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Recent Trends in SCADA and Power Factor Compensation on low Voltage Power Systems for Advanced Smart Grid

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***Abstract*— This paper presents an extending a smart grid to switched capacitor banks at the low-voltage three-phase four-wire distribution systems. New power factor regulators using MSP430 microcontrollers will be proposed instead of ordinary regulators to be suitable for connecting to the Supervisory Control and Data Acquisition (SCADA) system that actually has been implemented since 2005 in the Middle Egypt Electricity Distribution Company(MEEDCO). In MEEDCO, there are quite a lot of mounted power factor regulators in different locations, but most of these regulators are far from each other and also far from the control center of MEEDCO's SCADA system. This paper also discusses the suitable technology to communicate the suggested regulators with the control center efficiently and how this will be done in the framework of a secure smart grid.**

***Keywords*— Data Transfer, MSP430, Smart Grid, SCADA, Security.**

I. INTRODUCTION

Electricity distribution companies own and operate the infrastructure required to connect customers to the network. At present, the low-voltage three-phase four-wire distribution systems are facing the poor power quality problems such as high reactive power burden, unbalanced load excessive neutral current and voltage distortion [1]. Industrial plants typically present a poor power factor to the incoming utility due to proliferation of diode and thyristor rectifiers, induction motors and harmonic rich loads. Low power factor is the predominant problem nowadays [2]. Poor power factor has various consequences such as increased load current, large KVA rating of the equipment, greater conductor size, larger copper loss, poor efficiency, poor voltage regulation and reduction in equipment life. Therefore it is necessary to solve the problem of poor power factor. To improve the power factor, shunt capacitor banks have been applied in many power distribution systems and industrial circuits for reactive power compensation [3].

The power factor regulator is designed to optimize the control of reactive power compensation. Reactive power compensation is achieved by measuring continuously the reactive power of the system and then compensated by the switching of capacitor banks. At the end user connection points, the integrating breaker switched capacitor banks into a compact design with the intelligent control unit offers a reliable and affordable reactive power compensation solution for distribution systems. The benefits of doing so are:

(1) Improvement in power factor, which either eliminates or reduces the demand charges imposed by the utility.

(2) Reducing the energy loss in electrical conductors by reducing the required current.

(3) Maintaining a proper voltage level at the end user for improved productivity of industrial processes.

(4) Releasing of valuable system capacity.

(5) Increasing the useful life of pieces of distribution equipment.

(6) Improvements in planning where planning engineers can more precisely decide to place additional capacitor banks to account for load growth.

For years, many electric utilities have implemented SCADA systems for better control [4]. SCADA can provide information in a real-time environment that identifies problems as they occur and can take corrective action when assistance is needed [5]. SCADA systems provide centralized monitoring and control of field devices spread over large geographic areas. SCADA systems use a wide variety of networking technologies to enable transmission of field data from field sites to the control centers and of control information from control centers to field sites. Once field data reaches the control system, software systems provide capabilities to visualize and analyze the data.

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Based on automated or human-driven analysis, action is taken as needed such as recording the data, processing alarms or sending control information back to field sites. Since SCADA had already been in use in most electricity distribution companies and coupling SCADA systems with the embedded intelligence in the Intelligent Electronic Devices (IED) can generate a wealth of useful information. So, the proposed power factor controller using MSP430 microcontroller (IED)at the end user should be monitored and controlled by SCADA technology to get several features such as supervision, remote control and remote measurement. The monitored data can be the following:

1. The net interval energy consumption, the local voltage, current, power factor, active power and reactive power.
2. Status of a power factor controller (open or closed switch)
3. The time the data are collected and recorded.

Therefore, the extension of intelligent control over electrical power grid functions to the distribution layer and beyond (via distribution automation) is a key enabler for smart grid success. Smart grid is developing a more sophisticated electricity delivery infrastructure that requires embedding intelligence and communications at every node of the electric-power delivery system. Extending a smart grid network to power factor controller at the end user results in improvements in grid reliability, visibility into critical load information, asset management, reduced operations and maintenance costs and also results in improvements in customer satisfaction. The rest of the paper is organized as follows. Section 2 introduces a background for the SCADA system, smart grid and MSP430 microcontroller. Section 3 shows the proposed strategy to embed the reactive power compensation systems into MEEDCO's SCADA system.

II. BACKGROUND

A. SCADA systems

With the fast development of computer application technology, SCADA system is widely used in industry field, especially in a power system where SCADA is developing speedily [6]. SCADA is a smart grid distribution application providing the process control systems that enable computerized management of distribution grid elements [7]. The main purpose of SCADA is gathering real-time data, monitoring and controlling equipments and processes in the critical infrastructures [8].

