Appendix D -

OP-18 Metering And Telemetering Diagrams

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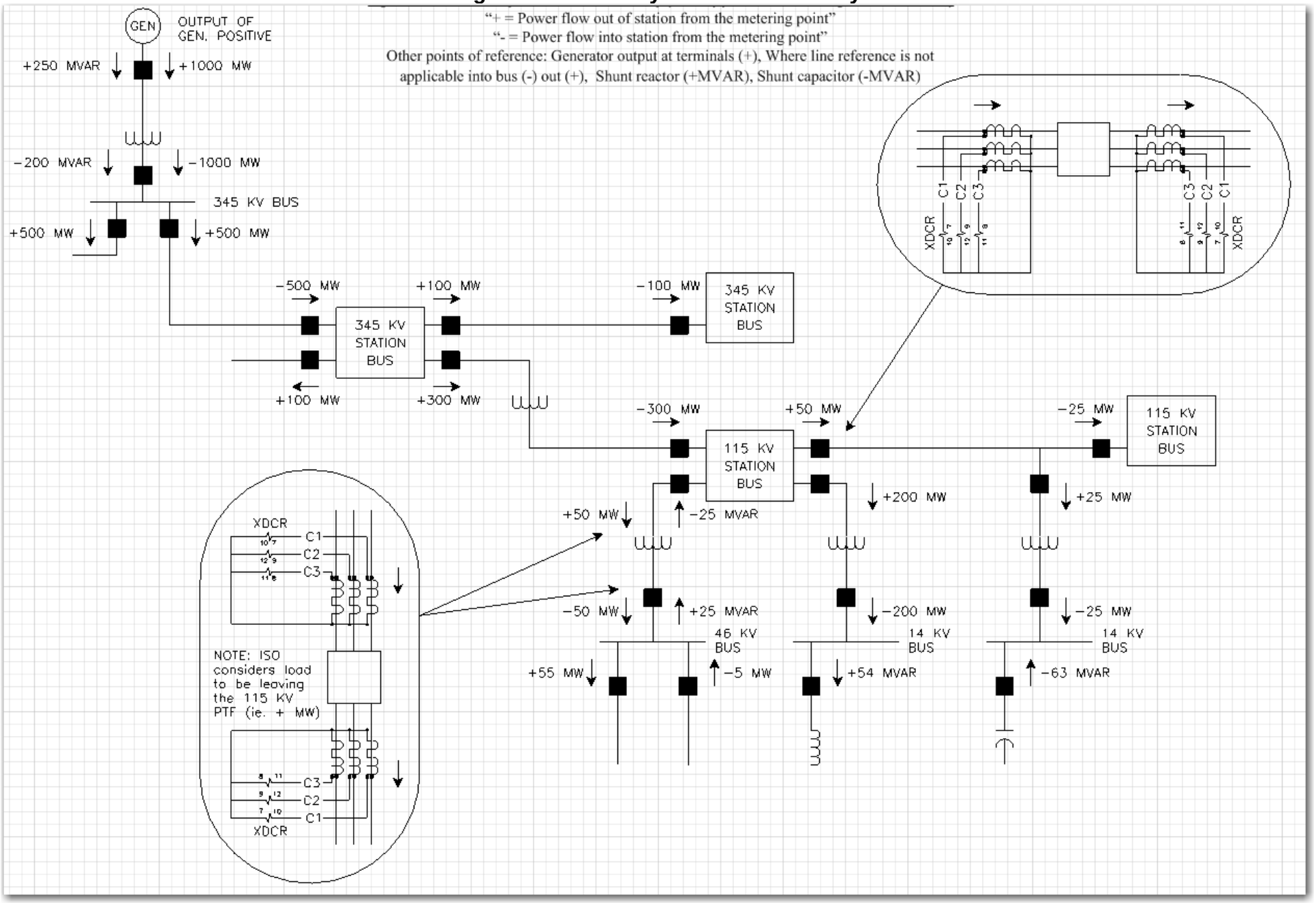
Figure 1 - Telemetry MW/MVAR Polarity



Terms & Definitions

The following diagrams illustrate how single and multiple generator facilities may be metered for Settlement & Telemetry. Such definitions are based on Market Rules and best engineering practice. This document is intended to provide guidance for metering design.

A, Gross Output: MW(h)/MVAR(h) as measured from the generator terminals.

B, Unit Auxiliary Load (running station service): MW(h)/MVAR(h) as measured from the high voltage winding of the dedicated station service/auxiliary transformer.

C, GSU Tertiary Aux. Load: MW(h)/MVAR(h) measured on a tertiary winding of the generator step-up unit transformer.

D, Locally Fed load attributable to the generator: MW(h)/MVAR(h) measured from the high voltage winding on an auxiliary (station service) transformer, *or segment of load of a station service system,* that is used by the generator owner for the operation and maintenance of the generator.

