End User Manual of CSM 2.3

Operations of CSM Application

Bandweaver R&D

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1. Revision History

Serial	Date	Author	Description
1	2010/01/07	JV	Initial English Draft for CSM 1.X
2	2012/09/15	XG Liang	Upgraded from 1.X into 2.X
3	2012/11/26	XG Liang	Updated Remote Communication Part
4	2013/5/7	F Yang	Updated According to New CSM Structure

2. Terms

Serial	Name	Description
1	CSM®	Cable Safety Monitoring (System / Application)
2	DTS	Distributed Temperature Sensor
3	DT	Distributed Temperature (Array)
4	Tbd	Boundary Temperature
5	Tcs	Cable Surface Temperature
6	Tcc	Cable Conductor Temperature
7	DCR	Dynamic Cable Rating (Algorithm/Model)
8	DCR-I®	DCR Sub-model, Real-time Tcc Calculation
9	DCR-II®	DCR Sub-model, Short-term Tcc Prediction
10	STPL	Short-term Permissible Load (One Output of DCR-II
11	STPD	Short-term Permissible Duration (One Output of DCR-II)
12	SCR	Static Cable Rating
13	TcsNom	Nominal Tcs (One Output of SCR)
14	cSTPL	Conservative STPL (One Output of SCR)
15	SPD®	Spatial Peak Detection (Algorithm)
16	BN	(Thermal) Bottle-neck
17	TLM	Total Load Management (System/Application)
18	CAE®	Concurrent Application Environment (Software Framework)
19	SMS	Short Message Service
20	APD	Avalanche Photo Diode (Photo-electric converter in DTS)

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3. Introduction

Cable Safety Monitoring (CSM) Application is one kind of PC based application software primarily intended for real-time monitoring of underground power cable conditions. Together with the PC, it could be called CSM Host.

Usually the overall system integrated by it could be called CSM System, which includes necessary sub-systems, one CSM Host, remote communication module, etc. CSM Application would be running on the CSM Host PC to conduct real-time monitoring task on

a continuous 7x24hr basis.

3.1. Functionalities

There are two core functions of CSM Application, DT Function and DCR Function. The former is to check if there is any abnormal temperature point along the cable, the latter to monitor cable thermal status and support decision making for short-term load dispatching. That is why CSM Host is called DCR Server in some occasions to emphasis its technical use.

To realize the above, CSM Application would read real-time inputs from the DTS sub-system and the Load Detector Sub-system, and re-map DT data for each circuit.

It would save locally full monitoring data for at least 3 months. And it could integrate remote communication module, typically to report summarized state data to the SCADA and/or a TLM Server.

All the information in the GUIs is organized and translated in a way called user object oriented view, which would accelerate the learning curve of the end user. And just by a quick scan of the main view, the operator is able to judge if there is any trouble of not only the circuits but also the monitoring system itself.

3.2. Project Configuration

CSM Application program itself is standard and universal for all CSM projects. A configuration file that is suffixed with *cae* would be created for a specific project. For the end user, the system would be handed-over in a turn-key status with the cae file created saved in the project folder, which would be loaded in automatically upon CSM Application is started.

DCR Model for each circuit would be built as part of the configuration.

3.3. PC Running Environment

CSM Application is designed to run on an industrial PC or a quality commercial PC with:
Operation System: Windows 2000, Windows XP, WIN7, WIN Server 2008/2012;
System software framework: MS Framework 2.0/4.0;
Default Hardware: RAM 4G, CPU 1.6G, Disc 500G.

Bandweaver PC Protection Script would be executed on the PC, which is to establish necessary anti-virus mechanism and will create two user accounts:

Serial	Account ID	User Permissions	Password
1	“administrator”	Full, Administrator	B&weaver142857
2	“user”	Limited, Power User	B@ndwe@ver

Account *administrator* is only kept for software installation, IP address settings, etc.

Account *user* is for CSM Application running, which will log on automatically and then auto-start CSM Application when system being powered on.

3.4. Installation Mode

There are two installation modes of CSM Application:

- Normal Mode: Installed at C:\Program files
- Quick Mode: Installed at D:\Csm\CsmApplication.

Project configuration files (cae files) and monitoring record data are saved together at D:\Csm\ProjectData\[Project Name].

So under Quick Mode, CSM Application, project configuration files (cae files) and monitoring data are all saved together at D:\Csm. This allows user engineer to create a CSM Historical Data Viewer on another PC or laptop by duplicating the whole folder.

3.5. Design Capacity

In default PC hardware configuration:

Serial	Item	Description
1	Overall size of DT	<=100,000 points (100km at 1.0m sampling resolution)
2	DCR model quantity	<=16
3	Real-time lag	<=5s

3.6. User Mode

There are four user modes or levels of CSM Application:

Serial	Level	Password	Description
1	L0	N/A	End User, Operator
2	L1	“B@ndwe@ver	Power User, End User Supervisory Engineer
3	L2	Not Open	Power User, Bandweaver Application Engineer
4	L3	Not Open	Power User, Bandweaver System Engineer

L0 and L1 would be open to the end user. CSM will be in L0 level when being started and the permission is limited within general operations and view-only operations of DT and DCR. L1 is allowed to set thresholds, DT zones, etc. Fundamental project configuration settings should be accomplished once-off under L2 before hand-over.

3.7. Development Information

Bandweaver started to develop CSM Application in 2006 and obtained software copyright registration in 2006. The program is coded mainly by C# under Microsoft VS.NET. A framework called CAE has been developed together to support generic functions of project configuration, real-time monitoring and automation control, database, etc.

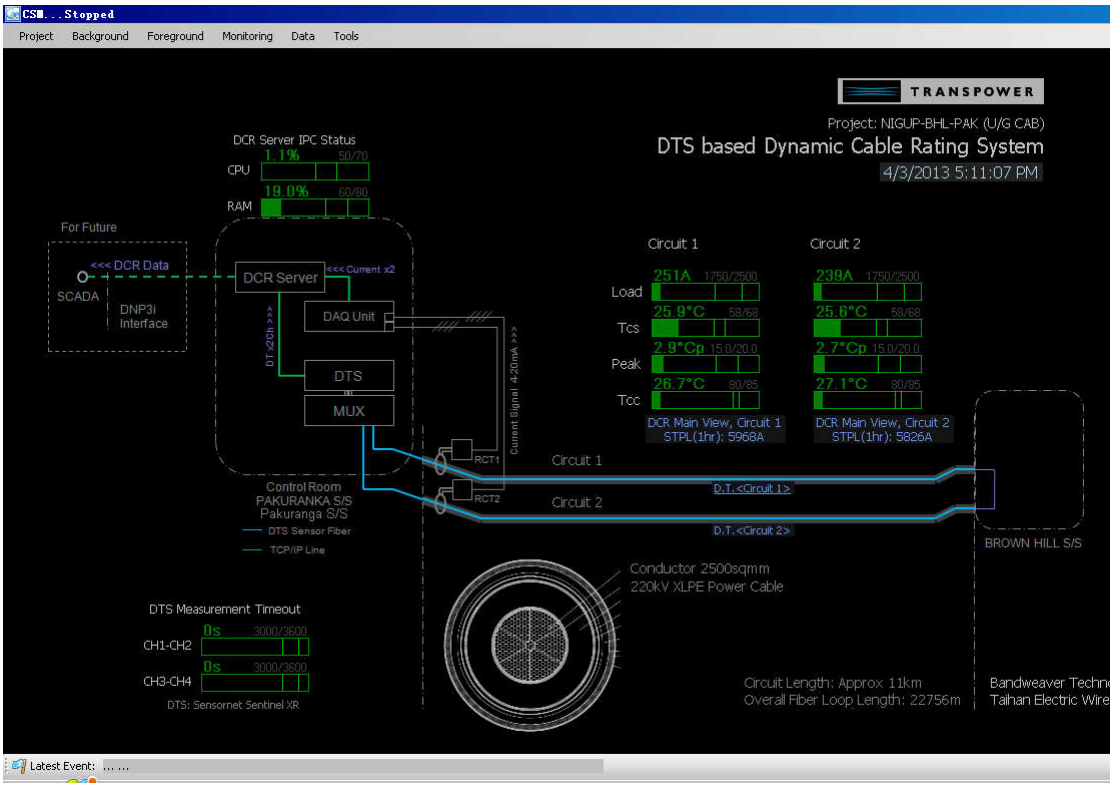
Default Real-time scanning time interval is 1000ms. Default language is English, secondary language Chinese.

DCR-I passed validation test by Shanghai Electric Cable Research Institute (SECRI) in 2007 and by China Electric Power Research Institute (China EPRI) in 2008. DCR-II passed validation test by China EPRI in 2010.

