POWER SYSTEM OPERATION CORPORATION LIMITED

New Delhi

Date: 11-06-2020

Subject: Detailed Signal List for connecting generators under Automatic Generation Control (AGC) to National Load Despatch Centre (NLDC), New Delhi

Sir / Madam,

Hon'ble CERC order dated 28th August, 2019 in petition number 319/RC/2018, directed the enabling of Automatic Generation Control (AGC) functionality at all the ISGS stations whose tariff is determined or adopted by CERC, before 28th February 2020 and the implementation of AGC in India.

NLDC on 17th September 2019, notified the minimum requirement of equipment(s)/actions at power plants for enabling AGC functionality (based on experience of AGC Pilot Project). The same was uploaded on the NLDC, POSOCO website at https://posoco.in/download/communication-to-power-plants-regarding-agc/?wpdmdl=24784

Following this, physical meetings were held at NLDC on 3rd Oct 2019 and 2nd Dec 2019 for clarifying queries regarding the way ahead for implementation of AGC. Email correspondences, teleconferences, video conferences were also held on the subject with requesting parties. All the generators have made progress in the arrangement of AGC connecting equipment at the power plants, which was communicated to CERC vide letters dated 31st Dec 2019 and 28th April 2020.

Since all the generators have reached the on-site implementation phase, please find below **Annexure-I**, which provides the detailed explanation for the AGC signal list to be exchanged between NLDC and power plants for facilitating ease of on-site implementation by cross-functional AGC teams at power plants in coordination with RLDCs and NLDC. Some simple logics to be created at power plant are also provided which intend to safeguard the power plant and resulting accounts in case of communication failure. This detailed signal list and logics may please be understood thoroughly by the respective implementation teams before undertaking on-site work. Annexure-I also provides the logic to be configured in the RTU.

Any queries may please be emailed to agcnldc@posoco.in

Sd/-

(N Nallarasan)
Chief General Manager
NLDC, POSOCO.

Annexe-I

The following signals would be handled as a minimum in AGC. Apart from the below mentioned signals, some other power plant specific signals also might be needed on case to case basis. Expansion and spares included in procurement may be used for the same. Detailed logics to be implemented at each power plant and its individual generating units are given below.

A) Analog data to be sent from power plants to NLDC

1. **Unit Load Set Point (ULSP)**

   Unit Load Set Point (ULSP) in MW is the unit-wise manual entry done by the plant shift engineer/operator in the digital control system (DCS) of the generating unit. ULSP is an ex-generating unit value entered by the power plant shift engineer in the DCS for each time block calculated by adding auxiliary power consumption of the unit and the ex-bus schedule provided by the RLDC. Note that ex-bus schedule is provided for the total power plant by the RLDC; this is distributed in between the on bar generating units by the plant operator considering on-site constraints.

2. **Actual Generation MW**

   Actual generation in MW is the ex-generating unit value available in the DCS for every generating unit.

3. **Unit Capability MW (max and min)**

   Unit Capability in MW is the ex-generating unit capability derived using the power plant declared capability which is divided amongst the units by the power plant operator. Note that power plant declares the capability on an ex-bus basis to RLDCs. Unit capability has to be calculated and updated by the power plant operator by distributing the ex-bus declared capability amongst the on bar generating units and adding the respective auxiliary consumption. This shall be entered by the power plant operator in the DCS / HMI. Similarly, minimum limit may also be provided. These signals will be used to limit final AGC set point to the power plant to never exceed the sum of individual unit capabilities.

4. **RGMO/FGMO/Governor input to governor**

   This signal is the MW input to the governor from the output of the RGMO control block in the DCS. Alternatively put, this signal in MW is the generation of the unit caused by primary frequency response alone.

