



Is Now Part of



**ON Semiconductor®**

To learn more about ON Semiconductor, please visit our website at  
[www.onsemi.com](http://www.onsemi.com)

Please note: As part of the Fairchild Semiconductor integration, some of the Fairchild orderable part numbers will need to change in order to meet ON Semiconductor's system requirements. Since the ON Semiconductor product management systems do not have the ability to manage part nomenclature that utilizes an underscore (\_), the underscore (\_) in the Fairchild part numbers will be changed to a dash (-). This document may contain device numbers with an underscore (\_). Please check the ON Semiconductor website to verify the updated device numbers. The most current and up-to-date ordering information can be found at [www.onsemi.com](http://www.onsemi.com). Please email any questions regarding the system integration to [Fairchild\\_questions@onsemi.com](mailto:Fairchild_questions@onsemi.com).

ON Semiconductor and the ON Semiconductor logo are trademarks of Semiconductor Components Industries, LLC dba ON Semiconductor or its subsidiaries in the United States and/or other countries. ON Semiconductor owns the rights to a number of patents, trademarks, copyrights, trade secrets, and other intellectual property. A listing of ON Semiconductor's product/patent coverage may be accessed at [www.onsemi.com/site/pdf/Patent-Marking.pdf](http://www.onsemi.com/site/pdf/Patent-Marking.pdf). ON Semiconductor reserves the right to make changes without further notice to any products herein. ON Semiconductor makes no warranty, representation or guarantee regarding the suitability of its products for any particular purpose, nor does ON Semiconductor assume any liability arising out of the application or use of any product or circuit, and specifically disclaims any and all liability, including without limitation special, consequential or incidental damages. Buyer is responsible for its products and applications using ON Semiconductor products, including compliance with all laws, regulations and safety requirements or standards, regardless of any support or applications information provided by ON Semiconductor. "Typical" parameters which may be provided in ON Semiconductor data sheets and/or specifications can and do vary in different applications and actual performance may vary over time. All operating parameters, including "Typicals" must be validated for each customer application by customer's technical experts. ON Semiconductor does not convey any license under its patent rights nor the rights of others. ON Semiconductor products are not designed, intended, or authorized for use as a critical component in life support systems or any FDA Class 3 medical devices or medical devices with a same or similar classification in a foreign jurisdiction or any devices intended for implantation in the human body. Should Buyer purchase or use ON Semiconductor products for any such unintended or unauthorized application, Buyer shall indemnify and hold ON Semiconductor and its officers, employees, subsidiaries, affiliates, and distributors harmless against all claims, costs, damages, and expenses, and reasonable attorney fees arising out of, directly or indirectly, any claim of personal injury or death associated with such unintended or unauthorized use, even if such claim alleges that ON Semiconductor was negligent regarding the design or manufacture of the part. ON Semiconductor is an Equal Opportunity/Affirmative Action Employer. This literature is subject to all applicable copyright laws and is not for resale in any manner.

# FGAF40N60UFD

## Ultrafast IGBT

### General Description

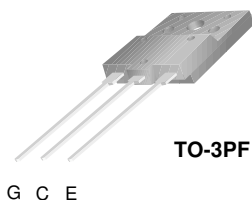
Fairchild's UFD series of Insulated Gate Bipolar Transistors (IGBTs) provides low conduction and switching losses. The UFD series is designed for applications such as motor control and general inverters where high speed switching is a required feature.

### Features

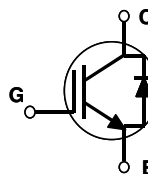
- High speed switching
- Low saturation voltage :  $V_{CE(sat)} = 2.3 \text{ V @ } I_C = 20\text{A}$
- High input impedance
- CO-PAK, IGBT with FRD :  $t_{rr} = 50\text{ns (typ.)}$

### Applications

AC & DC motor controls, general purpose inverters, robotics, and servo controls.



TO-3PF



### Absolute Maximum Ratings $T_C = 25^\circ\text{C}$ unless otherwise noted

Symbol	Description	FGAF40N60UFD	Units
$V_{CES}$	Collector-Emitter Voltage	600	V
$V_{GES}$	Gate-Emitter Voltage	$\pm 20$	V
$I_C$	Collector Current @ $T_C = 25^\circ\text{C}$	40	A
	Collector Current @ $T_C = 100^\circ\text{C}$	20	A
$I_{CM(1)}$	Pulsed Collector Current	160	A
$I_F$	Diode Continuous Forward Current @ $T_C = 100^\circ\text{C}$	15	A
$I_{FM}$	Diode Maximum Forward Current	160	A
$P_D$	Maximum Power Dissipation @ $T_C = 25^\circ\text{C}$	100	W
	Maximum Power Dissipation @ $T_C = 100^\circ\text{C}$	40	W
$T_J$	Operating Junction Temperature	-55 to +150	$^\circ\text{C}$
$T_{stg}$	Storage Temperature Range	-55 to +150	$^\circ\text{C}$
$T_L$	Maximum Lead Temp. for Soldering Purposes, 1/8" from Case for 5 Seconds	300	$^\circ\text{C}$

