Balancing Authority Ace Limit (BAAL) Proof-of-Concept BAAL Field Trial

Overview

The Reliability-based Control Standard Drafting Team and the Balancing Area Control Standard Drafting Team were combined to form the Balancing Area Reliability-based Control Standard Drafting Team (BARCSDT). This team continues to provide the support for the Balancing Area ACE Limit field trial initiated by the Reliability-based Control Standard Drafting team whose SAR included the following purpose statements:

A) To maintain Interconnection frequency within predefined frequency limits under all conditions (i.e., normal and abnormal), to manage frequency-related issues such as frequency oscillations, instability, and unplanned tripping of load, generation or transmission, that adversely impact the reliability of the Interconnection.

B) To support corrective action by the BA when its excessive Area Control Error, as determined by this standard, may be contributing to or causing action to be taken to correct an SOL or IROL problem.

C) To prevent Interconnection frequency excursions of short-duration attributed to the ramping of Interchange Transactions.

D) To support timely congestion relief by requiring the Balancing Authority to employ corrective load/generation management within a defined timeframe when participating in transmission loading relief procedures.

E) To address the directives of FERC Order 693 detailed in the SAR.

A draft standard, initially identified as BAL-007, was drafted by the Reliability-based Control Standard Drafting Team to address purpose statement A. This draft standard defined Balancing Authority ACE Limit (BAAL) and required the Balancing Authority to balance its resources and demand in real-time so that its clock-minute average of its Area Control Error (ACE) does not exceed its BAAL for more than 30 consecutive clock-minutes. The draft standard renamed Control Performance Standard 1 (CPS1) to Control Performance Measure (CPM) without changing its metrics and proposed the elimination of Control Performance Standard 2 (CPS2).

As a proof of concept for draft standard BAL-007, a BAAL field trial was approved by the NERC Standards Committee and the Operating Committee. Currently as of February 2011, there are 13 Balancing Authorities participating in the Eastern Interconnection, 25 Balancing Authorities participating in the Western Interconnection, the ERCOT Balancing Authority, and Hydro Quebec. Reliability Coordinators for all interconnections continue to monitor the performance of those participating Balancing Authorities and provide information to support the monthly analysis of the BAAL field trial.

BAAL field trial Preparation

Balancing Authorities not currently participating in the BAAL field trial are encouraged to consider participation by contacting either the Chair or any member of the BARCSDT. Prior to approval to operate under the BAAL field trial, each Balancing Authority must do the following:

1) Provide the BARCSDT with the name, phone number and email address of:
    a. the primary contact for the BAAL field trial,
    b. the party responsible for monthly performance reporting,
    c. the director/manager/supervisor over Balancing Authority operations,
    d. the compliance contact for its Reliability Entity
2) Provide one month or more of historic clock-minute data using the data format and calculations described in Attachment A to confirm the Balancing Authority's capability to accurately calculate and report performance under the BAAL field trial,
3) Provide screen-shots of the operator interface that will be used to monitor real-time performance under the BAAL field trial,
4) Provide confirmation that operators have been trained on the operator interface and actions that may be needed while under the BAAL field trial so that the clock-minute ACE does not exceed the BAAL for more than 30 consecutive clock-minutes, and
5) Provide contact information for its Reliability Coordinator and confirmation that the Reliability Coordinator has been contacted with regard to operating under the BAAL field trial. (One or more members of the BARCSDT will coordinate a joint conference call with Balancing Authority and its Reliability Coordinator to discuss the BAAL field trial and the timing for beginning operation.)
6) Provide verification that the Balancing Authority will maintain the capability to operate in compliance with the CPS2 requirement in the case where the Balancing Authority has been requested to cease operation under the BAAL field trial.

BAAL field trial Requirements

For the duration of the BAAL field trial, the participating Balancing Authorities will continue to be responsible for compliance under the NERC Standards including:

BAL-001 Real Power Balancing Control Performance (CPS1)
BAL-002 Disturbance Control Performance (DCS)
IRO-001 Reliability Coordinator - Responsibilities and Authority

Prior to a Balancing Authority beginning operation under the BAAL field trial, the BARCSDT Chair will provide documentation to the NERC Standards Committee, the NERC Vice President and Director of Standards, and the NERC Vice President and Director of Compliance, requesting that the Balancing Authority be added to the list of participating Balancing Authorities waived of compliance to NERC CPS2 while operating under the BAAL field trial.

Any requests for the Balancing Authority to take corrective action from the Reliability Coordinator will be documented by the Balancing Authority (including the duration of the Reliability Coordinator request) and provided to the BARCSDT within 24 hours of such event. Upon receipt of notification from the Balancing Authority, the Chair of the BARCSDT will contact the Reliability Coordinator to determine if a conference call is necessary. If so, the Chair will set up a call between the BARCSDT, the Balancing Authority, and its Reliability Coordinator to determine what actions are necessary to address the issues raised by the Reliability Coordinator.