E, Load attributable to a Generator Asset on separate point of interconnection: MW(h)/MVAR(h) measured from the high voltage winding on the a separate point of load interconnection separate from the generators point of interconnection. Ideally all loads attributable to the generator are netted from generation (like D loads). Consideration may be given to treat these loads separately if: (1) The separate load is significant (≥1% of facility rating); (2) The separate point of interconnection has a higher Locational Marginal Price (LMP).

F, Load within the point of interconnect not attributable to the generator: MW(h)/MVAR(h) measured on a power, distribution or station service transformer for the purpose of the interconnection transmission (or distribution) owner's own station service or load of their customer other than those loads noted in D.

Net_{LS}, GSU Low-Side Net (Net): MW(h)/MVAR(h) as measured from the low voltage side of the GSU or can be calculated by the generator as Gross minus Station Service ($Net_{LS} = A - B$) but for telemetry also nets the station service load ($Net_{TM} = A - (B + C + D^*)$). *(* may also include E loads as noted above)*

Net_{HS}, GSU High-Side Net (Net_1): MW(h)/MVAR(h) as measured from the high voltage side of the GSU for use in the energy markets and for AGC for those units bid in as an individual asset or compensated from low-side minus tertiary aux load (Transformer Loss Compensation(Net_{LS}) – C).

$Net_{HS\text{-}SUM}$, Multi-Generator Net (Net_2): Total sum (sum of Net1) of generator net MW(h) and MVAr(h) (e.g., for a combined cycle plant GT1 + GT2 + STG1) as measured from the high voltage side of the GSU used in the Markets and in accordance with Section IV.C of this procedure.

Net_{BUS}, Total Net of Station Service at Generator Substation (or point of interconnection if no line): MW(h)/MVAR(h) As measured leaving the generator substation towards point of interconnection (if not itself the point of interconnection) minus loads not attributable to the generator within the point of interconnection (F) or calculated as the total sum of GSU high-side metering minus locally fed load attributable to the generator ($Net_{HS} - D^*$ *or* $Net_{BUS} + F$.) *(* may also include E loads as noted above)*

Net_{POI}, Total Net of Station Service at point of interconnection: MW(h)/MVAR(h) As measured at the point of interconnection minus loads not attributable to the generator within the point of interconnection (F). This may be the same as Net_{BUS} if no line exists between the generator facility and the point of interconnection.

D, E and F loads may be totalized values as there may be redundant station service transformers serving their loads. On a related note these loads may share one or more station service transformer(s) and therefore metering of these loads may be separate feeds off the secondary of the shared station service transformers. Loads metered on the low-side of station service transformers should be compensated for station service transformer losses.

Additional Notes:

1- For the sake of the equations, net power flow in direction of arrow (in the diagrams) is positive; negative numbers indicate net power flow in opposite direction of arrow.

2- For Settlement, SCADA Telemetry & Capacity both the station service load and the losses to the point of interconnection (or other such agreed upon point noted in the interconnection agreement, also see §IV.B.7) shall be netted out of the gross generation value. *The exception is for SCADA Telemetry that the GSU (and line) losses are already accounted in the model so the telemetry system shall not be designed to double count those losses.

Settlement (note 2): $Net_{POI} = Net_{HS} - D\ (Net_{SM}\text{Gen when} > 0,\ Net_{SM}\text{Load when} < 0)$

Generator Asset — Load (or Station Service) Asset

MW/MVAR Telemetry: $Net_{TM} = A - (B + C + D)$

Capacity: $Net_{CP} = Net_{POI} - E\ (\text{when} > 0)$

***The above equations ignore line losses between generator bus and point of interconnection. If such a line exists (and the interconnection agreement states it) then the Settlement and Capacity equations will need to evaluate line loss in an appropriate fashion which should ideally be added to the interconnection agreement but otherwise agreed to by the parties of that agreement

