Labor kit circuits by Roberts Treize

The Foundation of Power - AC to DC Converter

In the heart of every electronic device lies the necessity to convert alternating current (AC) from our wall outlets into direct current (DC) for our devices to use. Imagine a river, its water current alternating in direction, needing to be channeled into a single, steady stream. This is the task of our AC-to-DC converter.

Key Components and Their Roles:

- **Rectifier:** Converts AC to pulsating DC using diodes.
- Filter: Smoothens the pulsating DC to a steady voltage.
- Diode: Ensures correct current direction
- Led: Indicates effectivity of DC conversion

Link: <u>https://tinyurl.com/24rvtllv</u>





Of course, sometimes, it is necessary to supply negative voltage, as the difference between positive voltage and the ground is insufficient. For this purpose, we can adjust our circuit to provide positive and negative voltage to the LED.

Link:<u>https://tinyurl.com/24v7b6lk</u> Photo:



The Efficient Traveler - Buck Converter

As we venture further, we encounter the buck converter, a master of efficiency, stepping down voltage while conserving energy. Think of it as an expert mountaineer, descending steep slopes while managing resources wisely.

Key Components:

- **Inductor:** Stores energy when current flows through it and releases energy when needed.
- Switch: Controls the flow of current, in this case a transistor.
- **Diode:** Ensures current flows in the correct direction.
- Capacitor: Filters and smoothens the output voltage.

Link:<u>https://tinyurl.com/2cfkoone</u> Photo:



Reaching New Heights - Boost Converter

Our journey takes us upward with the boost converter, elevating voltage levels to power-demanding devices. It's akin to using a pulley system to lift a heavy load to a higher platform.

Key Components:

- Inductor: Stores energy from the input voltage.
- Switch (Transistor): Controls the energy transfer process.
- **Diode:** Directs current flow.
- Capacitor: Stabilizes the output voltage.

Link: https://tinyurl.com/2784fpzn Photo:



Doubling Up - Voltage Doubler

The voltage doubler circuit doubles the input voltage, much like finding a hidden treasure that suddenly doubles your wealth, allowing you to power more demanding circuits.

Key Components:

- **Diodes:** Charge capacitors in sequence to double the voltage.
- **Capacitors:** Store and transfer charge.

Link: https://tinyurl.com/2xsws2uc



The Guardian - Schmitt Trigger

Meet the Schmitt Trigger, a vigilant guard that ensures signals are clean and noise-free, only allowing through signals of sufficient strength. Imagine a gatekeeper at a grand castle, admitting only the worthy.

Key Components:

- 1. 555 Timer IC: provider of the necessary logic and timing functions.
- 2. **Power Supply (+5V):** Provides the necessary voltage for the circuit to operate.
- 3. **Input Signals:** The alternating current (AC) signal serves as the input to the Schmitt Trigger.

How It Works:

- Thresholds and Hysteresis: The Schmitt Trigger with a 555 timer has two threshold voltages – an upper threshold (UT) and a lower threshold (LT). When the input signal exceeds the UT, the output switches to a high state. When the input signal drops below the LT, the output switches to a low state. This hysteresis creates a buffer zone, preventing rapid switching and ensuring stable output.
- 2. **Input Signal:** The input signal, often a noisy or fluctuating voltage, is fed into the circuit. As the input voltage changes, it is compared to the set thresholds.
- 3. **Output Signal:** The output of the 555 timer, influenced by the Schmitt Trigger configuration, switches states based on the input signal's relationship to the UT and LT. This results in a clean, digital output signal with well-defined high and low states.

Link:<u>https://tinyurl.com/29u5ms8u</u> Photo:



Dividing the Rhythm - Frequency Divider

Opposite to the frequency doubler, the frequency divider circuit slows down the signal frequency, akin to a maestro slowing down the orchestra for dramatic effect.

Key Components:

- Decade counter: Provide a sequence of output signals to be combined into one.
- **Feedback loop:** Provides feedback to reset the pin of the Decade counter as in means to split the output signal in the necessary frequency.
- **Diodes:** Ensure the correct current direction out of the counter.

Link:https://tinyurl.com/2c6m37sm Photo:

Embracing Chaos - The Chaos Generator

In the vibrant and ever-evolving world of electronics, certain circuits stand out for their ability to introduce unpredictability and complex behavior. The Chaos Generator is one such circuit, embodying the principles of chaos theory. It produces erratic and seemingly random signals that are invaluable in testing and experimental applications.

