Transistor trio makes vector anemometer

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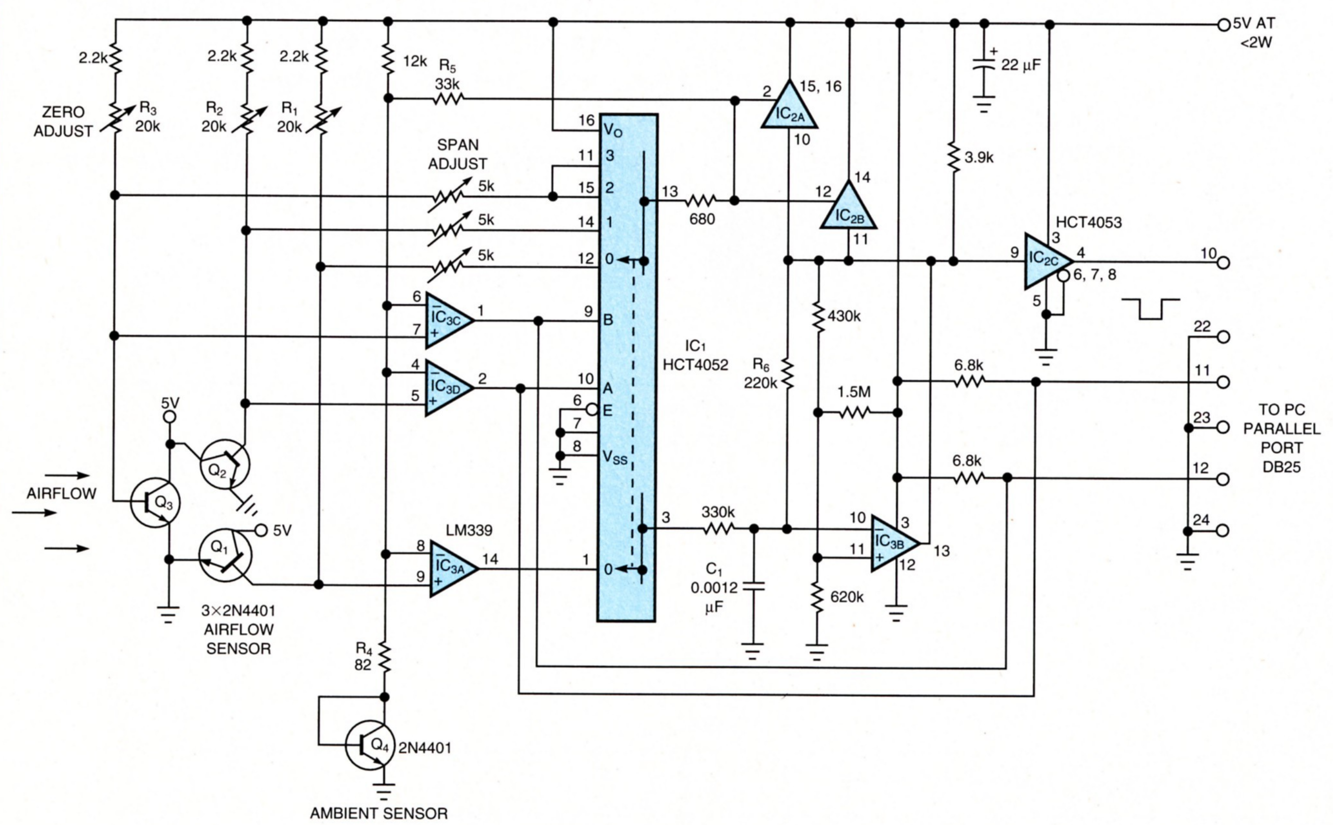
A previously published Design Idea (**Reference 1**) uses a heated transistor as an airspeed-to-frequency converter. Because it uses only one transistor, the circuit cannot determine the direction of airflow. Alternatively, a circuit that uses a trio of hot transistors can digitize both wind speed and direction (**Figure 1**).

The basic principle of operation is identical to that of the previous circuit. In the zero-airflow case, zero-adjust potentiometers R_1, R_2, and R_3 set quiescent bias currents for self-heated transistors Q_1, Q_2, and Q_3, respectively. If you properly adjust the resistors, collector power dissipation causes a still-air temperature rise in the transistor sensors of approximately 50°C, which in turn reduces the sensors' V_{BE}s by approximately 2 mV/° to just slightly below Q_4's V_{BE} plus the drop across R_4. Then, the voltages at the noninverting inputs of comparators IC_{3A}, IC_{3C}, and IC_{3D} are slightly lower than

FIGURE 1



Q_1 to Q_3 comprise an airflow sensor that enables the circuit to digitize both wind speed and direction.

the voltages at their inverting inputs. These comparators' outputs therefore go low, holding C_1 discharged and multivibrator IC_{3B} reset with its output high. This action causes a zero-frequency output on IC_{2C} and holds IC_{2A} and IC_{2B} off.

