A-3-6 A HIGH CURRENT GAIN, HIGH SPEED POWER GATE ASSOCIATED TRANSISTOR

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It has been desired to develop power transistors with common-emitter current gain (h_{FE}) of more than 20 and both rise time (t_r) and fall time (t_f) of less than 0.2μs for application to high speed inverters operating at 50 - 100 kHz.

Unfortunately, transistors have inherent difficulties for achieveing high current gain, high switching speed and high collector voltage simultaneously. So that conventional power transistors have h_{FE} of less than 10, both t_r and t_f of more than 0.3μs, collector-emitter sustaining voltage ($V_{CER(sus)}$) of 650 V and average collector current rating (I_{AC}) of 50 A.

Gate Associated Transistors (GAT's), proposed by us,[1)-4)] have been shown to overcome above difficulties. However, high power GAT with a current rating of 50A needs further development to satisfy above requirement.

We developed here a multi-emitter GAT. Optimum design of gate structure and multi-emitter structure decreased capacitance between gate and emitter and also reduced fall-off of current gain at high collector current.

In this paper, characteristics of the power GAT are described. The GAT has h_{FE} of 30, t_r of 0.17μs, t_f of 0.15μs, $V_{CER(sus)}$ of 630 V and I_{AC} of 50 A. The h_{FE} of the GAT is about 5 times as high as that of the conventional power transistor and both the t_r and the t_f of the former is about one half of those of the latter.

Fig.1 shows typical measurements of h_{FE} vs. collector current of both the GAT and the conventional power transistor. High h_{FE} in the GAT is achieved by the gate shielding effect[1)] and the relatively small fall-off in the h_{FE} at high collector current is accomplished by means of the multi-emitter structure. Fig.2 shows typical measurements of collector-emitter saturation voltage ($V_{CE(sat)}$) vs. base current (I_B) of both transistors. The I_B of the conventional transistor is about 3 times as large as that of the GAT at which $V_{CE(sat)}$'s of both transistors are same. This implys that a base circuit for the GAT can be simple compared with that of the conventional transistor. Fig.3 shows a turn-on wave form of collector current in the GAT. The t_r of the GAT is 0.17μs when I_B=4A, while that of the conventional transistor is 0.30μs when I_B=10A. The t_f of the GAT is also about one half of that of the conventional transistor. From figure 2, the $V_{CE(sat)}$ of the GAT is 0.36V when I_B=4A, while that of the conventional transistor is 0.49V when I_B=10A. These results imply that both a transient loss and a steady state loss of the GAT is smaller than those of the conventional transistor, moreover that the base current of the former can be less than one half of that of the latter. Table I shows electrical characteristics of the GAT compared with those of the conventional transistor.

In conclusion, application of the power GAT is suitable for improving performance of high power switching circuits because it shows smaller switching loss and it needs lower base current than the conventional transistor. The power GAT is promising for application to high speed inverters operating at 50 - 100 kHz.

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References: 1)H.Kondo,et al.,IEEE Trans.Electron Devices,vol.ED-27,pp.373-379,1980. 2)H.Kondo,et al.,1979 IEEE ISSCC Dig.Tech.Papers,vol.22,p.84. 3)H.Kondo,et al., 1979 International Conf.on Solid State Devices,Tokyo,A-6-13. 4)H.Kondo,et al., Japan.J.Appl.Phys.,vol.18,Supp.18-1,pp.329-333,1979.

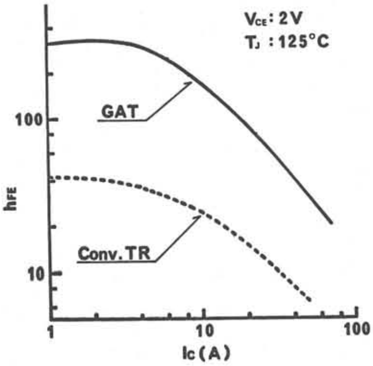

Fig.1 h_{FE} vs. I_C

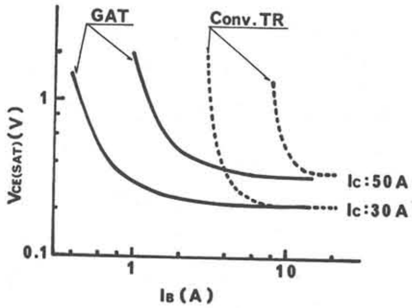

Fig.2 $V_{CE(sat)}$ vs. I_B

Fig.3

Turn-on wave form of the collector current of the power GAT
I_B=4A, I_C=50A, V_{CC}=300V
V:10A/div. H:0.1µs/div.

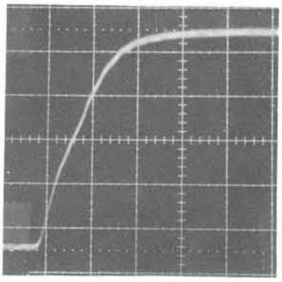

Table I Electrical characterictics of power GAT and conventional transistor

	Power GAT		Conventional transistor	
BV_{CBO}(V)	680	I_{CBO}=150µA	690	I_{CBO}=150µA
$BV_{CER(sus)}$(V)	630	I_C=1A, R_{EB}=50ohm	650	I_C=1A, R_{EB}=50ohm
I_{AC}(A)	50	h_{FE}=30	50	h_{FE}=6
h_{FE}	30	V_{CE}=2V, I_C=50A, T_j=125°C	6	V_{CE}=2V, I_C=50A, T_j=125°C
$V_{CE(sat)}$(V)	0.36	I_C=50A, I_B=4A	0.49	I_C=50A, I_B=10A
t_r (µs)	0.17	V_{CC}=300V, I_C=50A, I_{B1}=4A, I_{B2}=5A	0.50	V_{CC}=300V, I_C=50A, I_{B1}=$-I_{B2}$=10A
t_{stg}(µs)	3.5		2.5	
t_f (µs)	0.15		0.30	