Michael S. thread on restoring another Cortina 3070
6/12/21 Posted by Steve Lafferty, Tronola.com
Supplement for the Reader Comments section of article, "A Little Love for the Cortina 3070"

On May 29th, 2021, Michael S. wrote with questions about restoring an Eico Cortina 3070 and that started an email thread documented here, since it may be useful for other readers. Michael kindly agreed to let us publish it. Some parts may be edited or deleted for clarity or brevity. Michael's text is in green color.

Hi. You might remember me for some questions I asked you a while ago about the Eico 3070. I successfully restored a couple of these using the advice in your article. May I trouble you with a couple more questions? I just bought another 3070. This one is going as smoothly as the others. One channel works OK. More about that later. The other channel didn't work at all. I tested the three transistors on the driver board. One (Q302, the PNP driver) tested bad. The other driver (Q303 NPN) tested good. Q301 was also good. I looked up the parts on NTE and ended up buying something called an NTE129MCP (matched complementary pair of NTE128/npn and NTE129/pnp). I installed these and the left channel worked, but poorly. Massive distortion as the volume increases. The right channel (with the original driver transistors) works better, but not by much. I should mention that the output transistors (which test good) are not original RCA 40312s. Instead, there are four ECG175s. I suspect these are less-than-optimal substitutes for the RCA 40312s.

Should I give up on the NTE pair, reinstall the original RCA 40361, and find a 2N4032 to replace the blown RCA 40362? What about the ECG175s? When I put the "good" channel on my digital oscilloscope (with a 1000hz tone), the waveform at the speaker terminal is not clean. It's like there are high-frequency harmonics added to the top of the waveform. With no input, the 'scope shows a 12khz background waveform, at about 450mv. Do you think this is coming from the ECG175s? The input waveform (to the driver boards) is clean. The "good" channel sounds OK, but not great like my other 3070s.

Perhaps I just need to replace all of the driver & output transistors, just like you did. I performed all of your capacitor mods. I also replaced all of the 2N3391A with 2N5089s, and altered the bias resistors to reduce idle bias current to ~20mA. Any advice would be sincerely appreciated. Thanks, Mike S.

Hi Michael,
It's nice to hear from you again. I will need to dig-in and study all of these transistors. Do you have datasheets on NTE128, NTE129, ECG175? Only thing is, it may take me a couple days to get to the bottom of all this. I hate to say it but if you're in a hurry, replacing all the driver and output transistors as described in the article probably would be the most effective approach. That would include adding the 47pF and 390pF caps and using 2N6315, 2N4032, 2N3108, 2N2270 replacements. But I'll be happy to study the ones you mentioned if you want to pursue those. This reminds me of working in a repair shop part time when I was in college in the 70s. My inclination was usually to dig-in and analyze the situation while the techs who worked there full time always just tried guessing, replacing things and shot-gunning some. They often blew my doors off, getting stuff fixed :)
Steve

Hi again Michael,
First, I'm unclear about which channel is which. There was a good channel and a bad channel. There was also mention of the left and right channels. Trying to decode:
Guessing the bad channel was the left channel. There, Q302 tested bad--what did you find wrong with it? C-E short? This is the channel which had the NTE128/129 installed, right? But this channel still has high distortion. What kind of distortion on the scope? E.g. Top clipped? Bottom clipped?

So the "good" channel is the right channel, I take it. But you're seeing stuff on the waveform--can you send a pic of that? About that 12kHz background waveform: I'm worried that since this is a digital scope, it may be aliased-down from a high frequency. You can check by speeding up the horizontal sweep, e.g. making the time/div much shorter. If the 12kHz is true, it will stretch out like you would expect. If it's aliased, it might compress or change erratically. Eventually, reducing the time/div will make the once-aliased-wave change with time/div normally. That is, spread with one click lower time/div and compress horizontally with one click higher time/div. Once you get it showing normally, note the period of one cycle. One over that is the freq. It's critical to know what freq it's oscillating at.

You mentioned, "I performed all of your capacitor mods." Did that include adding the 47pF and 390pF? (Let's call those the "**taming caps**".) You know, those two were intended only if the new driver and output transistors were installed. They were needed to "tame" those higher-bandwidth devices. I don't know how those caps would affect the amp with other devices. The data on the NTE175 could indicate that it's higher bandwidth but there isn't enough info to tell clearly. IF you didn't install the taming caps, it's possible that the taming caps could fix it. Using 2N6315s in place of the 40312 output transistors was a biggie. Can you get those? I see that, wonder of wonders, Mouser has them. However, they want $38 each for them. But I see Quest has them for $3.15: https://www.questcomp.com/part/4/2n6315/44249500 I recommend getting lots of extras though, because the batch I got had a lot of poor ones. I'd suggest setting up a simple beta test as described under "Matching Power Transistors" on page-1 of the article. (It can be done more simply--I can provide details and a sketch if you're interested.) I looked into the ECG175 as best I could. Couldn't find much on it but some refs cross it to NTE175. That is a much higher voltage device but somewhat lower current. It's hard to tell much. When you tested them as good, I guess that just means no C-E short?

> Should I give up on the NTE pair, reinstall the original RCA 40361, and find a 2N4032 to replace the blown RCA 40362? What about the ECG175s?

--- I would have to go with your idea to replace all of the driver & output transistors (with the recommended substitutes) and install the 47pF and 390pF caps. That's the only thing I know for sure that works well. Be aware though, that there could be something else wrong here that the simple tests aren't revealing. Will be happy to help if you have further questions. Steve

Hi. Thank you so much for writing back. Lots of suggestions in your note. I will reply and answer all your questions. This may take a little time!

I did not install the "taming" caps. That's next.

When I say "tested", I mean that the transistor showed as NPN or PNP with appropriate hfe and forward voltage drop. I used this device:

Multifunction Meter DIY kit, kuman Mega 328 Graphic transistor Tester, NPN PNP Diodes Triode Capacitor ESR SCR MOSFET Resistor Inductance LCD Display Checker with case and screwdriver K77 $17.50

This has just been an awesome help. I think you would like it yourself.

NTE175 = ECG175. My understanding is that all ECG part numbers have NTE equivalents under the same number.

I'll try the "taming" capacitors and take the waveform pictures. The caps might fix this.

When I'm done, I'll take waveform pictures and send them to you.
Thanks again! Mike S.

