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# A Sourcebook of Modern Transistor Circuits



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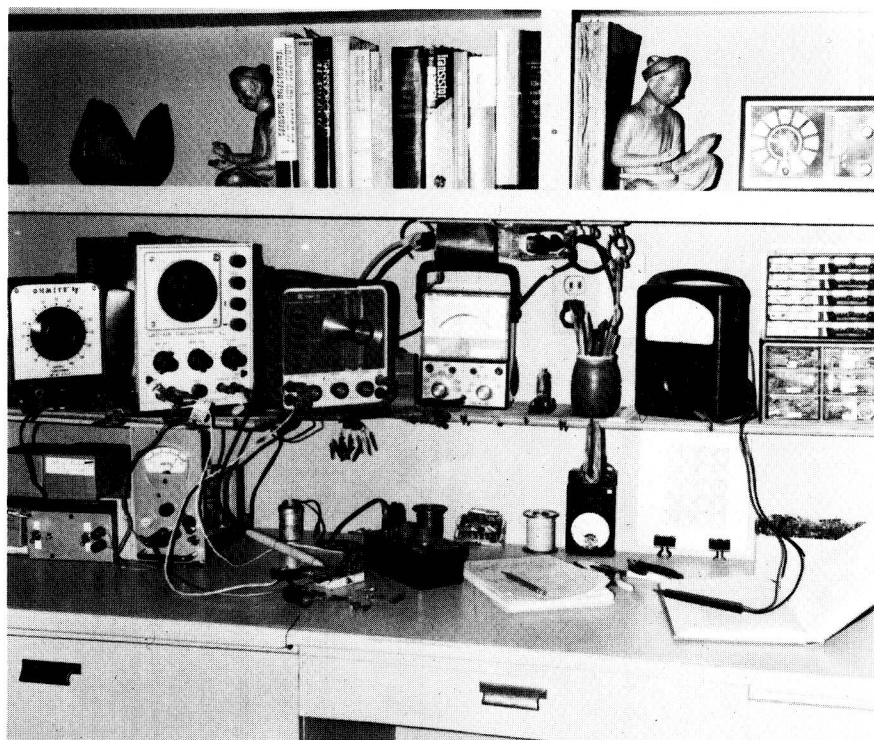
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**A Sourcebook  
of Modern  
Transistor Circuits**



A home electronics laboratory for the experimenter or engineer—the author's. From left to right: a variable-voltage transformer, oscilloscope, oscillator with attenuators, FET volt-ohmmyst, ac power jacks, D'Arsonval volt-ohmmeter, and small parts cabinets. Below: power supplies, breadboard circuits,  $\beta$ -tester, reactance chart, and notebook.

When a mathematician engaged in investigating physical actions and results has arrived at his conclusions, may not they be expressed in common language as fully, clearly, and definitely as in mathematical formulae? If so, would it not be a great boon to such as I to express them so?—translating them out of their hieroglyphics, that we also might work upon them by experiment.

Michael Faraday in a letter to James Clerk Maxwell,  
Nov. 13, 1857

*The Selected Correspondence of Michael Faraday,*  
L. Pearce Williams, Cambridge University Press, 1971

# Preface

The existing number and variety of semiconductor circuits have created the need for an up-to-date handbook of practical transistor and integrated circuits. This book, a product of my own needs for reliable circuits, offers both experimenters and designers a graded series of selected and carefully designed transistor circuits. The circuits, shown with component values and readily available semiconductors, may be used either for design or for study to obtain a working knowledge of practical circuits without an encumbering theory and mathematics. Circuits of equipment that may be purchased in manufactured or in kit form are not included and not needed in a sourcebook.

I have tried to describe mainly those amplifier, diode, and switching circuits that are used by experienced designers. Each circuit is a complete package that may be used alone or combined with others to achieve known performance characteristics. To make the book useful as a design manual I have included charts and tabulated data to help a designer change a circuit in order that it may serve many different purposes. An annotated bibliography is included for persons needing supplementary information. The references are selected carefully to supply working circuits and to serve practical needs without requiring resources beyond the reach of a small home library.