Participating Balancing Authorities will be fully responsible for operating and reporting their performance under the BAAL field trial. Each Balancing Authority will provide its clock-minute data for its first two weeks of operations under the BAAL field trial in the CSV format provided in Attachment A for analysis and review by the BARCSDT. For each calendar month of the BAAL field trial, each Balancing Authority will provide its clock-minute data for the prior month's operations to the BARCSDT by the tenth working day of following month in the CSV format provided in Attachment A.

Note: Currently there are efforts to investigating the feasibility to automate the collection of monthly clock-minute data. If that effort proves successful each participating Balancing Authority will be notified regarding future requirements for submission of data.

Responsibility to Follow Reliability Coordinator Directives
Recognizing the authority that the Reliability Coordinator has under the NERC standards for directing corrective action, this section provides suggested actions the Reliability Coordinator over each participating Balancing Authority may take related to operation under the BAAL field trial. If any Reliability Coordinator experiences a problem on its system that it believes may be attributed to the real-time ACE of a participating Balancing Authority, where that Balancing Authority's ACE has exceeded the BAAL, the Reliability Coordinator over the participating Balancing Authority may direct the Balancing Authority to restore its ACE within BAAL compliance limits. At its discretion or at the request of a Reliability Coordinator experiencing a problem on its system, the Reliability Coordinator over the participating Balancing Authority may also direct the participating Balancing Authority to restore ACE within safe limits until the system problem is addressed. The Reliability Coordinator will notify the Balancing Authority when it can resume operations under the BAAL field trial.

In addition to the information provided above, Attachment B proposes actions to be taken by the Reliability Coordinator in consideration of abnormal Interconnection frequency.

BAAL field trial Performance Reporting
For analysis of Control Performance Standard 1 (CPS1) and Balancing Authority ACE Limit performance under the BAAL field trial, clock-minute data will be provided in monthly files no later than the tenth working day following the operating month to the BARCSDT as described in Attachment A.

On a monthly basis, each Balancing Authority will review its performance for the prior month and identify any periods where the ACE was less than the low BAAL ($BAAL_{Low}$) or greater than the high BAAL ($BAAL_{High}$) for more than ten consecutive clock-minutes. To help the BARCSDT gain a better understanding of the circumstances that all Balancing Authorities may be faced while operating under the BAAL field trial, each Balancing Authority will provide a brief explanation of the circumstances related to any periods where the duration of consecutive clock-minutes exceeded twenty minutes. In the event that no period exceeded twenty minutes in the prior month, but the longest duration exceeded ten minutes, the Balancing Authority will provide a brief explanation of the circumstances related to the longest event exceeding ten minutes. The brief explanations provided above will be for BARCSDT use and should be provided by the tenth working day following the operating month. In the event that the Balancing Authority exceeds 30 consecutive clock-minutes in restoring its ACE within the BAAL, the BARCSDT will request the Balancing Authority to provide a detailed account of the associated event to the Chair of the BARCSDT so that it can be reviewed by the BARCSDT.

Early Termination or Withdrawal from the BAAL field trial

The BARCSDT may terminate the BAAL field trial participation of one or more Balancing Authorities based upon the performance under the BAAL field trial. Balancing Authorities participating in the BAAL field trial will immediately cease operating under the proposed Balancing Authority ACE Limit if so directed by the BARCSDT as described in this document. Among other items, the BARCSDT will consider actions taken by the Balancing Authority when the BAAL was exceeded, whether there were events lasting more than 30 consecutive clock minutes, and whether a reliability-related problem was attributed to its operation under the BAAL field trial.

Any participating Balancing Authority may withdraw from the BAAL field trial upon notification to the BARCSDT of the date when it will cease operating under the BAAL field trial and be held responsible for compliance under CPS2. Withdrawal must occur at the end of a calendar month, with CPS2 compliance beginning the first day of the following month. Upon notification, the BARCSDT will contact the Standards Committee, the NERC Vice President and Director of Standards, and the NERC Director of Compliance, of the change in BAAL field trial participation.

ATTACHMENT A
BAAL field trial Data Submittal Format

As previously mentioned, current efforts are investigating how the collection of monthly clock-minute data might be automated. If that effort proves successful, participating Balancing Authorities will be notified of their future requirements for data submittal. Currently participating Balancing Authorities are required to submit data as detailed in this Attachment A.

