FERRANTI semiconductors®

ZTX649

NPN Silicon Planar Medium Power Transistor

FEATURES

- **1.5W power dissipation at $T_{amb}=25°C$§**
- **2A continuous I_C**
- **Excellent gain characteristics up to 6A (pulsed)**
- **Low saturation voltages**
- **Fast swithing**
- **PNP complementary type available**

PLASTIC E-LINE (TO-92)

DESCRIPTION

A high perfomance transistor encapsulated in the popular E-line (TO-92) plastic package.

The 1.5W performance and outstanding electrical characteristics permit use in a wide range of industrial and consumer applications including lamp and solenoid drivers.

In addition the excellent gain characteristics at high collector current levels make the device ideal in pulsed applications.

The specially selected SILICONE encapsulation provides resistance to severe environments comparable with metal can devices.

Complementary to the ZTX749

ABSOLUTE MAXIMUM RATINGS

Parameter	Symbol	ZTX649	Unit
Collector-Base Voltage	V_{CBO}	35	V
Collector-Emitter Voltage	V_{CEO}	25	V
Emitter-Base Voltage	V_{EBO}	5	V
Peak Pulse Current*	I_{CM}	6	amps
Continuous Collector Current	I_C	2	amps
Practical Power Dissipation§	P_{totP}	1.5	watts
Power Dissipation at $T_{amb}=25°C$ derate above 25°C	P_{tot}	1 5.7	watt mW/°C
Operating and Storage Temperature Range		−55 to +200	°C

*Measured under pulsed conditions. Pulse width $=300\mu s$. Duty cycle $\leq 2\%$.

§The power which can be dissipated assuming device mounted in typical manner on P.C.B. with copper equal to 1sq. inch minimum.

ZTX649

CHARACTERISTICS (at 25°C ambient temperature unless otherwise stated).

Parameter	Symbol	Min.	Typ.	Max.	Unit	Conditions
Collector-base breakdown voltage	$V_{(BR)CBO}$	35	—	—	V	$I_C = 100\mu A$
Collector-emitter breakdown voltage	$V_{(BR)CEO}$	25	—	—	V	$I_C = 10mA$
Emitter-base breakdown voltage	$V_{(BR)EBO}$	5	—	—	V	$I_E = 100\mu A$
Collector cut-off current	I_{CBO}	—	—	0.1	μA	$V_{CB} = 30V$
		—	—	10	μA	$V_{CB} = 30V$, $T_{amb} = 100°C$
Emitter cut-off current	I_{EBO}	—	—	0.1	μA	$V_{EB} = 4V$
Collector-emitter saturation voltage	$V_{CE(sat)}$	—	0.12	0.3	V	$I_C = 1A$, $I_B = 100mA$*
		—	0.23	0.5	V	$I_C = 2A$, $I_B = 200mA$*
Base-emitter saturation voltage	$V_{BE(sat)}$	—	0.9	1.25	V	$I_C = 1A$, $I_B = 100mA$*
Base-emitter turn-on voltage	$B_{BE(on)}$	—	0.8	1.0	V	$I_C = 1A$, $V_{CE} = 2V$*
Static forward current transfer ratio	h_{FE}	70	200	—		$I_C = 50mA$, $V_{CE} = 2V$*
		100	200	300		$I_C = 1A$, $V_{CE} = 2V$*
		75	150	—		$I_C = 2A$, $V_{CE} = 2V$*
		15	50	—		$I_C = 6A$, $V_{CE} = 2V$*
Transition frequency	f_T	150	240	—	MHz	$I_C = 100mA$, $V_{CE} = 5V$ $f = 100MHz$
Output capacitance	C_{obo}	—	25	50	pF	$V_{CB} = 10V$, $f = 1MHz$
Switching times	t_{on}	—	55	—	ns	$I_C = 500mA$
	t_{off}	—	300	—	ns	$V_{CC} = 10V$ $I_{B1} = I_{B2} = 50mA$

*Measured under pulsed conditions. Pulse width = 300μs. Duty cycle ≤2%.

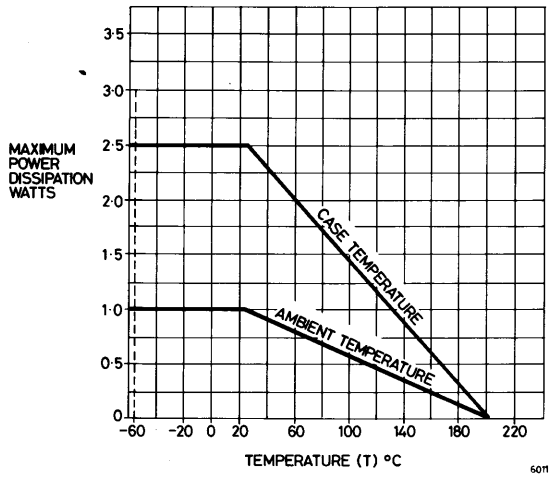
THERMAL CHARACTERISTICS

Parameter		Symbol	Maximum	Unit
Thermal Resistance:	Junction to Ambient$_1$	$R_{th(j\text{-}amb)1}$	175	°C/W
	Junction to Ambient$_2$	$R_{th(j\text{-}amb)2}$§	116	°C/W
	Junction to Case	$R_{th(j\text{-}case)}$	70	°C/W

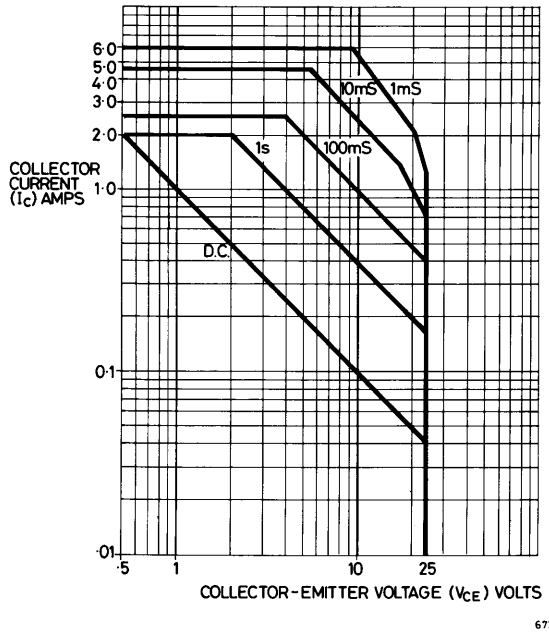
§Device mounted on P.C.B. with copper equal to 1sq. inch minimum.

