

Home-Made PIC 16F877 Microcontroller-Based Temperature Control System for Learning Automatic Control

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ABSTRACT: A closed-loop temperature control system, which is composed of a thermal plant and a controller, has been developed to support undergraduate students in learning automatic control delivered in the Special Topics in Instrumentation Physics course. The thermal plant was made from a plastic box covering a lamp and a fan, which heats and cools the air in the plastic box, respectively, as well as a temperature sensor. The controller with a proportional control action was realized by employing the PIC 16F877 microcontroller. The control signal updates pulse-width modulators (PWMs) in which driver circuits turn on or off the lamp and the fan. A mathematical model of the closed-loop control system was derived and a theoretical transient response was then obtained. It is found that the experimental transient responses were always much lower than the set point and the steady-state errors were high for the proportional sensitivity (K_p) lower than 10. For K_p higher than 10, the transient responses tend to approach the set point to cause small steady-state errors. These characteristics are consistent with the theoretical transient response. Further examination revealed that the closed-loop system is a higher order system due to the action of the PWMs and the driver circuits. © 2010 Wiley Periodicals, Inc. *Comput Appl Eng Educ* 19: 10–17, 2011. View this article online at www.interscience.wiley.com. DOI: 10.1002/cae.20283

Keywords: control system; instrumentation physics; microcontroller; proportional; thermal plant

INTRODUCTION

Control systems courses are traditionally offered by Electrical and Mechanical Engineering Departments [1–3]. Few departments outside electrical and mechanical engineering disciplines present courses on control systems in their curricula. Several Chemical Engineering Departments at several universities in USA have introduced modern control systems teaching to their undergraduate students [4,5]. The teaching of modeling, simulation, and control to students in the Department of Applied Physics, Faculty of Physics at the University of La Laguna, Spain, has been done [6]. School of Physics and Astronomy at the University of Nottingham in the United Kingdom has changed the curriculum of the second year practical laboratory course to implement Matlab in teaching undergraduate students about instrument control techniques [7].

Physics Study Program at the Faculty of Mathematics and Natural Sciences of Institut Teknologi Bandung offers some elective courses in the fourth year of undergraduate program. One of the elective courses is FI4172 Special Topics in Instrumentation Physics, which is a 3-credit unit course. It contains lectures on advanced instrumentation systems including instruments for characterizing materials, nuclear and Biophysics instruments as well as instruments in geophysics because the Physics Study Program has several subprograms such as Physics of Electronic, Magnetic and Photonic Materials, Nuclear Physics, Biophysics, and Geophysics. A very important topic delivered in the course is automatic control because it is easily found in the instruments.

In order to support theoretical concepts on automatic control that were explained by a lecturer in classroom, laboratory works that can be done by students must be provided. By executing the laboratory works, it is hoped that the students can learn the theoretical concepts easily and therefore grasp them more. This is reinforced by the survey done by Rickel [8], who found that students retain 25% of what they hear, 45% of what they hear and see, and 70% if they use the “learning-by-doing” method.

A personal computer or microcontroller has been used in learning control with laboratory scale models [9–11]. Festo [12]

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The Automated Pic Microcontroller Based Temperature Control

Gerro Prinsloo, Robert Dobson



The Automated Pic Microcontroller Based Temperature Control:

Microcontroller-Based Temperature Monitoring and Control Dogan Ibrahim, 2002-08-05 Microcontroller Based Temperature Monitoring and Control is an essential and practical guide for all engineers involved in the use of microcontrollers in measurement and control systems The book provides design principles and application case studies backed up with sufficient control theory and electronics to develop your own systems It will also prove invaluable for students and experimenters seeking real world project work involving the use of a microcontroller Techniques for the application of microcontroller based control systems are backed up with the basic theory and mathematics used in these designs and various digital control techniques are discussed with reference to digital sample theory The first part of the book covers temperature sensors and their use in measurement and includes the latest non invasive and digital sensor types The second part covers sampling procedures control systems and the application of digital control algorithms using a microcontroller The final chapter describes a complete microcontroller based temperature control system including a full software listing for the programming of the controller Provides practical guidance and essential theory making it ideal for engineers facing a design challenge or students devising a project Includes real world design guides for implementing a microcontroller based control systems Requires only basic mathematical and engineering background as the use of microcontrollers is introduced from first principles