For analysis of Control Performance Measure and Balancing Authority ACE Limit (BAAL) performance under the BAAL field trial, clock-minute data will be provided in monthly files under the following Comma-Separated-Variable (CSV) format:

BA, Date, Time, TimeZone, ACE, FreqError, FreqBias, ActFreq, SchedFreq, AQC, FQC, BAAL Low, MinCtLow, BAAL High, MinCtHigh, <*EOL*>

Field Name	**Description/Type**
BA	Number assigned to BA (5 characters in format BA-nn)
Date	Date format (MM/DD/YY),
Time	24-hour time format (hh:mm),
TimeZone	3-character time-zone abbreviation (EST, EDT, CST, CDT, etc)
ACE (REAL)	Clock-minute average Area Control Error (MW) (Minimum of 1 digit to right of decimal point)
FreqError (REAL)	Clock-minute average Frequency Error (Hz) *Frequency Error is equal to Actual Frequency minus Scheduled Frequency.* (Minimum of four digits to right of decimal point)
FreqBias (REAL)	Clock-minute average Frequency Bias Setting (MW/0.1 Hz) (Same precision as implemented in EMS)
ActFreq (REAL)	Clock-minute average Actual Frequency (Hz) (Minimum of four digits to right of decimal point)
SchedFreq (REAL)	Clock-minute average Scheduled Frequency (Hz) (Minimum of two digits to right of decimal point)
AQC* (INTEGER)	ACE Quality Code (0=valid data, 1=bad data)
FQC* (INTEGER)	Frequency Quality Code (0=valid data, 1=bad data)
BAAL Low (REAL)	$BAAL_{Low}$ (MW) (Minimum of 1 digit to right of decimal point)
MinCtLow (INTEGER)	Count of the consecutive minutes of ACE < $BAAL_{Low}$ when Actual Frequency is < 60 Hz.

BAAL High (REAL)	$BAAL_{High}$ (MW) (Minimum of 1 digit to right of decimal point)
MinCtHigh (INTEGER)	Count of the consecutive minutes of ACE > $BAAL_{High}$ when Actual Frequency > 60 Hz.

*If no quality code is available, then write 0 for all records. Ideally, the user should have the capability to update the quality code for the ACE and Frequency with each sample to flag whether that sample represents good or bad data. If over 50% of the samples of ACE for a given period have bad data, then AQC for that period should be flagged as "bad" (AQC=1) for the ACE represented. If less than 50% of the samples represent bad data, then AQC for the period should be flagged as "valid" (AQC=0) using only the good samples of ACE for that period. Likewise, if over 50% of the samples of frequency for a given period have bad data, then FQC for that period should be flagged as "bad" for the frequency represented. If less than 50% of the samples represent bad data, then FQC for that period should be flagged as "valid" using only the good samples of frequency for that period.

Example CSV records:

```
BA-03,11/21/2010,10:00,EST, -10.2,-0.0080,-90.0,59.9920,60.00,0,0,-281.3,0,0.0,0
BA-03,11/21/2010,10:01,EST,  -2.5,-0.0100,-85.0,59.9900,60.00,0,0,-212.5,0,0.0,0
BA-03,11/21/2010,10:02,EST,   1.6,-0.0070,-80.0,59.9930,60.00,0,0,-285.7,0,0.0,0
BA-03,11/21/2010,10:03,EST,-309.0,-0.0370,-80.0,59.9630,60.00,0,0, -54.1,1,0.0,0
BA-03,11/21/2010,10:04,EST,-310.4,-0.0420,-80.0,59.9580,60.00,0,0, -47.6,2,0.0,0
BA-03,11/21/2010,10:05,EST,-312.5,-0.0540,-80.0,59.9460,60.00,0,0, -37.0, 3,0.0,0
```

Note that the fourth row of data represents the first clock-minute record where the ACE of -309.0 MW was outside the $BAAL_{Low}$ boundary of -54.1 MW. As ACE remained outside the calculated BAAL boundary for the next two clock-minutes, "MinCtLow" was incremented for each record.

Note that column headings are <u>not</u> to be provided in the monthly CSV files.

Monthly File Naming Convention

Data will be provided to the BARCSDT on a monthly basis no later than the tenth working day of the month using the following naming convention:

YYYYMM_BA-**NN**.CSV, where YYYY is the four-digit year, MM is the two-digit month (01-12), and NN is the number assigned to the participating BA by the BARCSDT. For example, February 2011 data for BA-03 should be written to the file named “201102_BA-03.CSV” and provided to the BARCSDT.

