Document Purpose / Intent

An extended term case may require the insertion of additional modeled generation resources. There was no known method in PST to increase inertial generation during a simulation and the method used for removing a generator was unclear. This document is meant to describe initial work that has been done to develop a method to 'un-trip' a generator, as well as describe how a generator is tripped in PST. Various code additions and possible future work are also presented.

How PST Trips Generators

During simulation initialization, `g.mac.mac_trip_flags` is initialized as a row vector of zeros that correspond to the `mac_con` array, and `g.mac.mac_trip_states` variable is set to zero. To trip a generator, a `mac_trip_flag` is set to 1 via the user generated `mac_trip_logic` code. The `mac_trip_logic` is executed in the `initStep` function which alters `g.mac.mac_trip_flags` to account for any programmed trip. Specifically, a 0 in the `g.mac.mac_trip_flags` row vector is changed to a 1 to signify a generator has tripped.

The `g.mac.mac_trip_flags` vector is summed in the `networkSolution` (`networkSoltuionVTS`). If the resulting sum is larger than 0.5, the line number connected to the generator in the `g.line.line_sim` is found and the reactance is set to infinity (1e7). The reduced y matrices are then recalculated and used to solve the network solution via an `i_simu` call. If derivatives of the tripped machine are not set to zero, the generator's speed increases, mechanical power output eventually drops to zero/near-zero, and the attached exciter Efd appears to approach 1.

Performance Note

If a machine is tripped, altered reduced Y matrices are generated every simulation step. This repeated action could probably be reduced via use of globals and logic checks.

- create new globals handling the Y matrices selected during the network solution.

- create an `old_mac_trip_flags`

- compare `old_mac_trip_flags` to `mac_trip_flags`

- if there has been a new trip, update associated Y matrix globals

- if there hasn't been a new trip, but a machine has tripped, use the stored Y matrix

This is merely a calculation reduction and not required for tripping/un-tripping, but may result in a noticeable speed up.

Research
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Collection of Generator Tripping
and Un-Tripping Information

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Experimental 'Un-trip' Method

A method was devised to bring generation online that involves changing the `mac_trip_flag` from 1 to 0, re-initializing or bypassing models, and ramping exciter and governor reference values. Generally, the current method involves:

1. Ensure $P_{mech} = P_{elect} = 0$

2. 'Bypass' governor by setting $P_{ref} = 0$ and $\omega_{ref} =$ the current machine speed.

3. 'Bypass' Exciter by ignoring calculated `mac.vex` from exciter model. (may change)

4. Change `mac_trip_flag` from 1 to 0

5. Re-Initialize machine to current time index

6. Re-Initialize governor to current time index

7. Re-Initialize exciter and PSS to current time index

8. Ramp exciter and governor reference values

Changing a `mac_trip_flag` from 1 to 0 returns the line reactance to normal and effectively re-connects a generator to the system. However, the model states and reference values are no longer synchronized with the system and must be handled to avoid unrealistic issues and excessive transients. Test cases have been created that utilize the `mac_trip_logic` and `mtg_sig` user defined code files to manage the required bypassing, reinitializations, and reference ramping tasks.

Most PST models may be initialized if the passed in flag is 0. Individual models may be intialized if the passed in i is the internal number of the model to initialize. Unfortunately, the initialize functions were designed to work with values at time index 1 however, it appears simple enough to change this so that an arbitrary data index may be referenced for initialization procedures. Alternatively, additional functions, or flag functions of models may be created to handle re-initialization.

Added Code Functionality

- Exciter Bypass
- Zeroing of tripped Machine derivatives in FTS mode
- Update of PSS initialization routine to handle re-init.
- Creation of re-init functions for `mac_sub`, `tg`, `smpexc`.

Possible Future Work

- Initialize system with tripped generators (i.e. allow spinning reserve)
- Reduce Y matix redundant calculations when tripping via globals and logic
- Enable re-init for more generators/exciters
- Automatically zero derivatives of models attached to gen (exc, pss, gov)
- Devise better, more functionalized, method to more easily trip and un-trip generators
- Allow VTS to work with un-trips - will probably require indexing of saved solution vector.