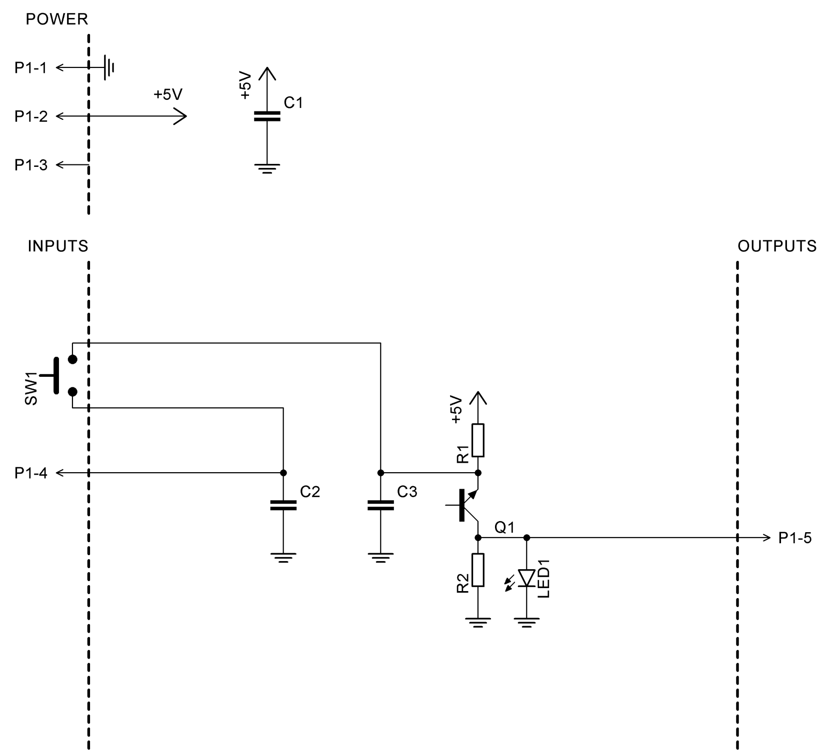
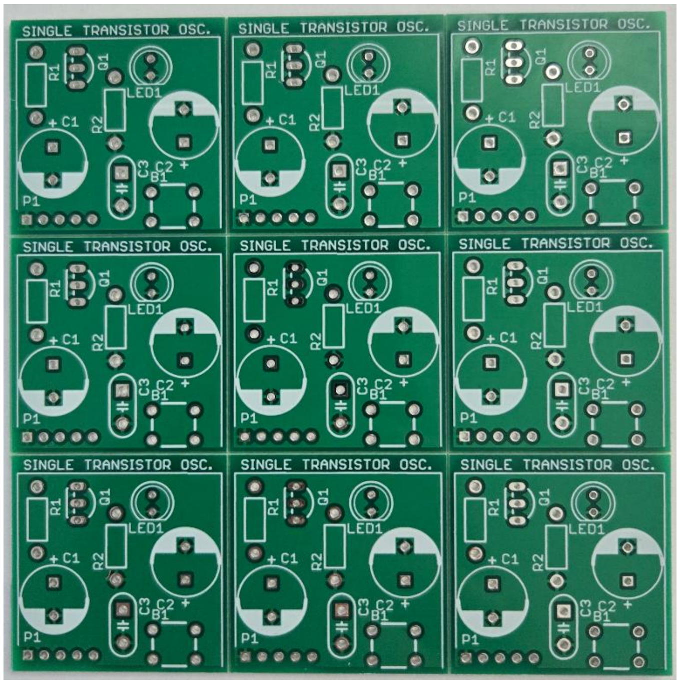
Single Transistor Oscillator

