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Guidance on the Use of the 2nd Generation Generic Renewable Energy Generator/Converter (REGC) Models

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1. Background on the 2nd Generation Generic Renewable Energy System Models

In 2010, under the Western Electricity Coordinating Council's (WECC) Renewable Energy Modeling Task Force (REMTF)[1] started work on the development of what are now called the 2nd generation generic models for Renewable Energy Systems (RES). In the years between 2010 to 2014 these models were developed, with significant input and research from the Electric Power Research Institute (EPRI), as well as the active participation of many stakeholders including several equipment manufacturers, and the four major developers of commercial power system simulation software in North America. Thus, these models now are standard library models in those tools (GE PSLF™, Siemens PTI PSS®E, PowerTech Labs DSATools™, and PowerWorld Simulator). For a detailed account of the models the reader may refer to references [1], [2] and [3].

Briefly, the generic RES models are a library of modules that can be used in the correct combination to develop the model of various renewable power plants, such as wind power plants (WPPs), photovoltaic power plants (PVPPs), battery-energy storage systems (BESS), and hybrid-power plants that are a combination of WPP, PVPP and BESS [2]. As an example, consider Figure 1. This figure shows the generic model of a type 3 (doubly-fed asynchronous generator type) WPP. This is the most complex of the RES models, for it contains all of the basic modules, namely:

1. the renewable energy generator/converter model A (*regc_a*),
2. the renewable energy electrical controls model A (*reec_a*),
3. the renewable energy plant controller model A (*repc_a*),
4. the wind turbine generator torque controller model A (*wtgq_a*),
5. the wind turbine generator pitch controller model A (*wtgp_a*),
6. the wind turbine generator aerodynamics model A (*wtga_a*), and
7. the wind turbine generator drive-train model A (*wtgt_a*).

A detailed account of these models can be found in [1] and [2]. However, some general discussion, and high-level comments, are warranted here in order to set the stage for the discussion in the next section.

Consider that the modules that make up the entire WPP consist of two main categories (i) those that involve the electrical components and controls (*regc_a*, *reec_a* and *repc_a*), and (ii) those that involve the mechanical components and controls (*wtgq_a*, *wtgp_a*, *wtga_a* and *wtgt_a*). Thus, the general structure of the model is consistent with the actual physical nature of the wind turbine power plant. Clearly, in the case of PVPP and BESS, the mechanical components are not needed. Also, experience and research has shown that for the case of a type 4 (full-converter interfaced) WPP, most of the mechanical models may be omitted for power system stability studies [1] and [2]. Now, if we were developing a user-written vendor-specific fundamental-frequency positive-sequence stability model for these RES technologies, it would generally have the same or similar structure. The key

[1] As of 2020 the WECC Modeling and Validation Working Group (MVWG) has been promoted to the Modeling and Validation Subcommittee (MVS), and the REMTF is now the Renewable Energy Modeling Working Group (REMWG) under the MVS.

difference between the generic models and vendor specific models is the internal details of each module, namely that the generic models simplify the details of the controls and do not pertain to the specific details of any particular vendors equipment, nor is there necessarily a one to one correspondence between the parameters of the generic models and the actual control parameters in a vendors equipment.

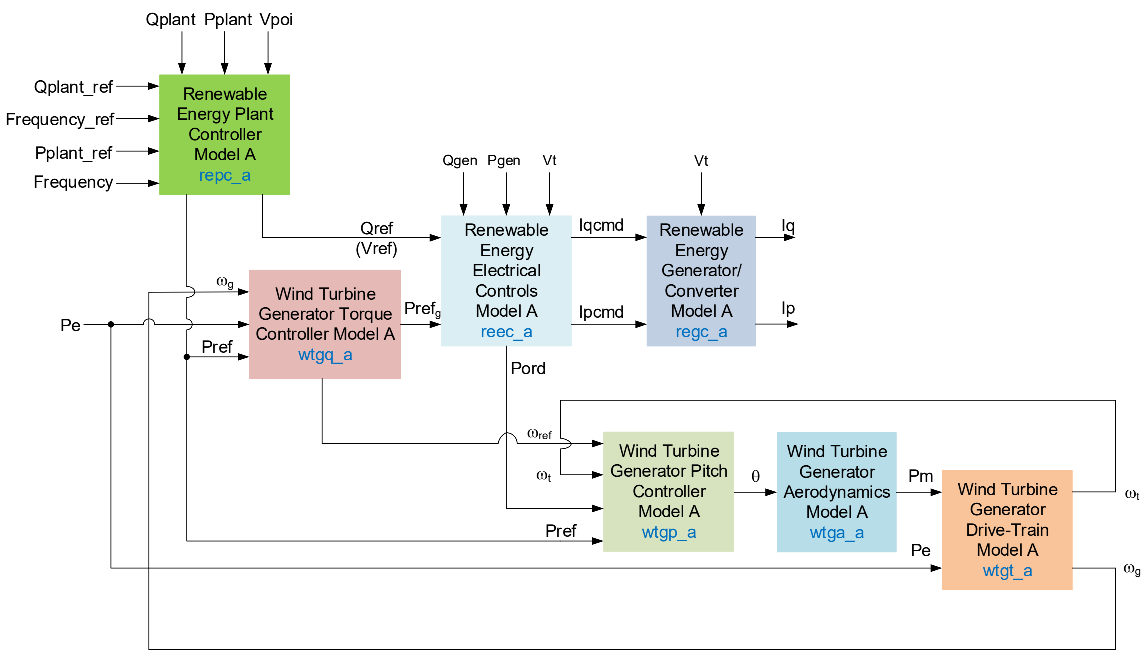

Figure 1: 2nd Generation Generic Model of a type 3 WPP.

All of the modules referred to above were designated "*_a*", for example, *regc_a*. This refers to the version of the model. Many of these modules have various versions, and presently even newer versions are being developed and discussed in WECC [4].

For power system planning studies, one of the tools that ERCOT uses is Siemens PTI PSS®E. For operational studies ERCOT uses PowerTech Labs TSAT™ tool which is part of the DSATools™ package. Both PSS®E and TSAT™ support the 2nd generation generic RES models. In such fundamental-frequency positive-sequence simulation tools time-domain dynamic stability simulations are performed in the general sequence shown in Figure 2. Consider now Figure 1 and Figure 2. If one considers the modules in Figure 1, almost all of these models (i.e. all of them with the exception of *regc_a*) are evaluated in the blue phases of Figure 2, that is the steps where the derivatives of the states of controllers are calculated and numerical integration takes place to calculate the value of the states in the next time step. This is because these components are essentially self-contained dynamic controllers or components of the plant and so can be described by a set of local variables and states and be solved internally over time. Thus, they are confined to the numerical integration path of the simulation process. However, the *regc_a* model represents the generator/converter interface with the power grid and thus involves not only the solving of any states associated with the generator/converter itself, but also the boundary conditions between the transmission network model and the generator/converter. Thus, certain aspects of this model involve solving the algebraic equations that interface the model with the network solution. Thus, this model has pieces that fall into both the orange and blue block in Figure 2.

