ZEN™ AMPLIFIER WITH GENESIC GA10JT12 TRANSISTOR

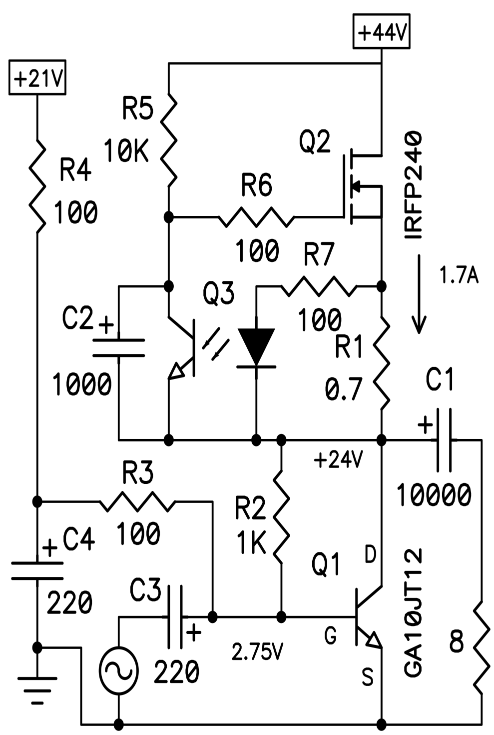
By Nelson Pass

Some discussion came up recently on www.diyaudio.com in the Pass Labs forum regarding the Genesic GA10JT12, a Silicon Carbide junction transistor. I procured some through distribution and tested them in a single-ended Class A amplifier operating in Common Source mode, the Zen™ Amplifier from 1994. Also my attorney who informs me that it is time to renew the Zen™ trademark, requiring an example of its use.

The GA10JT12 is described in the literature:

www.**genesics**emi.com/images/products_sic/sjt/**GA10JT12**-247.pdf

Unlike some of the Silicon Carbide transistors I have played with before, it does not operate with an insulated Gate nor does it behave as a typical junction FET transistor. The circuit symbol used by the company shows a bipolar transistor diagram with the pins labeled Source, Drain and Gate. Also different is that it has substantial Gate current in linear operation, and the gain is given as current gain, typically at a value of 100 of so. This results in a quite low impedance at the Gate compared to the usual FETs we have seen in Zen ™ amplifiers, and requires some adjustment in the circuitry. Here is the circuit:



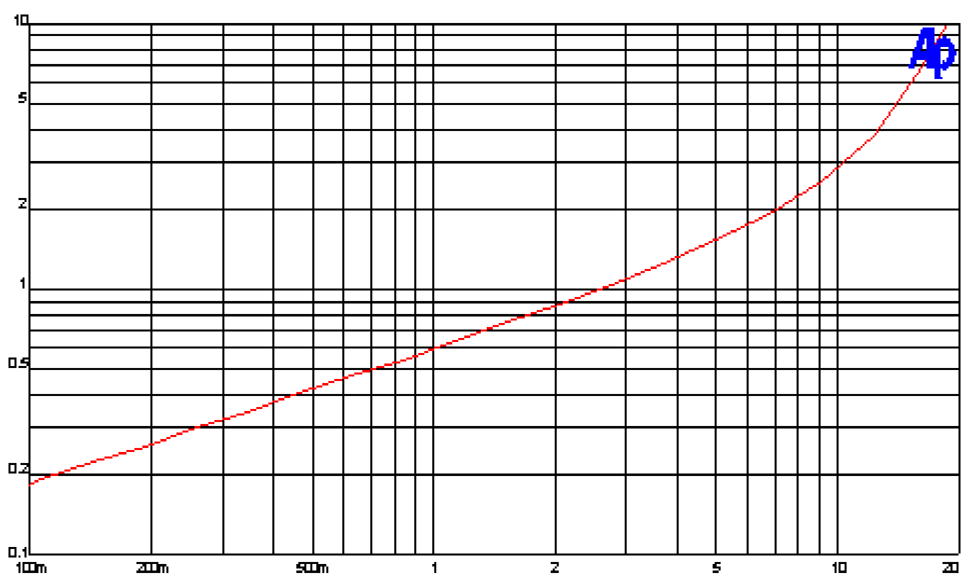
You can see a constant current source provided by Q2, R1, R5, R6, R7, C2 and an opto-isolator Q3 used as a current regulator. This circuit provides a relatively constant amount of DC current to bias Q1, the transistor of interest. Current through R1 develops about 1.1 volts across the LED portion of the opto-isolater which emits light that turns on the photo sensitive transistor of Q3 and this forms a feedback loop around Q2 which regulates the current.

Q1 also requires bias current into its Gate pin to put the GA10JT12 into forward conduction, and this is provided by R3, C4 and R4 which are supplied with 21 volts (adjustable), driving about 100 mA into the junction of Q1 so as to set the bias current at 1.7 amps and develop 24 volts DC at the output (before the output capacitor C1). R2 provides a small amount of feedback to help stabilize this DC value. An 8 ohm load resistor is placed on the output after C1.

The input signal comes from an Audio Precision analyzer with a 25 ohm source impedance, and it is capacitively coupled through C3.

