BENCH MANUAL № 2

Wire, Line & Code

Three figure families that are nothing but typed characters until the page is made.

Meridian Instruments Co.

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I. LINES THAT BECOME PICTURES

PART ONE OF THREE · ASCII PROMOTED TO VECTOR ART

A diagram in this format is not a picture the document carries. It is a rectangle of typed characters — hyphens, pipes, plus signs, a few arrowheads — that the engine reads as geometry and redraws as vector art at the resolution of the page.

Nothing here is a file. Open the source of this document in any editor and every figure in the next twenty pages is sitting there as text you can retype, diff, and merge. That is the whole argument for the format: a drawing that survives version control because it *is* version control's native material.

A. The Character Vocabulary §

Six classes of character carry the whole notation. Straight runs are hyphens and pipes; corners are plus signs, or a period and an apostrophe when the corner should be round. Everything else is decoration riding on top of a run.

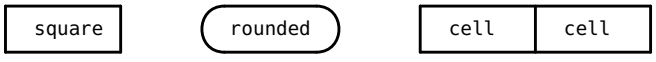


Diagram 1: Runs, corners and the rounded pair

Arrowheads point four ways and attach wherever a run ends. Points come in two weights: a hollow terminal and a solid junction.



Diagram 2: Arrowheads, terminals and junctions

A run that must cross another without touching it takes a parenthesis — the notation's wire jump. The left crossing below hops; the right one connects.

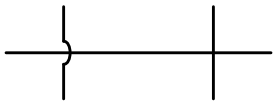


Diagram 3: A jump beside a junction

Diagonals run at the grid's own aspect, so slashes and backslashes close into figures without any hinting.

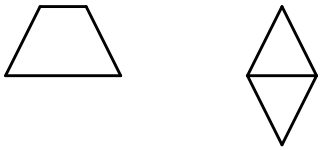


Diagram 4: Diagonals close a figure

The last class is fill. Four block characters give four gray levels, and four quarter-triangles chamfer a solid block — enough to key a drawing without leaving the keyboard.



Diagram 5: Gray levels and corner wedges

B. Worked Sheets §

Given that vocabulary, ordinary engineering drawings fall out of it. A block diagram is boxes and arrows; the only discipline is keeping the columns lined up.

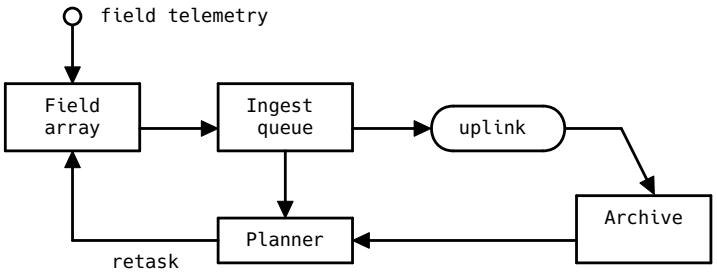


Diagram 6: The observing network

Where a drawing is really a table of extents, the gray levels do the work that hatching does on a real sheet.

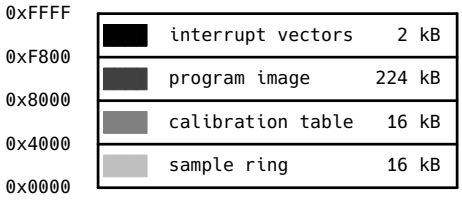


Diagram 7: Instrument memory map

C. A Diagram in the Margin of the Text §

A diagram takes the same float grammar as any other figure. Give it an alignment and a wrap extent and the prose reads past it.

The figure beside this paragraph declared `align=right`, `width=30%` and `wrap=image`, so it reserves three tenths of the measure and lets the following lines run past its left edge before the column widens back out. Nothing about the drawing itself changed — the same characters, sized by the scale attribute and floated by the wrap attribute. That separation is the point of the whole system: the picture is content, its placement is style, and neither has to know about the other.

Every diagram in this part is also numbered and collected: the list of diagrams in the back matter was generated from these blocks, not typed.