**Notes :**

(1) Repetitive rating : Pulse width limited by max. junction temperature

### Thermal Characteristics

Symbol	Parameter	Typ.	Max.	Units
$R_{\theta JC}$ (IGBT)	Thermal Resistance, Junction-to-Case	--	1.2	$^\circ\text{C/W}$
$R_{\theta JC}$ (DIODE)	Thermal Resistance, Junction-to-Case	--	2.6	$^\circ\text{C/W}$
$R_{\theta JA}$	Thermal Resistance, Junction-to-Ambient	--	40	$^\circ\text{C/W}$

### Electrical Characteristics of the IGBT T<sub>C</sub> = 25°C unless otherwise noted

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Units
<b>Off Characteristics</b>						
BV <sub>CES</sub>	Collector-Emitter Breakdown Voltage	V <sub>GE</sub> = 0V, I <sub>C</sub> = 250uA	600	--	--	V
ΔBV <sub>CES</sub> /ΔT <sub>J</sub>	Temperature Coefficient of Breakdown Voltage	V <sub>GE</sub> = 0V, I <sub>C</sub> = 1mA	--	0.6	--	V/°C
I <sub>CES</sub>	Collector Cut-Off Current	V <sub>CE</sub> = V <sub>CES</sub> , V <sub>GE</sub> = 0V	--	--	250	uA
I <sub>GES</sub>	G-E Leakage Current	V <sub>GE</sub> = V <sub>GES</sub> , V <sub>CE</sub> = 0V	--	--	± 100	nA

### On Characteristics

V <sub>GE(th)</sub>	G-E Threshold Voltage	I <sub>C</sub> = 20mA, V <sub>CE</sub> = V <sub>GE</sub>	3.5	5.1	6.5	V
V <sub>CE(sat)</sub>	Collector to Emitter Saturation Voltage	I <sub>C</sub> = 20A, V <sub>GE</sub> = 15V	--	2.3	3.0	V
		I <sub>C</sub> = 40A, V <sub>GE</sub> = 15V	--	3.1	--	V

### Dynamic Characteristics

C <sub>ies</sub>	Input Capacitance	V <sub>CE</sub> = 30V, V <sub>GE</sub> = 0V, f = 1MHz	--	1075	--	pF
C <sub>oes</sub>	Output Capacitance		--	170	--	pF
C <sub>res</sub>	Reverse Transfer Capacitance		--	50	--	pF

### Switching Characteristics

t <sub>d(on)</sub>	Turn-On Delay Time	V <sub>CC</sub> = 300 V, I <sub>C</sub> = 20A, R <sub>G</sub> = 10Ω, V <sub>GE</sub> = 15V, Inductive Load, T <sub>C</sub> = 25°C	--	15	--	ns
t <sub>r</sub>	Rise Time		--	30	--	ns
t <sub>d(off)</sub>	Turn-Off Delay Time		--	65	130	ns
t <sub>f</sub>	Fall Time		--	35	100	ns
E <sub>on</sub>	Turn-On Switching Loss		--	470	--	uJ
E <sub>off</sub>	Turn-Off Switching Loss		--	130	--	uJ
E <sub>ts</sub>	Total Switching Loss	--	600	1000	uJ	
t <sub>d(on)</sub>	Turn-On Delay Time	V <sub>CC</sub> = 300 V, I <sub>C</sub> = 20A, R <sub>G</sub> = 10Ω, V <sub>GE</sub> = 15V, Inductive Load, T <sub>C</sub> = 125°C	--	30	--	ns
t <sub>r</sub>	Rise Time		--	37	--	ns
t <sub>d(off)</sub>	Turn-Off Delay Time		--	110	200	ns
t <sub>f</sub>	Fall Time		--	80	250	ns
E <sub>on</sub>	Turn-On Switching Loss		--	500	--	uJ
E <sub>off</sub>	Turn-Off Switching Loss		--	310	--	uJ
E <sub>ts</sub>	Total Switching Loss	--	810	1200	uJ	
Q <sub>g</sub>	Total Gate Charge	V <sub>CE</sub> = 300 V, I <sub>C</sub> = 20A, V <sub>GE</sub> = 15V	--	77	150	nC
Q <sub>ge</sub>	Gate-Emitter Charge		--	20	30	nC
Q <sub>gc</sub>	Gate-Collector Charge		--	25	40	nC
L <sub>e</sub>	Internal Emitter Inductance	Measured 5mm from PKG	--	14	--	nH