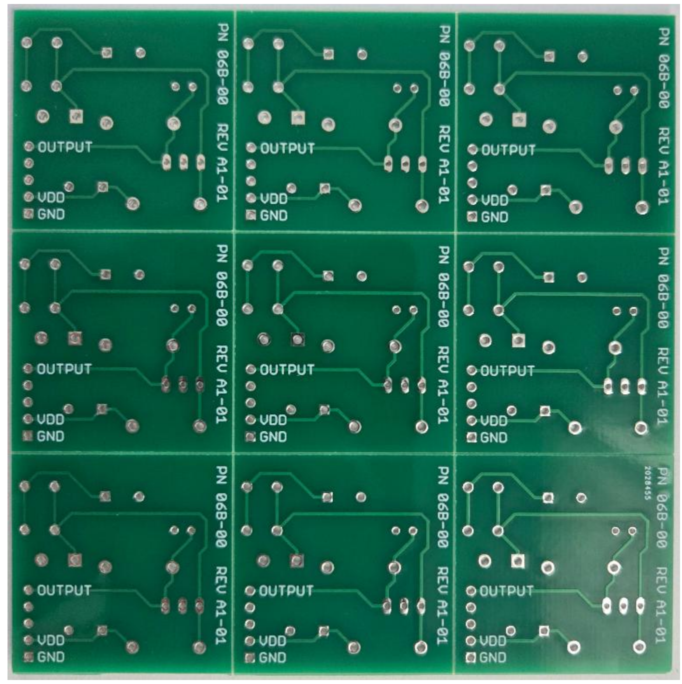


PARAMETER	VALUE
BASE MATERIAL	FR-4 TG130
NUMBER OF LAYERS	2
PCB DIMENSIONS	33 mm x 33 mm
PCB THICKNESS	1.60 mm
PCB COLOR	GREEN
SURFACE FINISH	HASL
COPPER WEIGHT	1 oz
IMPEDANCE CONTROL	NO

TITLE	SINGLE TRANSISTOR OSCILLATOR
SIZE	A
DWG NO	06B-00
REV	A1-02
SAVED	6/10/2025 9:34:30 PM
SHEET	1/1



Front Side



Back Side

miniPCB Part Number

PART NO	TITLE	PIECES PER PANEL
06B-00	Single Transistor Oscillator	9

miniPCB Revision History

REV	DESCRIPTION	DATE
A1-01	Initial Release	05JAN2025
A1-02		10JUN2025

Circuit Description

This board implements a **relaxation oscillator** built around a single NPN transistor (Q1). The circuit produces a rail-to-near-rail, square-like waveform that blinks **LED1** and is available on the **OUTPUT** pin (P1-5).

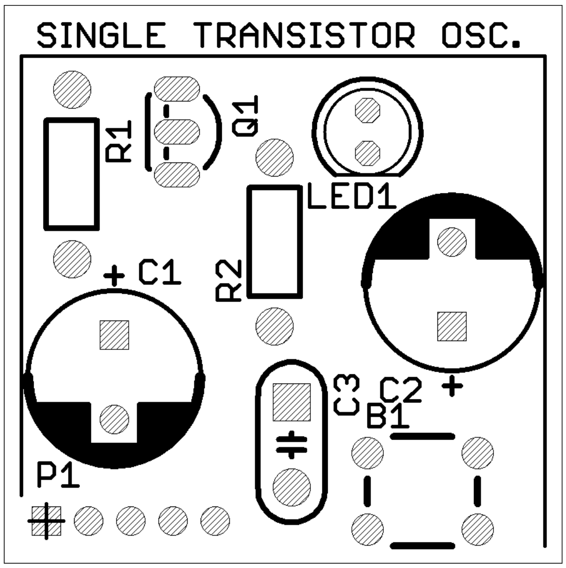


Figure 1 - Components Top Side

Power and Bypass

- **C1** is a local bypass capacitor that keeps the oscillator stable by shunting supply noise to ground.

Transistor Stage and Output

- **Q1** is reverse-biased in a unique way.
- **R1** provides the collector load and also serves as a **charging path** for the timing network.
- The output node (emitter of Q1) drives **LED1** to ground and is routed to **P1-5**, allowing the LED to visibly indicate oscillation.

Timing Network (the "RC" that makes it oscillate)

- **C3** (and optionally **C2** and the capacitance at **P1-4**) are timing capacitors to ground.
- **R2** provides a **discharge path** and sets the transistor's turn-on/turn-off thresholds (≈ 0.6–0.7 V at the base).
- **SW1** selects which timing capacitor is active (shorter vs. longer period) or can be used to engage/disengage an additional capacitor for coarse frequency switching.
- **P1-4** exposes the timing node so an external capacitor or signal can be connected for experiments.