Moreover, from a modeling stand point the generator/converter interface can be represented as a current source. What this means is that at each time step the active and reactive current formed at the terminal of the generator/converter is calculated and then that current is injected into the network model at the specific node. Alternatively, the interface can be represented as a voltage source interface [5]. It should be understood that this reference to current or voltage source representation is simply with reference to the method of mathematically modeling the interface. It has nothing to do with the control strategy of the actual power converter interface. Almost all modern inverter-based resources (IBR) use a current-regulated voltage-source converter as the line-side power converter interface [6].

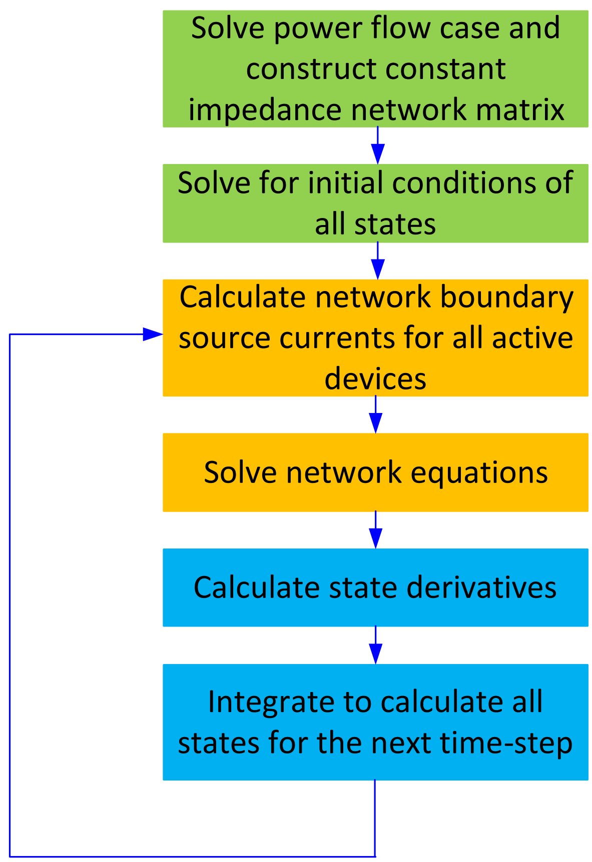

Figure 2: Steps involved in performing time-domain stability simulations in a positive-sequence stability program.

2. The Renewable Energy Generator/Converter (REGC) Generic Model

2.1 The REGC_A Model

The Renewable Energy Generator/Converter Model A (REGC_A) is developed numerically as a current source model, and is a standard library model in the four main positive-sequence stability software tools in North America. The model is shown in Figure 3, and its parameters listed and explained in Table 1.

The two parameters *Iqrmax* and *Iqrmin* are rate limits on the recovery of reactive-current following a fault (or a sudden jump in reactive current). *Iqrmax* limits the rate at which reactive-current returns to its original value following a fault if the initial reactive-current is positive (injecting into the gird). *Iqrmin* limits the rate at which reactive-current returns to its original value following a fault, if the initial reactive-current is negative (absorbing from the gird). These limits are rarely used, and offered in the model for flexibility in the rare cases they are used. For the vast majority of applications and vendors, these limits are not used and thus typically set to large numbers, i.e. 999 and -999. These are in units of per unit per second.

The parameter *Rrpwr* is the rate limit on active-current recovery after a fault. This is an important value and is in units of per unit per second

The parameters *Lvplsw*, *Lvpl1*, *Zerox*, *Brkpt* and *Tfltr* are associated with the Low-Voltage Power Logic (LVPL) block shown in Figure 3. They are a legacy of the 1st generation generic RES models. They were typically used by one vendor to emulate the drop in active-power at low voltages. To engage this logic *Lvplsw* is set to 1. For the majority of vendors this is not used and so *Lvplsw* = 0, and thus the value of the other four parameters becomes irrelevant. Moreover, even when there may be some dependence of active-current on voltage, it is recommended that this be modeled upstream in the electrical controls model (REEC_A, REEC_C or new model being developed REEC_D [4]) through the use of the so-called Voltage Dependent current Limits (VDL tables). **<u>Note:</u>** *Tfltr* is the time-constant representing the lag in the terminal voltage measurement process associated with the LVPL.

The lag time-constants *Tg* is very simple representations of the current regulator response time. Actual voltage-source converters, which *regc_a* is a simple model of, will have a phase-lock loop (PLL) that locks into the grid phasor, and an inner-current control-loop that monitors the terminal active and reactive-current of the converter and tightly controls them to their desired value (based on the current commands coming from the upstream electrical controls) and in-phase with the grid. None-of-this is modeled in *regc_a*. The time-constant *Tg* is a simple emulation of this process and its response time.

The parameter *Xe* is used only by some type 3 wind turbine manufacturer vendors to represent the generator effective impedance. In some cases, type 3 WTG vendors have shown that by including this effective generator impedance, the model can be made to quite reasonably match the more detailed 3-phase model of the type 3 WTG [7]. This is not the actual subtransient reactance of the wound-rotor asynchronous machines, but rather an "effective" reactance in this rather simple model to attempt to capture, in a very simple way, the overall response of the machine. Recently, none of the major equipment vendors use *Xe* and so typically it is set to zero. In general, the *regc_a* (and *regc_b* model discussed below) completely neglect the stator flux dynamics if used to represent a type 3 (doubly-fed asynchronous generator) WTG. **Important Note:** if *Xe* is none-zero, then in reactive command input into the model is now effectively *Eqcmd* (see Figure 4); thus, care should be taken with how the parameter *Imax* is scaled in the upstream electrical controls (REEC_*) model, as well as the VDL table elements for reactive-current, since now the reactive-current command from the upstream REEC_* model is interpreted as a stator flux component, *Eqcmd*.