Figure 2 - Single Generator Asset & Basic Generation Metering Concepts

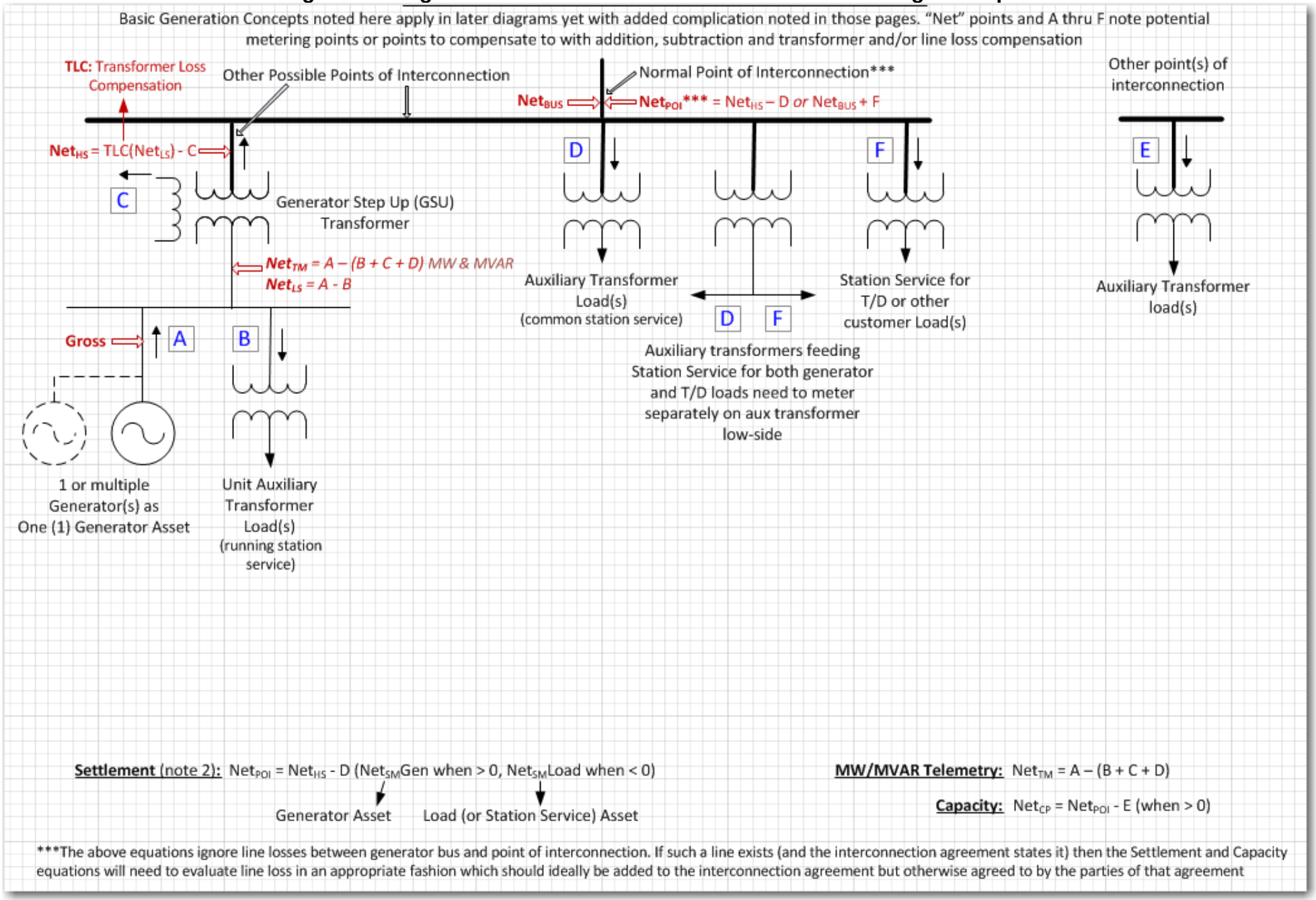
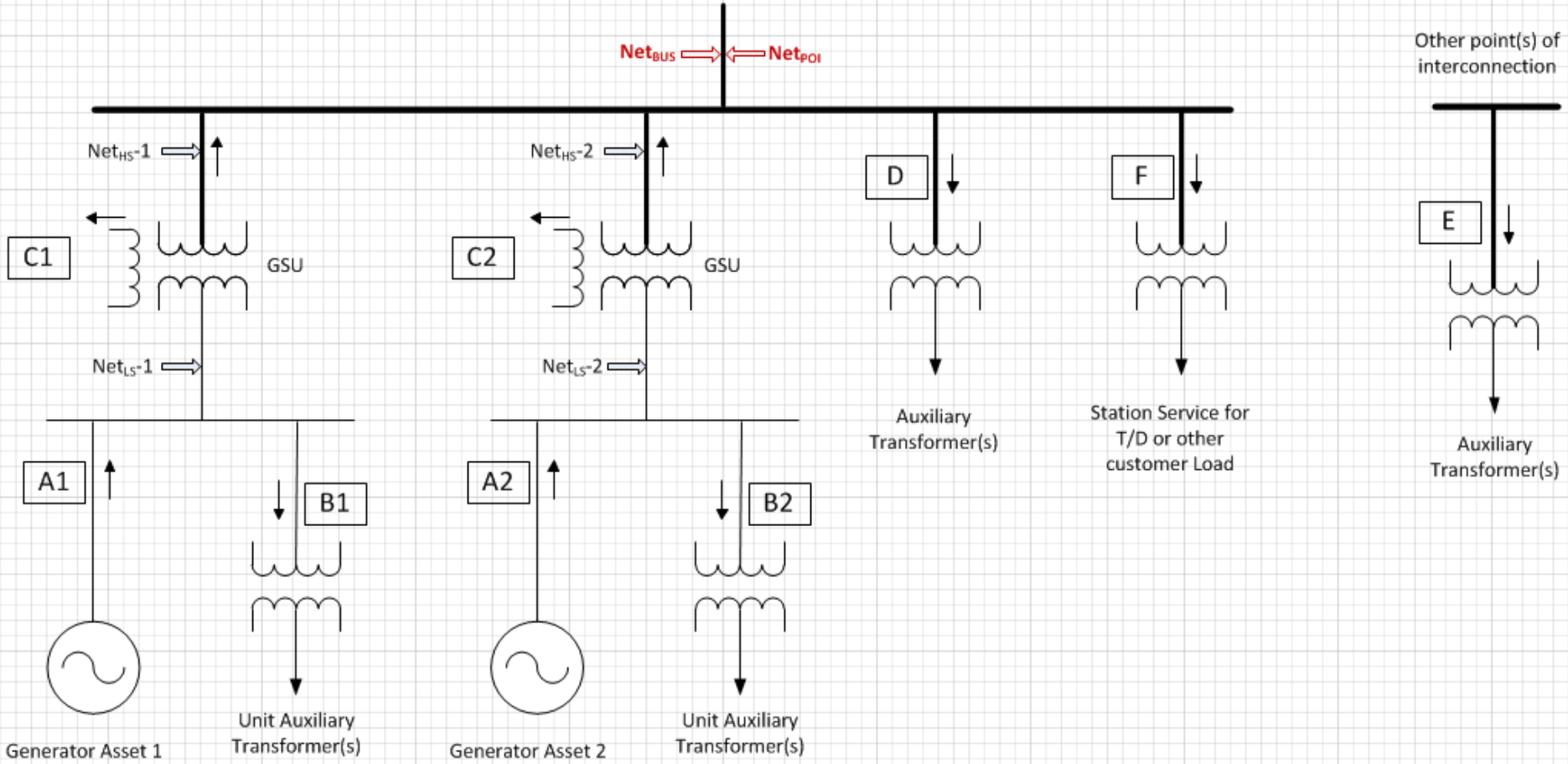