Hi Michael,
I'm glad you're using the Mega 328 for testing transistors. I use a somewhat similar Peak DCA55 tester for testing small signal transistors. It's pictured in the "Matching Power Transistors" section on page-1 of the article. Be aware though, that this type of tester uses a fairly low test current so results can be misleading for power transistors. For those, beta may fall off at very low currents.
Cheers, Steve

Hello again. I added the "taming" caps. I also put back the original 40361/Q303 NPN driver. Only Q302/NTE129/PNP driver is new. I changed C303 and R308 to Eico's suggested values (per your illustration). The ECG175 output transistors remain. The result was a significant improvement. High frequency harmonics are gone. The waveforms of both channels are clean. Both channels start to clip at about the same volume at the various test frequencies. Frequency response from 50-15000 hertz is good. Not linear, but pretty good. So, I think I have fixed it--thank you for your help.

Not sure about the ECG175s. I may try to obtain (4) 2N6315s, if I can find some at a reasonable price. I presume I will have to buy more than four and go through your matching process to get reasonably matched pairs. I don't think the ECG175s are matched. The waveforms don't clip evenly. Good enough for now.

Thanks again for your help! Next I am going to try a multiplex alignment of the companion Cortina 3200 tuner.
Sincerely, Mike S

P.S. I have four, good, matched (pairs) RCA SK3026 NPN power transistors. I found these specs:

SK3026 Datasheet, Equivalent, Cross Reference Search
Type Designator: SK3026
Material of Transistor: Si
Polarity: NPN
Maximum Collector Power Dissipation (Pc): 29 W
Maximum Collector-Base Voltage |Vcb|: 90 V
Maximum Collector-Emitter Voltage |Vce|: 60 V
Maximum Emitter-Base Voltage |Veb|: 7 V
Maximum Collector Current |Ic max|: 4 A
Max. Operating Junction Temperature (Tj): 200 °C
Transition Frequency (ft): 0.5 MHz
Collector Capacitance (Cc): 70 pF
Forward Current Transfer Ratio (hFE), MIN: 70
Noise Figure, dB: -
Package: TO66

Would these meet or exceed the specifications of the original RCA 40312s?

40312 Datasheet, Equivalent, Cross Reference Search
Type Designator: 40312
Material of Transistor: Si
Polarity: NPN
Maximum Collector Power Dissipation (Pc): 29 W
Maximum Collector-Base Voltage |Vcb|: 60 V
Maximum Emitter-Base Voltage |Veb|: 2 V
Maximum Collector Current |Ic max|: 4 A
Max. Operating Junction Temperature (Tj): 200 °C
Transition Frequency (ft): 0.375 MHz
Forward Current Transfer Ratio (hFE), MIN: 20
Noise Figure, dB: -
Package: TO66

Thanks, Mike

Congratulations, Michael! So glad that it's working now. I wouldn't worry too much about getting the beta match just right. It depends heavily on what collector current you match it at. No doubt you've seen the comments in the article about doing that. To get any reasonable current, you would need to set up a lab test. I settled on holding the base current at 1mA, which put the collector currents at ~76mA for the devices I had. But even that is nowhere near the 2000mA peak or so the critter has to deliver at full power. So I would consider a 20% match to be fine. About the waveforms clipping evenly: Note that this early type of power amp circuit necessarily uses a single-polarity power supply. The evenness of clipping will depend in part on how close the DC level at the output (before the big C6 coupling cap) comes to half the supply voltage. (Due to secondary issues, the exact voltage which evens-up clipping may be slightly different.)

A quick search, unsurprisingly, didn't turn up a real datasheet for the SK3026 and one cannot tell from the tabulated numbers how well it might perform in the circuit. There is no info on the critical safe-operating-area (SOA) performance. Max collector current and Ft are low compared to the 2N6315. We don't know what current they matched them at, so the fact that they claim they're matched is weak. If the 2N6315s really are available for just $3.15 each, they're a bargain. The only caveat: When I dealt with Quest Electronics many years ago, they had a $25 minimum order. But I would consider buying 8 units a reasonable shot at matching, getting spares and covering any poor ones.

The 2N6315 really is extraordinary and I seriously doubt one can beat it in a TO-66 package, certainly not with a flea-bitten replacement-type transistor :) A datasheet is attached [**at the end of this thread**]--a feast for the eyes:

- Check out the SOA curves on the last page: It holds 2 amps up to almost the full power supply of the Cortina.
- First page: Handles 7A continuous! 90W power diss!
- Page-2: Min beta of 20 guaranteed up to 2.5A, Ft = 4MHz minimum.
- Page-3: Typical beta curves show 70 at 1A and 45 at 2A.

That sucka walks on water! :-D Steve

Just ordered (12) 2N6315s. Cost: $36.45 including $11.65 shipping. At least they didn't charge tax. AND I have a second 3070 that I can convert to 2n6315s. So, it should be worth it.
Thanks again, Mike

Congrats! That's about $459 worth of silicon at Mouser's price!
Of course, you know to include the taming caps on the conversion(s).
Let me know how it goes.
All the best, Steve

Just got my (12) 2n6315s. I used my Kuman Mega 328 to match them. hfe ranged from 21 to 62. I created two matched pairs (hfe within 52 to 56). I then replaced the ECG175s. Turned it on. Transistors stayed cool. Idle current below 20ma. I played an instrumental track (called Louis' Blues) from an obscure 1973 Buddy Miles album called "Booger Bear". This seems like a rather unscientific test. However, previously, I could only play it at 2/3 volume without obvious distortion. This time I played it at full volume, and it sounded great! So, I would consider the 2N6315s a rousing success! I don't think the ECG175s were an adequate choice for this amp. Besides, according to the Kuman, the transistors were wildly mismatched. hfe ran from 59 to 264.

I have four other 2N6315s with hfe from 21 to 25. I'd like to use them in my other 3070. Of course, I'll have to include the "tamer" caps you recommended. Is it OK to use the lower hfe transistors if they are closely matched?
Thanks for all your help. Mike S.

Hi Mike,
Kudos for your success with the new transistors! Yes, I would say it's okay to use the ones with low-current hfe of 21-25. That's typical of many that I have. The Mospec datasheet shows minimum hfe of 20 at Ic=2.5A and 35 at Ic=0.5A. There isn't much indication of hfe at the low collector currents the Kuman would use. Does it show what collector current it used? The Peak DCA55 used Ic=2.5mA. As I mentioned before, hfe can change with Ic. I just took some lab data on two 2N6315s to see how hfe varied with Ic. I set the base current in decade values, so collector currents come out at odd values. Here is what I found. (I'm making this an image since I can't trust the email clients to retain formatting of the table.)

2N6315 Unit#10

Collector Current	Beta(hfe)
222.0mA	22.2
29.5	29.5
2.26	22.6
185.4uA	18.5
14.6	14.6

2N6315 Unit#5

Collector Current	Beta(hfe)
22.04mA	22.0
1.70	17.0
142.1uA	14.1
12.0	12.0

So it seems that 2.5mA current used by the Peak tester will get reasonable values. For matching, more current would be nice but probably isn't critical.