Chaos Theory in Electronics:

Chaos theory, often illustrated by the butterfly effect, shows how minute changes in a system can result in complex and unpredictable behavior. In the realm of electronics, this principle is harnessed to create circuits that generate chaotic signals. These signals can simulate complex systems or provide unique inputs for experimental setups.

Key Components:

- 1. **Operational Amplifiers (Op-Amps):** These create feedback loops that amplify and manipulate the signal chaotically.
- 2. **Resistors and Capacitors:** Set the time constants and feedback levels, which are critical in defining the chaotic behavior.
- 3. **Power Supply:** Provides the necessary voltage for the circuit to operate.

How It Works:

- 1. **Feedback Loops:** The core of the chaos generator is the feedback loop created by the operational amplifiers. These loops take the output signal and feed it back into the input in a manner that causes the signal to become unpredictable.
- 2. **Nonlinear Components:** Certain components, such as diodes or transistors, can be used to introduce nonlinearity into the circuit, further enhancing the chaotic behavior.
- 3. **Output Signal:** The result is an output signal that varies in a complex, non-repeating pattern, often sensitive to initial conditions and small changes in the circuit parameters.



Link:https://tinyurl.com/22nd9kdk

Precise Control - First-Order All-Pass Filter

Imagine a craftsman tasked with aligning the gears of a complex machine. This craftsman ensures that all components move in perfect harmony, without altering their inherent properties. The first-order all-pass filter performs a similar function in electronics, aligning the phase of signals while maintaining their amplitude.

Key Components and Their Roles:

- 1. **Operational Amplifier:** The main active component processes the input signal.
- 2. Resistor: Sets the resistance in the circuit, contributing to the phase shift.
- 3. **Capacitor:** Stores and releases electrical energy, working with the resistor to control the phase shift.
- 4. **Power Supply:** Provides the necessary voltage for the op-amp to operate.

Link: <u>https://tinyurl.com/238mazlz</u> Photo:



Advanced Control - Second-Order All-Pass Filter

Filters are fundamental in shaping and managing signals. The second-order all-pass filter stands out for its advanced ability to adjust the phase of a signal across a wider range of frequencies without altering its amplitude.

Key Components:

- 1. **Operational Amplifier:** Acts as the main active component that processes the input signal.
- 2. Resistor: Sets the resistance in the circuit, contributing to the phase shift.
- 3. **Capacitor:** Stores and releases electrical energy, working with the resistor to control the phase shift.
- 4. **Power Supply:** Provides the necessary voltage for the op-amp to operate.

Link: <u>https://tinyurl.com/2chgc7s8</u> Photo:



Generating Spikes - The Spike Generator

The ability to create precise, sharp pulses is essential for a variety of applications. The Spike Generator is a circuit designed to produce such pulses, often referred to as "spikes." These are crucial in simulating and testing rapid signal changes, much like lightning bolts in a controlled storm, providing valuable insights into the behavior of electronic systems under sudden changes.

Key Components:

- 1. **Capacitor:** Stores and releases electrical energy rapidly to create the spike.
- 2. **Resistor:** Controls the discharge rate of the capacitor, shaping the spike's duration.
- 3. **Diode:** Ensures current flows in the correct direction, protecting the circuit components.
- 4. **Power Supply:** Provides the necessary voltage for the circuit to operate.

Link: <u>https://tinyurl.com/25wgdg6c</u> Photo:



Adding the Edge - The Overdrive Circuit

In the dynamic world of audio electronics, creating unique sound effects is paramount for musicians and audio engineers. The Overdrive Circuit is a critical component in this domain, providing the gritty, raw sound that is synonymous with rock and blues music. This circuit is the heart of many guitar pedals, transforming clean tones into rich, distorted ones.

Key Components:

- 1. **Diodes:** Clip the signal to create distortion. By limiting the signal's amplitude, diodes introduce harmonic content, giving the overdrive its characteristic sound.
- 2. **Resistors:** Set the gain and frequency response of the circuit, shaping the tonal characteristics of the overdrive.
- 3. **Power Supply:** Provides the necessary voltage for the circuit to operate.

Link: <u>https://tinyurl.com/2dhd247c</u> Photo:



Generating Precise Impulses - The Impulse Generator

The Impulse Generator stands out for its ability to produce short, precise pulses of electrical energy. These impulses are essential in various applications, from testing electronic components to creating specific signal patterns in communication systems. The Impulse Generator, with its ability to generate controlled, high-energy pulses, is akin to the heartbeat of many electronic systems.