### Electrical Characteristics of DIODE T<sub>C</sub> = 25°C unless otherwise noted

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Units	
V <sub>FM</sub>	Diode Forward Voltage	I <sub>F</sub> = 15A	T <sub>C</sub> = 25°C	--	1.4	1.7	V
			T <sub>C</sub> = 100°C	--	1.3	--	
t <sub>rr</sub>	Diode Reverse Recovery Time	I <sub>F</sub> = 15A, di/dt = 200A/us	T <sub>C</sub> = 25°C	--	50	95	ns
			T <sub>C</sub> = 100°C	--	74	--	
I <sub>rr</sub>	Diode Peak Reverse Recovery Current	I <sub>F</sub> = 15A, di/dt = 200A/us	T <sub>C</sub> = 25°C	--	4.5	6.0	A
			T <sub>C</sub> = 100°C	--	6.5	--	
Q <sub>rr</sub>	Diode Reverse Recovery Charge	I <sub>F</sub> = 15A, di/dt = 200A/us	T <sub>C</sub> = 25°C	--	80	180	nC
			T <sub>C</sub> = 100°C	--	220	--	

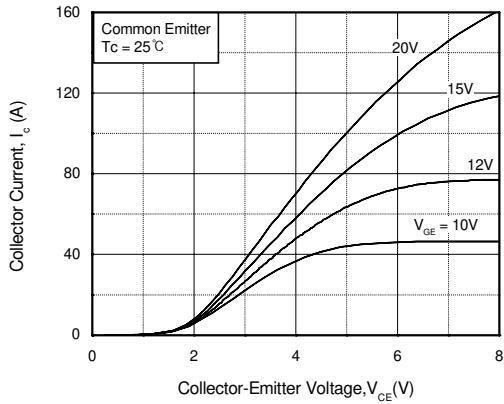


Fig 1. Typical Output Characteristics