Using the parameter names for the *regc_a* model in the Siemens PTI PSS®E implementation (called REGCAU2 in Version 33.12.1 and Version 34.6.1), after the above discussion, the only parameters that remain are: *Volim, Lvpnt1, Lvpnt0, Iolim, Khv* and *Accel.*

These six parameters do not really correspond to actual physical quantities in the generator/converter. They primarily serve the purpose of helping with the numerical solution of the network interface, and are associated with the algorithm inside the two blocks shown in Figure 3 called the High Voltage Reactive Current Management and Low Voltage Active Current Management. A more detailed description of the logic inside these two blocks is given in Appendix A of reference [1]. Also, what is provided in [1] is essentially a flow chart, but the details are somewhat software specific.

In simple terms the purpose of these parameters may be explained as follows:

1. *Volim* is the maximum allowed instantaneous terminal voltage limit during the network solution iterations. That is, if *Vt* exceeds *Volim* during an iteration, then the reactive-current is incremented, per the acceleration factor *Accel* (for PSS®E and TSAT™ this is called *Khv*), to try to avoid *Vt* momentarily jumping above *Volim*. In these iterations, the reactive-current is not allowed to go lower than *Iolim*. Thus, these again are limits used in the algebraic iterations to try to achieve network solution convergence, rather than settings or values from any actual controls. Typical values, and ranges of values, are shown in Table 1. Note that, *Khv/Accel* could be set to zero, what this will mean is that during the network solution iterations there will be no means of iteratively increment reactive-current (since the acceleration factor Khv = 0) to try to limit the instantaneous terminal voltage to *Volim*, and thus in some cases an excessive voltage spike may be seen for example after simulating a fault. Also, in weaker grid conditions it may also lead to network solution convergence problems. Also, values greater than one are possible for *Khv/Accel*, but they may not prove much more effective. Again, one should remember this is not a physical quantity, but rather a mathematical artifice to help with the numerical solution of the algebraic network solutions for a current-source model in the prevailing positive-sequence simulation platforms. Also, in most simulations where either the network is strong (high short circuit levels) or simulate events do not lead to changes in the terminal voltage of the IBR that get close to *Volim*, changing *Khv/Accel* will result in no noticeable difference in the simulation results.
2. In Siemens PTI PSS®E there is a further parameter, *Accel* (different from *Khv* and what is called *Accel* in the other software tools). This is an acceleration factor in

the numerical iterations for solving the network equations and achieving convergence during network boundary/source current algebraic solution iterations. Again, a good and typical value for *Accel* is 0.7. This acceleration factor, per the software's user manual, cannot be less than or equal to zero, nor can it be greater than 1. Given that it is purely for numerical stability purposes, the user may adjust it to help network solution convergence. However, at some point when the system is too weak (see next section and results for SCR < 1 cases) this model loses its efficacy. Once again in the vast majority of cases, changing this parameter will have little effect on the simulation results, since it only comes into play on fringe cases, and even then offers only some relief.

3. Finally, *lvpnt1* and *lvpnt0* are used in the low voltage active current management block (see Appendix A of reference [1]). Again, these are used to help with the network solution at the boundaries. The value of *lvpnt1* must be greater than *lvpnt0.* Thus, both values should never be set to zero. They can also be thought to broadly "emulate" the expected behavior of the higher order controls not represented, by emulating the reduction in active power at low voltages. That is, the active current injection cannot truly be sustained once the terminal voltage of the converter falls to very low levels (or zero). Thus, active current is linearly backed-off as the terminal voltage falls below *lvpnt1* and reaches zero when terminal voltage falls below *lvpnt0.* Thus, some vendors may choose to set *lvpnt0* to zero and *lvpnt1* to a small number, e.g. around 0.01 to 0.05, and instead utilize the VDL tables in the upstream electrical controls model. This should be ok, so long as both values are never set to zero (i.e. *lvpnt1 = lvpnt0 = 0* should not be done as this may lead to numerical stability issues with the network solution convergence). <u>Note:</u> Some vendors will set *lvpnt0* to a negative number and *lvpnt1* to a low positive number, to emulate the fact that their controls do not attempt to intentionally block current at zero voltage. This is reasonable, though not typical.

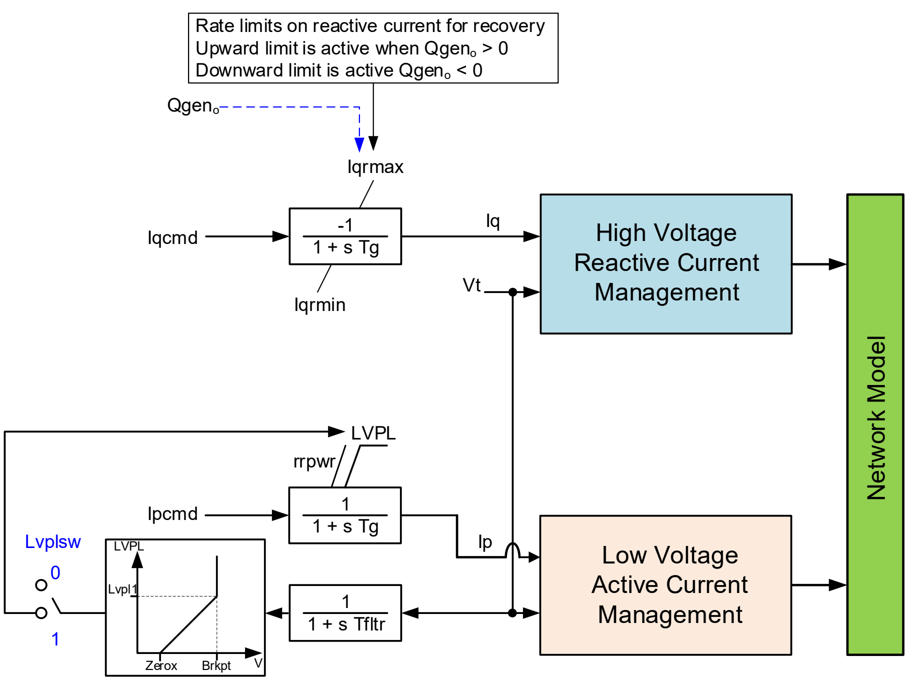

Figure 3: Block diagram of the REGC_A model.