Key Components:

- 1. Capacitor: Stores and releases electrical energy rapidly to create the impulse.
- 2. **Resistor:** Controls the discharge rate of the capacitor, shaping the impulse's duration.
- 3. **Transistor:** Acts as a switch to control the flow of current, ensuring precise timing of the impulses.
- 4. **Diode:** Ensures current flows in the correct direction, protecting the circuit components.
- 5. **Power Supply:** Provides the necessary voltage for the circuit to operate.

Link:<u>https://tinyurl.com/22zqq69d</u>





To calculate the length of the impulse in the given impulse generator, you need to determine the time constant of the circuit. The length of the impulse (T) is determined by the RC time constant of the capacitor and resistor connected to the base of the second transistor.

Given:

R=10kΩ

C=10nF

The time constant (T) can be calculated using the formula: T=R×C

Plugging in the values: T=10k Ω ×10nF=10,000×10×10⁻⁹=100 μ s

So, the length of the impulse is 100 microseconds.

Advanced Pulse Control - Impulse Generator Type II

Imagine an orchestra conductor who can control the duration of each note, regardless of how long the musicians play. Impulse Generator Type II serves a similar role, generating pulses of consistent duration, irrespective of the input signal's length. This capability ensures reliable and precise timing, which is essential in various electronic systems.

Key Components:

- 1. Capacitor: Stores and releases electrical energy rapidly to create the impulse.
- 2. **Resistor:** Controls the discharge rate of the capacitor, shaping the impulse's duration.
- 3. **Transistor:** Acts as a switch to control the flow of current, ensuring precise timing of the impulses.
- 4. **Diode:** Ensures current flows in the correct direction, protecting the circuit components.
- 5. **Power Supply:** Provides the necessary voltage for the circuit to operate.

How It Works:

- 1. **Triggering the Pulse:** An input signal initiates the charging of the capacitors through the resistors.
- 2. Charging Phase: The capacitors charge up to the supply voltage through the resistors.
- 3. **Impulse Generation:** The transistors switch on to provide a low-resistance path for the capacitors to discharge rapidly, creating the impulse.
- 4. **Output Signal:** The resulting impulse is a brief, high-energy pulse with a duration determined by the circuit components, not the input signal length.

Link:<u>https://tinyurl.com/2d336p5d</u> Photo:



Signal Stability - The Schmitt Trigger

In the bustling world of electronics, signals often encounter noise and fluctuations that can lead to instability and erroneous readings. The Schmitt Trigger is a circuit designed to provide clean, stable output signals by introducing hysteresis, a mechanism that creates two distinct threshold voltage levels.

Key Components:

- 1. **Transistors (NPN):** Act as switches to control the flow of current based on the input voltage.
- 2. **Resistors:** Set the threshold levels and biasing for the transistors.
- 3. **Power Supply:** Provides the necessary voltage for the circuit to operate.

How It Works:

- 1. **Input Signal:** The input signal, such as a 200Hz sine wave, is fed into the base of the first transistor through a resistor.
- 2. **Threshold Levels:** The resistors set two distinct threshold levels—an upper threshold and a lower threshold. The transistors switch states based on these thresholds.
 - When the input voltage exceeds the upper threshold, the first transistor turns on, and the second transistor turns off, resulting in a high output state.
 - When the input voltage drops below the lower threshold, the first transistor turns off, and the second transistor turns on, resulting in a low output state.
- 3. **Hysteresis:** This creates a buffer zone between the high and low states, preventing rapid switching and ensuring a stable output.

Link:https://tinyurl.com/2cu996yy Photo:



Splitting Signals with Precision - The Unity Gain Phase Splitter

Imagine an orchestra where every instrument must play in perfect harmony, even when some parts are inverted. The Unity Gain Phase Splitter ensures that the signals are split accurately, preserving their integrity and phase relationships. This circuit is vital in audio processing, ensuring balanced signal paths and reducing noise interference.

Key Components:

- 1. **Transistor:** Acts as the main amplifying and phase-splitting element.
- 2. **Resistors:** Set the biasing and gain of the circuit, ensuring proper operation and signal levels.
- 3. **Capacitors:** Block DC components and allow AC signals to pass, ensuring signal integrity.
- 4. **Power Supply:** Provides the necessary voltage for the circuit to operate.