Note: Practical Power Dissipation. Where space does not permit 1sq. inch copper the device fitted with Staver heat clip type F2-7 will offer the following:

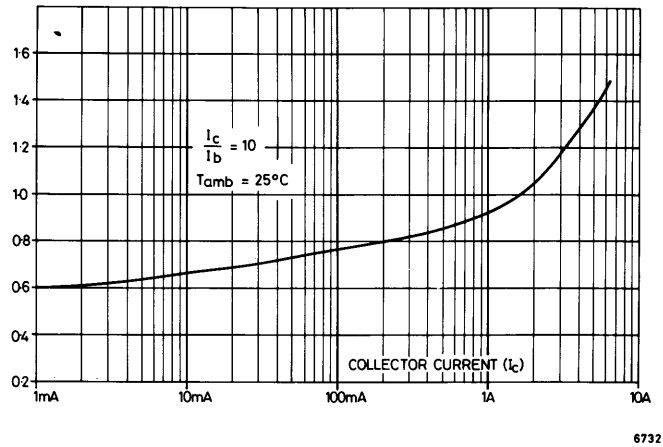
Power Dissipation at $T_{amb} = 25°C$ (P_{tot}) 1.4Watts
Derate above 25°C . . . . . 8.0mW/°C
Thermal resistance, Junction to Ambient . . . . 125°C/W



DISSIPATION DERATING CURVE

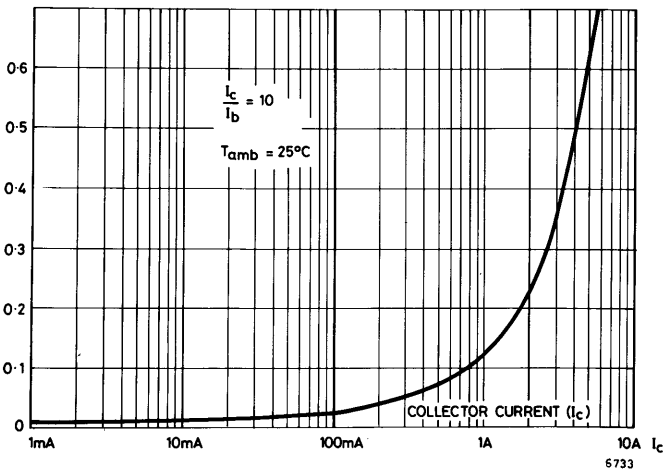


SAFE OPERATING AREA
at T_{amb} = 25°C (SINGLE PULSE)