So I'm very happy to hear that things are going well for your 3070 projects. Would you mind if I quote some of this in a write-up in the Reader Comments section of the article? I think it could be helpful for others. Please keep me posted. Thanks, Steve

MOSPEC

COMPLEMENTARY SILICON MEDIUM-POWER TRANSISTORS

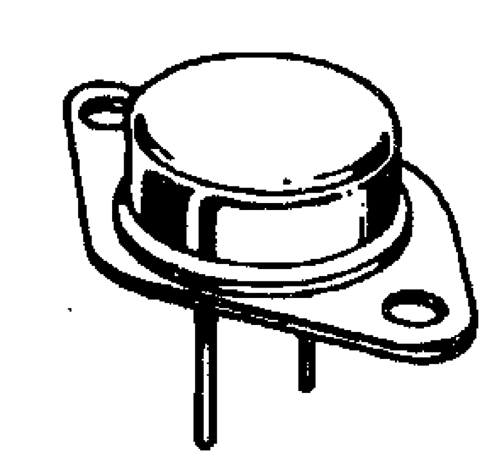
... designed for general-purpose power amplifier and application.

FEATURES:

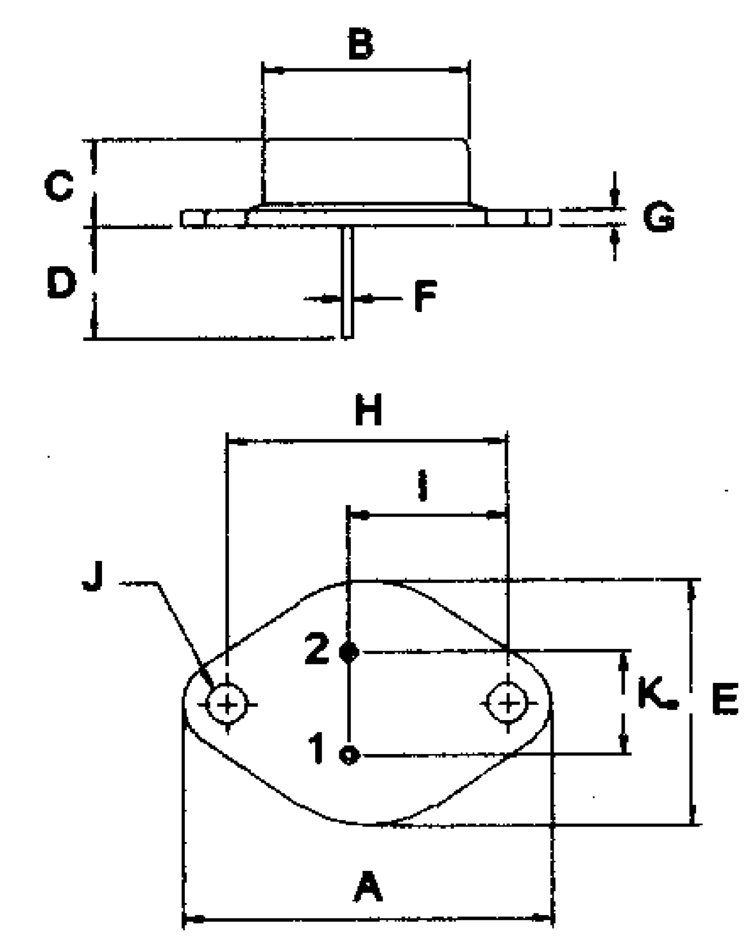
* Low Collector-Emitter Saturation Voltage $V_{CE(SAT)}$ = 1.0 V (Max) @ I_C = 4.0 A
* Excellent DC Current Gain- hFE = 20 (Min) @ I_C =2.5A
* Low Leakage Current - I_{cex}=250 uA (Max)

NPN	PNP
2N6315	2N6317
2N6316	2N6318

7.0 AMPERE
COMPLEMENTARY SILICON
POWER TRANSISTORS
60-80 VOLTS
90 WATTS



TO-66



PIN 1.BASE
2.EMITTER
COLLECTOR(CASE)

DIM	MILLIMETERS	
	MIN	MAX
A	30.60	32.52
B	13.85	14.16
C	6.54	7.22
D	9.50	10.50
E	17.26	18.46
F	0.76	0.92
G	1.38	1.65
H	24.16	24.78
I	13.84	15.60
J	3.32	3.92
K	4.86	5.34

