

Model Railroad Automated Track Inspection Car

Project# A3831



Circuit Cellar/Atmel AVR 2004 Design Contest

Model Railroad Automated Track Inspection Car—Project A3437

Circuit Cellar/Atmel Corporation AVR 2004 Design Contest

Abstract

The goal of this project is to design and build an Atmel AVR microcontroller-based model railroad car that helps locate and diagnose problems with your layout and track in order to improve the overall running performance of your model trains. The Diagnostic Track Inspection Car operates as it is pulled around the layout with a locomotive, just like any other rolling stock in your collection. The Track Inspection Car alerts the train operator of any potential trouble spots by sounding an audible beeper and simultaneously lighting color-coded LEDs. The different LEDs convey the nature of the problem encountered at that specific location of track.

This unique and novel design automates the otherwise tedious task of visually inspecting every inch of railroad track for small physical misalignments, bumps, or gaps between track sections. The automated Track Inspection Car also limits the need for manual electrical meter troubleshooting to locate voltage dropouts or “dead spots” caused by dirt, corrosion, or bad rail joiner connections along your track rails. Once all of the trouble spots in a layout have been noted, they can be repaired or cleaned, and then rechecked by running the Track Inspection Car around the track again. The Track Inspection Car also has the ability to detect and diagnose problems in hard-to-reach areas of a train layout, including remote corners or inside tunnels.

The design targets traditional DC-powered model railroads; HO scale (1:87) was selected for this project due to its popularity and because a railcar of this scale offers ample size to carry a suitable prototype circuit board. The Track Inspection Car draws its operating power from the rails through electrical contacts on its wheel trucks. The rails are powered by a DC power pack with a throttle for speed and direction control.

A two-axis $\pm 2g$ accelerometer is used to detect excessive side-to-side or up-and-down vibrations that may indicate a rough rail joint or other potential source of derailments. The sensitivity of each axis is adjustable via two trim potentiometers; this allows the user to adjust vibration alert thresholds for each axis independently. A simple voltage divider circuit is used to scale the railroad track voltage (typically ranging from 0 to 14 VDC) down to about 0 to 3 VDC for input to the AVR's Analog/Digital Converter. The accelerometer and track voltage inputs are also processed through the ATtiny26L's built-in 10-bit ADC.

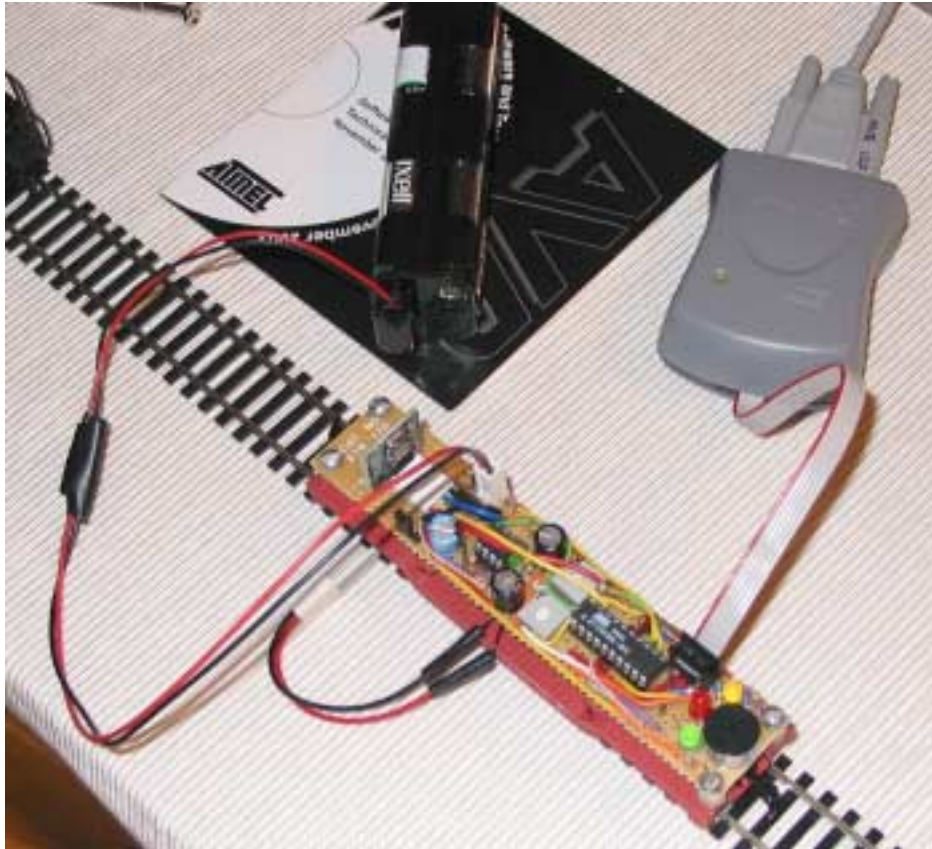
An HO scale search-light equipped flat car was purchased, modified and used as the base platform for the prototype Track Inspection Car. The flat car's all-metal chassis (for stability and better rail contact) and built-in electrical wheel pickups provide an excellent carriage for the ATtiny26L, sensors, and I/O circuitry.