Proper monitoring of a process can maintain operations at an optimal level by identifying and correcting problems before they turn into significant system failures. SCADA systems are divided into three important components, namely:

1- Master station or the control center, which gathers all relevant data in a system, maintains a database and processes commands issued through a human-machine interface by an operator. In complex systems, this component may consist of multiple servers running distributed application software.

2- Remote Terminal Units (RTU), is an IED that can be installed in a remote location and acts as a termination point for field contacts. The RTU can transfer collected data to other devices and receive data and control commands from other devices.

3- Communication infrastructure, is used to transport information between the control center and field sites via communication mediums such as telephone line, cable, fiber and radio frequency such as broadcast, microwave and satellite.

SCADA obtains and processes the information issuing from dispersed equipment in remote locations. It then sends this information to the operations control center. The SCADA simultaneously supervises and controls processes and installations located throughout large areas, generating a set of processed information such as trend graphs, historical information, operating reports and event programming among others. By implementing SCADA in the automation process, users can learn the status of the installations under their responsibility and coordinate, in an efficient manner, the detection of errors and anomalies in the electric grid. SCAD also allows users to execute maneuvers to reestablish service , carry out maintenance in the field , supervise and control critical operations and receive information in a dynamic manner and in real time for its ulterior processing.

B. Smart grid

It is a common belief that the energy, control and communications technologies have reached the level of maturity which is sufficient to put forward a new power utility shift known as the smart grid [9]. Huge and strong interests on a smart grid have increased extensively in recent years around the world. A smart grid is a complex distributed infrastructure composed of a set of domains and stakeholders.

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According to the conceptual model of the National Institute of Standards and Technology (NIST), these domains correspond to customers, markets, providers, energy generation, distribution and transmission networks as well as control systems such as SCADA system [10] [11]. This last domain can be considered as the core of the entire system that widely interconnects with the other domains. This interconnection enables the center of SCADA to know the performance of the entire grid and control its functions for delivering essential services such as electrical energy. The concept of smart grid was originally envisioned to stimulate the improvement of electric power network in accordance with certain goals such as: providing power quality for 21st century needs. The vision of a smart grid is to provide a modern, resilient and secure electric power grid as it boasts up with a highly reliable and efficient environment through the effective use of its information and communication technology. Smart grid technologies, including smart meters, micro grid controller, and remote monitoring system with SCADA functions have been employed to optimize the energy generation, monitor energy consumption, manage instantaneous power flow, maintain electricity quality and generate a fault alerts [12].The success of the smart grid heavily depends on fast and reliable data transmission since some smart grid applications should be performed in real time [13] [14] and many of smart grid applications do not require data rates of hundreds of Mbps [15] [16].Security and privacy play important roles in developing the technology of smart grid [17].Smart grid is the modernization of the traditional power grid which should ideally have some advanced functionalities like:

- Self-healing
- Motivates and includes the consumer
- Resists attack
- Power quality
- Accommodates all generation and storage options
- Enables electrical markets
- Assets and operates efficiently

C. MSP430 microcontroller

Known for its low-power consumption, MSP430 from Texas Instruments is a family of 16-bit microcontrollers commonly used in wireless sensors/actuator network and metering applications [18].

The utilization of these Microcontroller Unit (MCU) becomes too broad due to the introduction of new innovative features apart from low-cost and low power. The main features of MSP430 microcontroller are summarized in Table 1.

TABLE 1.
MAIN CHARACTERISTICS OF THE MSP430 MCU

Feature	Description
Instruction sets	27 RISC instructions
Registers	12 general purpose registers
Memory	16 Bit Word or Bytes Addressing
Addressing modes	Register direct, register indexed, register indirect and register indirect
Peripherals	USART, SPI, I²C, 10/12/14/16-bit ADCs, internal oscillator, timer, PWM, watch dog, brownout reset circuitry, comparators, on-chip op-amps, 12-bit DAC, LCD driver, hardware multiplier, USB, and DMA
Frequency	1Mhz- 25Mhz
Electric Power	<1µA in IDLE mode
On-Chip Memory	256KB Flash, 16 KB RAM

III. THE PROPOSED STRATEGY TO EMBED THE REACTIVE POWER COMPENSATION SYSTEMS INTO MEEDCO'S SCADA SYSTEM

1. MEDDCO profile and its SCADA system

Distribution networks utilize different voltage levels: High Voltage (HV 66kV), Medium Voltage (MV11kV to 22kV) and Low Voltage (LV 400V or 230V).The majority of residential and small business customers are connected to the LV network with single phase or three-phase connections. MEEDCO operates the distribution network of five governorates in upper Egypt. MEEDCO is providing almost 9682 [MWh/year] for approximately 3151860 customers through 21212 km of medium voltage lines and 35114 km of low voltage lines. The company is responsible for the distribution of electricity coming from the transmission company and for the sale of electric power to subscribers and implement connections for them**.** MEEDCO is continually making an effort to improve the performance of the distribution network through benefiting from advanced technologies. In 2002, the company moved to implement a SCADA project to cover Menya governorate and Assiut governorate.