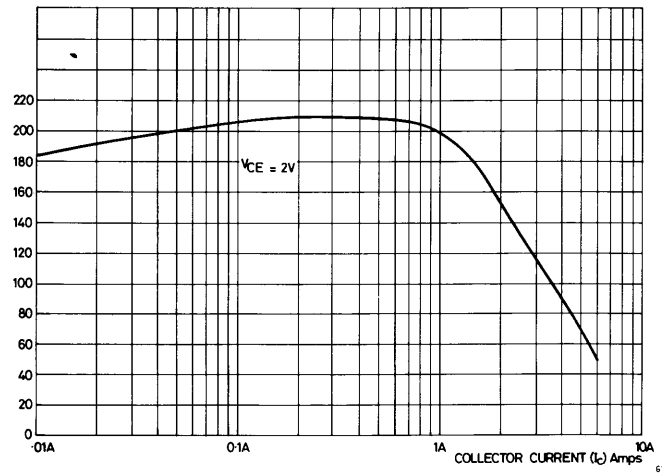
$V_{BE(sat)}/I_C$

TYPICAL BASE-EMITTER SATURATION VOLTAGE PLOTTED AGAINST COLLECTOR CURRENT



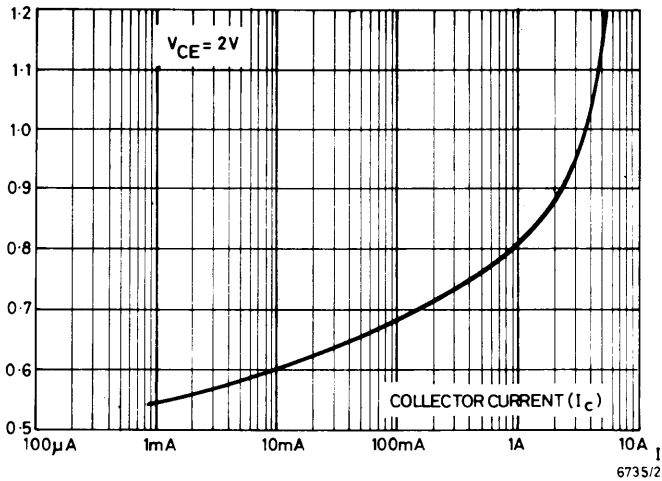
$V_{CE(sat)}/I_C$

TYPICAL COLLECTOR-EMITTER SATURATION VOLTAGE PLOTTED AGAINST COLLECTOR CURRENT



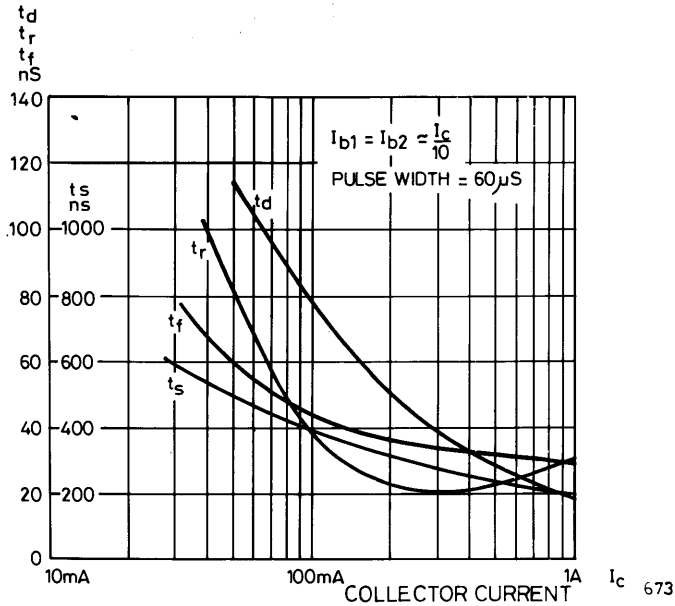
h_{FE}/I_C

TYPICAL STATIC FORWARD CURRENT TRANSFER RATIO PLOTTED AGAINST COLLECTOR CURRENT

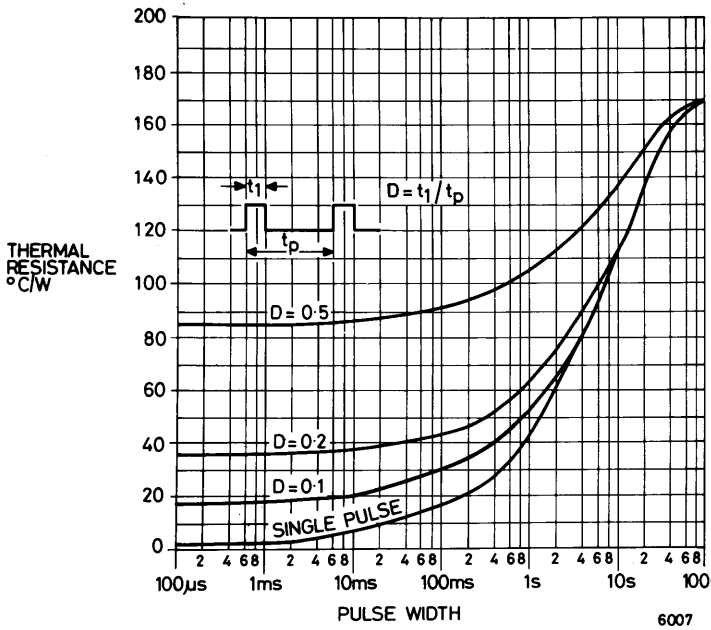


$V_{BE(ON)}/I_C$

TYPICAL BASE-EMITTER TURN-ON VOLTAGE PLOTTED AGAINST COLLECTOR CURRENT



TYPICAL SWITCHING SPEEDS



TYPICAL TRANSIENT THERMAL IMPEDANCE CURVES

FERRANTI semiconductors®

ZTX650
ZTX651
ZTX652
ZTX653

NPN Silicon Planar Medium Power Transistors

FEATURES

- 1.5W Power dissipation at $T_{amb} = 25°C$§
- 2A continuous I_C
- Excellent gain characteristics to 2A
- High V_{CEO}: up to 100 volts
- Low saturation voltages
- Guaranteed h_{FE} specified up to 2A
- Fast switching
- Exceptional price-to-power ratio
- Complementary types

PLASTIC E-LINE (TO-92)

DESCRIPTION

A range of high performance medium power transistors encapsulated in the popular E-line (TO-92) plastic package.

The 1.5W performance and outstanding electrical characteristics permit use in a wide variety of industrial and consumer applications including lamp and solenoid drivers, audio amplifiers, complementary drivers for hi-fi amplifiers.

In addition to achieving excellent linearity the devices are designed to function as high speed power switching transistors.

The specially selected SILICONE encapsulation provides resistance to severe environments comparable with metal can devices.

Complementary to ZTX750 series.

ABSOUTE MAXIUM RATINGS

Parameter	Symbol	ZTX650	ZTX651	ZTX652	ZTX653	Unit
Collector-Base Voltage	V_{CBO}	60	80	100	120	Volts
Collector-Emitter Voltage	V_{CEO}	45	60	80	100	Volts
Emitter-Base Voltage	V_{EBO}	5	5	5	5	Volts
Peak Pulse Current*	I_{CM}	6	6	6	6	Amps
Continuous Collector Current	I_C	2	2	2	2	Amps
Practical Power Dissipation§	P_{totP}	1.5	1.5	1.5	1.5	Watts
Power Dissipation: at $T_{amb} = 25°C$ derate above 25°C at $T_{case} = 25°C$	P_{tot}	1 5.7 2.5	1 5.7 2.5	1 5.7 2.5	1 5.7 2.5	Watts mW/°C Watts
Operating and Storage Temperature Range		55 to +200				°C

*Measured under pulsed conditions. Pulse width = 300μs. Duty cycle ≤2%.

§The power which can be dissipated assuming device mounted in typical manner on P.C.B. with copper equal to 1sq. inch minimum. See also note on Page SE71.

ZTX650/1

CHARACTERISTICS (at 25°C ambient temperature unless otherwise stated).

Parameter	Symbol	ZTX650			ZTX651			Unit	Conditions
		Min.	Typ.	Max.	Min.	Typ.	Max.		
Collector-base breakdown voltage	$V_{(BR)CBO}$	60	—	—	80	—	—	V	$I_C = 100\,\mu A$
Collector-emitter breakdown voltage	$V_{(BR)CEO}$	45	—	—	60	—	—	V	$I_C = 10\,mA$
Emitter-base breakdown voltage	$V_{(BR)EBO}$	5	—	—	5	—	—	V	$I_E = 100\,\mu A$
Collector cut off current	I_{CBO}	—	—	0.1	—	—	—	μA	$V_{CB} = 45V$
		—	—	10	—	—	—	μA	$V_{CB} = 45V$, $T_{amb} = 100°C$
		—	—	—	—	—	0.1	μA	$V_{CB} = 60V$
		—	—	—	—	—	10	μA	$V_{CB} = 60V$, $T_{amb} = 100°C$
Emitter cut off current	I_{EBO}	—	—	0.1	—	—	0.1	μA	$V_{EB} = 4V$
Collector-emitter saturation voltage	$V_{CE(sat)}$	—	0.12	0.3	—	0.12	0.3	V	$I_C = 1A$*, $I_B = 100\,mA$*
		—	0.23	0.5	—	0.23	0.5	V	$I_C = 2A$*, $I_B = 200\,mA$*
Base-emitter saturation voltage	$V_{BE(sat)}$	—	0.90	1.25	—	0.90	1.25	V	$I_C = 1A$*, $I_B = 100\,mA$*
Base-emitter turn on voltage	$V_{BE(on)}$	—	0.8	1.0	—	0.8	1.0	V	$I_C = 1A$*, $V_{CE} = 2V$*
Static forward current transfer ratio	h_{FE}	70	200	—	70	200	—		$I_C = 50\,mA$*, $V_{CE} = 2V$*
		100	200	300	100	200	300		$I_C = 500\,mA$*, $V_{CE} = 2V$*
		80	170	—	80	170	—		$I_C = 1A$*, $V_{CE} = 2V$*
		40	80	—	40	80	—		$I_C = 2A$*, $V_{CE} = 2V$*
Transition frequency	f_T	140	175	—	140	175	—	MHz	$I_C = 100\,mA$, $V_{CE} = 5V$, $f = 100\,MHz$
Switching times	T_{on}	—	45	—	—	45	—	ns	$I_C = 500\,mA$, $I_{B_1} = 50\,mA$, $I_{B_2} = 50\,mA$, $V_{CC} = 10V$
	T_{off}	—	800	—	—	800	—	ns	

*Measured under pulsed conditions. Pulse width = 300 μs. Duty cycle ≤2%.

THERMAL CHARACTERISTICS (ZTX650/1/2/3)

Parameter		Symbol	Maximum	Unit
Thermal Resistance:	Junction to Ambient[1]	$R_{th(j-amb)1}$	175	°C/W
	Junction to Ambient[2]	$R_{th(j-amb)2}$†	116	°C/W
	Junction to Case	$R_{th(j-case)}$	70	°C/W

†Device mounted on P.C.B. with copper equal to 1 sq. inch minimum.

