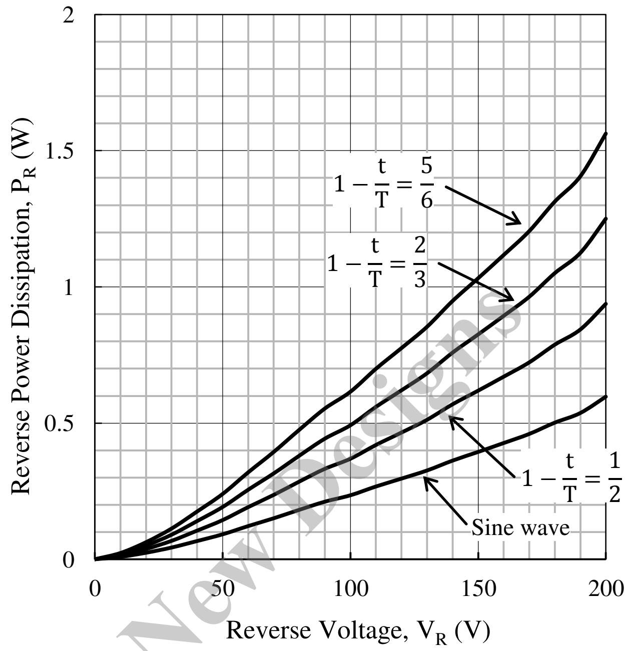


Figure 3-17 $P_R - V_R$

3.2.3.3. Derating Curves (T_j = 150 °C)

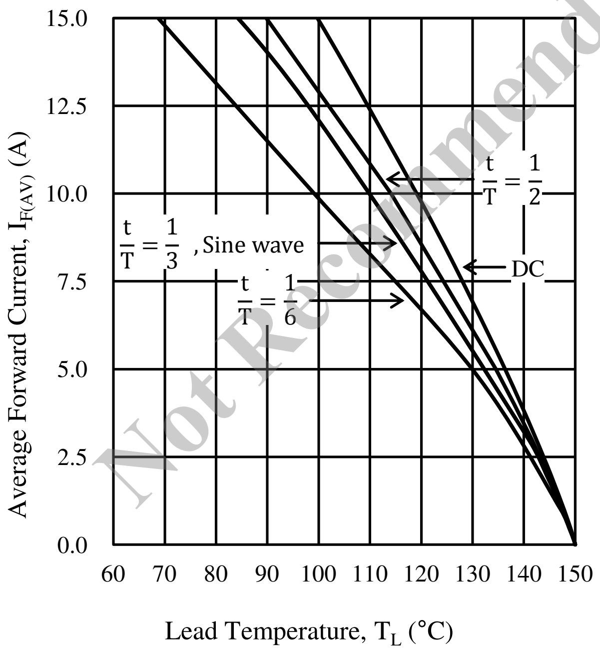


Figure 3-18 $I_{F(AV)} - T_L$ (V_R = 0 V)

