REMOTE CONTROL AND SCADA SYSTEM

INTRODUCTION
A Remote Control Centre (RCC) is set up near the Traffic Control Office on each Division having electric traction, to work in close liaison with the traffic control. The RCC includes the main control room, equipment room, Uninterrupted Power Supply (UPS) room, Remote Control laboratory and Battery Room and is the nerve centre of the Traction Power Control.
The following types of Remote Control Equipment are mainly in use on Indian Railways at present:

(i) Frequency Modulated Voice Frequency Telegraph (FMVFT), Strowger type equipment for supervisory control.

(ii) Supervisory Control And Data Acquisition (SCADA) systems with Microprocessor based equipment and/or Computer based equipment.
The FMVFT equipment was in use for all electrification schemes prior to 1980. Being mainly all relay system, the equipment has become outdated although some Remote Control Centres still continue to operate on this system.
The SCADA equipment based on State of the art technology has come into use after 1980. Considering the fast growth and development of computer based equipment, newer types with enhanced capabilities and new makes are being introduced. Additional facilities at each new RCC is also natural as new features get incorporated.
In the protection schemes employed at present, for any fault on the overhead equipment between a substation and a neutral section the feeder circuit breaker at the substation is called upon to clear the fault, in order to clear the fault or to isolate the same, certain operations are to be carried out involving opening and closing of interruptors and breakers all along the line. This has to be done in the quickest possible time to restore supply to healthy sections.
Further it would be necessary to carry out frequent switching operations for maintenance and operational needs. Supervisory remote control of traction power supply installations is therefore resorted to.

The alternate method of manning the switching stations with operators who carry out switching operations at the instance of telephone instructions from the control centre is attendant with abnormal delays for isolation of faults thereby adversely affecting train operations besides being prohibitively costly.
Equipments situated at relatively small distances from the operator can be remotely controlled with dc signals or power frequency ac signals. As the distances increase and the equipments spread out along the track at various places, which are several kilometers apart, remote control of all the equipments by these methods involves large number of physical circuits for transmission. This number could be reduced by coding the signals that would be of direct current (dc) or alternately using one or more current pulses with equal or unequal pauses.
Signal distortion sets the limitation for transmission of dc or low frequency ac signals. Further they cause interference and cross talk in adjacent circuits requiring independent cables for the remote control. Amplification of signals, which is inescapable with long distance transmission, is difficult with dc and low frequency ac signals.

Hence carrier systems like OFC which permit several channels on a single physical circuit are used to carry the signals. Carrier systems also reduce the number of physical pairs required for remote control.
To avoid any cross talk in the adjacent communication circuits (in the same cable) due to the remote control signals the same voice frequency band is used for transmission of remote control signals.

The superimposition of the signal currents on the carrier frequencies is called modulation. The three types of modulation available are amplitude modulation, frequency modulation and phase modulation.
In amplitude modulation the amplitude of the current is varied by the modulating frequency, the carrier frequency remaining constant, whereas in frequency modulation the carrier frequency is varied by the modulating frequency, amplitude of the carrier wave remaining constant.
In phase modulation the amplitude of the modulated wave is constant and equal to that of an un-modulated carrier but there is an infinite series of modulation components alternately in phase and in quadrature with the carrier, and also an infinite series of side frequencies spaced from carrier frequency by amounts corresponding to harmonics of the modulated frequency.
Phase modulation is not normally used and is replaced by frequency modulation. An important advantage of frequency modulation as compared with amplitude modulation is that a reduction of the effect of noise or interfering currents in the transmission link can be secured. In amplitude modulation such currents have the effect of varying the amplitude of the transmitted wave and are thus reproduced together with the signal in the rectified output of the receiver.
With frequency modulation although interfering currents still vary with the amplitude of the carrier their variation in amplitude can be eliminated by means of a limiting stage in the receiver prior to demodulation. This considerably improves signal to noise ratio.

In view of the above advantages frequency modulation, is employed for the remote control signal transmission.
Switching Equipment With Earlier System

- This is either of uni-selector type or of all relay type. The rotary selector mechanism was an electromagnetic device operating on the step-by-step principle. It employs a ratchet and Paul, which actuates a set of wipers and moves it over a series of bank contacts, which are arranged circumferentially with respect to the operating spindle. The inherent limitations of the selectors are the need for metal contact surfaces between the wiper and bank contacts, the inconvenience of flexible wiper cords and collector brushes and the necessity for periodical lubrication and maintenance.
In the All-relay system all the switching operations are made through simple relays. These systems were slow in operation and needed considerable maintenance of moving parts besides heavy power consumption. Further special features like logging of events, telemetry etc. were also not possible with these systems.
“सोच से संभावनाओं तक का सफर हौसलों से होकर गुजरता है।”
DUTIES OF SSE/ JE
REMOTE CONTROL
He is the senior supervisor working under the control of Sr.DEE/DEE/AEE (TRD) and directly responsible for the proper operation and upkeep of the RC equipment, which are vital for the efficient operation of the electric traction system. He shall be thoroughly conversant with all the technical details of the equipment under his control. In particular, he shall perform the following duties.