CHARACTERISTICS (at 25°C ambient temperature unless otherwise stated).

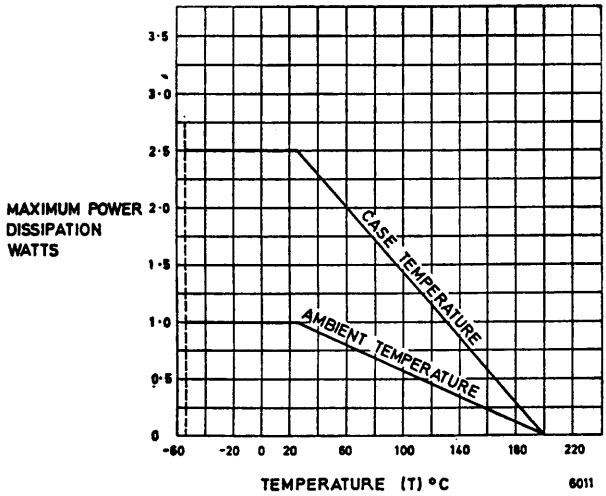
Parameter	Symbol	ZTX652			ZTX653			Unit	Conditions
		Min.	Typ.	Max.	Min.	Typ.	Max.		
Collector-base breakdown voltage	$V_{(BR)CBO}$	100	—	—	120	—	—	V	$I_C = 100\,\mu A$
Collector-emitter breakdown voltage	$V_{(BR)CEO}$	80	—	—	100	—	—	V	$I_C = 10$ mA
Emitter-base breakdown voltage	$V_{(BR)EBO}$	5	—	—	5	—	—	V	$I_E = 100\,\mu A$
Collector cut off current	I_{CBO}	—	—	0.1	—	—	—	μA	$V_{CB} = 80V$
		—	—	10	—	—	—	μA	$V_{CB} = 80V$, $T_{amb} = 100°C$
		—	—	—	—	—	0.1	μA	$V_{CB} = 100V$
		—	—	—	—	—	10	μA	$V_{CB} = 100V$, $T_{amb} = 100°C$
Emitter cut off current	I_{EBO}	—	—	0.1	—	—	0.1	μA	$V_{EB} = 4V$
Collector-emitter saturation voltage	$V_{CE(sat)}$	—	0.13	0.3	—	0.13	0.3	V	$I_C = 1A$*, $I_B = 100$ mA*
		—	0.23	0.5	—	0.23	0.5	V	$I_C = 2A$*, $I_B = 200$ mA*
Base-emitter saturation voltage	$V_{BE(sat)}$	—	0.90	1.25	—	0.90	1.25	V	$I_C = 1A$*, $I_B = 100$ mA*
Base-emitter turn on voltage	$V_{BE(on)}$	—	0.8	1.0	—	0.8	1.0	V	$I_C = 1A$*, $V_{CE} = 2V$*
Static forward current transfer ratio	h_{FE}	70	200	—	70	200	—		$I_C = 50$ mA*, $V_{CE} = 2V$*
		100	200	300	100	200	300		$I_C = 500$ mA*, $V_{CE} = 2V$*
		55	110	—	55	110	—		$I_C = 1A$*, $V_{CE} = 2V$*
		25	55	—	25	55	—		$I_C = 2A$*, $V_{CE} = 2V$*
Transition frequency	f_T	140	175	—	140	175	—	MHz	$I_C = 100$ mA, $V_{CE} = 5V$ f = 100 MHz
Switching times	T_{on}	—	80	—	—	80	—	ns	$I_C = 500$ mA, $I_{B1} = 50$ mA
	T_{off}	—	1200	—	—	1200	—	ns	$I_{B2} = 50$ mA, $V_{CC} = 10V$

*Measured under pulsed conditions. Pulse width = 300 μs, Duty cycle ≤2%.

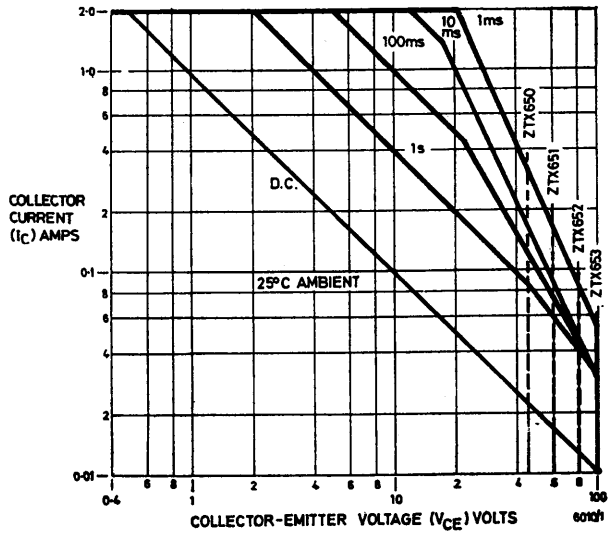
Note: Practical Power Dissipation. Where space does not permit 1 sq. inch copper the device fitted with Staver heat clip type F2-7 will offer the following:

Power Dissipation at $T_{amb} = 25°C$ (P_{tot}) .. 1.4 Watts
Derate above 25°C .. .. 8.0 mW/°C
Thermal resistance, Junction to Ambient .. 125°C/W

ZTX650 Series

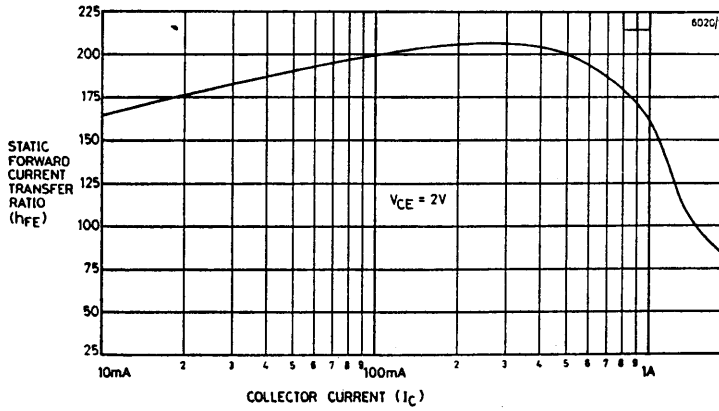


DISSIPATION DERATING CURVE FOR ALL TYPES



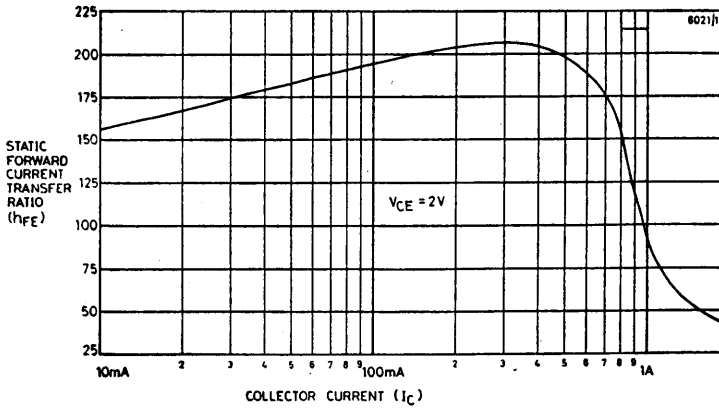
SAFE OPERATING AREA at T_{amb} = 25°C (SINGLE PULSE)