Laurence G. Cowles

# List of Symbols

|           |                                        |
|-----------|----------------------------------------|
| $C_I$     | Input capacitance                      |
| $C_M$     | Miller effect capacitance              |
| $C_N$     | Neutralizing capacitance               |
| $C_{OB}$  | Collector-to-base capacitance          |
| $e_I$     | AC input voltage                       |
| $e_O$     | AC output voltage                      |
| $e_p$     | Peak voltage or peak-to-peak voltage   |
| $e_s$     | AC signal voltage or generator voltage |
| $f_\beta$ | Beta cutoff frequency                  |
| $f_c$     | Cutoff frequency (half power, or 3 db) |
| $f_h$     | High frequency cutoff                  |
| $f_l$     | Low frequency cutoff                   |
| $f_T$     | Current gain-bandwidth product         |
| $G_i$     | Current gain                           |
| $G_v$     | Voltage gain                           |
| $G'_v$    | Voltage gain with feedback             |
| $i_b$     | AC base current                        |
| $I_B$     | DC base current                        |
| $i_c$     | AC collector current                   |
| $I_C$     | DC collector current                   |
| $I_{DSS}$ | Zero bias drain current                |
| $i_e$     | AC emitter current                     |



**xx** List of Symbols

|          |                                                                    |
|----------|--------------------------------------------------------------------|
| $I_E$    | DC emitter current                                                 |
| $I_I$    | AC input current                                                   |
| $I_L$    | AC load current                                                    |
| $i_O$    | AC output current                                                  |
| $P_O$    | AC output power                                                    |
| $R_A$    | Bias resistor (usually adjustable)                                 |
| $R_B$    | Base resistor                                                      |
| $R_C$    | Collector resistor                                                 |
| $R_E$    | Emitter resistor                                                   |
| $R_f$    | Feedback resistor                                                  |
| $R_I$    | Input resistance                                                   |
| $R_L$    | Load resistance                                                    |
| $R_S$    | Generator or source resistor                                       |
| $S$      | Usually $R_B/R_E$ or $R_f/R_L$ ; approximately the dc current gain |
| $V_B$    | DC base voltage (to ground)                                        |
| $V_{BB}$ | DC base supply voltage                                             |
| $V_C$    | DC collector voltage (to ground)                                   |
| $V_{CC}$ | DC collector supply voltage                                        |
| $V_D$    | DC drain voltage                                                   |
| $V_{DD}$ | DC drain supply voltage                                            |
| $V_E$    | DC emitter voltage (to ground)                                     |
| $V_{GS}$ | DC gate-to-source voltage                                          |
| $V_P$    | FET pinchoff voltage                                               |
| $V_R$    | DC regulated voltage                                               |
| $V_Z$    | DC zener diode voltage                                             |
| $\alpha$ | CB short-circuit current gain, i.e., $-h_{fb}$ ; approximately 1   |
| $\beta$  | CE short-circuit current gain, $h_{fe}$ ; approximately 50         |
| $\omega$ | Frequency in radians per second ( $2\pi f$ )                       |
| $\Omega$ | Ohms                                                               |

# Abbreviations

|            |                          |
|------------|--------------------------|
| A          | Ampere                   |
| B          | Base                     |
| C          | Collector                |
| CB         | Common base              |
| CC         | Common collector         |
| CE         | Common emitter           |
| D          | Drain                    |
| dB         | Decibel (see Appendix)   |
| dBm        | Decibel referred to 1 mW |
| E          | Emitter                  |
| G          | Gate                     |
| GHz        | Gigahertz                |
| Hz         | Hertz                    |
| IC         | Integrated circuit       |
| kHz        | Kilohertz                |
| k $\Omega$ | Kilohm                   |

**xxii**      Abbreviations

|                            |                 |
|----------------------------|-----------------|
| <b>mA</b>                  | Milliampere     |
| <b>mH</b>                  | Millihenry      |
| <b>mV</b>                  | Millivolt       |
| <b>pF</b>                  | Picofarad       |
| <b>p-p</b>                 | Peak-to-peak    |
| <b>Q</b>                   | Factor of merit |
| <b>Q-point</b>             | Quiescent point |
| <b>S</b>                   | Source (FET)    |
| <b>V</b>                   | Volts           |
| <b><math>\mu</math>A</b>   | Microampere     |
| <b><math>\mu</math>F</b>   | Microfarad      |
| <b><math>\mu</math>H</b>   | Microhenry      |
| <b><math>\Omega</math></b> | Ohms            |

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