

1. INTRODUCTION

The objective of this report is to provide a summary of historical (last 24 hours) Grid reliability performance metrics for voltage, stability and thermal for MISO Transmission Zones. For each Transmission Zone the report presents:

• Section 2 - Summary

Section 2 presents summary tables per Trnsmission Zone including those transmission lines with the 10 highest voltage, stability, and thermal margins. The tables show date-time, line name, max-min margin limits for each margin and the actual margin violations.

• Section 3 - Voltage Margin

Let $\Delta V_1 > 0$ and $\Delta V_2 > 0$ be the maximum allowed voltage excursion in the magnitude of voltages V_1 and V_2 around the nominal voltages V_1^{nom} and V_2^{nom} . Then, a per-second voltage margin index can be defined as:

$$L_1^v[i] = \frac{(V_1^{nom} - \hat{V}_1[i])^2}{\Delta V_1^2},$$

$$L_2^v[i] = \frac{(V_2^{nom} - \hat{V}_2[i])^2}{\Delta V_2^2}.$$

These per-second indices are the basis for defining any voltage margin reliability measure. For example:

$$H_1^v = \max_i \{\sqrt{L_1^v[i]}, i = 1, 2, \dots, 3600\},$$

would yield the normalized voltage largest deviation in one hour period. The normalized root-mean square voltage deviation yields another reliability measure

$$RMS_1^v = \sqrt{\frac{1}{3600} \sum_{i=1}^{3600} L_1^v[i]} = \frac{1}{\Delta V_1} \sqrt{\frac{1}{3600} \sum_{i=1}^{3600} (V_1^{nom} - \hat{V}_1[i])^2}$$

• Section 4 - Stability Margin

A per-second stability margin index can be defined as:

$$L^s[i] = 1 - \sin(\hat{\delta}_{12}[i])$$

These per-second indices are the basis for defining any stability margin reliability measure. For example:

$$H_1^s = \max_i \{L^s[i], i = 1, 2, \dots, 3600\},$$

would yield the normalized smallest angle-across-system margin for a one-hour period. An average angle-across-system margin for a one-hour period can be defined as:

$$AVG_1^s = \frac{1}{3600} \sum_{i=1}^{3600} L^s[i] = \frac{\delta_{12}^{max} - \frac{1}{3600} \sum_{i=1}^{3600} \hat{\delta}_{12}[i]}{\delta_{12}^{max}}.$$

• Section 5 - Thermal Margin

Let S_1^{max} and S_2^{max} be the maximum complex power magnitude that can flow into both ends of the line due to thermal limits. Then, a per-second thermal margin index can be defined as:

$$L_1^{th}[i] = \frac{S_1^{max} - \hat{S}_1[i]}{S_1^{max}},$$

$$L_2^{th}[i] = \frac{S_2^{max} - \hat{S}_2[i]}{S_2^{max}}.$$

These per-second indices are the basis for defining a thermal margin reliability measure. For example:

$$H_1^t = \max_i \{L_1^{th}[i], i = 1, 2, \dots, 3600\},$$

would yield the normalized smallest line thermal margin for a one-hour period. An average line- thermal margin for a one-hour period can be defined as

$$AVG_1^t = \frac{1}{3600} \sum_{i=1}^{3600} L_1^{th}[i] = \frac{S_1^{max} - \frac{1}{3600} \sum_{i=1}^{3600} \hat{S}_1[i]}{S_1^{max}}.$$

2. SUMMARY SECTION

2.1 10 Highest Violations of Voltage, Stability, and Thermal Metrics

Tables 1, 2 and 3 present for each Transmission Zone the transmission lines with the 10 most extreme metric violations for voltage, stability and thermal margins. Each table include date-time of violation, line name, metric thresholds and actual values

Table 1 - 10 Highest Voltage Margin Violations

MISO Transmissions Zones Voltage Margin Reliability Report					
Transmission Zone	Date - Time	Transmission Line	Rec Max Min	Actual	Observations
Transmission Zone 1	2011-08-17 13:05	GAR_HWY	>0.853 or <0.425	20.00	-
	2011-08-17 20:45	GAR_HWY	>0.853 or <0.425	20.00	-
	2011-08-17 13:05	HWY_GAR	>0.853 or <0.425	20.00	-
	2011-08-17 20:45	HWY_GAR	>0.853 or <0.425	20.00	-
	2011-08-17 13:05	RCK_ARP	>0.853 or <0.425	20.00	-
	2011-08-17 20:45	RCK_ARP	>0.853 or <0.425	20.00	-
	2011-08-17 13:05	ARP_RCK	>0.853 or <0.425	20.00	-
	2011-08-17 20:45	ARP_RCK	>0.853 or <0.425	20.00	-
	2011-08-17 15:10	HWY_GAR	>0.853 or <0.425	12.48	-
	2011-08-17 15:10	GAR_HWY	>0.853 or <0.425	12.47	-
Transmission Zone 2	-	-	-	-	-
Transmission Zone 3	-	-	-	-	-

Table 2 - 10 Highest Stability Margin Violations

MISO Transmissions Zones Stability Margin Reliability Report					
Transmission Zone	Date - Time	Transmission Line	Rec Max Min	Actual	Observations
Transmission Zone 1	2011-08-17 13:05	GAR_HWY	>0.983 or <0.231	20.00	-
	2011-08-17 20:45	GAR_HWY	>0.983 or <0.231	20.00	-
	2011-08-17 13:05	RCK_ARP	>0.983 or <0.231	20.00	-
	2011-08-17 20:45	RCK_ARP	>0.983 or <0.231	20.00	-
	2011-08-17 13:05	BLO_WOR	>0.983 or <0.231	20.00	-
	2011-08-17 15:10	RCK_ARP	>0.983 or <0.231	12.48	-
	2011-08-17 15:10	GAR_HWY	>0.983 or <0.231	12.47	-
	2011-08-17 13:50	RCK_ARP	>0.983 or <0.231	4.98	-
	2011-08-17 13:20	RCK_ARP	>0.983 or <0.231	4.28	-
	2011-08-17 14:50	RCK_ARP	>0.983 or <0.231	3.60	-
Transmission Zone 2	-	-	-	-	-
Transmission Zone 3	-	-	-	-	-