Fundamentals of Embedded Systems: Design and Applications

Mr.S.Anbarasan, 2025-09-09 Author Mr S Anbarasan Assistant Professor Department of Electronics and Communication Engineering Tittagudi Sengunthar Engineering College Tholudur Tamil Nadu India Proceedings of the 2nd International Conference on Computational and Bio Engineering S. Jyothi, D. M. Mamatha, Yu-Dong Zhang, K. Srujan Raju, 2021-09-27 This book presents the peer reviewed proceedings of the 2nd International Conference on Computational and Bioengineering CBE 2020 jointly organized in virtual mode by the Department of Computer Science and the Department of BioScience Sericulture Sri Padmavati Mahila Visvavidyalayam Women s University Tirupati Andhra Pradesh India during 4 5 December 2020 The book includes the latest research on advanced computational methodologies such as artificial intelligence data mining and data warehousing cloud computing computational intelligence soft computing image processing Internet of things cognitive computing wireless networks social networks big data analytics machine learning network security computer networks and communications bioinformatics biocomputing biometrics computational biology biomaterials bioengineering and medical and biomedical informatics

Programming and Customizing the PIC Microcontroller Michael Predko, 1998 Microchip s PIC microcontroller is rapidly becoming the microcontroller of choice throughout the world This hands on tutorial and disk provide everything electronic designers engineers and advanced hobbyists need to tap the power of this invaluable chip the most complete description of PIC available over 30 experiments and ten complete PIC application projects a full set of DOS and Windows PIC development tools reusable source code and a complete PIC application program that can easily be tailored

to the reader's needs Intelligent Computing and Optimization Pandian Vasant, Vladimir Panchenko, Elias Munapo, Gerhard-Wilhelm Weber, J. Joshua Thomas, Rolly Intan, Mohammad Shamsul Arefin, 2024-12-26 This book of Springer Nature is another proof of Springer's outstanding and greatness on the lively interface of Smart Computational Optimization Green Infrastructure Innovative Modeling and Deep Learning Architectures It is a Master Piece of what our community of Academics and Experts can provide when an Interconnected Approach of Joint Mutual and Meta Learning is supported by Holistic Operational Research and Experience of the World Leader Springer Nature The 7th edition of International Conference on Intelligent Computing and Optimization took place at Baitong Hotel Resort on October 26-27, 2023 with tremendous support from the global research scholars across the planet Objective was to celebrate Global Research Quality with Compassion and Wisdom with researchers, scholars, experts and investigators in Intelligent Computing and Optimization across the globe to share knowledge, experience and innovation a marvelous opportunity for discourse and mutuality by novel research invention and creativity This proceedings book of the 7th ICO 2023 is published by Springer Nature Creativity Label of Inspiration *Smart and Secure Embedded and Mobile Systems* Jorge Marx Gómez, Anael Elikana Sam, Devotha Godfrey Nyambo, 2024-06-29 This book gathers a selection of research papers that delve into the field of smart systems covering a wide range of applications in transportation, agriculture, healthcare, energy management and more Emphasizing the fusion of intelligence and security they reveal how advanced embedded and mobile systems are paving the way for a smarter and safer future The book presents peer-reviewed research articles from the First International Conference on Embedded and Mobile Systems ICTA EMOS which was held on November 24th-25th, 2022 in Arusha, Tanzania The book showcases the remarkable potential of advanced technologies in shaping a smarter and more secure world addressing topics such as transportation and mobility solutions, smart manufacturing and agriculture, ICT infrastructure and resource management, healthcare and energy management, system integration and control and solutions for innovation and monitoring **AI, Edge and IoT-based Smart Agriculture** Ajith Abraham, Sujata Dash, Joel J.P.C. Rodrigues, Biswaranjan Acharya, Subhendu Kumar Pani, 2021-11-10 AI Edge and IoT Smart Agriculture integrates applications of IoT edge computing and data analytics for sustainable agricultural development and introduces Edge of Things based data analytics and IoT for predictability of crop, soil and plant disease occurrence for improved sustainability and increased profitability The book also addresses precision irrigation, precision horticulture, greenhouse IoT, livestock monitoring, IoT ecosystem for agriculture, mobile robot for precision agriculture, energy monitoring, storage management and smart farming The book provides an overarching focus on sustainable environment and sustainable economic development through smart and e agriculture Providing a medium for the exchange of expertise and inspiration, contributions from both smart agriculture and data mining researchers around the world provide foundational insights The book provides practical application opportunities for the resolution of real-world problems including contributions from the data mining, data analytics, Edge of Things and cloud research communities

