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MACHINE
    WaterTank_2Ctrl_2Tanks
REFINES
    WaterTank_base
SEES
    WaterTank_2Ctrl_2Tanks_Ctx
VARIABLES  t , V1 , V2 , V1_sim , V2_sim , x_s1 , x_s2 , Delta_sim_1 , Delta_sim_2
INVARIANTS
    inv1 :  V1 ∈ RRealPlus → S
    inv2 :  V2 ∈ RRealPlus → S
    inv3 :  V1_sim ∈ RRealPlus → S
    inv4 :  V2_sim ∈ RRealPlus → S
    inv5 :  x_s1 ∈ STATES
    inv6 :  x_s2 ∈ STATES
    inv7 :  V = fadd(V1, V2)
    inv8 :  boundedBy(RRealPlus, fadd(V1, V2_sim), Vlow, Vhigh)
    inv9 :  boundedBy(RRealPlus, fadd(V1_sim, V2), Vlow, Vhigh)
    inv10 :  Delta_sim_1 ∈ RRealPlus
    inv11 :  Delta_sim_2 ∈ RRealPlus
    inv12 :  ∀t_ · t_ ∈ RRealPlus ⇒ abs(minus(V2(t_) ↦ V2_sim(t_))) ↦ Delta_sim_2 ∈ leq
    inv13 :  ∀t_ · t_ ∈ RRealPlus ⇒ abs(minus(V1(t_) ↦ V1_sim(t_))) ↦ Delta_sim_1 ∈ leq
    inv14 :  x_s = guess_gs(x_s1 ↦ x_s2)
EVENTS
    INITIALISATION
    WITH
        V' :  V' = fadd(V1', V2')
    THEN
        act1 :  t := Rzero
        act2 :
            V1, V1_sim, V2, V2_sim :|
                V1' ∈ RRealPlus → S ∧ V2' ∈ RRealPlus → S∧
                V1_sim' ∈ RRealPlus → S ∧ V2_sim' ∈ RRealPlus → S∧
                solutionOf(RRealPlus, V1', ode(NoFlow, V10, Rzero))∧
                solutionOf(RRealPlus, V2', ode(NoFlow, V20, Rzero))∧
                V1_sim' = V1' ∧ V2_sim' = V2'
        act3 :  x_s1, x_s2 := Stable, Stable
        act4 :  Delta_sim_1 :∈ RRealPlus
        act5 :  Delta_sim_2 :∈ RRealPlus
    END

    Progress
    REFINES  Progress
    THEN
        act1 :  t :| t' ∈ RRealPlus ∧ (t ↦ t' ∈ lt)
    END

    Behave
    REFINES  Behave
    ANY  e
    WHERE
        grd1 :  e ∈ DE(S)
        grd2 :  Solvable(Closed2Infinity(t), e)
    WITH
        V' :  V' = fadd(V1', V2')
    THEN
        act1 :
            V1, V2 :|
                V1' ∈ RRealPlus → S ∧ V2' ∈ RRealPlus → S∧
                AppendSolutionBAP(e, RRealPlus, Closed2Open(Rzero, t), Closed2Infinity(t), fadd(V1, V2), fadd(V1', V2'))
    END

    ctrl_sense_too_high_1
    REFINES  ctrl_sense_too_high
    WHERE
        grd1 :  plus(Vhigh ↦ Delta_sim_2) ↦ plus(V1(t) ↦ V2_sim(t)) ∈ leq
    THEN
        act1 :  x_s1 := Emptying
    END

    ctrl_sense_too_high_2
    REFINES  ctrl_sense_too_high
    WHERE
        grd1 :  plus(Vhigh ↦ Delta_sim_1) ↦ plus(V1_sim(t) ↦ V2(t)) ∈ leq
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THEN
    act1 : x_s2 := Emptying
END

ctrl_sense_too_low_1
REFINES ctrl_sense_too_low
WHERE
    grd1 : plus(V1(t) ↦ V2_sim(t)) ↦ minus(Vlow ↦ Delta_sim_2) ∈ leq
THEN
    act1 : x_s1 := Filling
END

ctrl_sense_too_low_2
REFINES ctrl_sense_too_low
WHERE
    grd1 : plus(V1_sim(t) ↦ V2(t)) ↦ minus(Vlow ↦ Delta_sim_1) ∈ leq
THEN
    act1 : x_s2 := Filling
END

ctrl_transition_emptying_1
REFINES ctrl_transition_emptying
WHERE
    grd1 : plus(Vlow ↦ Delta_sim_2) ↦ plus(V1(t) ↦ V2_sim(t)) ∈ lt
THEN
    act1 : x_s1 := Emptying
END

ctrl_transition_emptying_2
REFINES ctrl_transition_emptying
WHERE
    grd1 : plus(Vlow ↦ Delta_sim_1) ↦ plus(V1_sim(t) ↦ V2(t)) ∈ lt
THEN
    act1 : x_s2 := Emptying
END

ctrl_transition_filling_1
REFINES ctrl_transition_filling
WHERE
    grd1 : plus(V1(t) ↦ V2_sim(t)) ↦ minus(Vhigh ↦ Delta_sim_2) ∈ lt
THEN
    act1 : x_s1 := Filling
END