4. General Operations

4.1. Start-up

As a handover state, an icon named as CsmStart would be created on the windows desktop and the CSM application would be running with its main interface shown as:



Main Interface (Overview)

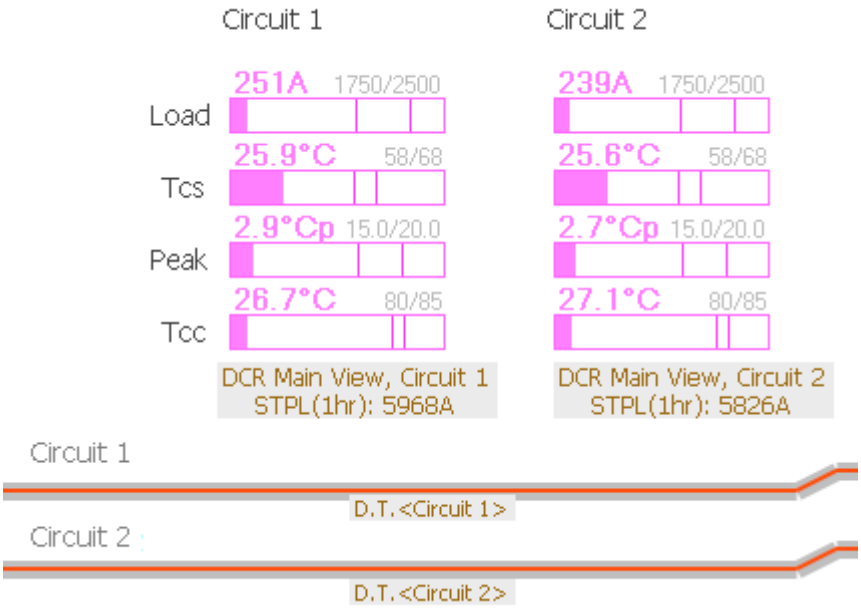
This main interface could be called CSM Overview presenting overall layout and states of monitored circuits and CSM components by below three kinds of visual control.

- Static images and labels: layout diagram, explanatory notes, etc, normally in gray and blue of color;
- Indicator: To show state of a checker in form of horizontal level strip. Green if in normal state, or yellow/orange/red if not;
- Dynamic Label: To show dynamic information and/or pop up a form when being clicked.

Normally six non-static controls will be created for each circuit:

- Indictor, Load:
- Indictor, Tcs;
- Indictor, Peak;
- Indictor, Tcc;
- Dynamic Label, DT;
- Dynamic Label, DCR.

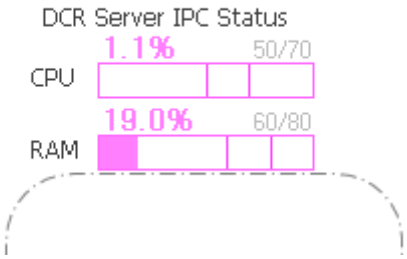
Below example shows those controls for two circuits.



Controls for Circuit

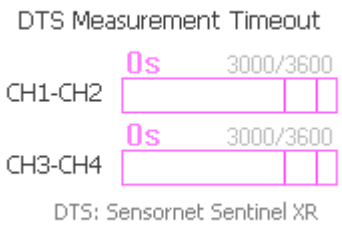
To monitor CSM Host PC status, there would be two indictors:

- Indicator, CPU (Occupation percentage rate);
- Indicator, RAM (Occupation percentage rate).



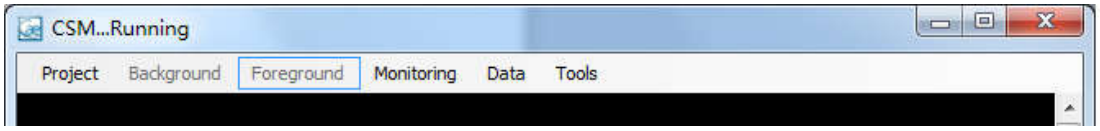
Controls for CSM Host PC

To check if DTS is working or not, there will be an indicator of measurement time-out for each optic channel or loop.



Controls for DTS

On the top of Main Interface is Main Menu:



Main Menu

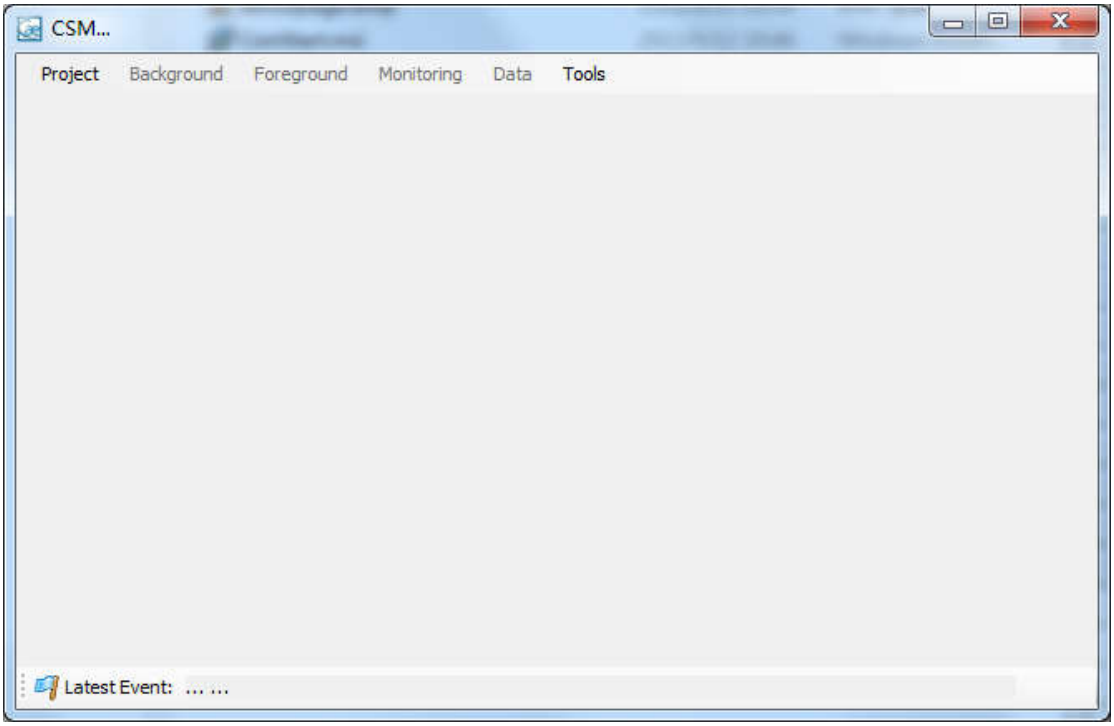
Main Menu items *Background* and *Foreground* is for project configuration, so for the end user, they are disabled.

Operations of End user L0 and Power User L1 would be within Main Interface and enabled items of Main Menu.

CSM is of auto-start design that means CSM Application should be started with right project configuration automatically after CSM Host PC is powered on manually or from a power breakdown. The auto-start is realized by a four level mechanism:

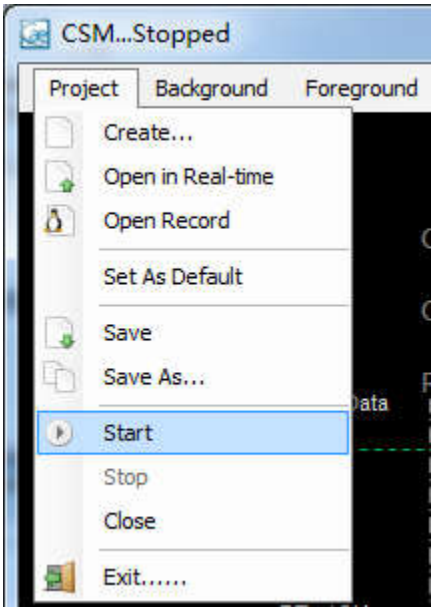
Serial	Level	Description
1	PC	PC starts automatically upon power being restored from breakdown
2	Account	PC account *user* logs on automatically by system registration settings
3	Application	CSM Application starts as an auto-start application of Windows
4	Project	CSM Application locates and loads last default project

The first three levels are unlikely to be wrong since the settings should have been set and tested before handover and should not modified in lifetime of the system. The user may have problems with the last one. If the user encounters below blank Main Interface, it means CSM Application starts but fails to load project configuration.



Main Interface in Blank

Under this circumstance the user have to click Main Menu>Project>Open in Real-time to re-locate Project Configuration file or cae file manually.



Main Menu > Project

The cae files should be saved in D:\Csm\ProjectData\[ProjectName]. Practically there would be array of historical cae files. Select the latest one if there is no special purpose.

Click Main Menu>Project>Start to start the monitoring.

Click Main Menu>Project>Set As Default to set current project configuration as default which will be loaded automatically in next start up.

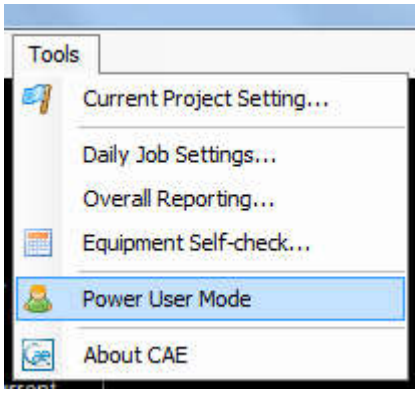
4.2. Close Project / Exit CSM

Click Main Menu>Project>Close to close current project and then the Main Interface will be in blank.

Click Main Menu>Project>Exit to close CSM Application.

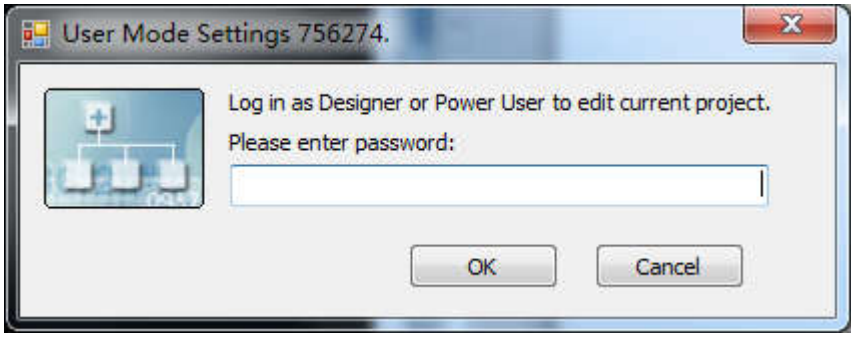
4.3. Enter Into Power User Mode

Click Main Menu>Tools>Power User Mode to get Power User Log On Form.



