



Implementación de sistemas de control de calefacción en vehículos de transporte público



Francisco Vázquez

Dpto. Ingeniería Eléctrica y Automática



Francisco Vázquez



- ▶ Doctor en Ciencias Físicas
- ▶ Profesor Titular, Universidad de Córdoba
 - Área de Ingeniería de Sistemas y Automática
 - Dpto. de Ingeniería Eléctrica y Automática
 - Escuela Politécnica Superior de Córdoba



- ▶ Director del Máster Dual en Industria 4.0
 - <http://www.uco.es/estudios/postgrado/masterindustria/>

- ▶ Responsable del Grupo de Investigación PRINIA (TEP-226)
 - <http://www.uco.es/grupos/prinia>



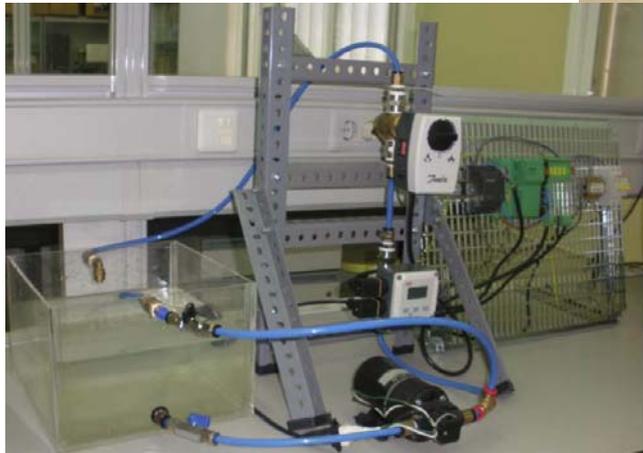
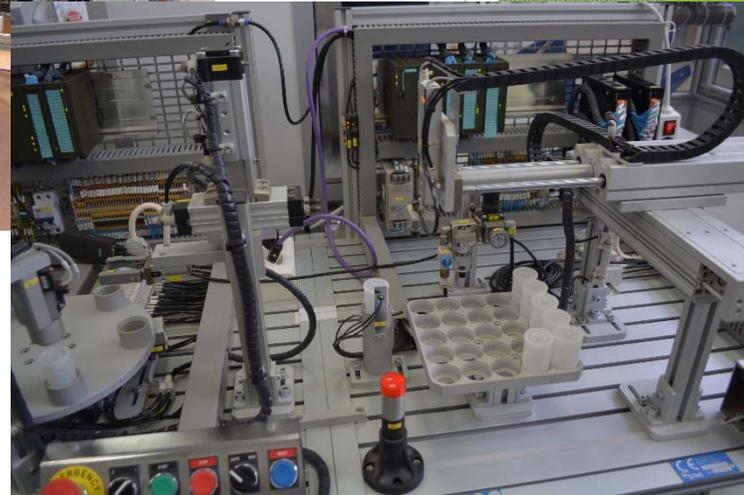
- ▶ Email: fvazquez@uco.es

- ▶ ORCID: <http://orcid.org/0000-0003-4544-6084>

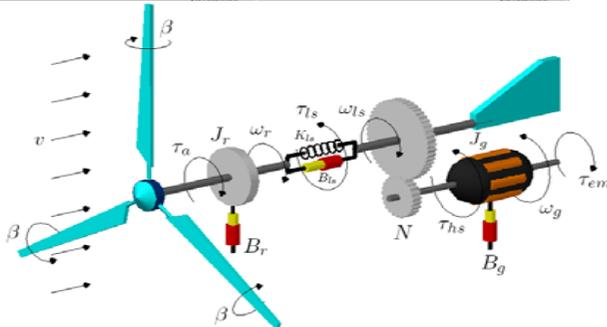
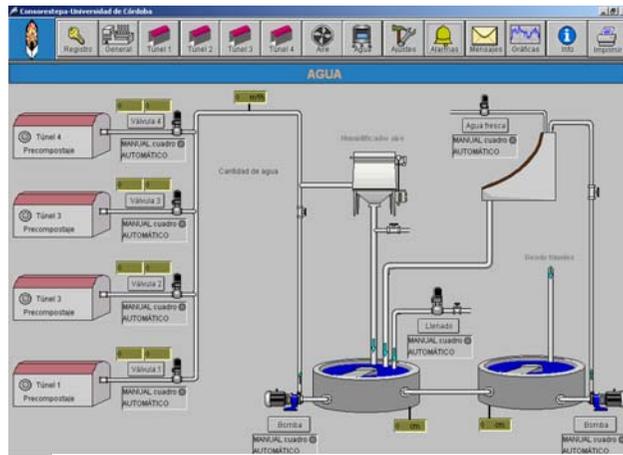
Área ISA



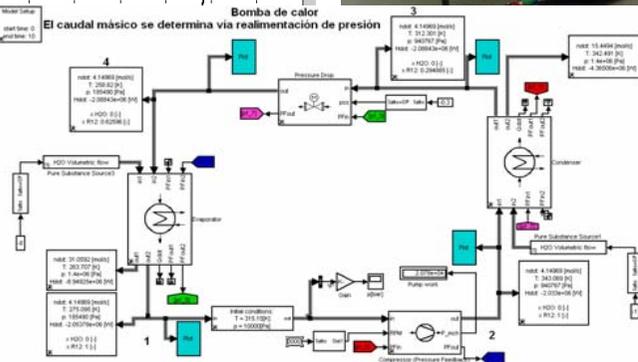
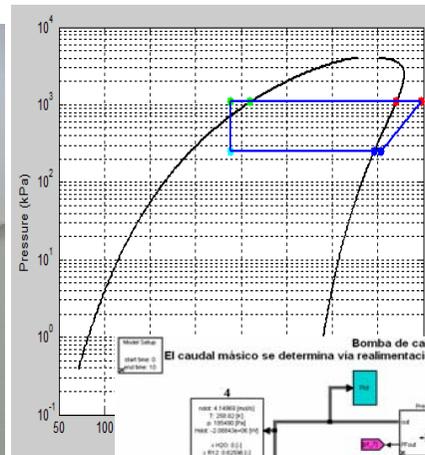
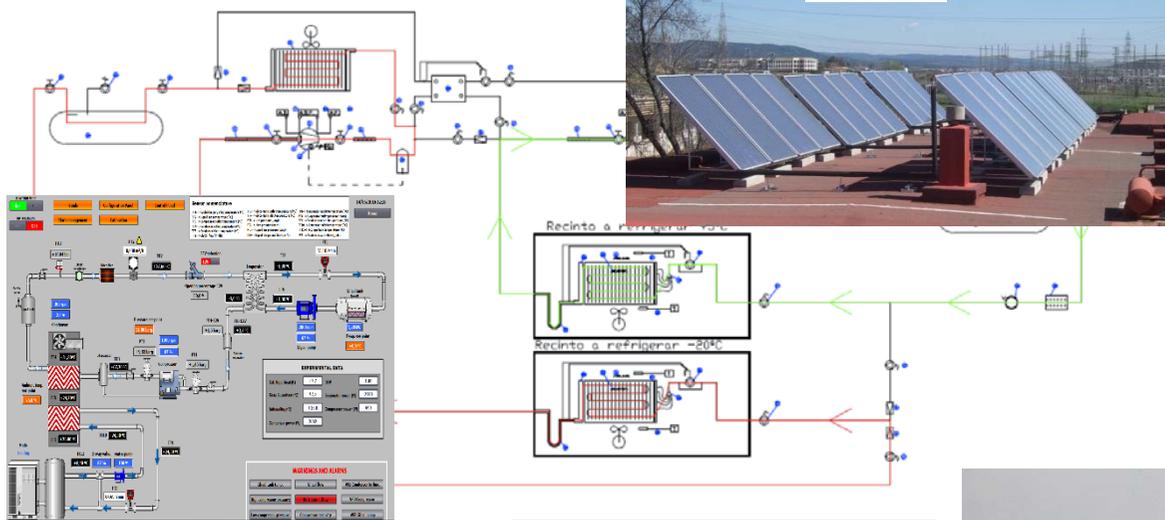
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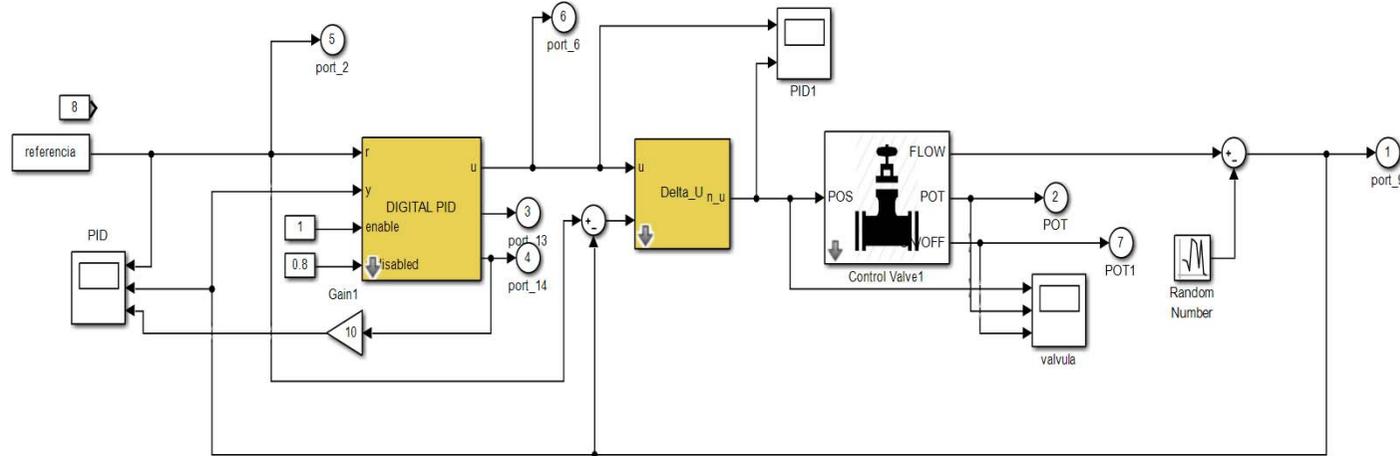
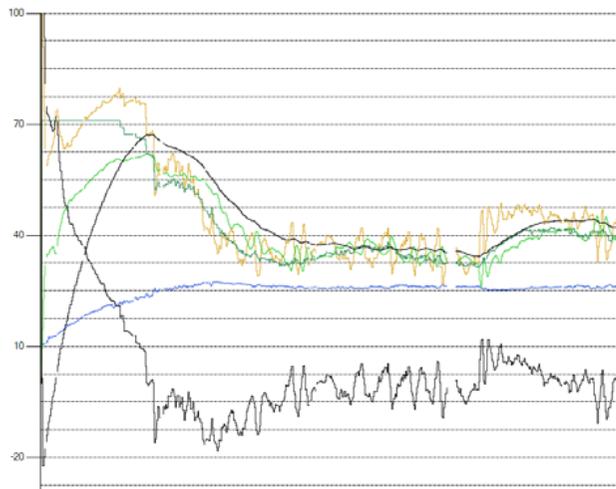
Proyectos I+D+T



Proyectos I+D+T



Proyectos I+D+T



INDICE

- ▶ Introducción
- ▶ Componentes del sistema de calefacción
- ▶ La válvula de control
 - Características
 - La válvula en LC
- ▶ Ensayos a bordo
- ▶ Trabajo actual