Figure 3 - Multiple Generator Assets - Dynamic (Ratio) Allocation of shared station service

See Figure 3 for Basic Generation Concepts. This diagram and formulas demonstrate how shared station service will be allocated for net generation using the "Dynamic Allocation" method which will allocate the shared station service based upon the actual generation in the settlement interval (or in real-time for telemetry)

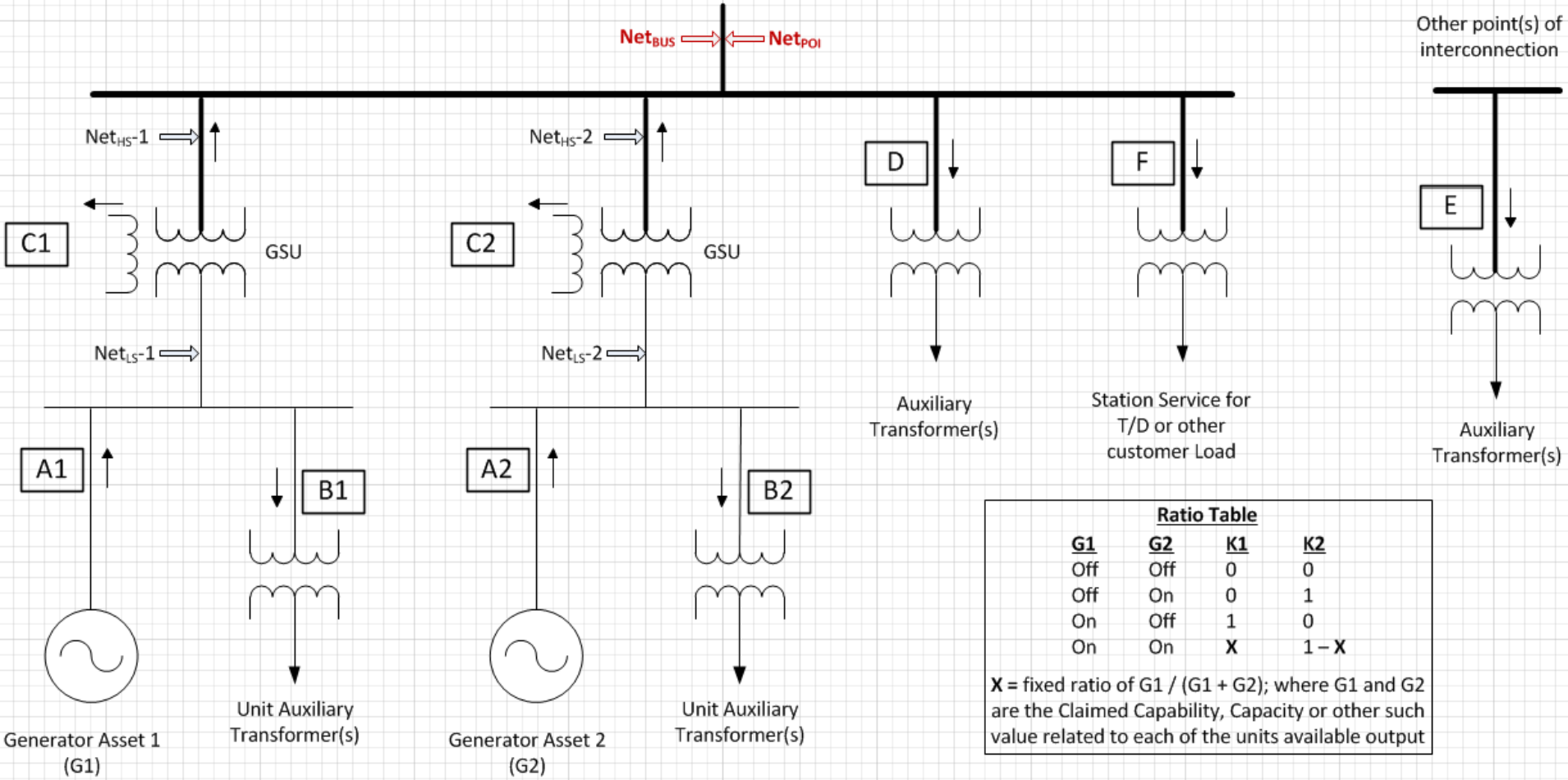


	Settlement:	MW/MVAR Telemetry:	Capacity:
Generator Asset 1	Net_{HS}-1 – D * A1 / (A1 + A2) (when > 0)	A1 – B1 – C1 – D * A1 / (A1 + A2)	Net_{HS}-1 – (D + E) * A1 / (A1 + A2) (when > 0)
Generator Asset 2	Net_{HS}-2 – D * A2 / (A1 + A2) (when > 0)	A2 – B2 – C2 – D * A2 / (A1 + A2)	Net_{HS}-2 – (D + E) * A2 / (A1 + A2) (when > 0)
Station Service Asset	D – Net_{HS}-1 – Net_{HS}-2 (when > 0)	N/A	N/A

