

Principles of Operation

The MagLev project uses an electromagnet removed from a commercial solenoid to hold a metal globe in equilibrium with the pull of gravity. An adapter is used to provide low voltage AC to the project's power supply. The power supply sources DC power to MagLev's electronics. A light beam aimed below the globe senses the globe's position and controls the pull of the electromagnet to keep the globe floating. If the globe drops, less light strikes the sensor resulting in more current applied to the electromagnet. Conversely, if the globe rises, more light strikes the sensor resulting in less current applied to the electromagnet. A proportional, integral, derivative or "PID" control system is used to maintain stable magnetic levitation operation.

The Circuit

Power for MagLev comes from a commercial low voltage AC adapter that steps down 120VAC to 12VAC. Full wave bridge rectifier BR1 converts the AC into pulsating DC and capacitor C1 filters the pulses. The unregulated DC output from C1 is used as the source of current for the electromagnet. Resistor R1, along with zener diode ZD1 and filter capacitor C2 set a constant 10V value at the base of pass transistor Q1. The constant voltage at the emitter of Q1 along with filter capacitor C3 provide regulated 9.5VDC to source all the remaining parts of MagLev's electronics.

A white LUCOLED along with current limiting resistor R2 is used for the light beam source. Cadmium sulfide LDR senses the light beam reaching it from under the floating globe. As it's resistance changes with light, the LDR and HEIGHT potentiometer R3 translate these changes into a varying voltage. Capacitor C4 acts as a low pass filter to integrate the voltage changes and reduce the circuit's sensitivity to noise. The filter's output is applied to $\frac{1}{2}$ of U1, a LM1458 dual operational amplifier configured as a unity gain buffer. The buffer amplifier isolates the sensor from the remaining part of the control circuitry.

The second half of U1 is configured as a single-supply inverting amplifier with variable gain set by STABILITY potentiometer R4. R4 provides proportional control. Resistors R6 and R7 divide the supply voltage and C6 filters this voltage for the non-inverting input of U1. C5 allows the amplifier to react quickly to changes in the globe's position. C5 is responsible for the derivative behavior of the control electronics.

U1's amplified output voltage is applied to the gate of power MOSFET Q2. Q2 controls the current flow to the electromagnet. R8 is used to reduce the gain of the MOSFET and compensate for sample-to-sample differences.