ctrl_transition_filling_2
REFINES ctrl_transition_filling
WHERE
    grd1 : plus(V1_sim(t) ↦ V2(t)) ↦ minus(Vhigh ↦ Delta_sim_1) ∈ lt
THEN
    act1 : x_s2 := Filling
END

ctrl_transition_normal_1
REFINES ctrl_transition_normal
WHERE
    grd1 : plus(Vlow ↦ Delta_sim_2) ↦ plus(V1(t) ↦ V2_sim(t)) ∈ lt
    grd2 : plus(V1(t) ↦ V2_sim(t)) ↦ minus(Vhigh ↦ Delta_sim_2) ∈ lt
THEN
    act1 : x_s1 := Normal
END

ctrl_transition_normal_2
REFINES ctrl_transition_normal
WHERE
    grd1 : plus(Vlow ↦ Delta_sim_1) ↦ plus(V1_sim(t) ↦ V2(t)) ∈ lt
    grd2 : plus(V1_sim(t) ↦ V2(t)) ↦ minus(Vhigh ↦ Delta_sim_1) ∈ lt
THEN
    act1 : x_s2 := Normal
END

ctrl_transition_stable_1
REFINES ctrl_transition_stable
WHERE
    grd1 : plus(Vlow ↦ Delta_sim_2) ↦ plus(V1(t) ↦ V2_sim(t)) ∈ lt
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148       grd2 : plus(V1(t) ↦ V2_sim(t)) ↦ minus(Vhigh ↦ Delta_sim_2) ∈ lt
149     THEN
150       act1 : x_s1 := Stable
151     END
152
153     ctrl_transition_stable_2
154     REFINES ctrl_transition_stable
155     WHERE
156       grd1 : plus(Vlow ↦ Delta_sim_1) ↦ plus(V1_sim(t) ↦ V2(t)) ∈ lt
157       grd2 : plus(V1_sim(t) ↦ V2(t)) ↦ minus(Vhigh ↦ Delta_sim_1) ∈ lt
158     THEN
159       act1 : x_s2 := Stable
160     END
161
162     ctrl_actuate_pumps
163     REFINES ctrl_actuate_pumps
164     ANY ss , e1 , e2 , ss1 , ss2 , fV1_sim , fV2_sim
165     WHERE
166       grd01 : ss ∈ STATES
167       grd02 : ss = guess_gs(ss1 ↦ ss2)
168       grd11 : e1 ∈ DE(S)
169       grd12 : Solvable(Closed2Infinity(t), e1)
170       grd13 : isFlowEq(ss1, Closed2Infinity(t), e1, Rzero, V1max)
171       grd14 : ss1 ∈ STATES
172       grd15 : x_s1 = ss1
173       grd16 : fV1_sim ∈ Closed2Infinity(t) → S
174       grd17 :
              ∀V1_ · V1_ ∈ Closed2Infinity(t) → S ∧ solutionOf(Closed2Infinity(t), V1_, e1) ⇒ (∀t_ · t_ ∈ Closed2Infinity(t) ⇒ abs(minus(V
175       grd21 : e2 ∈ DE(S)
176       grd22 : Solvable(Closed2Infinity(t), e2)
177       grd23 : isFlowEq(ss2, Closed2Infinity(t), e2, Rzero, V2max)
178       grd24 : ss2 ∈ STATES
179       grd25 : x_s2 = ss2
180       grd26 : fV2_sim ∈ Closed2Infinity(t) → S
181       grd27 :
              ∀V2_ · V2_ ∈ Closed2Infinity(t) → S ∧ solutionOf(Closed2Infinity(t), V2_, e2) ⇒ (∀t_ · t_ ∈ Closed2Infinity(t) ⇒ abs(minus(V
182     WITH
183       V′ : V′ = fadd(V1′, V2′)
184       e :
185         e ∈ DE(S) ∧ Solvable(Closed2Infinity(t), e) ∧ isFlowEq(guess_gs(ss1 ↦ ss2), Closed2Infinity(t), e, Rzero, Vmax)∧
186         (∀V1_, V2_ ·
187           V1_ ∈ Closed2Infinity(t) → S ∧ V2_ ∈ Closed2Infinity(t) → S∧
188           solutionOf(Closed2Infinity(t), V1_, e1)∧
189           solutionOf(Closed2Infinity(t), V2_, e2)
190           ⇒ solutionOf(Closed2Infinity(t), fadd(V1_, V2_), e)
191         )
192     THEN
193       act1 :
194         V1, V2, V1_sim, V2_sim :|
195           V1′ ∈ RRealPlus → S ∧ V2′ ∈ RRealPlus → S∧
196           V1_sim′ ∈ RRealPlus → S ∧ V2_sim′ ∈ RRealPlus → S∧
197           AppendSolutionBAP(e1, RRealPlus, Closed2Open(Rzero, t), Closed2Infinity(t), V1, V1′)∧
198           AppendSolutionBAP(e2, RRealPlus, Closed2Open(Rzero, t), Closed2Infinity(t), V2, V2′)∧
199           Closed2Open(Rzero, t) ◁ V1_sim′ = Closed2Open(Rzero, t) ◁ V1_sim∧
200           Closed2Infinity(t) ◁ V1_sim′ = fV1_sim∧
201           Closed2Open(Rzero, t) ◁ V2_sim′ = Closed2Open(Rzero, t) ◁ V2_sim∧
202           Closed2Infinity(t) ◁ V2_sim′ = fV2_sim
203     END
204
205 END
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