1. Maintain the RC equipment at the RCC and the controlled stations in accordance with the prescribed schedules.

2. Keep close liaison with the S&T department as to the sound condition of the cable pairs allotted for RC operation.
3. Measures periodically the levels of voice frequency signals at controlled stations and arrange with the S&T department for correction, when required, at their repeater stations.

4. Keep in constant touch with the TPC on shift duty and ensure prompt rectification of defects reported in the RC system.

5. Ensure proper maintenance of UPS/battery sets for uninterrupted operation of the RC equipment and the stand by generating set in the RCC.

6. Inspect the RC equipment at every controlled post once in two months.
7. Impart necessary training to the staff under him in the special techniques of maintenance of RC equipment as well as trouble shooting.

8. Ensure that the special instruments and tools provided for maintenance of the RC equipment are properly cared for.

9. Keep a watch on stocking of spare parts and other stores required for the RC equipment and Initiate timely action to recoup stocks.

10. Co-ordinate with SSE (PSI) and SSE (OHE) or territorial SSEs for manning the controlled posts in the event of persisting faults in the RC equipments.
11. Submit prescribed periodical returns on RC equipment to AEE (TrD) and Sr. DEE (TrD).

12. Keep his superior officer fully informed of all important developments and seek their guidance when required.

13. Carry out such other duties as may be allotted by his superior officers.

14. Carry out minimum monthly inspections as per manufacturers recommendations.
Investigation of Failures by SSE/JE

- As with any other equipment, every failure of RC equipment should be separately registered, investigated and rectified, making a brief note in the failure report of the action taken as well as classifying and finally pin-pointing the exact cause of the failure.

- The failures should be analyzed every month and any special steps required taken to overcome the trouble and prevent recurrence should be taken. A 'history sheet' showing the faults that have occurred on different items of equipment will assist in carrying out detailed investigation of recurring troubles in consultation with the Manufacturers of the equipment.
जो कार्य तुम आज कर सकते हो,
उसे कल पर कदापि मत छोड़ो।
SALIENT FEATURES OF SCADA

Phase II - Module No. STC-TrD-07
1. Tripping of bridging circuit breakers on under voltage at SP.

a) Instantaneous type under voltage circuits are provided at the SPs operated off 27500/110 V potential transformers and designed to trip the bridging circuit breakers if the catenary voltage drops below a preset limit. The operating range for the circuit is adjustable between 15,000 V and 22,000 V continuously, in steps of 1,000 V.
b) The arrangement shall be such that the bridging circuit breakers can be closed only when the section on one side of neutral section is dead and the under voltage circuit shall become operative only after the bridging circuit breaker is closed.
2. **Interlock release request facility for circuit breakers/interruptors control at boundary post.**

When a controlled station separates the zones controlled by two adjacent RCCs, control of breakers/interruptors at this controlled station shall be so arranged that the breakers/interruptors can be operated from one RCC only when an interlock is released from the other RCC.
3. **Auto reclosing scheme for feeder circuit breakers at TSS.**

a) In case of tripping of the feeder circuit breaker on fault at TSS, a single-shot auto-reclosing scheme re-closes that breaker automatically only once, after a pre-set time delay.

b) In the event of any fault on OHE persisting, the feeder circuit breaker trips again and the auto-reclosing scheme gets automatically “locked-out” to prevent reclosing of the breaker a second time. The locked out condition is telesignalled to RCC. The operator can release the “locked-out” condition when a telecommand is initiated through the keyboard console.
4. Automatic localization of OHE faults

- The system is designed for automatic localization of faults in OHE, segregation of faulty sub-sector/broken sub-sector and restoration of 25 kV power to healthy sections of OHE, through a suitable software package incorporated in the SCADA system. The fault localization process shall be initiated by the operator through the keyboard console. In general, the fault localization process employs the technique of energizing all the sub-sectors/broken sub-sectors that were live prior to the fault one after the other unit it identifies the faulty sub-sector/broken sub-sector by the tripping of the feeder circuit breaker.
The system also takes the following into account while localizing the fault automatically:

a) **Power block(s) imposed on an interrupter:**

Whenever power block is imposed on any interrupter, no further control on that interrupter shall be possible from the master station. For the purpose of fault localization, such interruptors shall be assumed as “open”.
b) Discontinuity caused in any sub-sector due to imposition of power block on an elementary section of that sub-sector.

The software adopted for the fault localization and isolation process is designed to take into account the inputs entered by the operator, and to ensure that no interrupter that was open prior to the occurrence of fault is closed during the fault localization process, and to segregate the fault by opening minimum number of interruptors.
Advantages for the Traction SCADA system – 0130 Rev2.


- Polling eliminated from RCC to RTU’s. Events communicated spontaneously. Fast updation to TPC.

- AFLN is now feasible. – Quick Segregation of faulty section and Normalization.