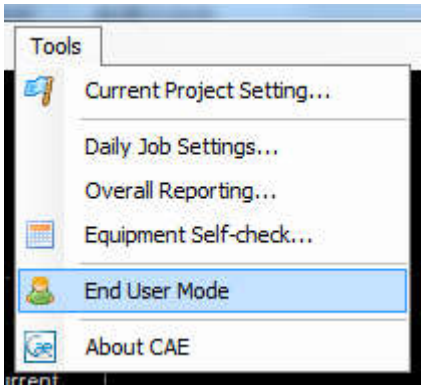
Get Power User Log On Form

Enter password of Power User in below form to get into corresponding Power User Mode.



Power User Log On Form

To return into End User Mode, click Main Menu>Tools>End User Mode:

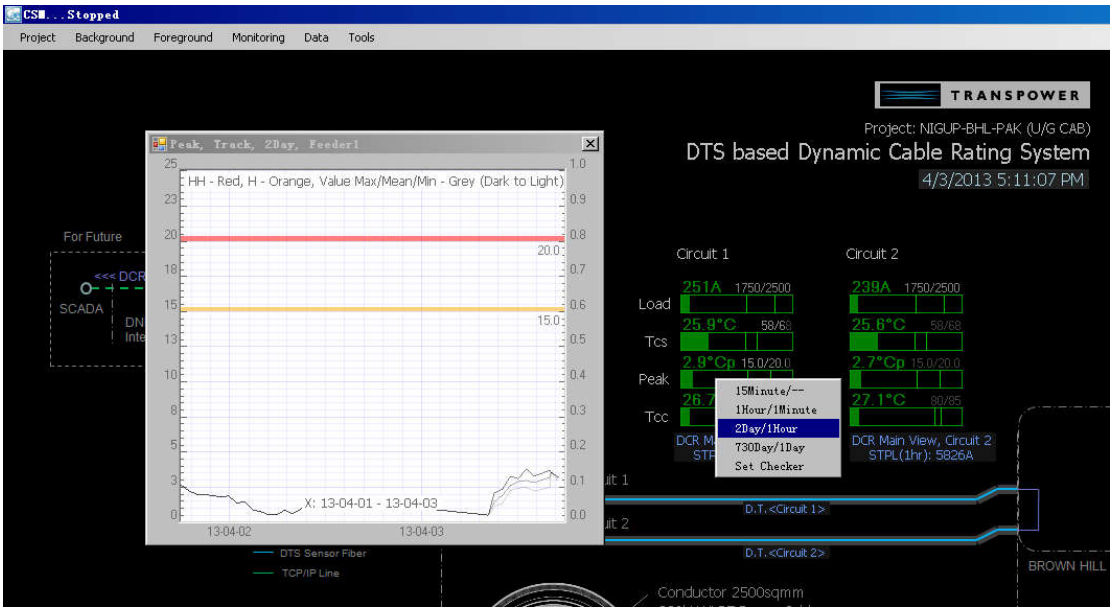


Return into End User Mode

4.4. View Checker History

Right click the indicator to get context menu of the corresponding checker.

There might be several selection items with the format as [Time Span 1] / [Time Span 2].



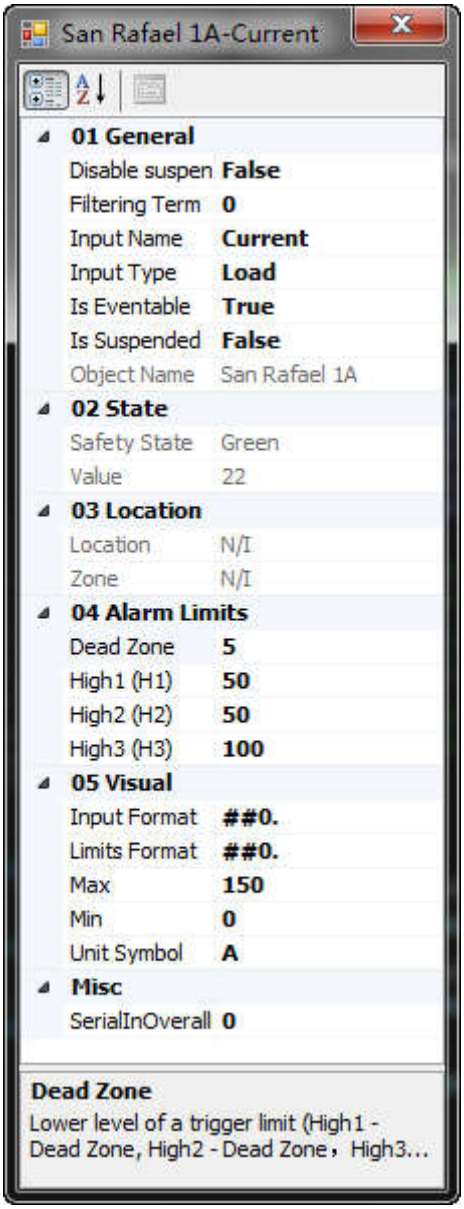
View Checker History

Click one to get Historical Track of the checker within latest period of Time Span 1 at sampling interval of Time Span 2. As summarized data during the sampling interval, the

track would consist of three lines: Max, Mean and Min.

4.5. Set Checker

Click Checker Context Menu>Set Checker to get Property Grid Form of the checker. Only Power User is allowed to do this operation.



Checker Property Grid Form

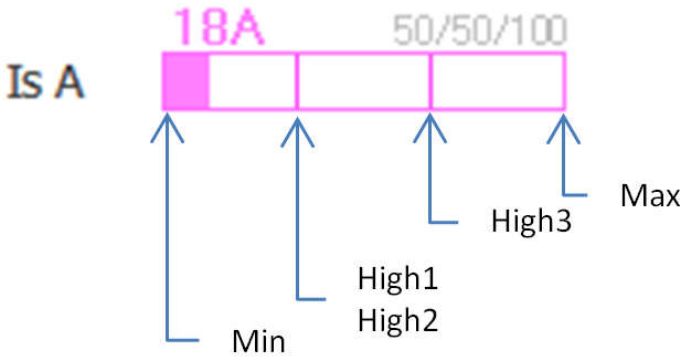
There are five properties that the user might edit:

Three for threshold settings:

- High1 (H1): Value of High Limit;
- High2 (H2): Value of High-high Limit;
- High3 (H3): Value of High-high-high Limit;

The other two relates to visual control:

- Min: Min value of state level strip or track chart;
- Max: Max value of state level strip or track chart.

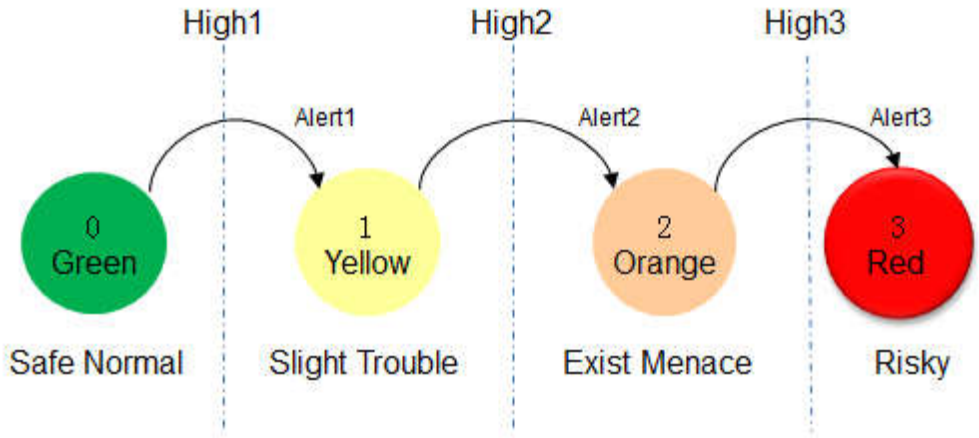


Five Important Properties of the Checker

In order to give a right presentation of the indicator and the track chart, Min should be set lower that High1, and Max higher than High3.And the threshold should be set High1<= High2<= High3.

Dead Zone may be adjusted if the checker would create multiple unnecessary alarms when the monitored variable passes or lingers around the threshold. Its default value would be 1/10~1/20 of gap between High1 and High2 or between High2 and High3.

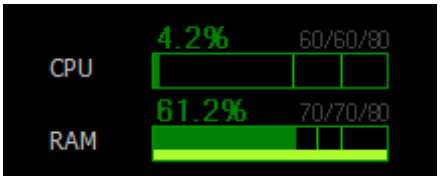
Divided by three thresholds of High1, High2 and High3, there are four kinds of state to define generic safety state of the checker. The checker should be in one of them at any point in time and would generate events upon state shifting.



Checker Safety States

For a checker, the starts are Green (0), Yellow (1), Orange (2) and Red (3).

