General Purpose- Remote Terminal Unit GP-RTU

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Abstract- An Embedded system is an information processing systems that interact with physical processes and are embedded into a larger product that is "Any device that includes a programmable Computer but is not itself intended to be a general purpose computer." Remote Terminal Units (RTU) is also embedded systems that are deployed in various industrial sectors. The operation/working of any RTU depends on the kind of application it is employed to do or perform. Comparative Survey is done by observing functionalities of various RTUs used in sectors such as Energy, Water, and Controlled Environment; to increase the efficiency and flexibility for commissioning one universal RTU without any internal modification in various sectors is proposed in this paper. That is, how one single RTU can be utilized different operations for different sectors without any major change in hardware or software and at a very low price.

Keywords – Embedded System; General purpose Computer Remote Terminal Unit.

I. INTRODUCTION

A Remote terminal unit (RTU) is a microprocessor-controlled electronic device that interfaces objects in the physical world to a distributed control system or SCADA (supervisory control and data acquisition) system by transmitting telemetry data to a master system, and by using messages from the master supervisory system to control connected objects. Another term that may be used for RTU is Remote Tele-control unit.
An RTU monitors digital and analog parameters from the field and transmits data to the Central Monitoring Station. It contains setup software to connect data input streams to data output streams, define communication protocols, and troubleshoot installation problems. An RTU may consist of one complex circuit card consisting of various sections needed to do a custom fitted function or may consist of many circuit cards including CPU or processing with communications interface(s), and one or more of the following: (AI) analog input, (DI) digital input, (DO/CO) digital or control (relay) output, or (AO) analog output card(s).
There are various sectors where a RTU can be used, such areas are Remote monitoring of functions and instrumentation for:

1. Oil and gas (offshore platforms, onshore oil wells)
2. Networks of pump stations (wastewater collection, or for water supply)
3. Environmental monitoring systems (pollution, air quality, emissions monitoring)
4. Mine sites
5. Air traffic equipment such as navigation aids (DVOR, DME, ILS and GP)
6. Hydro-graphic (water supply, reservoirs, sewage systems)
7. Electrical power transmission networks and associated equipment
8. Natural gas networks and associated equipment Outdoor warning sirens.

Role of a RTU is Collecting, Processing and Transmitting digital signal to SCADA the master, Collection, Processing and transmitting analog values to master. Receiving digital commands from master and processing on that commands.

II. RELATED WORK

Remote Terminal Unit is widely used in many of the industrial applications which serve as the unit that acquires the data from the find and sends it to Supervisory Control and Data Acquisition System. In the survey for existing system it was revealed that such type of embedded system is implemented in power industries for distribution of power in various division of the region. This RTU is installed in a substation; the central Hub of electricity provides each region a power line that has to be distributed along the region. The roles of RTU are to Step down the Voltage level and distribute the power to various areas and also monitor any of abnormalities in the power. This would be send to the SCADA for rectification. Currently the RTU is using a ARM9 processor which is being develop by one of the company called as Ramsdaq, United Kingdom. Each RTU provided are costly and have to be imported. Moreover the RTU studied in the survey is subjected only to Power Sector. So for a Company implementing this kind of becomes restricted to that sector only. Hence a solution to this is proposed in our project. We provide a Universal RTU that would work only for the power sector but also can be implemented an in-depth study of applying wireless sensor networks to real-world habitat monitoring. A set of system design requirements are developed that cover the hardware design of the nodes, the design of the sensor network, and the capabilities for remote data access and management. System architecture is proposed to address these requirements for habitat monitoring in general, and an instance of the architecture for monitoring seabird nesting environment and behavior is presented. The currently deployed network consists of 32 nodes on a small island off the coast of Maine streaming useful live data onto the web. The application driven design exercise serves to identify important areas of further work in data sampling, communications, network re tasking, and health monitoring

III. EXSITING WORK

Currently, RTUs are implemented in various industries. RTU process Digital Inputs, Analog Inputs and gives Digital Outputs. Existing system uses a Net Silicon's NS9750 ARM-9 Processor along with Black Fin Processor for DSP operations.