5. **Delta P feedback**

   This Delta P feedback signal shall be taken from the DCS. In the unit DCS, Delta P (calculated in RTU or DCS) would be added to ULSP to calculate the final unit AGC set point. As per required AGC design, there shall be limits enforced for each unit by the power plant to restrict

the total MW load set point input reaching master control. Delta P feedback shall be calculated after the limits are enforced.
Delta P feedback = (Unit AGC Set Point after limits are enforced at unit – ULSP)

The reason "Unit AGC Set Point after limits are enforced at unit" is needed is to exactly understand the MW quantum reaching the master control of the unit after adding AGC input to ULSP. This signal would be used in accounting and verification of the data exchange between NLDC and power plant, and is critical.

6. **Reactive Power Actual MVAR**

   Actual MVAR reactive power absorbed or delivered by the unit.

7. **AVR Voltage Set Point**

   Voltage set point of the automatic voltage regulator / exciter.

8. **Low Voltage (LV) side Actual Voltage**

   Voltage at the LV side of the generating unit.

9. **Generator Transformer (GT) Tap Position**

   Tap position setting of the generator transformer.

10. **Distribution Factor (fraction for distribution of AGC DeltaP in between the units of the power plant)**

    Distribution Factor is the fraction by which the power plant operator divides the AGC regulation signal (Delta P = Plant AGC Set Point – Plant ULSP) in between the generating units. This signal shall be made available in the user interface / human machine interface (HMI) of the newly installed remote terminal unit (RTU). Sum of all distribution factors of generating units in a power plant must be 1.

Additional Analog inputs from Hydro power plants

11. Minimum load at which unit can stably run after synchronization – Unit wise (P1) (in MW)
12. Forbidden zones or high cavitation zones - Unit-wise (From MW to MW) - P2 to P3
13. Maximum loading possible on unit (continuous) (P4)
14. Declared Energy for the day in million units (MU)
15. Schedule Energy in MU (Cumulative for the day)
16. Water gross head (m)

Additional Analog inputs from Gas power plants

17. Reference exhaust gas temperature

18. Actual exhaust gas temperature

B) Digital Input data required per generating unit

1. Circuit Breaker Status on/off: To understand whether the unit is on bar or off bar. Ensuring the quality of this information is also very critical for AGC.
2. Governor status on/off: To understand whether the unit is providing primary response also.
3. AGC Local/Remote:

   The manual choice to take unit into local or remote is with the power plant shift engineer through DCS. Suitable user interface may be developed by the instrumentation team at power plant for taking units into local/remote.

   "Remote" means unit Delta P shall be added to ULSP before processing the signal for maximum and minimum limits and further sending it to master control. Thus, if a unit is under remote, it is ready to accept and respond to AGC signals.

   "Local" means unit Delta P shall not be added to ULSP. This choice can be because of onsite problems, non-readiness to accept AGC signals, prolonged communication failure etc.

Additional Digital inputs from Hydro power plants

4. Pumping Status on/off: for pumped hydro power plants

C) Analog data sent from NLDC to Power plant

1. **AGC Set Point**

   AGC set point shall be provided for the total power plant for thermal generating units. This AGC set point is the main input to the power plants from AGC which will be used for calculation of Plant Delta P = Plant AGC Set point – Plant ULSP.

   For hydro power plants plant AGC set point or unit AGC set point can be provided based on the power plant request.

2. **AGC Suspend Status – Digital/Analog Output per unit**

   Some times AGC needs to be suspended by NLDC for reasons like intermittent communication, reboots, updations etc. This information would be sent as a digital status.

3. **SCED schedule:** Not for immediate use. Redundant extra signal to facilitate SCED schedule transfer to power plant (presently being updated through web-based scheduling by RLDCs).

D) Basic logics to be implemented at the power plant RTU and DCS

The basic logics given below may be implemented for safe operation. Apart from these, some other logics may need to be implemented on case to case basis.