Calculation of Variables

The Balancing Authority ACE Limit ("BAAL") should be calculated from the clock-minute averages of the data as follows:

Frequency Trigger Limits high and low should be those for the specific Interconnection. For example, Eastern Interconnection Frequency Trigger Limits are:

FTL_{Low} = 59.95 Hz
FTL_{High}= 60.05 Hz

X = Actual Frequency – 60 Hz
(Note: during time-error corrections, this variable is **not** equal to the Frequency Error which is always the sum of Actual Frequency minus Scheduled Frequency)

Needed to prevent division error when X = 0 but will be insignificant in the calculation when X < 0

If **X** <= 0 then
  $BAAL_{Low}$ = (-10*Frequency Bias*(FTL_{Low} -60 Hz)^2)/(**X** - 0.000000001)
  $BAAL_{High}$ = 0.0 (zero is used to reflect that the high bound is not applicable when X<=0)
Else
  $BAAL_{High}$ = (-10*Frequency Bias*(FTL_{High}-60 Hz)^2)/(**X**)
  $BAAL_{Low}$ = 0.0 (zero is used to reflect that the low bound is not applicable when X>0)
End If

The logic for the clock-minute counters (initialized at zero) would then use the logic:

If $BAAL_{Low}$ < 0 then
  If ACE < $BAAL_{Low}$ then
    MinCtLow = MinCtLow + 1
  Else
    MinCtLow = 0
  End If
  MinCtHigh = 0
End If

If $BAAL_{High}$ > 0 then
  If ACE > $BAAL_{High}$ then
    MinCtHigh = MinCtHigh + 1
  Else
    MinCtHigh = 0
  End If
  MinCtLow = 0
End If

Attachment B
Proposed Frequency Monitoring and Response Process For Reliability Coordinators in the Eastern Interconnection

Introduction

This document outlines a proposed frequency monitoring and response process for Reliability Coordinators in the Eastern Interconnection. The Balancing Authority ACE Limit (BAAL) under draft Balancing Authority ACE Limit can be applied consistently across all BAs (Balancing Authorities) as a measure to determine each BA's relative impact on the Interconnection frequency.

Short-Term Triggers (Reliability Coordinators (RC))

NOTE: If the frequency exceeds the FRL (Frequency Reliability Limit) or FAL (Frequency Abnormal Limit) High or Low, then immediate action is required. The Frequency Trigger Limit (FTL) represents the initial frequency where the Reliability Coordinators may be directing BAs to correct ACE (Area Control Error) after some period if necessary.

Clock-Minute Frequency	What	Actions
> 60.5	FRL_{High}	3
> 60.2	FAL_{High}	2
> 60.05 (if >10 minutes)	FTL_{High}	1
< 59.95 (if >10 minutes)	FTL_{Low}[1]	1
< 59.91	FAL_{Low}[1]	2
< 59.70	FRL_{Low}	3

Suggested RC Actions applicable to all BAs in the RC area:

1. BAs beyond BAAL for more than 30 consecutive clock-minutes may be directed to correct ACE. Contact all other BAs within your area with ACE beyond BAAL to make them aware of the frequency and the need for corrective action. Call Other RCs, communicate problem if known. Ask for cause if none reported. Log in RCIS under Frequency section. Notify Time Monitor of event and problem (if known). Time Monitor logs event and problem.
2. BAs beyond BAAL for more than 30 consecutive clock-minutes may be directed to correct ACE. If frequency is still beyond the FAL, contact all other BAs with ACE beyond BAAL to make them aware of the frequency and the need for corrective action. Call other RCs, communicate problem if known. Ask for cause if none is reported. Log into the Reliability Coordinator Information System (RCIS) under Frequency section. Notify Time Monitor of event and problem (if known). Time monitor logs event and problem.
3. Evaluate whether still interconnected. Direct emergency action. Call other RCs, communicate problem if known. Ask for cause if none is reported. Log in RCIS under Frequency section. Notify Time Monitor of event and problem (if known). Time monitor logs event and problem.

RCs should also log any unusual frequency events and report to the Time Monitor.

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[1] Based upon the prior Eastern Interconnection low Frequency Relay Limit of 59.82 Hz.

The Time Monitor will notify the Resources Subcommittee for all events logged by Time Monitor.

Metric	What	Actions
+/- 0.031Hz	Hourly Average	Call Other RCs, communicate problem if known. Ask for cause if none reported. Log in RCIS under Frequency section. Notify Time Monitor of event and problem (if known). Time Monitor logs event and problem.
28 mHz	Changes in one-minute average frequency deviation	Call Other RCs, communicate problem if known. Ask for cause if none reported. Log in RCIS under Frequency section. Notify Time Monitor of event and problem (if known). Time Monitor logs event and problem.
28 mHz	Change over 10 seconds (future-in CERTS)	Scan for corresponding ACE changes to capture unit trips for frequency response benchmarking. Call Other RCs, communicate problem if known. Ask for cause if none reported. Log in RCIS under Frequency section. Notify Time Monitor of event and problem (if known). Time Monitor logs event and problem.