In this setup, the gain of the amplifier is 19 dB, and with a 100 ohm source the gain is 8 dB. Clearly the gain is current gain, and the input impedance seen at the Gate pin is on the order of 2 ohms or so.

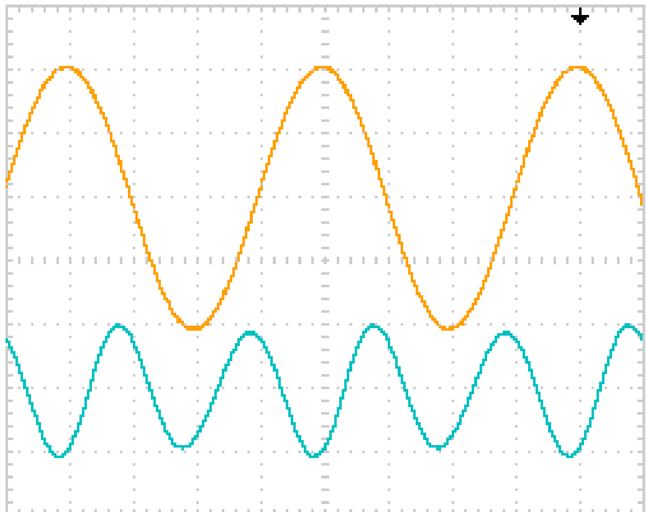
Here is a graph of the distortion vs output wattage into 8 ohms:



ZEN WITH GA10JT12 DISTORTION VS OUTPUT

This was with the 25 ohm source. Remarkably this is nearly identical to the distortion curve of the original Zen ™ Amp of 1994, and the gain was the same.

Here is the waveform of that distortion, a nice looking second harmonic:



DISTORTION WAVEFORM AT 1 WATT

Developed with almost no feedback, this is pretty good performance, however there are a couple of drawbacks:

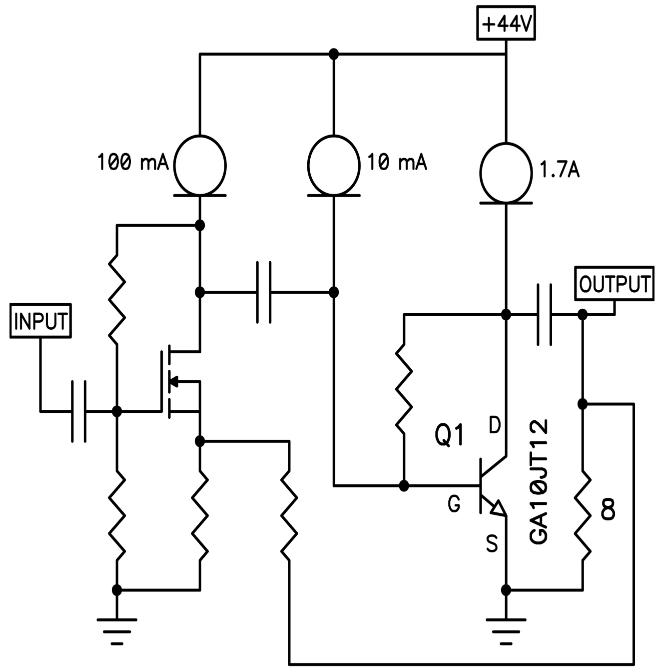
First, the input impedance is quite low, in the range of 2 ohms or so, so it needs to be driven by a current source. This will also lower the distortion figure – raising the source impedance to 100 ohms just about halves the distortion at a given output level.

At a bias of 1.7 Amps, the AC current gain of the transistor is about 30, and with a 10 mA input current we see 300 mA output current, for 2.4 volts into 8 ohms. With this circuit, we would get about 10 watts output with a 300 mA signal input.

This figure for current gain is less than the quoted 100 or so for this part, but that spec is for the transistor at higher currents, the transistor being originally intended for use mostly as a switch. However, you could drive it with a headphone amplifier, like our HPA-1 through a 20 ohm input resistor.

The second issue - the output impedance of this circuit without significant feedback is quite high, so your input current source will also want to take feedback from the output to lower the output impedance as well as the distortion.

Without elaboration, here is an example of a simple topology that would accomplish something like this. Constant current sources show simplified blocks where more complex discrete sub-circuits might be used. Ideally they would all be adjustable. An input Mosfet (a Toshiba 2SK2013 would be a good example) serves to provide input buffering and has a high impedance output so as to act as an active current source from its Drain while taking feedback from the overall output back to its Source pin. The various resistor values are set to give the desired gain and feedback.



This should not be considered the best possible circuit, but is intended to illustrate an approach where a current source input and feedback to the GA10JT12 might be simply achieved. Alternatively, you can control the bias and feedback with an op-amp circuit.

Higher bias current through the GA10JT12 will give more current gain and greater linearity, but at some point you will be limited by the temperature of the transistor, whose maximum junction temperature is 175 deg C.

Given its switching design origin, is the GA10JT12 an ideal transistor for a little single-ended Class A amplifier? Maybe. Given that many of the other parts we use are intended for switching, that wouldn't be a good reason to exclude it. The additional complexity of having Gate current complicates it a bit, but on the other hand, until you have listened to an amplifier using it, you never know.

and remember: *Zen* ™ is a trademark of Pass Laboratories, Inc.