Note: The above equations use the ratio of gross (A1 or A2) to the sum of gross (A1 + A2) but these may also may use the Net_{LS} or Net_{HS} metered values to determine the ratios. For example:
for Gen Asset 1 the ratio is noted as A1 / (A1 + A2) but could also be Net_{LS}-1 / (Net_{LS}-1 + Net_{LS}-2) or Net_{HS}-1 / (Net_{HS}-1 + Net_{HS}-2)

Figure 4 - Multiple Generator Assets - Dynamic (Condition) Fixed (Ratio) Allocation of shared station service

See Figure 3 for Basic Generation Concepts. This diagram and formulas demonstrate how shared station service load will be allocated for net generation using the "Dynamic-Fixed Allocation" method which will allocate the shared station service on a fixed ratio when both units are online or all to the online unit when one is offline during a settlement interval (or in real-time for telemetry)



Ratio Table

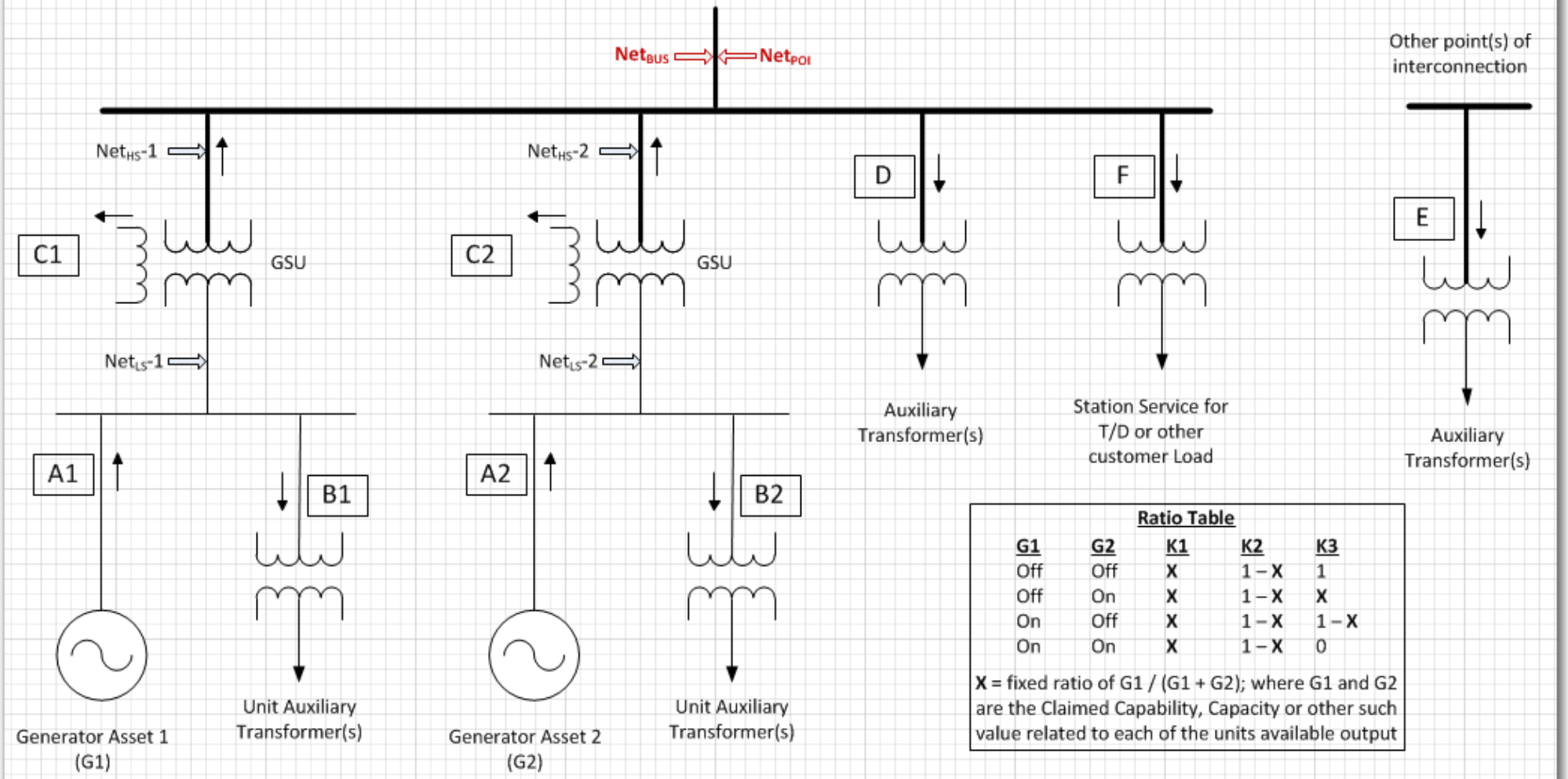
G1	G2	K1	K2
Off	Off	0	0
Off	On	0	1
On	Off	1	0
On	On	**X**	1 – **X**