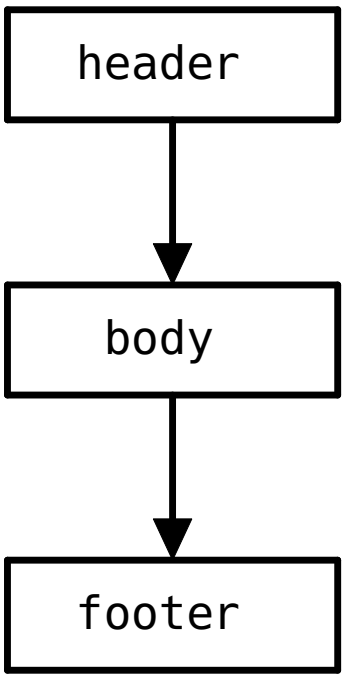


Diagram 8: The fold

II. CIRCUITS, TYPED

PART TWO OF THREE · A COMPONENT LIBRARY ON A CHARACTER GRID

A circuit block is the same character grid with one addition: certain letter runs are component names. Spell a name along a wire and the engine swaps in the symbol, keeps the wire's connection points, and paints the rest of the sheet exactly as it would a diagram.

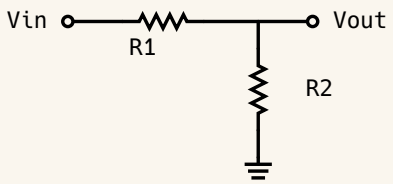
The notation is markdeep's, and its component table ships with the application, so a circuit costs the document nothing but the characters you type.

A. How the Notation Works §

There are three ways a component joins the grid, and the whole of Part II is built from them.

1	**Inline**	Spell the name into a horizontal run, plus signs at both ends: a resistor is `+resis+`, a capacitor `+capac+`. The two plus signs are its terminals.
2	**Upright**	Spell the same name down a column, one letter per line, plus signs above and below. The symbol turns with it.
3	**Pinned**	Some parts have terminals off the run — a transistor's collector and emitter, a gate's two inputs. Those land at fixed offsets from the name's own cell, so the wire meeting them just has to be in the right row.

The simplest complete circuit is one component and a ground. Here it is inline, upright, and grounded, all at once.



Circuit 1: Divider, inline and upright

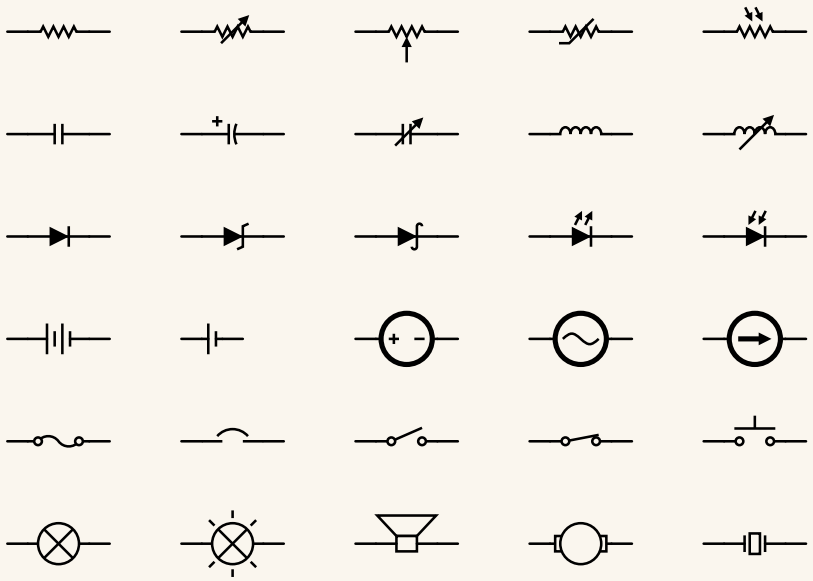
Four ground symbols are available and each is spelled the same way — the wire arrives from above and the name closes it: `+eg` earth, `+cg` chassis, `+sg` signal, `+ag` arbitrary.



Circuit 2: The four grounds

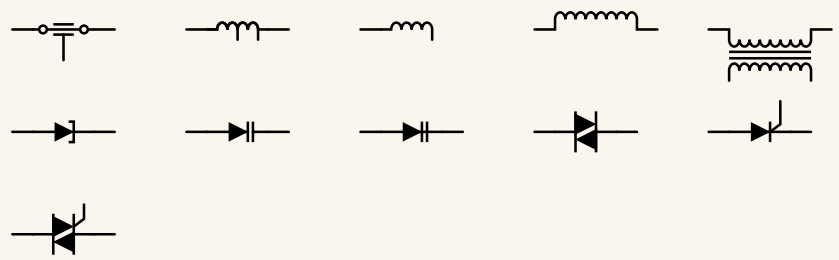
B. The Component Index §

The whole library, drawn from the table the application ships. Most parts are a name typed between two plus signs on a wire; a ground closes a wire from above, a gate needs no lead at all, and a transistor hangs its other two terminals off the grid to the right.