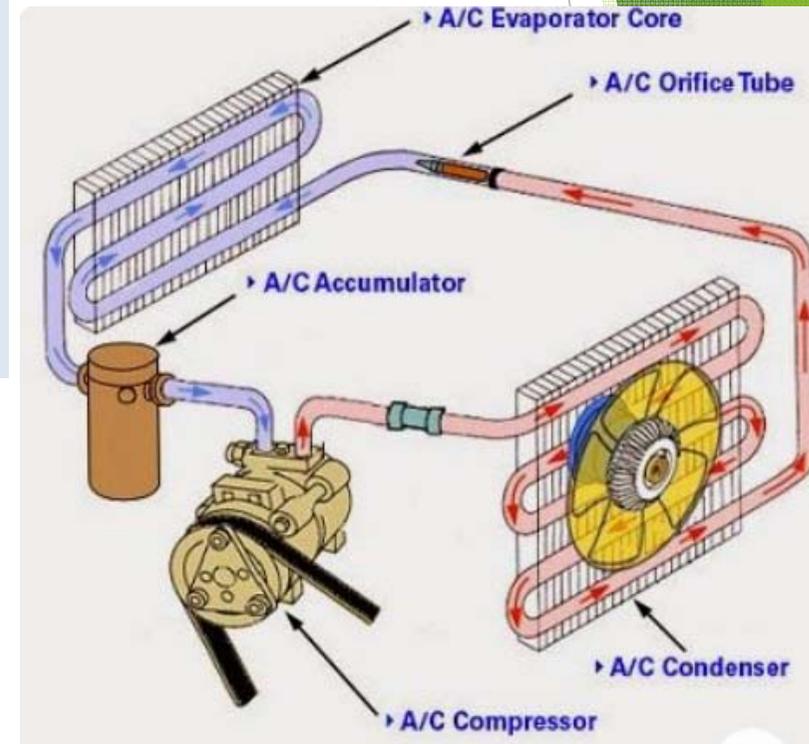
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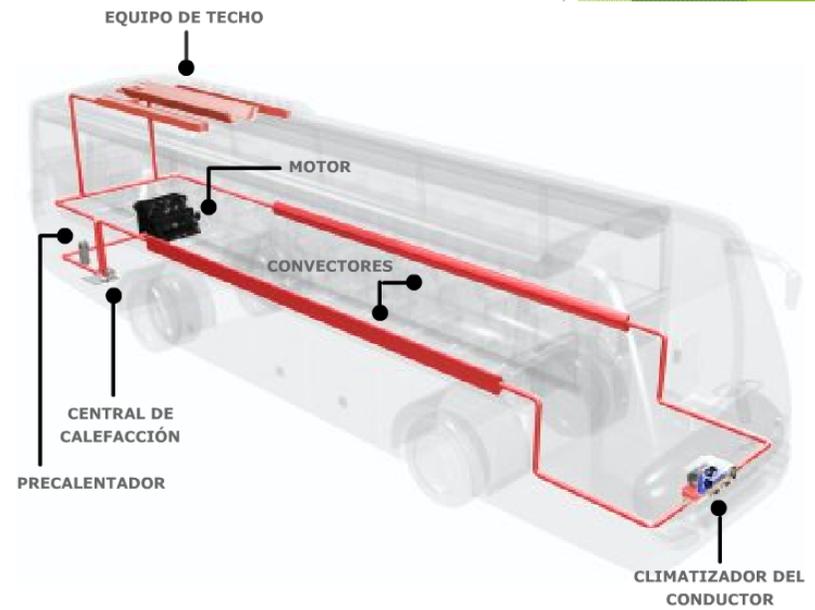
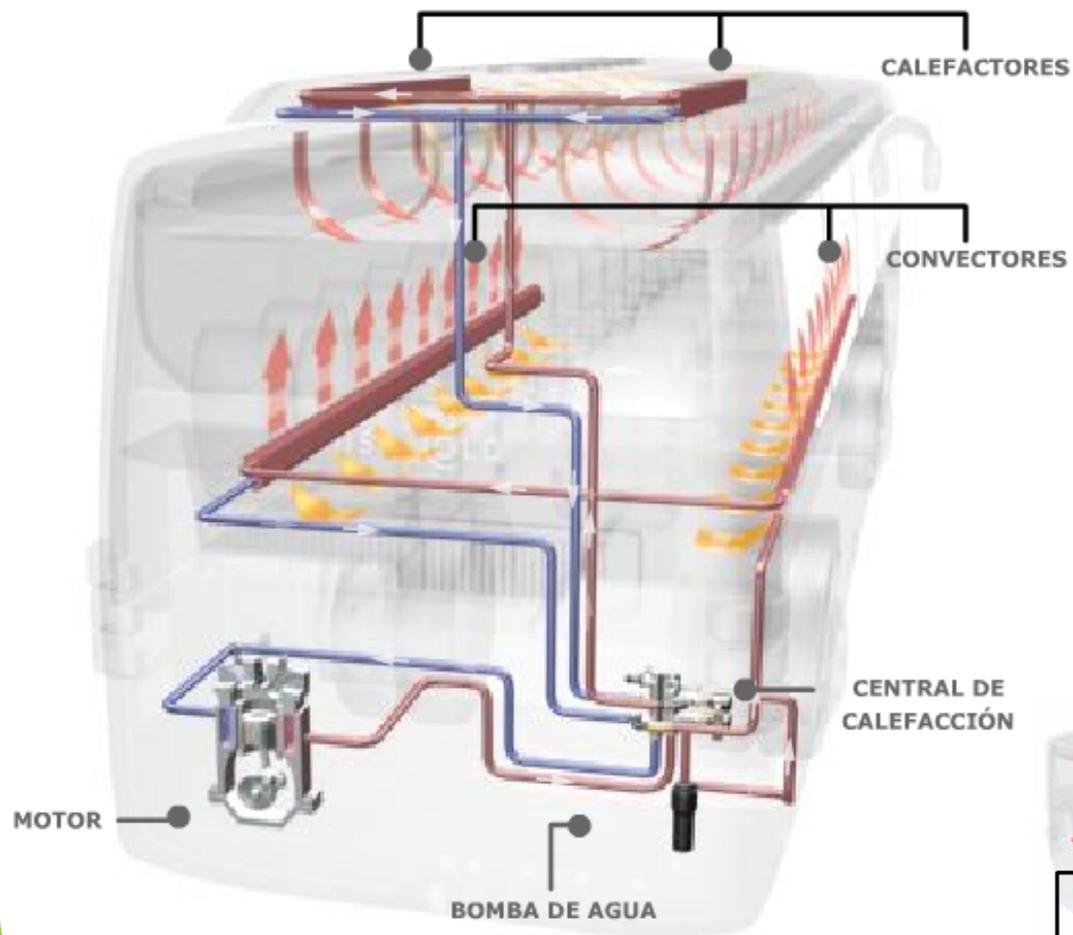
HVAC en vehículos



Generación de frío



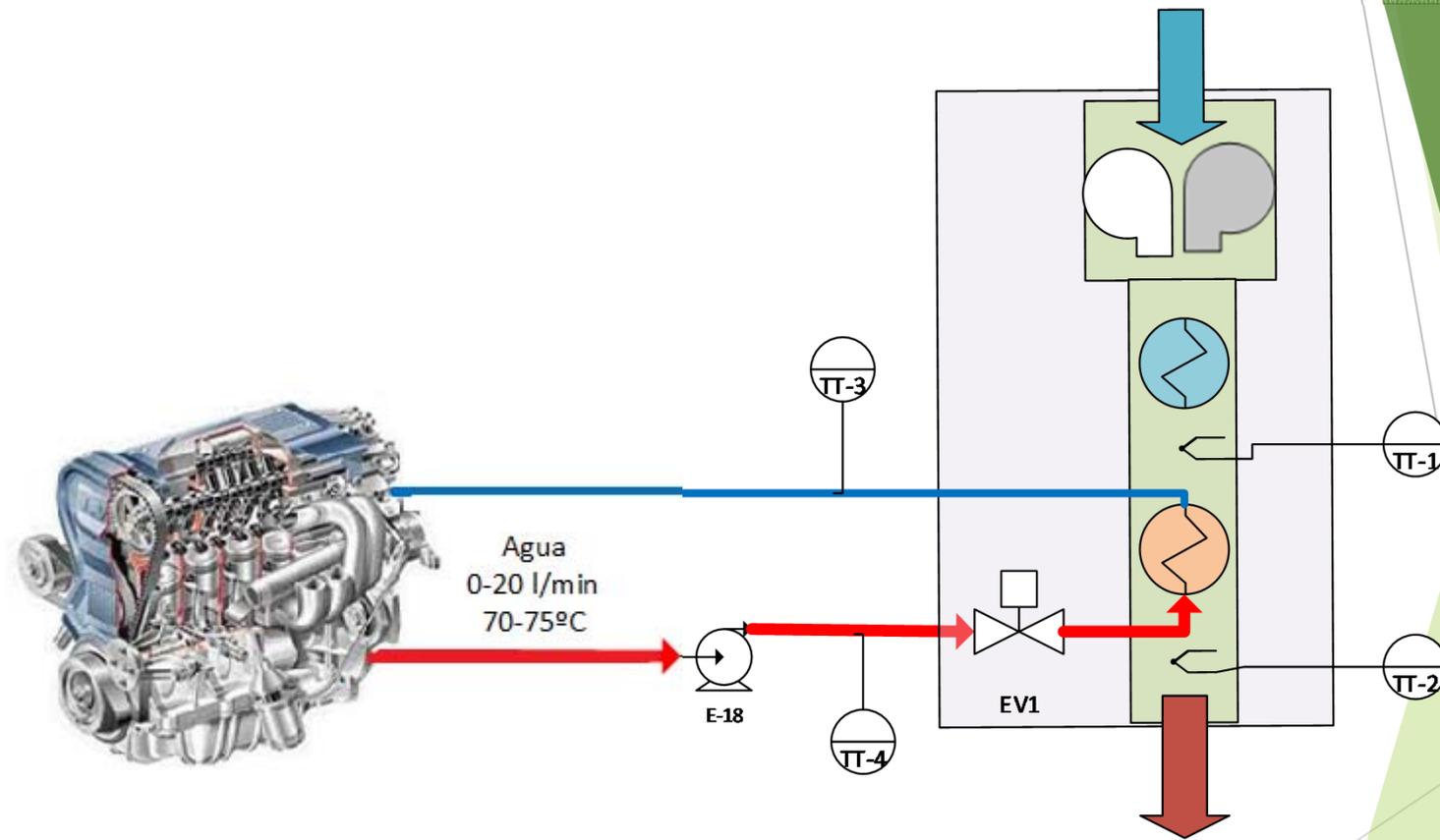
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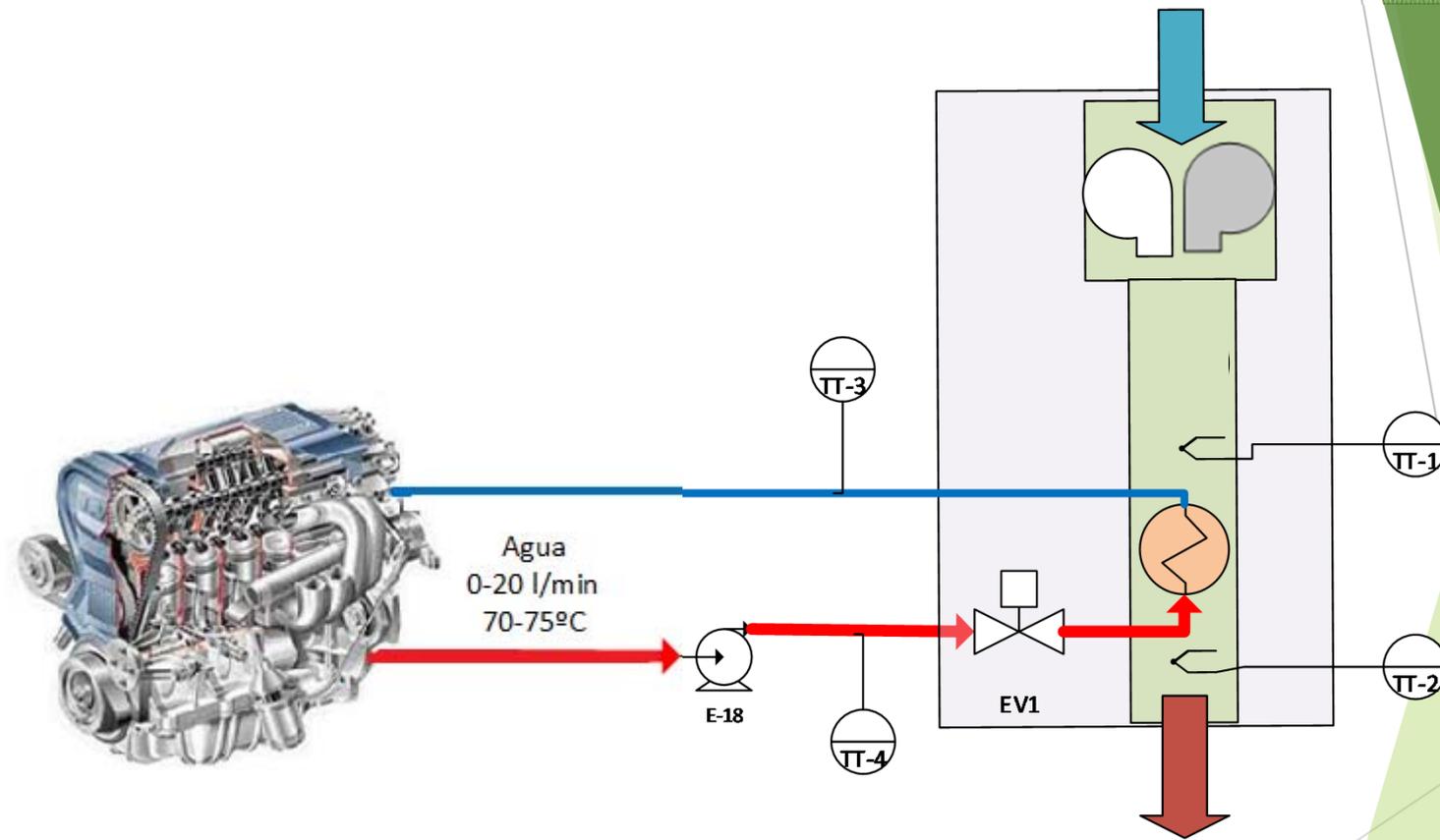
INDICE