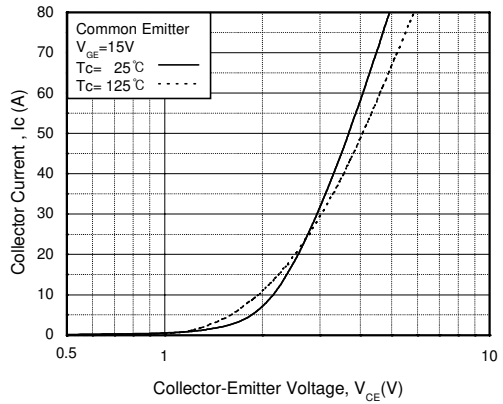


Fig 2. Typical Saturation Voltage Characteristics

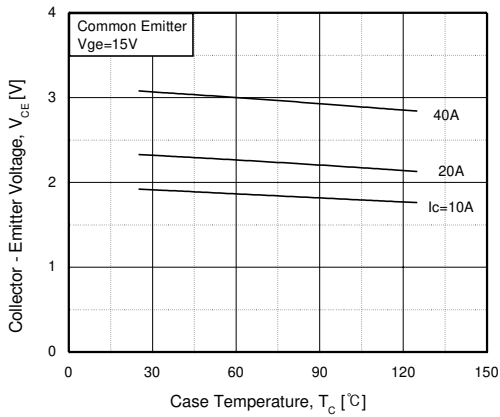


Fig 3. Saturation Voltage vs. Case Temperature at Variant Current Level

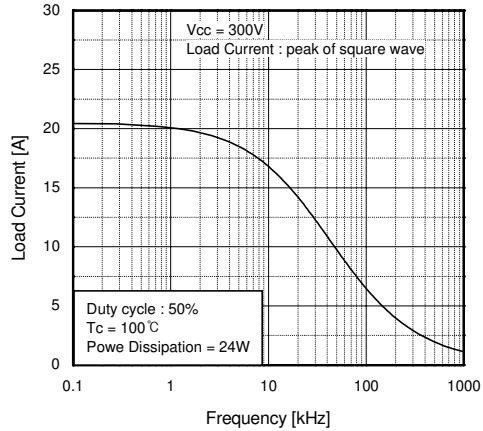


Fig 4. Load Current vs. Frequency

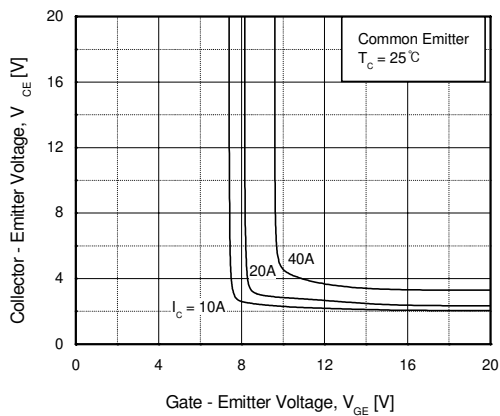


Fig 5. Saturation Voltage vs.  $V_{GE}$

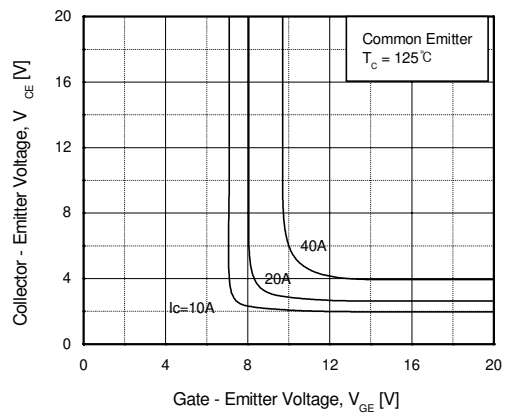
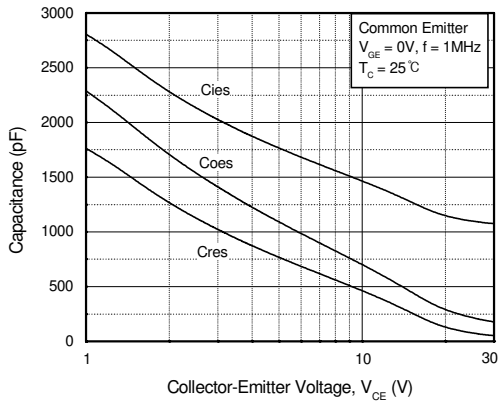
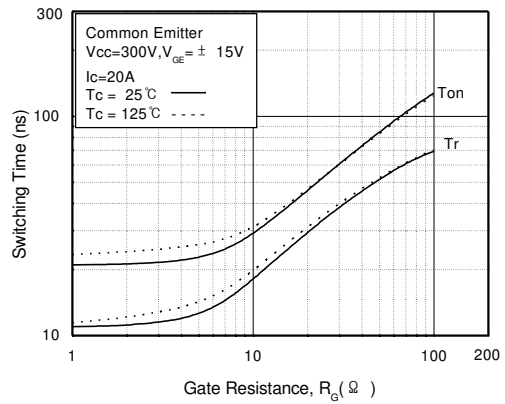


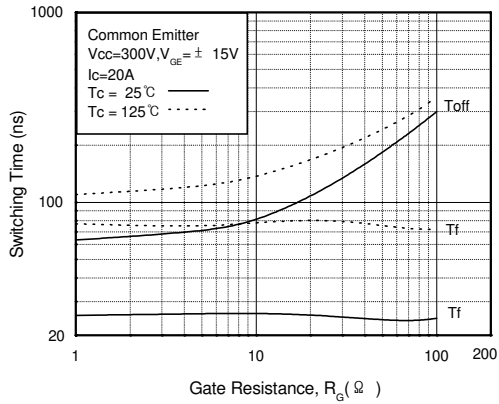
Fig 6. Saturation Voltage vs.  $V_{GE}$



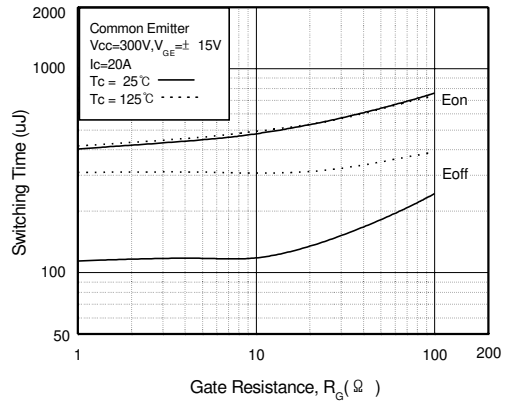
**Fig 7. Capacitance Characteristics**



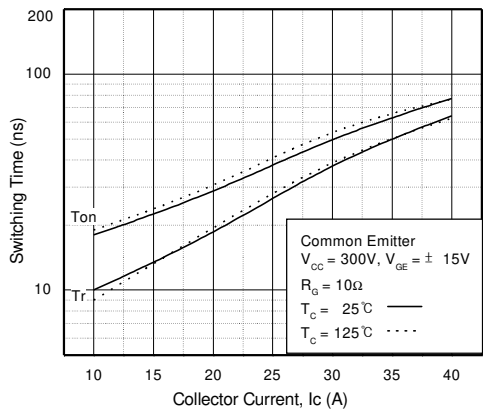
**Fig 8. Turn-On Characteristics vs. Gate Resistance**



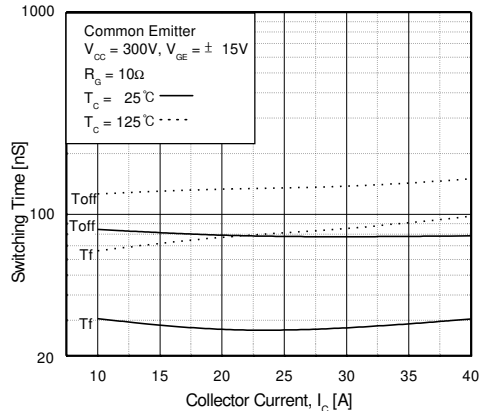
**Fig 9. Turn-Off Characteristics vs. Gate Resistance**



