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PSAT Training

Part 02A
Organization - Software

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Outline

- Folder organization
- PSAT units
- Parameter naming nomenclature
- PSAT structure

PSAT Folder Organization

- psat_v62
  - component
    - calculation
    - initialization ← Initialization files
    - model_library ← Simulink models
    - scaling ← Scaling files
  - gui
    - Images ← GUI files
    - Matlab Files
  - plugins
  - powertrain_controller ← Vehicle level control
    - initialization
    - model_library
  - projects ← Projects
  - root ← Software-level files
    - common
    - model_building
    - pictures
    - plot
    - post_processing
    - pre_processing
    - run
  - users ← User directories
  - vehicle ← Predefined vehicles
    - heavy_duty
    - light_duty

PSAT Folder Organization

- component
  - calculation
  - initialization
    - clutch_torque_converter
    - drive_cycle
    - driver
    - electrical_accessory
    - energy_storage
    - engine
    - environment
    - exhaust_aftertreatment
    - final_drive
    - fuel_cell
    - gearbox
    - generator
    - hydraulic_accessory
    - hydraulic_energy_storage
    - hydraulic_motor
    - mechanical_accessory
    - motor
    - power_converter
    - starter
    - steam_system
    - torque_coupling
    - transfer_case
    - vehicle
    - wheel_axle
  - model_library
  - scaling

The initialization files and models are organized by components

- powertrain_controller
  - initialization
    - braking
    - propelling
      - conventional
      - electric
      - fuelcell
      - parallel
      - power_split
      - series_eng
      - series_fc
      - series_parallel
    - shifting
    - transient

The controls are organized by configuration

PSAT Uses SI Units for All Models

Value	Units
Torque	Nm
Rotational speed	Rd/s
Inertia	Kg.m2
Vehicle speed	M/s
Force	N
Current	A
Voltage	V
Power	W
Energy	J
Rotational acceleration	Rd/s2
Linear acceleration	M/s2
Mass	Kg

Name Nomenclature - Component Models

- Based on three parts:
  - Type of component (e.g.: eng = engine)
  - Type of data (e.g.: trq = torque)
  - Complement of information (e.g.: max = maximum)
- All the model parameters and variables are composed using these three parts

Name Nomenclature - Type Of Component

accelec = electrical acc

accmech = mechanical acc

cpl = clutch / torque conv.

cyc = cycle

drv = driver

ess = energy storage

ex = exhaust

eng = engine

fc = fuel cell

fd = final drive

gc = generator

mc = motor

ptc = powertrain

sft = shifting

tc = torque coupling

gb = gearbox

veh = vehicle

wh = wheel…

Name Nomenclature - Type Of Data

trq = torque

spd = rotational speed

linear_spd = linear speed

curr = current

volt = voltage

pwr = power

energy = energy

inertia = inertia

mass = mass

soc = state-of-charge

temp = temperature

tau = time constant

voc = open circuit voltage

cmd = command…

Name Nomenclature – Complement of Information

chg = charge

dis = discharge

accel = acceleration

decel = deceleration

dnshift = downshift

upshift = upshift

min = minimum

max = maximum

avg = average

rms = root-mean-square

index = index

map = map

loss = loss

in = input

out = output

drag = drag

aero = aerodynamic

dmd = demand

trs = transient

cstr = constraint…

PSAT Structure

The information of the selected configuration / initialization files scaling / simulation setups are saved in a structure

```
» psat

psat =

        global: [1x1 struct]
         units: [1x1 struct]
       current: [1x1 struct]
    simulation: [1x1 struct]
```

- global: High level information
- units: List of units chosen by the user
- current: Type of study (simulation/testing)
- simulation: Initial simulation parameters and results