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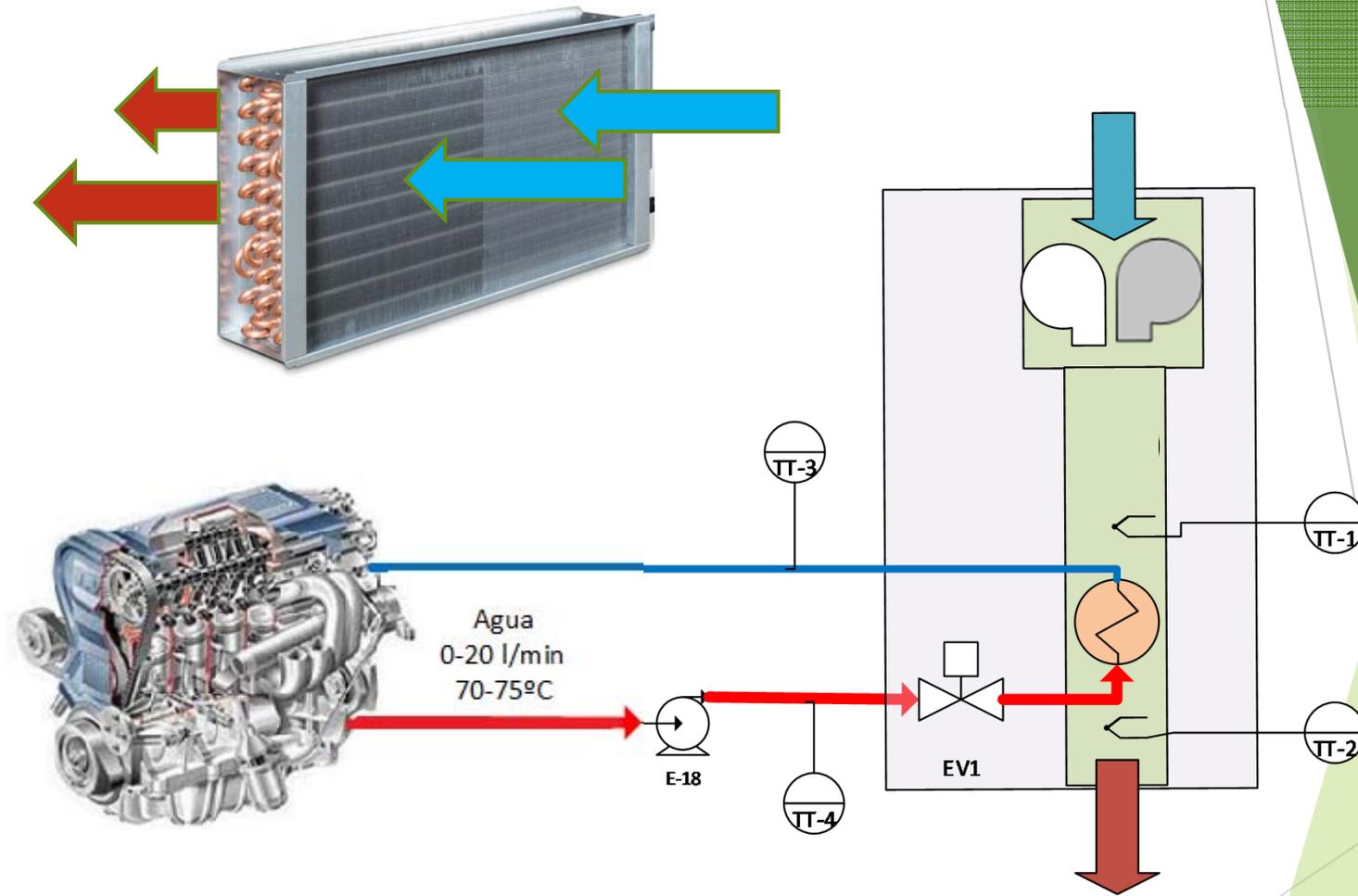
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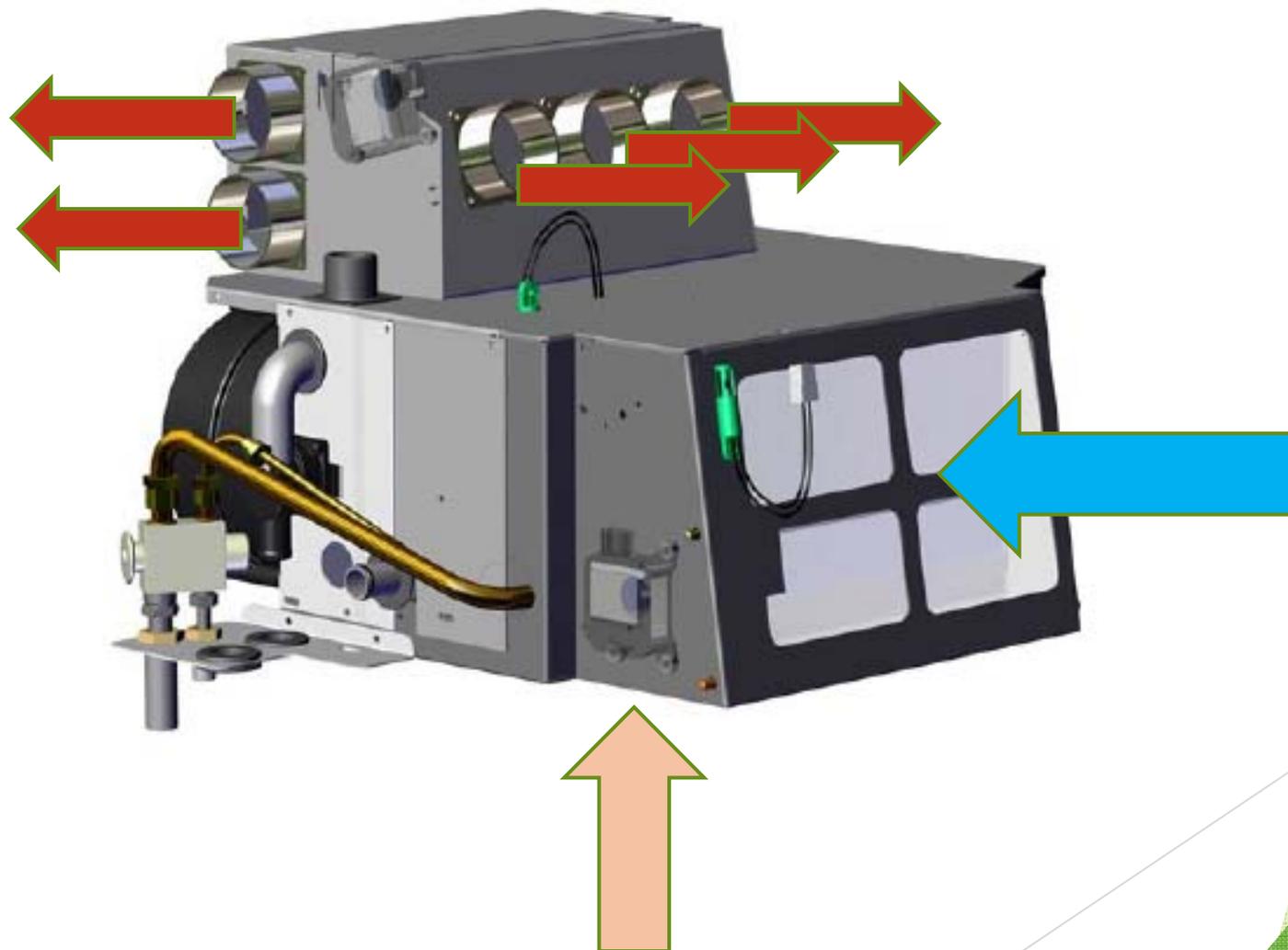
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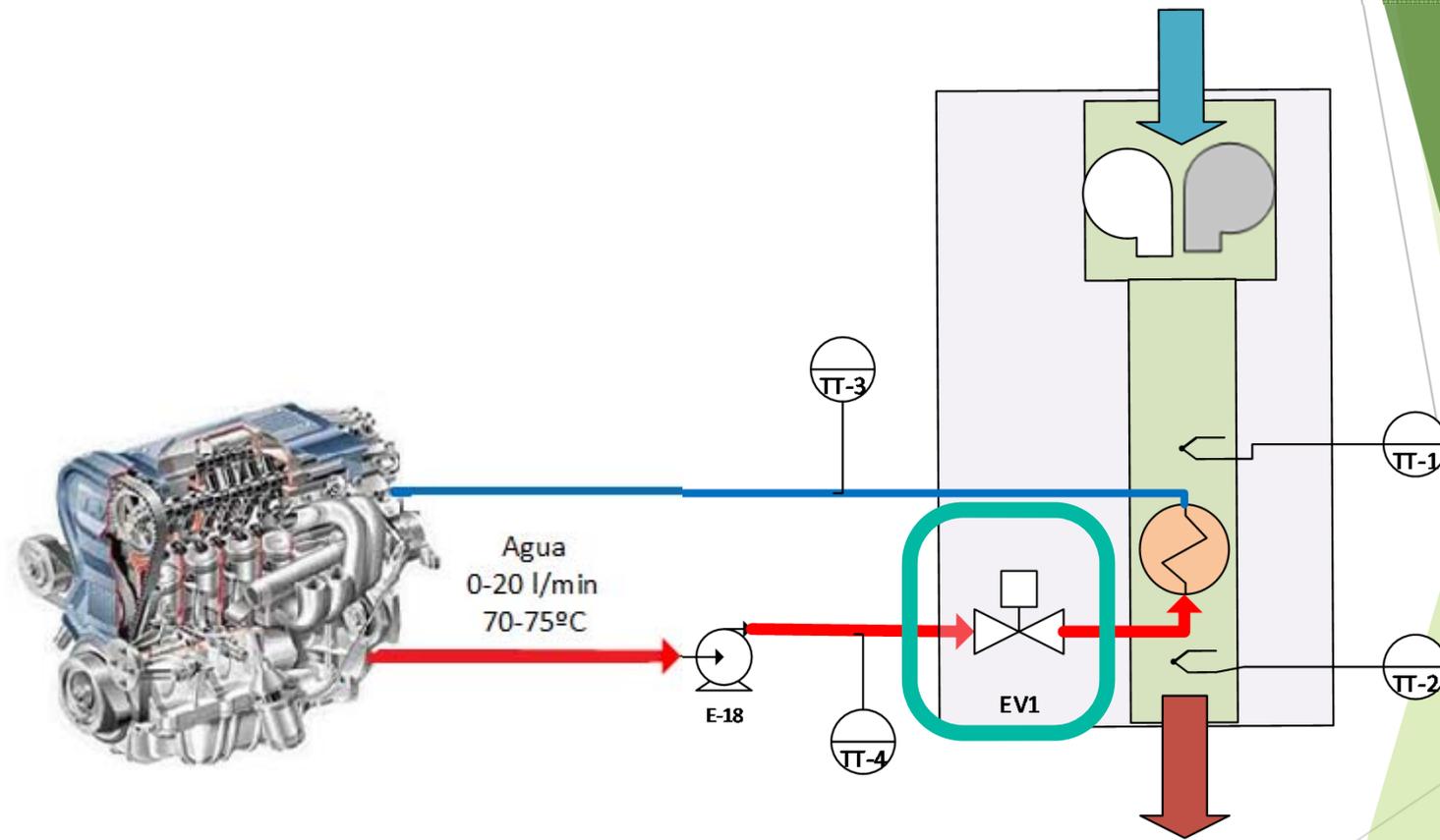
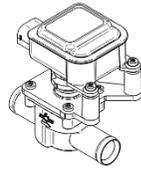
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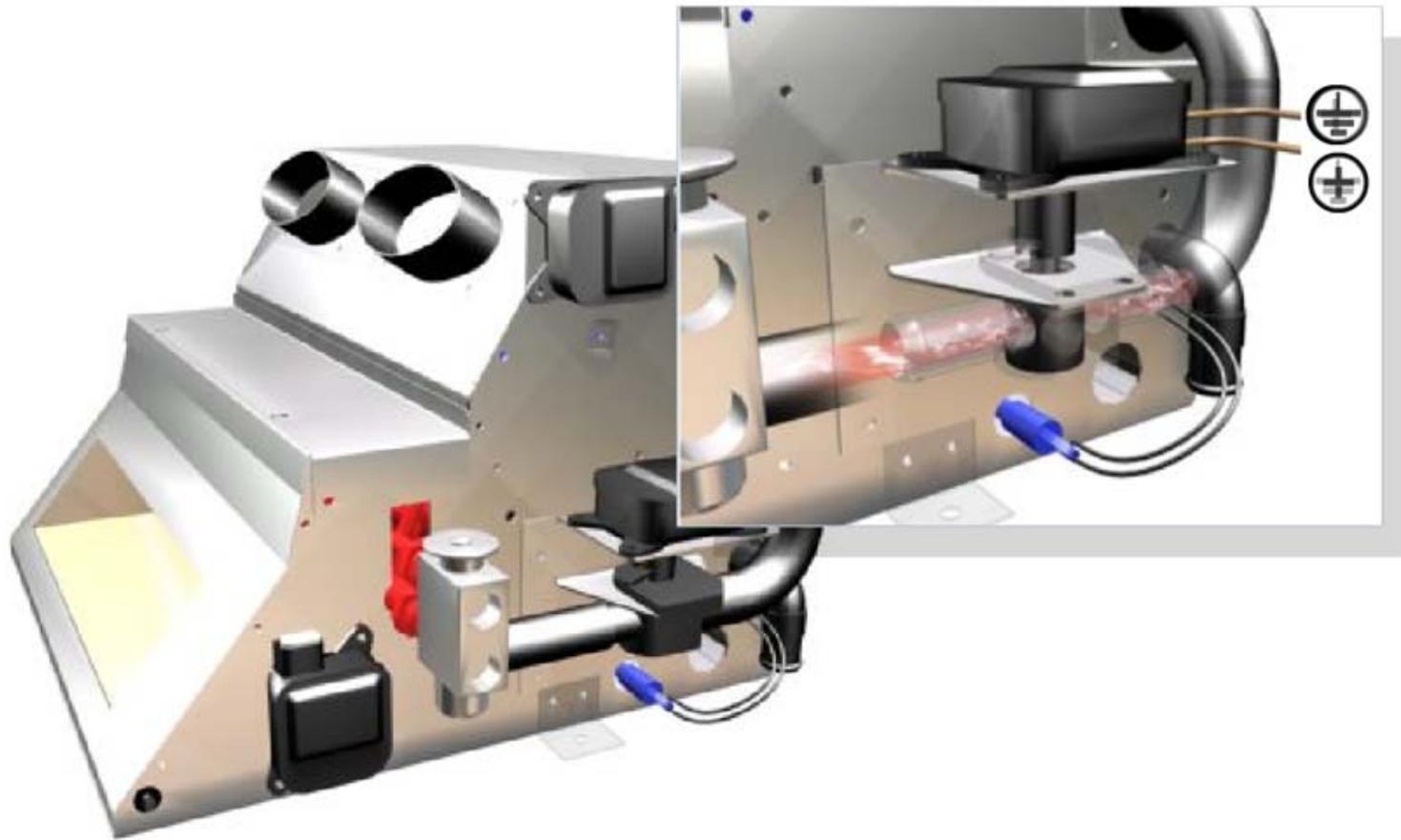
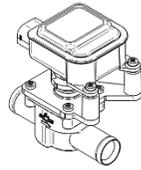
Calefacción



La válvula



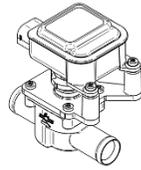
La válvula



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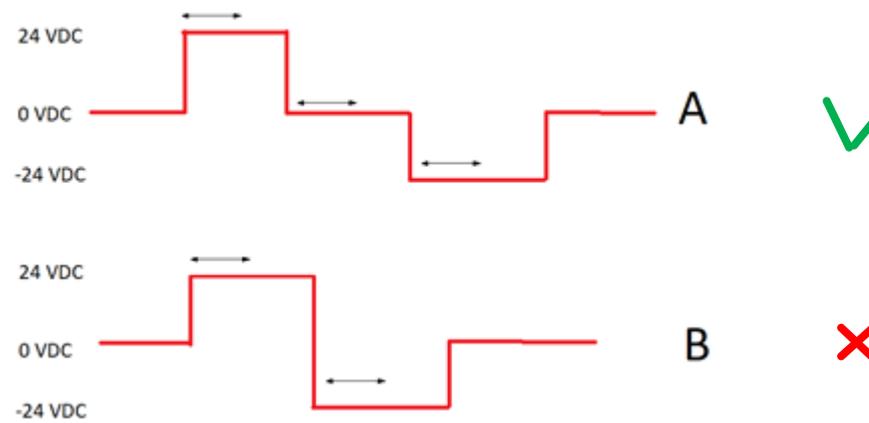
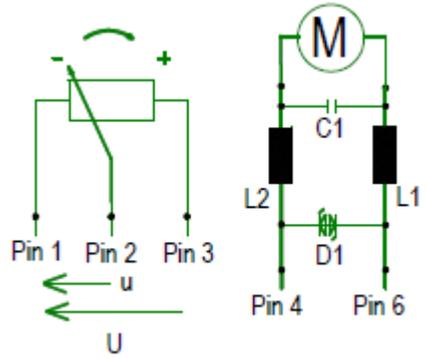
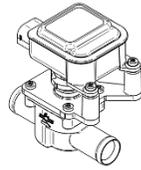
La válvula



