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Chapter 1 : Analog and Digital Control System Design | Chi-Tsong Chen |

*Analog and Digital Control System Design: Transfer-Function, State-Space, and Algebraic Methods (Saunders College Publishing Electrical Engineering) [Chi-Tsong Chen] on calendrierdelascience.com *FREE* shipping on qualifying offers.*

For example, an aneroid barometer uses the angular position of a needle as the signal to convey the information of changes in atmospheric pressure. Information is converted from some other physical form such as sound, light, temperature, pressure, position to an electrical signal by a transducer which converts one type of energy into another e. Any change in the signal is meaningful, and each level of the signal represents a different level of the phenomenon that it represents. For example, suppose the signal is being used to represent temperature, with one volt representing one degree Celsius. In such a system, 10 volts would represent 10 degrees, and Another method of conveying an analogue signal is to use modulation. In this, some base carrier signal has one of its properties altered: Other techniques, such as phase modulation or changing the phase of the carrier signal, are also used. An increase in the volume of the sound causes the fluctuation of the current or voltage to increase proportionally while keeping the same waveform or shape. Mechanical , pneumatic , hydraulic , and other systems may also use analogue signals. Inherent noise[edit] Analogue systems invariably include noise that is random disturbances or variations, some caused by the random thermal vibrations of atomic particles. Since all variations of an analogue signal are significant, any disturbance is equivalent to a change in the original signal and so appears as noise. Other sources of noise may include crosstalk from other signals or poorly designed components. These disturbances are reduced by shielding and by using low-noise amplifiers LNA. All operations that can be performed on an analogue signal such as amplification , filtering , limiting, and others, can also be duplicated in the digital domain. Every digital circuit is also an analogue circuit, in that the behaviour of any digital circuit can be explained using the rules of analogue circuits. The use of microelectronics has made digital devices cheap and widely available. Noise[edit] The effect of noise on an analogue circuit is a function of the level of noise. The greater the noise level, the more the analogue signal is disturbed, slowly becoming less usable. Because of this, analogue signals are said to "fail gracefully". Analogue signals can still contain intelligible information with very high levels of noise. Digital circuits, on the other hand, are not affected at all by the presence of noise until a certain threshold is reached, at which point they fail catastrophically. For digital telecommunications , it is possible to increase the noise threshold with the use of error detection and correction coding schemes and algorithms. Nevertheless, there is still a point at which catastrophic failure of the link occurs. In digital circuits the signal is regenerated at each logic gate , lessening or removing noise. However, noise is cumulative throughout the system and the amplifier itself will add to the noise according to its noise figure. Fundamental physical limits such as the shot noise in components limits the resolution of analogue signals. In digital electronics additional precision is obtained by using additional digits to represent the signal. The practical limit in the number of digits is determined by the performance of the analogue-to-digital converter ADC , since digital operations can usually be performed without loss of precision. The ADC takes an analogue signal and changes it into a series of binary numbers. The ADC may be used in simple digital display devices, e. However, a digital-to-analogue converter DAC is used to change a digital signal to an analogue signal. A DAC takes a series of binary numbers and converts it to an analogue signal. It is common to find a DAC in the gain-control system of an op-amp which in turn may be used to control digital amplifiers and filters. An analogue circuit is usually designed by hand, and the process is much less automated than for digital systems. Since the early s, there were some platforms that were developed which enabled Analog design to be defined using software - which allows faster prototyping. However, if a digital electronic device is to interact with the real world, it will always need an analogue interface. Circuit classification[edit] Analogue circuits can be entirely passive , consisting of resistors , capacitors and inductors. Active circuits also contain active elements like transistors. Many passive analogue circuits are built from lumped elements. That is, discrete components. However, an alternative is distributed element circuits built from pieces of transmission line.

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Chapter 2 : Analog & Digital Control System Design Solutions Manual by Chi-Tsong Chen

The text emphasizes design with discussions of problem formulation, design criteria, physical constraints, several design methods, and impleme Straightforward coverage includes an integrated treatment of both classical and modern control system methods.