Table 3 - 10 Highest Thermal Margin Violations

MISO Transmissions Zones Thermal Margin Reliability Report					
Transmission Zone	Date - Time	Transmission Line	Rec Max Min	Actual	Observations
Transmission Zone 1	2011-08-17 17:35	MER_WOR	>1.000 or <0.678	0.49	-
	2011-08-17 17:50	MER_WOR	>1.000 or <0.678	0.49	-
	2011-08-17 17:40	MER_WOR	>1.000 or <0.678	0.49	-
	2011-08-17 17:45	MER_WOR	>1.000 or <0.678	0.49	-
	2011-08-17 17:55	MER_WOR	>1.000 or <0.678	0.50	-
	2011-08-17 17:30	MER_WOR	>1.000 or <0.678	0.50	-
	2011-08-17 17:20	MER_WOR	>1.000 or <0.678	0.50	-
	2011-08-17 16:45	MER_WOR	>1.000 or <0.678	0.50	-
	2011-08-17 16:55	MER_WOR	>1.000 or <0.678	0.50	-
Transmission Zone 2	-	-	-	-	-
Transmission Zone 3	-	-	-	-	-

3. TRANSMISSION ZONE 1 VOLTAGE MARGIN

3.1 Voltage, Stability, Thermal Margin - Overview

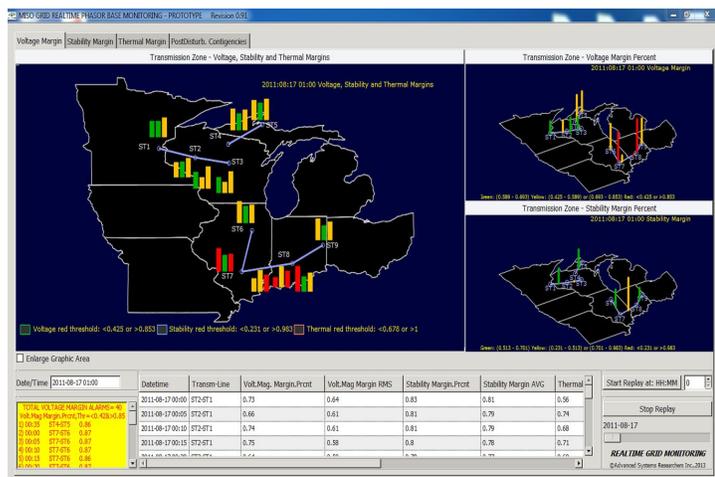


Fig 1 - Voltage, Stability, Thermal Margins

3.2 Voltage, Stability, Thermal Margins - Map 2D

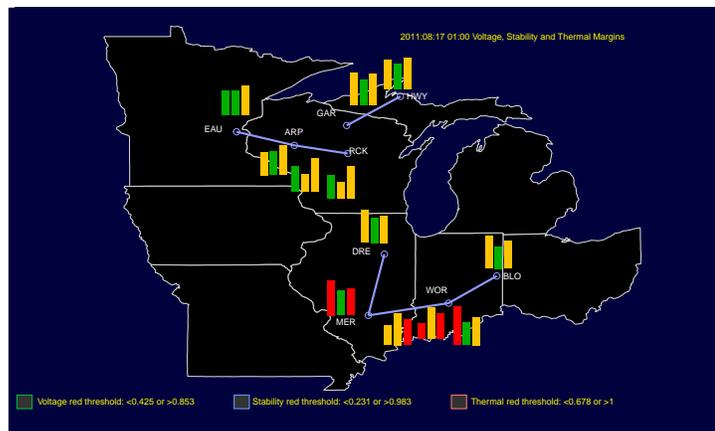


Fig 2 - Voltage, Stability, Thermal Margins Map 2D

Description:

Figure 2 presents the 2D Map with bars showing the Voltage, Stability,

and Thermal margin values for the two terminals for all transmission lines for 5 minutes periods.

3.3 Voltage Margin - Heatmap

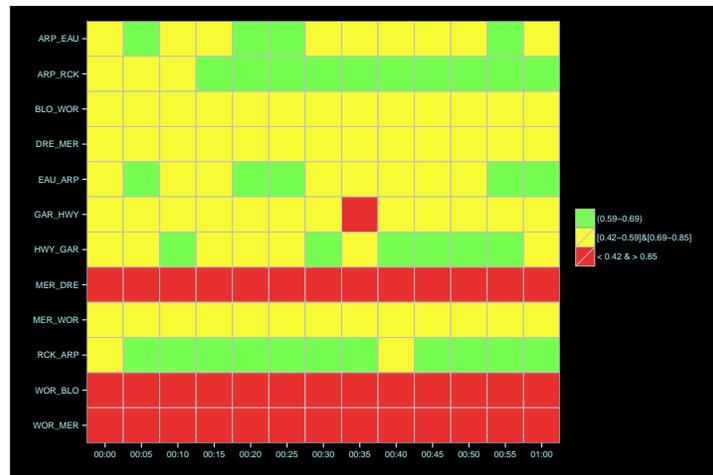


Fig 3 - Voltage Margin Heatmap

Description:

Figure 3 presents the Heatmap showing the Voltage Margin value for the two terminals for each transmission line for 5 minute periods in one hour