working in the farming production sector The book offers broad coverage of the concepts themes and instruments of this important and evolving area of IOT based agriculture Edge of Things and cloud based farming Greenhouse IOT mobile agriculture sustainable agriculture and big data analytics in agriculture toward smart farming Integrates sustainable agriculture Greenhouse IOT precision agriculture crops monitoring crops controlling to prediction livestock monitoring and farm management Presents data mining techniques for precision agriculture including weather prediction plant disease prediction and decision support for crop and soil selection Promotes the importance and uses in managing the agro ecosystem for food security Emphasizes low energy usage options for low cost and environmental sustainability Advances in Manufacturing Processes and Smart Manufacturing Systems Denni Kurniawan,Fethma M. Nor,2024-12-26 This book emphasizes the increasing role of smart technologies the exploration of sustainable materials and the importance of efficient processes across different sectors offering beneficial insights for academics and industry professionals This second in a two part series from the Global Congress on Manufacturing and Management GCMM 2023 which was held in Kuching Malaysia on December 4 7 2023 presents the use of Internet of Things for the control and monitoring of systems sustainable and efficient practices smart systems development logistics service processes supplier selection and optimization of manufacturing processes Proceedings of the Second International Conference on Computer and Communication Technologies Suresh Chandra Satapathy,K. Srujan Raju,Jyotsna Kumar Mandal,Vikrant Bhateja,2015-09-03 The book is about all aspects of computing communication general sciences and educational research covered at the Second International Conference on Computer Communication Technologies held during 24 26 July 2015 at Hyderabad It hosted by CMR Technical Campus in association with Division V Education Research CSI India After a rigorous review only quality papers are selected and included in this book The entire book is divided into three volumes Three volumes cover a variety of topics which include medical imaging networks data mining intelligent computing software design image processing mobile computing digital signals and speech processing video surveillance and processing web mining wireless sensor networks circuit analysis fuzzy systems antenna and communication systems biomedical signal processing and applications cloud computing embedded systems applications and cyber security and digital forensic The readers of these volumes will be highly benefited from the technical contents of the topics Plant Intelligent Automation and Digital Transformation Volume II Swapan Basu,2024-08-11 Plant Intelligent Automation and Digital Transformation Volume II Control and Monitoring Hardware and Software is an expansive four volume collection that reviews every major aspect of the intelligent automation and digital transformation of power process and manufacturing plants including specific control and automation systems pertinent to various power process plants using manufacturing and factory automation systems The book reviews the key role of management Information systems MIS HMI and alarm systems in plant automation in systemic digitalization covering hardware and software implementations for embedded microcontrollers FPGA and operator and engineering stations

Chapters address plant lifecycle considerations inclusive of plant hazards and risk analysis Finally the book discusses industry 4.0 factory automation as a component of digitalization strategies as well as digital transformation of power plants process plants and manufacturing industries Reviews supervisory control and data acquisitions SCADA systems for real time plant data analysis Provides practitioner perspectives on operational implementation including human machine interface operator workstation and engineering workstations Covers alarm and alarm management systems including lifecycle considerations Fully covers risk analysis and assessment including safety lifecycle and relevant safety instrumentation

Proceedings of the 2009 International Conference on Signals, Systems and Automation (ICSSA 2009)

Himanshu Soni, 2010-04-30 This book is a collection of papers from the 2009 International Conference on Signals Systems and Automation ICSSA 2009 The conference at a glance Pre conference Workshops Tutorials on 27th Dec 2009 Five Plenary talks Paper Poster Presentation 28-29 Dec 2009 Demonstrations by SKYVIEW Inc SLS Inc BSNL Baroda Electric Meters SIS On line paper submission facility on website 200 papers are received from India and abroad Delegates from different countries including Poland Iran USA Delegates from 16 states of India Conference website is seen by more than 3000 persons across the world 27 countries and 120 cities

Proceedings of the Multi-Conference 2011

Himanshu B. Soni, Apurva Shah, 2011-06-06 The International Conference on Signals Systems and Automation ICSSA 2011 aims to spread awareness in the research and academic community regarding cutting edge technological advancements revolutionizing the world The main emphasis of this conference is on dissemination of information experience and research results on the current topics of interest through in depth discussions and participation of researchers from all over the world The objective is to provide a platform to scientists research scholars and industrialists for interacting and exchanging ideas in a number of research areas This will facilitate communication among researchers in different fields of Electronics and Communication Engineering The International Conference on Intelligent System and Data Processing ICISD 2011 is organized to address various issues that will foster the creation of intelligent solutions in the future The primary goal of the conference is to bring together worldwide leading researchers developers practitioners and educators interested in advancing the state of the art in computational intelligence and data processing for exchanging knowledge that encompasses a broad range of disciplines among various distinct communities Another goal is to promote scientific information interchange between researchers developers engineers students and practitioners working in India and abroad