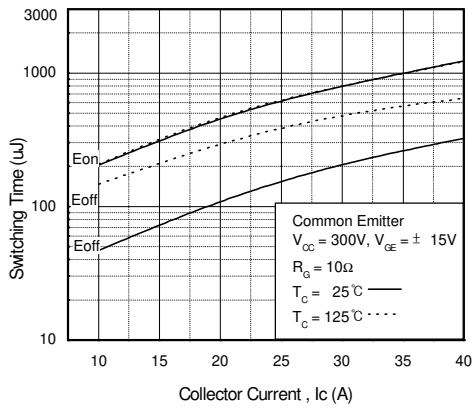
**Fig 10. Switching Loss vs. Gate Resistance**



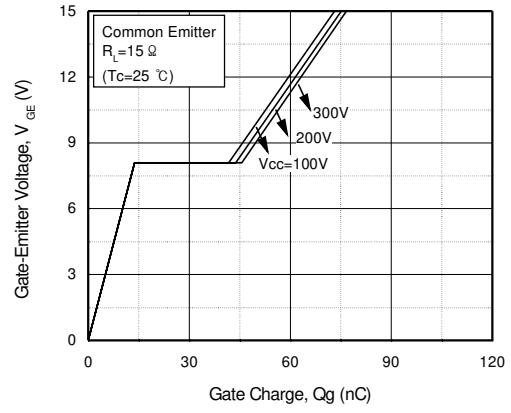
**Fig 11. Turn-On Characteristics vs. Collector Current**



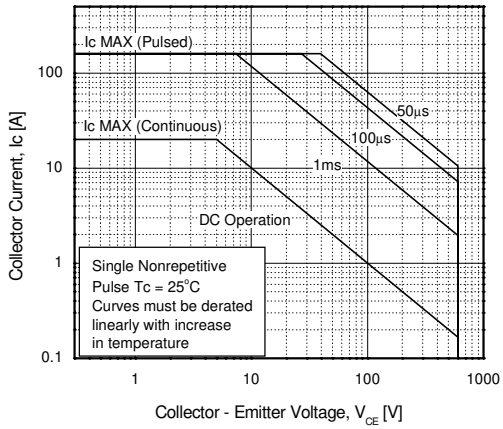
**Fig 12. Turn-Off Characteristics vs. Collector Current**



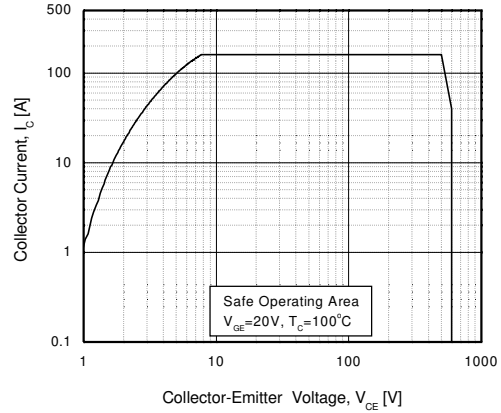
**Fig 13. Switching Loss vs. Collector Current**