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The implementation of the project took 3 years to finish and it is still working so far. The total number of measured, monitored and controlled points by the control center are 29661 points. The MEEDCO power's SCADA system covers some of the transformer stations of transmission company, some of the distribution transformers (kiosks) and most of the distribution panels that include incoming feeders, outgoing feeders, bus tie, digital relays, digital meters and charger. Figure 1 illustrates a snapshot of a SCADA system for monitoring EL FEKRIAH distribution panel.

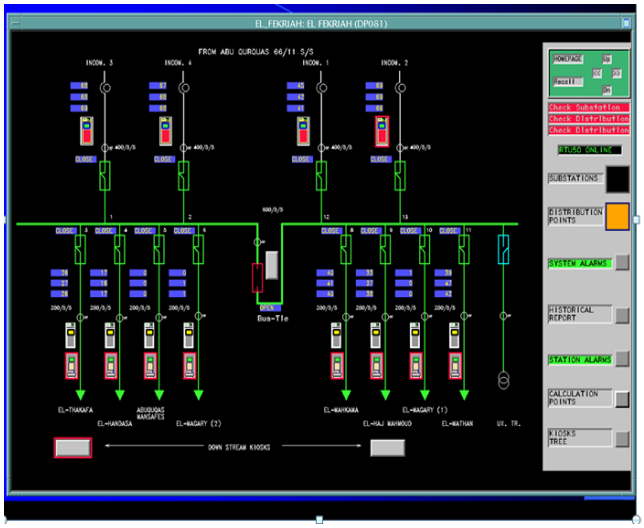

Fig1. Snapshot of SCADA system for EL FEKRIAH distribution panel.

The data gathered by RTUs at remote locations like kiosks and distribution panels are sent to the control center that contains a Local Area Network (LAN) that consists of servers, workstations, routers, switches, printers and large displays as seen in Figure 2. In MEEDCO power's SCADA system, the Mod bus communications protocol is used to connect a supervisory server with RTUs and the data exchange is implemented by using a mixture of wireless network and fiber-optic cable network according to the location and site conditions.

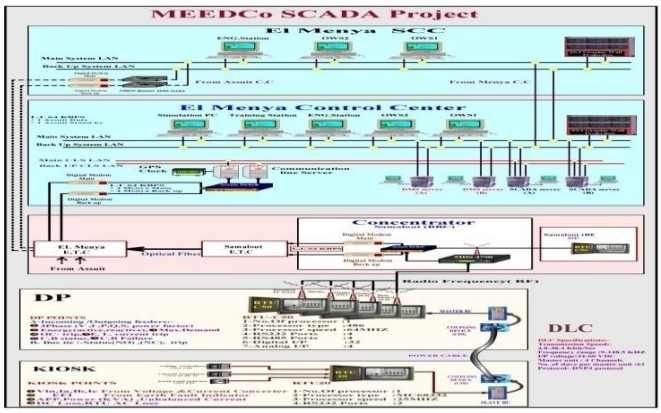

Fig 2. Communication remote devices with the control center

2. Implementing the power factor regulator in low voltage networks

MEEDCO consists of five sectors for electricity distribution. Our case study will focus on Menya sector which is the supplier of electricity in Menya governorate that contains nine large cities with an area of 32279 km2. The sector provides electricity to a very large number of participants. A slice of those participants nominates senior participants as an indication of their large consumption of electricity such as factories, stations lifting water, sewage plants, centrals and great business shops. These loads are mostly inductive in nature and it creates serious power quality problems for senior participants like low power factor, increased load current and reduction in voltage. To solve these problems, Menya sector has applied a control system for power factor compensation. The system has been implemented by placing capacitor banks in parallel with the load at the entrance point of the facility. The system uses a power factor regulator device to monitor the power factor of a 3-phase power line. The regulator automatically responds to changing power factor by closing or opening the internal relays of contactors who add or subtract capacitor banks on the line. These banks often include three to nine capacitor units connected in three-phase grounded-our configurations.