an RTU is a device installed at a remote location that collects data, codes the data into a format that is transmittable and transmits the data back to a central station, or master. An RTU also collects information from the master device and implements processes that are directed by the master. RTUs are equipped with input channels for sensing or metering, output channels for control, indication or alarms and a communications port. Modbus is often used to connect a supervisory computer with a remote terminal unit (RTU) in supervisory control and data acquisition (*SCADA*) *systems.*

Figure below shows the Hardware Functionally of a remote terminal unit in industry

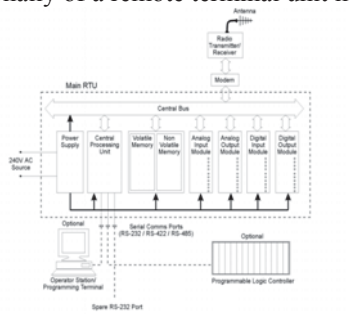

Fig 1- Block Diagram of RTU

Existing system of remote terminal unit concentrates only on application specified sectors such as Power, energy, agriculture etc. RTU used in power sector consists of a base unit contains both an ARM9 micro-processor and a digital signal processor (DSP). The micro-processor performs all the higher level software functions, working in concert with the DSP which is dedicated to time-critical AC computational tasks.

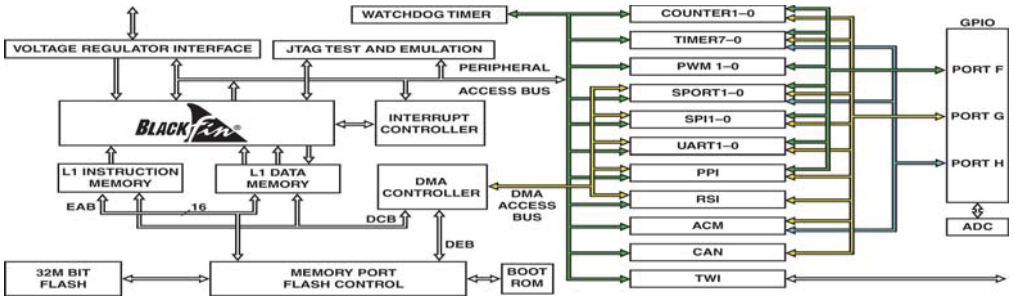

Fig: 2-Architecture of BLACKFIN

IV. DEVELOPED SYSTEM

The architecture of the proposed "General Purpose Remote Terminal Unit" is illustrated in Fig. 3. By implementing latest ARM Cortex M3 processor, proposed system provides Universal RTU that can work not only for the power sector but also can be implemented in various Sectors such as Water or Environment. The developed RTU will monitor power temperature humidity and Flow to which corresponding digital control outputs would also to be process to complete the functionality. The project proposes to monitor the energy, temperature and Flow of water. The need of this project is to make a general purpose embedded system that can be common for multiple fields hence the aim is to implement the industrial application of a RTU on a smaller scale. Digital inputs and Analog inputs would be collected by the RTU and would be processed, simultaneously identified and would send it to master (SCADA) simultaneously the master can login via website. Real time monitoring would be done. 230-48/24 V step down would be done and the input side of RTU would be various 48/24 v applications which would give to circuit breakers and via circuit breaker digital signals would be given to RTU. Also Analog inputs such as temperature, humidity will be monitored by giving it to RTU. Firstly the Temperature would be measured by a RTU. The RTU would sense the variation in the set Temperature value and send it to SCADA which is interfaced by using Raspberry Pie module. If the temperature variations are detected then the SCADA will give out the necessary commands to increase or decrease the Thermostat. Then we are going to measure various energy parameters by interfacing the energy meter to RTU via MODBUS protocol. Then we are going to measure the Water flow by generating dummy values and corresponding output would be changed by using some kind of valve. This application will prove that the RTU can be used in Water Management System in which the flow of water through large Water pipes can be controlled according to the demand. And also the RTU will be provided with Battery Back-up for uninterrupted operation during load shedding at remote places.