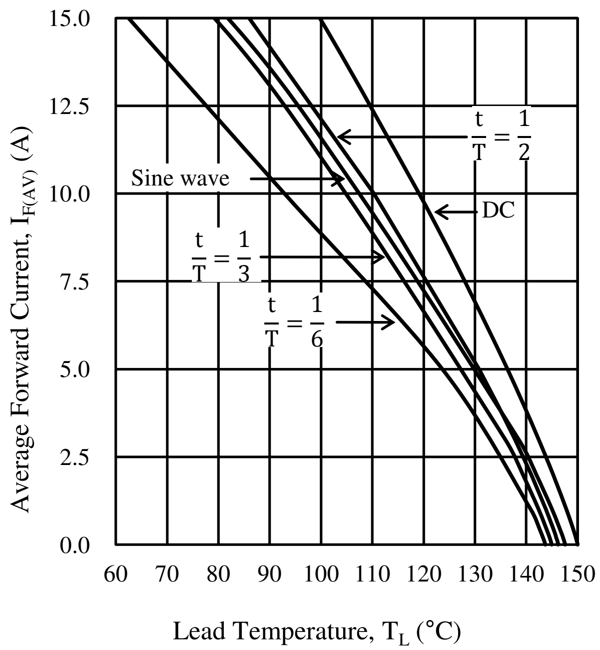
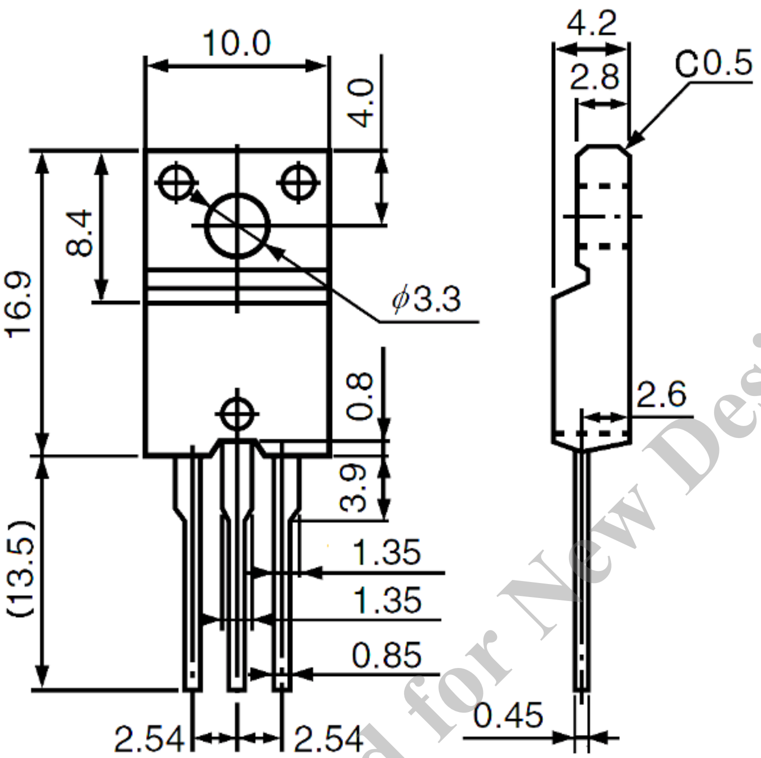


Figure 3-19 $I_{F(AV)} - T_L$ (V_R = 200 V)

4. External Dimensions

TO220F-3L



NOTES:

- Dimension is in millimeters.
- Lead treatment Pb-free. Device composition compliant with the RoHS directive.

5. Marking Diagram

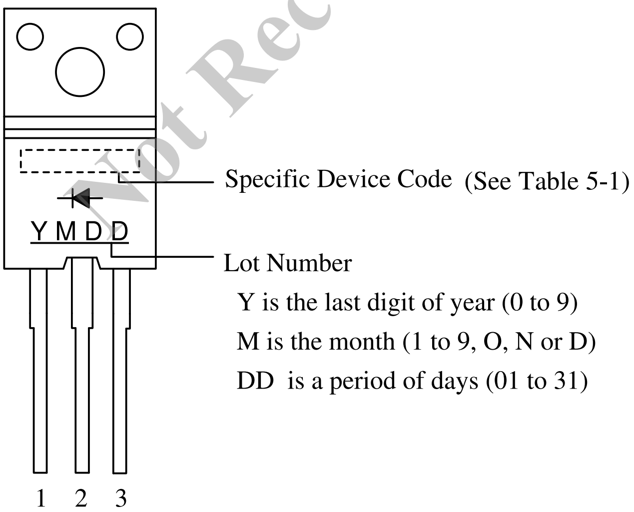


Table 5-1 Specific Device Code

Specific Device Code	Products
KS2052	FMKS-2052
KS2102	FMKS-2102
KS2152	FMKS-2152

6. Temperature Detection Application of FMKS Series

This section shows an example about a temperature detection circuit of a secondary rectifier diode in off-line flyback converters.

Figure 6-1 shows the reference of temperature detection circuit with a NTC thermistor. The NTC thermistor, coupled thermally with D_S secondary rectifier diode, is connected to the REF pin of the output voltage detection circuit in the converter.

As shown in Figure 6-2, as the temperature rises, the resistance of the NTC thermistor decreases.