- Network Level Redundancy – Ensures greater availability of all the equipments at the RCC.
• Most of the SCADA failures were due to failure of communication channel and RTU power supply.

• Redundant communication channel ensures greater availability of RTU even in case of primary path failure.

• RTU enhanced with Redundant CPU and Power Supply – Ensures greater availability and reliability of on Line data.

• Capacity Enhancement of RTU increased to handle 600 DI’s, 100 DO’s & 70 AI’s against 128 DI’s, 56 DO’s & 8 AI.

- Majority of the Status and Controls are available in the form of Soft Signals. – This eliminates the use of DI/DO cards.
GPS Time Synchronization

- Synchronization of Real Time Clock of SCADA with Relays done through the GPS clock. - SEQUENCE of EVENTS easy to analyze in case of major failure.
For Open Access

• SCADA RTU’s are Communicably interfaced with 0.2 S Class Energy meters installed at the HV Side of Control Relay Panel.

• Two EMS servers – Main and Standby, Two W/S, One Web server,

• Web Server shall be configured for the Data/Status to be transmitted to the Railway’s LDC & further to the State LDC.

• RTU level redundancy, Communication Channel Level redundancy, Network level redundancy and Server Level Redundancy ensures uninterrupted acquisition of real time data.

Following Reports are available with the EMS.

- The Energy data can be grouped to view
  - Supplier wise Energy Consumption
  - TSS wise Energy Consumption
- Total Consumption of the Entire Division
- Total Consumption State wise.
- Total Consumption Phase wise.
- Parameter History View – V, I, MW, Mvar, Mwh, Mvarh, Hz
विश्वास वह शक्ति है
जिसे उजड़ी हुई दुनिया में
प्रकाश लाया जा सकता है
SUPERVISORY CONTROL AND DATA ACQUISITION SYSTEM
With the advent of computers/microprocessors, data telecommunication, control systems and the developments in the associated hardware and software SCADA systems were developed to provide continuous vigil and supervision with high speed of functioning which suited the intrinsic management philosophy of reliability with overall economy and the traction engineers were quick enough to exploit its potential in supervisory remote control of traction power supply installations.
• SCADA stands for Supervisory Control and Data Acquisition. SCADA systems are employed for simultaneous acquisition of a large amount of data, real time processing, display and supervisory control. For the new electrification projects Railways have gone in for computer based SCADA systems for monitoring and controlling the traction power supply.
• SCADA enables the Traction Power Controller (TPC) to control from the Master station at the Remote Control Centre (RCC) the switching operations of the equipments at controlled stations i.e. traction substations and switching stations. It helps the TPC to achieve real time data acquisition, processing, display and control of data pertaining to the traction power supply to the 25 kV overhead traction systems over a geographical span of railway tracks extending over 400 to 600 km.
The main functions of Supervisory Control are:

- The remotely operate the bi-state devices which control the electric supply to the overhead equipment i.e. circuit breakers, interruptors etc.
- To remotely effect the release of locks-outs wherever necessary.
- To automatically carry out operation of circuit breakers and interruptors to localize any faults on the overhead equipment, segregate the faulty sub-section, and restore the 25 kV supply to the healthy sub-sections.
To remotely operate any indicator lights, like (flasher lights at traction substation) etc., at the remote stations if required.

Supervisory Control should have all the safeguards built into it to avoid faulty operation of control commands. Check-back-verify, or select-before-operate kinds of safeguards are incorporated.
Data Acquisition

The main Data Acquisition functions are as under:

• To acquire real time data regarding the status of all the circuit breakers, interruptors, transformer alarms and faults arising out of excessive transformer winding temperature, transformer Buchholz relay operation, transformer excessive oil temperature, pressure relief device operation etc.

• To acquire data regarding the abnormal and faulty conditions of various equipments.
• To acquire data regarding the power system measurands like current, voltage, power factor, maximum, demand etc.

• To perform, alarm functions on all the data acquired. Limit violations, abnormal states of status devices, rate-of-change violations etc. shall be processed.

• To log and printout all commanded and uncommanded changes which take place in the system.

• To print out log sheets and summaries in the desired formats, with station address, item address and time.
To compute, report and log “derived measurands” like maximum demand, status of overhead Equipment (energized/de-energized) etc.
Hardware Configuration

- The basic hardware configuration consists of nine Pentium PCs connected on a 16 port soft switchable active Ethernet LAN Hub. Out of nine PCs, two PCs act as main and standby Masters/Host, two PCs act as main and standby Front End Processors and remaining five PCs are utilized for MMI (man-machine interface) at RCC. Each PC/server has its own color monitor, Keyboard, mouse, floppy and CD-ROM drives, multimedia kit complete with speakers and microphone.
The PCs used in the SCADA system have minimum 256 MB RAM, 40GB hard disk and clock speed 1.8 GHz or better. Provisions are made in the software so that the telecommand operation can be carried out from any one of the MMI PCs provided at the operator’s workstation. In case of failure of main computer, the switchover takes place through the software to the standby computer system automatically.