The checker may still generate too many events due to wrong threshold settings or abnormal fluctuation of the monitored variable. A self-check mechanism will detect this kind of situation and suspend the checker by disabling it to generate event. Then property Is Suspended will be shown as true and the indicator as:



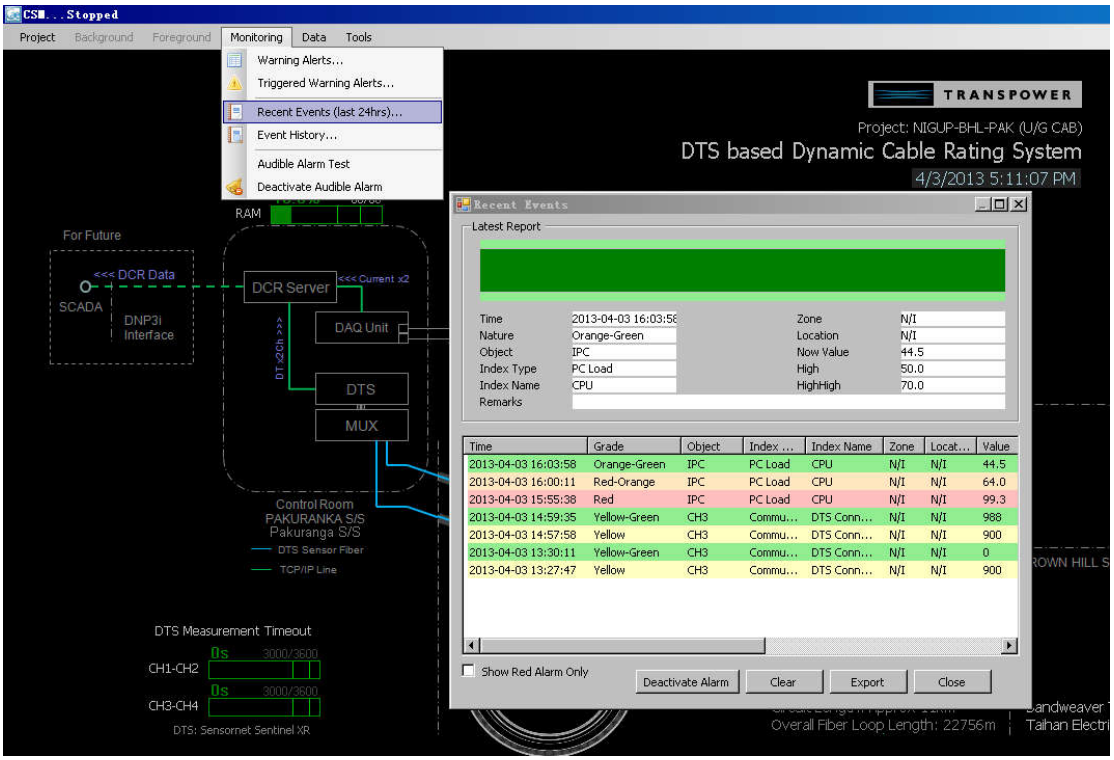
RAM Checker being suspended

If this situation occurs, the used needs to look closely at threshold settings and recognize what happens to the monitored variable.

Setting Is Eventable as false will simply disable the checker to generate event. Only Power User is allowed to do this operation.

4.6. View Event List

Click Main Menu>Monitoring>Recent Events (last 24hrs), an Event List Forms which contains all events being triggered during last 24 hours will show.



Events are created by the checkers and some other module. It format is as:
[Time]: Event Generated Time;
[Grade]: Last Safety State, Or Safety State Shift;
[Object]: Source Object; Or Object Name of checker;
[Index Type]: First Level Name; Or Input Type of checker;
[Index Name]: Second Level Name; Or Input Name of checker;
[Zone]: First Level Location Name;
[Location]: Second Level Location Name;
[Value]: Monitored Variable Value at that time;
[High1]: First Level Threshold;

[High2]: Second Level Threshold;
[High3]: Third Level Threshold;
[Remarks]: Remarks.

An event record may have some columns in blank, especially if it is not generated by a checker. For instance, a module called DtsFilter could trigger DTS sensor fiber broken event, of which columns of Value, High1, High2 and High3 would not be used, instead column Remarks would provide information like fiber length before and after fiber broken.

4.7. Create CSM Historical Data Viewer in another PC

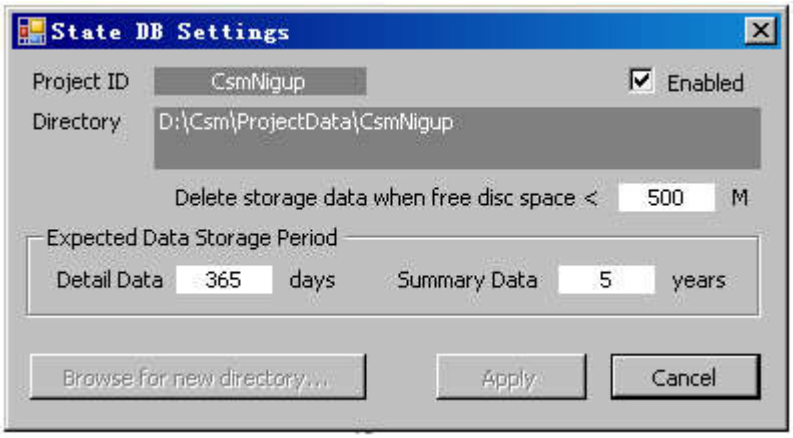
Under Quick Mode of installation, user engineer is able to create a CSM historical data viewer in another PC by duplicating D:\Csm folder to the hard disc D of the new PC and clicking CsmStart.exe in D:\Csm\CsmApplicaton\CsmRunning. CSM Application will start and load cae file automatically since all the file paths remain no change.

If the duplicated folder is not directly under disc D, for instance at directory path x, then the user need to click CsmStart.exe in X\Csm\CsmApplicaton\CsmRunning to start CSM Application with Main Interface in blank, and then select and open the cae file at X\Csm\CsmApplicaton\ProjectData\StateDb-[ProjectName].

Framework 4.0 should be installed in the new PC.

4.8. About Data Storage

Click Main Menu>Data>State DB Settings, State DB Settings Form would show.



State DB Settings Form

Only Power User L2 and L3 are permitted to modify the settings.

CSM would save historical data for the latest period of Expected Data Storage Period. But to prevent the disc from being filled full, CSM will always delete oldest data when free disc space is detected less than a limit (as shown in above sample form, 500M bytes).

As designed, Expected Data Storage Period is 90 days for Detail Data (Like full DT data),

and 5 years for Summary Data (Like event records).

Silixa DTS is PC based and capable to save DT data in its disc. The location of temperature files will be:
Data file path\Temperature*configuration name**channel name*

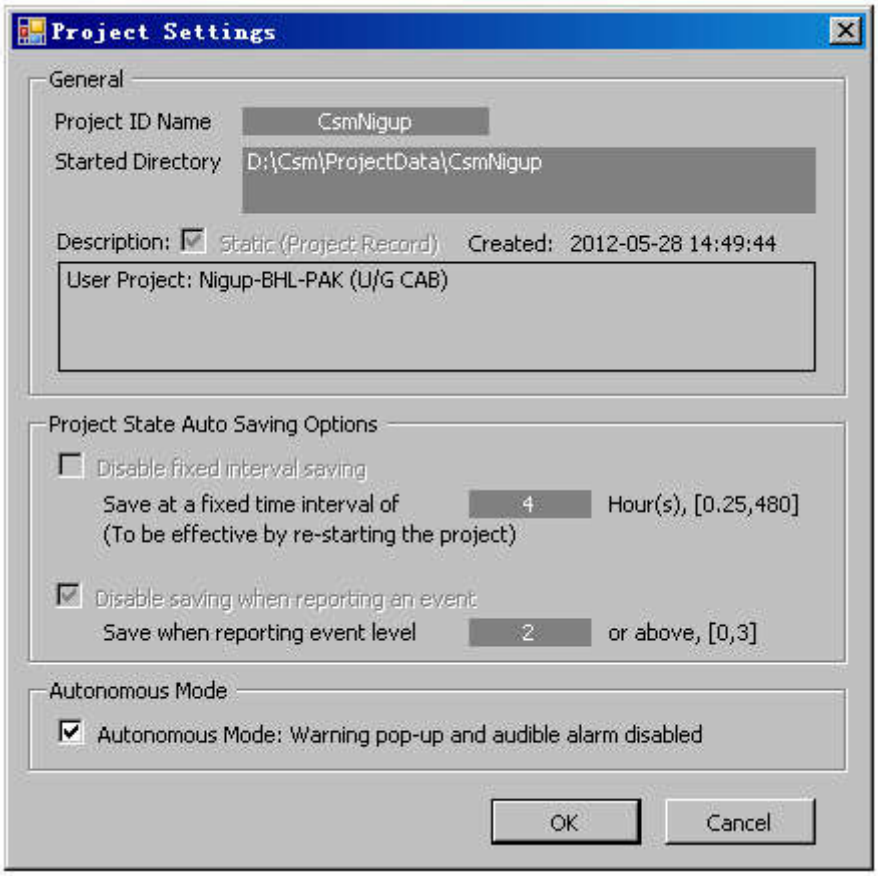
For example, the data file path may be:
C:\Users\Ultima\AppData\Local\UltimaData

In this case, with the settings shown below, the temperature data would be stored in C:\Users\Ultima\AppData\Local\UltimaData\Temperature\Fibre Test\Channel 1

After Silixa DTS data sent to CSM by CsmAgent software it will be deleted by CsmAgent.