Longer-Term Triggers and Benchmarks (Resources Subcommittee)

Metric	What	Actions
+/- 0.031Hz	Hourly Average	AIE Survey if no problem known. If problem known, survey entities involved to determine any lessons. Maintain record
20 mHz	Daily RMS1	Evaluate Day and determine need for survey. Maintain Record
16.8 mHz	Weekly RMS1	Evaluate Week and determine underlying cause. Maintain Record
28 mHz	Changes in one-minute average frequency deviation	If problem is known, maintain for excursion benchmarking. If problem is not known, ACE survey to determine problem.
28 mHz	Change over 10 seconds (future-in CERTS)	Scan for corresponding ACE changes to capture unit trips for frequency response benchmarking. If problem is not known, ACE survey to determine problem.

ATTACHMENT D

Monthly Review Procedure

By the tenth working day of each month, the participating Balancing Authorities provide the clock-minute data for the prior operating month to the BARCSDT as described in Attachment A. The clock-minute data for each Balancing Authority will be imported into a database where all records will be converted to GMT and time-aligned based upon the clock-minute Actual Frequency data.

The queries will provide the following:

1) All clock-minutes when FTL_{Low} was exceeded and

    a. Scheduled Frequency = 59.98 Hz
    b. Scheduled Frequency = 60.00 Hz
    c. Scheduled Frequency = 60.02 Hz

2) All clock-minutes when FTL_{High} was exceeded and

    a) Scheduled Frequency = 59.98 Hz
    b) Scheduled Frequency = 60.00 Hz
    c) Scheduled Frequency = 60.02 Hz

3) All clock-minutes where FTL_{Low} was exceeded, Scheduled Frequency = 59.98 Hz and Frequency Error was above -0.05 Hz.

4) All clock-minutes where FTL_{High} was exceeded, Scheduled Frequency = 60.05 Hz and Frequency Error was below 0.05 Hz.

5) The maximum number of clock-minutes that FTL_{Low} was exceeded for the month

6) The maximum number of clock-minutes that FTL_{High} was exceeded for the month

7) All clock-minutes where $BAAL_{Low}$ was exceeded for each Balancing Authority

8) All clock-minutes where $BAAL_{High}$ was exceeded for each Balancing Authority

9) The maximum number of clock-minutes that each Balancing Authority exceeded $BAAL_{Low}$

10) The maximum number of clock-minutes that each Balancing Authority exceeded $BAAL_{High}$

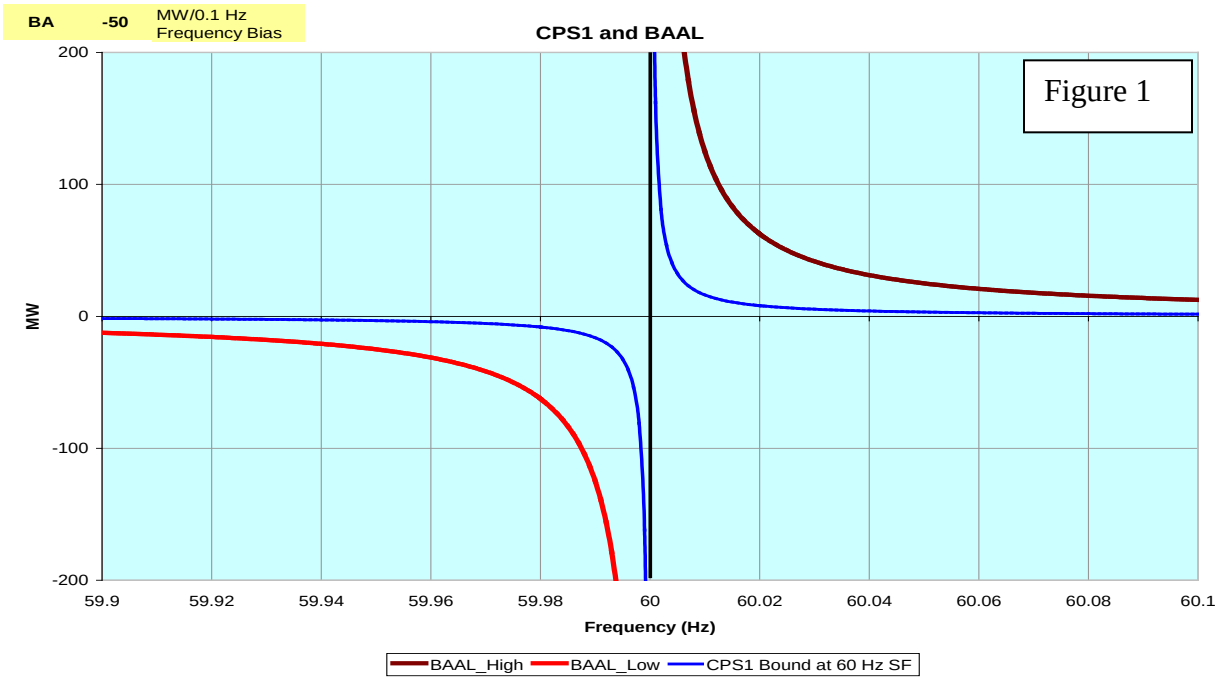
11) View of all Balancing Authorities for each clock-minute for comparison of