3.4 Voltage, Stability, Thermal Margins - Linear Plot

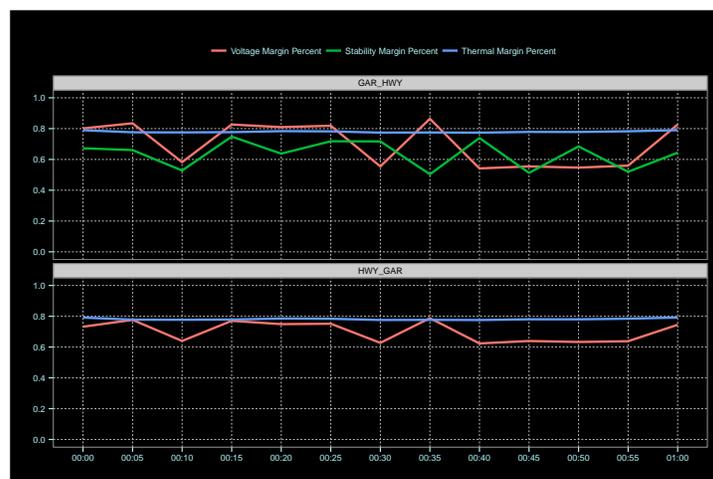


Fig 4 - Voltage, Stability, Thermal Margins Linear Plot

Description:

Figure 4 presents the linear graph showing the Voltage, Stability and Thermal margin values for both terminals for one transmission line for 5 minute periods for one hour.

3.5 Voltage, Stability, Thermal Margins - Circular Graph

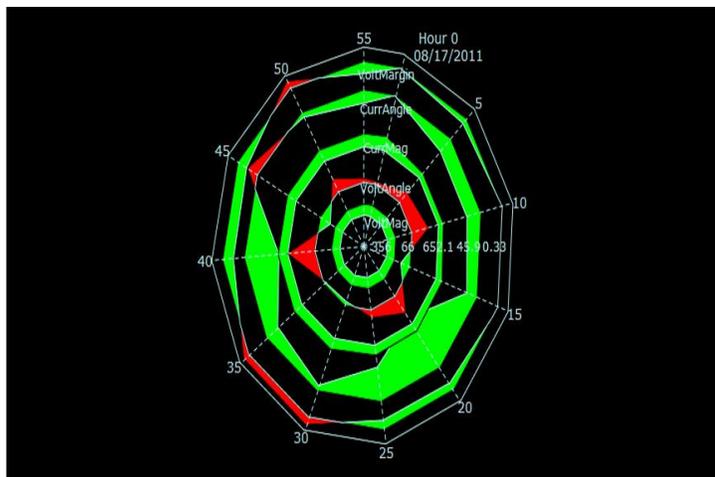


Fig 5 - Voltage, Stability, Thermal Margins Circular Graph

Description:

Figure 5 presents the circular graph showing the voltage and current magnitude and angle and the Voltage, Stability and Thermal margin values for one terminal for one transmission line for 5 minute periods for one hour.

3.6 Voltage Margin - Bar Plot

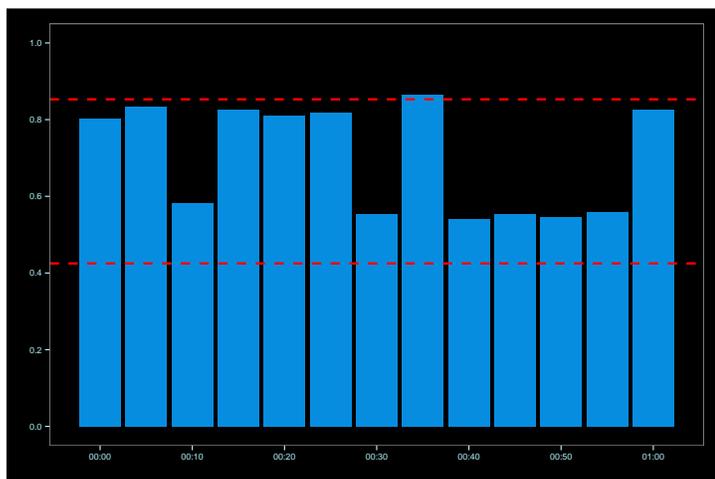


Fig 6 - Voltage Margin Bar Plot

Description:

Figure 6 presents the bar plot showing confiability bands for the Voltage margin value for one terminal for one transmission line for 5 minute periods for one hour.

3.7 Voltage Margin - Statistical Process Control (SPC)

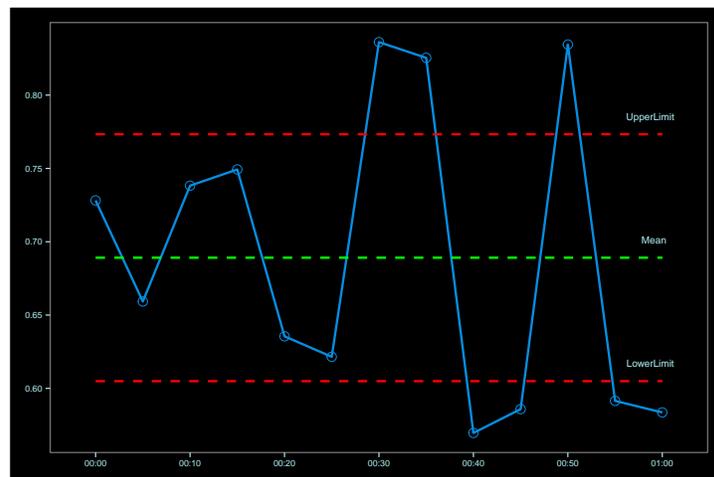


Fig 7 - Voltage Margin Statistical Process Control (SPC)

Description:

Figure 7 presents the linear plot showing statistical patterns for the Voltage margin value for one terminal for one transmission line for 5 minute periods for one hour.