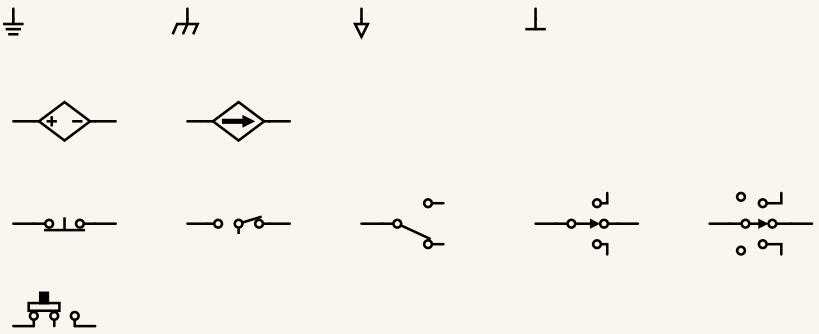
Circuit 3: Passives and sources

The reactive parts run deeper than one row, and the rectifier family past the plain diode covers the thyristors:



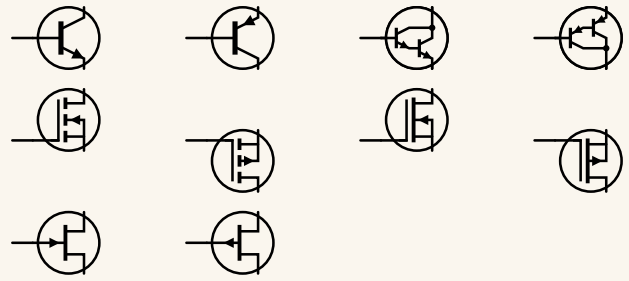
Circuit 4: Taps, transformers and thyristors

Four grounds, two dependent sources, and the switches the alarm loop did not need:



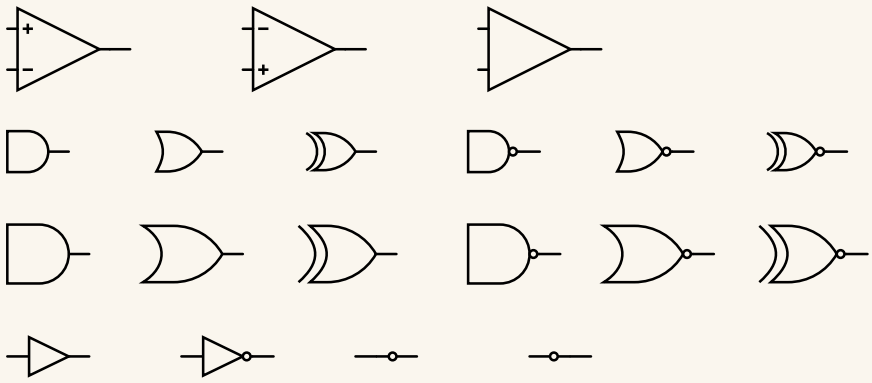
Circuit 5: Grounds, dependent sources and the rest of the switches

Ten transistors, in the three families the table carries — bipolar, MOSFET and JFET. Each hangs its other two terminals five cells to the right, three rows up and three down:



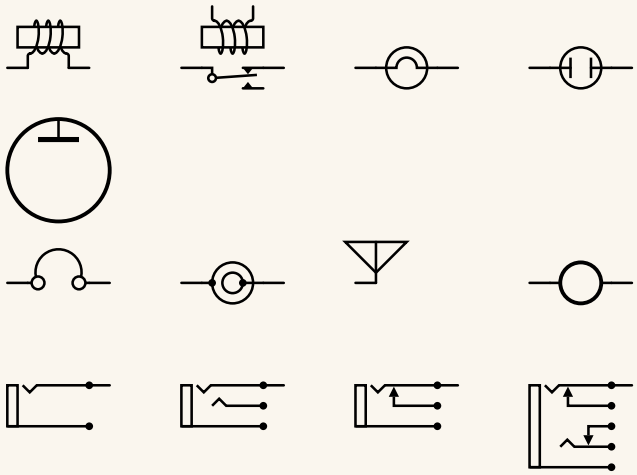
Circuit 6: Transistors

An amplifier takes its inputs two rows out; a gate takes them one row out, or two for a three-input part. Drawn on their own like this they need no leads at all:



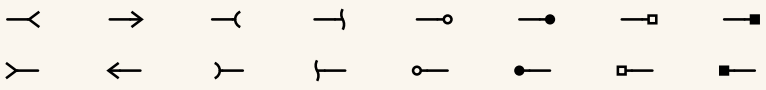
Circuit 7: Amplifiers and logic

The coil, the relay it drives, the lamps and the tube; then what a signal arrives on and leaves through:



Circuit 8: Electromechanical, transducers and connectors

Last, eight numbered terminals, each in a left-hand and a right-hand form:

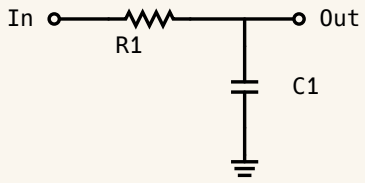


Circuit 9: Numbered terminals

That is every drawable name in the table. The one it declares and cannot draw is `+rela2+`, whose symbol is missing from the shipped artwork.

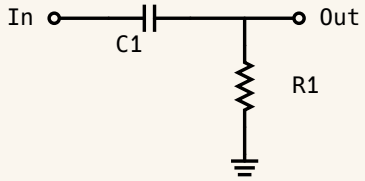
C. Passive Networks §

The first-order low-pass is the whole notation in eleven lines: a resistor in the series arm, a capacitor to ground, and two open terminals.



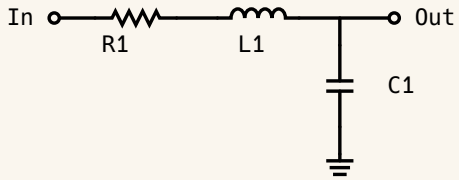
Circuit 10: First-order low-pass

Swap the two parts and the same drawing becomes a high-pass. Nothing else on the sheet moves.



Circuit 11: First-order high-pass

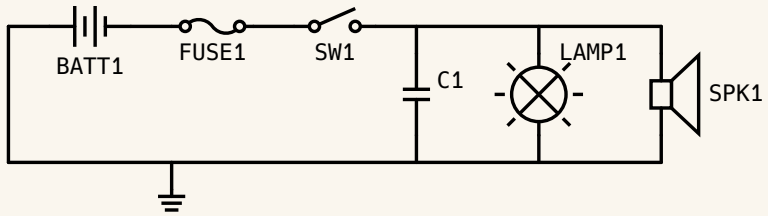
Put an inductor in the series arm beside the resistor and the network is second order — the circuit Part III will compute a resonance for.



Circuit 12: Series RLC, output across the capacitor

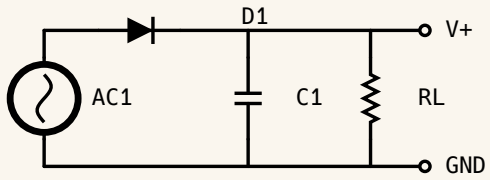
D. Power and Protection §

The station's alarm loop: a battery, a fuse, a switch, and three parallel legs — a timing capacitor, a lamp, and a speaker — closing on earth.



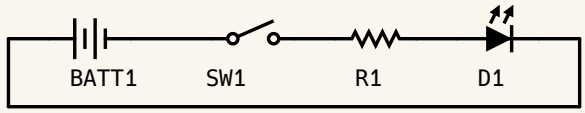
Circuit 13: Station power and alarm loop

Rectification and smoothing, drawn the same way: an AC source, a series diode, a reservoir capacitor and a load.