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In addition to the capacitors and contactors, a properly sized current transformer with a minimum burden rating of 2 VA and a 5 amp secondary is required. All components of the system are connected on the low side of the supply transformer. A simple schematic of the system for power factor compensation on low voltage networks is seen in Figure 3.

The following steps are performed for power factor correction:

1) The power factor control is performed by controlling the opening and closing of the capacitor switches based on the measured power factor.

2) The regulator measures voltage and current on the feeder side and the results of the computed power factor is compared to the predetermined target power factor setting.

3) Using measured and target power factors and the capacitor information, the regulator determines if one or more capacitor banks need to be switched on or off to bring the actual power factor as close as possible to the targeted power factor setting.

In Menya sector, there are quite a lot of mounted power factor regulators in different locations. But these regulators up till now use ordinary microcontrollers and still not connecting to the control center of Menya sector. With advances in integrated circuit technology, Microcontroller Units (MCUs) now have higher processor speeds as well as greater quantities of on-board ROM and RAM which combine to increase the newer MCUs computational capabilities of complex algorithms and signal processing routines. These advancements can be taken advantage of to produce a more effective controller for reactive power compensation. This paper suggests replacing the existing power factor regulators with new regulators using MSP430 microcontrollers as effective MCUs for communication with SCADA system.

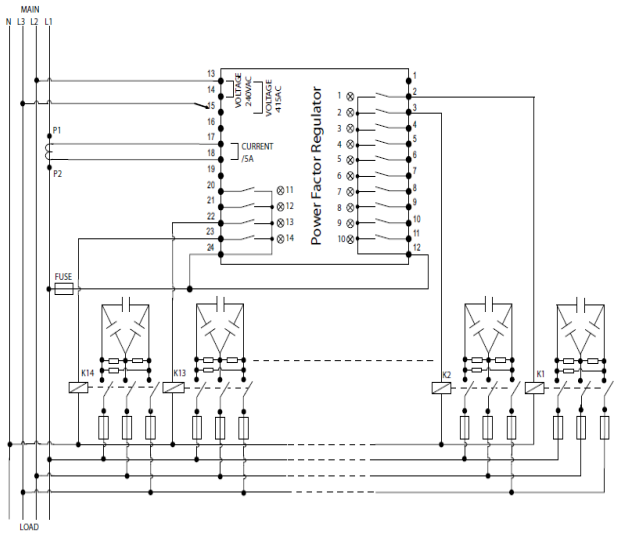

Fig 3. Simple schematic of the system for power factor compensation on low voltage

3- *The communication of the proposed regulators with the control center of Menya sector*

In Menya sector, Most of the regulators are far from each other and also far from the control center of Menya's SCADA system. This paper discusses the suitable technology to communicate the suggested regulators with the control center efficiently. In this section, we will present and discuss the proposed RTU architecture for our SCADA system. The architecture is chosen according to the qualitative study surveying the available technologies that can be used as a serious candidate for our studied system. Various considerations are taken into account in these choices, especially the extensibility and the cost impact.

3.1. The Proposed architecture

As mentioned before, factories are senior participants in Menya sector. In Figure 4, the proposed system illustrates the chosen architecture to connect many regulators who located in two factories with the supervision center.

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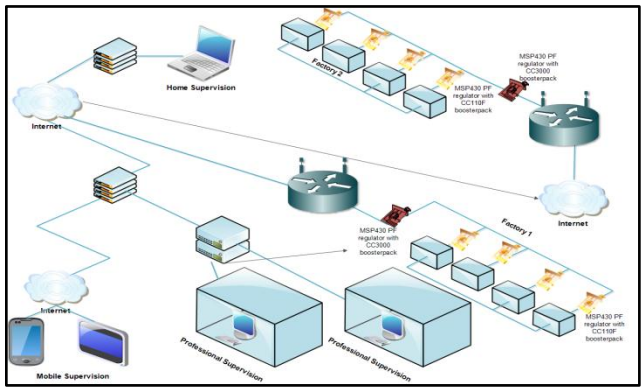


Fig4. The proposed system architecture

Each node in the factory has its own power factor regulator. This regulator has a CC110L Booster Pack offers a local wireless communication with others power factor regulators. This local ad-hoc network has a main role to achieve supervision data to the collection node based on an MSP430 board with CC3000 BoosterPack. The collection node is mainly used to connect the local factory network to the external internet network in order to offer professional supervision, home supervision or mobile supervision. In fact, all the data collected from the node inside the factory can be acceded anywhere across the globe.