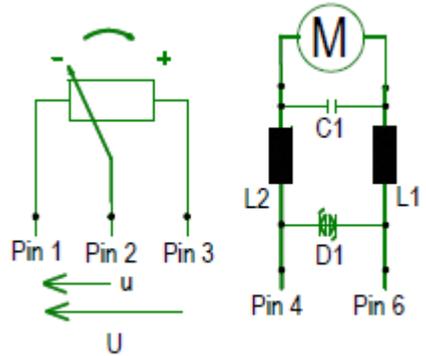
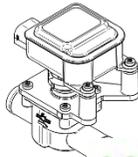
La válvula



La válvula



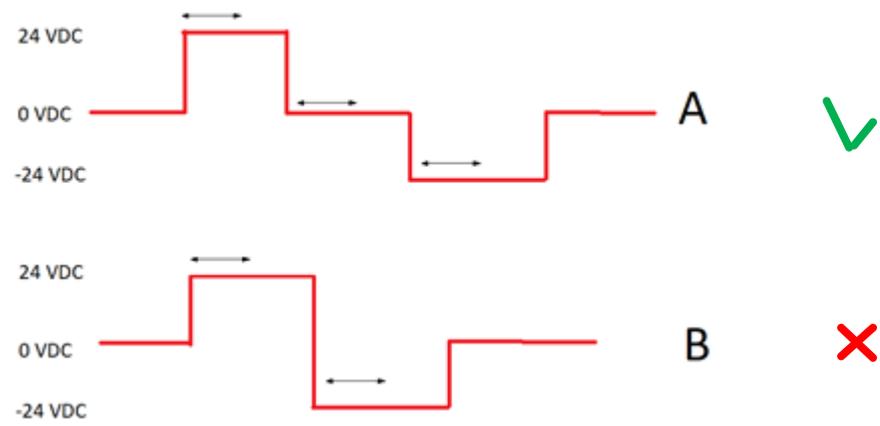
La válvula



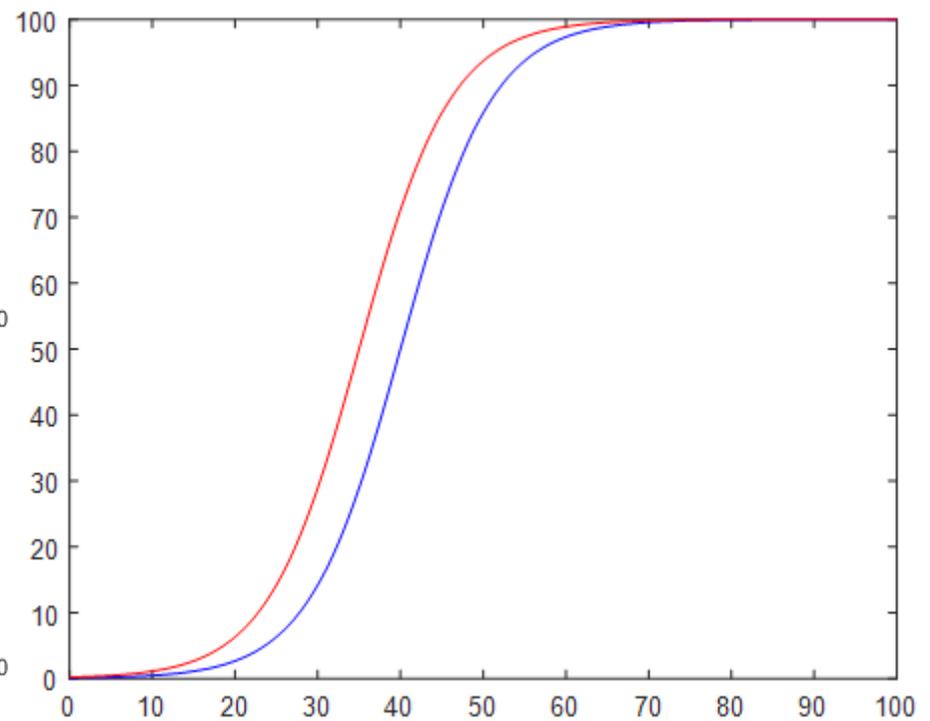
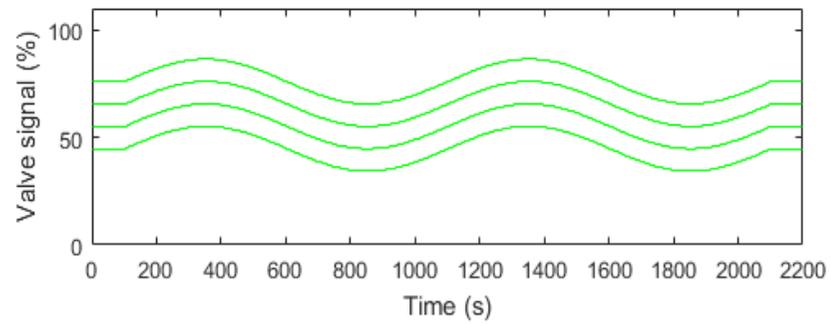
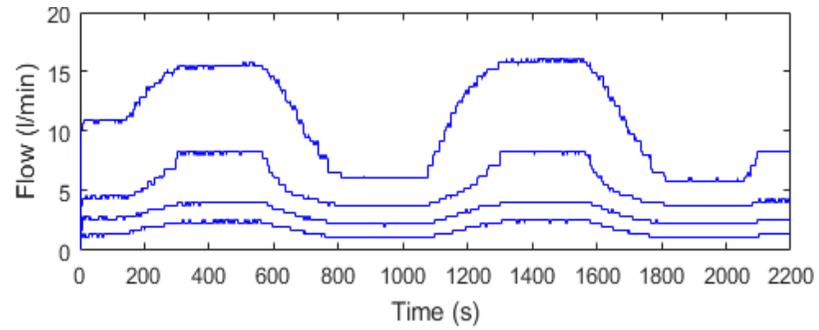
```

% ABRIENDO
if diferencia > limite_3 & (estado_anterior==11 | estado_anterior==0)
    estado=11;
elseif diferencia >= limite_2 & (diferencia <= limite_3) ...
    & (estado_anterior==11 | (estado_anterior==12 & salida_TON2) ...
    | estado_anterior==0)
    estado =12;
elseif diferencia > limite_1 & (diferencia < limite_2) & ...
    (estado_anterior==11 | estado_anterior==12 | ...
    (estado_anterior==13 & salida_TON3) | estado_anterior==0)
    estado =13;

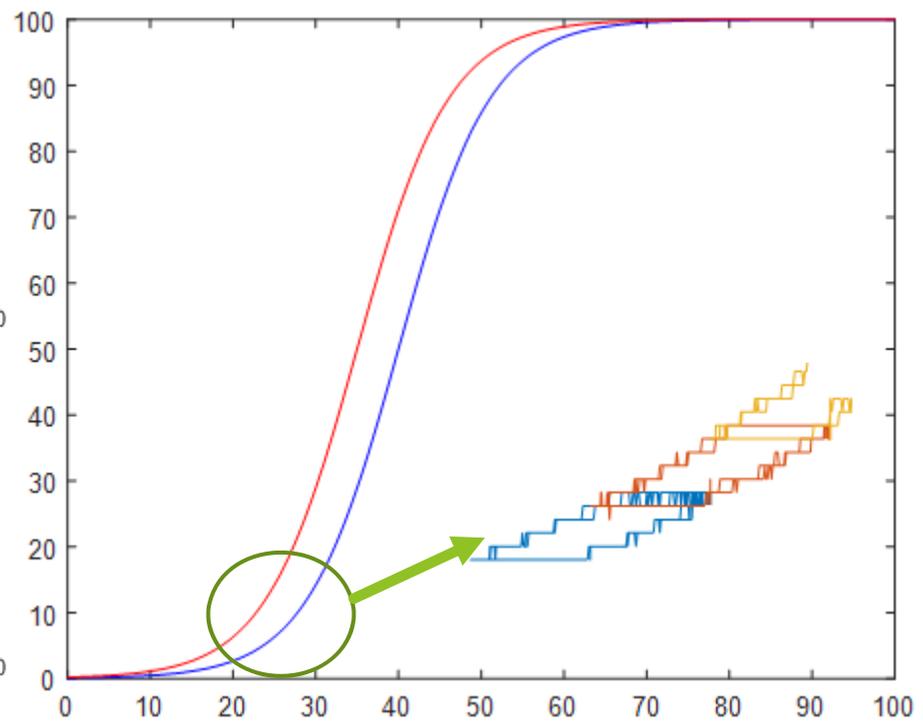
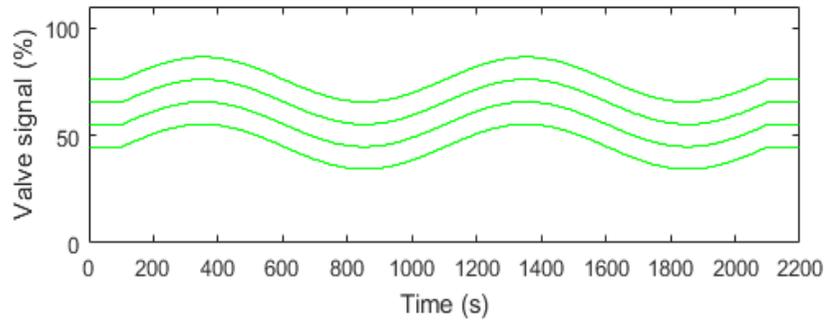
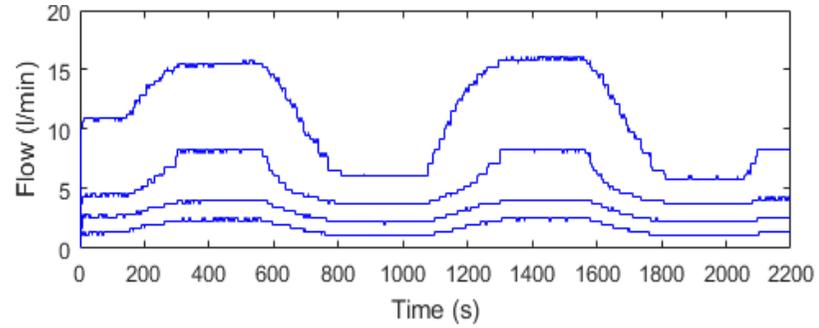
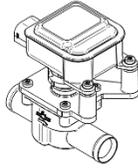
% CERRANDO
elseif -diferencia > limite_3 & (estado_anterior==11 | estado_anterior==0)
    estado=-11;
elseif -diferencia >= limite_2 & (-diferencia <= limite_3) ...
    & (estado_anterior==11 | (estado_anterior==12 & salida_TON2) ...
    | estado_anterior==0)
    estado=-12;
elseif -diferencia > limite_1 & (-diferencia < limite_2) & ...
    (estado_anterior==11 | estado_anterior==12 | ...
    (estado_anterior==13 & salida_TON3) | estado_anterior==0)
    estado=-13;
    
```