Medical Internet of Things

Anirban Mitra, Jayanta Mondal, Anirban Das, 2021-10-28 In recent years the Medical Internet of Things MIoT has emerged as one of the most helpful technological gifts to mankind With the incredible development in data science big data technologies IoT and embedded systems it is now possible to collect a huge amount of sensitive and personal data compile it and store it through cloud or edge computing techniques However important concerns remain about security and privacy the preservation of sensitive and personal data and the efficient transfer storage and processing of MIoT based data Medical

Internet of Things Techniques Practices and Applications is an attempt to explore new ideas and novel techniques in the area of MIIoT The book is composed of fifteen chapters discussing basic concepts issues challenges case studies and applications in MIIoT This book offers novel advances and applications of MIIoT in a precise and clear manner to the research community to achieve in depth knowledge in the field This book will help those interested in the field as well as researchers to gain insight into different concepts and their importance in multifaceted applications of real life This has been done to make the book more flexible and to stimulate further interest in the topic Features A systematic overview of concepts in Medical Internet of Things MIIoT is included Recent research and some pointers on future advancements in MIIoT are discussed Examples and case studies are included It is written in an easy to understand style with the help of numerous figures and datasets This book serves as a reference book for scientific investigators who are interested in working on MIIoT as well as researchers developing methodology in this field It may also be used as a textbook for postgraduate level courses in computer science or information technology

Security and Trust Issues in Internet of Things Sudhir Kumar Sharma,Bharat Bhushan,Bhuvan Unhelkar,2020-12-02 The purpose of this edited book is to present and showcase the basic fundamentals applications and integration of both IoT and Blockchain The trend of applying Blockchain to IoT is rapidly growing because it helps to overcome various challenges faced by IoT from smart manufacturing to unmanned aerial vehicles Thise book aims to showcase the basics of both IoT and Blockchain as well as the integration and challenges for existing practitioners Thise book initiates conversations among technologists engineers scientists and clinicians to synergize their efforts in producing low cost high performance highly efficient deployable IoT systems Thise book is theory based and is useful for engineers from various disciplines including industrial engineering computer science electronics telecommunications electrical agricultural and cybersecurity along with researchers professionals and students

Intelligent Systems for Social Good Shyamapada Mukherjee,Naresh Babu Muppalaneni,Sukriti Bhattacharya,Ashok Kumar Pradhan,2022-06-11 This book highlights the connections between two technologies artificial intelligence AI and Internet of things IoT It presents the application of these two technologies to solve various societal problems related to healthcare agriculture green environment renewable energies smart cities etc Each chapter in this book presents novel solutions to these problems along with the challenges in the application of AI and IoT to solve them It discusses the adverse attacks on machine Learning models and how to protect sensitive data over the IoT networks It also includes the security issues in IoT and their possible solutions

Emergence of Cyber Physical System and IoT in Smart Automation and Robotics Krishna Kant Singh,Anand Nayyar,Sudeep Tanwar,Mohamed Abouhawwash,2021-05-04 Cyber Physical Systems CPS integrate computing and communication capabilities by monitoring and controlling the physical systems via embedded hardware and computers This book brings together new and futuristic findings on IoT Cyber Physical Systems and Robotics leading towards Automation and solving issues of various critical applications in Real time The book initially overviews the concepts of IoT IIoT and Cyber Physical

Systems followed by various critical applications and discusses the latest designs and developments that provide common solutions for the convergence of technologies. In addition, the book specifies methodologies, algorithms, and other relevant architectures in various fields that include Automation, Robotics, Smart Agriculture, and Industry 4.0. The book is intended for practitioners, enterprise representatives, scientists, students, and Ph.D. Scholars in hopes of steering research further towards cyber physical systems design and development and implementation across various domains. Additionally, this book can be used as a secondary reference or rather one-stop guide by professionals for real-life implementation of cyber physical systems. The book highlights a critical coverage of various domains: IoT, Cyber Physical Systems, Industry 4.0, Smart Automation, and related critical applications. Advanced elaborations for target audiences to understand the conceptual methodology and future directions of cyber physical systems and IoT. An approach towards Research Orientations to enable researchers to point out areas and scope for implementation of Cyber Physical Systems in several domains for better productivity.

