A fast optical LED pulse generator

A very simple and reasonably fast optical pulse generator is presented here, based around a resonant cavity 650 nm light emitting diode. It produces very well collimated light form the LED's built-in optics and it has been found useful when testing various laboratory optical detectors, such as photomultipliers and photodiodes which need to operate over a broad range of times. The generator delivers flat-topped pulses, either from an internal oscillator or from an external TTL input. Rise and fall times of the order of 3 ns are achieved by shaping the LED drive pulse, derived from an 'F' series TTL inverter, as shown in Figure 1.

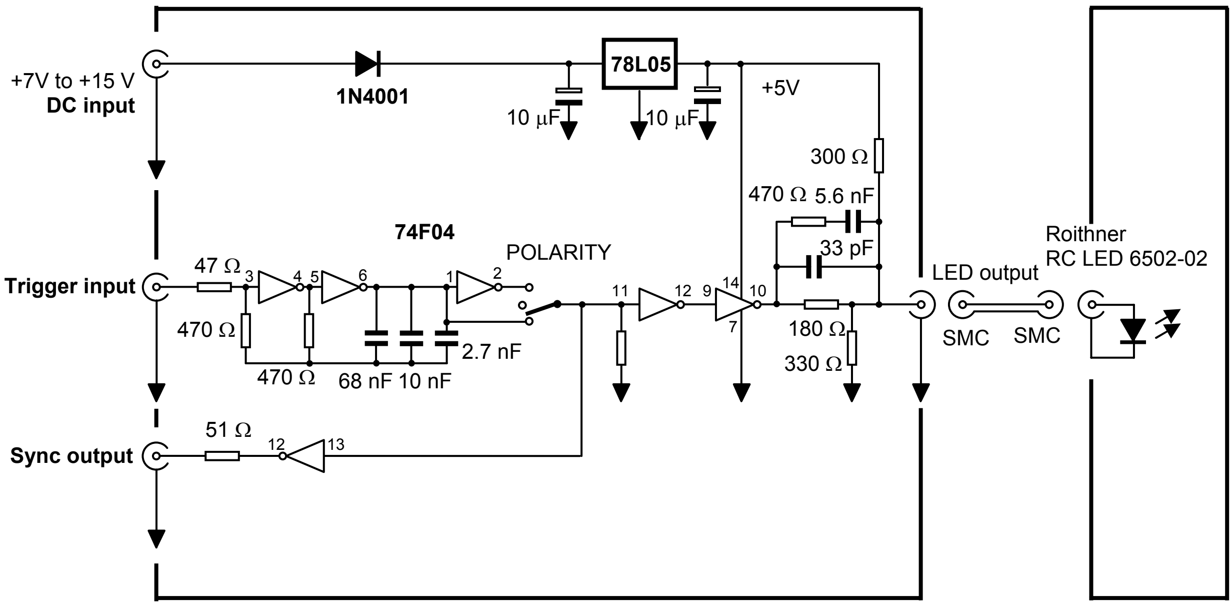

Figure 1: Circuit diagram of the fast optical pulse generator.

Tow of the inverters in the 74F04 package are wired as an RC oscillator, running at about 10 kHz; the exact frequency can be trimmed if required by selecting one of the timing capacitors (the 2.7 nF capacitor serves this 'tuning'). This oscillator is a classic two-inverter design The 470 Ω resistors should not be altered as they ensure biasing of the 'F' series inverter sections. With the trigger input open-circuited, the oscillator is active; when the trigger input is connected to a source of output impedance of 50 Ω or less, the 'oscillator' output follows the trigger input, down to a minimum pulse width of ~10 ns. When the trigger input is connected to an 'open-collector' type of output, or through a diode, it assumes the function of a gate input. An 'active low' sync output is provided by the last section of the 74F04 hex inverter.

However, the oscillator can be forced into a high or low state by an external trigger input and the resulting output can be inverted. A 3 way toggle switch (centre-off) selects between no output (centre position) or normal or inverted output pulse polarities. The last stage of the inverter drives the LED through an empirically-set resistive and capacitive network: the 300 Ω pull up resistor keeps the Led energised, while the inverter's job is to switch off the LED. The 33 pF capacitor and the 470 Ω + 5600 pF capacitor speed up the transition times as well as ensuring a flat output at longer times.