If a nonzero airflow impinges on the sensor array, the resulting increase in cooling rate tends to raise the airflow sensor's V_{BE} relative to Q_4's V_{BE}. This change reverses the voltage relation at one or more comparator input pairs and releases the reset on C_1. C_1 then charges through R_6 until the voltage at IC_{3B}'s inverting input is greater than the voltage at its noninverting input, causing IC_{3B}'s output to snap low, beginning the discharge of C_1 through R_6 and turning on IC_2. IC_1 now directs an approximately 700-μsec pulse through the span-adjust-potentiometer array to whichever sensor transistor triggered the cycle. The resultant pulse of collector current deposits a quantum of heat tending to warm that sensor's temperature enough to restore the original zero-flow voltage balance with Q_4. Until that temperature is restored, IC_{3B} continues to oscillate and cycle on IC_2. This feedback loop acts to maintain a constant temperature differential among sensors Q_1 to Q_3 and Q_4. The frequency at IC_{3B}'s output is therefore proportional to the extra power required to heat the array and thus directly related to airspeed.

Meanwhile, feedback through R_5 latches the address of the sensor transistor whose cooling triggered the cycle, so only that transistor receives the heating pulse. This binary (0, 1, or 2) sensor address is available at the output. Thermal coupling between the sensors depends on airflow direction. In **Figure 1**, for example, Q_3 is the most upwind sensor and is therefore the most strongly cooled. This effect is the basis for the computation of wind angle (see Basic program on *EDN*'s Web site, www.ednmag.com. To download the program, go into the Software Center and download the file from DI-SIG, #2073).

The anemometer's output is suitable for direct connection to the parallel port of a desk or laptop PC. You can then run the accompanying Basic program to report wind speed and direction once per second.

The maximum output frequency for the circuit as shown is 1 kHz. Appropriate adjustment of the span-adjust potentiometers establishes almost any desired full-scale flow rate from less than 1 to greater than 10 m/sec (which is equivalent to less than 2 to greater than 20 knots.) Response time is less than 2 sec because of the constant-temperature operation of the sensors. Tracking among Q_1, Q_2, Q_3, and Q_4 compensates for changes in ambient temperature. The circuit operates from one 5V power source. Power consumption depends on airflow rates but is typically less than 2W. (DI #2073) EDN

Reference

1. Woodward, W Stephen, "Self-heated transistor digitizes airflow," *EDN*, March 14, 1996, pg 86).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' Thermal Vector Transistor Anemometer Demo ... W. S. Woodward, 1996
     anacal = 1: ' airspeed scale factor
     tick% = 18.2065: '... # of MSDOS-compatible Time-of-Day "ticktocks"/second
     DEF SEG = 0: ' T.O.D. clock lives at memory addresses (&H46C,D)

' Pick a parallel port base address from the three a-priori' possibilities
pp% = &H379: ' LPT1
IF INP(pp% + 1) = 255 THEN pp% = &H3BD: ' LPT2
IF INP(pp% + 1) = 255 THEN pp% = &H279: ' Last (and least)...LPT3
IF INP(pp% + 1) = 255 THEN PRINT "***ERROR...Parallel Port NOT Found***"; CHR$(7): STOP

windvane:
 q0% = 0: q1% = 0: q2% = 0: ' Initialize sensor heatpulse sums
 tclk% = PEEK(&H46C): ' Sample Time-of-Day cell
   FOR i% = 1 TO tick%: ' Setup to sum heat pulses for ~1 second
    WHILE PEEK(&H46C) = tclk%
     q% = INP(pp%) AND &H70: ' Check for a heater pulse
     IF q% < &H40 THEN IF q% = &H10 THEN q1% = q1% + 1 ELSE IF q% THEN q2% = q2% + 1 ELSE q0% = q0% + 1
     WHILE (q% OR INP(pp%)) < &H40: WEND
    WEND: tclk% = PEEK(&H46C)
   NEXT: ' Tally clock ticktocks 'til 18 are accounted for
 sum% = q0% + q1% + q2%: PRINT USING "####.# "; anacal * sum% * sum%;
 IF sum% = 0 THEN PRINT : GOTO windvane
 IF q0% < q1% THEN IF q0% < q2% THEN a% = q1%: b% = q2%: c% = q0%: g = 120 ELSE a% = q0%: b% = q1%: c% = q2%: g
= 0 ELSE IF q1% < q2% THEN a% = q2%: b% = q0%: c% = q1%: g = 240 ELSE a% = q0%: b% = q1%: c% = q2%: g = 0
 d% = a% + b% - c% - c%: IF d% > 0 THEN PRINT USING "###"; g + ABS(120 * ((b% - c%) / d%)) ELSE PRINT
GOTO windvane
```