IoT Based Control Networks and Intelligent Systems P. P. Joby, Valentina E. Balas, Ram Palanisamy, 2022-10-11. This book gathers selected papers presented at International Conference on IoT Based Control Networks and Intelligent Systems ICICNIS 2022 organized by St. Joseph's College of Engineering and Technology, Kottayam, Kerala, India, during July 1-2, 2022. The book covers state-of-the-art research insights on Internet of things (IoT) paradigm to access, manage, and control the objects things people working under various information systems and deployed under wide range of applications like smart cities, health care industries, and smart homes.

ARM-Based Microcontroller Multitasking Projects Dogan Ibrahim, 2020-05-14. Most microcontroller-based applications nowadays are large, complex, and may require several tasks to share the MCU in multitasking applications. Most modern high-speed microcontrollers support multitasking kernels with sophisticated scheduling algorithms so that many complex tasks can be executed on a priority basis. ARM-based Microcontroller Multitasking Projects Using the FreeRTOS Multitasking Kernel explains how to multitask ARM Cortex microcontrollers using the FreeRTOS multitasking kernel. The book describes in detail the features of multitasking operating systems such as scheduling, priorities, mailboxes, event flags, semaphores, etc., before going on to present the highly popular FreeRTOS multitasking kernel. Practical working real-time projects using the highly popular Clicker 2 for STM32 development board which can easily be transferred to other boards together with FreeRTOS are an essential feature of this book. Projects include LEDs flashing at different rates, Refreshing of 7-segment LEDs, Mobile robot where different sensors are controlled by different tasks, Multiple servo motors being controlled independently, Multitasking IoT project, Temperature controller with independent keyboard entry, Random number generator with 3 tasks, live generator display, home alarm system, car park management system, and many more. Explains the basic concepts of multitasking. Demonstrates how to create small multitasking programs. Explains how to install and use the FreeRTOS on an ARM Cortex processor. Presents structured real-world projects that enable the reader to create their own.

Practical Solar Tracking Automatic Solar Tracking

Sun Tracking Автоматическое удержание Солнечная слежения ВС [REDACTED] Gerro Prinsloo, Robert Dobson, 2015-11-01 This book details Practical Solar Energy Harvesting Automatic Solar Tracking Sun Tracking Systems Solar Trackers and Sun Tracker Systems using motorized automatic positioning concepts and control principles An intelligent automatic solar tracker is a device that orients a payload toward the sun Such programmable computer based solar tracking device includes principles of solar tracking solar tracking systems as well as microcontroller microprocessor and or PC based solar tracking control to orientate solar reflectors solar lenses photovoltaic panels or other optical configurations towards the sun Motorized space frames and kinematic systems ensure motion dynamics and employ drive technology and gearing principles to steer optical configurations such as mangin parabolic conic or cassegrain solar energy collectors to face the sun and follow the sun movement contour continuously In general the book may benefit solar research and solar energy applications in countries such as Africa Mediterranean Italy Spain Greece USA Mexico South America Brazilia Argentina Chili India Malaysia Middle East UAE Russia Japan and China This book on practical automatic Solar Tracking Sun Tracking is in PDF format and can easily be converted to the EPUB MOBI AZW ePub FB2 LIT LRF MOBI PDB PDF TCR formats for smartphones and Kindle by using the ebook online convert com facility The content of the book is also applicable to communication antenna satellite tracking and moon tracking algorithm source code for which links to free download links are provided In harnessing power from the sun through a solar tracker or practical solar tracking system renewable energy control automation systems require automatic solar tracking software and solar position algorithms to accomplish dynamic motion control with control automation architecture circuit boards and hardware On axis sun tracking system such as the altitude azimuth dual axis or multi axis solar tracker systems use a sun tracking algorithm or ray tracing sensors or software to ensure the sun s passage through the sky is traced with high precision in automated solar tracker applications right through summer solstice solar equinox and winter solstice A high precision sun position calculator or sun position algorithm is this an important step in the design and construction of an automatic solar tracking system From sun tracing software perspective the sonnet Tracing The Sun has a literal meaning Within the context of sun track and trace this book explains that the sun s daily path across the sky is directed by relatively simple principles and if grasped understood then it is relatively easy to trace the sun with sun following software Sun position computer software for tracing the sun are available as open source code sources that is listed in this book Ironically there was even a system called sun chaser said to have been a solar positioner system known for chasing the sun throughout the day Using solar equations in an electronic circuit for automatic solar tracking is quite simple even if you are a novice but mathematical solar equations are over complicated by academic experts and professors in text books journal articles and internet websites In terms of solar hobbies scholars students and Hobbyist s looking at solar tracking electronics or PC programs for solar tracking are usually overcome by the sheer volume of scientific material and internet resources which leaves many developers in frustration when search