X = fixed ratio of G1 / (G1 + G2); where G1 and G2 are the Claimed Capability, Capacity or other such value related to each of the units available output

	Settlement:	MW/MVAR Telemetry:	Capacity:
Generator Asset 1	Net$_{HS}$-1 – D * K1 (when > 0)	A1 – B1 – C1 – D * K1	Net$_{HS}$-1 – (D + E) * K1 (when > 0)
Generator Asset 2	Net$_{HS}$-2 – D * K2 (when > 0)	A2 – B2 – C2 – D * K2	Net$_{HS}$-2 – (D + E) * K2 (when > 0)
Station Service Asset	D – (Net$_{HS}$-1 + Net$_{HS}$-2) (when > 0)	N/A	N/A

Figure 5 - Multiple Generator Assets - Static (Ratio) Allocation of shared station service

See Figure 3 for Basic Generation Concepts. This diagram and formulas demonstrate how shared station service load will be allocated for net generation using the "Static Allocation" method which will allocate the shared station service on a static ratio with only net loads (during a settlement interval) attributed to the station service asset



Ratio Table

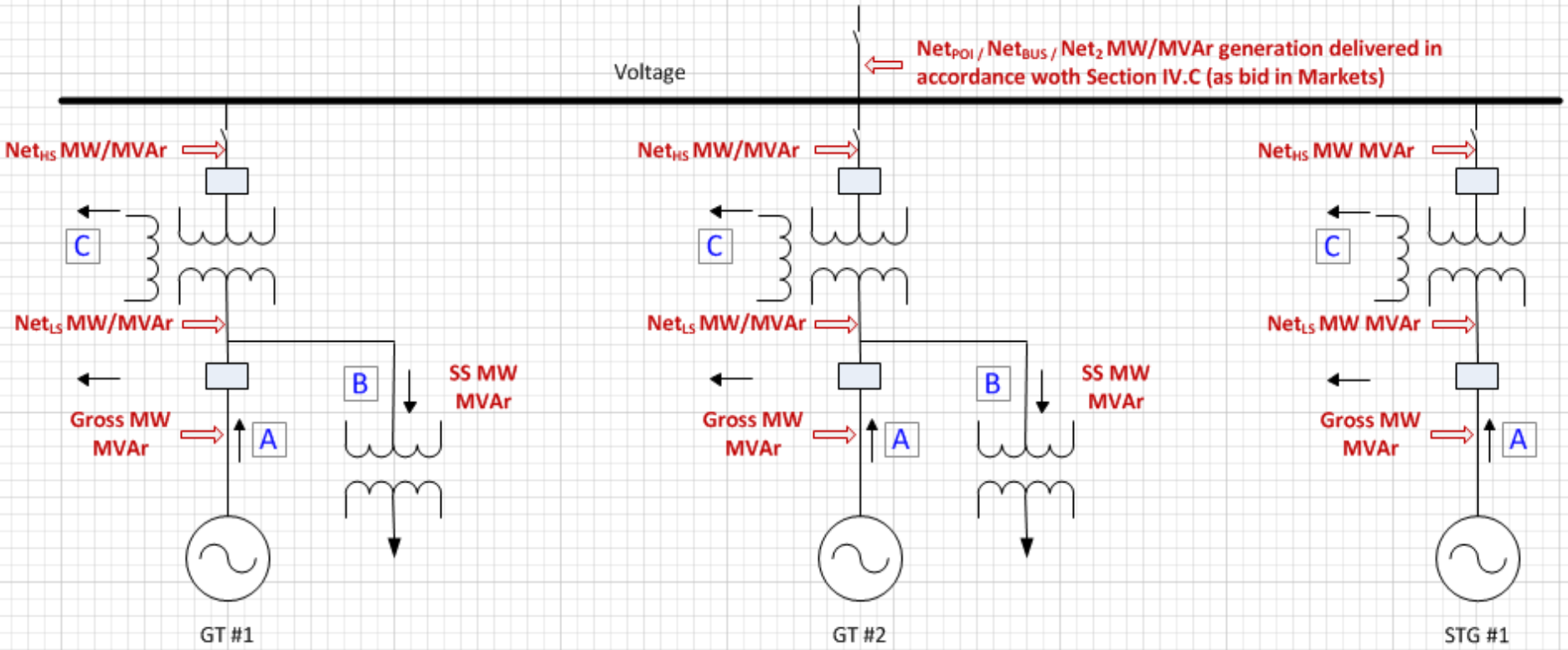
G1	G2	K1	K2	K3
Off	Off	X	1 – X	1
Off	On	X	1 – X	X
On	Off	X	1 – X	1 – X
On	On	X	1 – X	0