Circuit 14: Half-wave supply

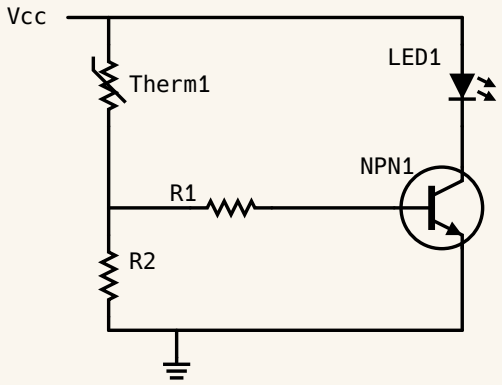
An indicator leg is a switch, a current-limiting resistor and an LED — the smallest circuit that does something visible.



Circuit 15: Indicator leg

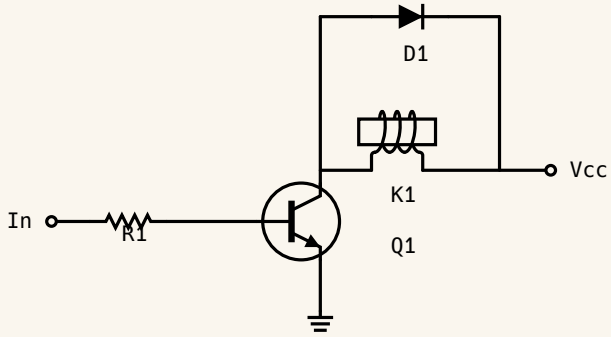
E. Semiconductors §

A transistor's base arrives on the run; its collector and emitter leave five cells to the right, three rows above and three below. Once that offset is understood the part places itself. A thermistor divider biasing the base, and the collector driving a lamp, is the station's thermal switch:



Circuit 16: The thermal switch

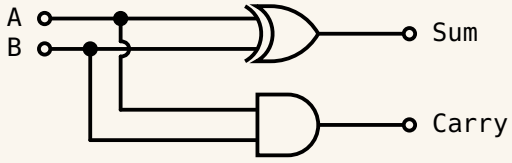
The same offsets drive an inductive load. Here the relay coil and its flyback diode sit side by side between the collector and the supply, so the diode conducts the coil's kick back into Vcc when the base turns off:



Circuit 17: Relay driver with flyback diode

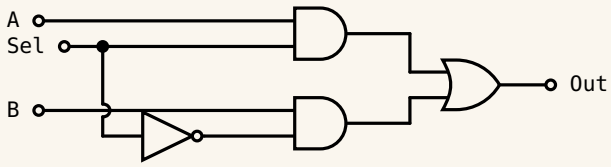
F. Logic §

Gates take their two inputs one row above and one row below the name's first cell, and hand the result out the trailing plus. A half adder is nine lines of text.



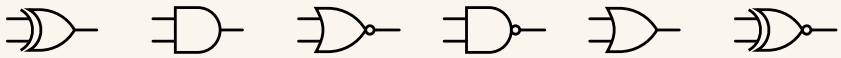
Circuit 18: Half adder

Four gates and one inverter make a two-to-one multiplexer. The select line branches once and feeds both AND gates, one of them through the inverter.



Circuit 19: Two-to-one multiplexer

The rest of the family is spelled the same way — the name changes, the geometry does not.



Circuit 20: The two-input family

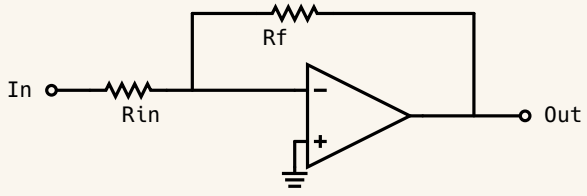
Buffers and inverters are inline parts, because they have one input.



Circuit 21: Buffer and inverter

G. Amplifiers §

The operational amplifier is a pinned part with its inputs two rows out from the name's first cell. Two spellings put the inverting input on either side: `opamp:plus+` carries the non-inverting input on top, `opamp:nega+` the inverting one. The second is what the classic inverting configuration wants — signal through Rin into the summing node, Rf closing the loop from the output, and the other input tied to ground:



Circuit 22: Inverting amplifier

III. PYTHON AT RENDER TIME

PART THREE OF THREE · FIGURES THE DOCUMENT COMPUTES FOR ITSELF

The third family is not drawn at all. A Python block names a script and hands it a few lines of input; the script runs while the page is being made and returns a figure. What reaches the paper is whatever the arithmetic decided.