All these would be interface to raspberry Pie and then a web-based GUI would be created which would act as SCADA, while a Local Data monitoring System (LDMS) would consist of Monitor which would replicate an on-site monitoring station. There would be two logins one supervisor and other engineer for SCADA. There would be local/Remote switch. By enabling local switch, SCADA cannot carry out any operation and RTU would only be operated from the field. The selection of the RTU hardware started from identifying all parts for the main circuit. The hardware consists of power supply, main board itself which has microcontroller, digital input and digital output, analog input, UART and serial communication port, real time clock and accessory part consists of LED Indicators, Buzzer and LCD Display

The basic block diagram of the Project is shown below

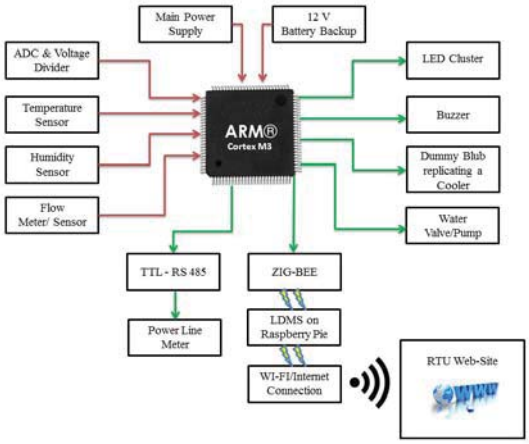

Fig: 3-Block Diagram of Proposed System

Software Requirements:-

1. Phython-TkInter
2. Language: Embedded C
3. Minimal Modbus version 0.6

Hardware Requirements

1. Power Supply
2. ARM cortex M3 processor ON ARDUINO DUE BOARD
3. Temperature, Humidity and flow sensor
4. Raspberry pie module
5. Zig-bee modules
6. Pump
7. RS485 communication using Modbus Protocol
8. Energy Meter
9. Battery Bank
10. Temperature Indicators
11. LCD, Keyboard, Mouse, Printer

V. OPERATIONAL FLOW GRAPH

Software Architecture

1. Power On and Initialize RTU, Raspberry Pie and Zig-bee Modules.
2. Login by Super user
3. Notify the Current status of the RTU to SCADA and LDMS (Date, time at which RTU is fully Functional, powered by which source „Battery/Mains", current battery voltage)
4. Check for the Digital Inputs and Analog Inputs
5. Report to the SCADA and LDMS
6. Acquire the control signals from SCADA.
7. Accordingly adjust the thermostat, Valve/Pump
8. Report the status of RTU and Generate a Log after every 3 hrs (Set according to User).
9. Continuously monitor the digital/analog inputs and Digital Control outputs for any abnormalities, and accordingly generate the log.
10. Notify the SCADA or LDMS is case of System Failure or Power Switch from battery to mains or vice versa

