Tachometer

Users Manual

Version: 1.00

PREFACE

This document provides an overview of how the Tachometer works, as well as the operating instructions, trouble shooting and an explanation of some of the design constraints.

This is not intended as a complete description of how the system operates.
Features:

- High update rate (10 × per second)
- Support for direct shaft sensing or gear tooth sensing (user configurable)
- Support for sensing through a gear-train (ratio) (user configurable)
- Auto shutdown (user configurable)
- Zero speed cutoff (user configurable)
- Supports a variety of power sources
- Available as a kit (with pre-programmed processor) or as a complete unit.
- Measures up to 100kHz input pulse frequency.
- Non-flicker display with a 100Hz update rate.

CONTENTS

CHAPTER 1

INTRODUCTION

1 Features

- Allows speed measurement from connected shafts/gears (ratio calculation)
- Fully digital operation
- 5 digit display allows speeds in excess of 10,000RPM.
- Measures input pulses up to 100kHz
- Wide power supply operation range. (5V; 7V-36V)
- Can use any pulse sensor with a pull-up or pull-down output.
- User customisable auto-power down

2 In the Box

- Speed converter and readout
- Speed sensor (optional)

3 Sensor Selection

The tachometer supports a wide range of sensors. This can include hall-effect sensors, magnetic sensors, The sensor requirements can be summed up as follows:

- 5V Power supply. If the sensor is to run off the tachometer power then the sensor needs to be a 5V compatible sensor. If a non-5V sensor is to be used, this can be accommodated. (See Annexure)
- The sensor output can be an NPN or PNP transistor. A sensor that outputs a 5V pulse can also be used.

CHAPTER 2

SETUP PROCEDURE

1. Connect power
2. Install sensor
3. Connect sensor
4. Set tachometer parameters

1 Connect Power

The tachometer can be connected to run on a 5V power supply, or a power supply with a voltage between 7V and 36V.

All power connections are made on the bottom of the PCB. The PCB needs to be removed from the enclosure to make the power connection.

Note that only one of the power supply terminals will be installed. This will need to be specified at the time of the order.

IMPORTANT: When the AC/DC input connection is used, the 0V connections are not at the same potential as earth. The sensor when connected must not have either of the power connections earthed.

1.1 5V Power Supply

A power supply such as a USB style power supply, can be used to power the device. The 5V connection point is marked as +5V and 0V. This connection is polarity sensitive and must be connected in the polarity marked on the board.

1.2 +9V to +36V Power Supply

This connection can accept an AC or a DC supply with a peak-voltage of +36V. The polarity of the connection is not important and can be connected either way without damaging the device.

AC Connection

As AC power sources are generally specified an measured as RMS volatage, (V_{RMS}), the RMS voltage must be converted to a peak voltage (VPK) by the equation:

$$V_{PK} = \sqrt{2}V_{RMS} \tag{2.1}$$

The maximum V_{PK} is 36V, this equates to 25.5V. This makes the device suitable for use with a 24VAC power source. Some lathes and milling machine use 24VAC as a control voltage, and the 24VAC control voltage can be used to power the tachometer.

There is a re-settable fuse included in the tachometer input to provide protection against short-circuits within the tachometer.

DC Connection

Any DC power source that provides power in the range +9VDC to +36VDC can be used. The connection is not polarity sensitive and can be connected either way.

2 Install Sensor

The sensor should be mechanically installed. This may require a bracket to be fabricated. The installation method and mechanical details are dependant on the type of lathe or milling machine, and where the probe is to be installed, thus details cannot be provided.

3 Connect Sensor

The sensor should be connected to the 3-position terminal block. The polarity of the connection is important. Only sensors having three-wires can be used. Each of the wires should be marked and the +VE should be connected to the +5V terminal, the -VE or 0V to the 0V terminal, and the remaining wire to the center (PUL) terminal. The sensors can have one of the following output stages (connections):

- NPN (NO): A normally open NPN or pull-down connection.
- PNP (NO): A normally open PNP or pull-up connection.
- NPN (NC): A normally closed NPN or pull-down connection.
- PNP (NC): A normally closed PNP or pull-up connection.
- +5V output signal.

Depending on the type of sensor, J5 on the front side of the board will need to have a jumper installed.

For a pull-down connection, the jumper should short the bottom and middle pins. For a pull-up connection, the jumper should short the to and middle pins. For a +5V output signal, the jumper should be removed.

4 Set Parameters

There are six user-configurable parameters, these are set based on desired operating features or modes. The details of the parameters are described in Chapter 3.

The tachometer can either be in "RUN" mode, or in "SET" mode. Mode changes can only be achieved by turning the power off and on.

To enter set mode, the mode-switch on the top left of the component side of the board in moved to the right, and the power turned on. This tachometer will startup in SET mode.