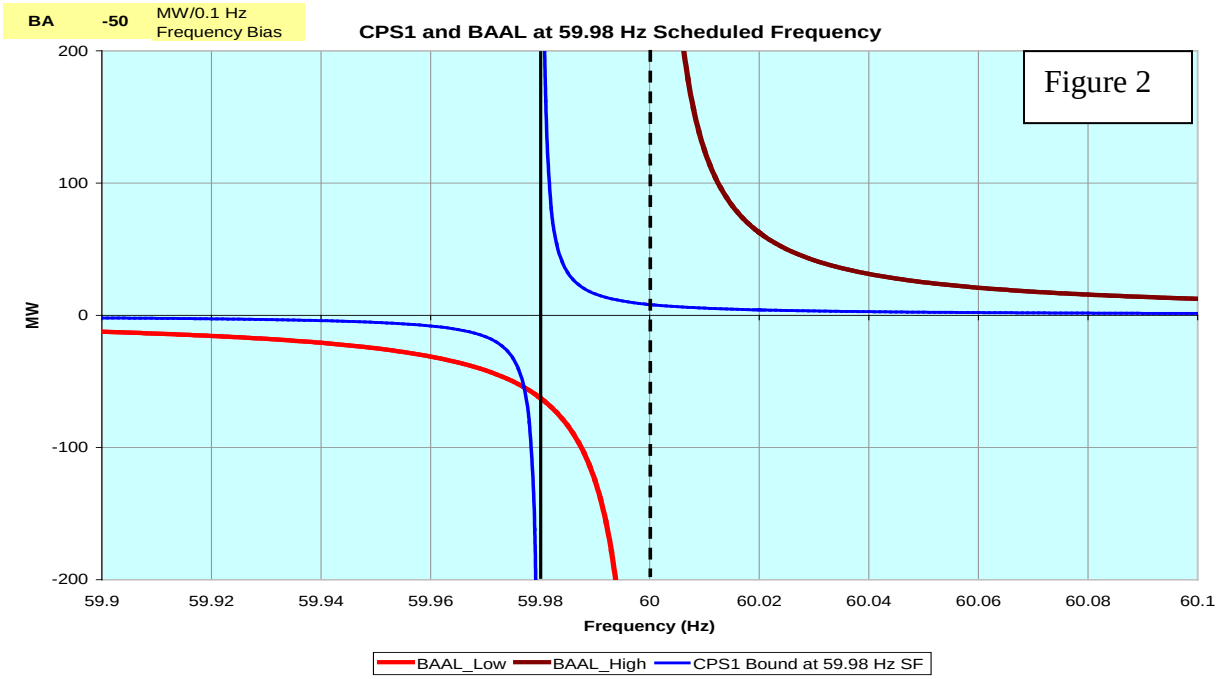
    a. Actual Frequency
    b. Scheduled Frequency
    c. ACE
    d. Minute Counts for $BAAL_{Low}$ or $BAAL_{High} > 0$
    e. CPS1
    f. ACPS1 (as described in Attachment D)

ATTACHMENT D

Sample Calculations and Available Tools for Balancing Authority ACE Limit Performance Evaluation

CPS1 is a calculation for control performance that considers Balancing Authority operation at all times to Scheduled Frequency. During fast or slow time-error corrections, the CPS1 curves shift in a manner symmetric about the Scheduled Frequency, as illustrated in Figures 1 and 2.