Smooth railroad track and uninterrupted electrical conduction are essential for a fun, realistic, and reliable model railroad. Identifying trouble spots can be frustrating and time consuming. The Atmel AVR-powered diagnostic Track Inspection Car helps make the task of maintaining your model railroad layout very easy. The highly sensitive automated car can quickly find potential causes of derailments and jerky train operation, even long before they become larger problems.

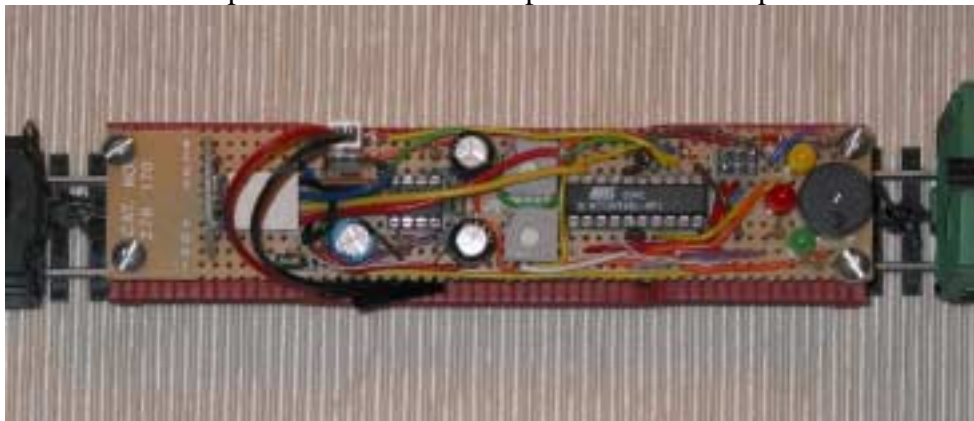
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Existing commercial track inspection cars for model railroading are very limited in number; those few that are available employ non-electronic, “low-tech” solutions relying primarily on manual “hand and eye” operation. Their design generally involves a see-through Plexiglas flat car that is pushed around the layout by hand while “feeling” and watching wheel sets for bumps or rough spots; the design does not monitor for any voltage changes along the train track. The innovative AVR-powered diagnostic Track Inspection Car takes the next step by taking advantage of many powerful features and built-in peripherals of the Atmel AVR ATtiny26L microcontroller to automate the process.