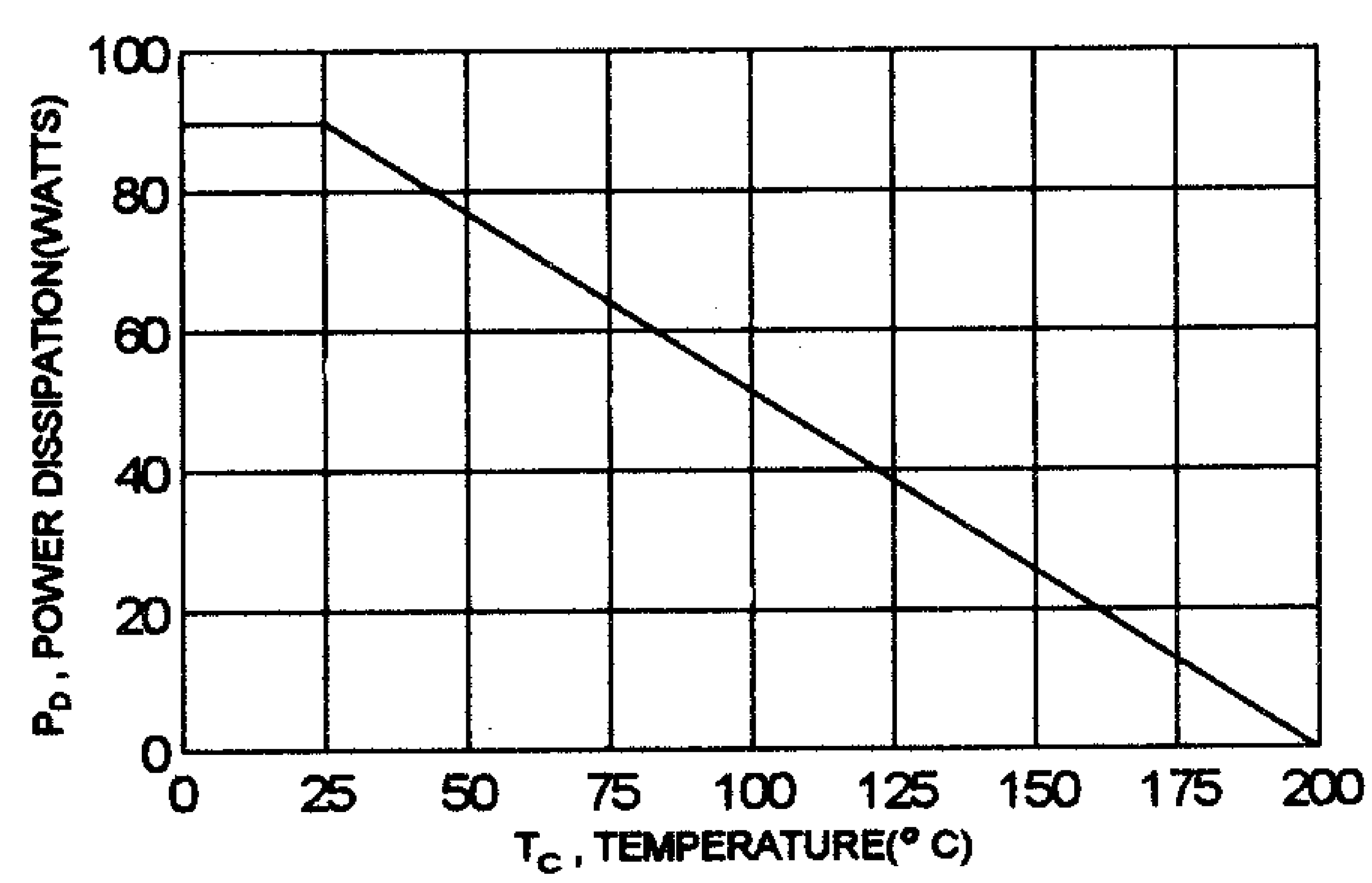
MAXIMUM RATINGS

Characteristic	Symbol	2N6315 2N6317	2N6316 2N6318	Unit
Collector-Emitter Voltage	V_{CEO}	60	80	V
Collector-Base Voltage	V_{CBO}	60	80	V
Emitter-Base Voltage	V_{EBO}	5.0		V
Collector Current-Continuous -Peak	I_C	7.0 15		A
Base Current	I_B	2.0		A
Total Power Dissipation @T_C=25°C Derate above 25°C	P_D	90 0.515		W W/°C
Operating and Storage Junction Temperature Range	T_J , T_{STG}	- 65 to +200		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance Junction to Case	Rθjc	1.94	°C/W

FIGURE -1 POWER DERATING



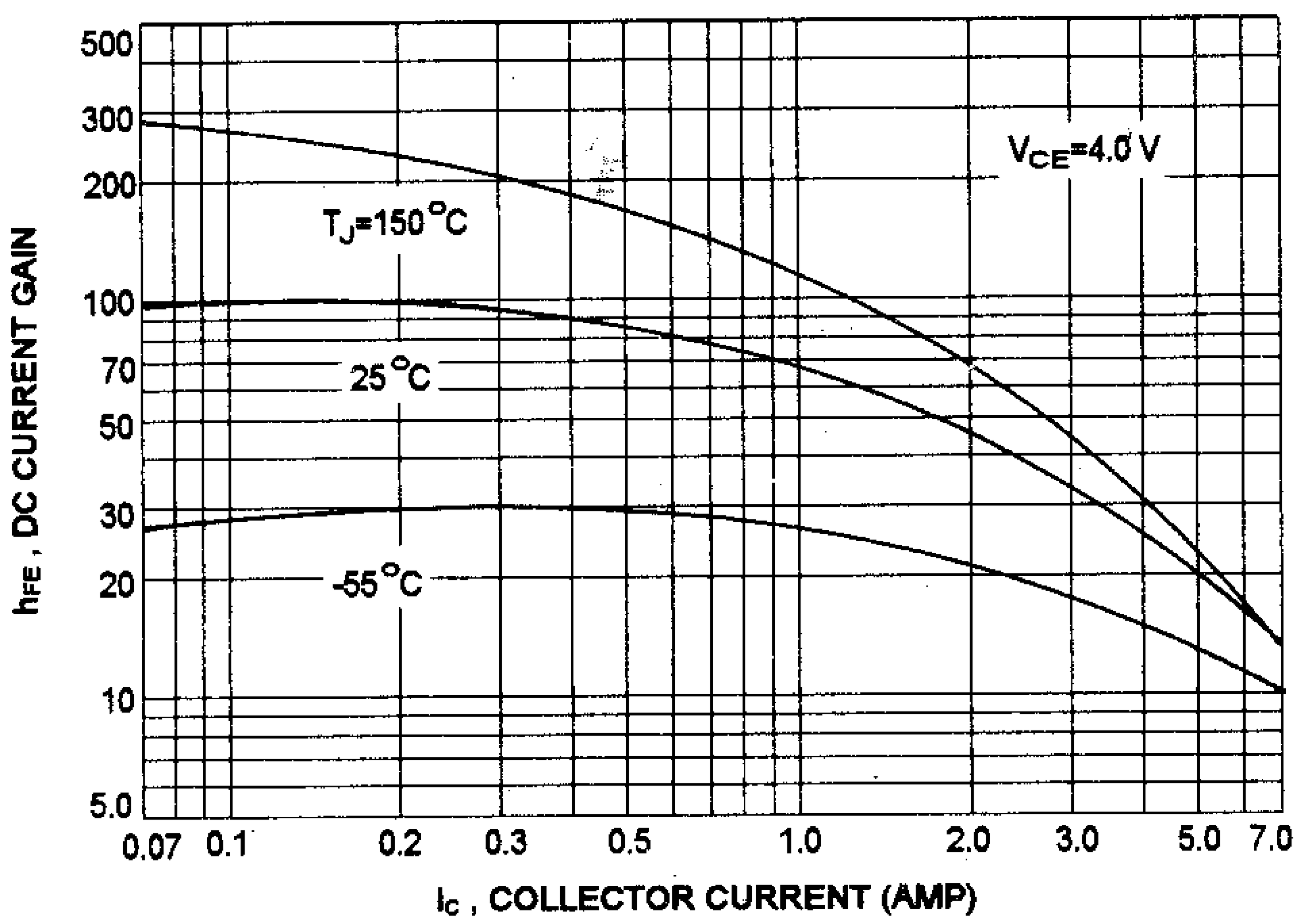
ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector - Emitter Sustaining Voltage (1) (I_C = 100 mA, I_B = 0)	 2N6315,2N6317 2N6316,2N6318	$V_{CEO(SUS)}$	 60 80		V
Collector Cutoff Current (V_{CE} = 30 V, I_B= 0) (V_{CE} = 40 V, I_B= 0)	 2N6315,2N6317 2N6316,2N6318	I_{CEO}		 0.5 0.5	mA
Collector Cutoff Current (V_{CE}=60 V, $V_{BE(OFF)}$ = 1.5 V) (V_{CE}=80 V, $V_{BE(OFF)}$ = 1.5 V) (V_{CE}=60 V, $V_{BE(OFF)}$ = 1.5 V, T_C = 150°C) (V_{CE}=80 V, $V_{BE(OFF)}$ = 1.5 V, T_C = 150°C)	 2N6315,2N6317 2N6316,2N6318 2N6315,2N6317 2N6316,2N6318	I_{CEX}		 0.25 0.25 2.0 2.0	mA
Collector Cutoff Current (V_{CB} = 60 V, I_E=0) (V_{CB} = 80 V, I_E=0)	 2N6315,2N6317 2N6316,2N6318	I_{CBO}		 0.25 0.25	mA
Emitter Cutoff Current (V_{EB} = 5.0 V , I_C = 0)		I_{EBO}		1.0	mA
ON CHARACTERISTICS (1)					
DC Current Gain (I_C = 0.5 A , V_{CE} = 4.0 V) (I_C = 2.5 A , V_{CE} = 4.0 V) (I_C = 7.0 A , V_{CE} = 4.0 V)		hFE	 35 20 4.0	 100 	
Collector - Emitter Saturation Voltage (I_C = 4.0 A , I_B = 0.4 A) (I_C = 7.0 A, I_B = 1.75 A)		$V_{CE(sat)}$		 1.0 2.0	V
Base - Emitter Saturation Voltage (I_C = 7.0 A, I_B = 1.75 A)		$V_{BE(sat)}$		2.5	V
Base - Emitter On Voltage (I_C= 2.5 A, V_{CE} = 4.0 V)		$V_{BE(on)}$		1.5	V
DYNAMIC CHARACTERISTICS					
Current Gain - Bandwidth Product (2) (I_C = 0.25 A , V_{CE} = 10 V , f = 1.0 MHz)		f_T	4.0		MHz
Small-Signal Current Gain (I_C=0.5 A, V_{CE}=4.0 V, f= 1.0 KHz)		h_{fe}	20		