4.9. About Project Settings

Click Main Menu>Tools>Current Project Settings, Project Settings Form will show.



Project Settings Form

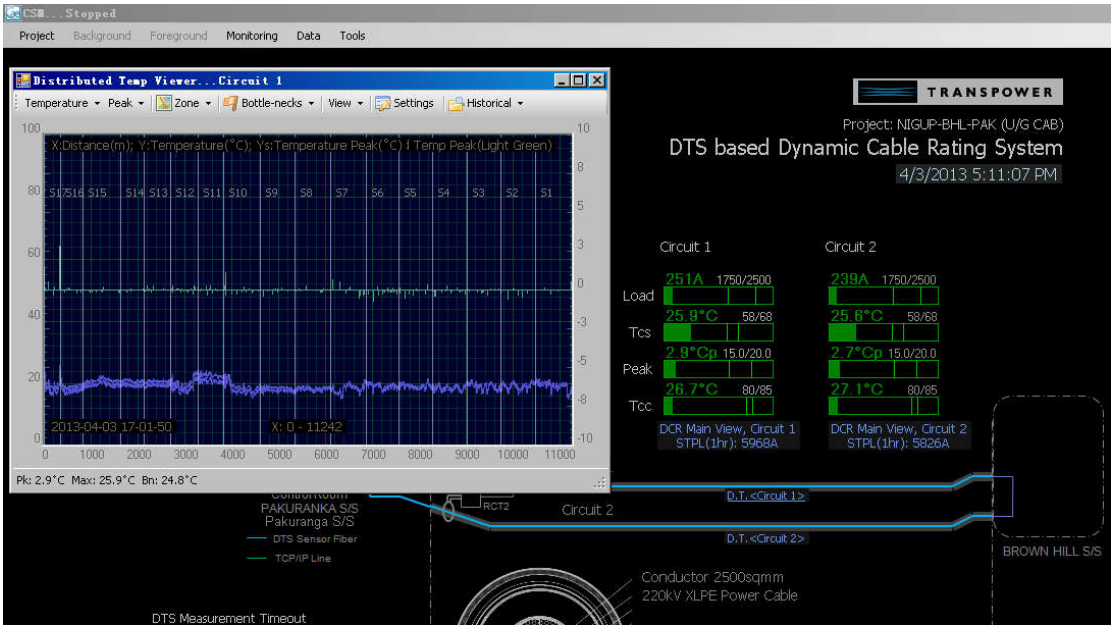
Autonomous Mode should be selected if the CSM Host is placed at an unattended substation.

Only Power User L2 and L3 are permitted to modify Project State Auto Saving Options. CSM would keep saving project configuration combined with current state data in a cae file at a fixed time interval (default 4 hours), and upon an event of and above certain grade being triggered (default grade 2, Orange).

5. DT Operations

5.1. View Present DT

Click Dynamic Label DT, a DT viewer will pop up, in which current DT curves would be shown in blue, peak curves in light green.

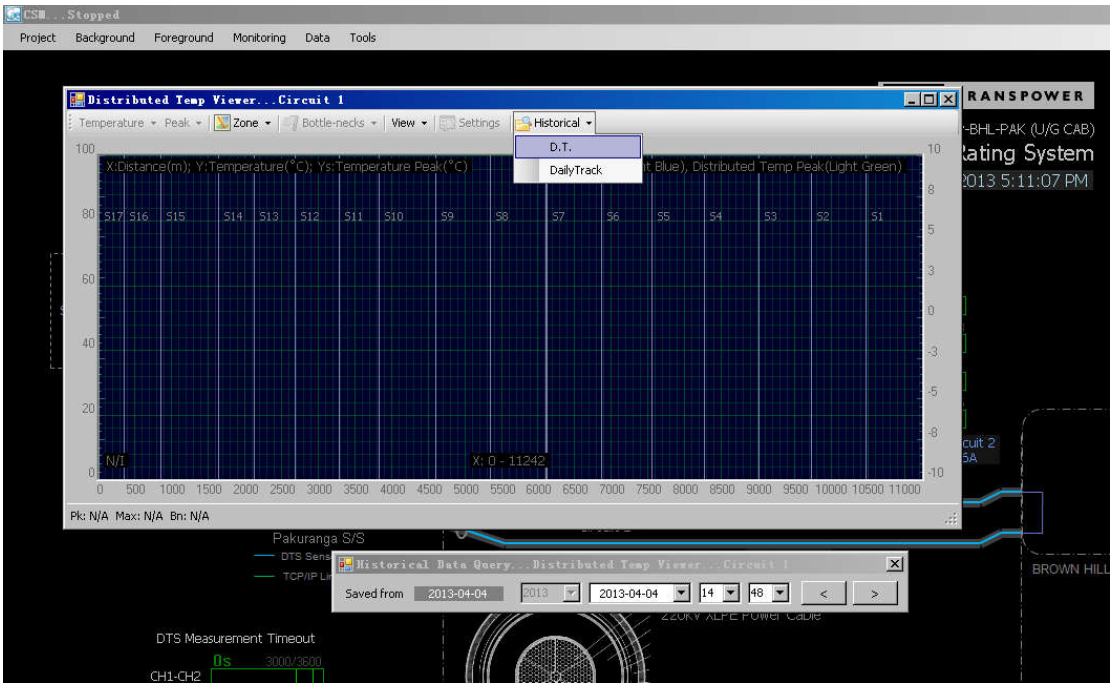


DT Viewer

If Zone>Show Zone Definitions is selected, coverage of zones will be shown with vertical strips.

5.2. View Historical DT

In the DT Viewer, click Menu>Historical>D.T., a Historical Data Query Form will show.

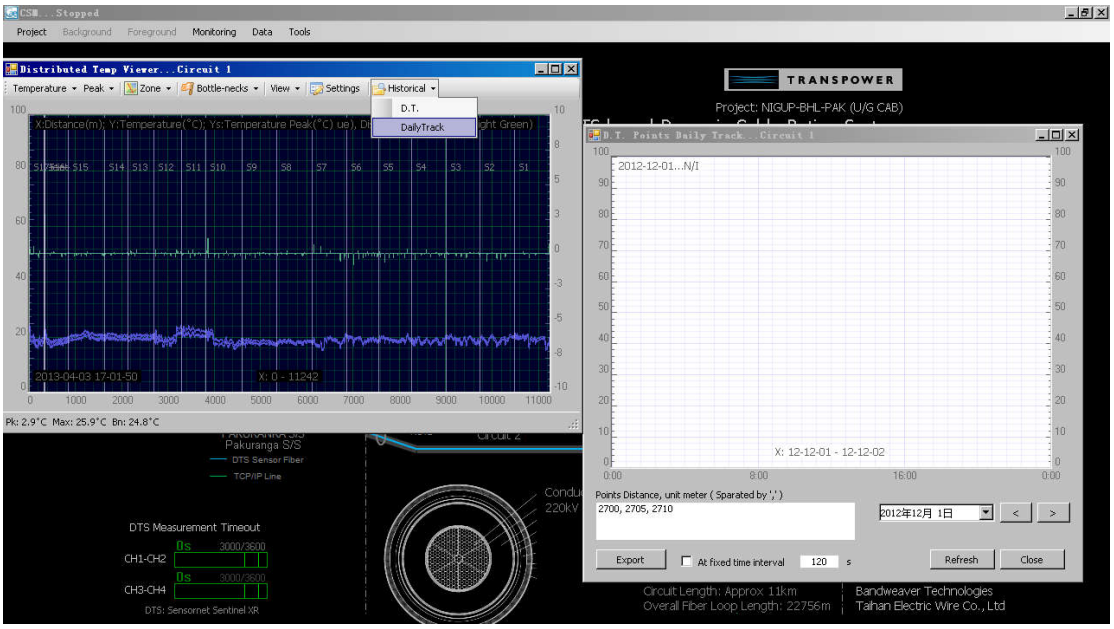


Historical Data Query Form

The user can select a point of time in the query form, and then the DT Viewer will present DT and Peak curves if exists. The user can use '<' and '>' to page up and page down.

5.3. View Temp Point Track

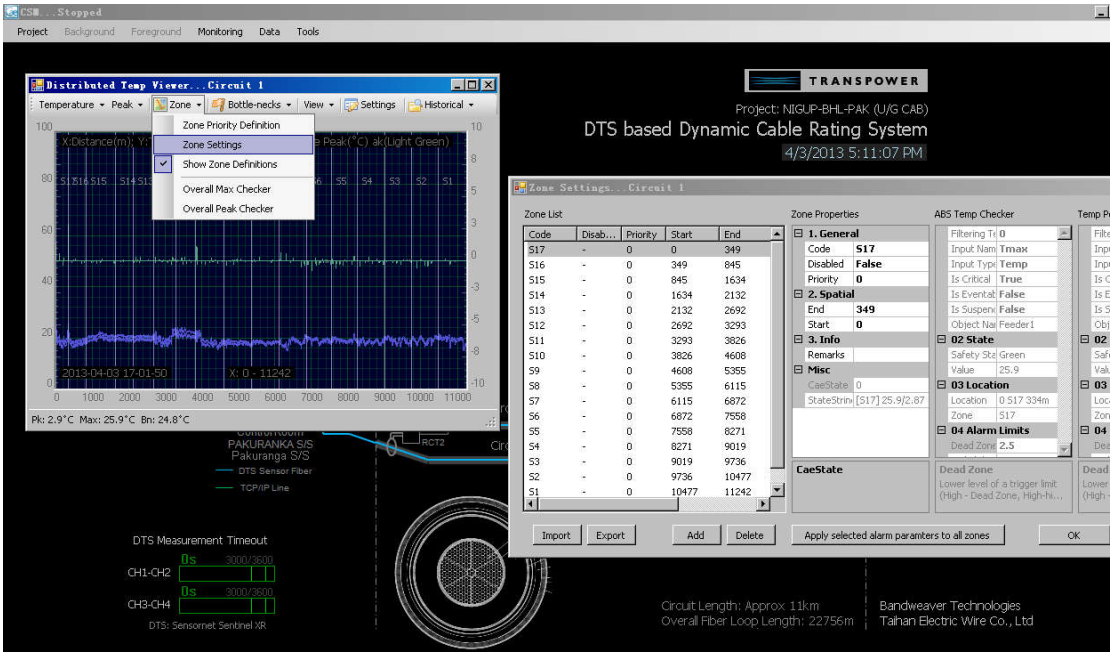
In the DT Viewer, click Menu>Historical>Daily Track, a DT Points Daily Track Form will show.