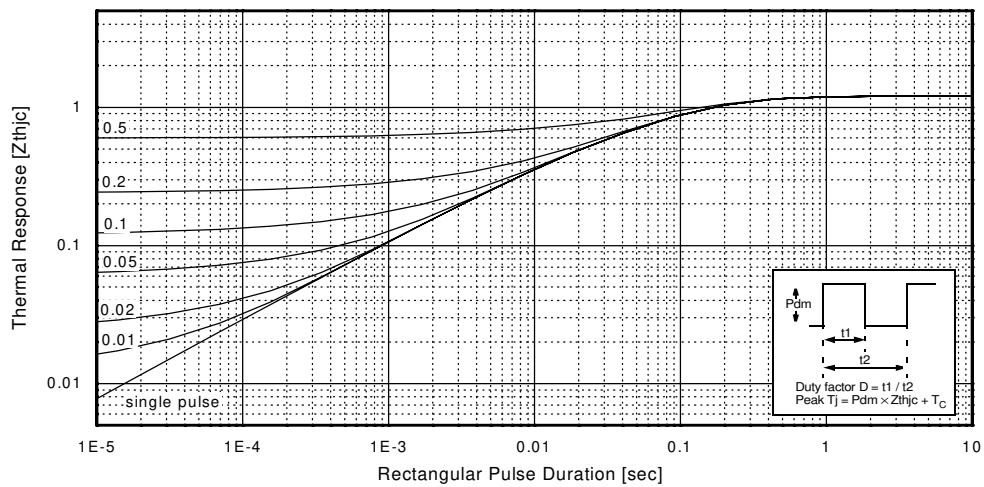
**Fig 14. Gate Charge Characteristics**



**Fig 15. SOA Characteristics**



**Fig 16. Turn-Off SOA Characteristics**



**Fig 17. Transient Thermal Impedance of IGBT**

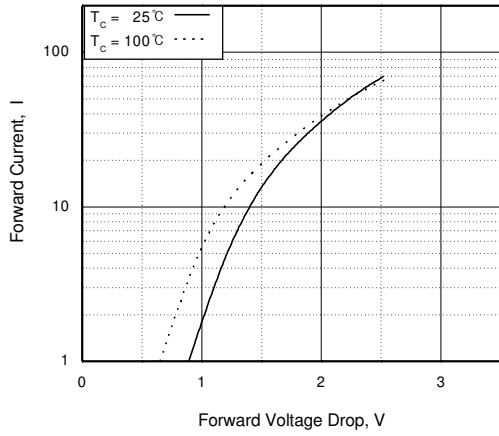


Fig 18. Forward Characteristics

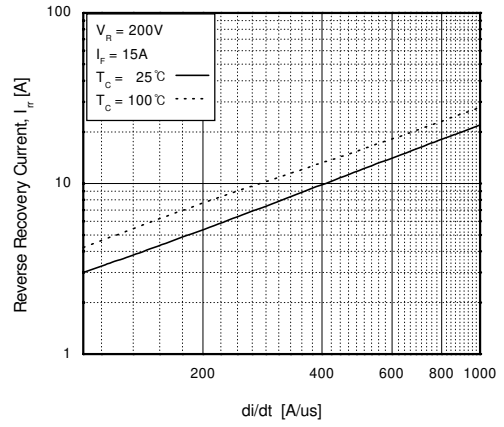


Fig 19. Reverse Recovery Current

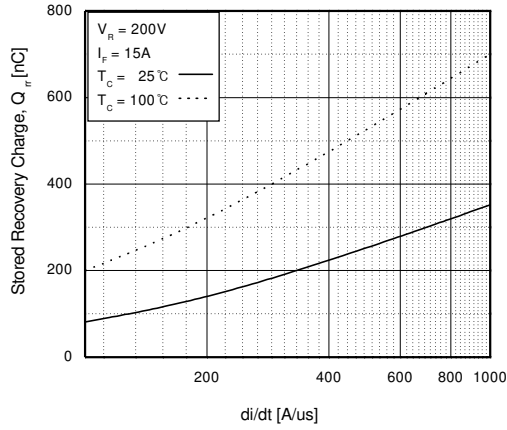


Fig 20. Stored Charge

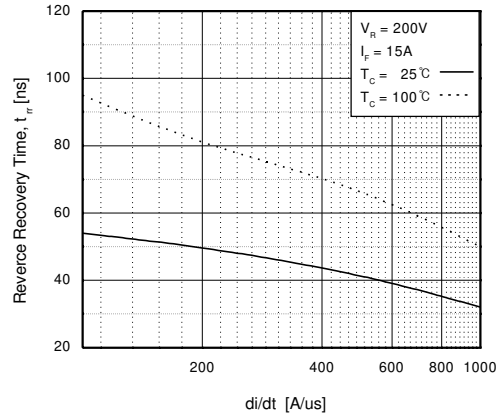
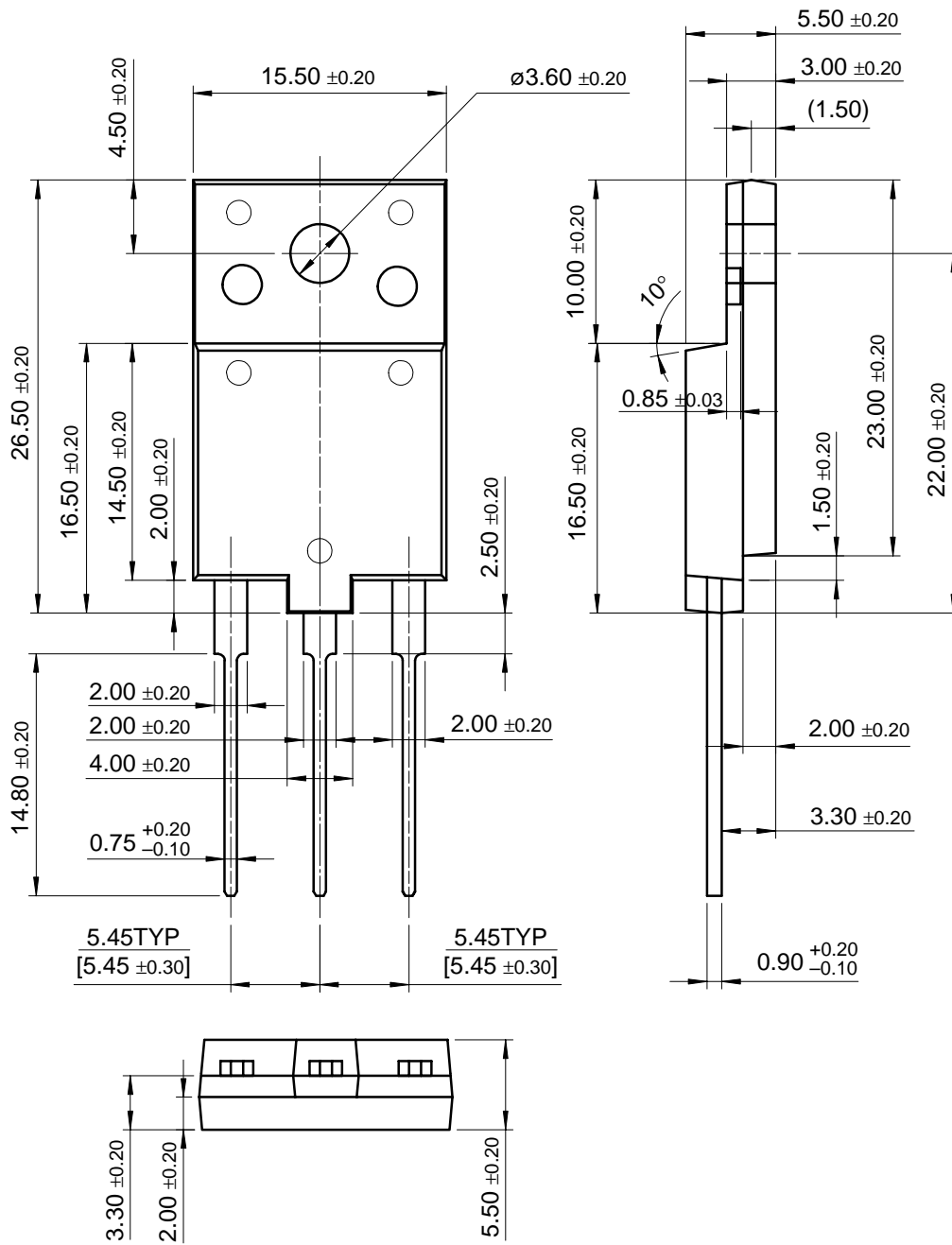


