# Ramp Generator Uses Microcontroller Emulation Of Unijunction Transistor

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**UNIJUNCTION TRANSISTORS (UJTs)** were common circuit elements several decades ago. A simple ramp generator could be built from a single UJT and a few other components *(Fig. 1)*.

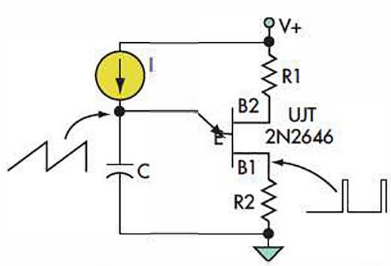
The operating principle is simple. The base-emitter junction is initially in a high-impedance state, and the current source linearly charges the capacitor until a breakdown voltage is reached. At that point, the capacitor discharges through the UJT base until a lower threshold voltage is reached. Then, the base-emitter connection returns to a high-impedance state, and the capacitor can recharge.

This approach still has a few advantages over digital circuitry, as there are tradeoffs when using a digital-to-analog converter (DAC) to create a ramp. Inexpensive microcontrollers include high-resolution analog-to-digital converters (ADCs), but high-resolution DACs are expensive peripheral components. While such DACs have limited resolution, an analog ramp like one produced by a UJT has infinite resolution.

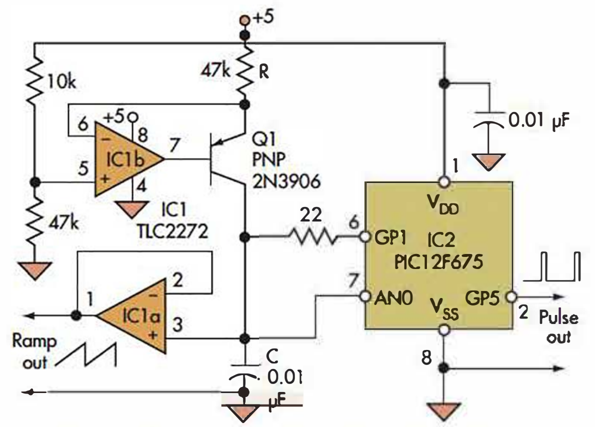
It's possible to emulate the action of a UJT using just three I/O pins of a microcontroller and a few other components. Most microcontrollers allow their I/O pins to be dynamically reconfigured to function as either a high-impedance input or as an output. This feature is the basis for a simple UJT-emulated ramp generator.

In the microcontroller emulation, the current source is implemented by the rail-to-rail operational amplifier IC1b of a dual device and Q1, while IC1a buffers the voltage on capacitor C and provides the ramp output *(Fig. 2)*. This capacitor is connected to both analog/digital converter pin AN0 of the microcontroller (IC2) and to its I/O pin GP1, which is initially configured as an input. A 22-Ω current-limiting resistor allows high-value capacitors to be used without damage to the microcontroller.

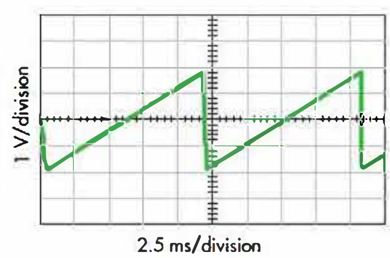
The pseudocode listing for the microcontroller continually monitors the capacitor voltage *(see the code at electronicdesign.com)*. When it reaches a threshold, it switches the I/O pin from its high-impedance input state to an output state at ground potential. When the capacitor voltage goes below another threshold, the I/O pin is switched back to a high-impedance state, and the cycle repeats *(Fig. 3)*. The circuit also provides a pulse synchronized with the ramp cycles that can be used for timing and triggering.




**1. In a simple UJT-based ramp generator, the current source linearly charges the capacitor to create a voltage ramp. A synchronizing output pulse is also available.**




**2. The microcontroller-based emulation of a UJT ramp generator switches the function of an I/O pin from a high-impedance input state to an output state to implement the ramp-generation function.**




**3. The ramp output repetition rate is about 85 Hz using the values shown. It can be changed via resistor R, which sets the charging current, and capacitor C.**

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# Current Source For LED Microscope Illuminator Provides Full-Spectrum Light

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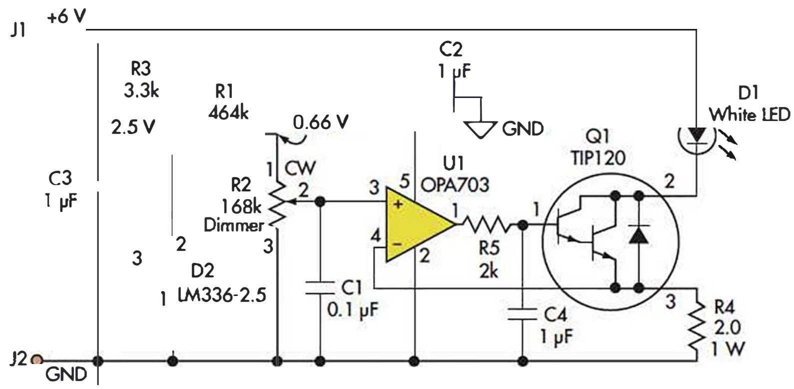
**WHEN THE BUILT-IN** incandescent light source of my venerable Olympus microscope failed after many years of use, I decided to design a reliable modern replacement. A 1-W white LED (SEOUL X42182, 350 mA max, Vf = 3.25 V) was the obvious choice to provide high brightness and full-spectrum light without the heat of incandescent or xenon arc lamps. The microscope lamp brightness needs to be adjustable, however, to accommodate the different objective lenses, which offer magnifications from 40× to 1000×.




This circuit provides adjustable dimming of the white LED over a wide range, a requirement for the microscope application with its settable magnifications. It takes what appears to be a linear current source and uses it in a PWM mode.

This simple circuit allows full-range dimming by driving the LED with a stable current source while generating little heat *(see the figure)*. Shunt voltage regulator Q2 sets a stable 2.5-V reference that is divided by R1 and R2 to give a maximum voltage of 0.66 V at the top of R2. Different values of R1 and R2 may be used as long as the sum of their values is greater than 20 kΩ, so as to keep Q2 in regulation.

As the nominal end-to-end resistance of potentiometers may have wide tolerances, measure the value of R2 that you are using and then calculate R1 to provide the 0.66-V maximum voltage at the non-inverting input of U1.

The inverting input of U1 monitors the voltage generated by the current through R4 and sets that voltage to match the voltage at the potentiometer wiper. The current through R4 must pass through the LED and Q1. Although this circuit appears to be a linear current source, the combined gain of U1 and Q1 is so high that the op amp operates in pulse-width modulation (PWM) mode, running at about 100 kHz. R5 and C4 create a 12.5-kHz low-pass filter, reducing any ripple of the current through the LED to less than 1%. The circuit thus creates a stable and fully adjustable light source without discernible flicker.

The LED requires a 1-W heatsink, which may also be used for the mechanical mounting to hold the LED rigidly in place in the optical axis of the microscope, as the LED must not jiggle if the microscope is touched or adjusted. Q1 also needs a small heatsink as it generates about 0.75 W of heat at full brightness, while R4 produces only 0.25 W of heat and barely gets warm.

Any 6-V isolated dc supply capable of providing 400 mA or more can be used for powering the circuit. Commercial wall-plug switching supplies are available and work well here. For certain medical or laboratory use, though, voltage isolation and leakage-current specifications of the supply might have to meet special standards such as IEC 60601.

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