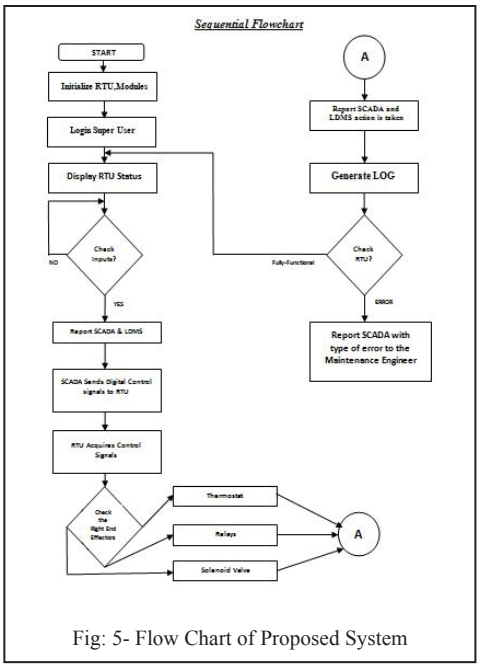

Fig: 5- Flow Chart of Proposed System

VI. EXPERIMENTAL SETUP

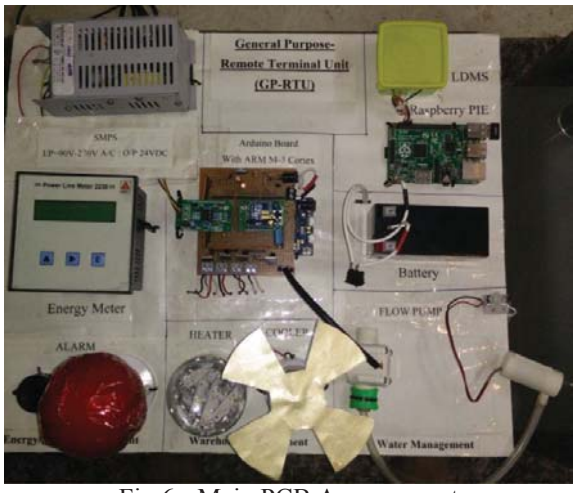

Fig 6:- Main PCB Arrangement

Fig 7:- Pictorial Representation of Proposed System

VII. RESULTS AND ANALYSIS

Mains Grid Voltage and Status

Fig. 7.1 Average Peak to Peak Voltage monitored on 16/05/2016 at 18:23

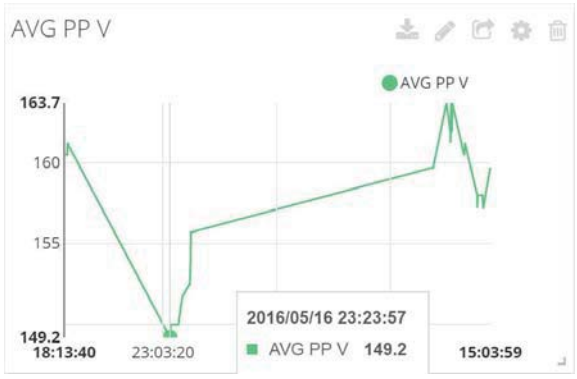

Fig. 7.2 Average Peak to Peak Voltage monitored on 16/05/2016 at 23:23

Fig. 7.3 Average Phase Voltage monitored on 17/05/2016 at 12:55

Fig. 7.4 Average PN Voltage monitored on 16/05/2016 at 18:23

Fig. 7.5 Average PN Voltage monitored on 17/05/2016 at 12:55

Fig. 7.6 Average LN Voltage monitored on 17/05/2016 at 12:55

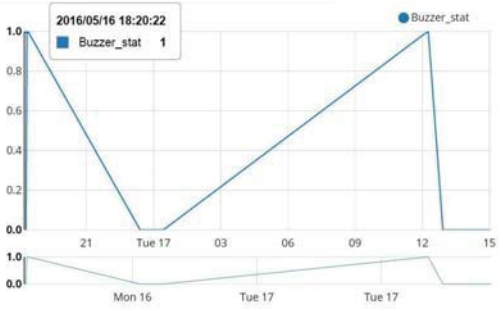

Fig. 7.9 Buzzer trigger at 16/05/2016 at 18:20

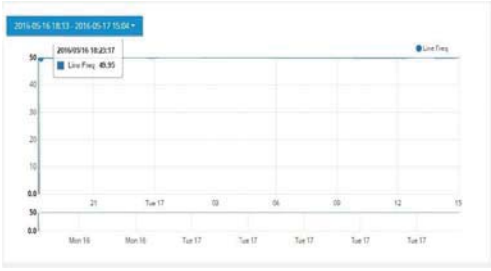

Fig. 7.7 Line Frequency monitored on 16/05/2016 at 18:13

Analysis:

Grid Supply was monitored for two days from 16/05/2016 to 17/05/2016. Phase Voltage, Line Voltage and Line frequency was monitored. Figures 18.1 to 18.3 depict phase to phase voltage from 16/05/2016 at 18:23 to17/05/2016 at 12:55; considerable amount of voltage fluctuations were observed which provides vital information how the input power was abnormal and without necessary protection can damage vital devices connected to that phase. Outcome of this experiment is show how monitoring of supply voltage helps to switch the important device or application connect to it on battery/UPS source of power to avoid the down time of vital application. If such fluctuations are not being monitored, over voltage or current will damage the application. Response to this condition buzzer was triggered to indicate the fluctuations. Figure 18.9 and 18.10 depict the same. Also monitored was the line frequency which remained unchanged as no load was connected to Energy Meter.

