Design of a motor speed sampling, amplification, filtering and display circuit

Engineering

The paper " Design of a Motor Speed Sampling, Amplification, Filtering, and Display Circuit " is an outstanding example of an assignment on engineering and construction. This project is aimed at designing the circuits used for motor speed sampling, amplification, filtering, and display. In this project, I have designed this circuit using the circuit maker software called Proteus. I have in cooperated analog and digital designs and optimization in this project, I have also designed a low-pass filter to filter the design. The design output is in the form of a 7-segment display decoder. Project DescriptionA remote motor speed sensor provides a DC current signal of 2. 5 mA. I have designed a circuit that converts the 2. 5mA current signal to 3V DC voltage signal using the appropriate amplification devices, after the conversion, I used a low pass filter to suppress any noise AC signal with a frequency higher than 100Hz. I have used an 8-bit digital-to-analog converter that is to convert the output of the analog circuit into an 8-bit digital signal. The 8-bit signal goes through the 7 decoders so that the value of the 8-bit digital signal is displayed in two-bit hex decimal accordingly on two seven-segment display devices to indicate the safe running speed of the motor in 0-255 scales. Procedure

- Use an AC current source with a very low frequency of 0. 01 Hz to emulate the slowly changed DC current output signal from the remote motor speed sensor
- Design the current sampling/amplification circuit using appropriate circuits so that you can achieve the required output voltage
- Demonstrate the gain, Bandwidth, Rin of your op-amp circuits by both calculation and simulation.

- Design the low-pass filter. Demonstrate the bandwidth of the filter by both calculation and simulation.
- Combine the op-amp and the filter
- Demonstrate the gain, Bandwidth, phase shift, Rin of your combined circuit by both calculation and simulation.
- The output voltage signal from the analog circuit should then be converted into an 8-bit digital signal, which represents the levels of the motor speed.
- You can choose the generic 8-bit ADC device from the Proteus library => Modelling Primitives => ADC_8 for this task
- Design an 8-bit synchronous counter by using D-type flip-flops. The counter should be driven by a CLK signal running at 256k Hz. You should show how the counter is designed, and simulate the circuit.
- The MSB output of the counter should be used to connect to the clock terminal of ADC_8 converter
- The value of the output of the adc_8 converter should be displayed in two 7-segment display units, the MSB four bits are displayed in one and the LSB four bits in another. In order to achieve this, you should design the 4-to-7 decoder for the 7-segment display
- Complete the truth table for the 4-to-7 decoder: Use Karnaugh map to simply the logic expressions for the 4-to-7 decoder. You should convert the expressions from the SOP form to the POS form so that the NAND gates only can be used.

- Connect the 8-bit counter outputs to two 4-7 decoders which drive two seven-segment display units, respectively. Simulate the circuit and demonstrate that entire circuit works properly

ResultsKarnaugh Map 0000000100110010010001010111011010001001101110101100110111111110000100010000000000000110000000000000000110000000000000000010000100000000000010010001000100000001010000000000000000111010000001000000011010000000000000000Reduced Form from Karnaugh Map for the first displayACBDEFG + ABCDFG + AGBCDEF + ACDEFG + EABCDF + ABDGCEDesignWaveformsInputOutput Operational amplifierAn operational amplifier, which is regularly referred to as op-amp, is a DC-coupled high-gain electronic voltage amplifier. The amplifier has differential inputs and a single output. The output of the op-amp is under control of the negative feedback, which to a great extent determines the magnitude of its output voltage gain. It can also be under control of the positive feedback, which facilitates regenerative gain and oscillation. High input impedance at the input terminals and low output impedance are important typical characteristics. Linear circuit applicationsDifferential amplifierDifferential amplifierThe circuit presented is employed in finding the distinction of two voltages when each is multiplied by some constant (determined by the resistors).

- Differential Zin (between the two input pins) = R1 + R2

Amplified differenceWhenever R1 = R2 and Rf = Rg, Vout = A (V2 − V1) and A = Rf / R1 Inverting amplifierInverts and amplifies a voltage (multiplied by a negative constant)

Zin = Rin (because V − is a virtual ground)A third resistor, of value, added between the non-inverting input and ground, while not necessary, minimizes errors due to input bias currents. Non-inverting amplifierNon-inverting amplifierAmplifies a voltage (multiplies by a constant greater than 1)

(Realistically, at least the input impedance of the op-amp itself, 1 MΩ to 10 TΩ. In most cases, the input impedance is considerably higher. This is as a result of the feedback network).

- A resistor of value, a third one, between the Vin source and the non-inverting input, cuts down on errors due to input bias currents.
- Although this circuit has a great input impedance, it suffers from the error of input bias current.

Voltage followerVoltage follower amplifierThis is used as a buffer in the elimination of loading effects or to interface impedances (connecting a device with high source impedance to a device with low input impedance). As a result of strong feedback, this circuit becomes unstable when driving a load of high capacity. Connecting a load through a resistor helps to avoid this. Summing amplifierSums several (weighted) voltages

- When, and Rf independent
- When
- Output is inverted
- Input impedance Zn = Rn, for each input (V − is a virtual ground)

IntegratorIntegrator amplifierIntegrates the (inverted) signal over time(Where Vin and Vout are the functions of time, Vinitial is the output voltage of the integrator at time t = 0.) DifferentiatorFig 9: Differentiator amplifier. Differentiates the (inverted) signal over time(Where Vin and Vout are functions of time)ComparatorComparatorComparator is what makes a comparison of two voltages and switches its output to designate the largest voltage.(Where Vs is the supply voltage and the opamp is powered by + Vs and − Vs.)Instrumentation amplifierInstrumentation amplifierIn making very accurate, low-noise measurements, the instrumentation amplifier makes a combination of a very high input impedance, high common-mode rejection, low DC offset, and other properties used. Schmitt trigger Schmitt trigger. A comparator with hysteresisHysteresis from to. Negative impedance converter (NIC)Negative impedance converterThis comes up with a resistor that has a negative value for any signal generator. In such a case, the ratio between the input voltage and the input current (thus the input resistance) can be given by: The internal circuitry of 741 type op-ampEven though designs differ between products and their manufacturers, all op-amps have essentially the same inside structures, which are made up of three stages:

1. Differential amplifier
    - Input stage — it ensures low noise amplification, high input impedance, and a differential output.
2. Voltage amplifier
    - Ensures there are high voltage gain, a single-pole frequency roll-off, and a single-ended output.
3. Output amplifier

- Output stage — this is the source of a high current driving capability, low output impedance, current limiting, and short circuit protection circuitry.

A component-level diagram of the common op-amp Dotted lines outline: current mirrors (red); differential amplifier (blue); class A gain stage (magenta); voltage level shifter (green); output stage (cyan). ConclusionThe project design and implementation were both successful. At the beginning of this project, I put forward the objectives which I wanted to achieve. I can confidently say that the major objectives have been met to a good degree. I wanted to design the circuits used for motor speed sampling, amplification, filtering, and display. Using the above information as my basis I can say that my general objective was achieved. In my specific objectives, I had set myself to designing the circuits used for motor speed sampling, amplification, filtering, and display. The design part was finished and the implementation is done. From the theory gained above, I was able to achieve design and implementation.