3.8 Voltage Margin - Map 3D

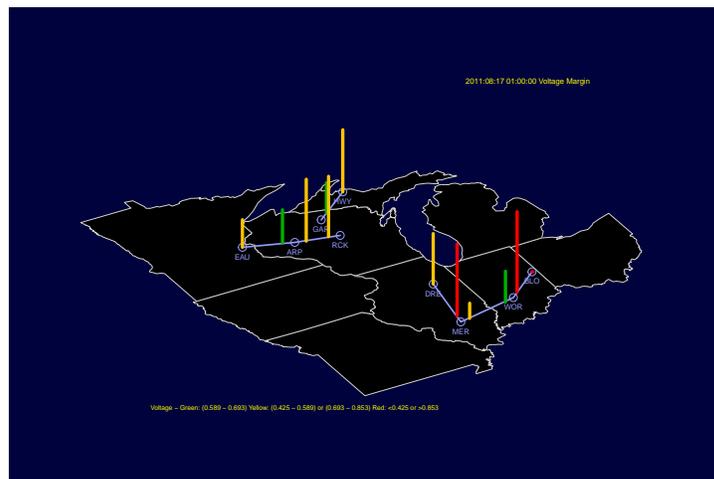


Fig 8 - Voltage Margin Map 3D

Description:

Figure 8 presents the 3D map with bars showing Voltage margin for the two terminals for all transmission lines for 5 minute periods.

3.9 Voltage, Stability, Thermal Margins - Map 3D

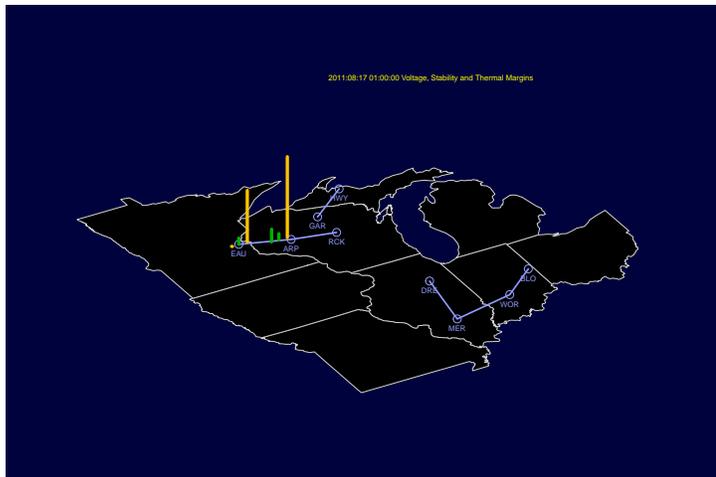


Fig 9 - Voltage, Stability, Thermal Margins Map 3D

Description:

Figure 9 presents the 3D map with bars showing the value for the Voltage, Stability, and Thermal margins for the two terminals for all transmission lines for 5 minute periods.

4. TRANSMISSION ZONE 1 STABILITY MARGIN

4.1 Stability Margin - Overview

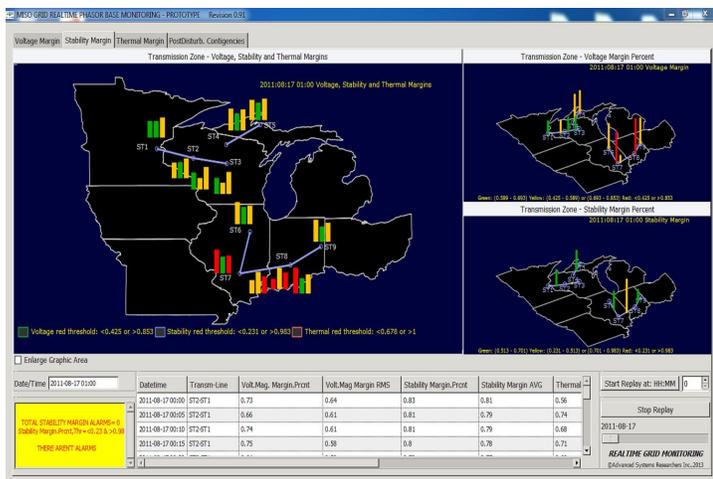


Fig 10 - Stability Margin Overview

4.2 Voltage, Stability, Thermal Margins - Map 2D

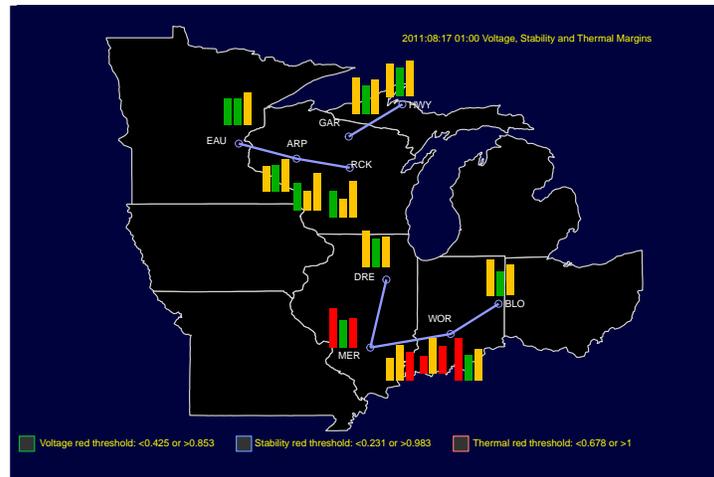


Fig 11 - Voltage, Stability, Thermal Margins Map 2D

Description:

Figure 11 presents the 2D map with bars showing the value for the Voltage, Stability, and Thermal margins for the two terminals for all transmission lines for 5 minute periods.