for simple experimental solar tracking source code for their on axis sun tracking systems This booklet will simplify the search for the mystical sun tracking formulas for your sun tracker innovation and help you develop your own autonomous solar tracking controller By directing the solar collector directly into the sun a solar harvesting means or device can harness sunlight or thermal heat This is achieved with the help of sun angle formulas solar angle formulas or solar tracking procedures for the calculation of sun s position in the sky Automatic sun tracking system software includes algorithms for solar altitude azimuth angle calculations required in following the sun across the sky In using the longitude latitude GPS coordinates of the solar tracker location these sun tracking software tools supports precision solar tracking by determining the solar altitude azimuth coordinates for the sun trajectory in altitude azimuth tracking at the tracker location using certain sun angle formulas in sun vector calculations Instead of follow the sun software a sun tracking sensor such as a sun sensor or webcam or video camera with vision based sun following image processing software can also be used to determine the position of the sun optically Such optical feedback devices are often used in solar panel tracking systems and dish tracking systems Dynamic sun tracing is also used in solar surveying DNI analyser and sun surveying systems that build solar infographics maps with solar radiance irradiance and DNI models for GIS geographical information system In this way geospatial methods on solar environment interaction makes use use of geospatial technologies GIS Remote Sensing and Cartography Climatic data and weather station or weather center data as well as queries from sky servers and solar resource database systems i e on DB2 Sybase Oracle SQL MySQL may also be associated with solar GIS maps In such solar resource modelling systems a pyranometer or solarimeter is normally used in addition to measure direct and indirect scattered dispersed reflective radiation for a particular geographical location Sunlight analysis is important in flash photography where photographic lighting are important for photographers GIS systems are used by architects who add sun shadow applets to study architectural shading or sun shadow analysis solar flux calculations optical modelling or to perform weather modelling Such systems often employ a computer operated telescope type mechanism with ray tracing program software as a solar navigator or sun tracer that determines the solar position and intensity The purpose of this booklet is to assist developers to track and trace suitable source code and solar tracking algorithms for their application whether a hobbyist scientist technician or engineer Many open source sun following and tracking algorithms and source code for solar tracking programs and modules are freely available to download on the internet today Certain proprietary solar tracker kits and solar tracking controllers include a software development kit SDK for its application programming interface API attributes Pebble Widget libraries widget toolkits GUI toolkit and UX libraries with graphical control elements are also available to construct the graphical user interface GUI for your solar tracking or solar power monitoring program The solar library used by solar position calculators solar simulation software and solar contour calculators include machine program code for the solar hardware controller which are software programmed into Micro controllers Programmable Logic Controllers PLC

programmable gate arrays Arduino processor or PIC processor PC based solar tracking is also high in demand using C Visual Basic VB as well as MS Windows Linux and Apple Mac based operating systems for sun path tables on Matlab Excel Some books and internet webpages use other terms such as sun angle calculator sun position calculator or solar angle calculator As said such software code calculate the solar azimuth angle solar altitude angle solar elevation angle or the solar Zenith angle Zenith solar angle is simply referenced from vertical plane the mirror of the elevation angle measured from the horizontal or ground plane level Similar software code is also used in solar calculator apps or the solar power calculator apps for IOS and Android smartphone devices Most of these smartphone solar mobile apps show the sun path and sun angles for any location and date over a 24 hour period Some smartphones include augmented reality features in which you can physically see and look at the solar path through your cell phone camera or mobile phone camera at your phone s specific GPS location In the computer programming and digital signal processing DSP environment free open source program code are available for VB Net Delphi Python C C C PHP Swift ADM F Flash Basic QBasic GBasic KBasic SIMPL language Squirrel Solaris Assembly language on operating systems such as MS Windows Apple Mac DOS or Linux OS Software algorithms predicting position of the sun in the sky are commonly available as graphical programming platforms such as Matlab Mathworks Simulink models Java applets TRNSYS simulations Scada system apps Labview module Beckhoff TwinCAT Visual Studio Siemens SPA mobile and iphone apps Android or iOS tablet apps and so forth At the same time PLC software code for a range of sun tracking automation technology can follow the profile of sun in sky for Siemens HP Panasonic ABB Allan Bradley OMRON SEW Festo Beckhoff Rockwell Schneider Endress Hauser Fudji electric Honeywell Fuchs Yokonawa or Muthibishi platforms Sun path projection software are also available for a range of modular IPC embedded PC motherboards Industrial PC PLC Programmable Logic Controller and PAC Programmable Automation Controller such as the Siemens S7 1200 or Siemens Logo Beckhoff IPC or CX series OMRON PLC Ercam PLC AC500plc ABB National Instruments NI PXI or NI cRIO PIC processor Intel 8051 8085 IBM Cell Power Brain or Truenorth series FPGA Xilinx Altera Nios Intel Xeon Atmel megaAVR MPU Maple Teensy MSP XMOS Xbee ARM Raspberry Pi Eagle Arduino or Arduino AtMega microcontroller with servo motor stepper motor direct current DC pulse width modulation PWM current driver or alternating current AC SPS or IPC variable frequency drives VFD motor drives also termed adjustable frequency drive variable speed drive AC drive micro drive or inverter drive for electrical mechatronic pneumatic or hydraulic solar tracking actuators The above motion control and robot control systems include analogue or digital interfacing ports on the processors to allow for tracker angle orientation feedback control through one or a combination of angle sensor or angle encoder shaft encoder precision encoder optical encoder magnetic encoder direction encoder rotational encoder chip encoder tilt sensor inclination sensor or pitch sensor Note that the tracker s elevation or zenith axis angle may measured using an altitude angle declination angle inclination angle pitch angle or vertical angle zenith angle sensor or inclinometer Similarly the tracker s azimuth axis angle