A Python figure is written like an image whose file happens to end in `.py`. The lines under it, down to a `~~~` fence, are the script's input.

```
1: ![Caption](script.py){scale=1.15}
2: R 10k
3: C 100n
4: ~~~
```

The shape of a Python figure

The script exposes one function. It returns either a height — having painted through the vector API — or a height and a string of raw SVG. Both channels are used in this part.

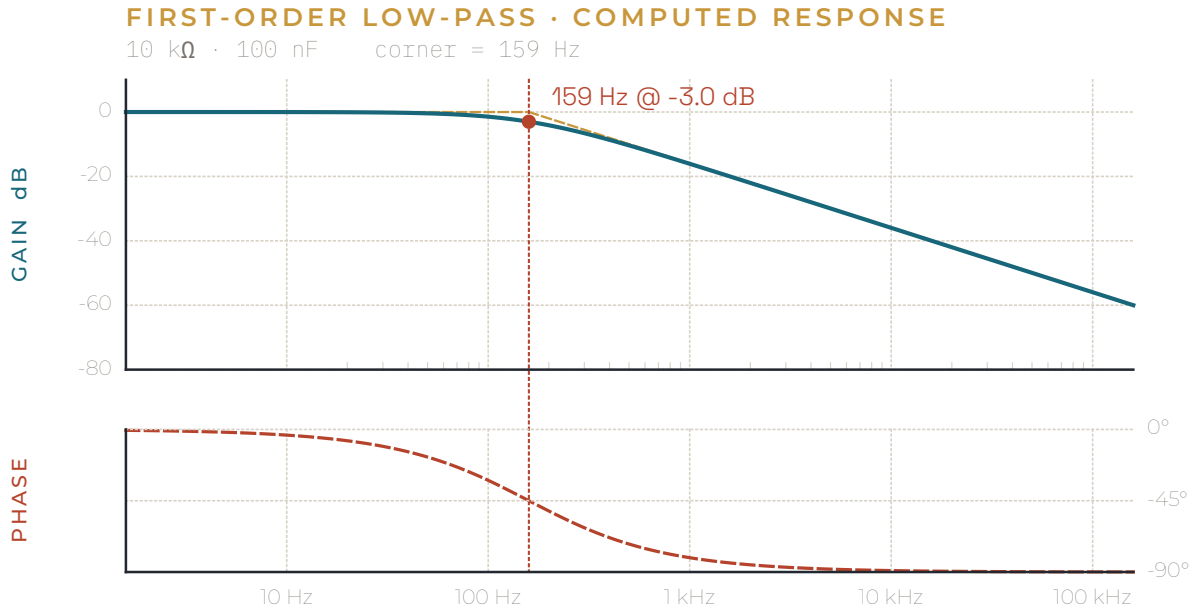
```
1: import qtdraw
2:
3: def render(content):
4:     qtdraw.setPen("#17667A", 1.8)
5:     qtdraw.drawPolyline(points_from(content))
6:     return 220 # painted through the API
7:
```

```
def render(content): # or, instead:
    return (300, "<svg ...>...</svg>") # returned as raw SVG
```

The two return channels

A. The Filter, Answered §

Part II drew a first-order low-pass and never said what it does. Here is the same network handed to a script as two component values. The corner frequency, the decade span, the decibel scale, the asymptote and the marker are all computed — the document holds two lines of input.