3.2. CC110L RF and CC3000 BoosterPack

As a response to the proposed architecture, we inspected the available wireless MSP430 Boosterpack. For our purpose, we found two interesting solutions that can be easily adopted in our project. The first one who is a CC110L RF module can be an excellent choice for local SCADA connection needs. On the other hand, CC3000 module can be very interesting solution for connection bridging since this module can add Wi-Fi connectivity to the MSP430 Launchpad.

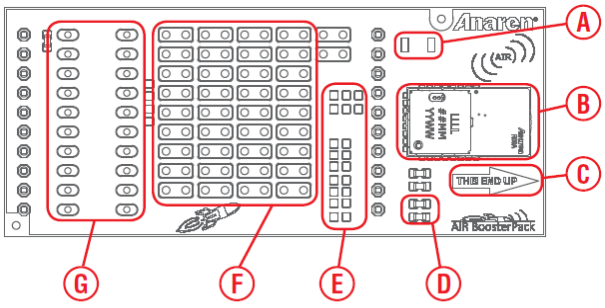
3.2.1 CC110L RF BoosterPack

CC110L RF BoosterPack is shown in Figure 5 was initially designed in cooperation between Texas Instruments (TI) and Anaren companies to offer a reliable, cost efficient radio communication platform. This BoosterPack based on CC110L has the benefit to offer reliable, cost-efficient and low power communication.

It is designed to be used with the MSP430 Launchpad board, the reference firmware can be easily customized to use more powerful Launchpad board. The main usage of this board in our system is to offer wireless connectivity between different power factor regulators in order to deliver the collected data to the final node responsible to deliver this data to external world through Wi-Fi network.

3.2.2 CC3000 BoosterPack

CC3000 Wi-Fi BoosterPack shown in Figure 6 is an extension board designed to add Wi-Fi connectivity to the MSP430 Launchpad. The included features shown in Table 2 and the software ecosystem related to this board can dramatically improve several metrics related to the quality and the cost of the designed system. As always, the TI platform offers a high level of abstraction that can be very valuable in this kind of application, especially reducing the level of required RF expertise and software reuse. This kind of possibility, combined with the use of TI ultra-low cost /low-power MCUs contribute to dramatically reduce the global cost of the final system. Furthermore, CC3000 is introduced with Smart Config™ technology that can dramatically reduce the number of steps necessary to connect the suggested regulators to the wireless network.



A Pads for optional SWITCH
B AIR Radio Module
C Range Test optimal orientation indicator (see Users Manual)
D Pads for optional LED
E Data path jumper settings (preset defaults)
F "Prototype area." Use these pads to build your project onboard
G Pads for MCU expansion

Figure 5. Block diagram of CC110L RF BoosterPack

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Figure 6.CC3000 BoosterPack

TABLE 2.
MAIN TECHNOLOGICAL FEATURE OF THE CC3000 BOOSTERPACK

Feature	Description
Wireless network processor	IEEE 802.11 b/g (2.4GHz) Embedded IPv4 TCP/IP stack
Best-in-class radio performance	TX power: +18.0 dBm at 11 Mbps, CCK RX sensitivity: –88 dBm, 8% PER, 11 Mbps
Works with low MIPS and low-cost MCUs with compact memory footprint	Small code size (Flash and RAM) required for MCU

IV. IMPLEMENTATION OF A SECURE SMART GRID

As the power grid evolves the smart grid, the security of the SCADA system becomes even more important than ever. The basic security requirement is to guarantee the secure exchange of messages between the nodes in the system. The power system has faced several cyber related attacks which have raised the question regarding the security vulnerabilities and its large scale impact on the critical power system infrastructure [19]. Earlier SCADA system was based on an event-driven operating system and basic serial communications. This kind of solution does not have any security threats because complete physical isolation SCADA devices from any external intrusion.

Thanks to Moor Law, SCADA applications become cost effective and ubiquitous. Such solution is based on standard hardware, open source software and open protocols. Any compromise in SCADA system security can have serious consequences [20]. During this last decade, many research works have studied the security of such system and proposed innovative solutions, [21], [22], and [23]. In this study, we introduce an authentication solution using a hashing algorithm for MSP430 microcontroller for SCADA RTU. The proposed solution has the authentication system or algorithm using various profiles of Quark [18] hashing algorithm which are chosen after qualitative and quantitative surveys that are presented in this paper.

4.1 Hardware Platform

4.1.1 MSP430 family and development tools

Texas Instrument has a wide range of MSP430 flavors designed for diverse applications such as smart metering, wireless communication, motor control, personal health care, etc. For each application of MSP430 flavor Texas Instrument has a development or evaluation board. The most successful development boards are MSP-EXP430F5529, eZ430 Chronos [24] and MSP430 Launchpad [25]. MSP430 has the advantage of the complete software ecosystem ranging from powerful development environment such as IAR, Code Composer Studio and Energia to very appropriate software stack such as SimpliciTI [26] or Capacitive Touch sense library. In the other hand, TI MCU solutions are also very cost effective and scalable. The wide variety of available TI MCU offers the possibility to easily change from one TI MCU to another.