TYPICAL CHARACTERISTICS



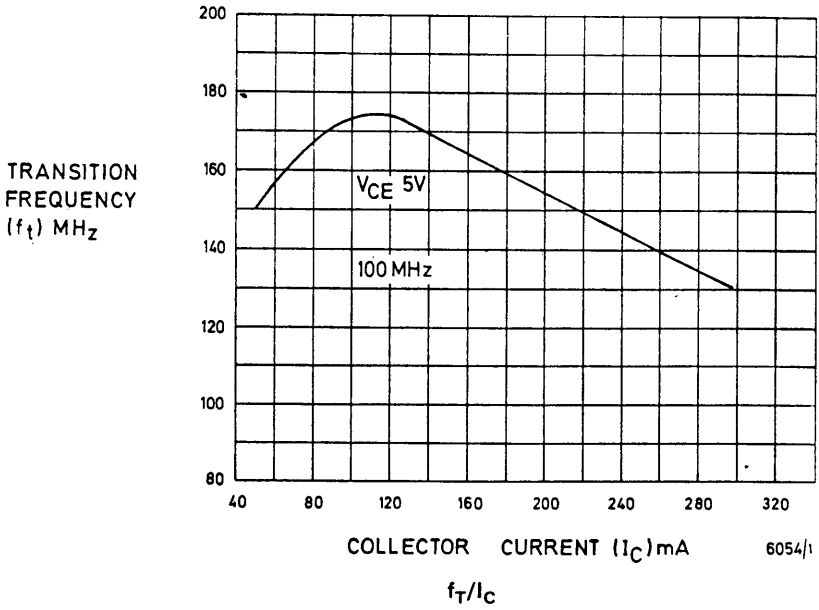
h_{FE}/I_C

STATIC FORWARD CURRENT TRANSFER RATIO PLOTTED AGAINST COLLECTOR CURRENT FOR ZTX650/651



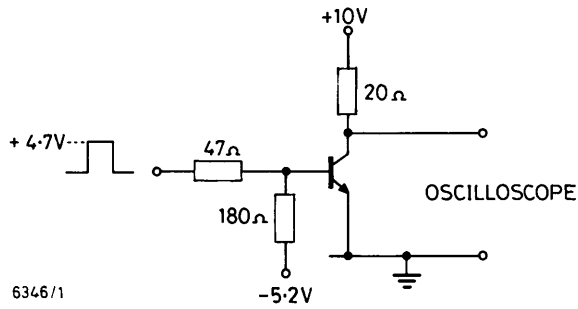
h_{FE}/I_C

STATIC FORWARD CURRENT TRANSFER RATIO PLOTTED AGAINST COLLECTOR CURRENT FOR ZTX652/653

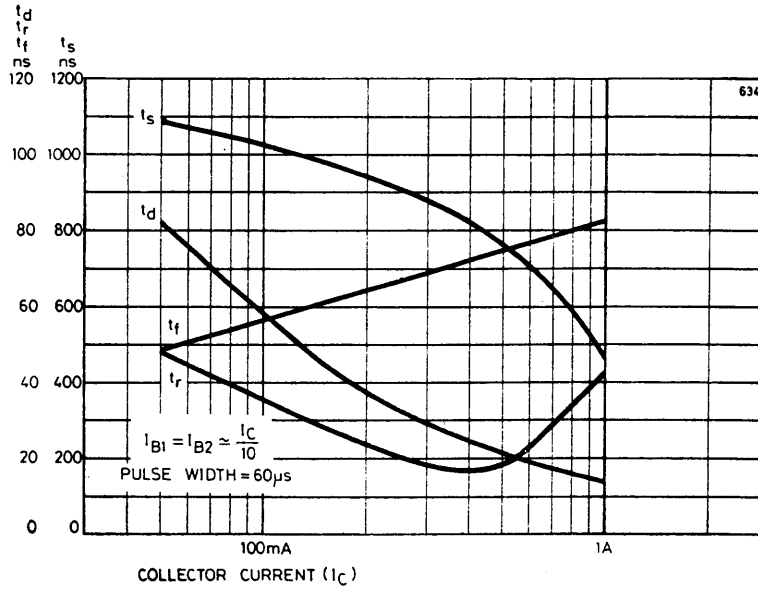


f_T/I_C

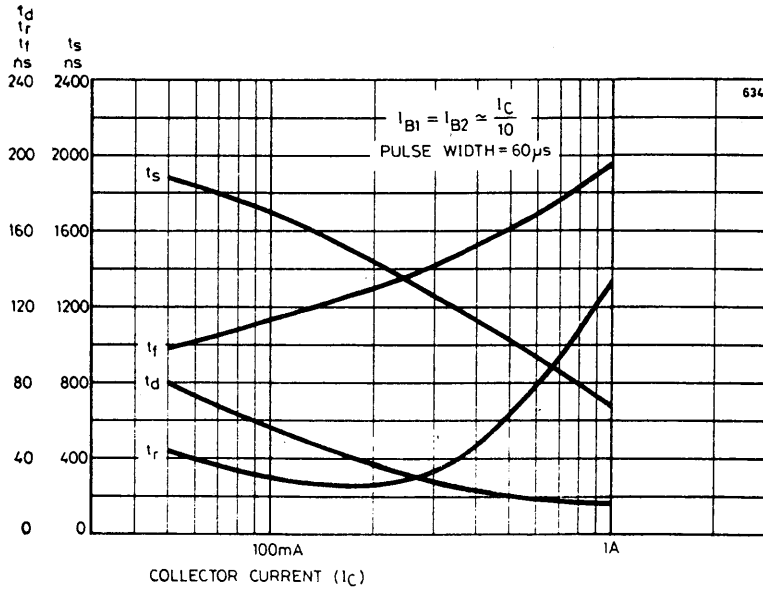
TYPICAL TRANSITION FREQUENCY PLOTTED AGAINST COLLECTOR CURRENT FOR ZTX650



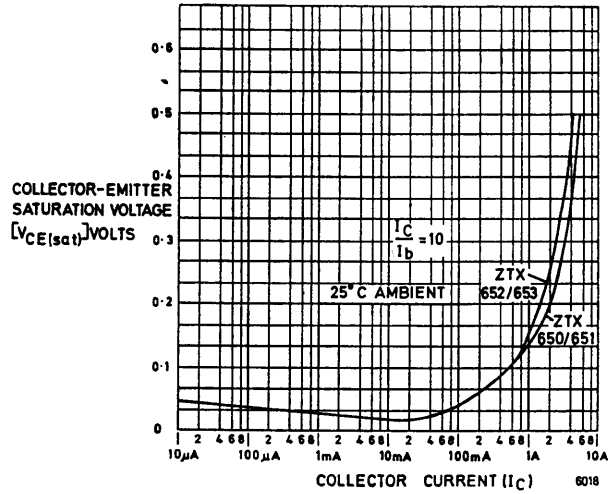
SWITCHING SPEEDS TEST CIRCUIT



TYPICAL SWITCHING SPEEDS (ZTX650/651)