Isolation Yes Output modules may have current outputs, voltage outputs, or a combination. A classical solution that uses discrete components to implement a 4 mA to 20 mA loop is shown in Figure 4. This current is mirrored through R2. Discrete 4 mA to 20 mA implementation. This discrete design suffers from many drawbacks: Its high component count engenders significant system complexity, board size, and cost. Calculating total error is difficult, with multiple components adding varying degrees of error with coefficients that can be of differing polarities. It does not include a voltage output, which is required in many industrial control modules. Adding any of these features would increase the design complexity and the number of components. They provide a solution that offers a fully integrated programmable current source and programmable voltage output designed to meet the requirements of industrial process-control applications. Analog outputs are short-circuit protected, a critical feature in the event of miswired outputsâ€”for example, when the user connects the output to ground instead of to the load. The AD also has an open-circuit detection feature that monitors the current-output channel to ensure that no fault has occurred between the output and the load. Figure 6 shows the output module used in the PLC evaluation system. Three channels of the ADuM communicate in one direction; the fourth channel communicates in the opposite direction, providing isolated data readback from the converters. For newer industrial designs, the ADuM and other members of its family of digital isolators provide enhanced system-level ESD protection. Output module block level. The AD generates its own logic supply DVCC , which can be directly connected to the field side of the ADuM, eliminating the need to bring a logic supply across the isolation barrier. The AD includes an internal sense resistor, but an external resistor R1 can be used when lower drift is required. Because the sense resistor controls the output current, any drift of its resistance will affect the output. The input module design specifications are similar to those of the output module. High resolution and low noise are generally important. In industrial applications, a differential input is required when measuring low-level signals from thermocouples, strain gages, and bridge-type pressure sensors to reject common-mode interference from motors, ac power lines, or other noise sources that inject noise into the analog inputs of the analog-to-digital converter ADCs. Sigma-delta ADCs are the most popular choice for input modules, as they provide high accuracy and resolution. In addition, internal programmable-gain amplifiers PGAs allow small input signals to be measured accurately. Figure 7 shows the input module design used in the evaluation system. As shown, two input terminal blocks are provided per input channel. One input allows for a direct connection to the AD The user can program the internal PGA to provide analog gains up to In this case, the input signal is attenuated, amplified, and level shifted to provide a single-ended input to the ADC. In addition to providing the level shifting function, the AD also features very good common-mode rejection, important in applications having a wide dynamic range. To measure a 4 mA to 20 mA input signal, a low-drift precision resistor can be switched S4 into the circuit. S4 is left open when measuring a voltage. Isolation is required for most input-module designs. Figure 7 shows how isolation was implemented on one channel of the PLC evaluation system. In addition to providing four isolated signal channels, the ADuM also contains an isolated dc-to-dc converter that provides a regulated 5-V, mW output to power the analog circuitry of the input module. An overview of the complete system is shown in Figure 8. It also supports a bit thumb mode, which allows for greater code density if required. The ADuC has 16 kB of on-board flash memory and allows interfacing to up to kB external memory. The ADME incorporates isoPower technologyâ€”making a separate isolated dc-to-dc converter unnecessary. Evaluation System Software and Evaluation Tools: The evaluation system is very versatile. Communication with the PC is achieved using LabView. Figure 9 shows the main screen interface. Under each ADC and DAC menu there is a pull-down range menu, which is used to select the desired input and output ranges to be measured and controlled. The following input and output ranges are available: Evaluation software main screen controller.