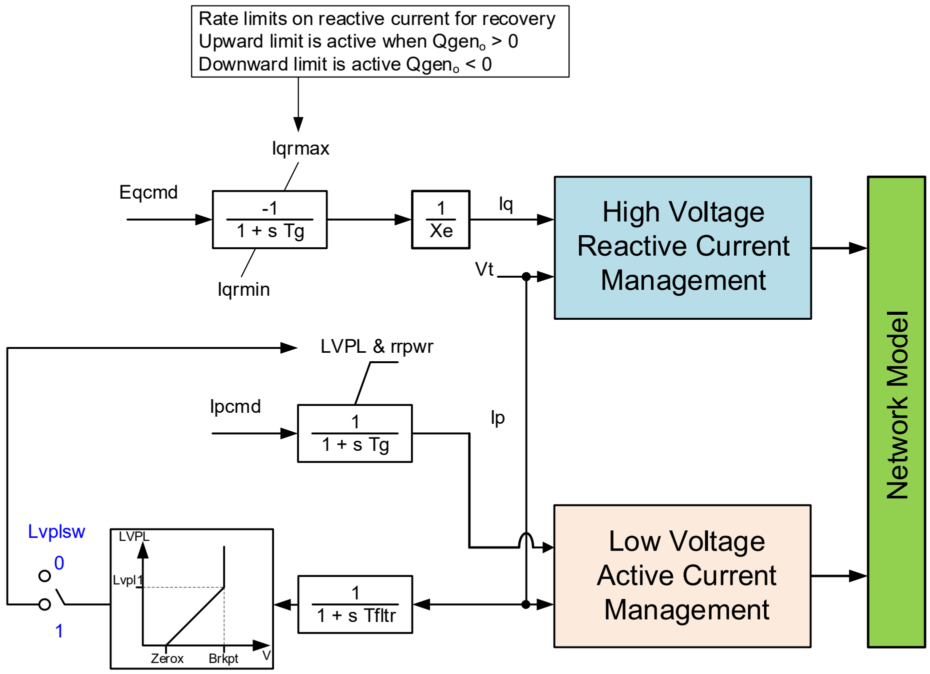

Figure 4: Block diagram of the REGC_A model, with a non-zero value of *Xe*.

Table 1: Parameters for the *regc_a* model.

Parameter name in GE PSLF™	Parameter name in Siemens PTI PSS®E	Parameter name in TSAT™	Parameter name in PowerWorld Simulator	Typical value or range of values	Explanation
Lvplsw	ICON(M)	Lvpl_sw	Lpvlsw	1 or 0	Must be active (1) or disabled (0). Switch to turn on/off Low-Voltage Power Logic
Tg	Tg	Tg	Tg	0.017 to 0.03	Lag time constant emulating current regulator response time. [s]
Rrpwr	Rrpwr	Rlvpl	Rrpwr	1 to 20	Rate limit on active power recovery rate after a large voltage dip, or sudden change in active power command. [pu/s]
Brkpt	Brkpt	Vlvpl2	Brkpt	0.05 to 0.9	Upper break-point on Low-Voltage Power Logic [pu]
Zerox	Zerox	Vlvpl1	Xerox	0.02 to 0.5	Lower break-point on Low-Voltage Power Logic [pu]
Lvpl1	Lvpl1	Lvplv	Lvpl1	1.1 to 1.5	Upper active current limit on Low-Voltage Power Logic [pu]
Vtmax	Volim	Volim	Vlim	1.1 to 1.3	Most typical value is 1.22; this is voltage limit used in the numerical interface with the network solution in High Voltage Reactive Current Management logic [pu]
Lvpnt1	Lvpnt1	Lvpnt1	Lvpnt1	0.02 to 0.8	High voltage point used in the numerical interface with the network solution in the Low Voltage Active Current Management logic [pu]
Lvpnt0	Lvpnt0	Lvpnt0	Lvpnt0[2]	0.001 to 0.4	Low voltage point used in the numerical interface with the network solution in the Low Voltage Active Current Management logic [pu]
Qmin	Iolim	Iolim	Iqextra	-1.3	This is the reactive current limit used in the numerical interface with the network solution in High Voltage Reactive Current Management logic [pu]
Tfltr	Tfltr	Tfltr	Tfltr	0.017 to 0.05	Lag time constant representing the lag in the terminal voltage measurement process [s]
Accel	Khv	Khv	Accel	0.7	Gain/acceleration factor in the High Voltage Reactive Current Management logic. Note: values greater than 1 are used by some and possible, yet a value of 0.7 seems to yield a good result in most cases.
Iqrmax	Iqrmax	Iqrmax	Iqrmax	999	Rate limit on reactive current recovery after a fault if the initial reactive current is positive (injecting into the grid). Typically, not used and thus set to 999. [pu/s]
Iqrmin	Iqrmin	Iqrmin	Iqrmin	-999	Rate limit on reactive current recovery after a fault if the initial reactive current is negative (absorbing from the grid). Typically, not used and thus set to -999. [pu/s]
N/A	Accel	N/A	N/A	0.7	Numerical acceleration factor; $0 < \text{Accel} \leq 1$; This is to help with numerical stability and can be adjusted by the user as necessary. A value of 0.7 yields a good result in most cases.
Xe	Xe	Xe	Xe	0 to 1	Generator effective impedance (none zero only when modeling a type 3 WTG) [pu]

[2] Some vendors will set Lvpnt0 to a negative number and Lvpnt1 to a low positive number, to emulate the fact that their controls do not attempt to intentionally block current at zero voltage. This is reasonable, though not typical.

2.2 The REGC_B Model

The way that most common fundamental-frequency positive-sequence stability programs decouple and solve the differential-equations of the system and the algebraic network equations, has implications when modeling a device as a current source (i.e. as is done in the case of *regc_a*). The current-source model is easy to implement. However, when the point of interconnection of the device to the network becomes exceedingly weak, that is, the Thevenin equivalent impedance looking into the network becomes exceedingly high, then the network solution (steps in orange in Figure 2) can start to have issues with numerical convergence. This can be understood basically by considering that when a small perturbation in current injection is effected into a very large impedance, it will cause a very large change in voltage. Thus, it becomes difficult to bring the iterative solution to convergence, if the tolerance of voltage deviations is small for the network solution to be considered as solved. A high Thevenin equivalent impedance looking into the network is essentially the same as a low short-circuit ratio (SCR) at the point of interconnection. By low is meant an SCR of say less than 2 or so. In these cases, when a fault is simulated near the plant one may see repeated warnings from the simulation software, during the integration steps, that say the network solution did not converge since the change in voltage during the solution steps exceeds the designated delta-voltage tolerance[3].

In an attempt to try to mitigate some of these effects for running the models at lower SCRs, the new *regc_b* model has been developed based on [5]. A description of the model is included in [4]. This model uses a voltage-source model for the interface with the network. The model block diagram is shown in Figure 5.