Link:<u>https://tinyurl.com/2d7lr2n7</u> Photo:



Crafting Smooth Waves - The Triangle-Wave Oscillator

Imagine a calm, undulating wave in a serene lake, rising and falling with perfect symmetry, paired with the distinct, sharp edges of a square. The Triangle-Wave and Square-Wave Oscillator replicates these forms in the electronic realm, producing both smooth and sharp waveforms.

Key Components:

- 1. **Operational Amplifiers:** Act as the main active components that generate and shape the waveform.
- 2. **Resistors and Capacitors:** Set the timing and amplitude of the waveform.
- 3. **Power Supply:** Provides the necessary voltage for the circuit to operate.

How It Works:

- 1. **Integration Stage:** The first op-amp configuration integrates a constant current to produce a linear ramp signal. This is achieved using a capacitor and resistor.
- 2. **Switching Stage:** The second op-amp is configured as a comparator, which switches the direction of the current flow once the output reaches certain threshold voltages. This creates the rising and falling edges of the triangle wave.
- 3. **Feedback Loop:** The comparator's output is fed back to control the current direction in the integrator stage, ensuring a continuous triangular waveform.

Link: https://tinyurl.com/2xoto6hx



Capturing Peaks - The Positive Peak Detector

Imagine a mountain climber whose goal is to identify and mark the highest peaks they reach. In our electronic city, the Positive Peak Detector serves a similar role, capturing the highest points of an input signal. This circuit ensures that the peak values are preserved and made available for further processing or measurement.

Key Components:

- 1. **Operational Amplifiers:** Act as the main active components that amplify and buffer the signal.
- 2. **Diode:** Allows current to flow in one direction, ensuring that only positive peaks are captured.
- 3. Capacitor: Stores the peak voltage value.
- 4. **Resistor:** Sets the discharge rate of the capacitor.
- 5. **Reset Switch:** Allows the capacitor to be discharged, resetting the peak detector.
- 6. **Power Supply:** Provides the necessary voltage for the circuit to operate.

How It Works:

- 1. Input Signal: The input signal, which can vary over time, is fed into the first op-amp.
- 2. **Peak Detection:** The first op-amp, configured as a buffer, drives the diode. When the input signal exceeds the voltage stored in the capacitor, the diode conducts, charging the capacitor to the new peak voltage.
- 3. **Storage:** The capacitor stores the peak voltage, ensuring it is held until a higher peak is detected or the circuit is reset.
- 4. **Output Signal:** The second op-amp, also configured as a buffer, ensures that the stored peak voltage is available at the output without discharging the capacitor.
- 5. **Reset Function:** The reset switch allows the capacitor to discharge, resetting the peak detector and allowing it to capture new peaks.

Link: https://tinyurl.com/2cpfobhs



Half-wave rectifier

Link:<u>https://tinyurl.com/2bbqk84k</u> Photo:



Full-wave rectifier(using Op-amps improved)

Link:<u>https://tinyurl.com/2br7kovc</u> Photo:



Shaping Signals - The Waveform Clipper

Imagine an artist sculpting a block of marble, carefully chiseling away excess material to reveal the desired shape. Waveform Clipper performs a similar function, trimming the peaks of an input signal to keep it within desired limits. This circuit ensures that the signal remains within a specified range, protecting downstream components and shaping the signal as needed.

Key Components:

- 1. **Diodes:** Allow current to flow in one direction, clamping the voltage to a specified level and preventing it from exceeding that level.
- 2. **Resistors:** Set the current flow and work with the diodes to determine the clipping voltage.
- 3. **Power Supply:** Provides the necessary voltage reference for the diodes to clamp the signal.

How It Works:

- 1. Input Signal: The input AC signal, such as a 40Hz sine wave, is fed into the circuit.
- 2. **Clipping Action:** When the input signal exceeds the forward voltage of the diodes plus the reference voltage, the diodes conduct and clamp the signal to the reference voltage.
- 3. **Positive Clipping:** The upper diode conducts during the positive half-cycle of the input signal, limiting the positive peak to the reference voltage (e.g., +5V).
- 4. **Negative Clipping:** The lower diode conducts during the negative half-cycle, limiting the negative peak to the reference voltage (e.g., -5V if applicable).
- 5. **Output Signal:** The resulting output signal has its peaks clipped, keeping it within the specified voltage range.

P.S. Better clipper function can be attained by adding a similar segment in the line. **Link:**https://tinyurl.com/2c8cudl4



Out the Noise - The Sallen-Key Low-Pass Filter

Imagine tuning a radio to a specific station, carefully filtering out all the static and interference to hear the music. The Sallen-Key Low-Pass Filter performs a similar function allowing only low-frequency signals to pass through while attenuating higher frequencies. This ensures that the output signal is clean and free from unwanted noise.