4.3 Stability Margin - Heatmap

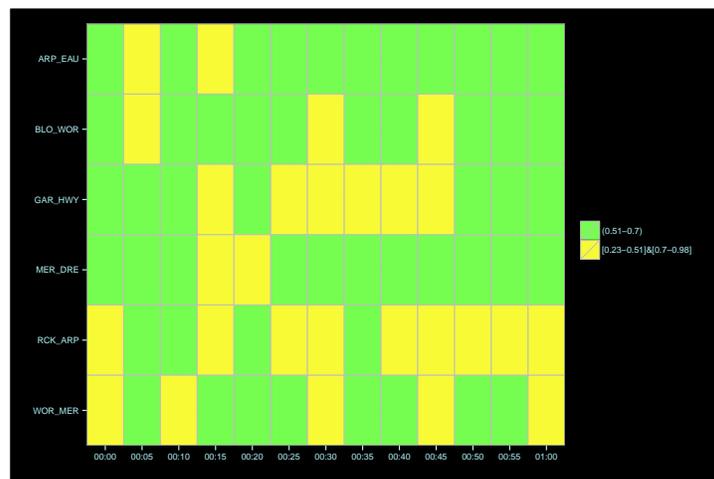


Fig 12 - Stability Margin Heatmap

Description:

Figure 12 presents the Heatmap showing the value for the Stability margin for the two terminals for each transmission line for 5 minute periods for one hour.

4.4 Voltage, Stability, Thermal Margins - Linear Plot

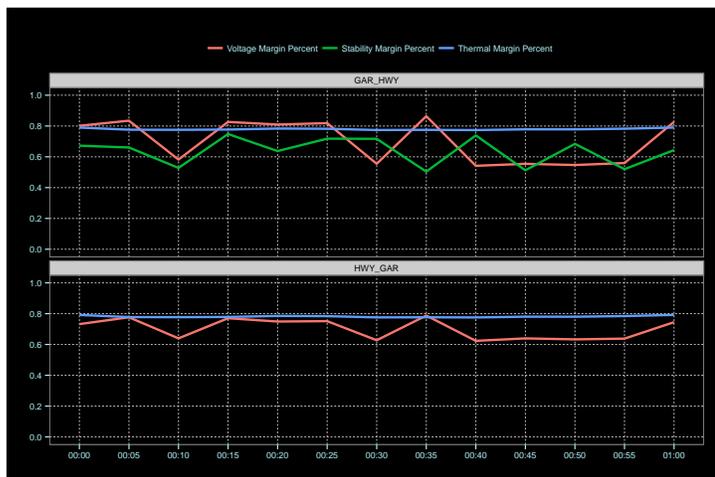


Fig 13 - Voltage, Stability, Thermal Margins Linear Plot

Description:

Figure 13 presents the linear graph showing the Voltage, Stability, and Thermal margin values for both terminals for one transmission line for 5 minute periods for one hour.

4.5 Voltage, Stability, Thermal Margins - Circular Graph

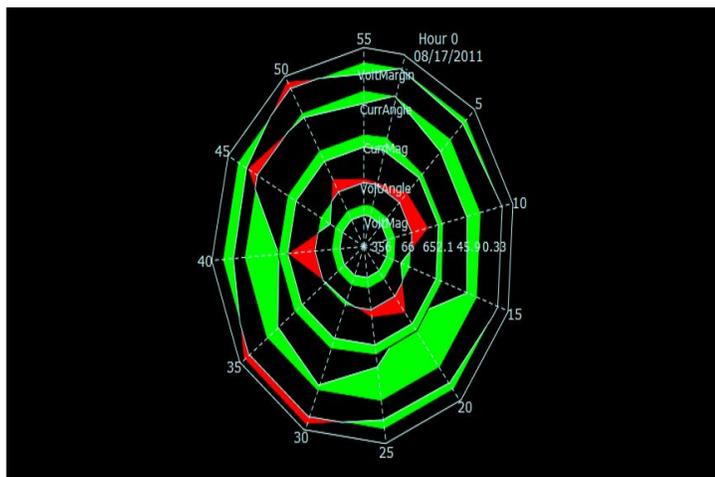


Fig 14 - Voltage, Stability, Thermal Margins Circular Graph

Description:

Figure 14 presents the circular graph showing the voltage and current magnitude and angle and the Voltage, Stability, and Thermal margin values for one terminal for one transmission line for 5 minute periods for one hour.

4.6 Stability Margin - Bar Plot

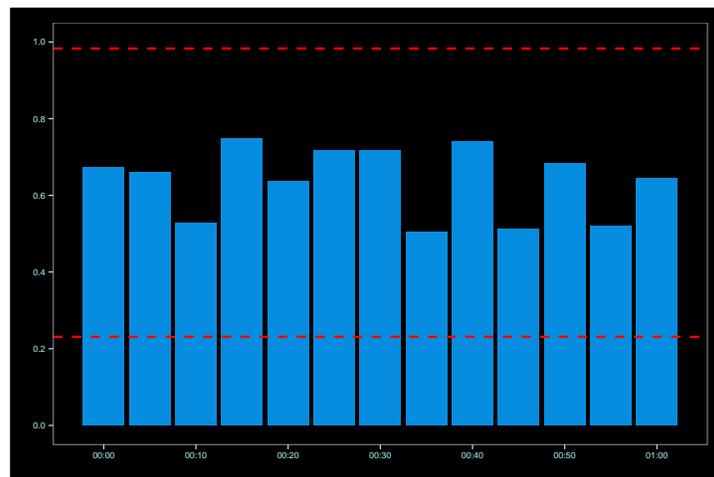


Fig 15 - Stability Margin Bar Plot

Description:

Figure 15 presents the bar plot showing confiabiitiy bands for the Stability margin value for one terminal for one transmission line for 5 minute periods for one hour.