The parameters of this model are rather simple and described in Table 2. The parameters *Tg, Tfltr, Rrpwr Iqrmax* and *Iqrmin* are identical to those used in *regc_a,* and described in the previous section. The parameter *Rateflg* is a flag that allows the user to switch between applying *Rrpwr* as a rate limit to active-power or active-current. This is because, due to grid codes, primarily outside of North America, many vendors actually apply the rate limit to active-power instead of active-current. The parameter *Imax* is the maximum current rating of the converter, and the parameter *pqflg* indicates whether the converter is operated in Q or P-priority. The LVPL has been completely removed from the model and thus the intent is for the user to exercise any current limit dependence on voltage in the upstream electrical controls model in the so-called VDL tables (see [4]).

The remaining parameters, unique to this model, are *Te*, *Re* and *Xe*. The small time-constant *Te* represents delays in the firing controls of the converter. In real-life these are extremely small delays, typically less than a few milliseconds (i.e. 4 to 5 ms). For the purposes of large power system simulations, the typical integration time-step used in commercial software platforms by system planners is in the range of ¼ cycle, i.e. 4.167 ms in North America. Thus, it is not feasible to set *Te* to such small values. Hence some compromise is needed here and *Te* is typically set to 0.01 to 0.017 seconds. The other reason for having *Te* is for numerical stability. By introducing a state variable in the network solution loop, some additional numerical stability may be gained.

[3] There are other parallel processing-based simulation methods, that are computationally more intense, but can alleviate this problem with current source models, see for example [8],

Finally, the parameters *Re* and *Xe* represent the effective source impedance of the inverter-based generator. The parameter *Re* is typically set to zero, while *Xe* may range between 0.05 to 0.3 pu. Note, theoretically, as *Xe* tends to a large value this model will tend towards a current source and so begin to behave more like *regc_a*. Also, setting *Te* to zero may have a similar effect.

Finally, note again that this model caters really to a full converter interfaced inverter-based generator, such as a type 4 wind turbine generator, a photovoltaic generator or a battery-energy storage system. It can be used to emulate a type 3 wind turbine generator, but if done so it must be understood that there is no real representation of stator flux dynamics.

2.3 Illustrating the Potential Value of the REGC_B Model

To illustrate the efficacy of the *regc_b* model, some simulations were performed to compare *regc_b* with *regc_a*. Note that as of the writing of this memo, the *regc_b* model is still only available as a beta version[4] of the model, and it has not yet been officially released as a fully approved model in any of the software platforms. However, it is expected to be approved and released soon[5]. Thus, there is a slight chance that the actual final released version, may be slightly modified from that shown here.

Consider the simulations in Figure 6 through Figure 11. Figure 6, Figure 7 and Figure 8 are simulations performed in Siemens PTI PSS®E (Version 34.6.1). Figure 9, Figure 10 and Figure 11 are simulations in GE PSLF™ (Version 21.08.01). The simulations were performed in a simple five machine system, as illustrated diagrammatically in Figure 12[6]. The system is realistic, though fictitious. That is, it does not represent any particular actual power system. The system and models are nominally identical between the two software platforms, however, it must be understood that since the system is more complex than a simple single-machine infinite bus, the results are not identical in the two simulation platforms, though they are very similar. Also, given the way in which a fault is invoked in each of the two tools, the exact value of the fault impedance may be slightly different in the two simulation platforms. In all cases the inverter-based resource (IBR) is represented by a generator/converter model, appropriate electrical controls and a plant level controller.

There are three scenarios being simulated:

- A high short-circuit ratio (SCR) scenario. In this case the IBR is modelled to have a rating of 24 MVA. The total synchronous generation in the system is around 3500 MVA. It is a heavy load condition. Thus, the SCR at the IBR is about 30.

[4] The beta version of the model is available in GE PSFL™ Version 20.08.01, which is the one used here. The beta version of the model was graciously provided to us by Siemens PTI PSS®E as a user-written DLL to be used with Siemens PTI PSS®E Version 34.6.1. The official version of the *regc_b* model is expected to be release by all software vendors (i.e. Siemens PTI PSS®E, GE PSLF™, PowerTech Labs DSATools™ and PowerWorld Simulator) in the next official release of the tools.

[5] When this work was first started *regc_b* had not yet been approved. As of the second revision of this report, it has been approved and soon to be released in the various software tools. The version of *regc_b* used here are those that were available in early August, 2020, which were near final version of the model but prior to its final approval.

[6] The five-machine simple system is a model developed pervious by for educational purposes. It was not developed for, or during, this work, nor is it claimed to represent any real system.

- A low short-circuit ratio (SCR) scenario. In this case the IBR is modelled to have a rating of 350 MVA. The total synchronous generation in the system is around 900 MVA. All but one of the synchronous generators are placed out-of-service. It is a light load condition. Thus, the SCR at the IBR is about 2.
- An extremely low short-circuit ratio (SCR) scenario. In this case the IBR is modelled to have a rating of 350 MVA. The total synchronous generation in the system is around 900 MVA. All but one of the synchronous generators are placed out-of-service. It is a light load condition. The impedance of line 1 has been increased to reduce the SCR. Thus, the SCR at the IBR is less than 1.

In all cases, the simulation is a fault at the remote end of line 2 and tripping of the line.

The overall observation from the figures is this:

1. For the high SCR condition, the behavior of both the *regc_a* and *regc_b* models are very similar, and both behave well numerically.
2. For the low SCR condition, both models still behave well numerically, however, their behavior starts to diverge from each other. This is, the network solution starts to exceed the solution tolerance during the fault for *regc_a,* and hence we start to see unrealistic spikes in voltage at fault inception and clearing for the regc_a model. Note, however, than once the fault clears, within a fraction of a second the response of the two models agree.
3. For the extremely weak SCR condition, clearly the *regc_a* model is numerical unstable and results of the simulation are meaningless, while the *regc_b* model does provide a converged network solution once the fault is cleared.

The general conclusion is that as one gets to the weaker system conditions, the *regc_b* model is numerically better behaved. An extremely important note here is that when SCR is less than or equal to 2, most equipment manufacturers will indicate that detailed analysis is required, using 3-phase vendor specific EMT models to ensure that the converter high-band width control-loops (e.g. inner-current control loop and its coordination with the phase-lock loop) are stable and well behaved. Thus, fine tuning of these controls, together with other possible mitigation strategies (e.g. weak-grid option controls) may be necessary. Thus, it is imperative that one understands that the *regc_b* model is not able to be used for such detailed analysis pertaining to vendor specific equipment, and it is not a substitute for such detailed analysis for actual IBR plants to be built under such extremely weak grid conditions. What the *regc_b* model may offer is a numerically stable way of simulating the behavior of such plants, once it has been otherwise established through detailed facilities studies (e.g. in an EMT software platform) that the actual vendor equipment will perform adequately and in a stable fashion. Moreover, another model has been proposed for use in fundamental-frequency positive-sequence simulation platforms, called *regc_c* [9], which does include a representation of the inner-current control loops and the PLL. This model is yet to be implemented by the software vendors, but once implemented (as shown in [9]) it may offer an opportunity for some more detailed analysis in positive-sequence programs as and intermediate step between positive-sequence and EMT analysis. The *regc_c* model, however, does require much smaller integration-time steps (e.g. of the order of 1 ms) and so may not be practical for interconnection wide use on a large number of RES.