Two data-logging printers are connected to the system, one on-line and other as standby. In case of failure of one printer, the other printer starts logging the data.
Communication with RTUs

- Standardized communication protocol is used between master and the remote station. Each LAN system is interfaced through FEP and modems with the RTUs (Remote terminal units). The modem provided for communication between the Front End Processor and RTUs works on 600/1200-baud speed on 4-wire communication in half duplex mode.

Modes of Operation

- The modes of operation include the supervisory mode, control mode, edit and programming mode.
To ensure a high degree of system security and to prevent unauthorized operations, the following levels of access are provided.

- **Operator’s level** – This is for interaction of the TPC with the computer for his day-to-day working.

- **Supervisory level** – This is meant only for getting information from the computer. Control operation of electric switchgear shall not be possible from this level. This level can create more operators in the system.
• Engineer’s level – This has total access to all the programmes stored in the system.

• The operator’s console desk forms part of the SCADA equipment.
Mimic diagram board (MDB)

- A mimic diagram board and its associated mimic driver were earlier provided at the RCC. The MDB depict the traction power supply diagram, indicating the energized / de-energized condition of sub-sectors of catenary, status of the interruptors and feeder circuit breakers at TSS & FP, SSP and SP. However, in the latest system of SCADA, the functions of MDB are being carried out on PC itself.
Real-time display and control:

- Man Machine Interface (MMI) computers ensure graphic coloured displays of the full section indicating clearly the devices at TSSs, SPs and SSPs. Any three adjacent controlled stations are displayed for viewing to operator at any time; however other stations can be seen by scrolling through key board or mouse. The display includes both fixed and variable data, namely ON/OFF status of equipment/catenary (such as feeder CB trip, AC and DC fail/low, RTU fail/Remote station defective/Communication fail & Machine down etc.) alarms, measurands and names of the controlled stations.
Bridging interrupters and paralleling interrupters (to be controlled during feed extension) are displayed for extending feed in case of power supply failure. The condensed picture for full section is displayed so that status of full power supply diagram can be viewed on workstation.
Function of Software

- The operating system is suitably designed for multi-user, multi-tasking, networking and real time applications. The latest window based operating software is used. Master station software is working on window 2000 Operating system or its latest versions. The protocol between master station and RTU has been standardized as SPORT (Standard Protocol for Railway Traction) by RDSO and is given in SCADA specification TI/SPC/RCC/SCADA/0988 Vol-II.
The protocol defines rules and regulation for various types of information exchanged between RCC computers and RTU. This protocol has been designed on basis of IEC-870-5-1.

Above development has resulted into better control over SCADA system maintenance and augmentation apart from advantages of interchangeability of RTU’s.
**VDU Displays:**

The software supports the following VDU displays.

a) Station diagrams:

Semi graphic, colored displays of any three adjacent controlled stations including both fixed and variable data, namely ON/OFF status of equipments, catenaries, alarms, measurands along with the names of the controlled stations which permit transmission of tele-commands to circuit breakers, interruptors and other equipments, by simple key-board operations by the operator. Facility for marking (manual input) is provided for any alarms, equipment status including manually operated isolators, measurands and limit-settings, by simple key-board operations by the operator.
b) Tabular displays: Tabular display of data of a controlled station includes equipment status, alarms and measurands.

c) Alarm list: Display of the alarm list in a chronological order starting from any given time.

d) Event list: Display of the event list, which includes commanded and uncommanded changes in equipment status, acknowledgement of alarms, markings, in a chronological order starting from any given time.

e) System alarms: The alarms generated by the SCADA equipment, and not by the traction power supply system, are displayed.
f) Trend diagrams: The time versus value plot of up to four measurands can be displayed in a trend diagram. Each measurand can be displayed in a separate colour. The trending includes both historical trending and dynamic trending of the current data.

g) Histograms: For both current and historical data the time versus value plot of any measurand by histogram can be provided.

h) Bargraphs: Display of the current values of up to four measurands by bargraphs – each bar having a different colour can be provided.
i) Message pad: One page is provided for the operator to record important messages.

Calling any of the VDU displays shall be by simple keyboard operations by the operator. NEXT/PREVIOUS or PAGE UP/DOWN option is also available.
The software for the SCADA equipment is designed so as to cater for updating for adding or deleting controlled stations or individual parameters such as telecommand, telesignal or measurand at any of the existing controlled stations.

Facilities are provided for the operator, through simple keyboard commands to:

- Take out of scan and control (Process inhibit) any alarm point/control point/measurand or a complete RTU.
• Block/ de-block a complete RTU as well as any control point (circuit breaker, interruptor and other equipments at the controlled stations) which disables/enables control operations from the RCC. The blocked condition of any equipment is suitably indicated on the VDU, for example by a change in colour of the corresponding equipment display.

• Inhibit any alarm point, which shall discontinue processing of the alarm point at the RCC.
The master station equipment normally scans continuously all the RTUs in a predefined cyclic sequence, to update the equipment status, alarms, events and measurands. Exchange of information between the master station and the RTUs is on interrogation by the master followed by the reply from the RTU.

