Tachometer for Sheaff's Buddy's Boat

Colin Leary
Chris Martin

January 30, 2017

University of Maine
ECE403 Final Report

Abstract

abstract here

Contents

List of Figures

List of Tables

1 Introduction

This report describes the design and construction of a tachometer for a power boat. A tachometer is a device that measures the speed an engine is turning. The tachometer in this project is being designed to work with a four cylinder, four stroke, gasoline engine. In a gasoline engine, the ignition coil is connected to a distributor providing spark to the individual spark plugs. Since each cylinder fires every other rotation, the coil fires twice per revolution on a four cylinder engine, thus the revolutions per minute (RPM) can be calculated with a simple equation.

The tachometer being described in this report is intended to replace a failed unit that is no longer available. The power boat, belonging to Stewart Harvey, has an analog gauge and defective analog driver circuitry. The tachometer being built will connect to the input signal from the ignition coil and output a signal to the analog gauge to display the engine RPM. The gauge must show the engine RPM ± 100RPM in the normal operating range of 1000RPM to 4000RPM.

Additional features of the tachometer is that it has a detachable liquid crystal display (LCD) showing analog engine information such as temperatures and pressures. Although not necessary for operating a boat, additional engine information alerts the operator of any potential engine problems and assists running the engine within safe limits.

There are similar products on the market, however, they are not designed to drive an existing analog gauge. They are designed with their own gauge that must be mounted to the dashboard which is not as elegant a solution. This replacement device interfaces to the existing systems and dashboard already in place on the power boat in a clean, professional manner.

2 Breakdown

To understand how the tachometer works, Figure 1 breaks the project into smaller functional blocks.

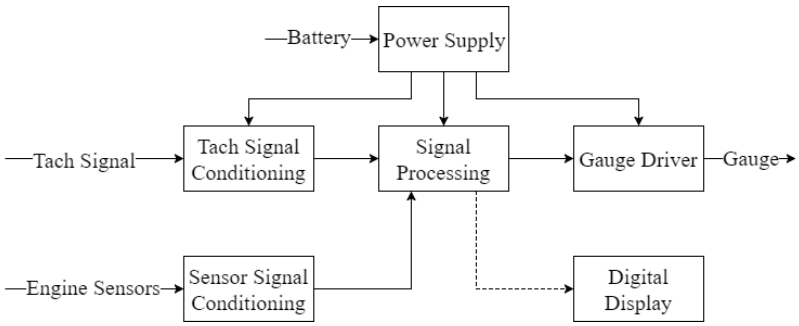

Figure 1: Tachometer block diagram

The power supply steps the nominal 12V of the battery down to a lower voltage for the microcontroller and other electronic components. The tachometer signal conditioner takes

the signal from the ignition system and buffers it such that the microcontroller will be able to measure it. The tachometer signal conditioner also has the important job of protecting the rest of the system from the high voltages of the ignition system. Both the tachometer and sensor signal conditioners feed into the signal processor which is responsible for controlling the gauge driver and digital display. The digital display is a detachable LCD screen which is capable of displaying the engine RPM as well as the oil pressure, engine temperature and battery voltage. The gauge driver ~~takes the~~ signal from the signal processor ~~and amplifies it~~ ~~in order~~ to drive the gauge to the proper position. The signal processor can be calibrated upon install, allowing the tachometer to be adjusted to gauge variations.

2.1 Power Supply

The power supply is a DC-DC converter used to step the battery voltage down to a more suitable voltage for the signal processing unit. The DC-DC converter is powered by a TI simple switcher integrated circuit, which simplifies the design and construction process of the DC-DC converter. Using a simple switcher means there is no need to select a transistor or design a bootstrap circuit. It also has a built in feedback network, which is able to compensate for variations in the input voltage.

2.2 Tach Signal Conditioning

The tach signal conditioner (TSC) is responsible for turning the tach signal from the engine into a readable wave for the signal processing unit. As the tachometer signal comes off of the engine's ignition coil, there is a significant amount of noise present with the signal. There are also voltage spikes in excess of 100V which would prove fatal for the tachometer if not properly handled. In order to protect the rest of the tachometer circuitry from these voltage spikes, the TSC must clamp the tach signal to the power supply voltage.

~~In order~~ to increase the reliability of the signal processor's ability to measure the tach signal frequency, the TSC must also filter out the high frequency noise caused by the ignition coil. This is done by filtering the signal and then generating a square wave which is then fed to the signal processing unit.

2.3 Gauge Driver

The gauge driver runs the physical tachometer gauge. Figure 2 shows the arrangement of the coils in the gauge.

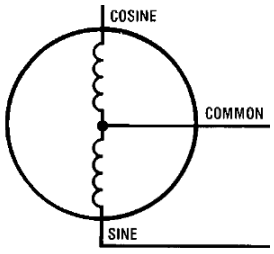

Figure 2: Coil arrangement

The two coils, sin and cos, are arranged 90 degrees from each other. A shaft with magnet

runs between the coils with the gauge needle attached to one end of the shaft. The needle deflects in proportion to the amount of current flowing through each coil. For linear rotational movement of the needle, the ratio of current flowing through each coil must be the arctan of the desired deflection angle. Each coil has a resistance of 220Ω and must be supplied with a maximum of between 20mA and 40mA to produce enough torque. To achieve more than 180 degrees of deflection, current needs to flow both directions in each coil, thus either sin or cos input voltage needs to be positive or negative with respect to common. To achieve this, 5V is applied to common and sin and cos inputs are varied between 0V and 10V.

The gauge driver takes a 0V to 5V input signal and converts it to a 0V to 10V output signal with a common 5V.

2.4 Sensor Signal Conditioning

The engine sensors are a heat controlled resistor, and a pressure controlled resistor. The gauges in the dashboard of the boat work by driving a current through the resistive sensor and measuring the voltage. The voltage ranges from about 6V to about 11V, while the signal processing unit needs less than 5V. The signal conditioning unit uses a very high impedance resistor divider to lower the voltage values, then buffers the voltage with an operational amplifier. The output of this stage is a 0V to 5V direct current signal.

2.5 Digital Display

The digital display lets the user see a readout of the engine RPM and engine sensors. The display is not swappable. When the display is plugged in, a signal is sent to the signal processing unit that turns on and initializes the display output.

2.6 Signal Processing

Signal processing unit (SPU) takes input signals and produces output signals that ultimately become human readable. First, the SPU receives the conditioned tachometer signal and calculates frequency. An algorithm finds engine RPM from the input and produces an output signal to run the gauge driver.

Next the SPU uses a analog to digital converter (ADC) to convert the engine sensor inputs to a digital value. Using an ADC calibration algorithm, these values are converted into values for pressure, temperature, and battery voltage.

Finally the SPU sends the engine RPM and sensor information to the digital display.

3 Details

3.1 Hardware

3.1.1 Power Supply

3.1.2 Signal Conditioning

3.1.3 Gauge Control

3.2 Software

3.2.1 Data representation

3.2.2 Drivers

3.2.3 Algorithms

4 Results

5 Conclusion