4.1.2 Launchpad board

Since 2010, Texas Instrument has expanded MSP430 portfolio by introducing MSP430 Value Line shown in Figure 7. This new low cost family starting at 0.25$, is essentially intended to replace the old 8-bits MCU. To promote this new family, TI has introduced the MSP-EXP430G2 LaunchPad showed in Figure 8.This evaluation board is a low cost very valuable evaluation platform. Launchpad can be used to develop applications for the overall Value Line MSP430 microcontrollers.

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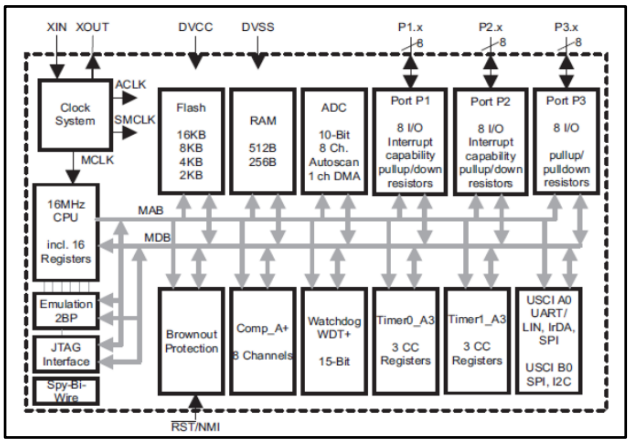

Fig 7. Functional Block Diagram, MSP430G2x53

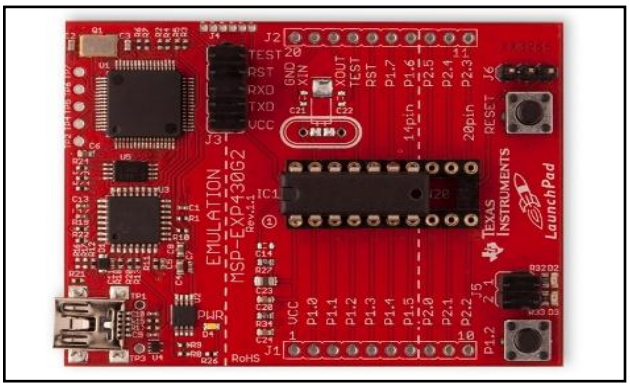

Fig 8. Launchpad Board

4.2. Choice and adaptation of lightweight hashing algorithm

The goal of this section is to review the available hashing algorithm in order to adopt an appropriate one as an authentication solution for our SCADA system. The choice of the hashing algorithm will be made according to security level, computational complexity and memory footprint. The two last criteria are primordial since our hardware MSP430G2553 microcontroller uses 16Kbyte of flash memory, 512 Byte of RAM memory, and cannot go over 16MHz in frequency.

4.2.1. Introduction hashing algorithm

Hashing algorithms [27] are commonly used in computing, their main purpose is to map a variable message length to a fixed length message. It consists of applying H (hashing function) to x (message) to produce H (x) called the message hash. On the other hand, finding 'y' as H (y) =H (x) must be computationally infeasible. This behavior can be used in the following fields:

- Authentication algorithms
- Password storage mechanisms
- Digital Signature Standard (DSS)
- Transport Layer Security (TLS)
- Internet Protocol Security (IPSec)
- Random number generation algorithms

In our application, hashing algorithm will be used to protect the authenticity of transmitting information and to offer reliable authentication mechanism.

4.2.2. Review of lightweight hashing algorithm

Hashing algorithms are widely used for a broad type of applications. Nowadays, many hashing algorithms are available. Each algorithm can be more adapted for specific fields such as a powerful video platform, FPGA platforms, low performance platforms etc. Table 3, review these algorithms to deliver a big view about these algorithms. Based on this review, we will take the right algorithm to be suitable for our application.

4.2.3. Quark hashing algorithm for MSP430G2553 microcontroller

In the research work [28], designers of lightweight cryptographic algorithms or protocols to have to trade-off between two opposite design philosophies. The first one consists in creating new schemes from scratch, whereas the second consists in reusing available schemes and adapting them to system constraints. The main features of Quark are separating digest length, security level and working with shift registers. In our SCADA system, the execution of the hashing algorithm is just used during new supervision node connection, then this algorithm can have a middle complexity level since during the authentication the system does not have any notable load.