The communication technique is based on Digital Address Time Division Multiplexing. Each transmitted information contains sufficient parity check bits so as to allow an effective error detection code to detect different combination of transmission errors.
**Operation of Power Block**

- Power block is generally given for maintenance of any equipment like transformer, circuit breaker, interruptor, section of OHE or any other equipment by de-energizing the equipment/section of OHE. Provision is made for entering into the computer necessary pass words to the operator at RCC in connection with the requisition for issue/cancellation of the power block and the time duration for which the power block is given. If a power block is not cancelled at the end of the permitted duration, a message “Power Block Time exceeded” appears on the VDU along with the equipment/section reference and time, with an audible alarm to attract the attention of the operator.
• When equipment is under power block, it is not possible to operate that equipment unless the power block is first cancelled from the RCC. In case the telecommand for operating that equipment is attempted, a message “Equipment under power block” appears on the VDU. Power block cancellation should be possible through Operator’s password only
1. **Indication for complimentary faults**

- The status of any bi-state device like circuit breaker, interrupter is monitored through two auxiliary contacts of the device, the status (open/close) of the two contacts being normally complement (opposite) of each other in the ON/OFF condition of the device. However, when both the auxiliary contacts are either in open or in closed condition, such faults are detected and identified as complimentary faults. The event is logged and suitable indication appears on the VDU.
2. **Alarm processing**

- Any and every change in the state of telesignals, uncommanded change in the status of equipments like circuit breaker, interruptors, and limit violation of telemetered parameters (measurands) is processed as alarms. Each and every alarm attracts the attention of the operator by an audible hooter/prerecorded voice message and by a change in the display of the equipment status or change in colour of display of the telemetered parameter or change in colour of display of the alarm (telesignals) point as applicable, and the display shall start flashing. Upon acknowledgement by the operator, the audible alarm ceases and the display on VDU becomes steady.
3. **Historical data storage**

a) SCADA equipment at RCC is designed to cater for historical data storage of the traction power supply system data for a period of one year.

i) All alarms/events/measurands of the controlled stations and all system alarms.

ii) Day-wise storage of average feeder current and voltage during the day, maximum demand, maximum and minimum feeder voltages, total number of operations of feeder protective relays viz. OCR, DPR and WPC relays, and maximum and minimum OHE voltages at SP on both sides of the neutral section or phase break in 2 x 25 kV system.
A sufficient memory capacity is provided for this purpose in the hard disk.

b) A facility is provided for accessing any data from the SCADA data-base from any other remote computer terminal/RCC or from a centralized computer located at the zonal railway headquarters.
Uninterruptible Power System At RCC

- Dual stand-alone UPS system of adequate capacity is provided for supplying stabilized 240 V ac, 50 Hz, single-phase supply to various equipments of the SCADA system at master station. Input supply to the UPSs is 415 V AC, 50 Hz, 3 phase with a permissible variation between +10 and –15% for the voltage and +3 and –3% for the frequency. Both the UPSs work in parallel to share the load of the system.
However, the capacity (VA rating) of each UPS is designed to meet with the entire load of the system in the eventuality of the failure of the other. The taking over the load by the healthy UPS is automatic without affecting the normal working of the system. The failed UPS disconnects itself from the circuit automatically. The UPSs provide for trickle/normal/boost/auto charging of the battery in addition to supplying normal load to the various equipments.
- Alarm and mimic facilities are provided on the facia of the UPS for ease of operation and maintenance. The acoustic noise level generated by UPS is kept as low as possible and shall not exceed 50 dB when working alone.

- A single set of storage battery of low maintenance Lead Acid type is provided with both the UPSs. The battery has adequate Ah capacity to provide two hours of supply to various equipments in case of failure of input 415 V ac supply.
DATA-LOGGING

1. Data logging printers

Two alphanumeric desk jet printers are provided.

2. Alarm/Event logging

All events such as signals and alarms, commanded and uncommanded changes and limit violations of telemetered parameters are printed automatically by the data-logger with date (year, month and day) and time of occurrence (hours, minutes, seconds and milli-seconds) stamp.
3. **Diagnostics**

The system provides diagnostic checks for faults in the SCADA equipment at the RCC. These faults are printed out with details such as names of controlled station, card number with date and time stamp.

4. **On-demand facility**

The facility is provided for the operator to obtain reports on-demand through the keyboard. Such reports include current status of bi-state devices, signals and alarms at the remote stations, communication failures, telemetry printout and other information required.
5. Periodic printouts

The data-logger gives periodic printouts, whenever required by the operator, as under:

a) 15/30 minutes printout giving average values of all the analogue parameters at TSSs and SPs during the last 15/30-minute period.

b) 8 hourly printouts giving summary of all important events that occurred during the immediately proceeding 8 hours. Events that occurred during the periods when the data-logger is printing ‘periodic’ or ‘on demand’ reports are not to be lost but printed out thereafter with their time of occurrence stamp.
1. Hardware

The RTU is microprocessor based with its associated digital input/output modules, alarm input modules, analogue input modules, watchdog transducers, memory, modems, interposing contactors, summation current transformers, power supply units and surge arrestors and other items necessary for its proper functioning. A suitably designed circuit for giving initialization pulse to the CPU at pre-defined interval of time, which itself shall be user selectable, is provided in the RTU so that the CPU gets initialized automatically in case it halts due to any reason.