In the form, the user can select points of interest and a date, and then click Refresh. Track curves of these points would be drawn on the graph.

5.4. Modify Zone Settings

In the DT Viewer, click Menu>Zone>Zone Settings, Zone Settings Form will show.



Zone Settings Form

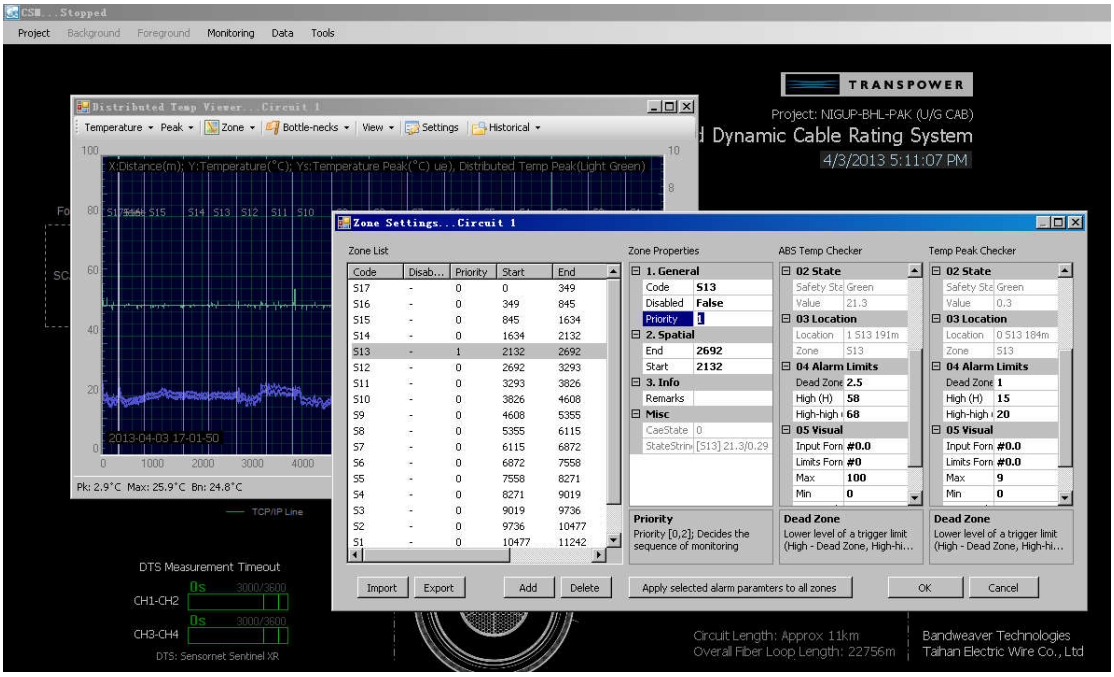
Only Power User L1 and above can modify the settings. To define a zone:

- Start: Start position, unit m;
- End: End position, unit, m;
- Priority: Level 0 (default), Level 1, Level 2;
- Disabled: Default false.

5.5. Set Different Thresholds for a Zone

For DT of a circuit, there would be two overall checkers for Tcs and Peak respectively. Zones of Level 0 would adopt same thresholds of them. But a zone of Level 1 will establish independent DT and Peak checkers. It means their thresholds could be set different from the overall.

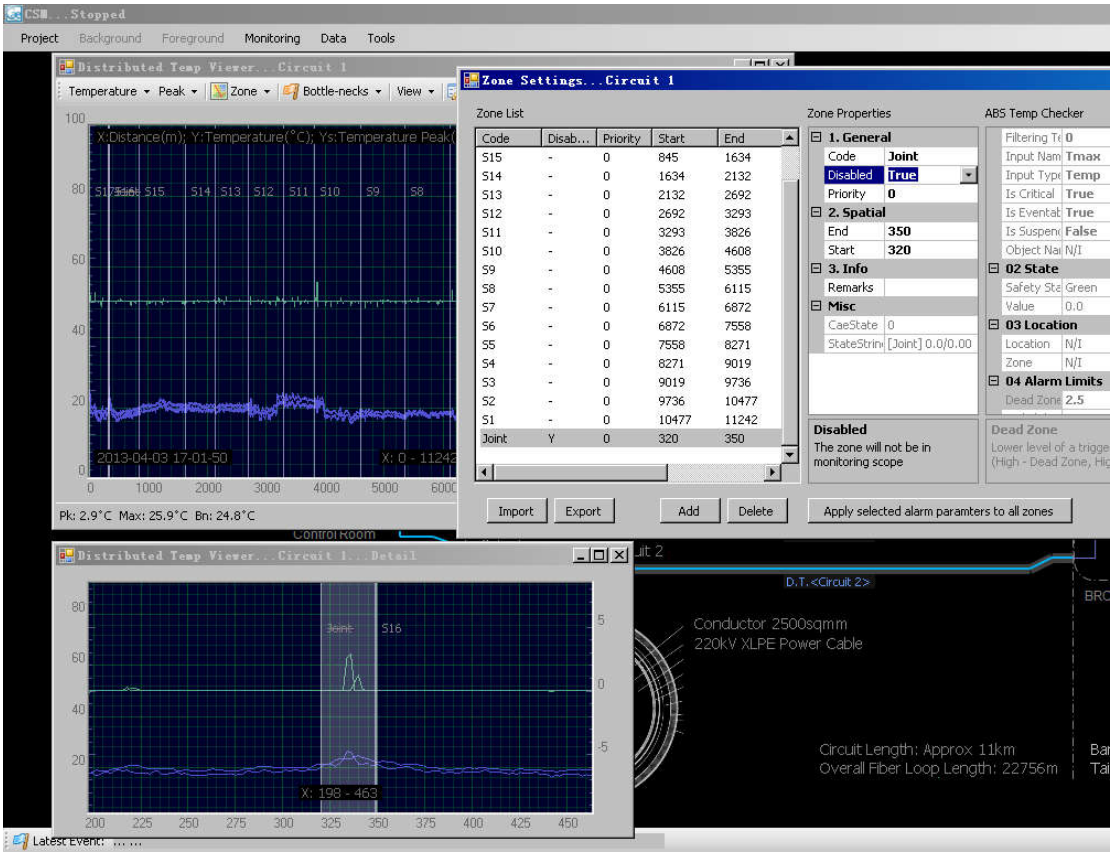
So the first step is to set zone priority as 1 (Level 1), and then modify the thresholds of the two checkers.



Set Different Thresholds for a Zone

5.6. Ignore a Segment of DT

To ignore a segment of DT, the user could add a zone for it and select its property Disabled as true. Then in the graph of DT Viewer, coverage strip of this zone will be in gray.



Disable a Zone

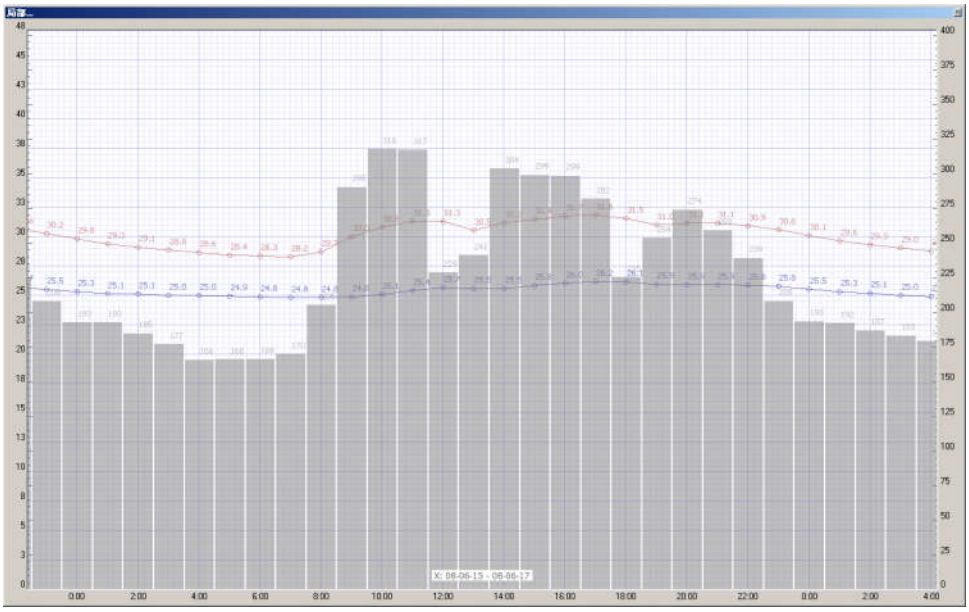
6. DCR Operations

6.1. View Load-Temp Response Curves

Click Dynamic Label DCR, DCR Viewer will show.

