THE CURVE TRACER

APPENDIX G

A handy instrument for exploring transistor behavior of both BJTs (Chapter 2) and MOSFETs (Chapter 3) is the *curve tracer*. Most simply, it plots collector current versus collector voltage for a family of equally spaced base currents (or, if you want to be an Ebers–Mollian, base *voltages*), and with a selectable current-limiting collector resistor.[1] Figure G.1 shows what you get from a random 2N3904, driven with seven successive base current steps of 5 μA each while sweeping the collector voltage from 0 to 50 V. You can see clearly the rise of beta with collector voltage, and the onset of breakdown somewhat below 50 V (maximum V_{CEO} is specified as 40 V). This particular curve tracer obligingly displays the scale factors, including "β per div," which is about 200 for this specimen (the datasheet specifies $100 \leq \beta \leq 300$ at I_C=10 mA). A curve tracer makes it easy to select closely matched pairs.

Sadly, the traditional curve tracer has disappeared from the product lines of most T&M (test and measurement) manufacturers, including the venerable Tektronix. You can still find them used, for example on eBay, for a thousand dollars or so. Agilent offers some pretty fancy contemporary instruments that will do the job, though it's best to be sitting down when you ask the prices; they go by names like Semiconductor Parameter Analyzer (model 4155C), or Power Device Analyzer/Curve Tracer (model B1505A).

[1] You can run it as common base, if you like; and it has many amusing knobs to play with.

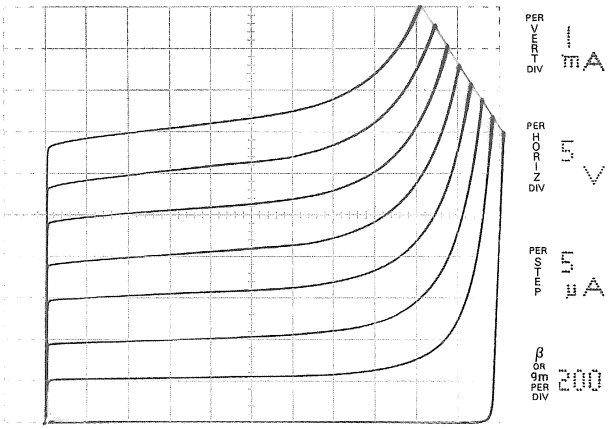

Figure G.1. Tektronix 576 Curve Tracer display of a 2N3904.

A less expensive alternative is to use a "source-measure unit" (SMU), a delightful instrument that lets you source voltages and currents to selected terminals of a device (or subcircuit), simultaneously measuring and logging other voltages or currents. You can program the excitation as dc, or ramps, steps, or pulses, and you can display the logged results via software running on an attached laptop computer; you can also save the logged data as a spreadsheet, to be manipulated to your heart's content. Take a look, for example, at Figure 8.39, or the figures in the "Power Transistors for Linear Amplifiers" section of Chapter *3x*, all of which plot data we collected with a SMU.