LEGENDS
- CU. COMM. CABLE
- IEC60870-5-103
- MODBUS RTU

CONTROL & RELAY PANEL

TO MUX

LAN EXTENDER

REDUNDANT CPU

FIELD I/O's

MODBUS RTU

FIELD I/O's

MODBUS RTU

FIELD I/O's

REDUNDANT POWER SUPPLY

IEC60870-5-103

MFM

Phase II - Module No. STC-TrD-07
2. Reporting of events and alarms

All the changes in the status of the circuit breakers/interruptors/motor-operated isolators and alarms that may occur between consecutive polling shall be stored by the RTU unit they are reported to the master station along with their time of occurrence. No event is lost without being reported to the master station. The feature is essential in view of the fact that the normal polling may get suspended due to failure of communication channel or other reasons.
3. Power Supply Units

The RTU shall normally operate of 240 V ac, 50 Hz, single phase supply from the auxiliary transformer provided at the controlled station. This voltage may vary from 155 V to 290 V due to variation in the catenary voltage (25 kV). In case of failure of ac supply, the RTU shall operate of the 110 V DC battery supply. The load of the RTU is within 1 A at 110 V dc.
1. **Parameters to be telemetered/computed (measurands)**

The RTU are designed to telemeter two feeder currents and one OHE voltages and one P.F from each TSS, and two OHE voltages from each SP. The arrangement for telemetry is as under:
a) From TSS

i) **Feeder currents:** Two current transducers are provided one each for either side of the TSS, taking reference from the two feeder CTs of that side through a summation CT.

ii) **Feeder voltages:** Two voltage transducers are provided, one each for either side of the TSS, taking reference from the two OHE PTs of that side through a suitable change-over device. In the event of supply failure in any of the PTs, the change-over device shall automatically connect the live PT to the transducer.
iii) **Power Factor:** The power factor value is acquired by the RTU through p.f. Transducer and sent to the RCC.

b) **From SP**

Voltage of the OHEs on either side: Two voltage transducers are provided, taking reference either from the UP or DOWN line PT through a suitable changeover device. The other measurands such as Capacitor bank current and 132 kv/220 kV incoming voltage can be acquired if demanded by purchaser.
2. Limit settings of telemetered parameters for Alarm generation

Provision is made for ‘low’ and ‘high’ limits of voltages at TSS and SP, ‘high’ limit for currents. The voltage setting can be selectable continuously between 15 kV and 30 kV. The current setting can be selectable continuously between 300 A and 1000 A. The settings are software selectable.
3. **Transducers**

Transducers provided at the controlled stations (TSS and SP) are self powered or Auxiliary-powered and are of quick response type with a response time not greater than 1 second and have linear characteristic over the entire range giving an output proportional to the input from current transformers and potential transformers at the SP.
System Alarms

The system alarms are provided in the event of partial or complete failure of the RTU to communicate with the master station due to failure of RTU, or on failure of individual I/O modules and other modules in the RTU. The nature of fault is indicated on the VDU.

Remote station defective: This alarm appears in the event of partial or complete failure of the RTU to communicate with the master station due to failure of RTU, or on failure of individual I/O modules and other modules in the RTU.

Master Station Defective: This alarm appears in the event of failure of any computer at master station.
1. The SCADA equipment is typically designed for the following capacity of telecommands, telesignals and telemetered parameters (measurands) for a typical TSS, SSP, SP and ATP of a double line section. Capacity may be increased based on actual requirement.
2. Typical telecommads, telesignasl and measurands of different type of RTU are given as follows.

<table>
<thead>
<tr>
<th>SN</th>
<th>Controlled station</th>
<th>Telecommands</th>
<th>Telesignals</th>
<th>Measurands</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>TSS</td>
<td>24</td>
<td>96 (48+48)</td>
<td>8</td>
</tr>
<tr>
<td>2</td>
<td>SP</td>
<td>8</td>
<td>28 (16+12)</td>
<td>4</td>
</tr>
<tr>
<td>3</td>
<td>SSP</td>
<td>8</td>
<td>28 (16+12)</td>
<td>-</td>
</tr>
<tr>
<td>4</td>
<td>ATP</td>
<td>-</td>
<td>8</td>
<td>-</td>
</tr>
</tbody>
</table>

When the number of parameters to be commissioned initially is less than the above, the balance-designed capacity shall be available for future use.
3. **Speed of transmission and update time:**