Global Field

```
» psat.global

ans =

                 project_dir: 'l:\modeling\development\psat_v60_beta6'
                   user_name: 'arousseau'
                   perso_dir: 'l:\modeling\development\psat_v60_beta6\users\arousseau'
                    psat_dir: {6x1 cell}
                    set_path: 1
                  rerun_list: [1x1 struct]
                     rtw_ver: [0x0 struct]
            run_acceleration: 0
            run_gradeability: 0
          run_test_procedure: 0
                   run_cycle: 0
               run_coastdown: 0
           simulation_number: 2
                      sample: 0.0100
                 list_fields: {'cycle'}
                cycle_choice: []
                  time_cycle: []
                fuel_cell_dir: 'none'
                  cpt_choice: 1
        pwt_list_hist_param: {1x98 cell}
    complete_list_hist_param: {1x116 cell}
        ptc_list_hist_param: {1x18 cell}
                gbl_stop_time: 135
```

Provides information on what type of simulation needs to be run

Units Field

```
» psat.units

ans =

                          area: 'm2'
    brake_specific_fuel_economy: 'g/(kW-hr)'
                       current: 'amps'
                       density: 'kg/liter'
                      distance: 'mile'
                      emission: 'kg/m'
                        energy: 'Wh'
            energy_consumption: 'J/m'
                         force: 'N'
                   fuel_economy: 'mile/gallon'
                       inertia: 'kg.m^2'
                        length: 'm'
           linear_acceleration: 'm/s2'
                  linear_speed: 'mile/h'
                          mass: 'kg'
                     mass_flow: 'kg/s'
                    normalized: '[0,1]'
                         power: 'kW'
                      pressure: 'Pa'
        rotational_acceleration: 'rd/s2'
               rotational_speed: 'rad/s'
                 specific_energy: 'Wh/kg'
           specific_fuel_economy: 'liter/m/kg'
                  specific_power: 'kW/kg'
                     temperature: 'C'
                            time: 's'
                          torque: 'Nm'
                         voltage: 'volt'
                          volume: 'liter'
                  volumetric_flow: 'liter/s'
```

Current Field

```
» psat.current

ans =

          field: 'simulation'
     simulation: 1
```

The current field can be simulation or testing

Provides the total number of simulations run to increment the field psat.simulation

Simulation Field

```
» psat.simulation

ans =

       vehicle: [1x1 struct]
      building: [1x1 struct]
    drivetrain: [1x1 struct]
    controller: [1x1 struct]
         setup: [1x1 struct]
         debug: [1x1 struct]
        solver: [1x1 struct]
          mode: 'Normal'
       results: [1x1 struct]
```

- vehicle → Vehicle Name
- building → Information to build the model
- drivetrain → Component information
- controller → Control information
- setup → Details on what simulation to run
- debug → Debugging choices
- solver → Simulink solver details
- results → Scalar results

Simulation/Building Field

```
» psat.simulation.building

ans =

          name: 'par_2wd_p1_dm'
          pos2: ''
          pos1: 'Starter_motor_alternator'
         trans: 'dm'
          axle: '2 wheel drive'
           pwt: 'Parallel Hybrid'
    name_compo: {13x1 cell}
     pos_compo: {13x2 cell}
```

```
» psat.simulation.building.name_compo

ans =

    'drv'
    'accmech'
    'cpl'
    'ess'
    'mc'
    'gb'
    'fd'
    'wh'
    'veh'
    'ex'
    'pc_accelec'
    'accelec'
    'eng'
```

List of component names

Simulation/Drivetrain Field

```
» psat.simulation.drivetrain

ans =

                    drv: [1x1 struct]
                accmech: [1x1 struct]
                    cpl: [1x1 struct]
                    ess: [1x1 struct]
                     mc: [1x1 struct]
                     gb: [1x1 struct]
                     fd: [1x1 struct]
                     wh: [1x1 struct]
                    veh: [1x1 struct]
                     ex: [1x1 struct]
            pc_accelec: [1x1 struct]
               accelec: [1x1 struct]
                    eng: [1x1 struct]
                    ptc: [1x1 struct]
    select_to_workspace: 'off'
```

```
>> psat.simulation.drivetrain.eng

ans =

         model: 'eng_map_hot'
    technology: 'si'
          init: 'eng_si_1600_85_civic'
     param_var: []
           trs: [1x1 struct]
         scale: ''
          calc: {'eng_calculation'}
     variables: [1x1 struct]
```

```
» psat.simulation.drivetrain.eng.variables

ans =

          name: {19x1 cell}
     extension: {19x1 cell}

» psat.simulation.drivetrain.eng.variables.name

ans =

    'eng_trq_out'
    'eng_spd_out'
    'eng_ex_gas_temp'
    'eng_temp'
    'eng_temp_coeff'
    'eng_htrej_cum'
    'eng_htrej_rate'
    'eng_fuel_cum'
    'eng_fuel_rate'
    'eng_ex_equiv'
    'eng_ex_gas_flow'
    'eng_o2'
    'eng_pm'
    'eng_nox'
    'eng_co'
    'eng_hc'
    'eng_stat'
    'eng_cmd'
    'eng_on'
```