be measured with a azimuth angle horizontal angle or roll angle sensor Chip integrated accelerometer magnetometer gyroscope type angle sensors can also be used to calculate displacement Other options include the use of thermal imaging systems such as a Fluke thermal imager or robotic or vision based solar tracker systems that employ face tracking head tracking hand tracking eye tracking and car tracking principles in solar tracking With unattended decentralised rural island isolated or autonomous off grid power installations remote control monitoring data acquisition digital datalogging and online measurement and verification equipment becomes crucial It assists the operator with supervisory control to monitor the efficiency of remote renewable energy resources and systems and provide valuable web based feedback in terms of CO₂ and clean development mechanism CDM reporting A power quality analyser for diagnostics through internet WiFi and cellular mobile links is most valuable in frontline troubleshooting and predictive maintenance where quick diagnostic analysis is required to detect and prevent power quality issues Solar tracker applications cover a wide spectrum of solar applications and solar assisted application including concentrated solar power generation solar desalination solar water purification solar steam generation solar electricity generation solar industrial process heat solar thermal heat storage solar food dryers solar water pumping hydrogen production from methane or producing hydrogen and oxygen from water HHO through electrolysis Many patented or non patented solar apparatus include tracking in solar apparatus for solar electric generator solar desalinator solar steam engine solar ice maker solar water purifier solar cooling solar refrigeration USB solar charger solar phone charging portable solar charging tracker solar coffee brewing solar cooking or solar drying means Your project may be the next breakthrough or patent but your invention is held back by frustration in search for the sun tracker you require for your solar powered appliance solar generator solar tracker robot solar freezer solar cooker solar drier solar pump solar freezer or solar dryer project Whether your solar electronic circuit diagram include a simplified solar controller design in a solar electricity project solar power kit solar hobby kit solar steam generator solar hot water system solar ice maker solar desalinator hobbyist solar panels hobby robot or if you are developing professional or hobby electronics for a solar utility or micro scale solar powerplant for your own solar farm or solar farming this publication may help accelerate the development of your solar tracking innovation Lately solar polygeneration solar trigeneration solar triple generation and solar quad generation adding delivery of steam liquid gaseous fuel or capture food grade CO₂ systems have need for automatic solar tracking These systems are known for significant efficiency increases in energy yield as a result of the integration and re use of waste or residual heat and are suitable for compact packaged micro solar powerplants that could be manufactured and transported in kit form and operate on a plug and play basis Typical hybrid solar power systems include compact or packaged solar micro combined heat and power CHP or mCHP or solar micro combined cooling heating and power CCHP CHPC mCCHP or mCHPC systems used in distributed power generation These systems are often combined in concentrated solar CSP and CPV smart microgrid configurations for off grid rural island or isolated microgrid minigrid and distributed power