4.7 Stability Margin - Statistical Process Control (SPC)

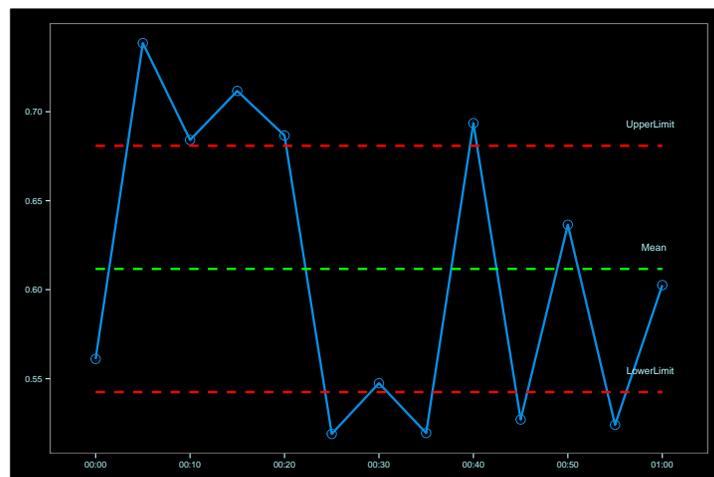


Fig 16 - Stability Margin Statistical Process Control (SPC)

Description:

Figure 16 presents the linear plot showing statistical patterns for the Stability margin value for one terminal for one transmission line for 5 minute periods for one hour.

4.8 Stability Margin - Map 3D

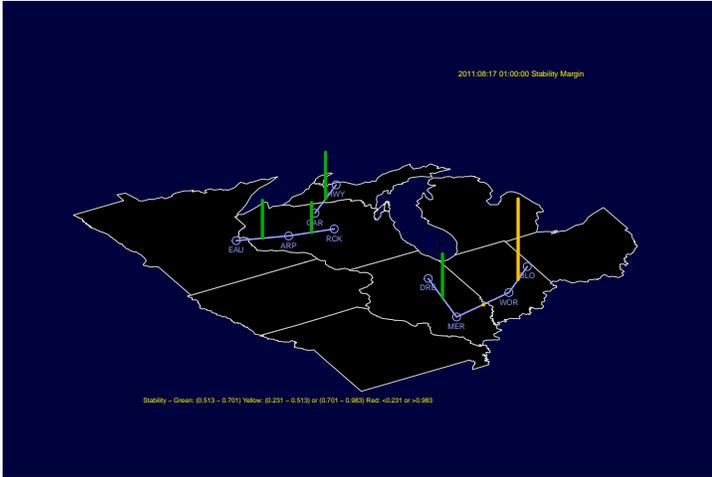


Fig 17 - Stability Margin Map 3D

Description:

Figure 17 presents the 3D map with bars showing Stability margin for the two terminals for all transmission lines for 5 minute periods.

4.9 Voltage, Stability, Thermal Margins - Map 3D

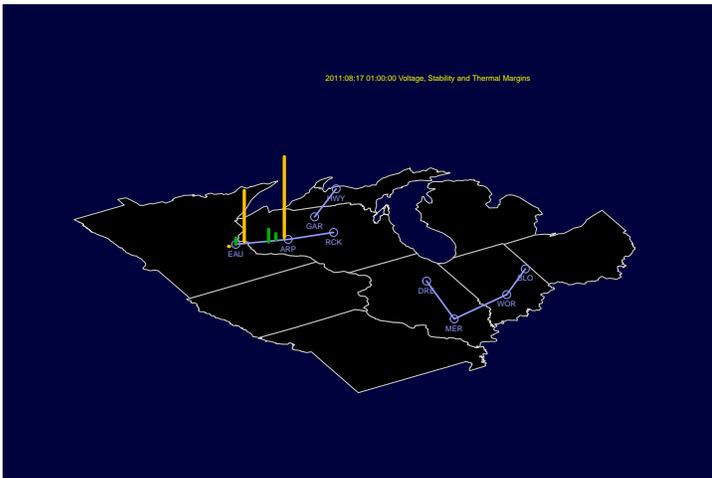


Fig 18 - Voltage, Stability, Thermal Margins Map 3D

Description:

Figure 18 presents the 3D map with bars showing the value for the Voltage, Stability, and Thermal margins for the two terminals for all transmission lines for 5 minute periods.