X = fixed ratio of G1 / (G1 + G2); where G1 and G2 are the Claimed Capability, Capacity or other such value related to each of the units available output

	Settlement:	MW/MVAR Telemetry:	Capacity:
Generator Asset 1	Net_{HS}-1 – D * K1 (when > 0)	A1 – B1 – C1 – D * K1	Net_{HS}-1 – (D + E) * K1 (when > 0)
Generator Asset 2	Net_{HS}-2 – D * K2 (when > 0)	A2 – B2 – C2 – D * K2	Net_{HS}-2 – (D + E) * K2 (when > 0)
Station Service Asset	D * K3	N/A	N/A

Figure 6 - Combined Cycle Generator Assets

See Figure 3 for Basic Generation Concepts. This diagram and formulas demonstrate how combined cycle generators are handled differently



Definition of generator telemetry terms:

A, Gross Output: MW(h)/MVAR(h) as measured from the generator terminals.

B, Unit Aux. Load: MW(h)/MVAR(h) as measured from the high voltage winding of the dedicated station service/auxiliary transformer.

Net_{LS}, GSU Low-Side Net: MW(h)/MVAR(h) as measured from the low voltage side of the GSU or can be calculated by the generator as Gross minus Station Service **Net_{LS} = A – B**).

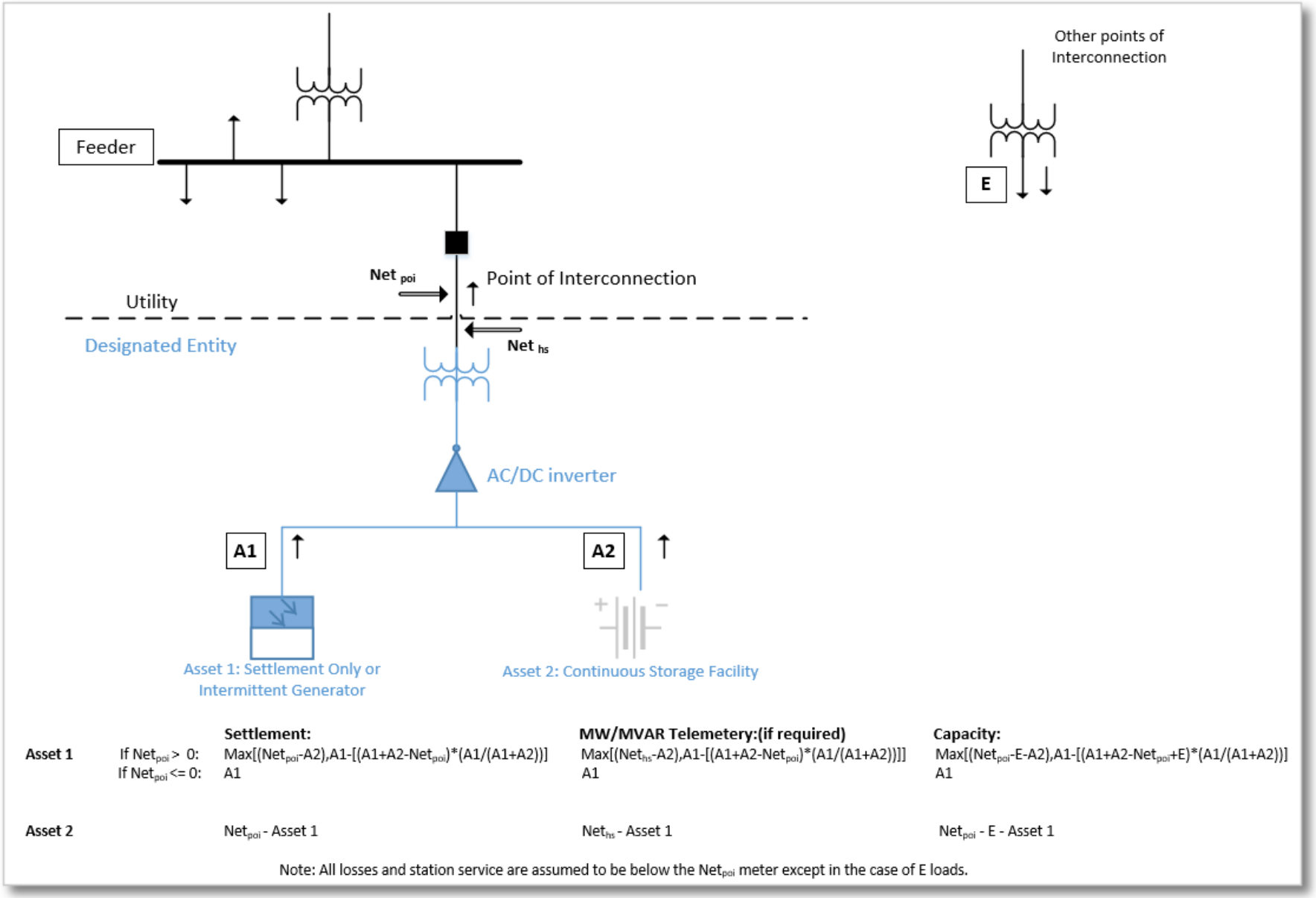
C, GSU Tertiary Aux. Load: MW(h)/MVAR(h) measured on a tertiary winding of the generator step-up unit transformer.

D, Locally Fed load attributable to the generator: MW(h)/MVAR(h) measured on an aux transformer, *or segment of load of a station service system,* that is used be the generator owner for the operation and maintenance of the generator.

Net_{HS} – Net$_1$: MW(h)/MVAR(h) as measured from the high voltage side of the GSU for use in the energy markets and for AGC for those units bid in as an individual asset.

$Net_{POI/BUS}$ – Net2: Total sum (sum of Net$_1$) of generator net MW(h) and MVAr(h) (e.g., for a combined cycle plant GT1 + GT2 + STG1) as measured from the high voltage side of the GSU used in the Markets and in accordance with Section IV.C of this procedure.