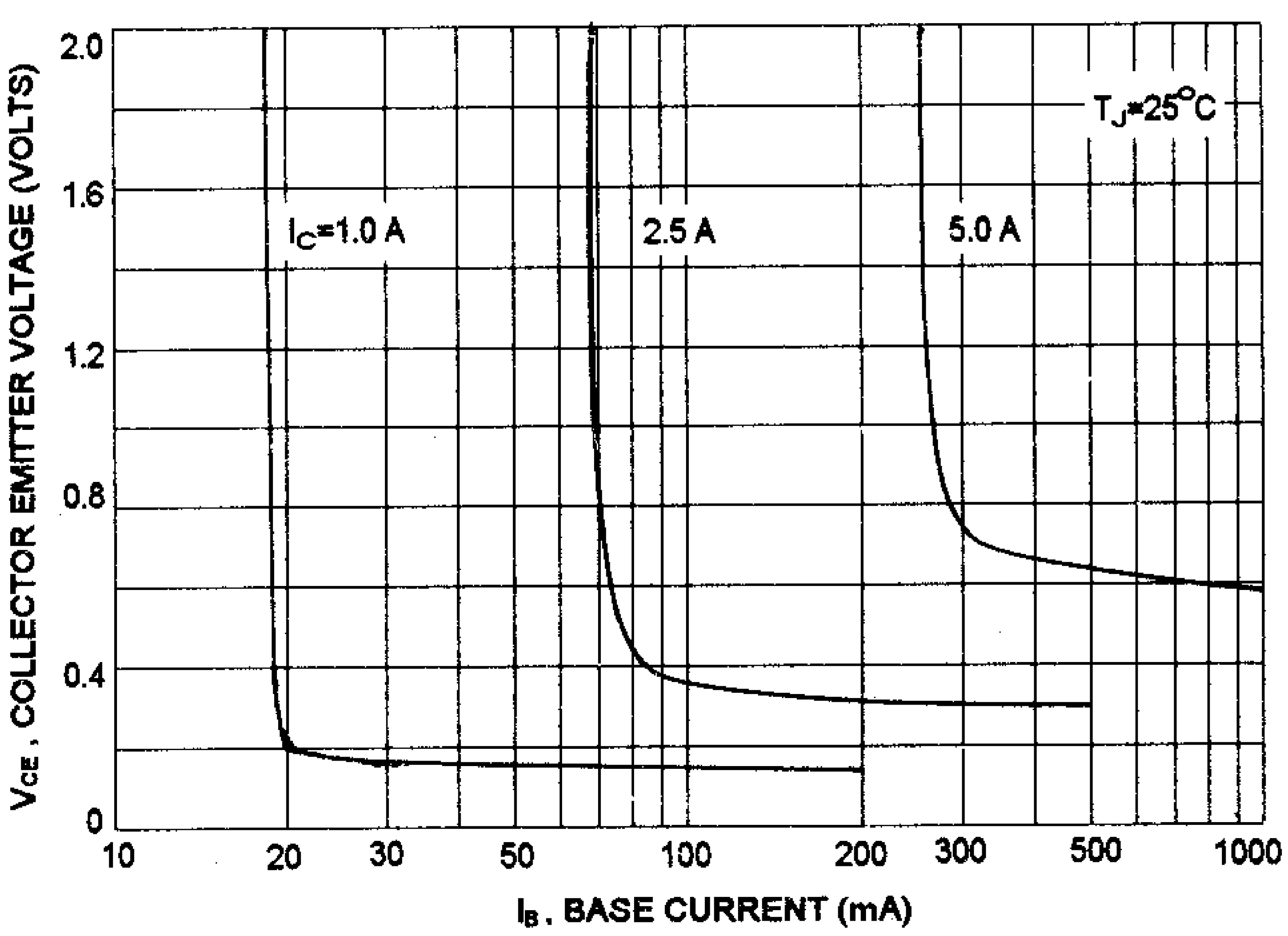
(1) Pulse Test: Pulse width = 300 μs , Duty Cycle ≦ 2.0%
(2) $f_T = |h_{fe}| \circ f_{test}$