5. TRANSMISSION ZONE 1 THERMAL MARGIN

5.1 Thermal Margin - Overview

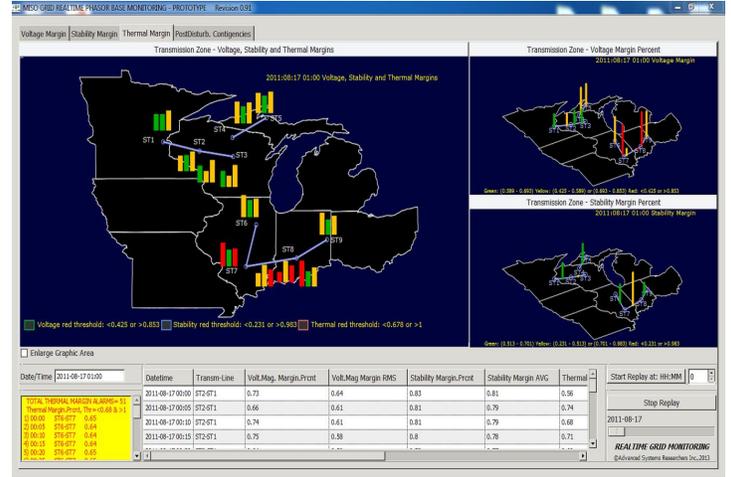


Fig 19 - Thermal Margin Overview

5.2 Voltage, Stability, Thermal Margins - Map 2D

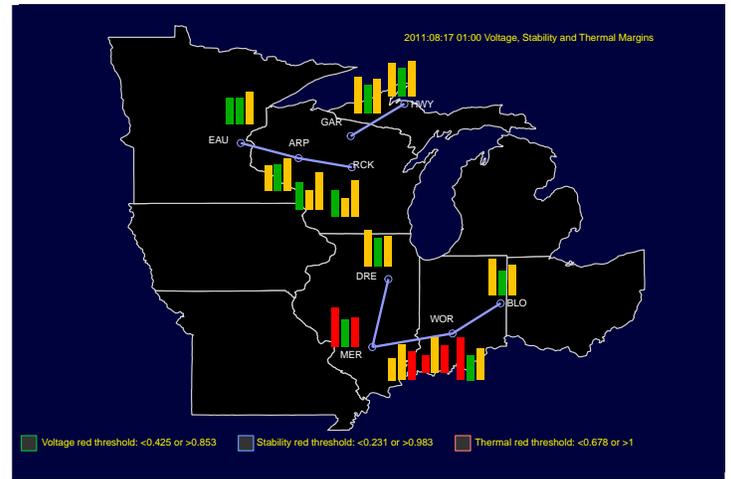


Fig 20 - Voltage, Stability, Thermal Margins Map 2D

Description:

Figure 20 presents the 2D map with bars showing the value for the Voltage, Stability, and Thermal margins for the two terminals for all transmission lines for 5 minute periods.

5.3 Thermal Margin - Heatmap

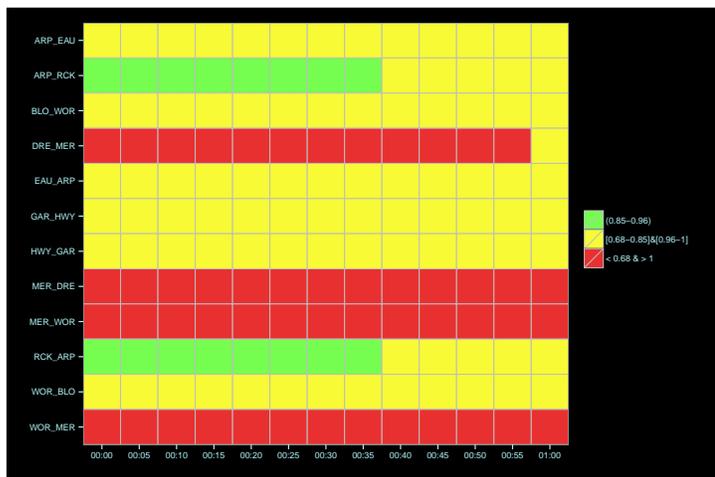


Fig 21 - Thermal Margin Heatmap

Description:

Figure 21 presents the Heatmap showing the value for the Thermal margin for the two terminals for each transmission line for 5 minute periods for one hour .

5.4 Voltage, Stability, Thermal Margins - Linear Plot

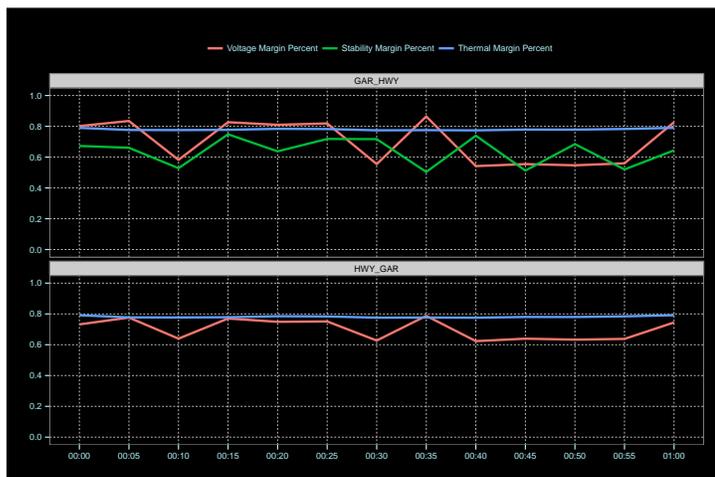


Fig 22 - Voltage, Stability, Thermal Margins Linear Plot

Description:

Figure 22 presents the linear graph showing the Voltage, Stability, and Thermal margin values for both terminals for one transmission line for 5 minute periods for one hour.

5.5 Voltage, Stability, Thermal Margins - Circular Graph

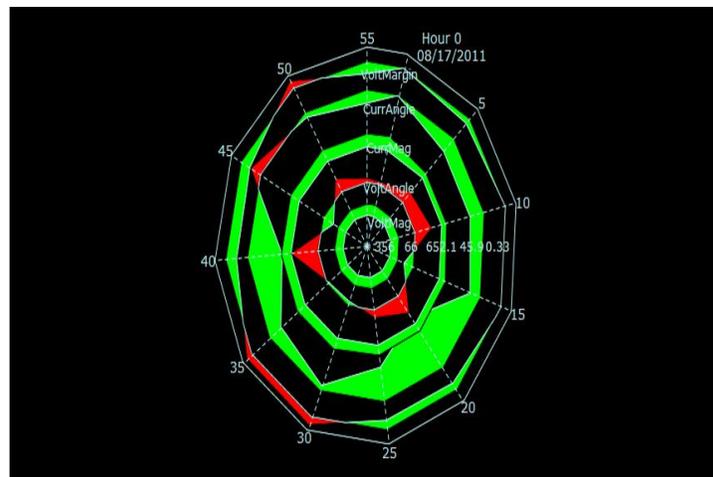


Fig 23 - Voltage, Stability, Thermal Margins Circular Graph

Description:

Figure 23 presents the circular graph showing the voltage and current magnitude and angle and the Voltage, Stability, and Thermal margin values for one terminal for one transmission line for 5 minute periods for one hour.