The communication between the master station and the RTUs shall be at a suitable transmission speed 600 baud and above. Whenever the number of controlled stations is more than 30 and the RCC is located somewhere in the middle of the section, the controlled stations on one side of the RCC are polled simultaneously in parallel with the controlled stations on the other side of the RCC, so that the cyclic update time is kept to the barest minimum. The master station equipment configuration is designed for such simultaneous polling.
4. **Priority of data exchange between master station and RTUs.**

While the master station is polling the RTUs cyclically, the telecommands receive the highest priority. The normal polling is interrupted for sending the telecommand and for receiving the telesignal from the RTU for change of status resulting from execution of telecommand before normal polling restarts.
5. **Priority of data exchange between RTUs and master station.**

During polling the RTU transmits data to the master station in the order of importance. Any tripping of feeder circuit breaker on fault (relay operation) gets the highest priority.
MODEMS

a) The modems provided for communication between the master station and the RTUs utilize frequency shift keying (FSK) modulation and include send, receive and timing functions. The send and receive functions are independently programmed. The modem is capable of satisfactorily working up to an input signal level of –45 dbm. It also performs a watch dog role and turns the transmitter off in the event of any fault occurring within the equipment.
b) The modem also incorporates necessary amplifiers with a gain of 30 db to compensate for any signal variation at different points of the system. Suitable attenuation pads are provided in the amplifiers to adjust the output signal level between 0 and –30 db in steps of 1 db.

c) A test switch on the modem allows a square wave data pattern to be transmitted continuously at maximum baud rate to allow receiver levels and bias distortion to be set.
• For transmission of signals from the Master station to RTUs; the underground telecommunication trunk cables provided by the Railways are generally used. Three pairs of conductors i.e. one pair for transmission, one pair for reception and the third pair as spare, are used. Star quads of the cable circuits are used for this purpose.
The salient features of these conductors which are paper insulated are as under:

<table>
<thead>
<tr>
<th>i)</th>
<th>Diameter of copper conductor</th>
<th>0.9 mm</th>
</tr>
</thead>
<tbody>
<tr>
<td>ii)</td>
<td>Loop resistance at 20(^\circ) C</td>
<td>55.2 ohm/km</td>
</tr>
<tr>
<td>iii)</td>
<td>Mutual capacitance of the pairs of paper insulated VF quads</td>
<td>0.041(\mu)F/km</td>
</tr>
<tr>
<td>iv)</td>
<td>Characteristic impedance at 800 Hz when loaded</td>
<td>1120 ohm</td>
</tr>
<tr>
<td>v)</td>
<td>Loading of intervals of 1.33 km</td>
<td>33 milli Henry</td>
</tr>
<tr>
<td>vi)</td>
<td>Attenuation at 800 Hz when loaded</td>
<td>0.25 dB/km</td>
</tr>
</tbody>
</table>
• On these lines isolating transformers are installed at every 10 to 20 km to limit the induced voltages. They have a dielectric strength of 2000 V ac (rms) for one minute. At the point of tapping the underground trunk cable isolating transformers with impedance ratio 1120/1120 ohms are provided. Voice frequency repeaters with a gain of 20 dB incorporating equalizers to compensate for line distortion upto 0.02 dB/kHz/km are provided at every 40 to 50 km to boost the signal level.
• Cross talk attenuation of repeated section between any two VF pairs at 800 Hz will not be less than 65 dB at far end and 61 dB at near end. SCADA equipment incorporates amplifiers with 30 dB gain to cater for signal variations at different points in the system.

• On same sections the communication between Master station is provided by dedicated Microwave channel at carrier frequency of 18 GHz.

• Optical fiber cable is also being introduced for communication in some electrified sections, with suitable interface between the optical fiber cable and the MS and RTUs. The particulars of optical fiber cable and optical line terminating unit are as under:-
• The cable consists of six/eight mono mode fibers as per CCIIT recommendations No.G652. The optimized wave length band is 1300 nano meters. The nominal mode-field diameter is 9 to 10 micrometer with a cladding diameter of 125 microns. The cut-off wave length is 1120 to 1280 nanometers.

• The attenuation is less than 0.5 dB/km at 1300 nanometer band and the splicing loss is 0.15 dB/joint. The optical line terminating equipment consists of electrical and optical interfaces. The electrical interface has a line impedance of 75 ohms unbalanced or 120 ohms balanced with a line bit rate of 2048 KB/s. The optical interface has the same line bit rate and uses LED for transmission and SIAPD for reception. Intensity modulation is used.
If a particular station does not receive the signal from master station, or information does not reach the master station a break in the transmission or reception pair is indicated. Sometimes if the repeaters are not properly functioning, the RTUs beyond it are disturbed. If the attenuation in transmission pairs increases, RTUs before the repeaters are disturbed. In all such cases failure of communication is indicated and appropriate rectification action on the communication circuit is called for.
Telephone Facilities At RCC

- On each of the two desks in the Remote Control Centre, a series of push buttons permits selective calling of each of the telephones connected to the circuit concerned. In case one of the operators is absent the control circuits of both can be concentrated at one desk. A loudspeaker is situated near the operator at the control centre permanently. In case any one of the persons on the TPC circuit wants to contact the operator, he has to simply take off his receiver and announce himself.
• The telephone system enables the operators to communicate directly with the stations responsible for ensuring protection of the overhead equipment when current is switched off, with the substations and switching stations, with the locomotive sheds, overhead equipment maintenance depots and with the high tension substations of the Electricity Boards.