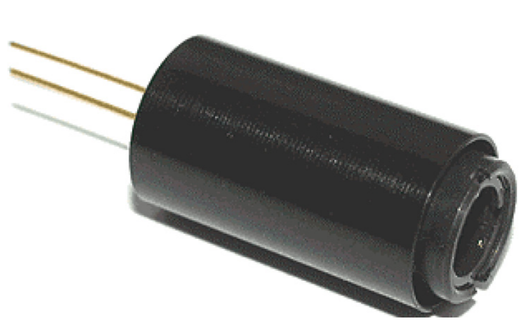

Figure 2. The 650 nm resonant cavity collimated LED

The resonant cavity LED (type RC-LED-650-02) is available from Roithner LaserTechnik (Wiedner Hauptstraße 76, 1040 Vienna, Austria, http://www.roithner-laser.com) mounted in an aluminium housing (10 mm diameter), as shown in Figure 2. It produces a collimated output beam diameter of just under 5 mm (beam divergence <6 mrad). The peak output power is ~200 µW when driven at 20 mA, as this circuit delivers. We mounted this LED inside a simple circular housing and connected directly to a SMC coaxial connector, as shown in Figure 3.

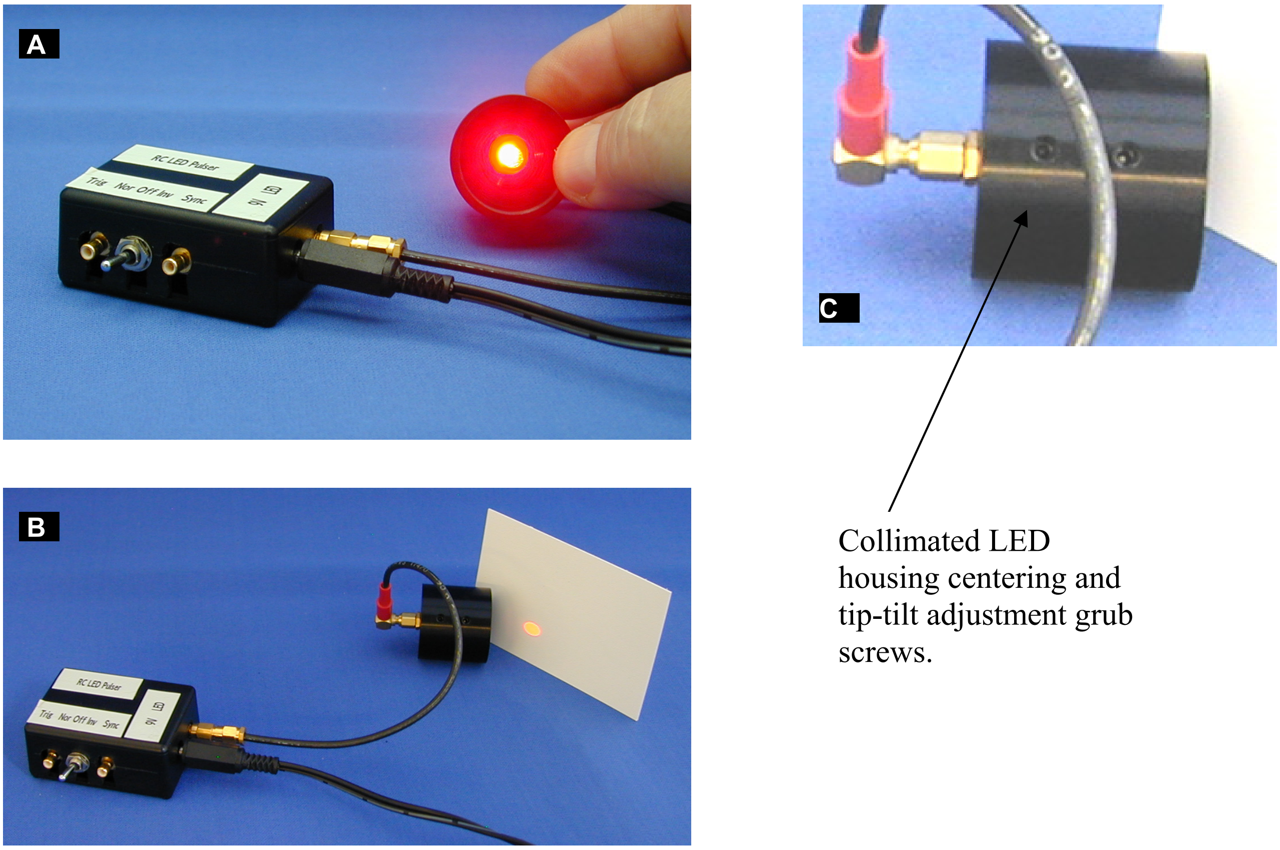

Figure 3.The completed pulse generator and LED housing. A: The pulse generator is constructed in a small plastic enclosure and coupled to the LED's input connector using SMC-terminated coaxial cable. The somewhat over-exposed collimated beam can just be discerned in 'B' beam. Two sets of grub screws are arranged around the periphery of the housing ('C') to allow tip-tilt and centering adjustments to be performed.

The performance of the devices is shown in Figure 4. The step response is acceptably fast, and more than adequate to check photodetector response times of the order of 5-10 ns. The device is very simple to construct; indeed it took no more than a few hours to assemble and test the performance of the prototype device. We did not check the wavelength stability of the device, nor the variation of output with temperature; these are well document in the device data sheet. Dc input power is supplied from a small wall-plug power supply; the DC voltage output is not critical and can be in the range of +7V to >+15V, since the internal supply is regulated to +5V.

It is important to appreciate that the actual component values in the LED drive circuit depend on the regulated supply voltage and on the particular samples of the 74F04 inverter and the LED; the circuit waveforms should thus always be checked with a properly calibrated detector. It is equally important to couple the LED through only a short length of RG174 cable (SMC connectors) and not to alter its length without adjusting the 'speed-up' component values.

This device has been used for a number of years and has proved invaluable for testing laboratory optical instrumentation. One drawback is that only red light at 650 nm is available. At some point in the future, we intend to develop similar devices for use at other wavelengths, though it is unlikely that fast transition times could be obtained with such a simple circuit.