5.6 Thermal Margin - Bar Plot

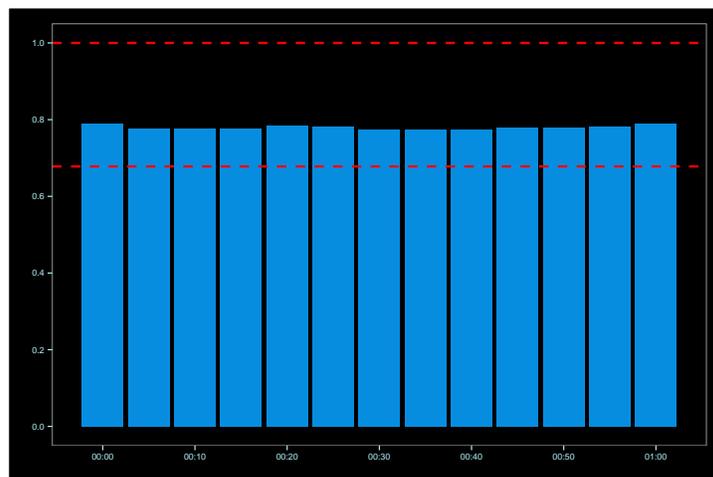


Fig 24 - Thermal Margin Bar Plot

Description:

Figure 24 presents the bar plot showing confiabilitiy bands for the Thermal margin value for one terminal for one transmission line for 5 minute periods for one hour.

5.7 Thermal Margin - Statistical Process Control (SPC)

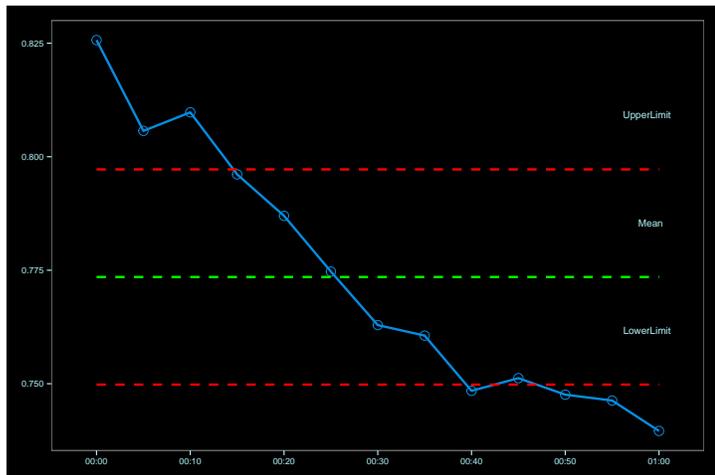


Fig 25 - Thermal Margin Statistical Process Control (SPC)

Description:

Figure 25 presents the linear plot showing statistical patterns for the Thermal margin value for one terminal for one transmission line for 5 minute periods for one hour.

5.8 Thermal Margin - Map 3D

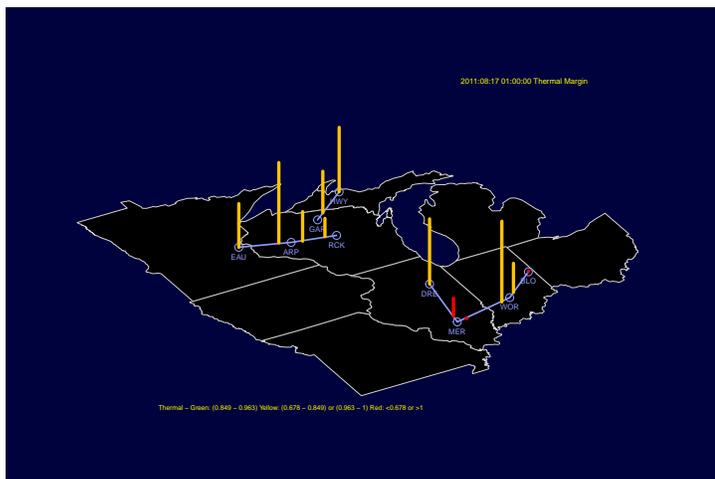


Fig 26 - Thermal Margin Map 3D

Description:

Figure 26 presents the 3D map with bars showing the Thermal margin for the two terminals for all transmission lines for 5 minute periods.

5.9 Voltage, Stability, Thermal Margins - Map 3D

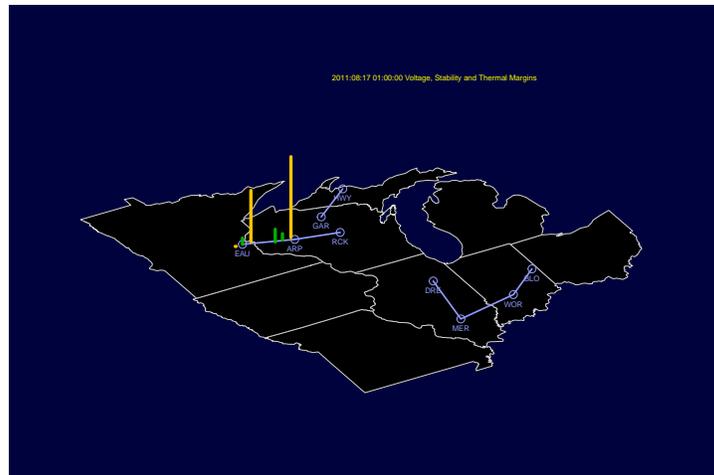


Fig 27 - Voltage, Stability, Thermal Margins Map 3D

Description:

Figure 27 presents the 3D map with bars showing the value for the Voltage, Stability, and Thermal margins for the two terminals for all transmission lines for 5 minute periods.

Footnotes

1. NERC Reliability Coordinators Working Group, "Guideline for Operating State Alert Levels," Response to August 2003 Blackout Recommendation, May 22, 2007.
2. Please note that an emergency state results when load is dropped, and hence no performance metrics data is presented.