When the temperature of D_S rises due to such a cause as overload state, the resistance of NTC thermistor decreases, and the ratio of resistance voltage divider is changed. When the voltage of R_S shown in Figure 6-1 reaches the reference voltage of U1 shunt regulator, the current flows to PC1 optocoupler, and the converter IC in the primary limits the output power. Thus, the rise of D_S temperature can be limited.

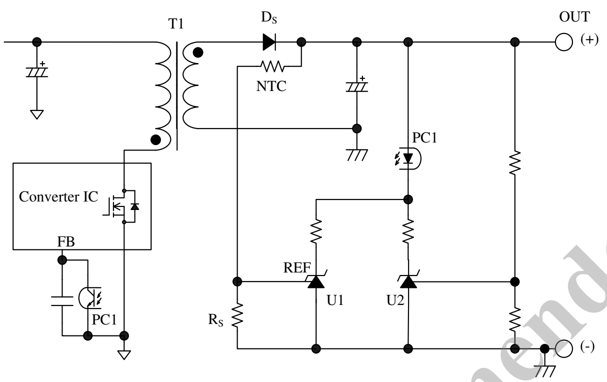


Figure 6-1 Reference temperature detection circuit with NTC thermistor

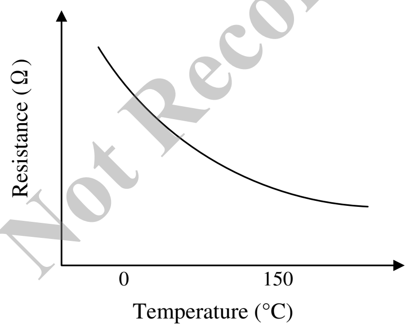


Figure 6-2 Reference characteristics of NTC thermistor

The temperature detection circuit with thermistor has the following issues.

- Since some attachment distance occurs between the thermistor and D_S, the accurate temperature of D_S cannot be detected.
- Thermistor cannot follow the rapid temperature change.
- Increasing the accuracy of temperature detection by reducing the thermal resistance between D_S and the thermistor, it is necessary to attach the thermistor to D_S with high thermal conuctivity material between them.

In contrast with the temperature detection of thermistor, the FMKS series can achieve high accuracy of temperature detection by the following.

- The internal structure is formed a Schottky barrier diode for temperature detection, SBD, and a fast recovery diode, FRD, on the same die as shown in Figure 6-3. Thus, the temperature is about the same between SBD and FRD.
- The temperature detection uses the temperature characteristics of the leakage current for SBD, which increases as the temperature rises as shown in Figure 6-4.

The temperature detection circuit with FMKS series has the following advantages.

- Highly accurate and stable temperature detection of FRD.
- Real time temperature detection of FRD.
- Circuit component reduction such as thermistor, and easy attachment.
- Power supply downsizing.

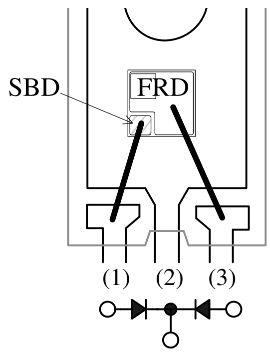


Figure 6-3 Internal structure of FMKS series

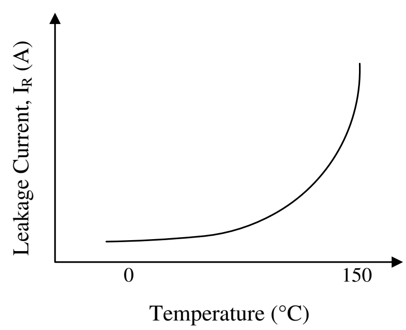


Figure 6-4 Reference temperature characteristics of SBD leakage current

Figure 6-5 shows the reference of temperature detection circuit with FMKS series. The ANODE pin of SBD for the temperature detection in D_S secondary rectifier diode is connected to the REF pin of the shunt regulator of the output voltage detection circuit in the converter.

When the temperature of D_S rises due to such a cause as overload state, the leakage current, I_R, of SBD for temperature detection increases, and the voltage of R_S shown in Figure 6-5 increases. When R_S voltage reaches the reference voltage of U1 shunt regulator, the current flows to PC1 optocoupler, and the converter IC in the primary limits the output power. Thus, the rise of D_S temperature can be limited.