a) Plant DeltaP analog is calculated as, $Plant\ Delta\ P = (Plant\ AGC\ Set\ Point - \sum_1^n(ULSP_n)) * AGC\ Suspend\ Status * Communication\ Failure$

b) For Distribution Factor Analog Input of 'n'units, check $\sum_1^n(Distribution\ Factor_n)$ = 1

c) $Unit\ Delta\ P_n = Plant\ Delta\ P * Distribution\ Factor_n *$ AGC Local Remote$_n$

d) $Unit\ AGC\ Set\ Point_n = Unit\ Delta\ P_n + ULSP_n$

e) Enforce minimum and maximum limits at each unit to process $Unit\ AGC\ Set\ Point_n$ and convert it to $Unit\ AGC\ Set\ Point\ after\ Limits_n$

f) $Unit\ Delta\ P\ Feedback_n = Unit\ AGC\ Set\ Point\ after\ Limits_n - ULSP_n$

g) Scheduled Energy (Cumulative MU) for Hydro is calculated as $\sum_{t=1}^{TB}(Scheduled\ MW/4000)$ Where TB is the current time block.

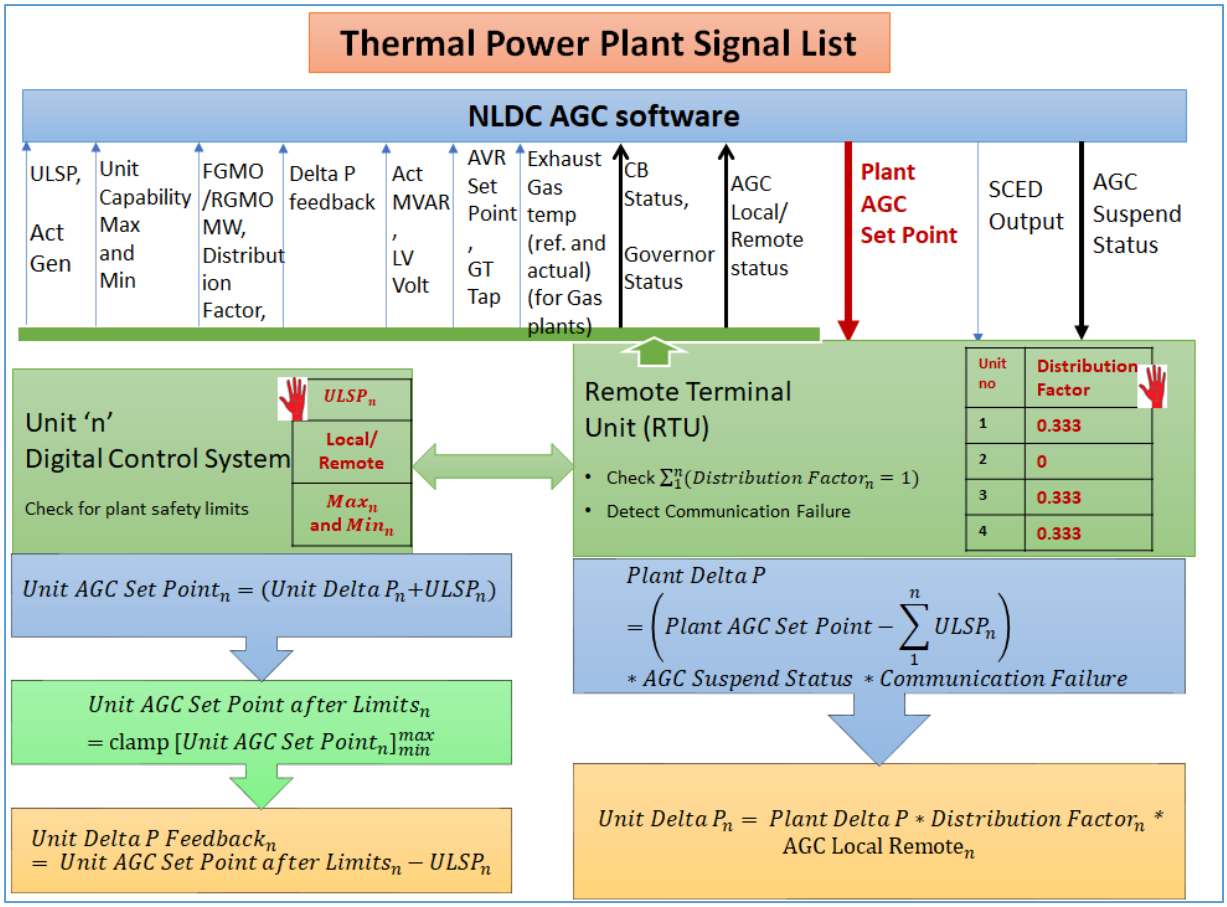
h) For hydro power plants, NLDC can send directly $Unit\ AGC\ Set\ Point_n$ for each unit. Hydro plant shall select one the operating modes specified below:

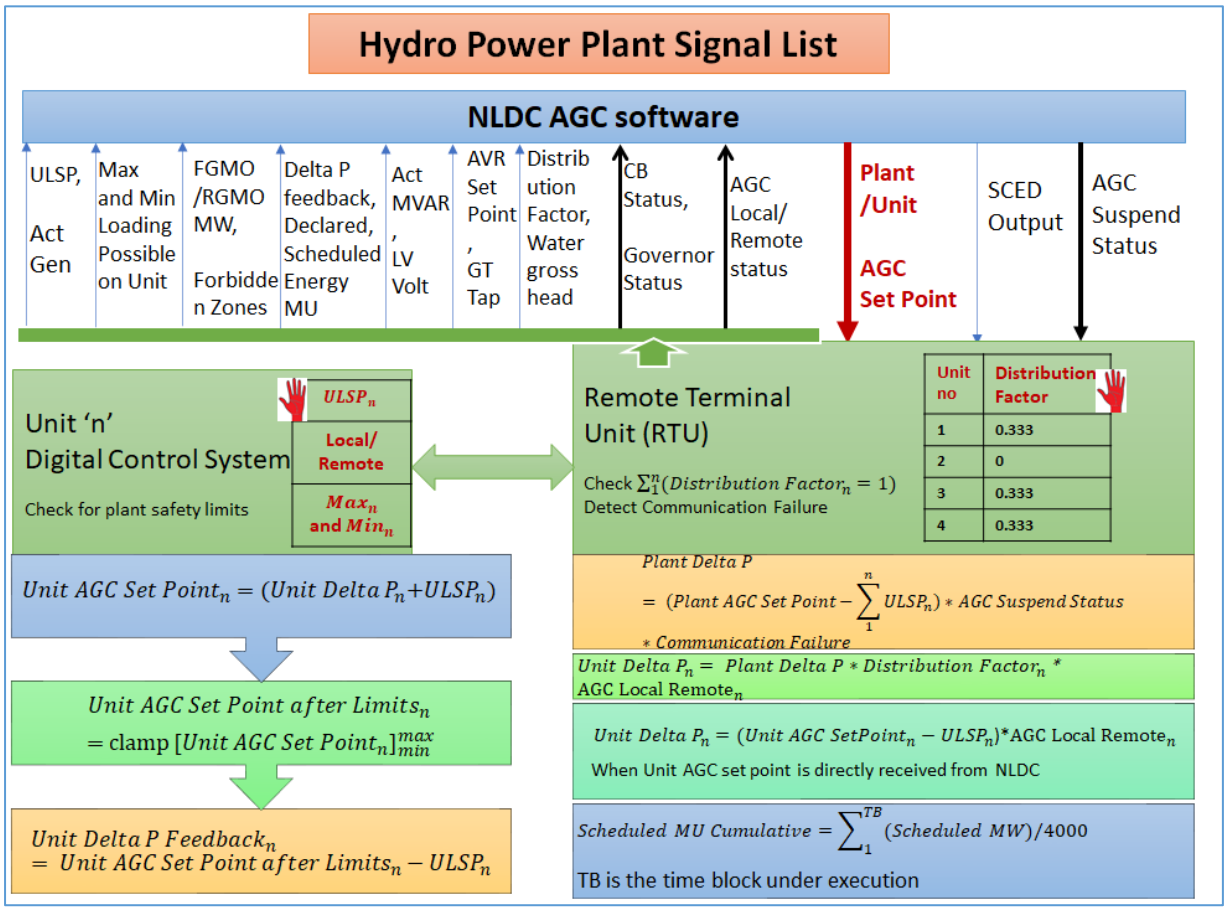
- Plant AGC set point will be communicated from NLDC and use specified distribution factors for calculating unit Delta P as above.
- Unit AGC set points communicated from NLDC will be used for calculating unit Delta P
- Unit AGC set points communicated from NLDC be converted to Plant AGC set point and use specified distribution factors for calculating unit Delta P.