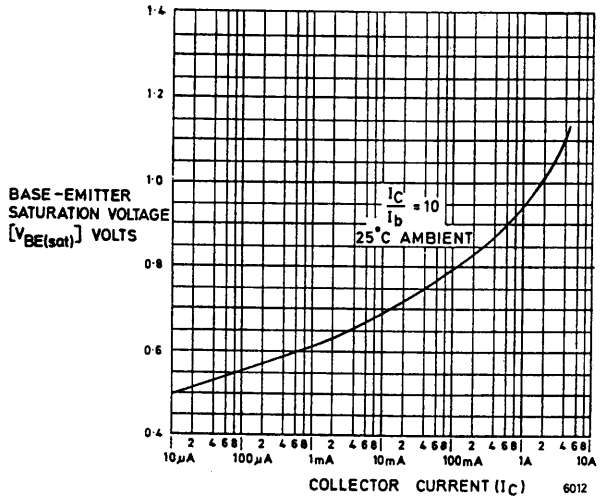


TYPICAL SWITCHING SPEEDS (ZTX652/653)



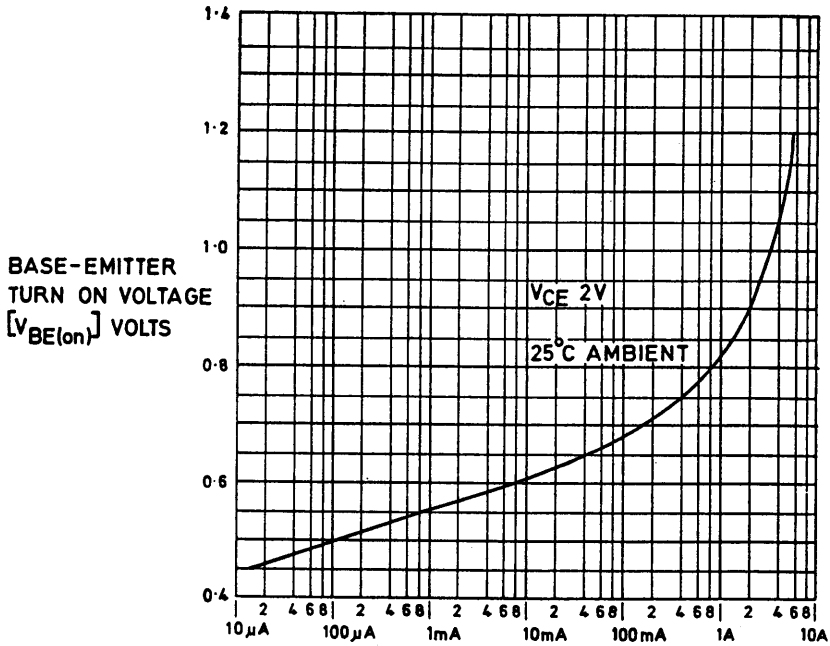
$V_{CE(sat)}/I_C$

TYPICAL COLLECTOR-EMITTER SATURATION VOLTAGES PLOTTED AGAINST COLLECTOR CURRENT



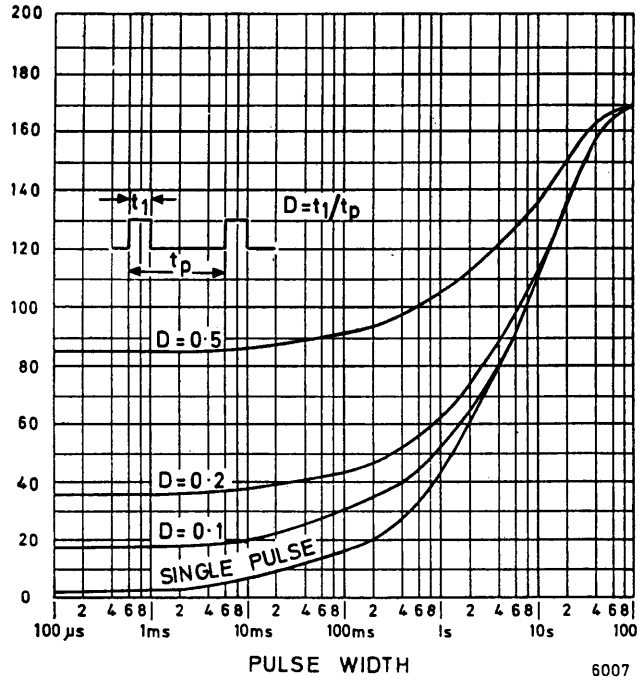
$V_{BE(sat)}/I_C$

TYPICAL BASE-EMITTER SATURATION VOLTAGES PLOTTED AGAINST COLLECTOR CURRENT FOR ALL TYPES



$V_{BE(on)}/I_C$

TYPICAL BASE-EMITTER TURN ON VOLTAGES
PLOTTED AGAINST COLLECTOR CURRENT FOR ALL TYPES



TYPICAL TRANSIENT THERMAL IMPEDANCE CURVES

FERRANTI semiconductors®

ZTX 656
ZTX 657

NPN Silicon Planar Medium Power High Voltage Transistors

FEATURES

- 1W power dissipation at $T_{amb} = 25°C$
- Excellent gain characteristics at $I_C = 100mA$
- Voltages up to 300 volts
- Low saturation voltages
- Complementary types

PLASTIC E-LINE (TO-92)

DESCRIPTION

These plastic encapsulated, medium power transistors are designed for applications requiring high breakdown voltages and low saturation voltages.

The E-line package is formed by injection moulding a SILICONE plastic specially selected to provide a rugged one-piece encapsulation resistant to severe environments and allow the high junction temperature operation normally associated with metal can devices.

E-line encapsulated devices are approved for use in military, industrial and professional equipments.

Alternative lead configurations are available as plug-in replacements of TO-5/39 and TO-18 metal can types, and for flat mounting. Also available on tape for automatic handling.