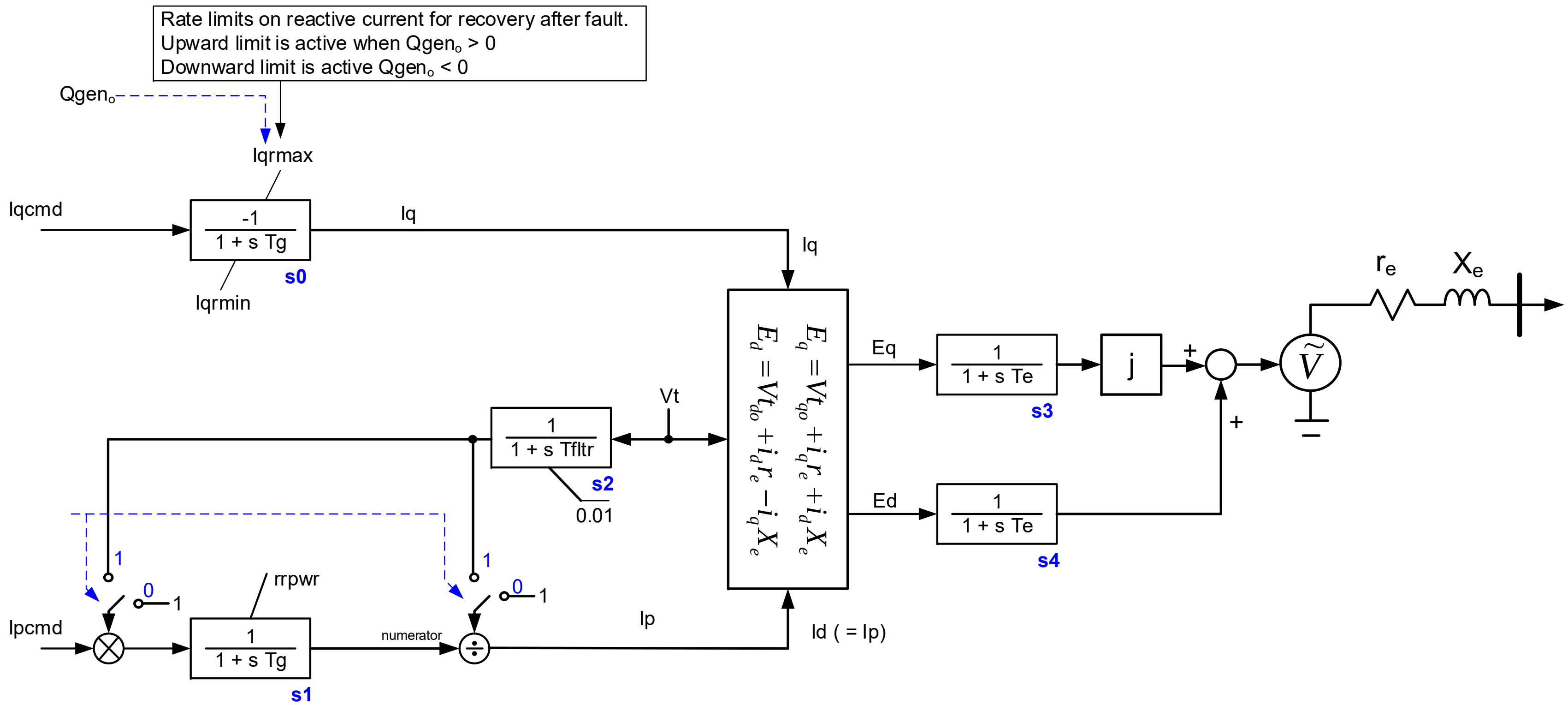

Figure 5: Block diagram of the REGC_B model.

Table 2: Parameters for the *regc_b* model.

Parameter name	Typical value or range of values	Explanation
Tg	0.017 to 0.03	Lag time constant emulating current regulator response time. [s]
Te	0.01 to 0.017	Lag time constant representing delay in converter firing controls. [s]. *(Should generally not set this to zero)*
Tfltr	0.017 to 0.05	Lag time constant representing the lag in the terminal voltage measurement transducer [s]
Rrpwr	1 to 20	Rate limit on active power recovery rate after a large voltage dip, or sudden change in active power command. [pu/s]
Re	0 to 0.02	Equivalent source resistance. [pu]
Xe	0.05 to 0.3	Equivalent source reactance. [pu]
Iqrmax	999	Rate limit on reactive current recovery after a fault if the initial reactive current is positive (injecting into the grid). Typically, not used and thus set to 999.
Iqrmin	-999	Rate limit on reactive current recovery after a fault if the initial reactive current is negative (absorbing from the grid). Typically, not used and thus set to -999.
Rateflg	0 or 1	Flag for choosing to apply *rrpwr* as a (0) rate limit on active current, or (1) rate limit on active power
Imax	1 to 1.5	Maximum converter current limit [pu]
Pqflag	0 to 1	P/Q priority: (0) reactive current priority or (1) active current priority