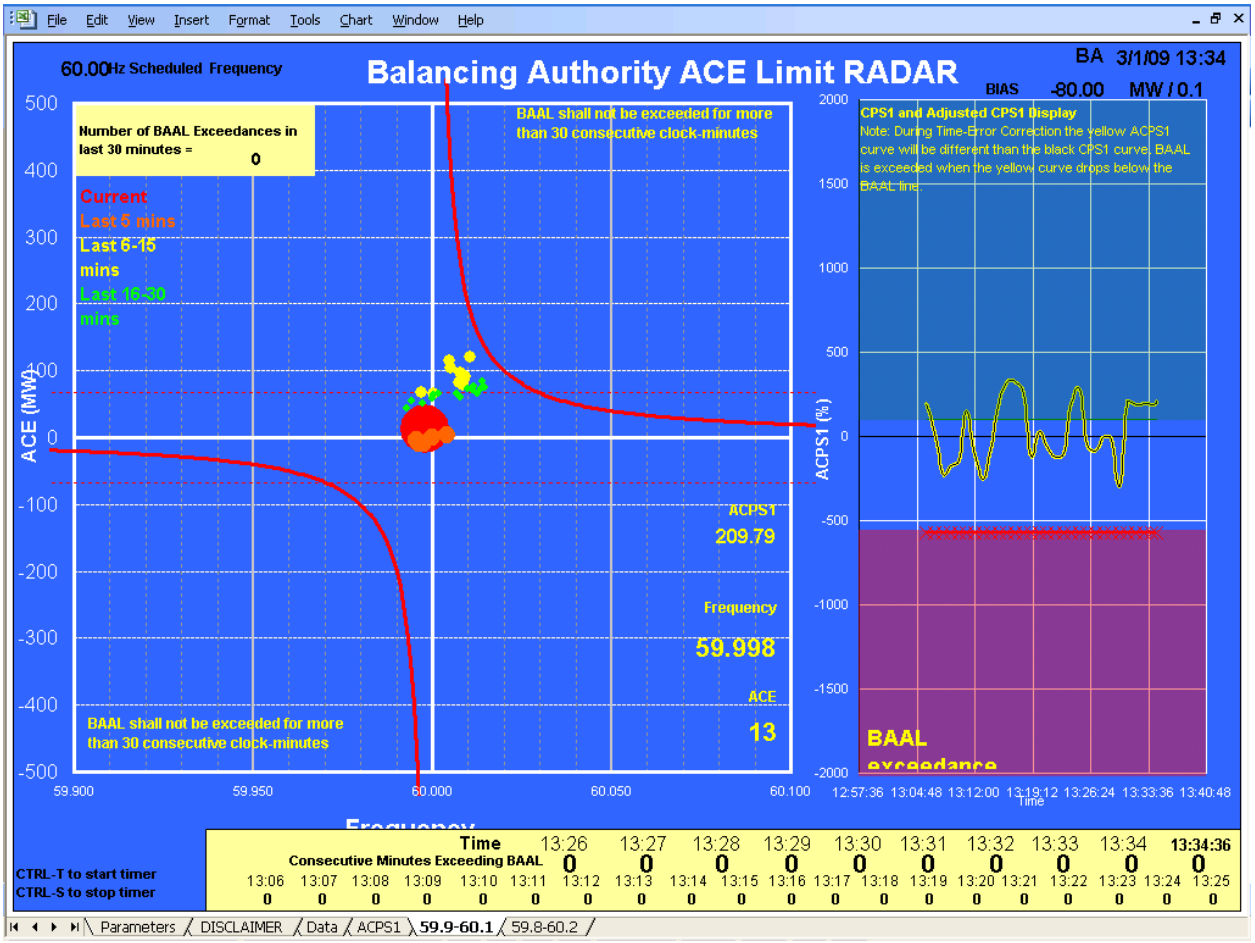


The Balancing Authority ACE Limit ("BAAL") was developed "from the ground up", considering the targeted research and development of Interconnection-specific Frequency Relay Limits, Frequency Abnormal Limits, and Frequency Trigger Limits. As the BAAL calculation is not a function of the Scheduled Frequency, its associated curves do not shift in a manner similar to CPS1, rather the limits remain symmetric about 60 Hz. as illustrated in Figures 1 and 2.

Though good performance in the long term under CPS1 is based upon control about the Scheduled Frequency, good performance in real-time under the BAAL is based also upon control in support of the Interconnection frequency and taking action to limit the duration of operating outside a variable bound that gets "tighter" as Actual Frequency deviates further from 60 Hz.

One type of display used to monitor when ACE exceeds the BAAL is provided below. The chart tracks the number of consecutive clock-minutes that ACE exceeds the BAAL along with displaying clock-minute ACE in relation to the clock-minute Actual Frequency.

Figure 3



The screen above is from an Excel worksheet that brings in data from an OSI PI DataLink server (real-time and historic data) to display the last 30 clock-minutes of ACE where the color and size of the dots reflect the length of time passed. The Excel file is available on the NERC Reliability-Based Control website along with instructions for implementation with PI DataLink. As the duration of ACE exceeding the BAAL is a critical aspect of the draft requirement, Balancing Authorities may prefer to trend a value as a function of time similar to other operator interfaces where time is displayed on the X or Y axis, as provided below.

In Eastern Interconnection, NERC CPS1 is calculated as follows:

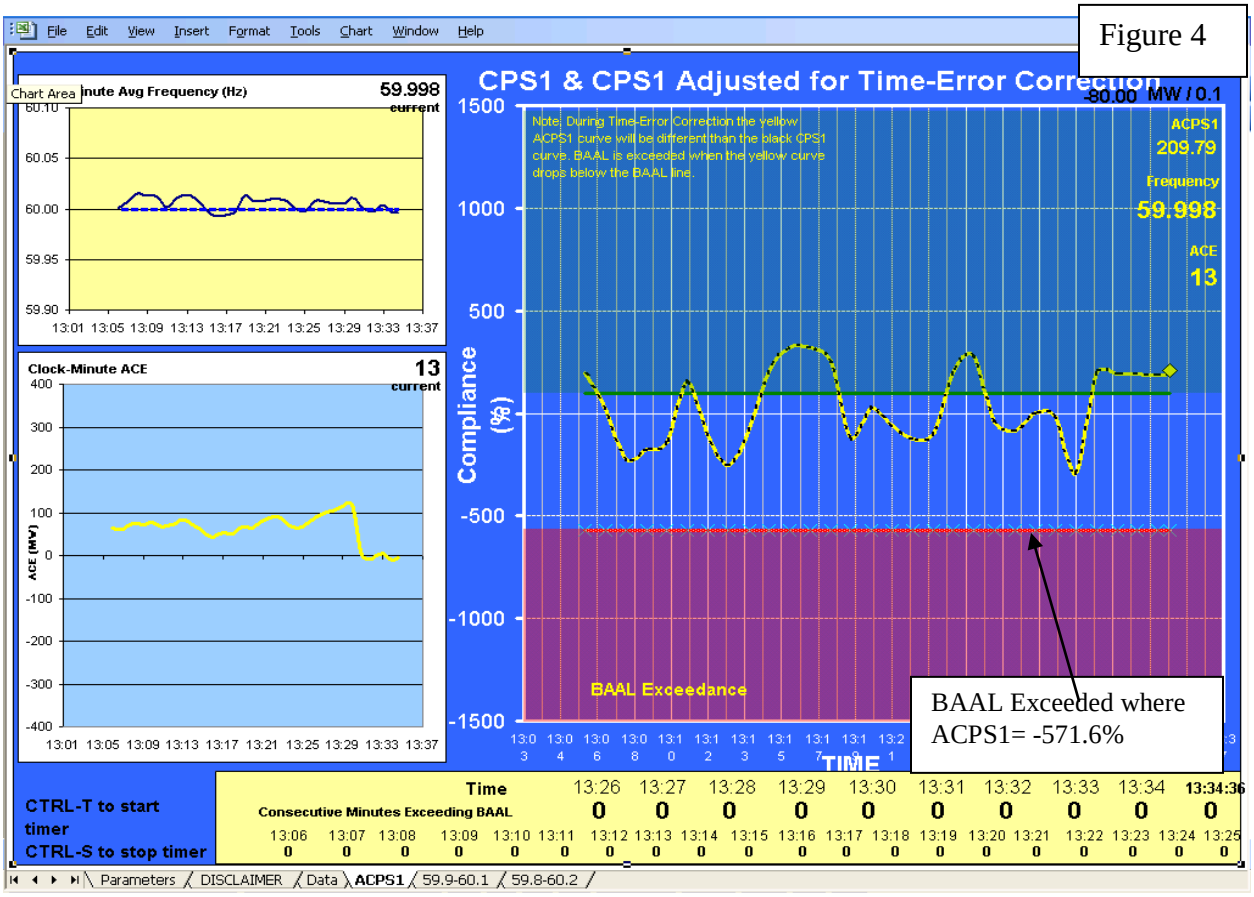
CPS1 = (2-(ACE*Frequency Error)/(-10*Frequency Bias*0.018*0.018))*100
Note: clock-minute average values must be used for all variables

In addition to calculating real-time performance under the BAAL by comparing the clock-minute value of ACE to the calculated clock-minute value of the BAAL, the Balancing Authority can also monitor an adjusted version of the NERC CPS1 calculation that is not dependent upon Scheduled Frequency and referred to in this document as “ACPS1”. In the ACPS1 calculation below, Frequency Error is replaced with the term “(Actual Frequency – 60)”.

ACPS1 = (2-(ACE*(Actual Frequency - **60**))/(-10*Frequency Bias*0.018*0.018))*100
Note: clock-minute average values must be used for all variables
Note: when Scheduled Frequency = 60 Hz, the calculations of CPS1 and ACPS1 are identical

The BAAL calculation provided in Attachment A shows that BAAL varies as a function of the Actual Frequency. By substituting BAAL for ACE in the ACPS1 calculation for a given value of Actual Frequency, one can determine that ACE exceeds the BAAL when ACPS1 is worse than approximately minus 571.6% for any Balancing Authority in the Eastern Interconnection. This information is useful in that the operator can monitor its performance against a bound that remains fixed with the value being monitored (ACPS1) being a function of ACE and Actual Frequency.

Figure 4



In the display above, the dotted line in the main chart to the right represents the CPS1 calculation and the yellow line represents the ACPS1 calculation. When Scheduled Frequency = 60 Hz, the values are identical; however, during times of fast or slow time-error correction, the curves will be different, requiring the operator to monitor operation to the long-term goal of averaging above 100% for CPS1, but also take action when the yellow line drops below -571.6% ACPS1 reflecting when the BAAL has been exceeded. The chart displayed can be selected from the same Excel worksheet as the prior display available on the NERC Reliability-Based Control website.