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TABLE 2.
CANDIDATE HASHING FUNCTIONS

Algorithm	Presentation
SHA family	Secure Hash Algorithms are a family of Hash Algorithms published by NIST since 1993. SHA has many derivative standards such as SHA-0, SHA-1, SHA-3
MD4 MD5 MD6	Message-Digest Algorithm is a family of broadly used cryptographic hash function developed by Ronald Rivest that produces a 128-bit for MD4 and MD5, 256-bit for MD6
Quark	Family of cryptographic functions designed for resource-constrained hardware environments.
CubeHash	A very simple cryptographic hash function designed in University of Illinois at Chicago, Department of Computer Science
Grøstl	Hashing algorithm designed by a team of cryptographers from Technical University of Denmark (DTU) and TU Graz
Lane	Cryptographic hash function suggested in the NIST SHA-3 competition by the COSIC research group
Shabal	Cryptographic hash function submitted by the France funded research project Saphir to NIST's
Spectral Hash	Cryptographic hash function family based on the discrete Fourier submitted to the NIST hash function competition
Keccak-f	Cryptographic hash function submitted to the NIST SHA-3 hash function competition
Whirlpool	Whirlpool is a cryptographic hash function recommended by the NESSIE project, adopted by the ISO and IEC as part of the ISO/IEC 10118-3 standard.
UHASH	UHASH is a keyed hash function, specified in RFC4418. The primary application of this algorithm is in UMAC message authentication code.
SPONGENT	Lightweight hash-function family, known for their small footprint for hardware implementation
Photon	A lightweight hash - function designed for very constrained devices
dm-present	Ultra-lightweight block cipher designed for RFID applications
SQUASH	Not collision resistant, suitable for RFID applications

4.3 Performance evaluation of various Quark profiles running under MSP430G2553

4.3.1. Obtained results

After adapting the various Quark algorithm profiles for MSP430G2553, we did some performance evaluation according execution time detailed in Table 4 and algorithm footprint detailed in Table 5.

TABLE 3.
EXECUTION TIME OF VARIOUS PROFILES OF QUARK ALGORITHM

Alghorithm	Execution time (ms)
UQUARK	1.414027149
DQUARK	1.486546752
SQUARK	1.652073352
CQUARK	1.902949572

TABLE 4. FOOTPRINT OF VARIOUS PROFILES OF QUARK ALGORITHM

4.3.2 Results analysis

The obtained result reflects the good performance of Quark algorithm, the lighter version can be very appropriate for wireless sensor network applications. On the other hand, the overhead of complete profile is acceptable and we think that this interpretation can be more adapted for modern SCADA applications. We would like to emphasize that this outcome is obtained with 1 MHz MCU frequency, which can be easily improved by increasing the frequency of the MCU since the adopted MCU can run up to 16 MHz or by switching to higher MCU family.

V. CONCLUSION

Control from anywhere and at any time is nowadays a matter of paramount importance in critical systems. This paper proposes an integrated solution for embedding the reactive power compensation systems of low voltage power networks into MEEDCO's SCADA system. New power factor regulators using MSP430 microcontrollers (IDE) have been presented instead of the traditional compound regulators. An efficient technology for data transfer between the control center of MEEDCO's SCADA system and power factor regulators in a secure way has been introduced. This work can be valid for many applications in the smart grid to cover every node on the electric-power delivery system.

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REFERENCES

[1] Jianguo, Zhou, et al. "Load balancing and reactive power compensation based on capacitor banks shunt compensation in low voltage distribution networks."Control Conference (CCC), 2012 31st Chinese. IEEE, 2012.

[2] Mujawar, Irfan I., et al. "An Innovative TCR Compensator for Closed Loop Reactive Power Compensation of Dynamic Loads." changes 2.1 (2014).

[3] Tinggren, R., et al. "Power factor controller-an integrated power quality device."Transmission and Distribution Conference, 1999 IEEE. Vol. 2. IEEE, 1999.

[4] Lippincott, Colin. "Secure wireless data communications for distribution automation in the Smart Grid." Innovative Smart Grid Technologies (ISGT), 2012 IEEE PES. IEEE, 2012.

[5] Endi, Mohamed, Y. Z. Elhalwagy, and Attalla Hashad. "Three-layer plc/scada system architecture in process automation and data monitoring." Computer and Automation Engineering (ICCAE), 2010 The 2nd International Conference on. Vol. 2. IEEE, 2010.