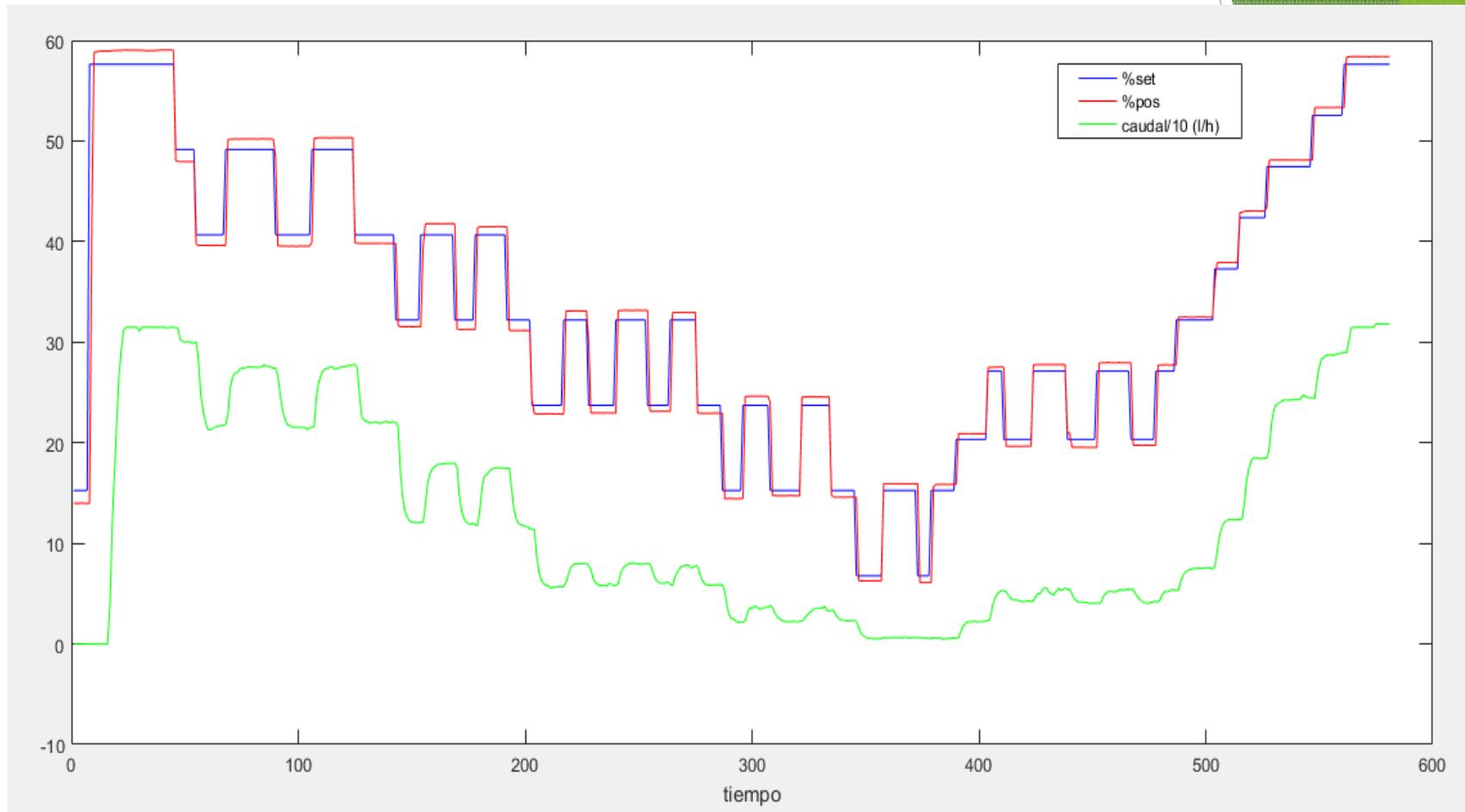
La válvula



La válvula

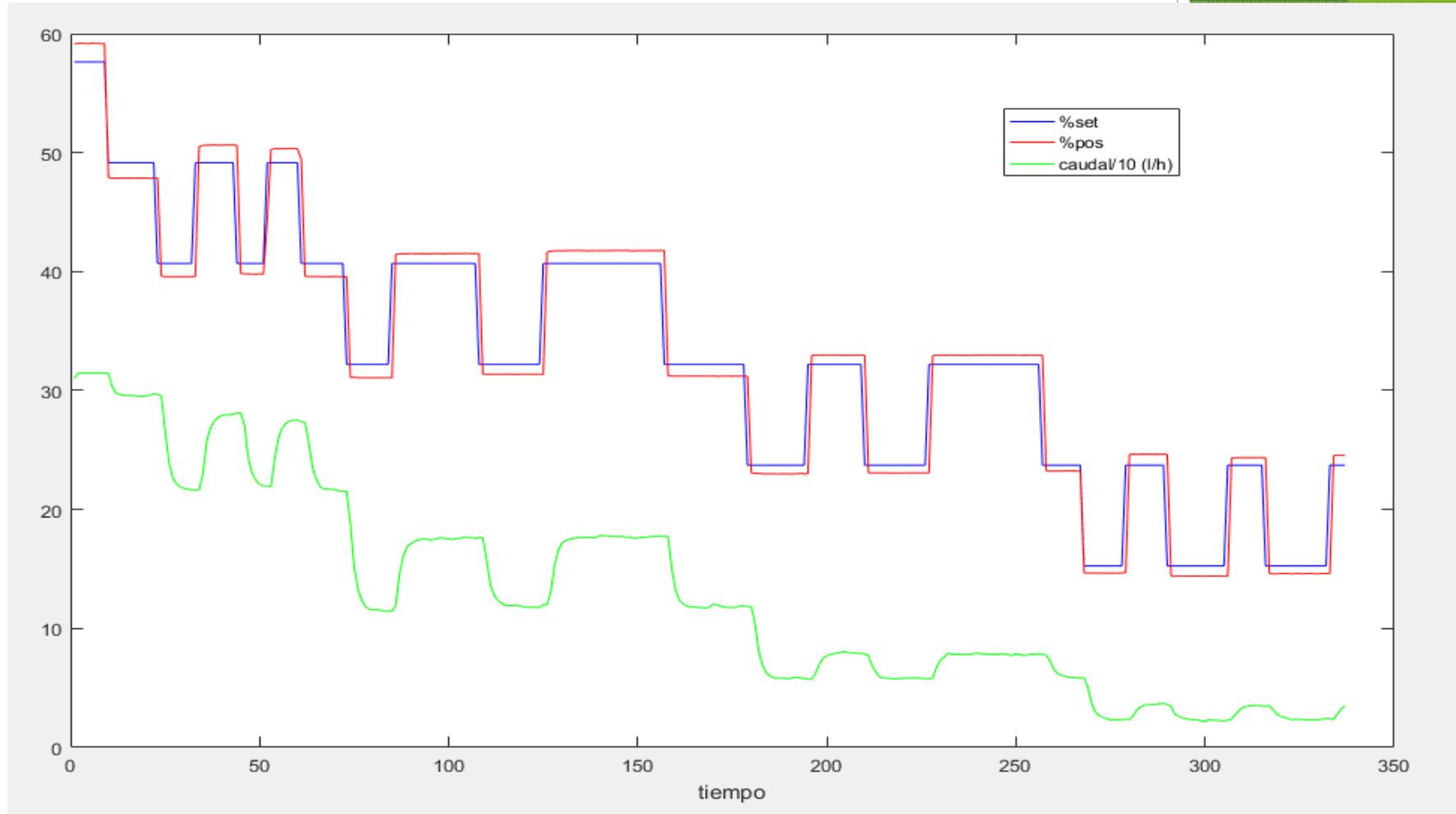
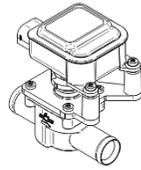


La válvula

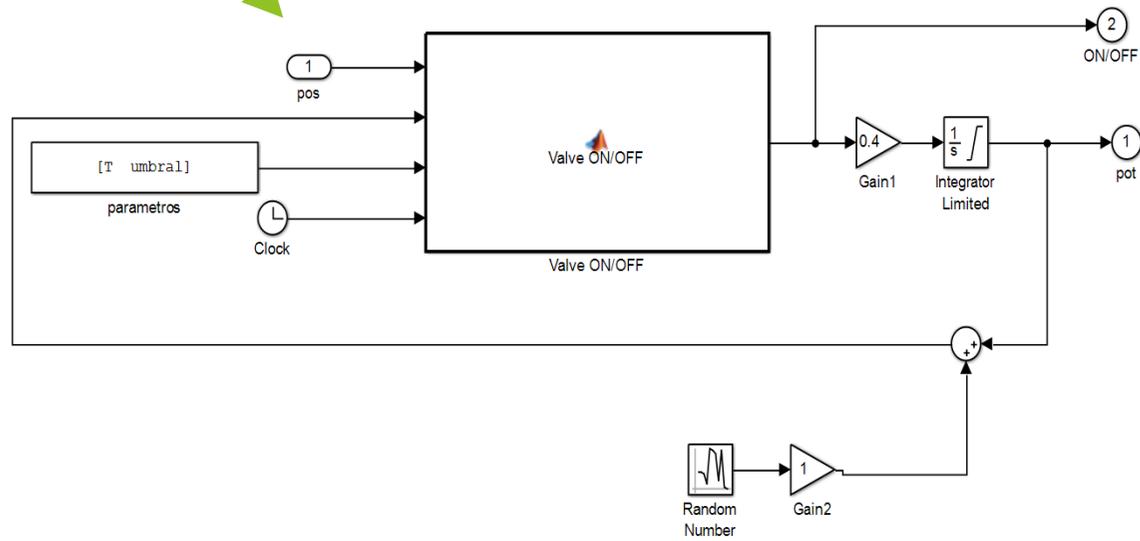
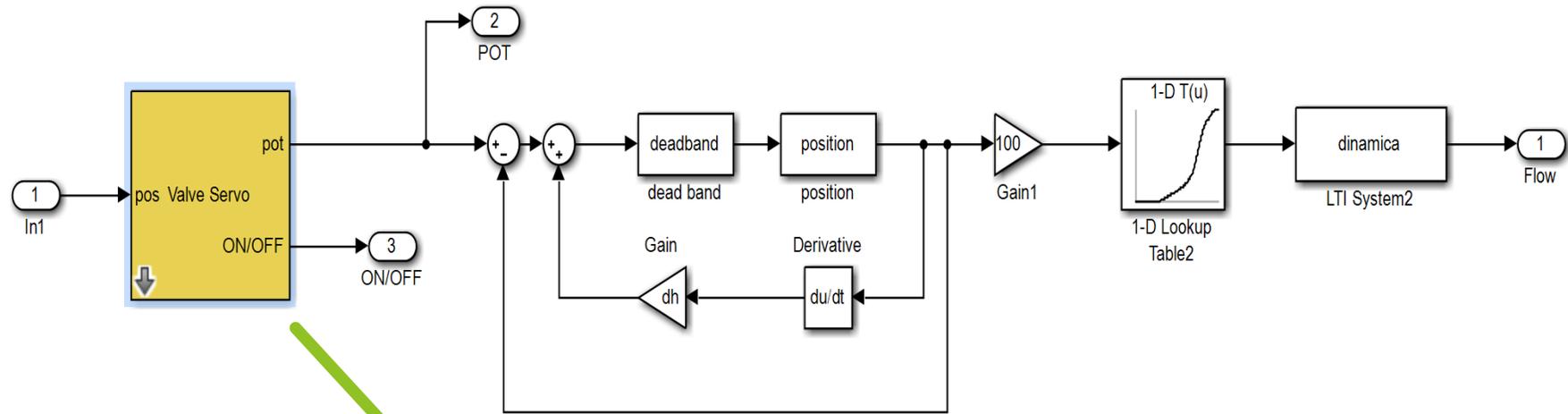
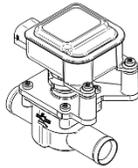


Salto en torno a	40%	30 %	25 %	15 %
Ganancia	0.093	0.089	0.030	0.020

La válvula



La válvula



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Válvula en LC: el PID

$$u(t) = K_p \left(e(t) + \frac{1}{T_i} \int e(t) dt + T_d \frac{d e(t)}{dt} \right)$$

$$e(k) = r(k) - y(k)$$

$$p(k) = K_p (r(k) - y(k))$$

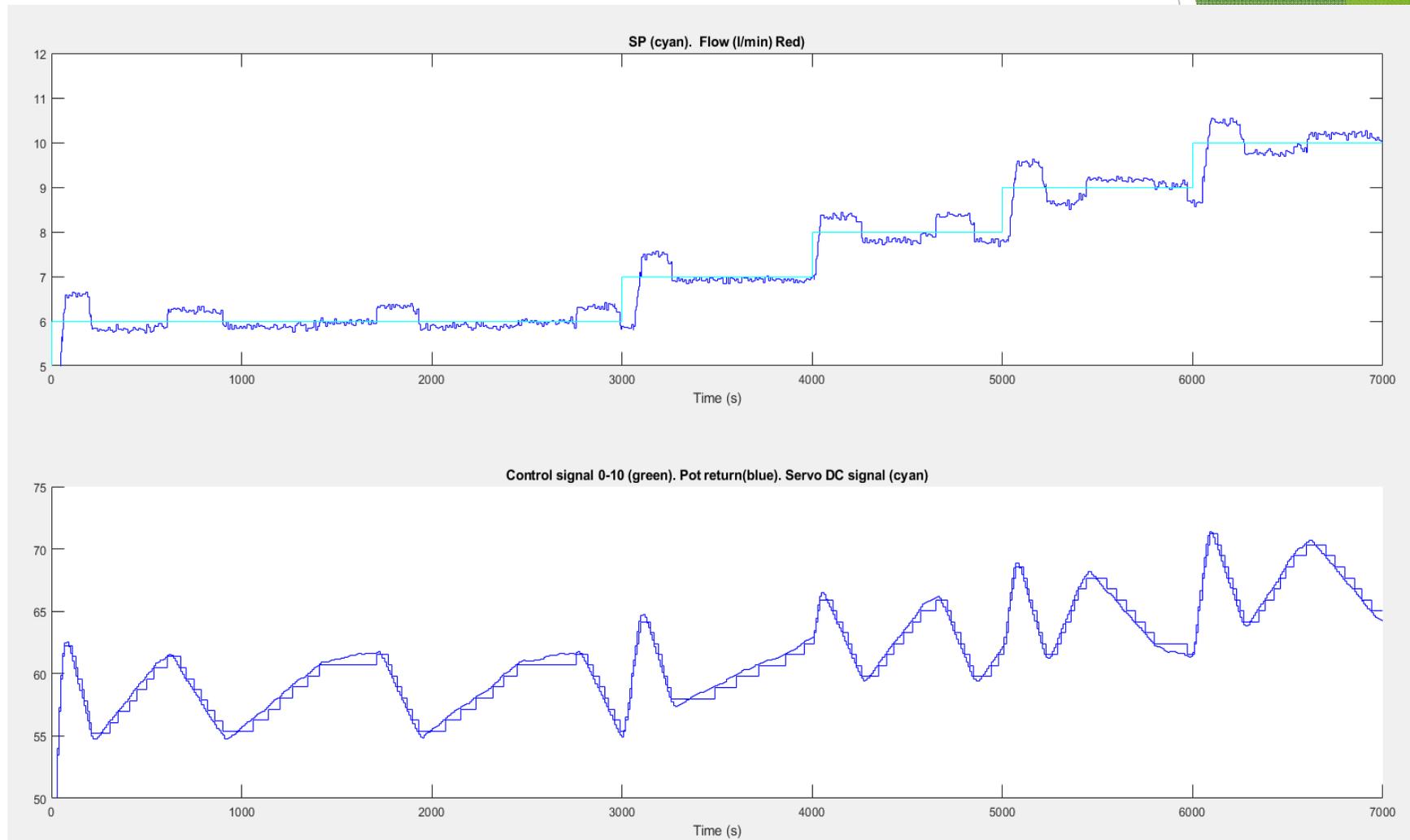
$$i(k) = i(k-1) + \frac{K_p T}{T_i} \frac{e(k) + e(k-1)}{2}$$