When using this method of calibration, therefore, the offset and gain errors of the AD dictate the offset and gain of each channel. If these provide insufficient accuracy, ultrahigh-precision current and voltage sources can be used for calibration if desired. On this screen, the user chooses the number of data points to record; the software generates a histogram of the selected channel, calculates the peak-to-peak and rms noise, and displays the results. In the measurement shown here, the input is connected through the AD to the AD The peak-to-peak resolution is If the ADC conditions remain the same but the 2. Power Supply Input Protection: A regulated dc supply 18 V to 36 V is connected to the board through a 2- or 3-wire interface. This supply must be protected against faults and electromagnetic interference EMI. The following precautions, shown in Figure 13, were taken in the board design to ensure that the PLC evaluation system will survive any interference that may be generated on the power ports. Power supply input protection. A piezoresistor, R1, is connected to ground adjacent to the power input ports. During normal operation, the resistance of R1 is very high megohms , so the leakage current is very low microamperes. When an electric current surge caused by lightning, for example is induced on the port, the piezo-resistor breaks down, and tiny voltage changes produce rapid current changes. Within tens of nanoseconds, the resistance of the piezo resistor drops dramatically. This low-resistance path allows the unwanted energy surge to return to the input, thus protecting the IC circuitry. Three optional piezoresistors R2, R3, and R4 are also connected in the input path to provide protection in cases when the PLC board is powered using the 3-wire configuration. The piezoresistors typically cost well under one US dollar. A positive temperature coefficient resistor, PTC1, is connected in series with the power input trace. The PTC1 resistance appears very low during normal operation, with no impact to the rest of the circuit. This high-resistance mode limits the current and protects the input circuit. The resistance returns to its normal value when the current flow decreases to the nominal limit. These safety capacitors require low resistance and high voltage endurance. Designers must use Y capacitors that have UL or CAS certification and comply with the regulatory standard for insulation strength. Inductors L1 and L2 filter out the common-mode conducted interference coming in from the power ports. Diode D1 protects the system from reverse voltages. A general-purpose silicon or Schottky diode specifying a low forward voltage at the working current can be used. The PLC board can accommodate both voltage and current inputs. Figure 14 shows the input structure. Load resistor R5 is switched in for current mode. Resistors R6 and R7 attenuate the input. Resistor R8 sets the gain of the AD These analog input ports can be subjected to electric surge or electrostatic discharge on the external terminal connections. When a high-energy transient appears on the analog input, the TVS goes from high impedance to low impedance within a few nanoseconds. It can absorb thousands of watts of surge power and clamp the analog input to a preset voltage, thus protecting precision components from being damaged by the surge. Its advantages include fast response time, high transient power absorption, low leakage current, low breakdown voltage error, and small package size. Instrumentation amplifiers are often used to process the analog input signal. These precision, low-noise components are sensitive to interference, so the current flowing into the analog input should be limited to less than a few milliamperes. External Schottky diodes generally protect the instrumentation amplifier. Even when internal ESD protection diodes are provided, the use of external diodes allows smaller limiting resistors and lower noise and offset errors. Dual series Schottky barrier diodes D4-A and D4-B divert the overcurrent to the power supply or ground. When connecting external sensors, such as thermocouples TCs or resistance temperature devices RTDs , directly to the ADC, similar protection is needed, as shown in Figure The filter has three functions: The â€”3-dB differential-mode and common-mode bandwidth of this filter are 7. The PLC evaluation system can be software-configured to output analog voltages or currents in various ranges. The output is provided by the AD precision, low-cost, fully integrated, bit digital-to-analog converter, which offers a programmable current source and programmable voltage output. The AD voltage and current outputs may be directly connected to the external loads, so they are susceptible to voltage surges and EFT pulses. The output structure is shown in Figure A nonconductive ceramic ferrite bead L3 is connected in series with the output path to add isolation and decoupling from high-frequency transient noises. Above kHz, ferrites become resistive, an important characteristic in high-frequency filter designs. The ferrite bead provides three functions: When ferrites saturate, they becomes nonlinear and lose their filtering properties. Thus, the dc saturation current of the ferrites must not go over their limit, especially when producing high currents.

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Description. This text's contemporary approach focuses on the concepts of linear control systems, rather than computational mechanics. Straightforward coverage includes an integrated treatment of both classical and modern control system methods.

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All analog methods, except the frequency-domain method, are directly applicable to design digital compensators without any modification. If a plant can be modeled as linear, time-invariant, and lumped, then a good control system can be designed by using one of the methods discussed in this text.

Chapter 9 : PLC Evaluation Board Simplifies Design of Industrial Process-Control systems | Analog Device

techniques and circuits for analog-to-digital and digital-to-analog conversions, and an explanation of what a digital processor is and how it works. There is a chapter on data transmissions and one on power control.