Fig 21. Reverse Recovery Time

Package Dimensions

TO-3PF

FGAF40N60UFD



Dimensions in Millimeters



## TRADEMARKS

The following are registered and unregistered trademarks Fairchild Semiconductor owns or is authorized to use and is not intended to be an exhaustive list of all such trademarks.

ACE <sup>x</sup> <sup>TM</sup>	FACT Quiet Series <sup>TM</sup>	ISOPLANAR <sup>TM</sup>	POP <sup>TM</sup>	Stealth <sup>TM</sup>
ActiveArray <sup>TM</sup>	FAST <sup>®</sup>	LittleFET <sup>TM</sup>	Power247 <sup>TM</sup>	SuperFET <sup>TM</sup>
Bottomless <sup>TM</sup>	FAST <sup>r</sup> <sup>TM</sup>	MICROCOUPLER <sup>TM</sup>	PowerSaver <sup>TM</sup>	SuperSOT <sup>TM</sup> -3
CoolFET <sup>TM</sup>	FPST <sup>TM</sup>	MicroFET <sup>TM</sup>	PowerTrench <sup>®</sup>	SuperSOT <sup>TM</sup> -6
CROSSVOLT <sup>TM</sup>	FRFET <sup>TM</sup>	MicroPak <sup>TM</sup>	QFET <sup>®</sup>	SuperSOT <sup>TM</sup> -8
DOMEST <sup>TM</sup>	GlobalOptoisolator <sup>TM</sup>	MICROWIRE <sup>TM</sup>	QS <sup>TM</sup>	SyncFET <sup>TM</sup>
EcoSPARK <sup>TM</sup>	GTO <sup>TM</sup>	MSX <sup>TM</sup>	QT Optoelectronics <sup>TM</sup>	TinyLogic <sup>®</sup>
E <sup>2</sup> CMOS <sup>TM</sup>	HiSeC <sup>TM</sup>	MSXPro <sup>TM</sup>	Quiet Series <sup>TM</sup>	TINYOPTO <sup>TM</sup>
EnSigna <sup>TM</sup>	I <sup>2</sup> C <sup>TM</sup>	OCX <sup>TM</sup>	RapidConfigure <sup>TM</sup>	TruTranslation <sup>TM</sup>
FACT <sup>TM</sup>	ImpliedDisconnect <sup>TM</sup>	OCXPro <sup>TM</sup>	RapidConnect <sup>TM</sup>	UHC <sup>TM</sup>
Across the board. Around the world. <sup>TM</sup>		OPTOLOGIC <sup>®</sup>	SILENT SWITCHER <sup>®</sup>	UltraFET <sup>®</sup>
The Power Franchise <sup>TM</sup>		OPTOPLANAR <sup>TM</sup>	SMART START <sup>TM</sup>	VCX <sup>TM</sup>
Programmable Active Droop <sup>TM</sup>		PACMAN <sup>TM</sup>	SPM <sup>TM</sup>	

## DISCLAIMER

FAIRCHILD SEMICONDUCTOR RESERVES THE RIGHT TO MAKE CHANGES WITHOUT FURTHER NOTICE TO ANY PRODUCTS HEREIN TO IMPROVE RELIABILITY, FUNCTION OR DESIGN. FAIRCHILD DOES NOT ASSUME ANY LIABILITY ARISING OUT OF THE APPLICATION OR USE OF ANY PRODUCT OR CIRCUIT DESCRIBED HEREIN; NEITHER DOES IT CONVEY ANY LICENSE UNDER ITS PATENT RIGHTS, NOR THE RIGHTS OF OTHERS.