$$u(k) = p(k) + i(k)$$

La válvula



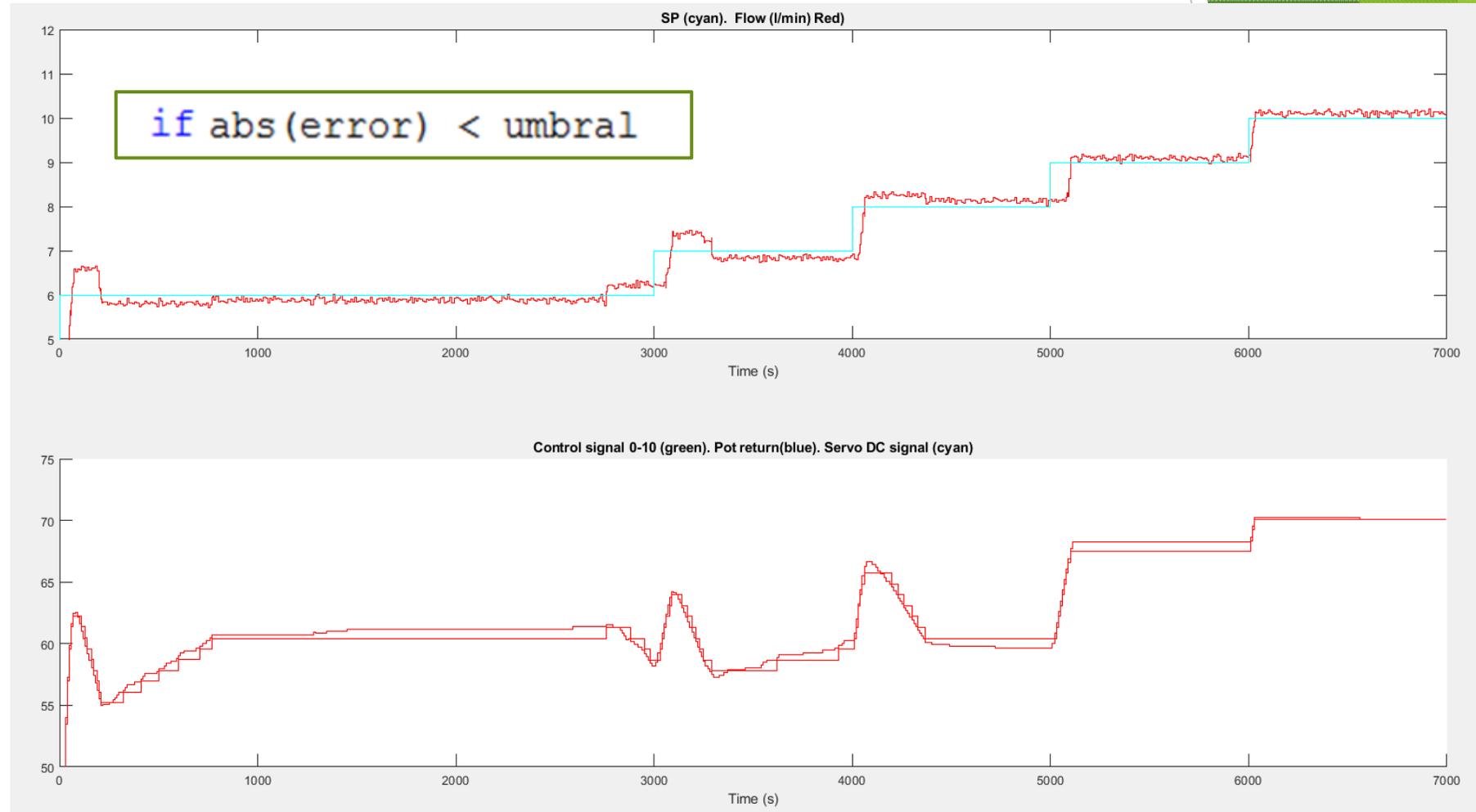
Respuesta con PI estándar



La válvula



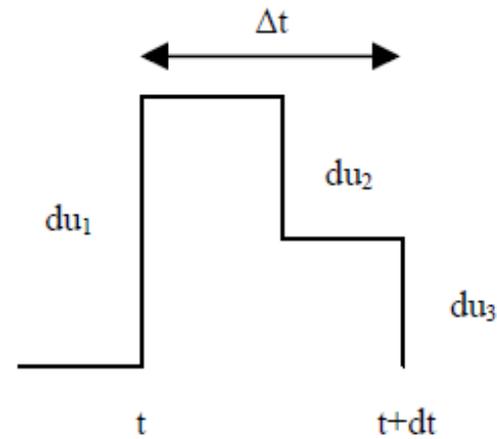
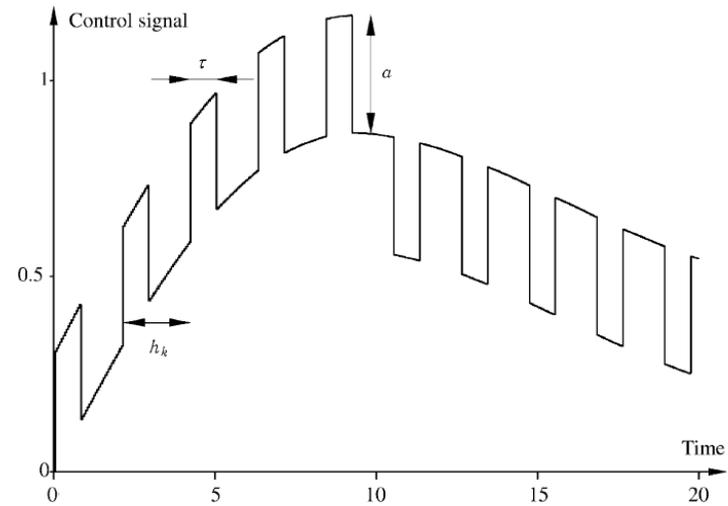
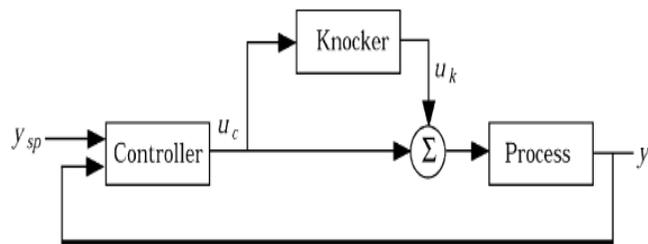
Añadiendo histéresis al PID



La válvula



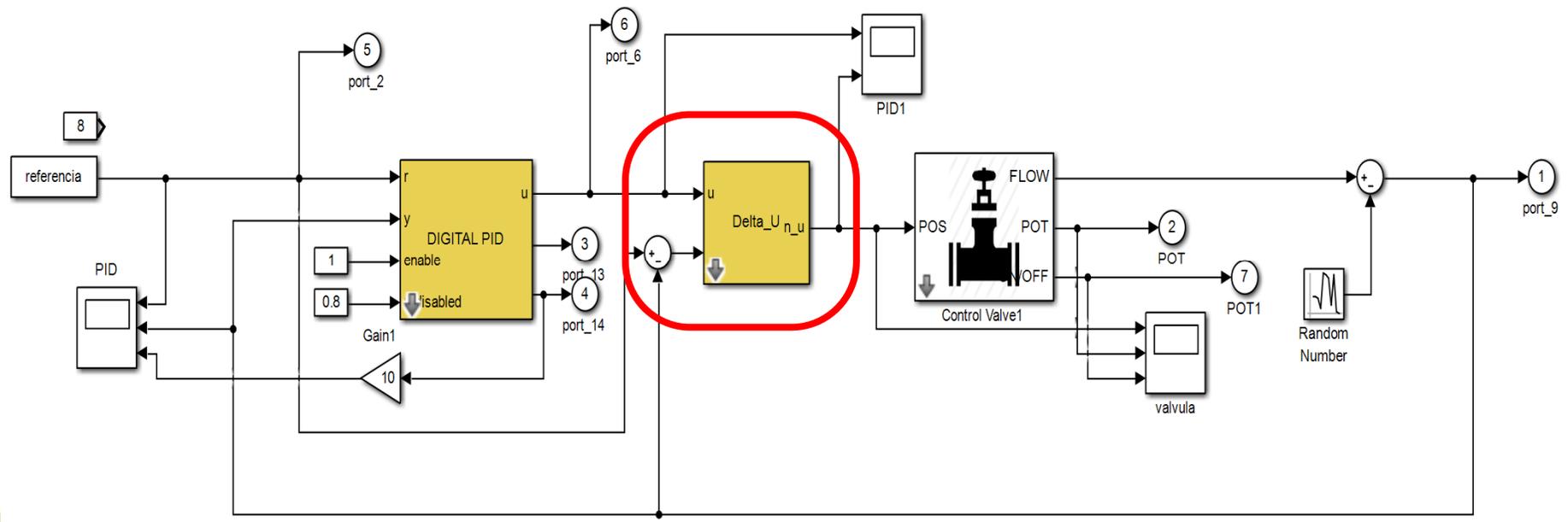
Añadiendo impulsos al PID



La válvula



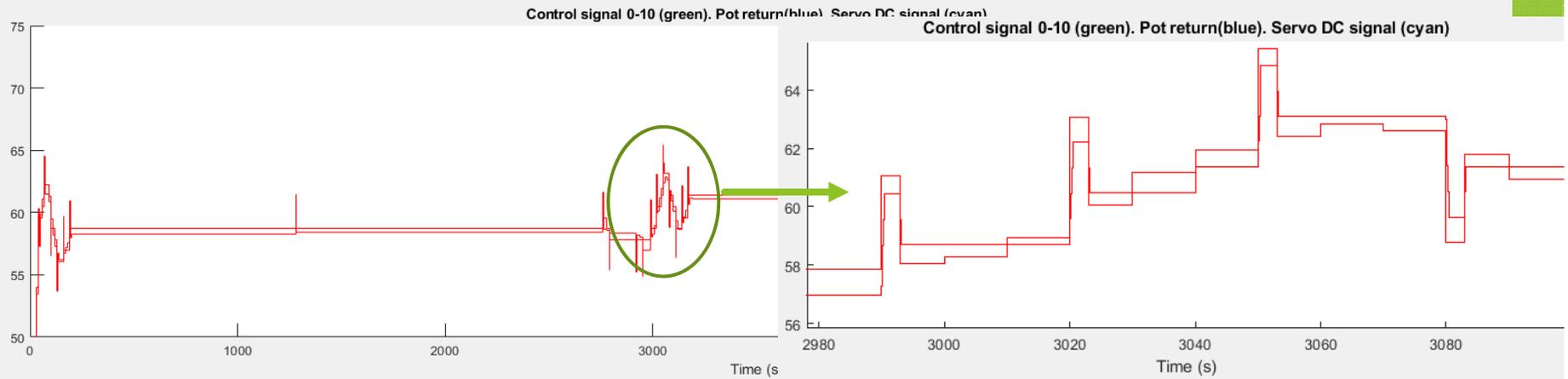
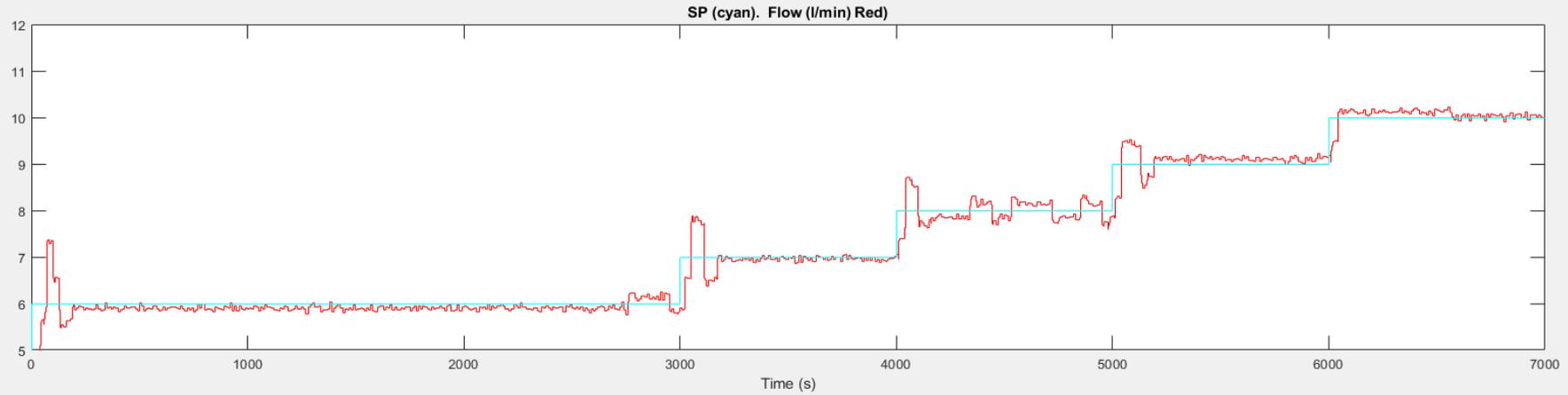
Añadiendo generador de impulsos