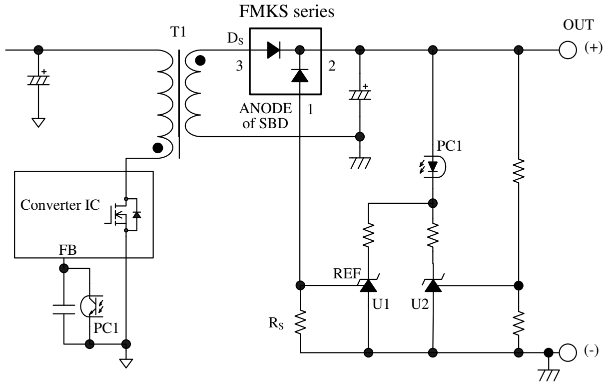


Figure 6-5 Reference temperature detection circuit with FMKS series.

In Figure 6-5, R_S value is calculated as follows.

$$R_S = \frac{V_{REF}}{I_{R(TD)MAX}}$$

where,
V_{REF} is the reference voltage of U1 shunt regulator,
$I_{R(TD)MAX}$ is the maximum leakage current of SBD at the temperature detection value of T_D in Figure 6-6 or Section 3.1.

When T_D is 115 °C, $I_{R(TD)MAX}$ is 1 mA as shown Figure 6-6. Thus, when V_{REF} is 2.5 V, R_S value is 2.5 kΩ, and thus the FMKS series can detect in the range of 115 °C to 127 °C.

When R_S value is chosen 2.7 kΩ from E24 series close to the above value, $I_{R(TD)MAX}$ is 0.93 mA, and thus the temperature detection range is 114 °C to 126 °C.

When the junction temperature of SBD rises close to 150 °C, the leakage current of SBD increases rapidly and the power dissipation increases. Thus, R_S should be set so that the temperature is detected in 140 °C or less including variation.

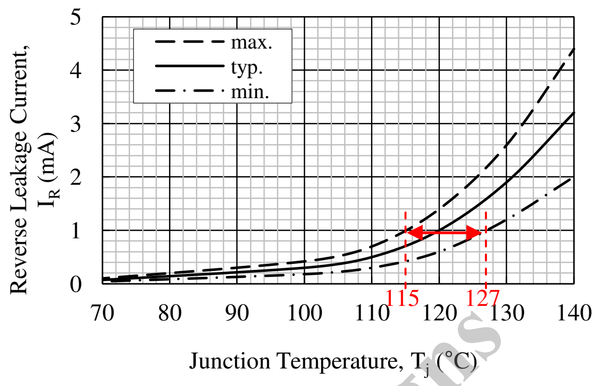


Figure 6-6 Temperature detection range at I_R= 1.0mA

Figure 6-7 shows the reference circuit for multi-outputs with FMKS series in off-line flyback converter.

In the case that FMKS series and the synchronous rectification device, Q_{SYN}, for the other output are attached on the same heatsink so that the temperature from Q_{SYN} is conducted to FMKS series, the FMKS series can detect the temperature in the following.

- The overload state of Q_{SYN}.
- The rectification state by the rectifier diode in Q_{SYN} because the synchronous rectification IC malfunctions and thus Q_{SYN} is kept off.

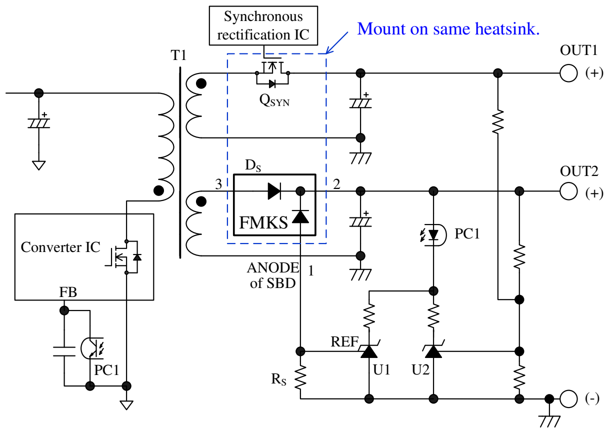


Figure 6-7 Reference circuit with FMKS series in the multi-output flyback converter circuit

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