Figure 7 – DC coupled asset metering distribution concept



		Settlement:	MW/MVAR Telemetery:(if required)	Capacity:
Asset 1	If Net_{poi} > 0: If Net_{poi} <= 0:	Max[(Net_{poi}-A2),A1-[(A1+A2-Net_{poi})*(A1/(A1+A2))] A1	Max[(Net_{hs}-A2),A1-[(A1+A2-Net_{poi})*(A1/(A1+A2))]] A1	Max[(Net_{poi}-E-A2),A1-[(A1+A2-Net_{poi}+E)*(A1/(A1+A2))] A1
Asset 2		Net_{poi} - Asset 1	Net_{hs} - Asset 1	Net_{poi} - E - Asset 1

Note: All losses and station service are assumed to be below the Net_{poi} meter except in the case of E loads.

OP-18 Appendix D Revision History

Document History (This Document History documents action taken on the equivalent NEPOOL Procedure prior to the RTO Operations Date as well revisions made to the ISO New England Procedure subsequent to the RTO Operations Date.)

Rev. No.	Date	Reason
Rev 0	04/13/99	
Rev 1	10/21/99	
Rev 2	06/21/02	
Rev 3	10/01/04	
Rev 4	02/01/05	Updated to conform to RTO terminology
Rev 4.1	02/13/15	Periodic review performed requiring no changes;
Rev 4.2	01/27/17	Periodic review performed requiring no changes; Made administrative changes required to publish a Minor Revision;
Rev 5	04/10/17	Periodic review performed by procedure owner; Created a new reformatted document; Added required corporate document identity and replaced page numbering with Page XofY format in all page footers; Deleted original diagram; Added new Figures 1 through 6; Added Terms and Definitions page;
Rev 5.1	01/23/19	Periodic review performed requiring no changes; Made administrative changes required to publish a Minor Revision;
Rev 6	08/07/20	Periodic review performed by procedure owner; Added Figure 7 – DC metering distribution concept
Rev 6.1	08/01/22	Biennial review completed by procedure owner requiring no changes.
Rev 6.2	07/24/24	Biennial review completed by procedure owner requiring no changes.