List of output parameters

Simulation/Controller Field

```
» psat.simulation.controller

ans =

    strategy: [1x1 struct]
         trs: [1x4 struct]
```

```
» psat.simulation.controller.strategy

ans =

        prop: [1x1 struct]
     braking: [1x1 struct]
    shifting: [1x1 struct]
```

```
» psat.simulation.controller.strategy.prop

ans =

    model: 'p_par_1mc_conso_start_alter'
     init: 'p_par_1mc_conso_start_alter'
```

```
» psat.simulation.controller.trs(1)

ans =

    compo: 'gb'
    model: 'lib_trs_tx_dm'
     init: 'trs_tx_cpl'
```

Setup/Debug/Solver Fields

```
» psat.simulation.setup

ans =

    choice: 'cycle'
     cycle: [1x1 struct]
```

```
» psat.simulation.debug

ans =

              debug_psat: 0
    stop_simu_before_end: 0
           show_building: 0
         manual_sim_stop: 0
                building: [1x1 struct]
             prototyping: 0
              decimation: 10
      optimize_driveline: 1
```

```
» psat.simulation.debug.building

ans =

    model: 1
      bus: 1
```

```
» psat.simulation.solver

ans =

             AbsTol: 'auto'
              Debug: 'off'
         Decimation: 1
       DstWorkspace: 'current'
     FinalStateName: ''
          FixedStep: '0.01'
       InitialState: []
        InitialStep: 'auto'
           MaxOrder: 5
         SaveFormat: 'Matrix'
            MaxRows: 0
            MaxStep: 'auto'
       OutputPoints: 'all'
    OutputVariables: 'ty'
             Refine: 1
             RelTol: '0.001'
             Solver: 'ode4'
       SrcWorkspace: 'base'
              Trace: ''
          ZeroCross: 'off'
            SimStep: 'Fixed'
         SolverMode: 'auto'
```

Results Fields

```
» psat.simulation.results

ans =

              analysis: [1x1 struct]
    cycle_consumption: [1x1 struct]
              save_dir: 'par_2wd_p1_dm_Japan10_081104_102560'
```

```
» psat.simulation.results.analysis

ans =

         general: [1x1 struct]
         current: [1x1 struct]
           power: [1x1 struct]
         voltage: [1x1 struct]
           speed: [1x1 struct]
          torque: [1x1 struct]
           force: [1x1 struct]
    linear_speed: [1x1 struct]
          energy: [1x1 struct]
      efficiency: [1x1 struct]
           cycle: [1x1 struct]
```