NPN 2N6315,2N6316

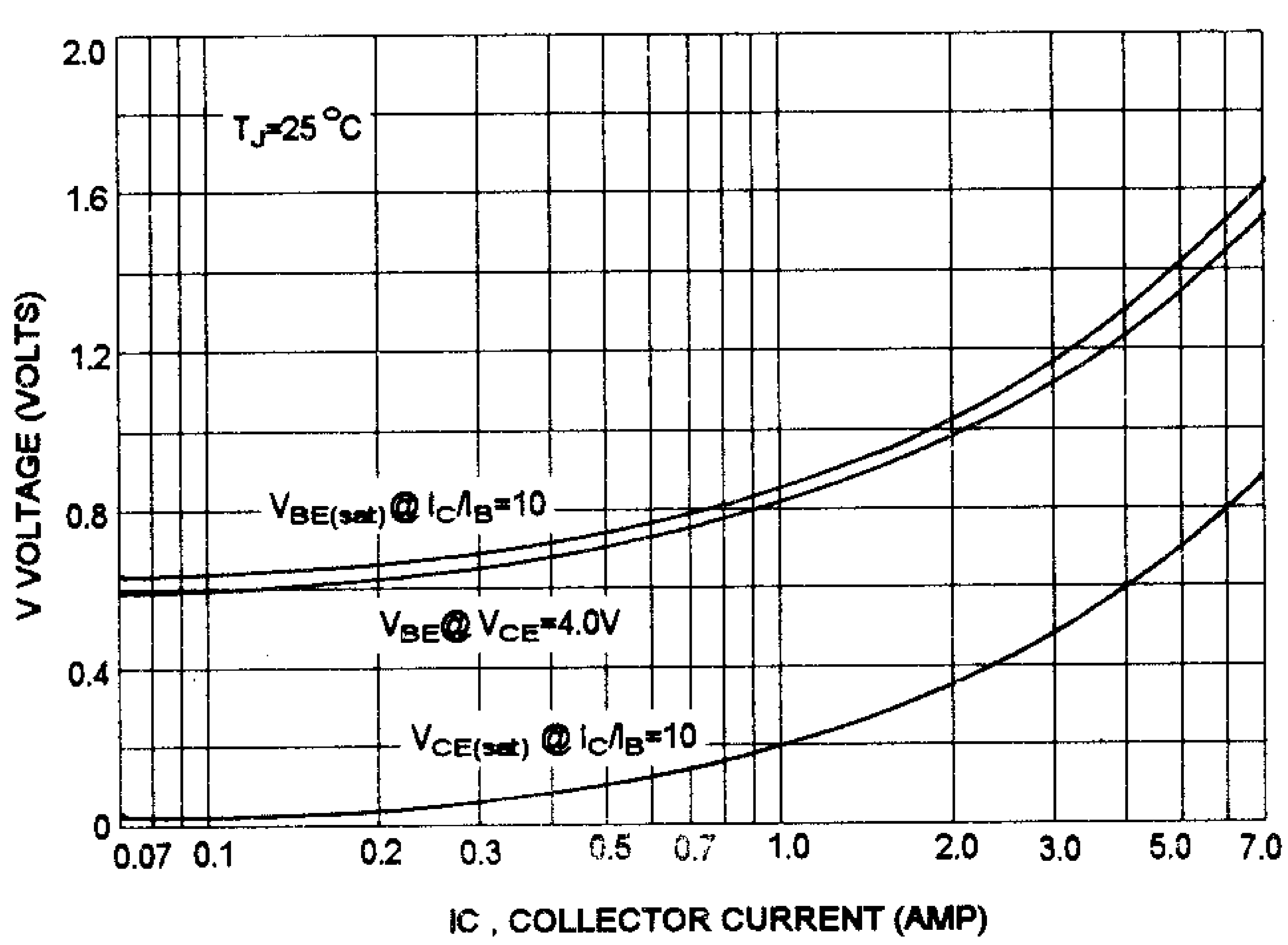
DC CURRENT GAIN



COLLECTOR SATURATION REGION

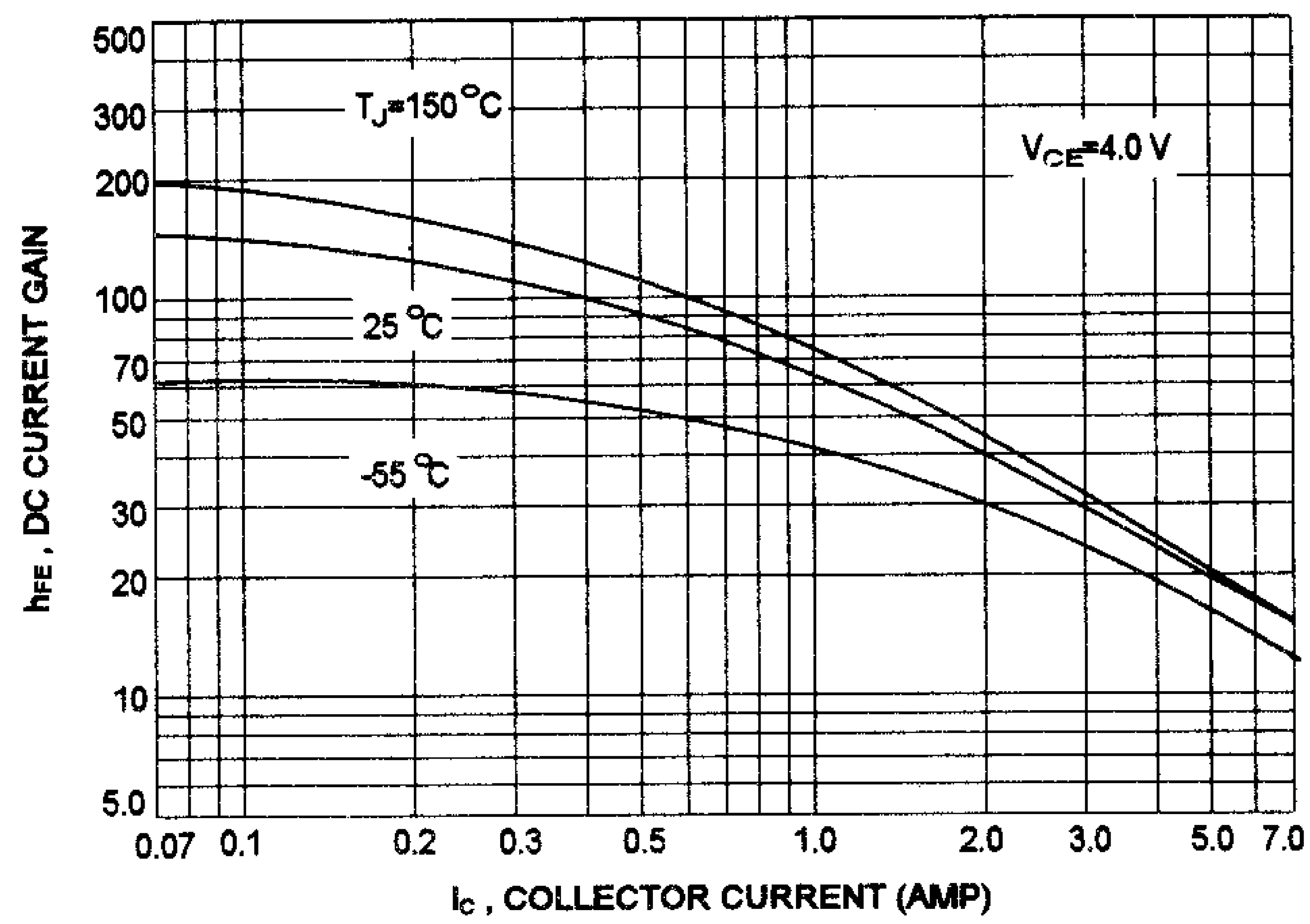