When in "SET" mode, the parameters can be displayed and/or updated one -at-a-time.

To return to "RUN" mode, the switch should be changed to the "RUN" or left position, and the power turned off and on. The tachometer will then start.

When in SET mode, the four push-buttons on the PCB are used to change the parameters. Within the SET mode, there are two sub-modes. The first sub-mode is the VIEW mode. This allows the values of the various parameters to be viewed without changing the value. The second sub-mode is the EDIT mode. This allows the values of parameters to be changed. The OK and CANCEL buttons are used to change between the VIEW sub-mode and the EDIT sub-mode.

When in the EDIT sub-mode, one of the digits will be flashing to indicat the digit currently being edited. The value of the digit can then be increased or decreased using the INC or DEC buttons respectively.

OK Button

The OK button is used to accept edited values, or to start editing values.

CANCEL button

The CANCEL button is used to cancel value editing.

NEXT Button

The next button moves to the next digit or parameter.

CHAPTER 3

PARAMETERS

There are four user-configurable parameters that need to be setup for the tachometer to operate correctly. These are:

- Input pulses per revolution
- Input gear numerator
- Input gear denominator
- Zero speed threshold
- Auto sleep time
- Oscillator trim value

1 Input Pulses per revolution (PPR)

If the sensor is mounted directly on the shaft that is to have the speed measured, there are limitation as to the lowest possible speed that can be measured. For this reason it is better to mount the sensor on a gear that is connected to the shaft. This allows more than one pulse per revolution, thus allowing a better speed resolution and a lower speed threshold.

With a magnetic sensor, it is also possible to mount additional magnets on the sensed shaft. This allows additional pulses per revolution and thus better low-speed sensing.

If used on a gear, the PPR parameter is the number of teeth on the gear that the sensor is mounted on. For instance, if the sensor is mounted on a gear with 32 teeth, this parameter should be set to 32.

If the sensor sensors the output shaft directly, (or the shaft of a gear), this parameter should be set to one (or the number of magnets mounted on the shaft).

Valid Range: [1, 9999], Sensible range: [1, 100]

2 Input Gear Numerator (NUM)

If the sensor is sensing the shaft speed through a gear train, the numerator is the ratio of the gears that accelerate the output shaft.

Valid Range: [1, 9999], Sensible range: [1, 150]

3 Input Gear Denominator ($DENOM$)

If the sensor is sensing the shaft speed through a gear train, the numerator is the ratio of the gears that decelerate the output shaft.

Valid Range: [1, 9999], Sensible range: [1, 1500]

4 Zero Speed Threshold (ZST_1)

When sensing speed by measuring the interval between pulses, there is a need to determine when zero speed occurs. The challenge is to capture the zero speed while remaining responsive. This is a limitation of any digital system. Effectively the tqime between pulses at zero speed is infinite.

The approach taken is that if there are pulses 'missing' when updating the speed, the speed calculation assumes the shaft is slowing. The speed ramps down for $ZST_1 \times 100ms$, and then assumes that the speed is zero.

Valid Range: [1, 20], Sensible range: [5, 15]

5 Shutdown Time (SDT)

If no pulses are received within SDT seconds, then device will go into sleep mode and disable the display and indicators. Once a pulse is detected, the device will restart and display the calculated RPM.

Note: The power source LED's will remain lit even in shutdown mode. Valid Range: [1, 9999].

6 Oscillator Tuning ($OSCTUNE$)

While the oscillator used is generally accurate, it may drift over time. The $OSCTUNE$ value may be adjusted to increase the accuracy.

This should only be adjusted if it is possible to have a known fixed frequency source to set the speed and then adjust the oscillator tuning value.

Valid Range: [-64, 64]

CHAPTER 4

METHOD OF OPERATION

The Tachometer measures the time between the pulses to a high degree of accuracy. ($0.5\mu s$) The time between pulses is then converted to an RPM value by using the equation:

$$n = 60 \times f \tag{4.1}$$

Where f is the frequency. The frequency is calculated from the interval between the pulses.

$$f = \frac{1}{\Delta t} \tag{4.2}$$

Where Δt is the interval between pulses.

$$n = \frac{60}{\Delta t} \tag{4.3}$$

The complete equation is:

$$n = \frac{60 \times DIV}{\Delta t \times PPR \times NUM} \tag{4.4}$$

In practice, the calculations are carried out using 32-bit unsigned values. The division cannot be pre-calculated as there would be unacceptable loss of precision and the choice of unsigned integers for storage makes it impossible to store accurately. It is possible to pre-calculate the $60 \times DIV$ and the denominator term $PPR \times DIV$, as these are constant and would not suffer a loss of precision