• Emergency telephone sockets are installed along the tracks at intervals of a kilometer to enable the train staff or the permanent way staff to plug in their telephones to communicate with the operator for switching off power in cases of emergency etc.
• These are occasionally used by certain stations not otherwise connected to TPC circuit; they are mostly used by overhead equipment maintenance staff and also by train staff in case of derailments or damages. Such calls can only be initiated from the emergency sockets. A bell rings at the control room when the receiver of any telephone plugged into the emergency socket is lifted.

• Moreover direct telephone facilities are available for the TPC to communicate with the adjacent traffic controllers and adjoining remote control centers.
The first computer based SCADA system on Indian Railways was commissioned at Secunderabad for Vijayawada-Balharshah section of S.C. Railway. For better appreciation of the SCADA system, Basic Block Diagram of SCADA schematic & details of Telecommand, Telesignal and Measurands are included.
## Details Of Telecommands, Telesignal And Mesurands

<table>
<thead>
<tr>
<th>S.No</th>
<th>Details of telecommands</th>
<th>TSS</th>
<th>SP/SSP</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.0</td>
<td>132/220 kv C.B.</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>1.1</td>
<td>25 kv C.B.</td>
<td>4</td>
<td>0</td>
</tr>
<tr>
<td>1.2</td>
<td>25kv Interrupters</td>
<td>5</td>
<td>4</td>
</tr>
<tr>
<td>1.3</td>
<td>Auto reclosore release with lock out indication</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>1.4</td>
<td>Transformer tap changer</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>1.5</td>
<td>Interlock release request at boundary post</td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td>1.6</td>
<td>To disable the panto flashover relay from circuit</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>1.7</td>
<td>Spare</td>
<td>8</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td><strong>Total Telecommands</strong></td>
<td>24#</td>
<td>8</td>
</tr>
</tbody>
</table>

#These telecommand includes 24 ON and 24 OFF

*As per site conditions and as specified by the purchaser.*
<table>
<thead>
<tr>
<th>S.No.</th>
<th>Details of telesignals</th>
<th>TSS</th>
<th>SP/SSP</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.1</td>
<td>110 V D.C. low / charger fail</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>2.2</td>
<td>240 V A.C. Fail</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>2.3</td>
<td>PSU on D.C.</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>2.4</td>
<td>PSU overloaded</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>2.5</td>
<td>Catanery indication</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>2.6</td>
<td>Transformer alarm</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>2.7</td>
<td>Transformer fault</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>2.8</td>
<td>Transformer trip circuit 110 V D.C. fail</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>2.9</td>
<td>Transformer alarm circuit 110 V D.C. fail</td>
<td>2</td>
<td>0</td>
</tr>
</tbody>
</table>
** These 48 telesignal shall exclusive of 24 ON status and 24 off status of devices.

<table>
<thead>
<tr>
<th>S.No.</th>
<th>Details of telesignals</th>
<th>TSS</th>
<th>SP/SSP</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.10</td>
<td>Feeder CB operated on DPR</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>2.11</td>
<td>Feeder CB operated on OCR</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>2.12</td>
<td>Feeder CB operated on WPC</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>2.13</td>
<td>Feeder CBs operated on Panto Bridging</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>2.14</td>
<td>Panto bridging relay bypassed</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>2.15</td>
<td>Transformer tap position 1 to 6 position</td>
<td>12</td>
<td>0</td>
</tr>
<tr>
<td>2.16</td>
<td>Auto recloser locked out</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>2.17</td>
<td>Spare</td>
<td>13</td>
<td>4</td>
</tr>
<tr>
<td>2.18</td>
<td>Total telesignals</td>
<td>48**</td>
<td>12</td>
</tr>
<tr>
<td>S.No</td>
<td>Details of Measurands</td>
<td>TSS</td>
<td>SP/SSP</td>
</tr>
<tr>
<td>------</td>
<td>-----------------------------------</td>
<td>-----</td>
<td>--------</td>
</tr>
<tr>
<td>3.1</td>
<td>25 KV bus / OHE voltage</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>3.2</td>
<td>Feeder Currents</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>3.3</td>
<td>Power factor</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>3.4</td>
<td>Spare</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td>3.5</td>
<td>Total Measurands</td>
<td>8</td>
<td>4</td>
</tr>
</tbody>
</table>
Basic Block Diagram Of SCADA System

16-port LAN HUB

Workstation - 1

21”VDU

Server Main

FEP1

Modem

RTU

Workstation - 2

21”VDU

Printer

Printer

Server Standby

FEP2

Modem

RTU

Modem

RTU

Modem

RTU

Modem

RTU
जितना कठिन संघर्ष होगा जीत उतनी ही शानदार होगी ........