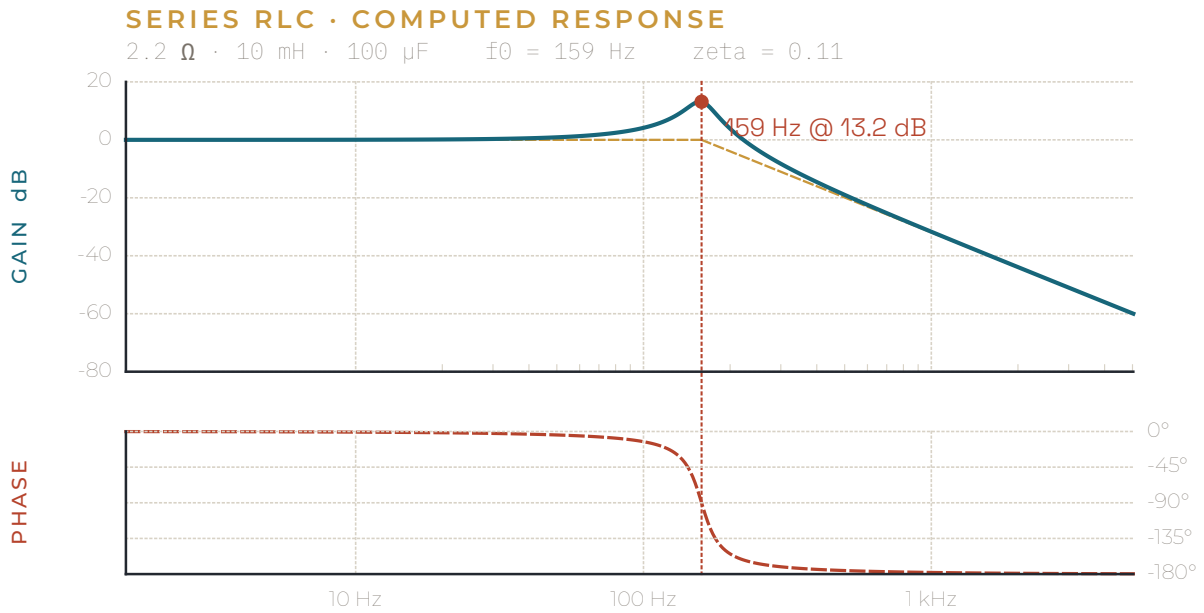
The first-order low-pass of Part II, solved from values

The transfer function the script is evaluating, typeset by a second script on the same channel:

$$H(j\omega) = \frac{1}{1 + j\omega RC}, \qquad f_c = \frac{1}{2\pi RC}$$

The first-order transfer function.

Add the inductor from the series RLC and the same script finds a second-order response instead — a resonant peak, a phase that swings the full half turn, and a roll-off that has doubled. Nothing about the block changed except one line of input.



The series RLC, with the peak and the doubled roll off

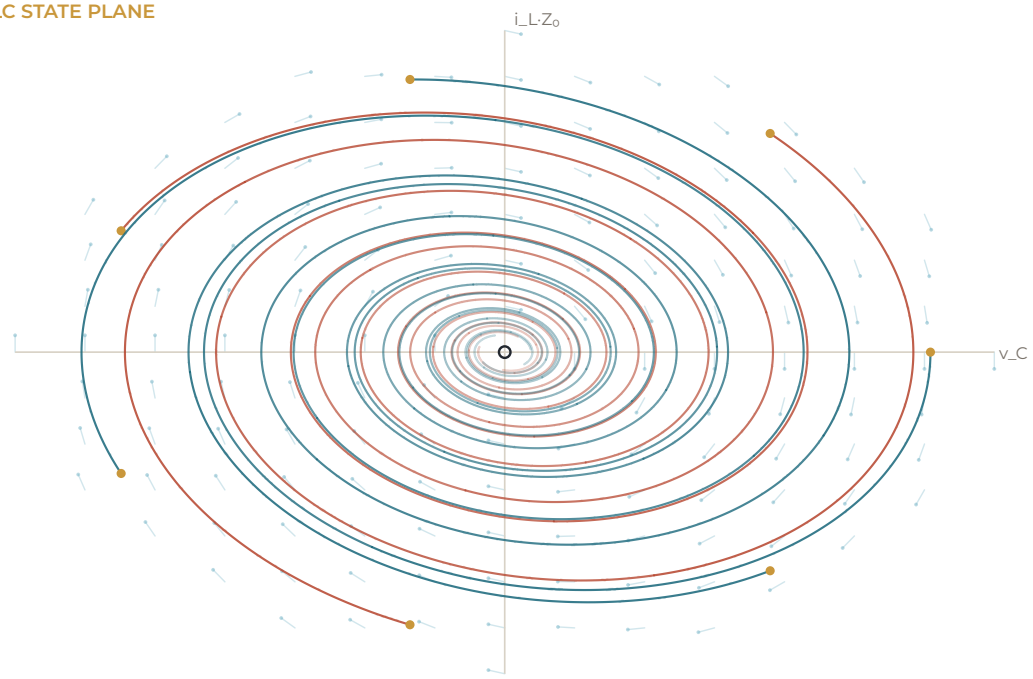
$$H(s) = \frac{\omega_0^2}{s^2 + 2\zeta\omega_0 s + \omega_0^2}, \qquad \zeta = \frac{R}{2}\sqrt{\frac{C}{L}}$$

The second-order transfer function, in the damping-ratio form

B. The State Plane §

The same three components, integrated instead of solved. This figure comes back as raw SVG: the script steps the circuit's two state variables through a fourth-order Runge–Kutta from seven starting conditions, and returns several thousand path segments that fade as the energy leaves the loop.