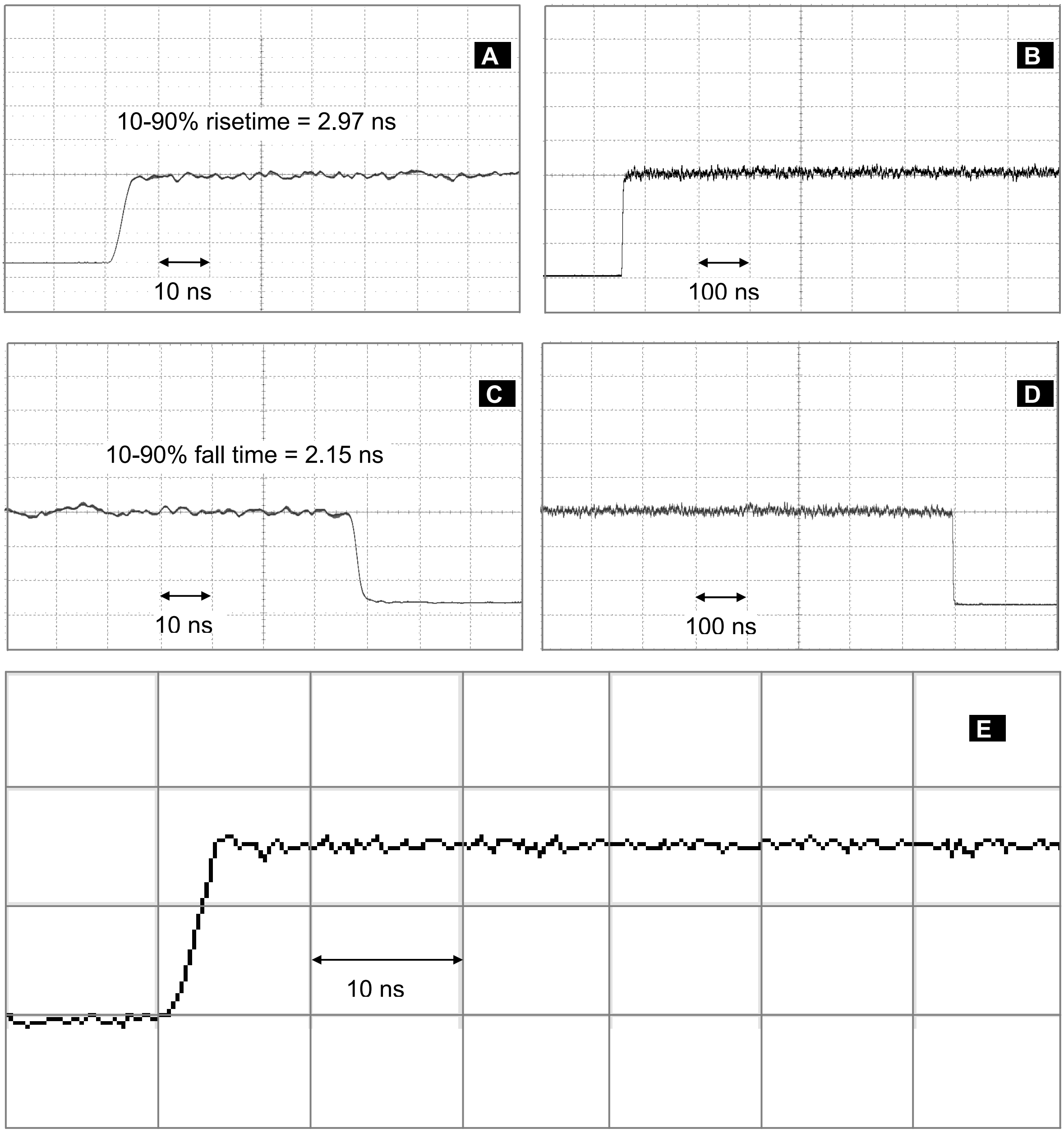

Figure 4. Typical pulse performance of the optical generator. Panels A and C show the rise and fall times of the optical output of the generator, while panels B and C show the flatness of the step/pulse at the onset of optical output and the end, i.e. when the LED is turned off. Data on panels A-D is acquired using a 1 GHz bandwidth oscilloscope preceded with a <0.8 ns response time photomultiplier detector. The negative-going output of the photomultiplier has been inverted for clarity (increase in light is shown as a higher level output on the traces). The risetime is actually somewhat faster when the optical output is acquired using a time-correlated single photon counting system with ~100 ps time resolution, as shown in panel E

Finally, Figure 5 shows another example of an fast LED driver based around a 2N918 screened can RF transistor, which is still available. We tried this arrangement in the past and it works extremely well; its rise/fall time performance is similar to that of the system just described. But a hex-inverter is so much easier to use!

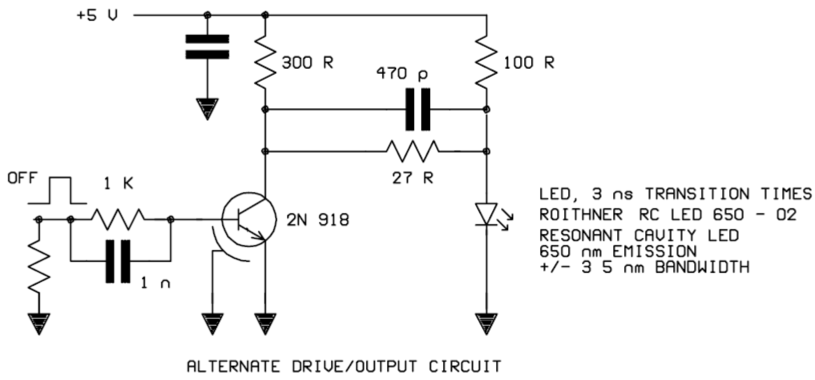

Figure 5. For people who prefer discrete devices, this LED drive circuit may prove useful

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