Complementary to
ZTX756
ZTX757

ABSOLUTE MAXIMUM RATINGS

Parameter	Symbol	ZTX656	ZTX657	Unit
Collector-Base Voltage	V_{CBO}	200	300	Volts
Collector-Emitter Voltage	V_{CEO}	200	300	Volts
Emitter-Base Voltage	V_{EBO}	5	5	Volts
Peak Collector Current*	I_{CM}	1	1	Amps
Continuous Collector Current	I_C	0.5	0.5	Amps
Practical Power Dissipation†	P_{totP}	1.5	1.5	Watts
Power Dissipation : at $T_{amb} = 25°C$ derate above 25°C	P_{tot}	1 5.7	1 5.7	Watts mW/°C
Operating and Storage Temperature Range		−55 to +200		°C

*Measured under pulsed conditions. Pulse width = 300μS. Duty cycle $\leq 2\%$.

†The power which can be dissipated assuming device mounted in typical manner on P.C.B. with copper equal to 1 sq.inch minimum. See also note overleaf.

ZTX656/657

CHARACTERISTICS (at 25°C ambient temperature unless otherwise stated).

Parameter	Symbol	ZTX656		ZTX657		Unit	Conditions
		Min.	Max.	Min.	Max.		
Collector-base breakdown voltage	$V_{(BR)CBO}$	200		300		volts	$I_C = 100\mu A$
Collector-emitter breakdown voltage	$V_{(BR)CEO}$	200		300		volts	$I_C = 10mA$
Emitter-base breakdown voltage	$V_{(BR)EBO}$	5		5		volts	$I_E = 100\mu A$
Collector cut-off current	I_{CBO}		100		100	nA nA	$V_{CB} = 160V$ $V_{CB} = 200V$
Emitter cut-off current	I_{EBO}		100		100	nA	$V_{EB} = 3V$
Collector-emitter saturation voltage	$V_{CE(SAT)}$		0.5		0.5	volts	$I_C = 100mA^*$, $I_B = 10mA$
Base-emitter saturation voltage	$V_{BE(SAT)}$		1.0		1.0	volts	$I_C = 100mA^*$, $I_B = 10mA$
Static forward current transfer ratio	h_{FE}	50 40		50 40			$I_C = 100mA^*$, $V_{CE} = 5V$ $I_C = 10mA$, $V_{CE} = 5V$
Base-emitter turn on voltage	$V_{BE(ON)}$		1.0		1.0	volts	$I_C = 100mA^*$, $V_{CE} = 5V$
Transition frequency	f_T	30		30		MHz	$I_C = 10mA$, $V_{CE} = 20V$ $f = 20MHz$
Output capacitance	C_{obo}		20		20	pF	$V_{CB} = 20V$, $f = 1MHz$

*Measured under pulsed conditions. Pulse width = 300μS. Duty cycle ≤ 2%.

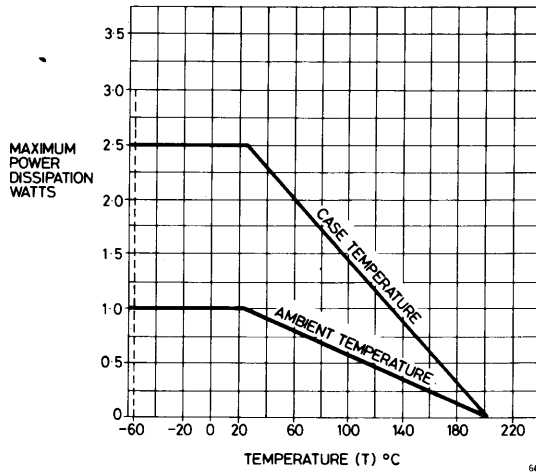
THERMAL CHARACTERISTICS (ZTX656/657)

Parameter		Symbol	Maximum	Unit
Thermal Resistance:	Junction to Ambient$_1$	$R_{th(j\text{-}amb)1}$	175	°C/W
	Junction to Ambient$_2$	$R_{th(j\text{-}amb)2}$†	116	°C/W
	Junction to Case	$R_{th(j\text{-}case)}$	70	°C/W

†Device mounted on P.C.B. with copper equal to 1 sq.inch minimum.

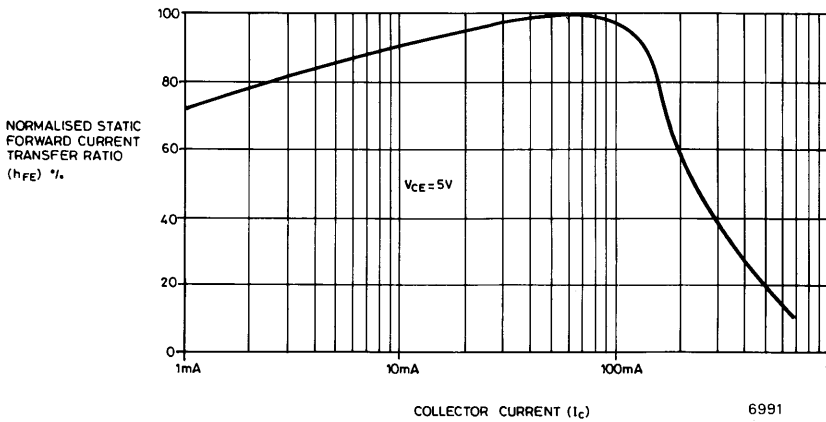
Note: Practical Power Dissipation. Where space does not permit 1 sq.inch copper the device fitted with Staver heat clip type F2-7 will offer the following:

Power Dissipation at $T_{amb} = 25°C$ (P_{tot}) . . . . 1.4 Watts
Derate above 25°C . . . . . 8.0mW/°C
Thermal Resistance, Junction to Ambient . . 125°C/W