DCR Viewer

It presents Load-Temp Response Curves of Last 96 Hours (4 days). The user can select to see those of Last 60 Minutes and Last 365 Days.

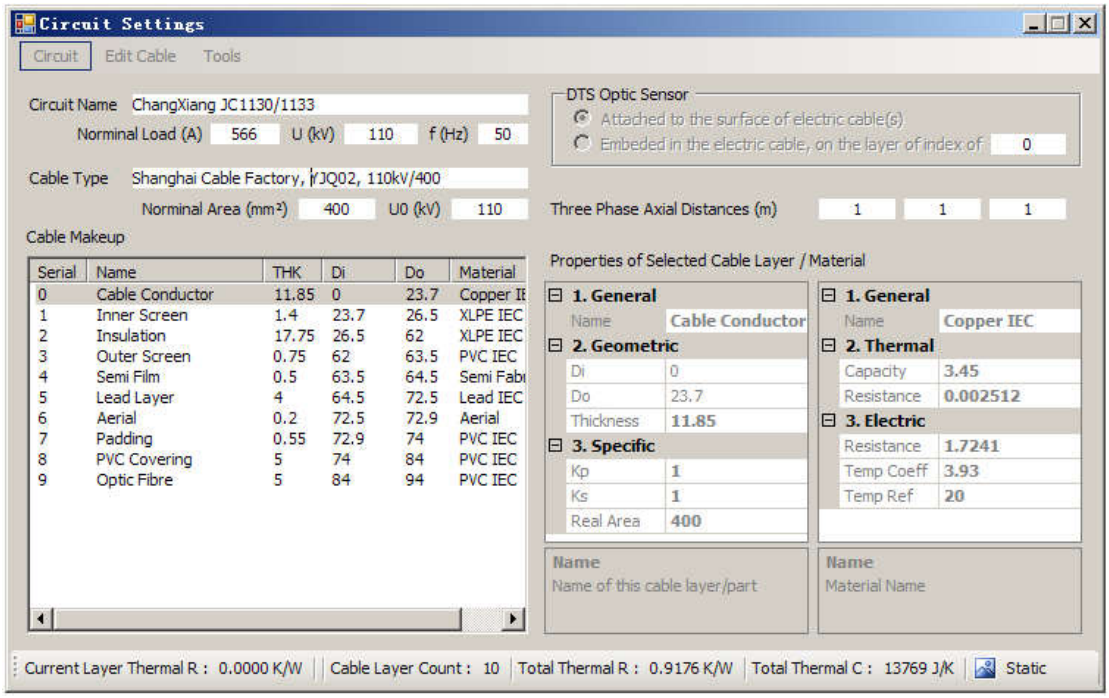


Load-Temp Response Curves

In the graphic of Load-Temp Response Curves, X axis is of time series. Load series is in gray histogram, Tcs in blue line, and Tcc in red line.

6.2. View DCR Model Parameters

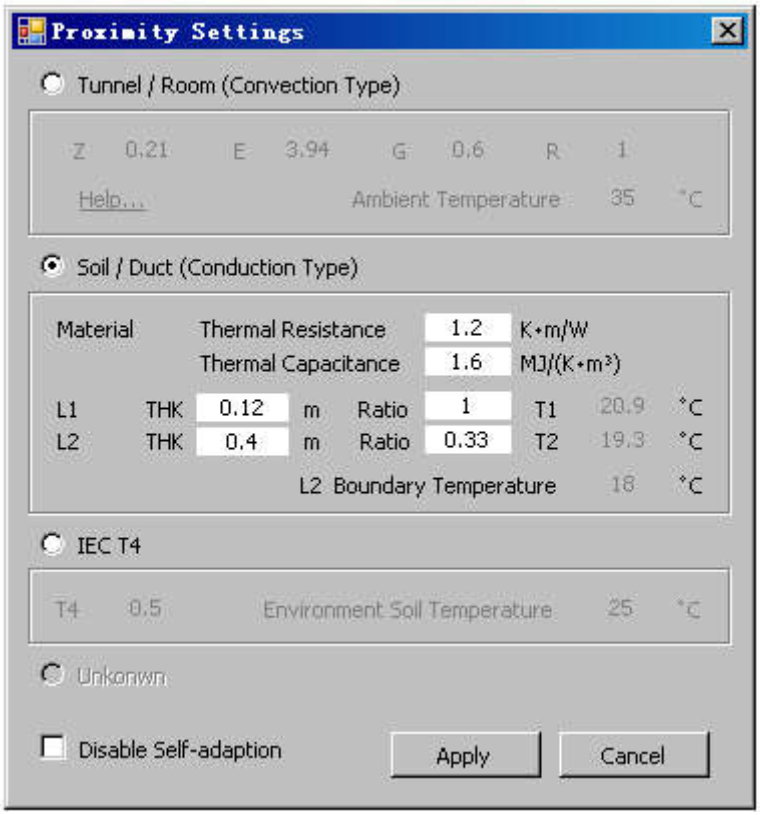
In the DCR Viewer, click Menu>Circuit Info, a Circuit Settings Form will show, which practically includes all necessary parameter of the DCR-I Model.



Circuit Settings (DCR-I Parameters) Form

This form is read only.

Click Menu>Current Bottle-neck, a Dynamic Rating Calculations Form will show. Click Proximity Settings label at the top left corner in that form, a Proximity Settings Form will show, which practically includes DCR-II parameters.



Proximity Settings (DCR-II Parameters) Form

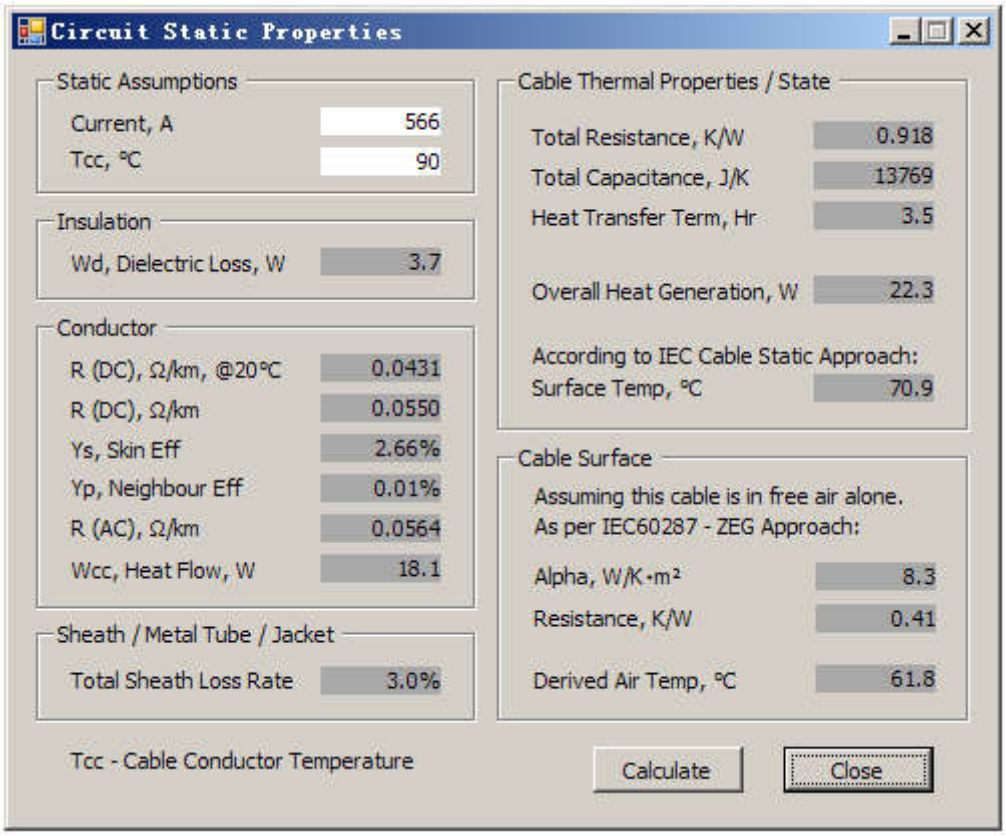
The user can modify the settings.

6.3. Conduct SCR Calculations

Click Static label at bottom right corner of Circuit Settings Form, a Circuit Static Properties Form will show.

In this form, SCR calculations could be executed with two inputs: Given Current and Given Tcc of an assumed static scenario. Static states of conductor, insulation, sheath and cable overall will be output. Especially, static cable surface temperature will be calculated.