The analysis field regroup all information not related to consumption

```
» psat.simulation.results.analysis.general

ans =

                      condition_chg: 'ess_curr_out_simu'
                  condition_chg_pwr: 'ess_pwr_in_simu'
                     percent_eng_on: 0.3264
                   number_eng_start: 18
                 energy_regen_ideal: -2.8695e+005
          energy_regen_recuperated: -1.2131e+005
           energy_regen_brake_lost: -2.0625e+004
percent_energy_regen_recuperated: 0.4227
                  energy_used_veh: 2.7662e+005
                 energy_loss_drag: 8.1924e+004
                 energy_loss_aero: 2.0191e+004
                 energy_loss_grade: 0
            energy_loss_veh_total: 1.0212e+005
                time_zero_veh_spd: 204
            distance_zero_veh_spd: 0
        percent_time_zero_veh_spd: 0.1510
              time_cycle_duration: 135
             veh_acceleration_max: 4.4654
             veh_acceleration_min: -4.6519
        time_veh_acceleration_max: 108.2000
        time_veh_acceleration_min: 94.6000
                  time_pos_wh_trq: 30.7000
                  time_neg_wh_trq: 84.0000
              distance_pos_wh_trq: 195.2142
              distance_neg_wh_trq: 457.9166
          percent_time_pos_wh_trq: 0.2274
          percent_time_neg_wh_trq: 0.6222
          time_pos_wh_trq_ess_chg: 30.7000
          time_pos_wh_trq_ess_dis: 0
          time_neg_wh_trq_ess_chg: 84.0000
          time_neg_wh_trq_ess_dis: 0
      distance_pos_wh_trq_ess_chg: 195.2142
      distance_pos_wh_trq_ess_dis: 0
      distance_neg_wh_trq_ess_chg: 457.9166
      distance_neg_wh_trq_ess_dis: 0
  percent_time_pos_wh_trq_ess_chg: 0.2274
  percent_time_pos_wh_trq_ess_dis: 0
  percent_time_neg_wh_trq_ess_chg: 0.6222
  percent_time_neg_wh_trq_ess_dis: 0
```

Results Fields

```
» psat.simulation(1).results.cycle_consumption

ans =

            total: [1x1 struct]
      electrical: [1x1 struct]
          thermal: [1x1 struct]
     soc_adjusted: [1x1 struct]
```

All the units are always in SI. For example, fuel economy is in liter/meter and energy in Joule.

```
» psat.simulation.results.cycle_consumption.combined

ans =

                                                pwt_efficiency_simu: [1351x1 double]
                                                   wh_energy_in_net: 2.1514e+005
                                                  wh_energy_out_net: 3.1304e+005
                                                  wh2_energy_in_net: 0
                                                 wh2_energy_out_net: 0
                                                     pwt_energy_out: 4.4872e+005
                                                      pwt_energy_in: 2.3505e+006
                                                combined_energy_use: 2.0304e+006
                                          efficiency_tank_to_wheel: 0.1909
                                          ess_erg_stored_estimated: -2.0308e+004
                       fuel_economy_student_competition_offboard: 9.8365e-005
                        fuel_economy_student_competition_onboard: 9.8977e-005
                                      fuel_economy_psat_offboard: 1.0226e-004
      fuel_economy_psat_onboard_thermal_100_ess_eff_chg_ess_dis: 8.2076e-005
    fuel_economy_psat_onboard_thermal_regen_ess_eff_chg_ess_dis: 1.0611e-004
            fuel_economy_psat_onboard_thermal_100_ess_eff_lumped: 1.0611e-004
```

Results Fields

```
» psat.simulation.results.cycle_consumption.thermal

ans =

              eng_energy_in_net: 2.0200e+006
                fuel_energy_use: 2.0200e+006
                      mass_fuel: 0.0474
                       vol_fuel: 0.0633
      mass_fuel_gasoline_equiv: 0.0474
       vol_fuel_gasoline_equiv: 0.0633
   fuel_economy_gasoline_equiv: 9.6973e-005
                  fuel_economy: 9.6973e-005
                   emission_hc: 0
                   emission_co: 0
                  emission_nox: 0
                   emission_pm: 0
                  emission_co2: 2.2933e-004
             mechanical_energy: 3.1840e+005
                thermal_energy: 2.0399e+006
                   mean_fc_eff: 0.1561
          specific_fuel_economy: 6.0608e-008
             mass_fuel_320miles: 37.4050
```

```
» psat.simulation.results.cycle_consumption.electrical

ans =

                ess_energy_in_net: 1.1538e+005
               ess_energy_out_net: 1.3568e+005
               ess2_energy_in_net: 0
              ess2_energy_out_net: 0
                  ess2_energy_use: 0
                   ess_energy_use: 1.0410e+004
                     ess_soc_init: 0.7000
                ess_final_abs_soc: 0.6988
                ess_final_usb_soc: 0.6988
           ess_energy_consumption: -31.0940
          ess2_energy_consumption: 0
      electrical_energy_consumption: -31.0940
```