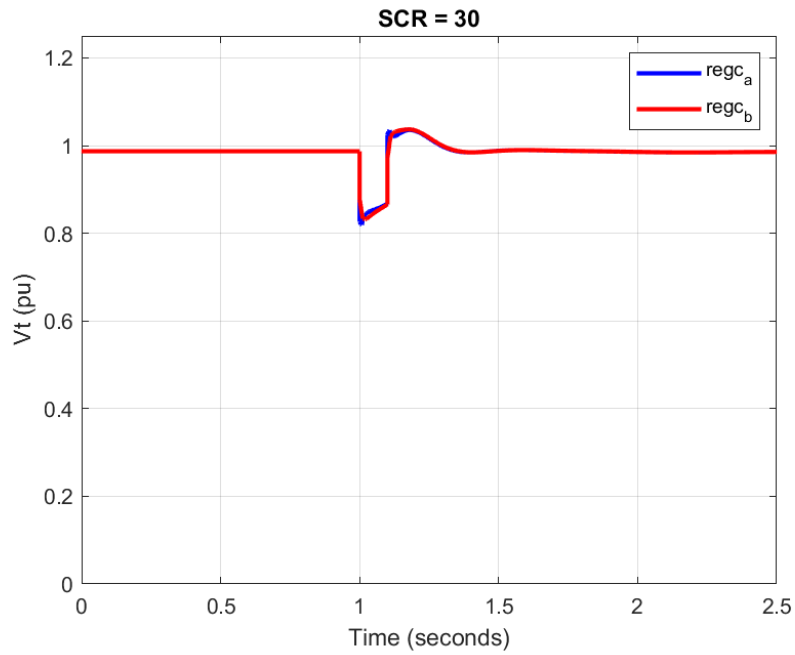

Figure 6: Fault and trip of a line near the point of interconnection of an inverter-based generator modeled using REGC_A and REGC_B. Simulation ran in Siemens PTI PSS®E using a as available beta version of the REGC_B model at the time of writing this memo.

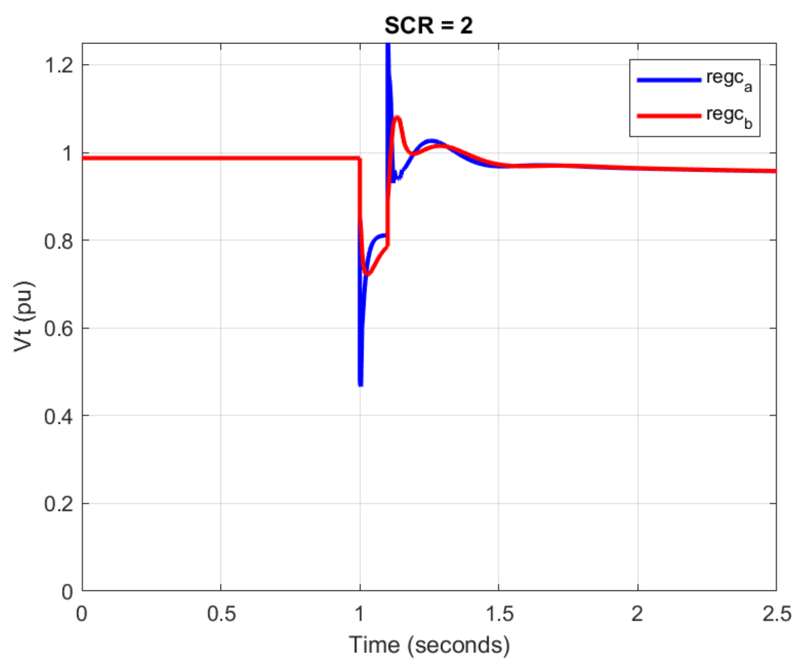

Figure 7: Fault and trip of a line near the point of interconnection of an inverter-based generator modeled using REGC_A and REGC_B. Simulation ran in Siemens PTI PSS®E using a as available beta version of the REGC_B model at the time of writing this memo.

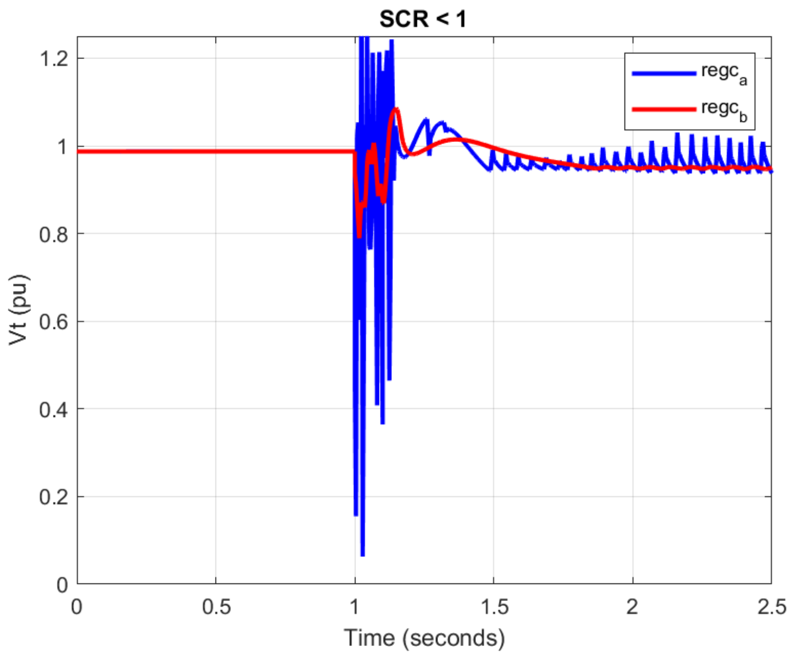

Figure 8: Fault and trip of a line near the point of interconnection of an inverter-based generator modeled using REGC_A and REGC_B. Simulation ran in Siemens PTI PSS®E using a as available beta version of the REGC_B model at the time of writing this memo.

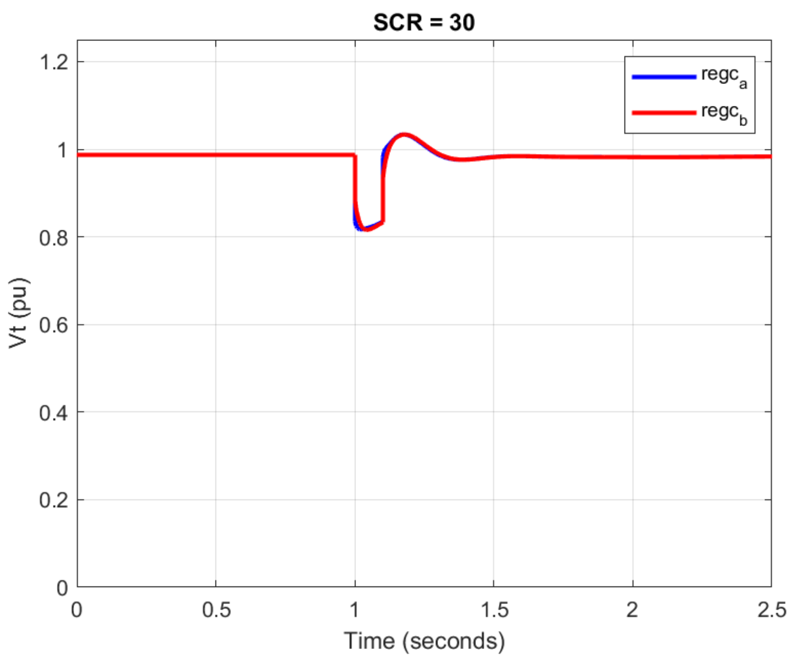

Figure 9: Fault and trip of a line near the point of interconnection of an inverter-based generator modeled using REGC_ Simulation ran in GE PSLF™ Version 21.08.01 using a as available beta version of the REGC_B model at the time of writing this memo.