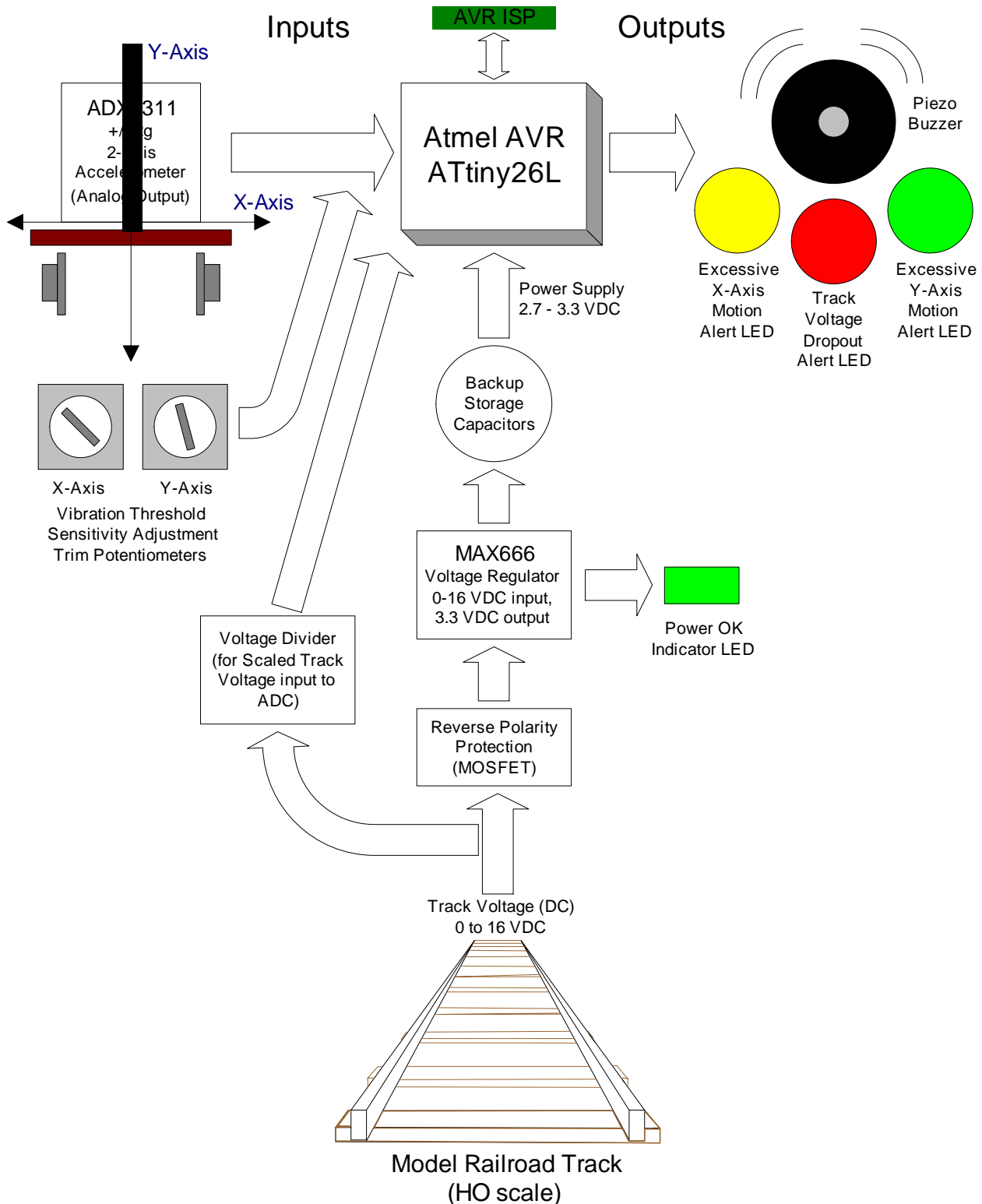
Track Inspection Car connected to AVR ISP for firmware updates,
and a top view of the Track Inspection Car as it operates:



Model Railroad Automated Track Inspection Car—Project A3437

Circuit Cellar/Atmel Corporation AVR 2004 Design Contest

Automated Track Inspection Car — Block Diagram
Entry A3437



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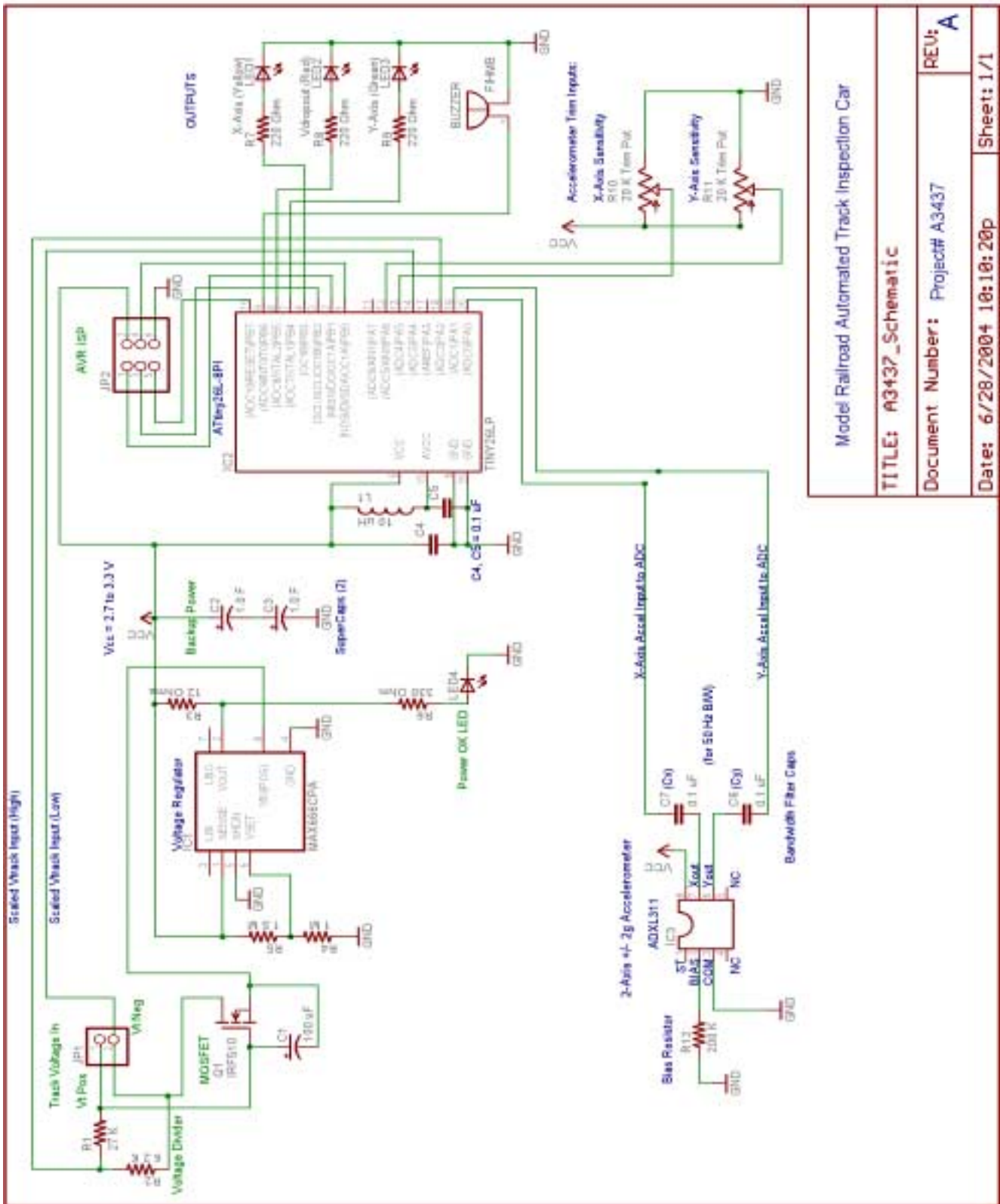
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Model Railroad Automated Track Inspection Car -- Flowchart Entry A3437



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Model Railroad Automated Track Inspection Car—Project A3437

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The automated Track Inspection Car's firmware must perform the following duties as the car operates on a layout:

- Continually scan and update readings from the Accelerometer's X and Y-Axis outputs, as well as the X- and Y-Axis sensitivity potentiometers. The ATtiny26L's 10-bit ADC is used to read these inputs.
- Continually monitor the scaled-down track voltage for any voltage drops. Once operating at a fixed speed, the Track Inspection Car notes the track voltage as a reference for comparison in case it encounters any "dead spots" on the track. The ATtiny26L's 10-bit ADC is used to read this input.
- Signal the operator with momentarily lit LED(s) and buzzer outputs when a bad track condition is detected. A bad track condition could mean excessive X- or Y-Axis motion/vibration, or that a voltage dropout has occurred in the railroad tracks. Port B output pins are used to drive the alert LEDs and buzzer.