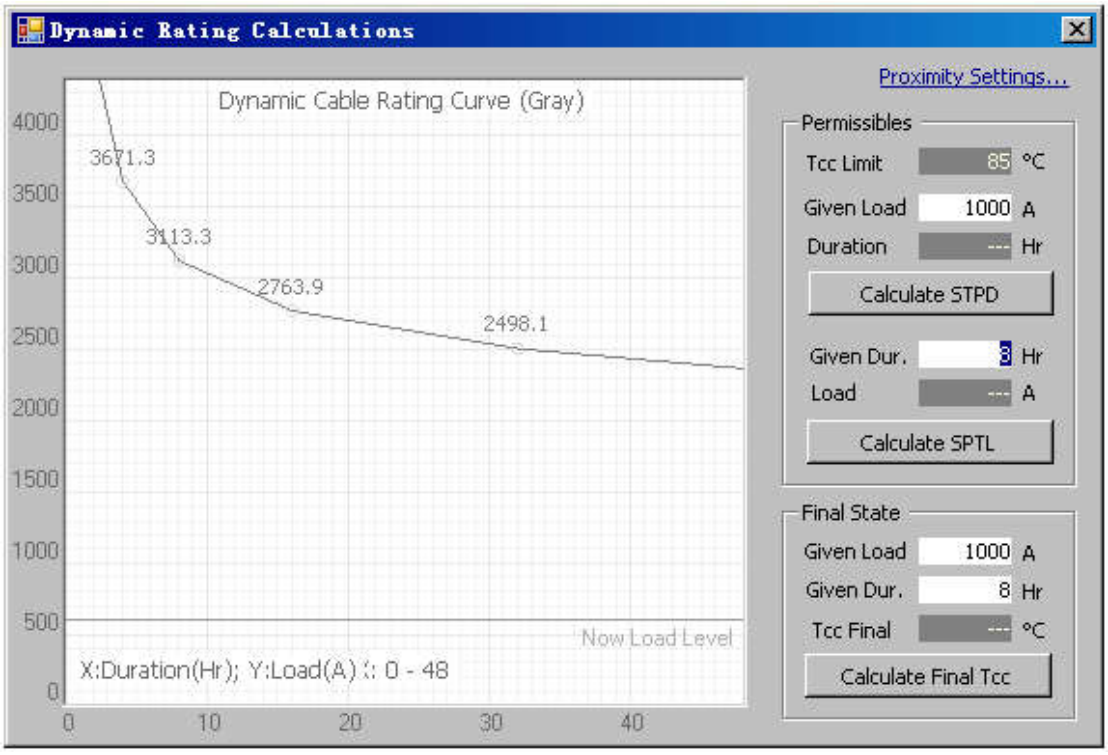
Nominal Cable Surface Temperature (TcsNom) can be calculated with Given Load set as the circuit nominal rating and Given Tcc as 90°C. TcsNom could be the Tcs threshold of a circuit operated near its nominal rating.



Circuit Static Properties Form

6.4. Calculate STPL/STPD Manually

Click Menu>STPL, a Dynamic Rating Calculations Form will show.



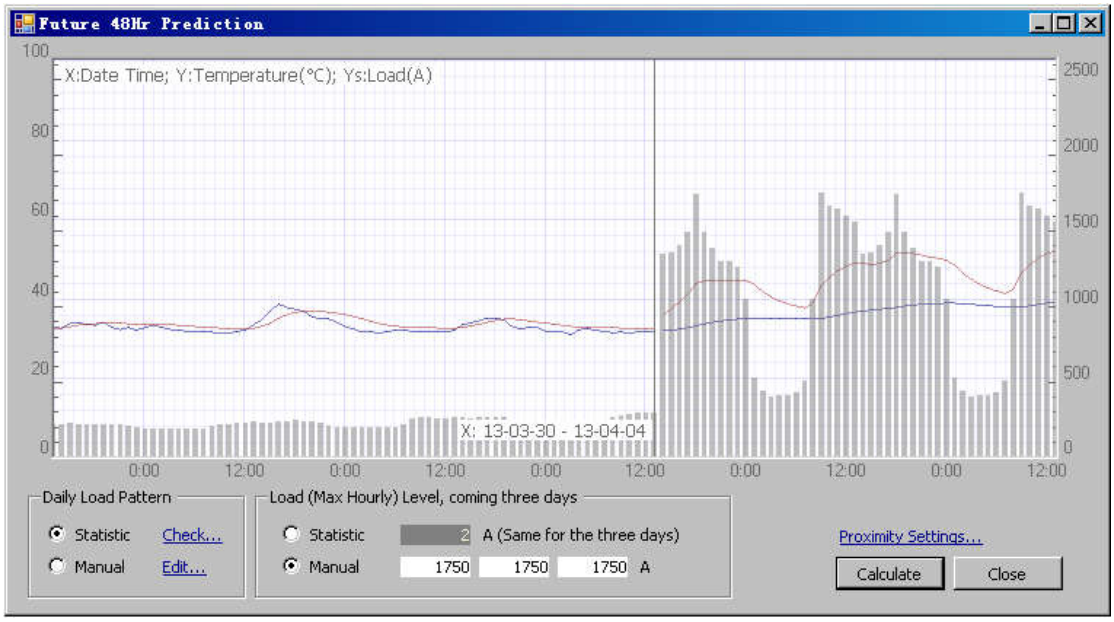
Dynamic Rating Calculations Form

The left graphic shows a curve called Dynamic Rating Curve. Its X axis is time duration in hour, and y axis is permissible load in ampere. At the right side, three kinds of calculation can be operated manually:

- Calculate STPD for given Tcc limit and load;
- Calculate STPL for given Tcc Limit and duration;
- Calculate Final Tcc for given load and duration.

6.5. Run 48Hr Simulation

Click Menu>48Hr Prediction, a Future 48Hr Prediction Form will show.



Future 48Hr Prediction Form

It is to predict Tcc and Tcs in future 48 hours. Load in future 48 hours should be input with a daily pattern and an hourly max value. Daily pattern could be statistic based on historical data or given manually. As well Hourly max value can be statistic or manual.

7. Remote Communication

CSM Application could report DCR State Data to SCADA according to user defined protocol. The DCR State Data is defined as:

- For each circuit;
- DcrState float [5]:
- DcrState[0] Load: Current of the circuit;
- DcrState[1] Tcs: Max Cable Surface Temperature;
- DcrState[2] Tcc: Max Cable Conductor Temperature;
- DcrState[3] STPL: Short Term Permissible Load (60min);
- DcrState[4] BnPosition: Thermal Bottle-neck distance position.

CSM system could be integrated by a TLM Server. In this integration, CSM Application will

report DCR State Data and Event Data to the TLM Server via user's intranet, and the latter would establish a web site to present these data and maintain remote desktop link to the CSM system.

Following ports are reserved for CSM Application to communicate external systems.

- UDP: 62009;
- TCP: 62010;
- HTTP: 62011 (not used yet);
- HTTP: 80;
- Remote Desktop: 3389.

For DNP3, there would be an additional UPD Port: 20000.

User's IT department might be involved to allocate IP addresses and open the ports on the router or firewall.

8. Maintenance and Repair

CSM Host, including PC and CSM Application, is designed for long-term permanent running without maintenance or repair. Its continuous run time should not be less than 20000 hours. But a holistic maintenance scheme should be required to cover all components of the CSM system, in order to cope with following potential weaknesses or risks of the system:

Serial	Category	Item	Description
1	General	PC Virus Attack	CSM PC and DTS PC could be attacked by virus lead in via network / USB disc
2	General	PC Disc Failure	Hard disc fails due to mechanical vibration, sudden power down, heavy load of operations
3	General	Power Module Failure	Power modules in CSM PC, DTS PC, Load Detector, LAN Switch may breakdown
4	General	Socket / Connection Loose	Including DTS fiber socket, LAN cable socket, connections of RCT signal cables, etc.
5	DTS Sub-system	Laser or APD Aging or Failure	Two weakest parts of DTS
7	DTS Sub-system	Sensor Fiber Broken	Damaged mainly due to external force
7	Load Sub-system	RCT Failure	Exposed to outdoors environment and may be damaged if short circuit current passes
8	Remote Communication	Network Failure	Due to network unsteady or re-mapped

Three kinds of role should be appointed from or on behalf of the user side:

- Substation Inspector;
- Engineer in-charge;
- IT Engineer.

Relevant and potential tasks would include:

Serial	Task	User Role Involved	Description
1	Weekly Patrol	Substation Inspector	General Look-listen-feel; To check if there is alert or alarm; Report to Engineer in-charge
2	Yearly Maintenance (Every 20khr)	Engineer in-charge	Check performance of DTS and Load sub-systems; Do re-calibration if necessary; Check all connection lines and fittings. Exercise Heat-to-alarm test.
3	Repair DTS Sub-system	Engineer in-charge	Supported by Bandweaver
4	Repair Load Sub-system	Engineer in-charge	Supported by Bandweaver
5	Remote Communication Alteration	IT Engineer, Engineer in-charge	Supported by Bandweaver; User IT Engineer is to help on IP address and router/firewall settings
6	Configuration Alteration	Engineer in-charge	Supported by Bandweaver
7	CSM Application Upgrading	Engineer in-charge	If necessary, Bandweaver will issue new software package with detailed step-by-step description of how to do the job.

Among the above, weekly patrol is the most important one. The main interface of CSM Application presents running states of not only the monitored circuits but also CSM system itself. It could help the user to find almost all kinds of troubles at an early stage.

Task of Weekly Patrol could be described as:

Serial	Items	Description
1	Check CSM Application on the LCD screen	Check items: ● Clock Time Label is Refreshing; ● Each Indicator is Green; ● Event List with no Orange or Red Items
2	Overall Look-Listen-Feel	Noise and heat of DCR Server and DTS is equivalent to normal Industrial PC
3	Report if necessary	Report immediately to person in-charge if anything issues.

It is designed to be done in five minutes.