Key Components and Their Roles:

- 1. **Operational Amplifier:** Acts as the main active component that amplifies and buffers the signal.
- 2. Resistors: Set the frequency response of the filter.
- 3. Capacitors: Work with the resistors to determine the cutoff frequency of the filter.
- 4. **Power Supply:** Provides the necessary voltage for the op-amp to operate.

How It Works:

- 1. Input Signal: The input AC signal, such as a 32.3Hz sine wave, is fed into the circuit.
- 2. **RC Network:** The combination of resistors and capacitors forms an RC network that determines the cutoff frequency. The cutoff frequency is the point where the filter starts to attenuate high-frequency signals.
- 3. **Amplification and Filtering:** The op-amp amplifies the signal and, together with the RC network, attenuates frequencies above the cutoff frequency. This ensures that only low-frequency signals are allowed to pass through to the output.
- 4. **Output Signal:** The filtered signal, which contains primarily low-frequency components, is available at the output of the op-amp.

P.S. Need calculations to ba added, how resistor and capacitor values change filter.



Sallen-Key High-pass Filter

The Sallen-Key High-Pass Filter performs a similar function allowing only High-frequency signals to pass through while attenuating lower frequencies



Link:<u>https://tinyurl.com/2cxl345n</u>

Combining Sounds - The Summing Amplifier

Imagine a concert where different musical instruments play simultaneously, and their sounds need to be combined into a single, harmonious output. The Summing Amplifier performs a similar function in the electronic realm, combining multiple input signals into a single output signal. This circuit is crucial for mixing audio signals and ensuring that different sources can be combined effectively.

Key Components and Their Roles:

- 1. **Operational Amplifier:** Acts as the main active component that sums the input signals.
- 2. **Resistors:** Set the gain and ensure that each input signal contributes equally to the output.
- 3. **Power Supply:** Provides the necessary voltage for the op-amp to operate.

How It Works:

- 1. **Input Signals:** Multiple input signals, such as the 282.9Hz and 671.3Hz sine waves, are fed into the inverting input of the op-amp through equal-value resistors.
- 2. **Summing Action:** The op-amp sums the input currents flowing through the resistors. Since the inverting input is at virtual ground (0V), the sum of the input currents is converted to a voltage at the output.
- 3. **Output Signal:** The output of the op-amp is the inverted sum of the input signals. The resistor at the output stage can be used to set the overall gain of the summing amplifier.
- 4. **Audio Output:** The resulting output signal, which is the sum of the input signals, is available at the audio out terminal.

Link:https://tinyurl.com/2a5996zb



Oscillating Circuits - The Astable Multivibrator

Imagine a lighthouse with its light blinking continuously, providing a rhythmic signal to passing ships. The Astable Multivibrator functions similarly in the electronic world, generating a continuous square wave signal that alternates between high and low states. This circuit is crucial for creating clock pulses, timing signals, and more.

Key Components :

- 1. Transistors (NPN): Act as switches to alternately charge and discharge the capacitors.
- 2. **Capacitors**: Store and release electrical energy to create the timing intervals for the oscillation.
- 3. **Resistors**: Set the timing intervals by controlling the charging and discharging rates of the capacitors.
- 4. **Power Supply (+5V)**: Provides the necessary voltage for the circuit to operate.

How It Works:

- 1. Initial State: Assume one transistor (Q1) is on and the other (Q2) is off.
- 2. **Charging and Discharging:** The capacitor connected to the collector of Q1 charges through the resistor connected to the base of Q2. When the voltage across the capacitor reaches a certain threshold, Q2 turns on and Q1 turns off.
- 3. **Oscillation:** The process repeats with the roles of the transistors reversed. This alternating charging and discharging of the capacitors create a continuous oscillation, resulting in a square wave output.
- 4. **Output Signal**: The output can be taken from the collector of either transistor, providing a square wave signal that alternates between high and low states.

Link:https://tinyurl.com/26tugafq Photo:



Saw symmetry and frequency adjuster

This circuit allows the creation of a saw waveform and adjust its symmetry(angle of attack) as well as using a potentiometer to adjust frequency and offset. An important part of the circuit is using capacitor values to set ranges for frequency(create calculations)

Link:https://tinyurl.com/2bjrg6nu

