

Ethernet 10BaseT simulator jig yields zero emissions

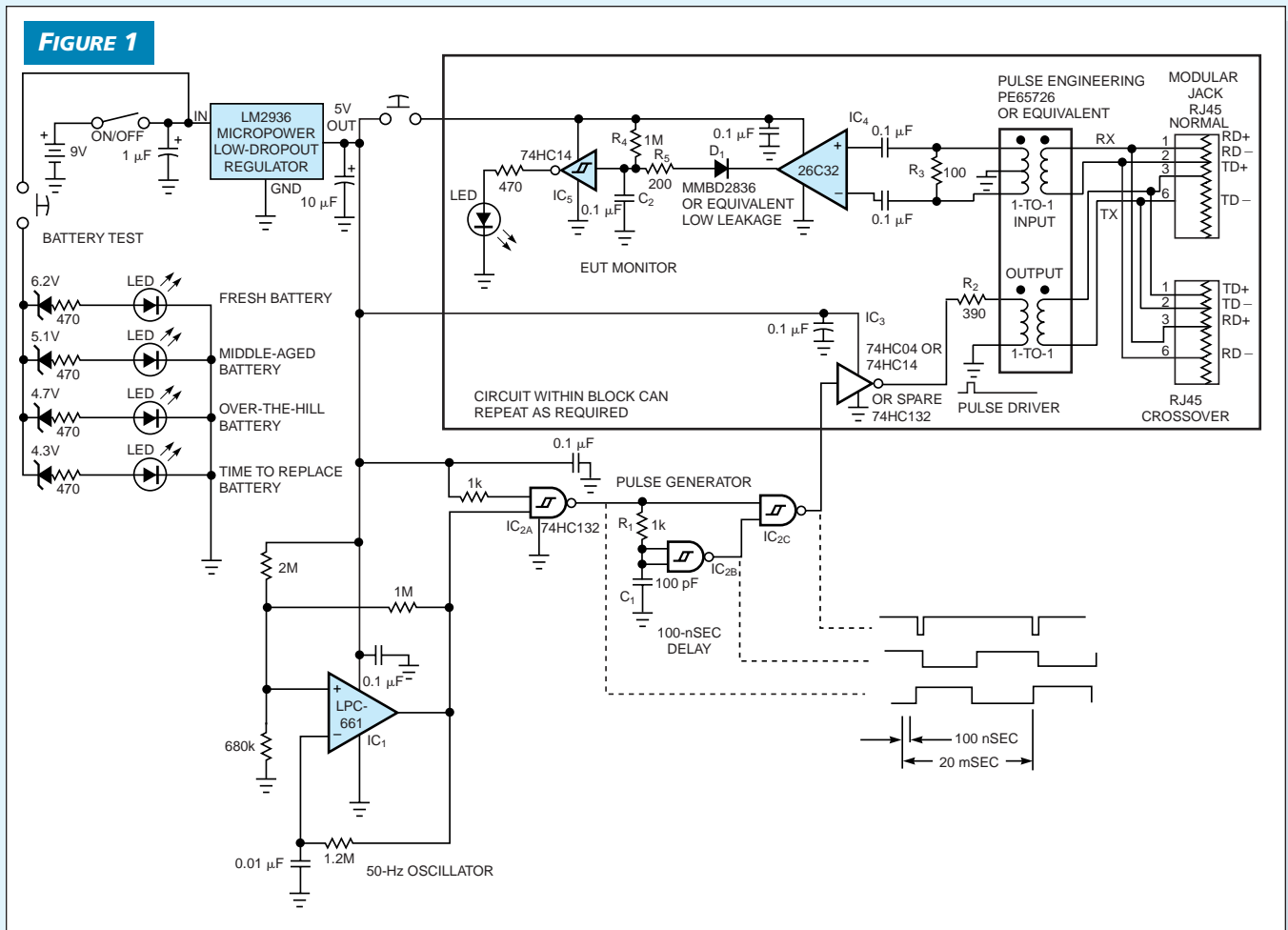
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A test jig (**Figure 1**) is a valuable tool because it evaluates RF emissions from Ethernet unshielded-twisted-pair (UTP) 10BaseT LAN-interface devices without contaminating the measured results with its own RF emissions. When an RF-emissions-measurement lab tests a multiport, UTP 10BaseT Ethernet device for compliance with FCC-radiated emission limits, the test is meaningful only if the device transmits data packets from all 10BaseT ports. To enable this transmission, the 10BaseT ports must receive a steady stream of link test pulses from attached 10BaseT devices. Unfortunately, the attached devices commonly radiate from their attached cables on the same frequencies as the equipment under test (EUT). This problem makes EUT performance evaluation and any trial fixes difficult, if not impossible. The solution is to

eliminate the radiated noise from the ancillary equipment.