Battery Voltage

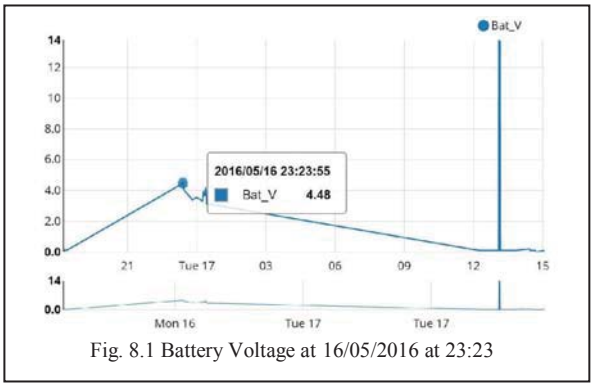

Fig. 8.1 Battery Voltage at 16/05/2016 at 23:23

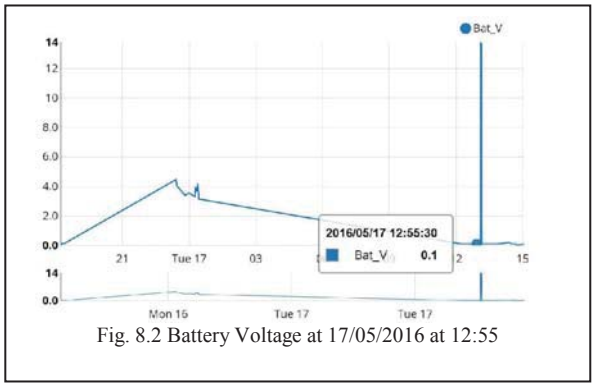

Fig. 8.2 Battery Voltage at 17/05/2016 at 12:55

Analysis:

Battery voltage was monitored which is considered as Auxiliary power supply to main RTU

Temperature

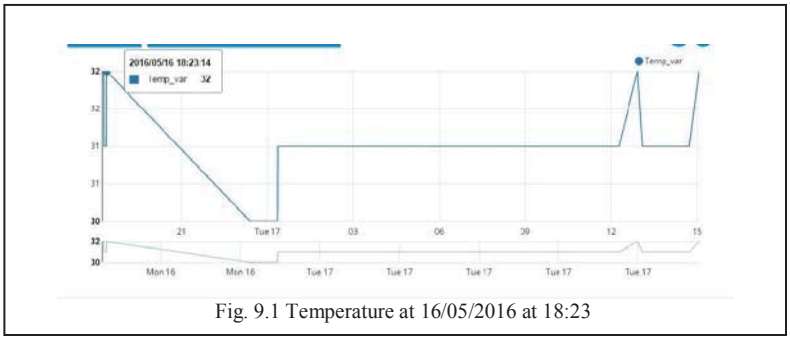

Fig. 9.1 Temperature at 16/05/2016 at 18:23

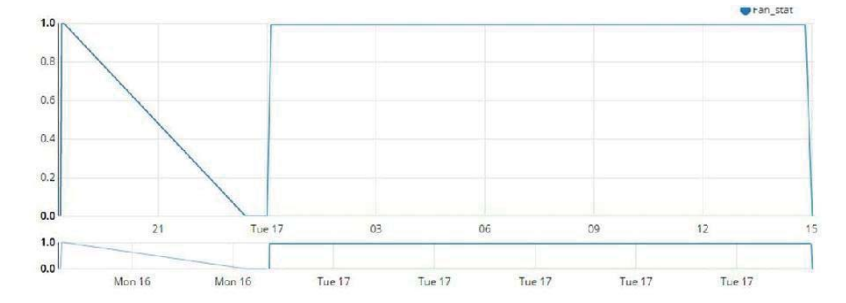

Fig. 9.4 Fan Status from 16/05/2016 to 17/05/2016

Analysis:

Temperature was monitored for two days from 16/05/2016, 18:13 to 17/05/2016, 15:03. Set point for temperature was 30* C. Hence we can see the fan status in figure 19.3 as 1 or 0 corresponding to the equivalent temperature. So to Temp above 30*C Fan was ON.