"ON" VOLTAGES



PNP 2N6317,2N6318

DC CURRENT GAIN



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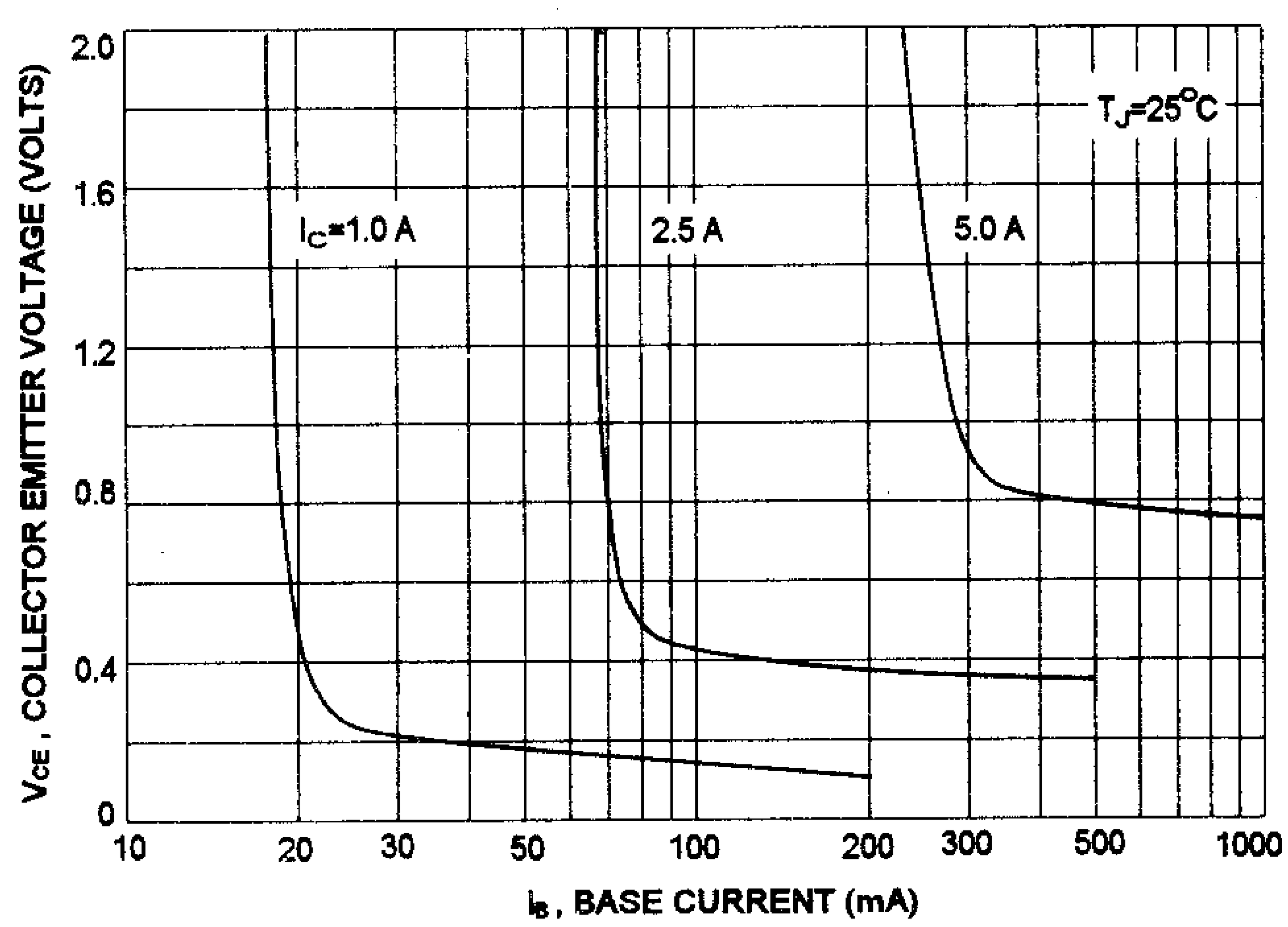