A test generator outside the measurement area can avoid interfering emissions from the generator and its cables by generating the packet data and feeding it over optical fiber to an EUT port. But the EUT 10BaseT ports still need a source of link test pulses to retransmit the data packets. To evaluate EUT emissions from the cables, these sources must connect to the EUT by UTP cables of at least 1m. Only emission-free link-test-pulse sources provide an accurate evaluation of the EUT. The emission-free requirement is difficult to meet when the link-test-pulse sources are 10BaseT devices with noisy 20-MHz clock oscillators and digital circuitry.

The circuit in **Figure 1** generates the required link-test pulses without RF emissions. The pulse must have a width of 60



A useful test jig, which includes an equipment-under-test (EUT) monitor and pulse-driver circuit, evaluates RF emissions from Ethernet unshielded-twisted-pair LAN-interface devices without contaminating the measured results with its own RF-emissions.

to 130 nsec with a repetition frequency of 42 to 125 Hz. Pulse amplitude should be 500 mV to 3V. This test jig outputs pulses of about 1V, but you can easily change this level by changing the value of R_2 .

For convenience, the jig operates from a 9V battery. The use of CMOS devices results in a current drain of less than 100 μ A. According to battery specifications, this current drain translates to an expected battery life of several thousand hours. The duty cycle of the link test pulses is 100 nsec/20 msec=0.0005%, so little battery energy is necessary to drive the EUT receivers. A pushbutton battery-test feature using zener diodes and a four-LED bar-graph display ensures that the battery is capable of the day's testing. To extend battery life, a pushbutton EUT-monitor circuit verifies that the EUT is working properly and is actually transmitting data packets from each port you test.

The frequency of the master oscillator (IC_1) is 50 Hz, which spaces the link-test pulses at 20-msec intervals. This low frequency has low harmonic energy in the 30-MHz and higher portion of the RF spectrum; thus, it achieves the primary design goal. IC_1 , a micropower LPC661, has low power consumption, yet its slew rate is fast enough that the input of the following 74HC132 Schmitt trigger stage (IC_{2A}) is between the rails for a minimum time.

You can eliminate IC_1 and use IC_{2A} as the oscillator, but the power consumptions of HCMOS gates and Schmitt triggers tend to rise drastically when the input voltages are not at supply rails. A Schmitt-trigger CMOS oscillator has a constant sawtooth centered linearly between its trip points at its input. The measured difference in the jig's total power drain is 6.5 mA with the HCMOS oscillator and 85 μ A with the LPC661 oscillator. Long battery life is a secondary design goal.

The pulse generator uses a 100-nsec RC-delay line (R_1 , C_1), and a Schmitt-trigger buffer (IC_{2B}) to present the 50-Hz square wave and a 100-nsec delayed version of this square wave to the inputs of NAND gate IC_{2C} . Thus, IC_{2C} 's output consists of 100-nsec-wide pulses at 20-msec intervals. The pulse-driver gate (IC_3) inverts these pulses to drive the output transformer through a 390 Ω current-limiting resistor (R_2). The transformer is a 1-to-1 Ethernet transformer. You can use other types of transformers with built-in filters; however, the low

pulse-repetition rate does not require a bandlimiting filter. Changing the value of R_2 varies the nominally 1V output's amplitude.

Two RJ45 jacks connect the simulator to the EUT. The test jig includes both normal and crossover-wired jacks so that you always have the jack you need for the available UTP cable.

The EUT-monitor circuit includes the 100 Ω termination (R_3) for the EUT-transmit pair. Keep the leads in this area short and symmetrical to avoid reradiating the data packets from the EUT and causing false emission readings. Even with V_{CC} off, IC_4 has a high input impedance to avoid generating and reradiating harmonics of the data packets. When you depress the EUT-monitor test button, any input data activity causes the IC_4 's output to toggle at the packet data rate. The negative-going data pulses discharge C_2 , resulting in a high output from IC_5 's Schmitt-trigger inverter, which in turn lights the LED.

R_5 , a 200 Ω resistor, slows the capacitor's discharge time constant enough to ensure that any overshoot or ringing from the EUT's positive-going, individual link test pulses do not light the LED. Only actual data packets have a pulse density sufficient to light the LED. Once discharged, the low-leakage diode, D_1 , and the 1M R_4 increase the capacitor's recharge time (the period after the end of the packet when IC_4 's output is high again). The lengthy recharge time extends the LED's on-time to 100 msec for maximum visibility.

You can add any number of pulse-driver and EUT-monitor sections to the basic circuit, depending on the number of simulator ports and the limits of the LM2936 regulator when all LEDs are on. If you wish to power the EUT-monitor circuit from a separate higher power regulator, place the pushbutton at the additional regulator input so that the regulator's quiescent-current drain does not unnecessarily load the battery. If you don't wish to incorporate the EUT-monitor circuit, you still need to place the 100 Ω termination resistor across the EUT-transmit pair, but you will no longer need the input transformer. (DI #2235)

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