i) To detect communication failure and convert Plant DeltaP analog output to zero

j) To detect AGC Suspend status and convert Plant DeltaP analog output to zero

k) To detect AGC Local status and convert Plant DeltaP analog output to zero


Thermal Power Plant Signal List
NLDC AGC software
ULSP, Act Gen
Unit Capability Max and Min
FGMO /RGMO MW, Distribution Factor,
Delta P feedback
Act MVAR , LV Volt
AVR Set Point , GT Tap
Exhaust Gas temp (ref. and actual) (for Gas plants)
CB Status, Governor Status
AGC Local/ Remote status
Plant AGC Set Point
SCED Output
AGC Suspend Status
Unit 'n' Digital Control System
Check for plant safety limits
$ULSP_n$
Local/ Remote
Max_n and Min_n
Remote Terminal Unit (RTU)
Check $\sum_1^n(Distribution\ Factor_n = 1)$
Detect Communication Failure
Unit no
Distribution Factor
1 0.333
2 0
3 0.333
4 0.333
$Unit\ AGC\ Set\ Point_n = (Unit\ Delta\ P_n + ULSP_n)$
$Plant\ Delta\ P = \left(Plant\ AGC\ Set\ Point - \sum_1^n ULSP_n\right) * AGC\ Suspend\ Status * Communication\ Failure$
$Unit\ AGC\ Set\ Point\ after\ Limits_n = \text{clamp}\ [Unit\ AGC\ Set\ Point_n]_{min}^{max}$
$Unit\ Delta\ P_n = Plant\ Delta\ P * Distribution\ Factor_n *$ AGC Local Remote$_n$
$Unit\ Delta\ P\ Feedback_n = Unit\ AGC\ Set\ Point\ after\ Limits_n - ULSP_n$


Hydro Power Plant Signal List
NLDC AGC software
ULSP, Act Gen
Max and Min Loading Possible on Unit
FGMO /RGMO MW, Forbidden Zones
Delta P feedback, Declared, Scheduled Energy MU
Act MVAR , LV Volt
AVR Set Point , GT Tap
Distribution Factor, Water gross head
CB Status, Governor Status
AGC Local/ Remote status
Plant /Unit AGC Set Point
SCED Output
AGC Suspend Status
Unit 'n' Digital Control System
Check for plant safety limits
$ULSP_n$
Local/ Remote
Max_n and Min_n
Remote Terminal Unit (RTU)
Check $\sum_1^n(Distribution\ Factor_n = 1)$
Detect Communication Failure
Unit no
Distribution Factor
1 0.333
2 0
3 0.333
4 0.333
$Unit\ AGC\ Set\ Point_n = (Unit\ Delta\ P_n + ULSP_n)$
$Plant\ Delta\ P = (Plant\ AGC\ Set\ Point - \sum_1^n ULSP_n) * AGC\ Suspend\ Status * Communication\ Failure$
$Unit\ AGC\ Set\ Point\ after\ Limits_n = \text{clamp}\ [Unit\ AGC\ Set\ Point_n]_{min}^{max}$
$Unit\ Delta\ P_n = Plant\ Delta\ P * Distribution\ Factor_n *$ AGC Local Remote$_n$
$Unit\ Delta\ P_n = (Unit\ AGC\ SetPoint_n - ULSP_n)$*AGC Local Remote$_n$
When Unit AGC set point is directly received from NLDC
$Unit\ Delta\ P\ Feedback_n = Unit\ AGC\ Set\ Point\ after\ Limits_n - ULSP_n$
$Scheduled\ MU\ Cumulative = \sum_1^{TB}(Scheduled\ MW)/4000$
TB is the time block under execution