La válvula



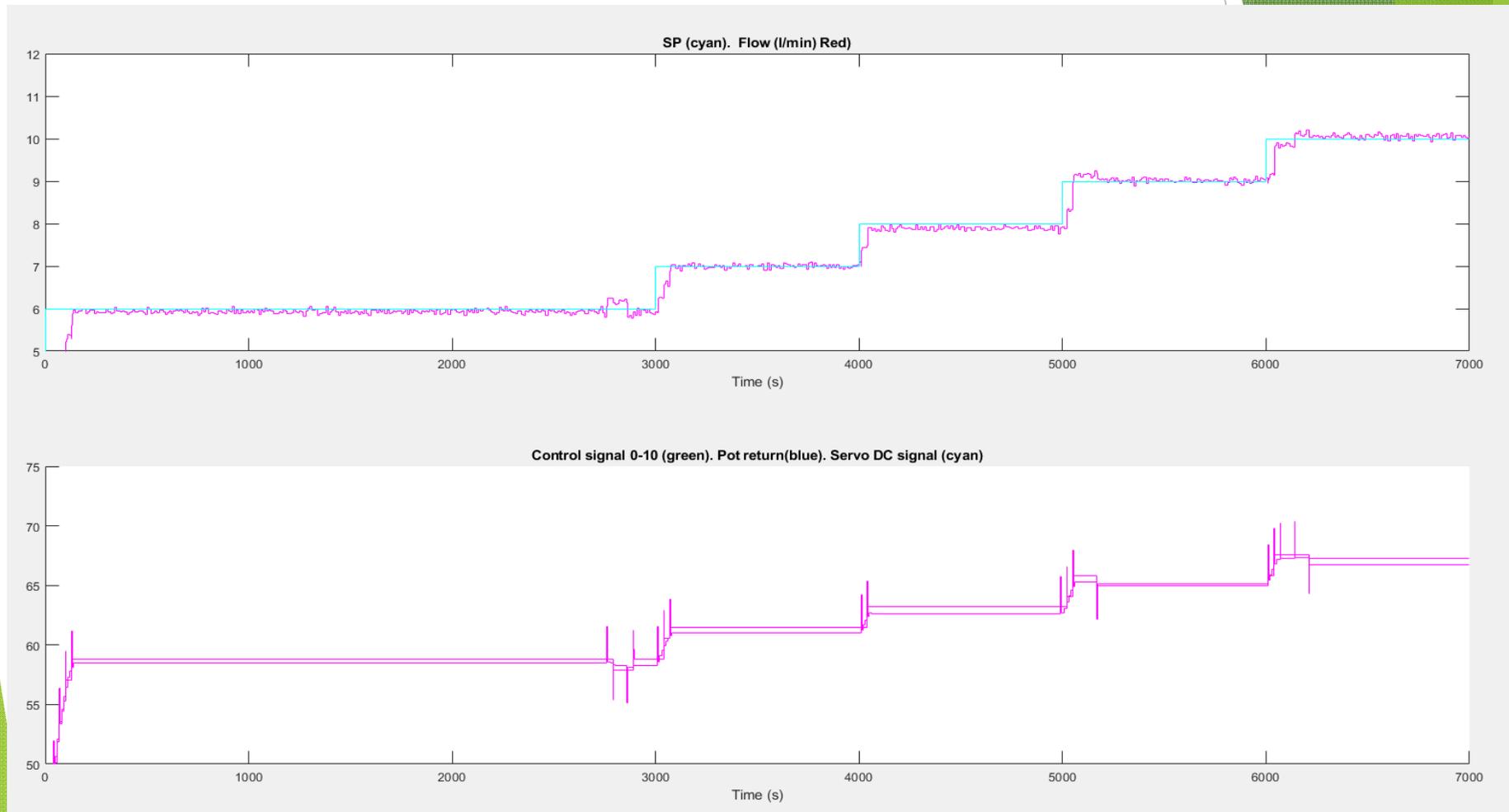
Añadiendo generador de impulsos



La válvula



Añadiendo generador de impulsos + resintonía

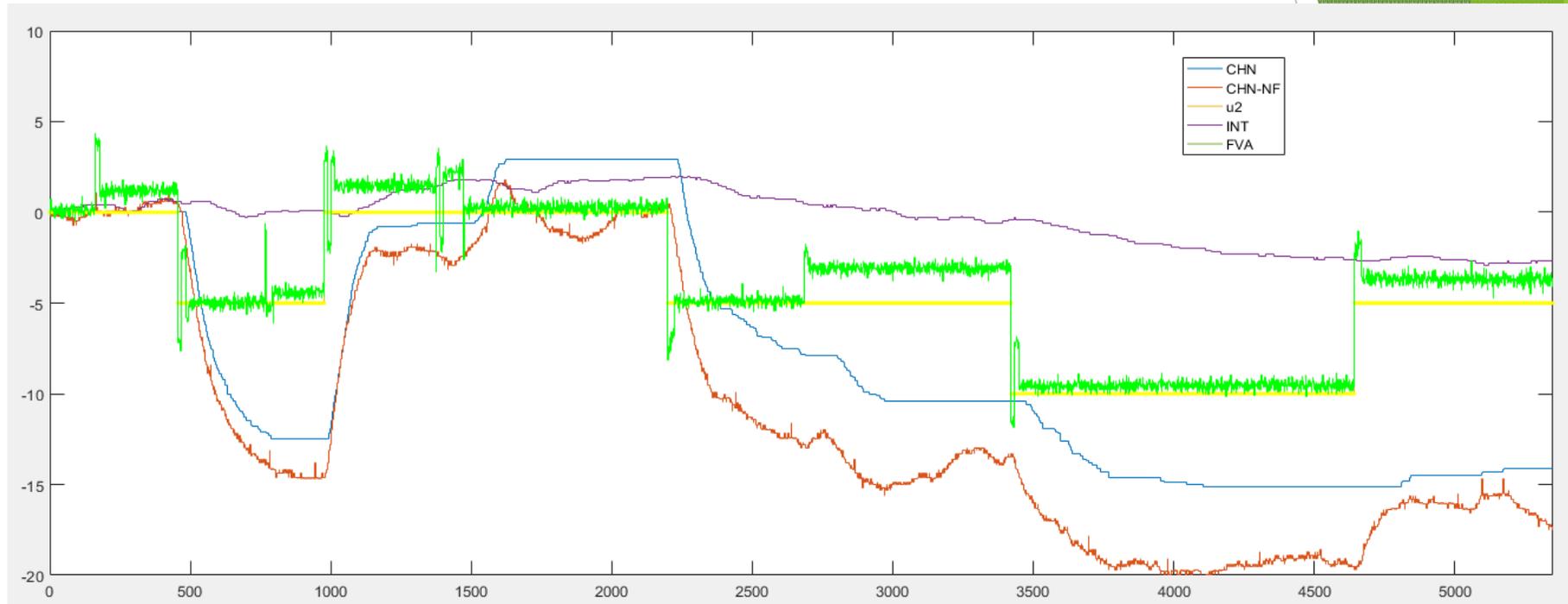


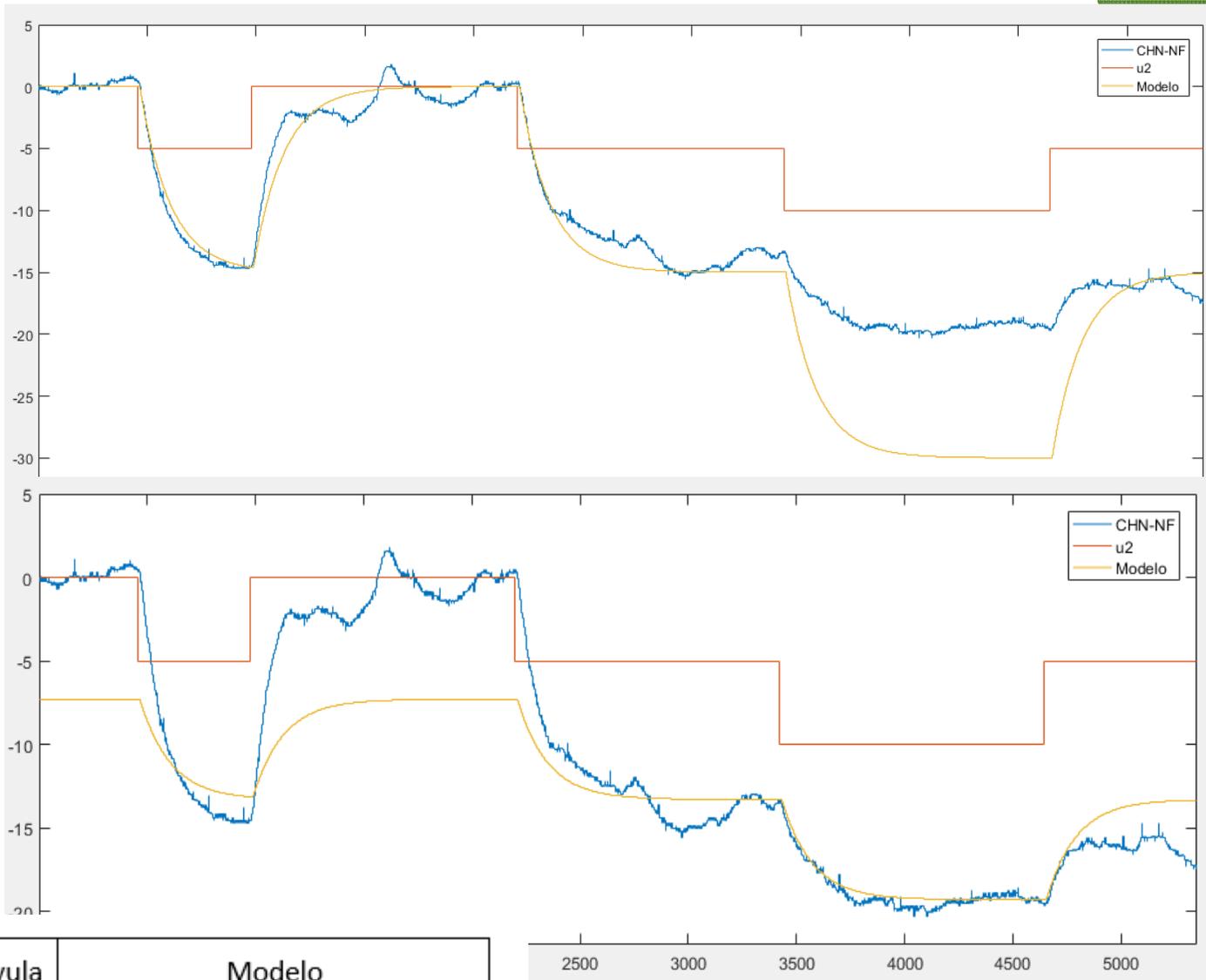
INDICE

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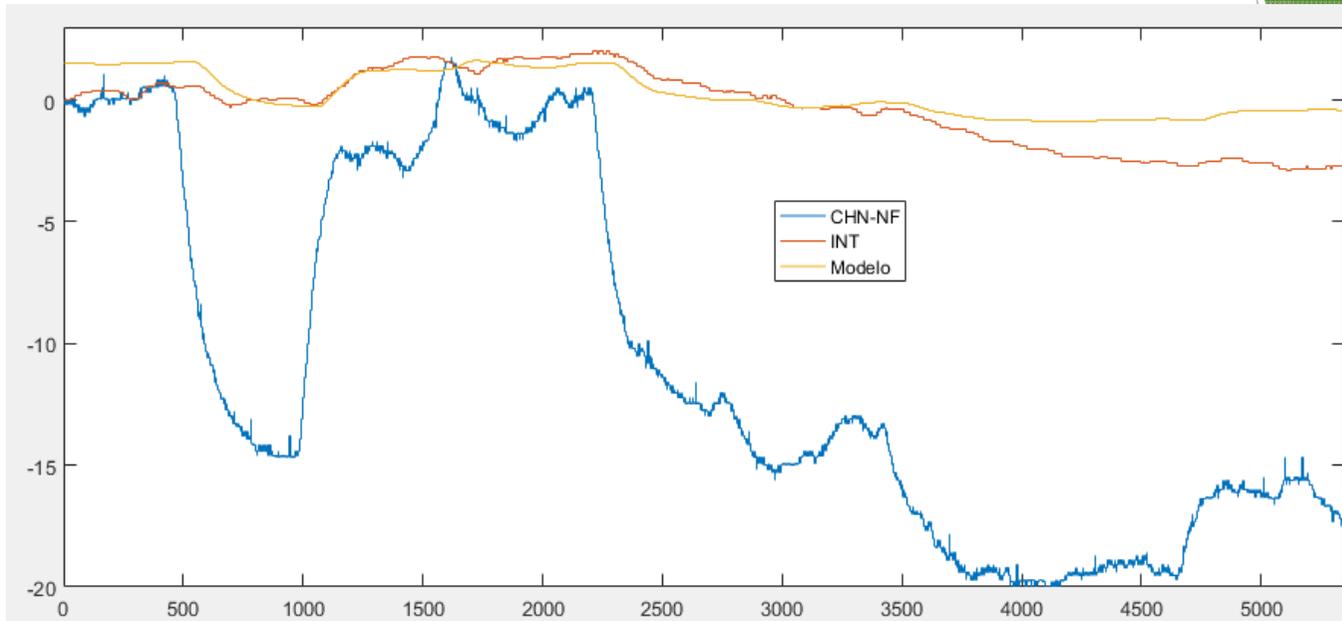