RLC STATE PLANE



R 2.2Ω · L 10mH · C 100µF → ζ = 0.110 (underdamped), f₀ = 159.2 Hz

Seven trajectories of the series RLC in the plane of capacitor voltage against inductor current, with the tangent field behind them.

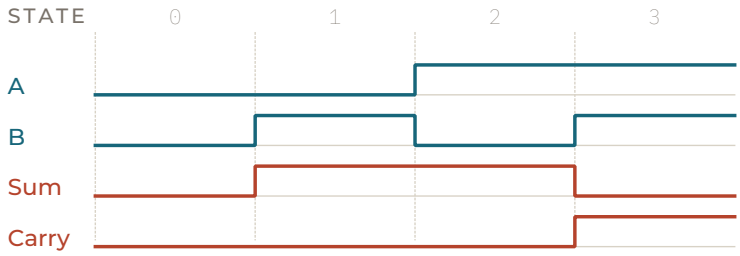
> Both axes are volts: the current is scaled by the network's characteristic impedance, so a lossless circuit would trace circles and the damping shows as the inward pitch of the spiral.

C. The Logic, Enumerated §

The half adder of Part II is two Boolean expressions. Written out as expressions, the script enumerates every input combination itself and draws both the table and the waveforms — no truth table is typed anywhere in this document.

HALF ADDER

A	B	Sum	Carry
0	0	0	0
0	1	1	0
1	0	1	0
1	1	0	1

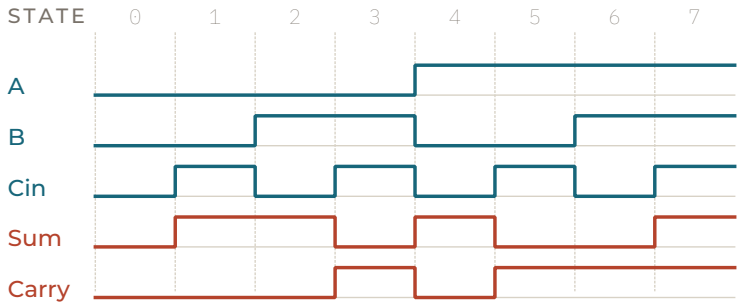


The half adder's table and timing, enumerated from its two expressions.

Three inputs and two longer expressions give the full adder, at the same cost in typing.

FULL ADDER

A	B	Cin	Sum	Carry
0	0	0	0	0
0	0	1	1	0
0	1	0	1	0
0	1	1	0	1
1	0	0	1	0
1	0	1	0	1
1	1	0	0	1
1	1	1	1	1



The full adder, from three inputs and two expressions.

$$S = A \oplus B \oplus C_{in}, \qquad C_{out} = AB + C_{in}(A \oplus B)$$

The carry expression the script evaluated.

D. The Script, Shown §

There is no privileged machinery here. The response plot above is ninety lines of ordinary Python; this is the part of it that chooses the decibel scale and clips the asymptote to the frame.

```
# The span is chosen from the roll-off, not fixed: the asymptote should fall
# about 60 dB inside the frame whether it leaves at 20 or 40 dB per decade.
slope = -40.0 if L else -20.0
x_lo = math.log10(f0) - 2.0
x_hi = math.log10(f0) + 60.0 / abs(slope)

db_peak = max(s[1] for s in samples)
db_hi = 10.0 if db_peak <= 3.0 else 20.0 * math.ceil((db_peak + 3) / 20.0)
db_lo = 20.0 * math.floor((min(s[1] for s in samples) - 4) / 20.0)
```

From schem_bode.py

> *Three families, one file: a diagram is characters, a circuit is characters with names in it, and a Python figure is characters that run.*

E. What the Document Costs §

Everything in these pages is plain text in one file. The three scripts it calls sit beside it; the component symbols come from the application. There is no image on disk anywhere in this manual.

Diagrams drawn	11
Circuits drawn	22
Component symbols shown	111
Python figures computed	8
Image files used	0

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