renewable energy systems Solar tracking algorithms are also used in modelling of trigeneration systems using Matlab Simulink Modelica or TRNSYS platform as well as in automation and control of renewable energy systems through intelligent parsing multi objective adaptive learning control and control optimization strategies Solar tracking algorithms also find application in developing solar models for country or location specific solar studies for example in terms of measuring or analysis of the fluctuations of the solar radiation i.e direct and diffuse radiation in a particular area Solar DNI solar irradiance and atmospheric information and models can thus be integrated into a solar map solar atlas or geographical information systems GIS Such models allows for defining local parameters for specific regions that may be valuable in terms of the evaluation of different solar in photovoltaic or CSP systems on simulation and synthesis platforms such as Matlab and Simulink or in linear or multi objective optimization algorithm platforms such as COMPOSE EnergyPLAN or DER CAM A dual axis solar tracker and single axis solar tracker may use a sun tracker program or sun tracker algorithm to position a solar dish solar panel array heliostat array PV panel solar antenna or infrared solar antenna A self tracking solar concentrator performs automatic solar tracking by computing the solar vector Solar position algorithms TwinCAT SPA or PSA Algorithms use an astronomical algorithm to calculate the position of the sun It uses astronomical software algorithms and equations for solar tracking in the calculation of sun's position in the sky for each location on the earth at any time of day Like an optical solar telescope the solar position algorithm pin points the solar reflector at the sun and locks onto the sun's position to track the sun across the sky as the sun progresses throughout the day Optical sensors such as photodiodes light dependant resistors LDR or photoresistors are used as optical accuracy feedback devices Lately we also included a section in the book with links to microprocessor code on how the PixArt Wii infrared camera in the Wii remote or Wiimote may be used in infrared solar tracking applications In order to harvest free energy from the sun some automatic solar positioning systems use an optical means to direct the solar tracking device These solar tracking strategies use optical tracking techniques such as a sun sensor means to direct sun rays onto a silicon or CMOS substrate to determine the X and Y coordinates of the sun's position In a solar mems sun sensor device incident sunlight enters the sun sensor through a small pin hole in a mask plate where light is exposed to a silicon substrate In a web camera or camera image processing sun tracking and sun following means object tracking software performs multi object tracking or moving object tracking methods In an solar object tracking technique image processing software performs mathematical processing to box the outline of the apparent solar disc or sun blob within the captured image frame while sun localization is performed with an edge detection algorithm to determine the solar vector coordinates An automated positioning system help maximize the yields of solar power plants through solar tracking control to harness sun's energy In such renewable energy systems the solar panel positioning system uses a sun tracking techniques and a solar angle calculator in positioning PV panels in photovoltaic systems and concentrated photovoltaic CPV systems Automatic on axis solar tracking in a PV solar tracking system can be dual axis sun tracking or

single axis sun solar tracking It is known that a motorized positioning system in a photovoltaic panel tracker increase energy yield and ensures increased power output even in a single axis solar tracking configuration Other applications such as robotic solar tracker or robotic solar tracking system uses robotica with artificial intelligence in the control optimization of energy yield in solar harvesting through a robotic tracking system Automatic positioning systems in solar tracking designs are also used in other free energy generators such as concentrated solar thermal power CSP and dish Stirling systems The sun tracking device in a solar collector in a solar concentrator or solar collector Such a performs on axis solar tracking a dual axis solar tracker assists to harness energy from the sun through an optical solar collector which can be a parabolic mirror parabolic reflector Fresnel lens or mirror array matrix A parabolic dish or reflector is dynamically steered using a transmission system or solar tracking slew drive mean In steering the dish to face the sun the power dish actuator and actuation means in a parabolic dish system optically focusses the sun s energy on the focal point of a parabolic dish or solar concentrating means A Stirling engine solar heat pipe thermosyphin solar phase change material PCM receiver or a fibre optic sunlight receiver means is located at the focal point of the solar concentrator The dish Stirling engine configuration is referred to as a dish Stirling system or Stirling power generation system Hybrid solar power systems used in combination with biogas biofuel petrol ethanol diesel natural gas or PNG use a combination of power sources to harness and store solar energy in a storage medium Any multitude of energy sources can be combined through the use of controllers and the energy stored in batteries phase change material thermal heat storage and in cogeneration form converted to the required power using thermodynamic cycles organic Rankin Brayton cycle micro turbine Stirling with an inverter and charge controller Solar Tracking Tracking Systems Solar Tracker Systems Tracker PC Recent Trends in Image Processing and Pattern Recognition K. C. Santosh,Ravindra S. Hegadi,2019-07-16 This three book set constitutes the refereed proceedings of the Second International Conference on Recent Trends in Image Processing and Pattern Recognition RTIP2R 2018 held in Solapur India in December 2018 The 173 revised full papers presented were carefully reviewed and selected from 374 submissions The papers are organized in topical sections in the tree volumes Part I computer vision and pattern recognition machine learning and applications and image processing Part II healthcare and medical imaging biometrics and applications Part III document image analysis image analysis in agriculture and data mining information retrieval and applications

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