## LIFE SUPPORT POLICY

FAIRCHILD'S PRODUCTS ARE NOT AUTHORIZED FOR USE AS CRITICAL COMPONENTS IN LIFE SUPPORT DEVICES OR SYSTEMS WITHOUT THE EXPRESS WRITTEN APPROVAL OF FAIRCHILD SEMICONDUCTOR CORPORATION.

As used herein:

1. Life support devices or systems are devices or systems which, (a) are intended for surgical implant into the body, or (b) support or sustain life, or (c) whose failure to perform when properly used in accordance with instructions for use provided in the labeling, can be reasonably expected to result in significant injury to the user.
2. A critical component is any component of a life support device or system whose failure to perform can be reasonably expected to cause the failure of the life support device or system, or to affect its safety or effectiveness.

## PRODUCT STATUS DEFINITIONS

### Definition of Terms

Datasheet Identification	Product Status	Definition
Advance Information	Formative or In Design	This datasheet contains the design specifications for product development. Specifications may change in any manner without notice.
Preliminary	First Production	This datasheet contains preliminary data, and supplementary data will be published at a later date. Fairchild Semiconductor reserves the right to make changes at any time without notice in order to improve design.
No Identification Needed	Full Production	This datasheet contains final specifications. Fairchild Semiconductor reserves the right to make changes at any time without notice in order to improve design.
Obsolete	Not In Production	This datasheet contains specifications on a product that has been discontinued by Fairchild semiconductor. The datasheet is printed for reference information only.

ON Semiconductor and  are trademarks of Semiconductor Components Industries, LLC dba ON Semiconductor or its subsidiaries in the United States and/or other countries. ON Semiconductor owns the rights to a number of patents, trademarks, copyrights, trade secrets, and other intellectual property. A listing of ON Semiconductor's product/patent coverage may be accessed at [www.onsemi.com/site/pdf/Patent-Marking.pdf](http://www.onsemi.com/site/pdf/Patent-Marking.pdf). ON Semiconductor reserves the right to make changes without further notice to any products herein. ON Semiconductor makes no warranty, representation or guarantee regarding the suitability of its products for any particular purpose, nor does ON Semiconductor assume any liability arising out of the application or use of any product or circuit, and specifically disclaims any and all liability, including without limitation special, consequential or incidental damages. Buyer is responsible for its products and applications using ON Semiconductor products, including compliance with all laws, regulations and safety requirements or standards, regardless of any support or applications information provided by ON Semiconductor. "Typical" parameters which may be provided in ON Semiconductor data sheets and/or specifications can and do vary in different applications and actual performance may vary over time. All operating parameters, including "Typicals" must be validated for each customer application by customer's technical experts. ON Semiconductor does not convey any license under its patent rights nor the rights of others. ON Semiconductor products are not designed, intended, or authorized for use as a critical component in life support systems or any FDA Class 3 medical devices or medical devices with a same or similar classification in a foreign jurisdiction or any devices intended for implantation in the human body. Should Buyer purchase or use ON Semiconductor products for any such unintended or unauthorized application, Buyer shall indemnify and hold ON Semiconductor and its officers, employees, subsidiaries, affiliates, and distributors harmless against all claims, costs, damages, and expenses, and reasonable attorney fees arising out of, directly or indirectly, any claim of personal injury or death associated with such unintended or unauthorized use, even if such claim alleges that ON Semiconductor was negligent regarding the design or manufacture of the part. ON Semiconductor is an Equal Opportunity/Affirmative Action Employer. This literature is subject to all applicable copyright laws and is not for resale in any manner.

## PUBLICATION ORDERING INFORMATION

### LITERATURE FULFILLMENT:

Literature Distribution Center for ON Semiconductor  
19521 E. 32nd Pkwy, Aurora, Colorado 80011 USA  
**Phone:** 303-675-2175 or 800-344-3860 Toll Free USA/Canada  
**Fax:** 303-675-2176 or 800-344-3867 Toll Free USA/Canada  
**Email:** [orderlit@onsemi.com](mailto:orderlit@onsemi.com)

**N. American Technical Support:** 800-282-9855 Toll Free  
USA/Canada  
**Europe, Middle East and Africa Technical Support:**  
Phone: 421 33 790 2910  
**Japan Customer Focus Center**  
Phone: 81-3-5817-1050

**ON Semiconductor Website:** [www.onsemi.com](http://www.onsemi.com)  
**Order Literature:** <http://www.onsemi.com/orderlit>  
For additional information, please contact your local  
Sales Representative