[6] Anjia Mao, ChaozhongXiong, ShashaLuo, Shanshan Zhao, and Dongxia Zhang, "An Approach of State Estimation Based on Process Measurement Data," Power and Energy Engineering Conference. Asia-Pacific, pp. 1-6, March 2009.

[7] Trilliant company (2014, April). "Manage Your Distribution Grid Elements with SCADA " [Online]. Available: http:// www.trilliantinc.com

[8] IEEE Std C37.ITM-2007, "IEEE Standard for SCADA and Automation Systems" IEEE Power and Energy Society, IEEE, USA, 2008, pp. 19-21.

[9] Dragicevic, Tomislav, et al. "Advanced LVDC Electrical Power Architectures and Microgrids: A Step towards a New Generation of Power Distribution Networks."IEEE Electrification Magazine (2014)

[10] NIST (2012), NIST Framework and Roadmap for Smart Grid Interoperability Standards, Release 2.0, NIST Special Publication 1108R2.

[11] Knapp, Eric, and Joel Langill. Industrial Network Security: Securing Critical Infrastructure Networks for Smart Grid, SCADA, and Other Industrial Control Systems. Elsevier, 2011.

[12] Fan, Yang, et al. "Design and Implementation of stand-alone smart grid employing renewable energy resources on PulauUbin Island of Singapore."Electromagnetic Compatibility (APEMC), 2012 Asia-Pacific Symposium on. IEEE, 2012.

[13] Hledik, Ryan. "How green is the smart grid?." The Electricity Journal 22.3 (2009): 29-41.

[14] Lee, Keonkook, et al. "Cognitive beamforming based smart metering for coexistence with wireless local area networks." Journal of Communications and Networks 14.6 (2012): 619-628.

[15] Galli, Stefano, Anna Scaglione, and Zhifang Wang. "For the grid and through the grid: The role of power line communications in the smart grid." Proceedings of the IEEE 99.6 (2011): 998-1027.

[16] Y. Zhang and J.-L. Chen, "Wide-area SCADA system with distributed security framework," J. Commun. Netw., vol. 14, no. 6, pp. 597–605, Dec. 2012.

[17] Fan, C., S. Huang, and Y. Lai. "Privacy Enhanced Data Aggregation Scheme Against Internal Attackers in Smart Grid." (2014): 1-1.

[18] Aumasson, Jean-Philippe, et al. "Quark: A lightweight hash." Cryptographic Hardware and Embedded Systems, CHES 2010. Springer Berlin Heidelberg, 2010. 1-15.

[19] Anwar, Adnan, and AbdunNaserMahmood. "Cyber security of smart grid infrastructure." arXiv preprint arXiv:1401.3936 (2014).

[20] Vulnerability Assessment of Cybersecurity for SCADA Systems, Chee-Wooi Ten, Student Member, IEEE, Chen-Ching Liu, Fellow, IEEE, and GovindarasuManimaran, Member, IEEE, IEEE TRANSACTIONS ON POWER SYSTEMS, VOL. 23, NO. 4, NOVEMBER 2008

[21] Wang, Yongge. "sSCADA: Securing SCADA infrastructure communications."arXiv preprint arXiv:1207.5434 (2012).

[22] A Testbed for Secure and Robust SCADA Systems, AnnaritaGiani, Gabor Karsai, Tanya Roosta, Aakash Shah, Bruno Sinopoli, Jon Wiley

[23] Secure SCADA framework for the protection of energy control systems, Cristina Alcaraz1, Javier Lopez1, Jianying Zhou2 and Rodrigo Roman1, Concurrency Computat.: Pract. Exper. 2011; 23:1431–1442

[24] Yoo, Seong-eun. "A Wireless Sensor Network-Based Portable Vehicle Detector Evaluation System." Sensors 13, no. 1 (2013): 1160-1182.

[25] Chernbumroong, Saisakul, Anthony S. Atkins, and Hongnian Yu. "Activity classification using a single wrist-worn accelerometer." Software, Knowledge Information, Industrial Management and Applications (SKIMA), 2011 5th International Conference on. IEEE, 2011.

[26] Nikitin, Pavel V., Shashi Ramamurthy, and Rene Martinez. "Simple Low Cost UHF RFID Reader."

[27] Igure, V. M., Laughter, S. A., & Williams, R. D. (2006). Security issues in SCADA networks. Computers & Security, 25(7), 498-506.

[28] Bogdanov, A., Knežević, M., Leander, G., Toz, D., Varıcı, K., &Verbauwhede, I. (2011). SPONGENT: A lightweight hash function. In Cryptographic Hardware and Embedded Systems–CHES 2011 (pp. 312-325). Springer Berlin Heidelberg.