Humidity

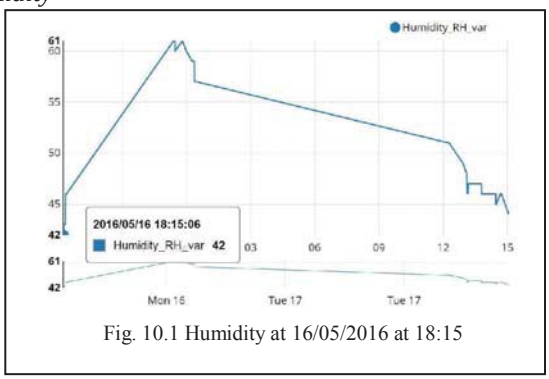

Fig. 10.1 Humidity at 16/05/2016 at 18:15

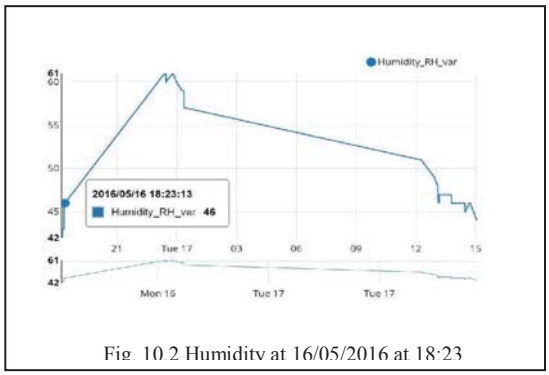

Fig. 10.2 Humidity at 16/05/2016 at 18:23

Analysis:

Humidity was monitored of surrounding atmosphere and notable variations can observe during test period.

Analysis and End Result

After conducting series of successful experiments and getting their opt results, it is seen that the General Purpose Remote Terminal Unit proves very beneficial for Power, Water and Warehouse Management. Its purpose been fulfilled we is reflected by the above Results and their analysis. In Power Management, the RTU monitors the "Main Grid" supply and gives its report to local Data monitoring and control system and also to Supervisory Monitoring station for any kind of abnormalities noted during the period of time with generation of Alarm. During complete Power failure, the RTU switches itself to an Auxiliary power supply without creating any down time for itself. It also monitors its auxiliary power and notifies the concern authority when it is switched back to mains supply.

In Water Management, the RTU successfully takes input from the flow sensor about how much water flow through it and when it crosses the set point it gave a corresponding output to turn off the Valve/Pump. Similar notification is sent to Supervisory Monitoring station via Internet for monitoring the amount of water been dissipated for that period of time. The Set Point for the management can be varied depending upon the capacity of a particular area. In experiments the set point was 11 units.

Finally, in Warehouse Management RTU monitors the temperature and humidity of a particular warehouse then compares it with the sent point and notifies the local and Supervisory system to take necessary steps i.e. to turn on cooler or heater accordingly.

With three applications been successfully monitored and correspondingly given the appropriate control to the variations in their specific inputs the end result of the "General-Purpose Remote Terminal Unit" can be said "Profitable" from industrial point of view.

VIII. Conclusion and Future Work

In this project, we have developed an embedded system that can be implemented as Industrial embedded system and much low cost. Multiple sectors such as Power, Water and Stock Holding have been explored via this project and describe how a RTU can be utilized in the most optimum manner. Developed RTU in this project not only monitors the key elements which are necessary for smooth functionality of any application but also gives equivalent control signals to avoid the change in desired operating condition of that application. Project uses an ARM M3 Cortex which have distinctive features like enhanced number of Registers, efficient interrupt handling capability, efficient power management, Strong OS support and most importantly Cortex-M3 supports the Thumb-2 instruction set, This is one of the most important features of the Cortex-M3 processor because it allows 32-bit instructions and 16-bit instructions to be used together for high code density and high efficiency. By using this RTU we can monitor grid supply power, water supply to specific area and ambient temperature of a warehouse where stocks are stored for long period of time. Enabling the monitoring of the conditions via internet it helped the user to have check on its application from any face of the earth. Supervisory Control is proposed in this project which is a future development

or upgrade of this project which will enable the user to control the system via internet and not rely on Local monitoring substation. A website called as www.GP_RTU.com can be developed for this specific RTU instead of depending on a 3rd party source i.e. www.ubidots.com. This project has a limitation of fewer input nodes but has a provision to increase the nodes by making arrangement on PCB as per requirement. Processors can also be upgraded with developing technology. With increase in number of inputs gives us opportunity to increase the number of application that can be run through this single RTU also upgrading processor to Cortex M-4 or Cortex M-7 will yield successful implementation of applications such as AIR quality Management, Green House System, Chemical Toxicity Control and Monitoring etc. through a single embedded system that is

So to conclude with, we can say that a Low power low cost embedded system is developed which has an advance processor unit which flawlessly supports various kinds of inputs and gives corresponding digital outputs which complies an "Industrial Automation"

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