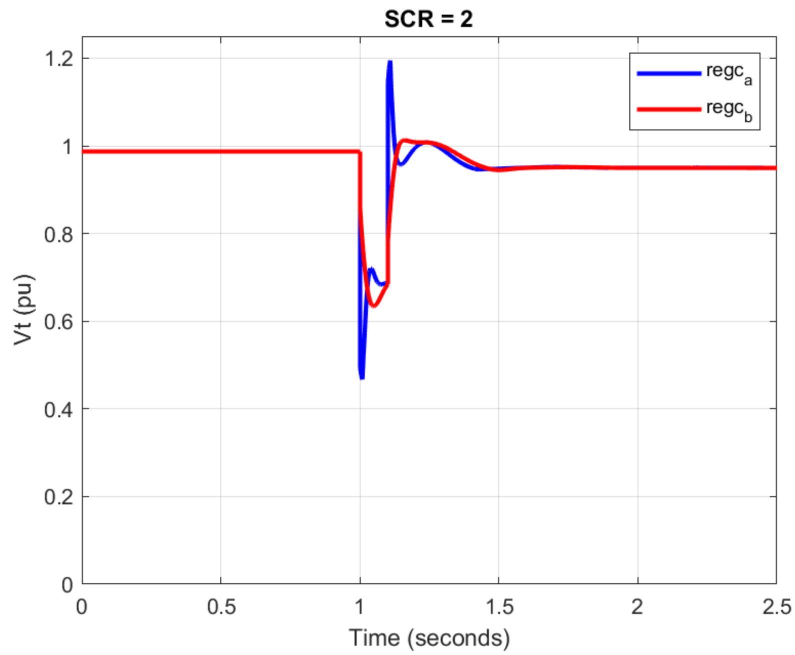

Figure 10: Fault and trip of a line near the point of interconnection of an inverter-based generator modeled using REGC_A and REGC_B. Simulation ran in GE PSLF™ Version 21.08.01 using a as available beta version of the REGC_B model at the time of writing this memo.

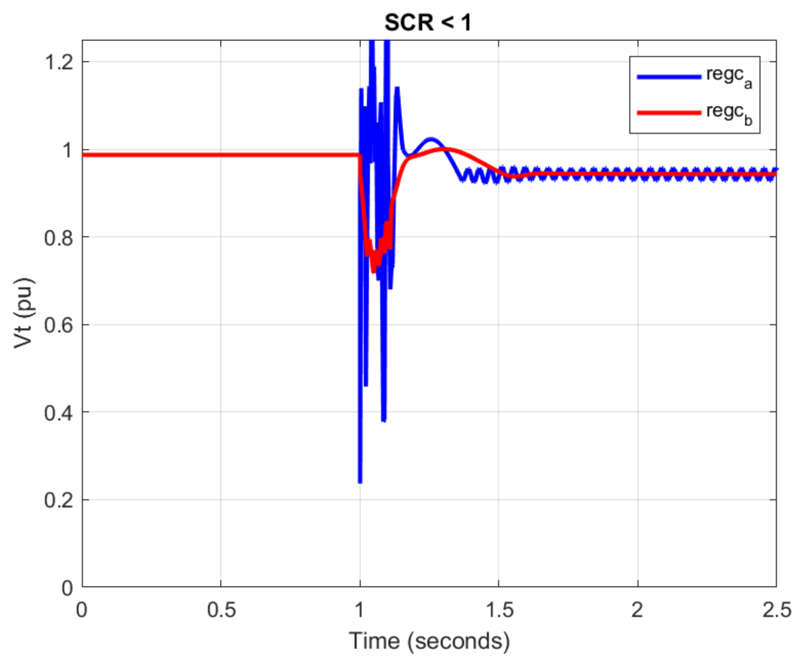

Figure 11: Fault and trip of a line near the point of interconnection of an inverter-based generator modeled using REGC_A and REGC_B. Simulation ran in GE PSLF™ Version 21.08.01 using a as available beta version of the REGC_B model at the time of writing this memo.

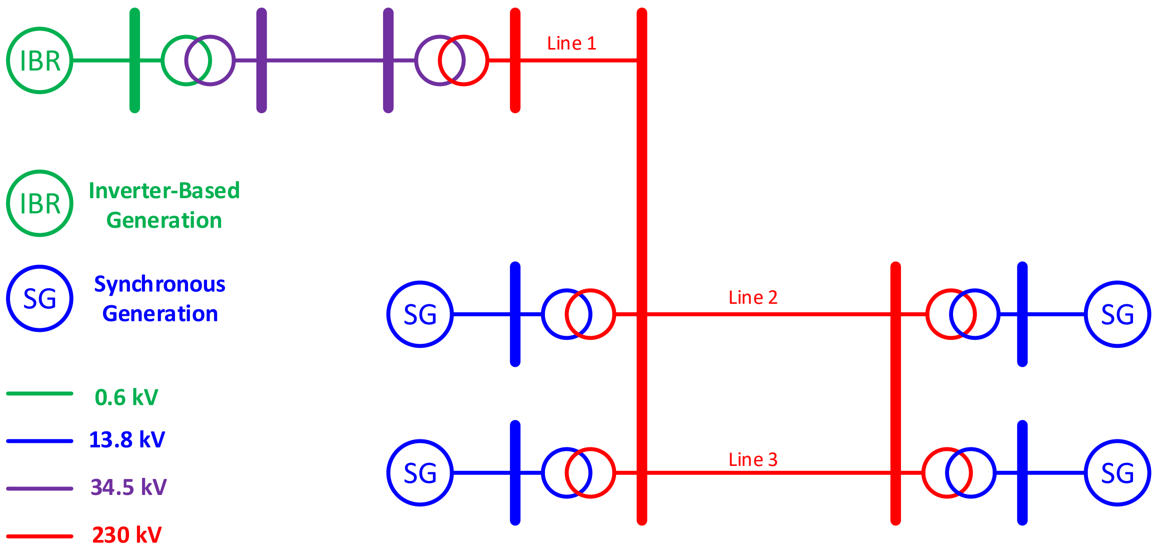

Figure 12: Simple system modeled.

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