Dissipation Derating Curve for all types

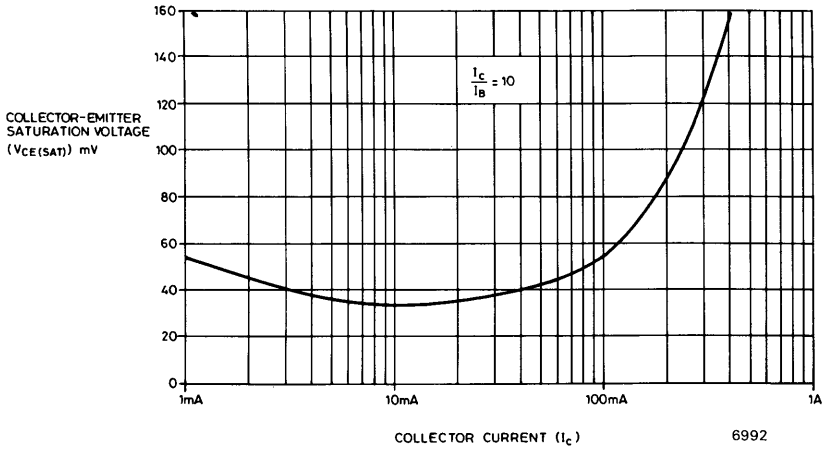
Typical Characteristics



h_{FE}/I_C

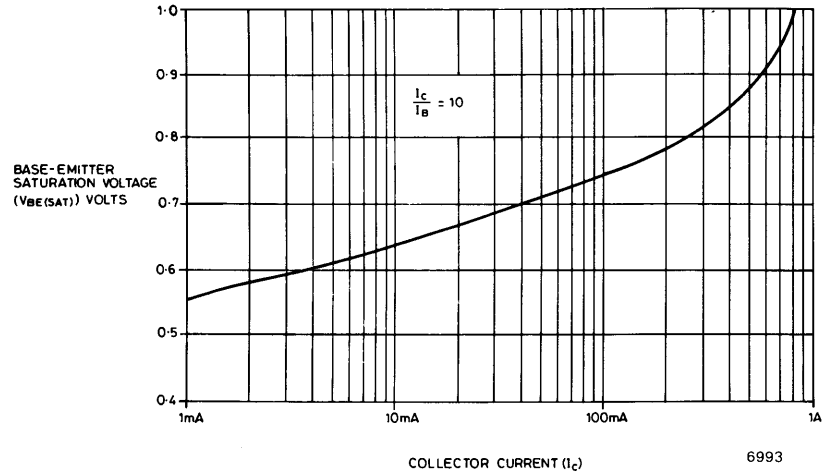
Typical Static Forward Current Transfer Ratio Plotted against Collector Current

Typical Characteristics



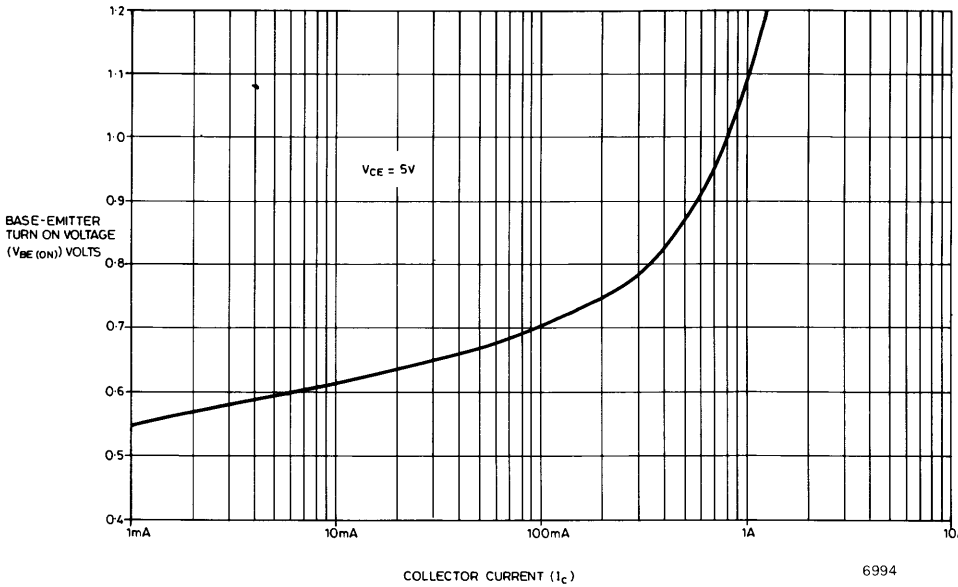
$V_{CE(sat)}/I_C$

Typical Collector-Emitter Saturation Voltages Plotted against Collector Current



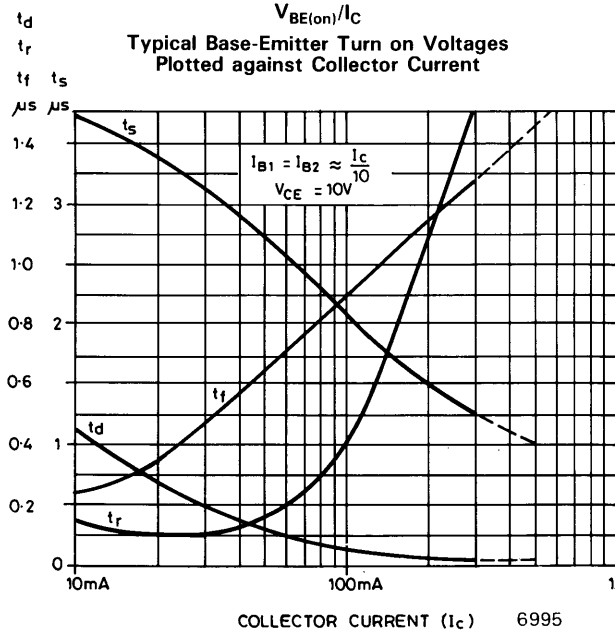
$V_{BE(sat)}/I_C$

Typical Base-Emitter Saturation Voltages Plotted against Collector Current

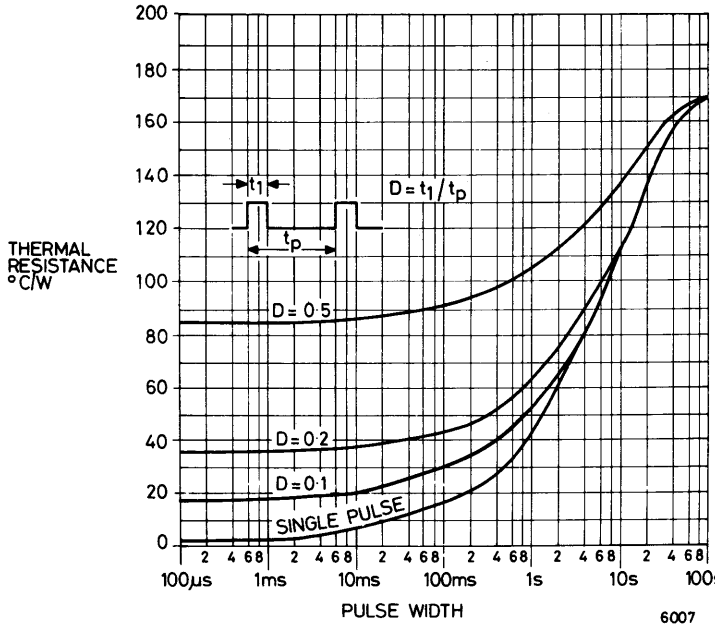


$V_{BE(on)}/I_C$

Typical Base-Emitter Turn on Voltages Plotted against Collector Current



Typical Switching Speeds



TYPICAL TRANSIENT THERMAL IMPEDANCE CURVES