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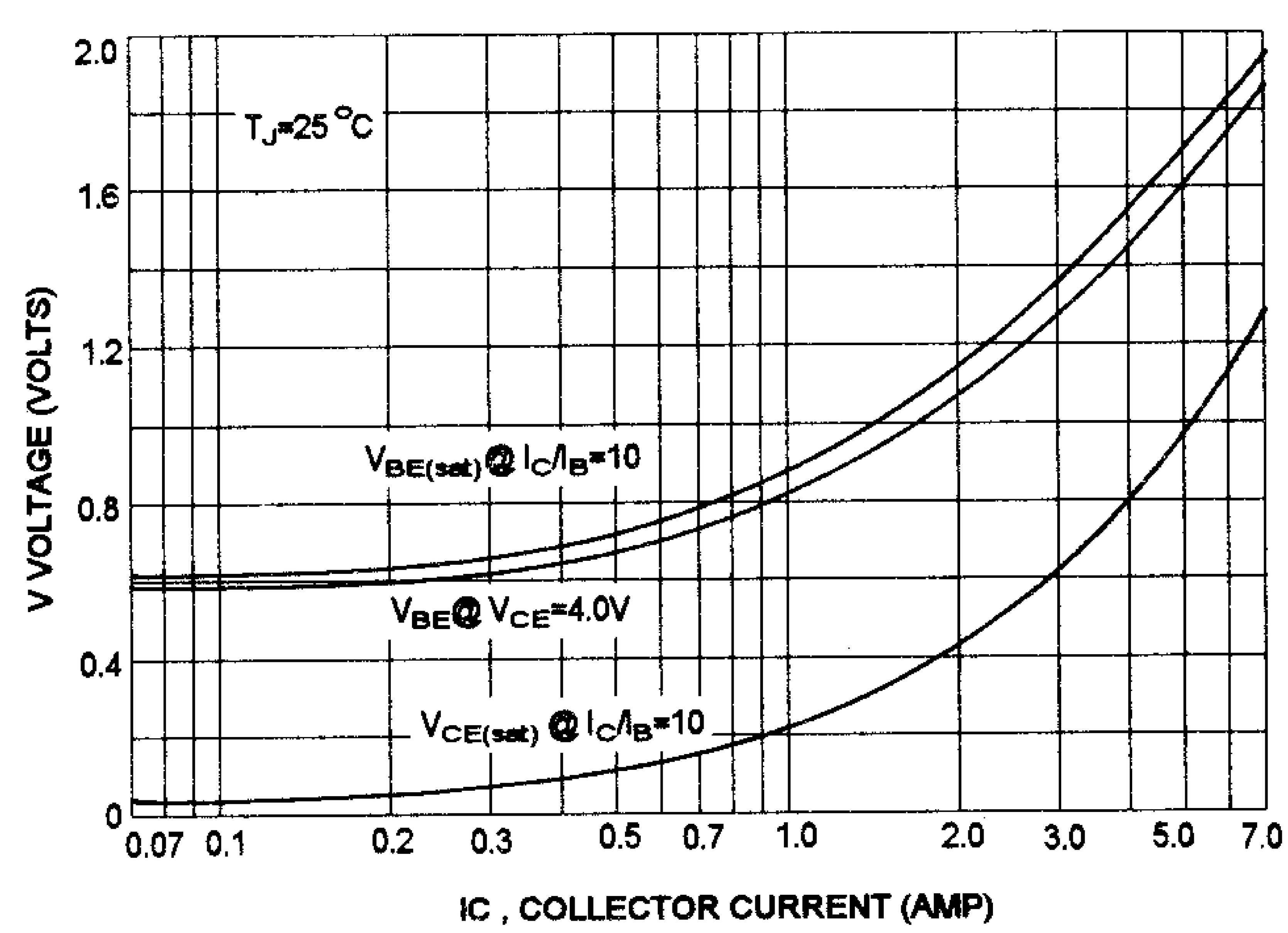
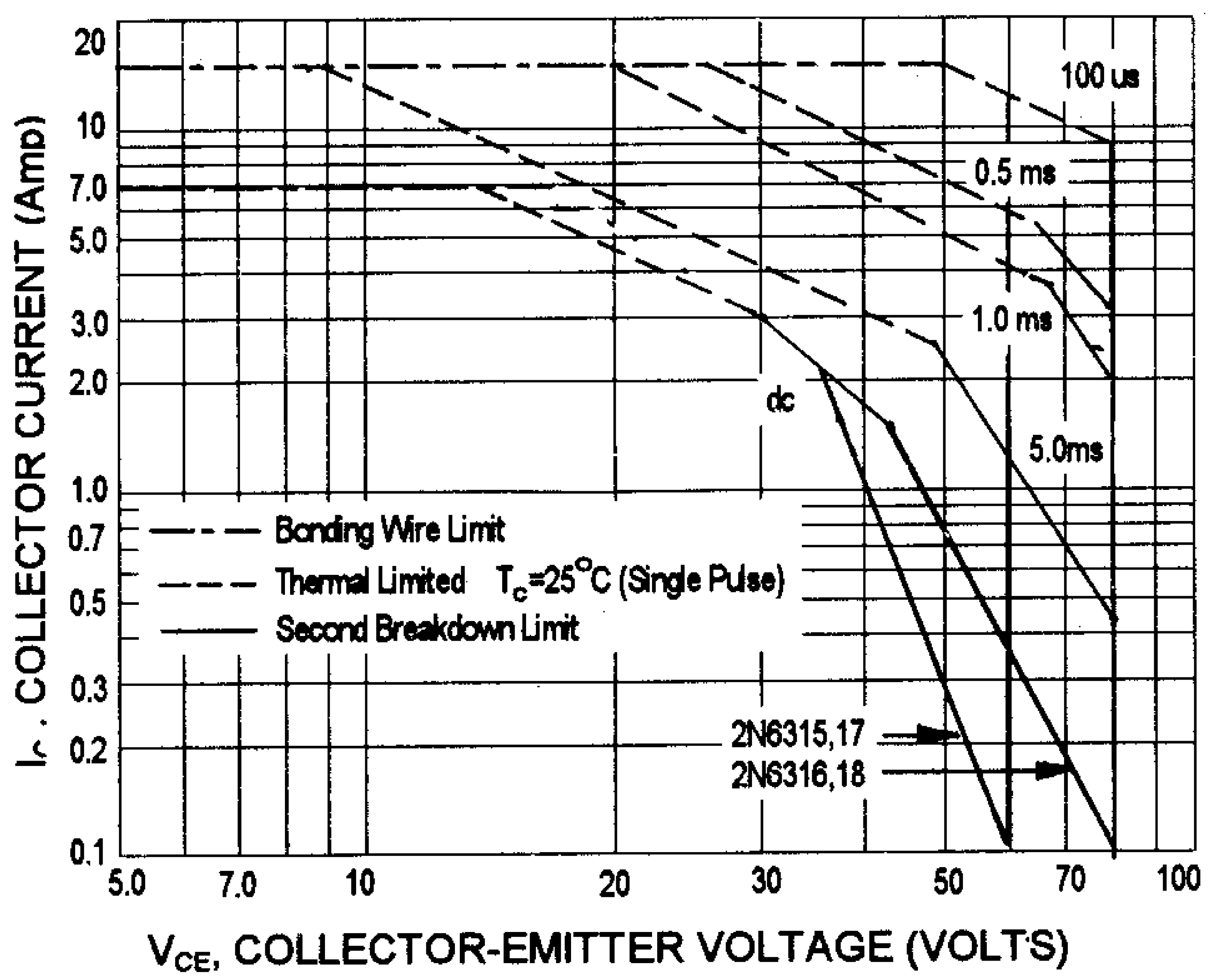


ACTIVE-REGION SAFE OPERATING AREA (SOA)



There are two limitation on the power handling ability of a transistor:average junction temperature and second breakdown safe operating area curves indicate I_C-V_{CE} limits of the transistor that must be observed for reliable operation i.e., the transistor must not be subjected to greater dissipation than curves indicate.

The data of SOA curve is base on $T_{J(PK)}$=200 °C;T_C is variable depending on conditions. second breakdown pulse limits are valid for duty cycles to 10% provided $T_{J(PK)} \leq 200$°C,At high case temperatures, thermal limitation will reduce the power that can be handled to values less than the limitations imposed by second breakdown.