Firmware Source Code Sample: (used ImageCraft AVR C compiler)

```
//-----  
// Model Railroad Automated Track Inspection Car  
// Firmware Source Code Listing  
//  
// Project entry # A3437  
// Circuit Cellar/Atmel AVR 2004 Design Contest  
//  
// Target : ATtiny26L  
// Crystal: 4.0000Mhz  
//  
//-----  
  
// Model Railroad Track Inspection Car  
// Main Routine  
void main(void)  
{  
    // Declare temp storage for individual ADC  
    // result values, for comparisons:  
    int nXacc, nYacc; // X & Y-Axis accelerometer readings  
    int nXadj, nYadj; // X & Y-Axis sensitivity adjust settings  
    int nVtrack;      // Scaled (via voltage divider) Track Voltage  
    int nXband, nYband; // for X,Y-Axis sensitivity deviations  
  
    int i, j;  
  
    // Initialize ATtiny26L I/O ports, timers, and ADC  
    init_devices();  
  
    // Pause before starting track inspection; allows  
    // ADC data to stabilize and populate result array.  
    Sleep();
```

Model Railroad Automated Track Inspection Car—Project A3437

Circuit Cellar/Atmel Corporation AVR 2004 Design Contest

```
//  
  
while (1)  
{  
    // Main routine functionality:  
    // ADC_Result[] array is getting updated by  
    // the "ADC conversion complete" interrupt with  
    // ADC in Free-running mode.  
  
    // Copy current ADC array readings into these  
    // temporary variables for this inspection cycle:  
    nXacc = ADC_Result[XaccIdx];  
    nYacc = ADC_Result[YaccIdx];  
    nXadj = ADC_Result[XadjIdx];  
    nYadj = ADC_Result[YadjIdx];  
    nVtrack = ADC_Result[VtrackIdx];  
  
    // Compute X,Y Sensitivity Band values, used for  
    // determining "excessive" X,Y-Axis vibrations (g's)  
    nXband = nXadj >> 5; // Xadj Potentiometer  
    nYband = nYadj >> 5; // Yadj Potentiometer  
  
    // Check for excessive X-Axis (transverse g) vibration  
    if ( (nXacc < (XAXIS_REST_VALUE - nXband)) ||  
        (nXacc > (XAXIS_REST_VALUE + nXband)))  
    {  
        // X-Axis vibration exceeds limits-  
        // Light X-Axis LED (Green) and sound Buzzer  
        PORTB |= (XledOut | BuzzerOut);  
        nXtimer = 1; // Momentary Light/Sound Alert  
    }  
  
    // Check for excessive Y-Axis (Up/Down g) vibration  
    if ( (nYacc < (YAXIS_REST_VALUE - nYband)) ||  
        (nYacc > (YAXIS_REST_VALUE + nYband)))  
    {  
        // Y-Axis vibration exceeds limits-  
        // Light Y-Axis LED (Yellow) and sound Buzzer  
        PORTB |= (YledOut | BuzzerOut);  
        nYtimer = 1; // Momentary Light/Sound Alert  
    }  
  
    // Check for an excessive % Track Voltage drop,  
    // using the running average of Track values in  
    // the circular buffer (last 10 values)-- uses Timer0:  
    if ((TrackVSetPt - TrackVAvg) > 5)  
    {  
        // Track Voltage has dropped below the stored steady state  
        // "set point" constant operating voltage; alert user  
        // to a voltage drop condition:  
        // Light Red LED and Sound Alert  
        PORTB |= (VdropOut | BuzzerOut);  
        nVdroptimer = 1; // Momentary Light/Sound Alert  
    }  
}
```

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```
} // end while  
}
```