How one cycle works

1. With Q1 off, the selected timing capacitor **charges through R1** toward +5 V.
2. When the **base** of Q1 rises to roughly the base-emitter threshold (~0.65 V), Q1 turns **on**. The emitter follows upward, lighting **LED1** and pulling the output high.
3. Turning on Q1 provides a discharge path via **R2** and the base-emitter junction, so the timing capacitor **discharges**.
4. As the base voltage falls below the threshold, Q1 turns **off**, the emitter/output drops, and the cycle repeats.

The result is a self-sustaining oscillation. The **period** is mainly set by the selected **R–C** product:

$$f = \frac{1}{k \cdot R \cdot C}$$

where k (typically ~0.7–1.2) depends on transistor gain and the exact turn-on/turn-off thresholds. Increasing **C slows** the blink; increasing **R1** or **R2** also reduces frequency.

Design/Teaching Notes

- The LED duty cycle depends on the relative charge and discharge paths; swapping values of **R1** and **R2** or changing the capacitor changes both **frequency** and **duty cycle**.
- The output at **P1-5** is a convenient logic-level clock for driving other miniPCB experiments (e.g., counters or dividers).
- Keep **C1** close to P1 to ensure clean oscillation, especially when powering from long leads or a noisy bench supply.
- For a wider frequency range, make **C2** and **C3** different by a factor of 5–10, and consider socketing them so students can experiment with values.

Theory of Operation

The purpose of this circuit is to generate a square wave using a single NPN transistor in a basic relaxation oscillator. A pushbutton allows temporary frequency adjustment, making it suitable for tone generation, timing demos, or driving digital inputs.

This circuit is supplied with 3.3V to 5V DC across VCC and GND. A collector resistor limits current, while an RC network on the base sets the oscillation frequency based on capacitor charge timing.

The pushbutton connects capacitor C2 in parallel with C3, increasing total capacitance when pressed. This lowers the frequency due to a longer RC time constant. Releasing the button returns the circuit to the default frequency set by C3.

The output signal is connected to P1 pin 5, taken from Q1’s collector. The resulting square wave toggles between high and low, usable for LEDs, counters, or logic clocks. The DC-coupled output preserves voltage levels for digital interfacing.

While educational, this circuit is rarely used in real designs due to several limitations:

1. Poor frequency stability from supply voltage, temperature, and component drift
2. Imprecise control, unsuitable for applications needing accurate tuning
3. Weak output drive and inconsistent signal quality
4. Manual input via pushbutton limits automation
5. Unreliable switching from contact bounce and lack of debouncing
6. Better alternatives like 555 timers, crystal oscillators, or microcontrollers are more stable, flexible, and compact

Example Parts List

REF DES	PART TYPE	VALUE / DESCRIPTION
B1 / SW1	BUTTON SWITCH	6 MM
C1	CAPACITOR	100 uF
C2	CAPACITOR	47 uF
C3	CAPACITOR	1 uF
LED1	LIGHT EMITTING DIODE	RED
P1	PIN HEADER	5 PIN, 0.1” PITCH, RIGHT ANGLE
Q1	TRANSISTOR	2N3904
R1	RESISTOR	1 kΩ
R2	RESISTOR	1 kΩ

Parts List Form

REF DES	PART TYPE	VALUE / DESCRIPTION
B1 / SW1	BUTTON SWITCH	
C1	CAPACITOR	
C2	CAPACITOR	
C3	CAPACITOR	
LED1	LIGHT EMITTING DIODE	
P1	PIN HEADER	5 PIN, 0.1” PITCH, RIGHT ANGLE
Q1	TRANSISTOR	
R1	RESISTOR	
R2	RESISTOR	

Build

NEED TO ADD

Testing

NEED TO ADD

Industry Feedback

Send your feedback to nolan@minipcb.com.

References

- https://www.minipcb.com/06/06B-00.html
- https://www.youtube.com/@minipcb

Revision History

REV	DESCRIPTION	DATE
A	Initial Release	29APR2025
B	Added example part values Added default datasheet sections: Build, Testing, Industry Feedback, References Updated schematic per A1-02	13AUG2025
C	Updated header Added references, miniPCB revision history	02DEC2025