Pruebas a bordo: LA

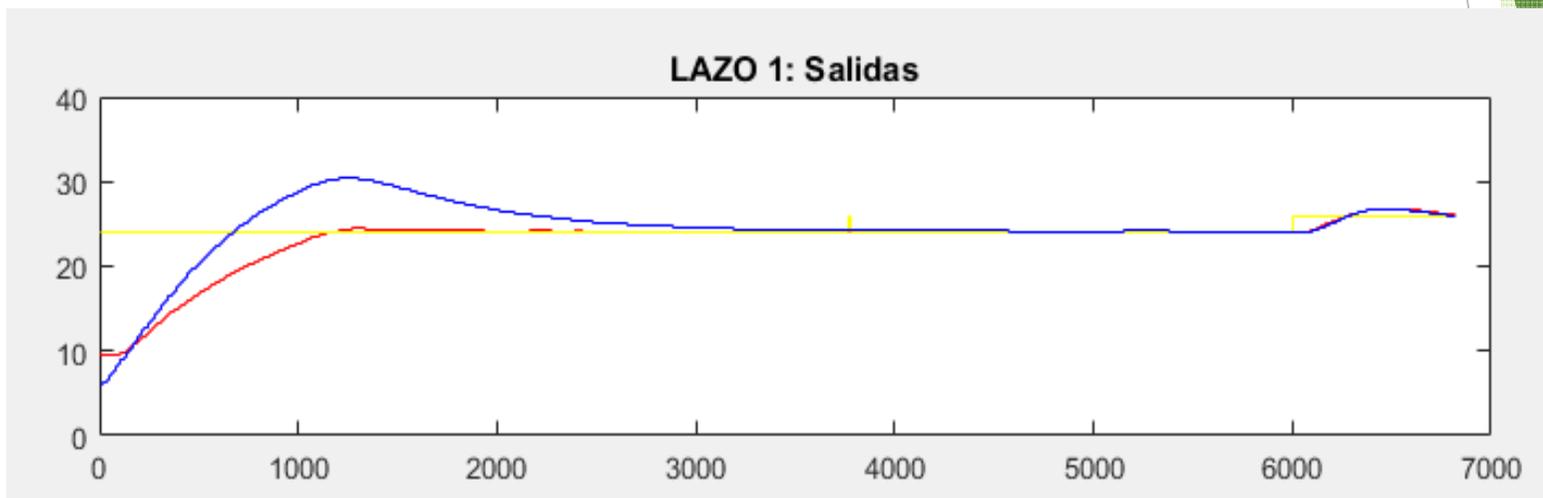
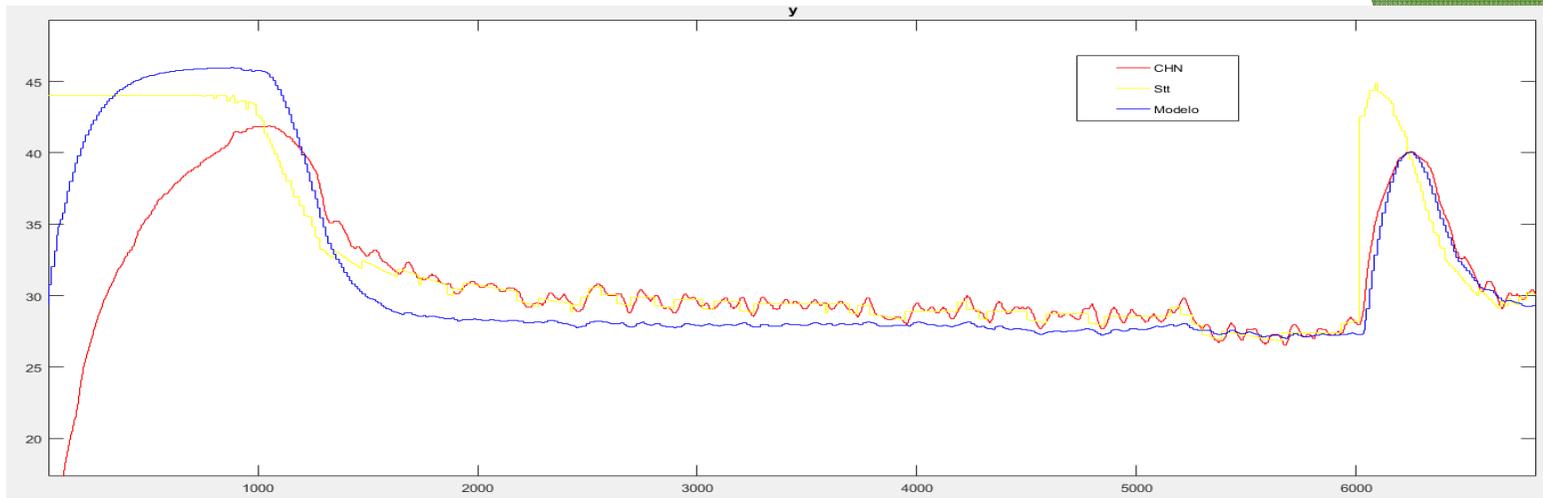




Válvula	Modelo
%40	$GC2(s) = \frac{300}{140s + 1} e^{-10s}$
%25	$GC2(s) = \frac{130}{140s + 1} e^{-10s}$



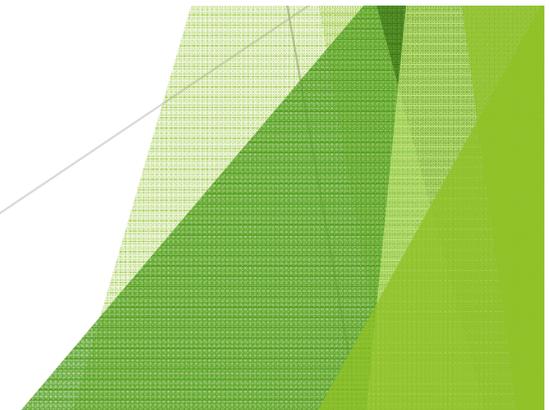
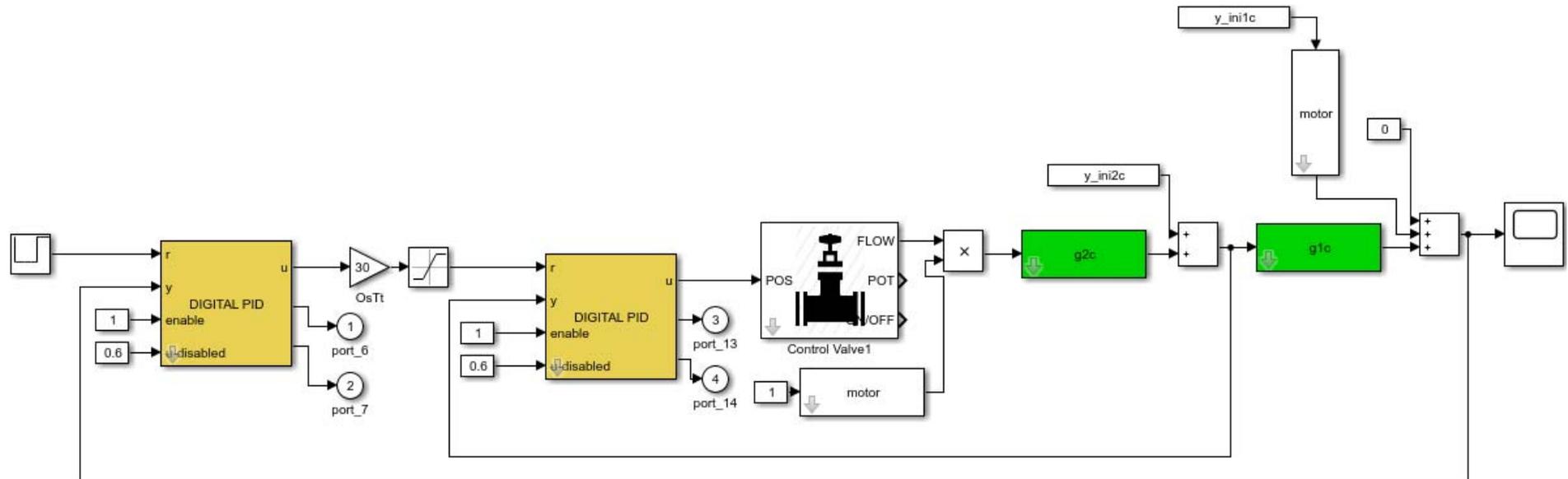
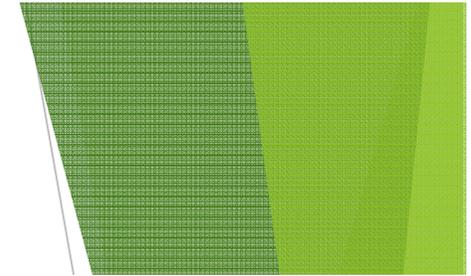
$$GC1(s) = \frac{0.12}{35s + 1} e^{-80s}$$



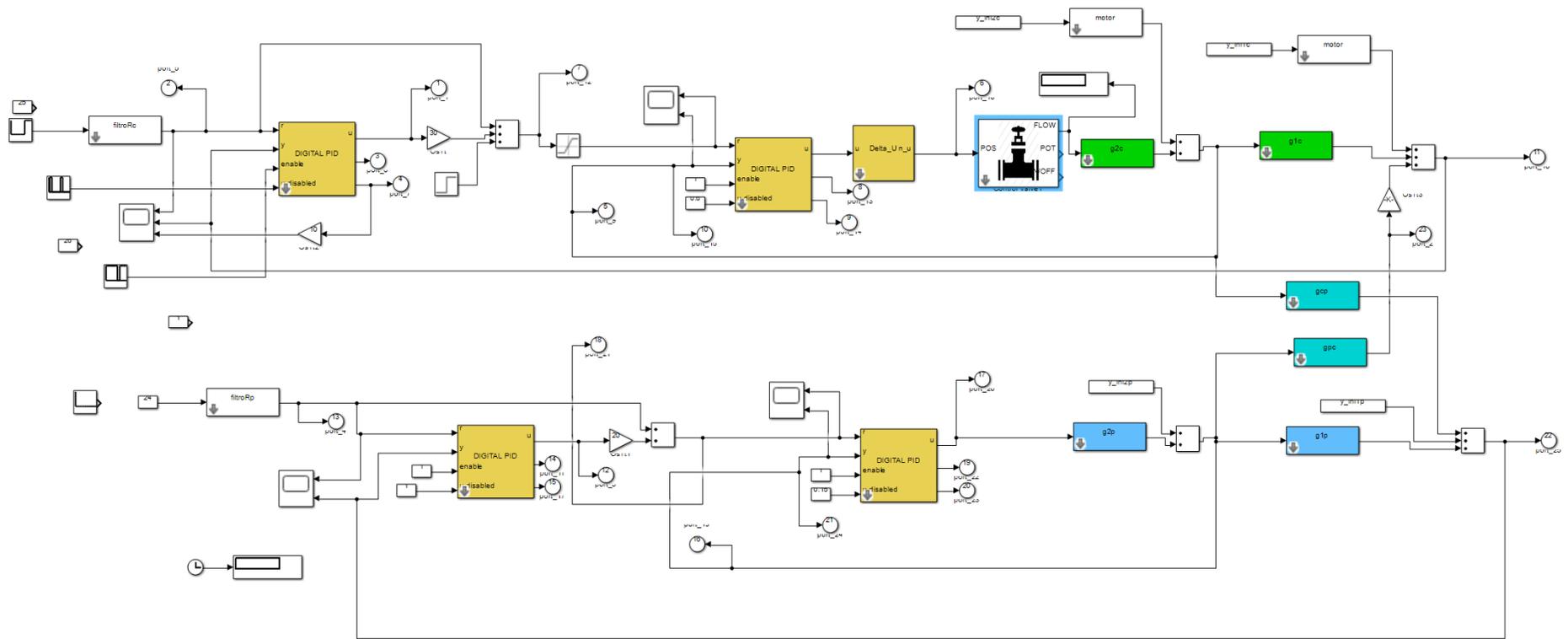
$$GP1(s) = \frac{0.64}{635s + 1} e^{-10s}$$

$$GP2(s) = \frac{20}{140s + 1} e^{-10s}$$

Pruebas a bordo: modelo



Pruebas a bordo: modelo

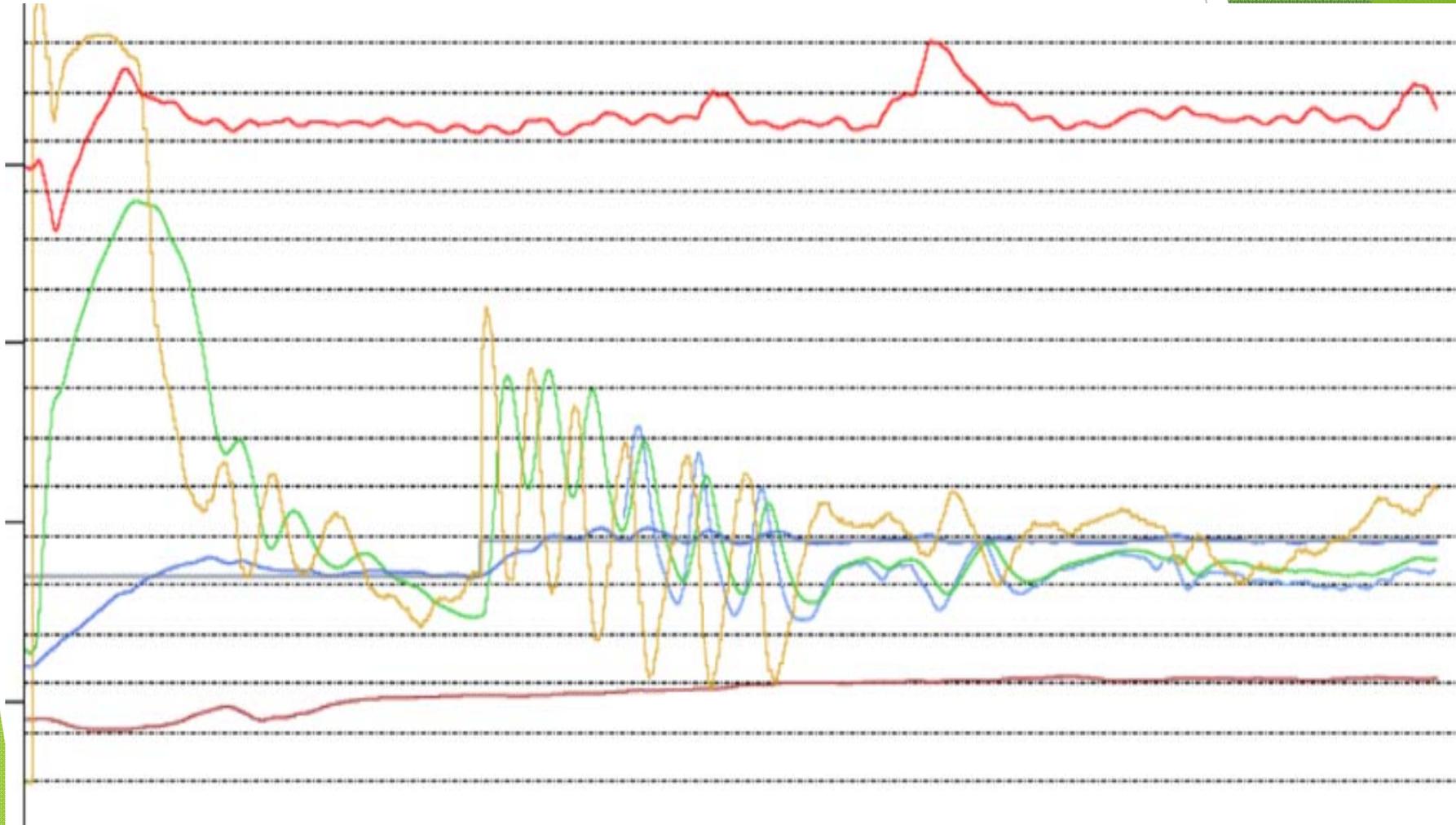


Pruebas a bordo: interacción



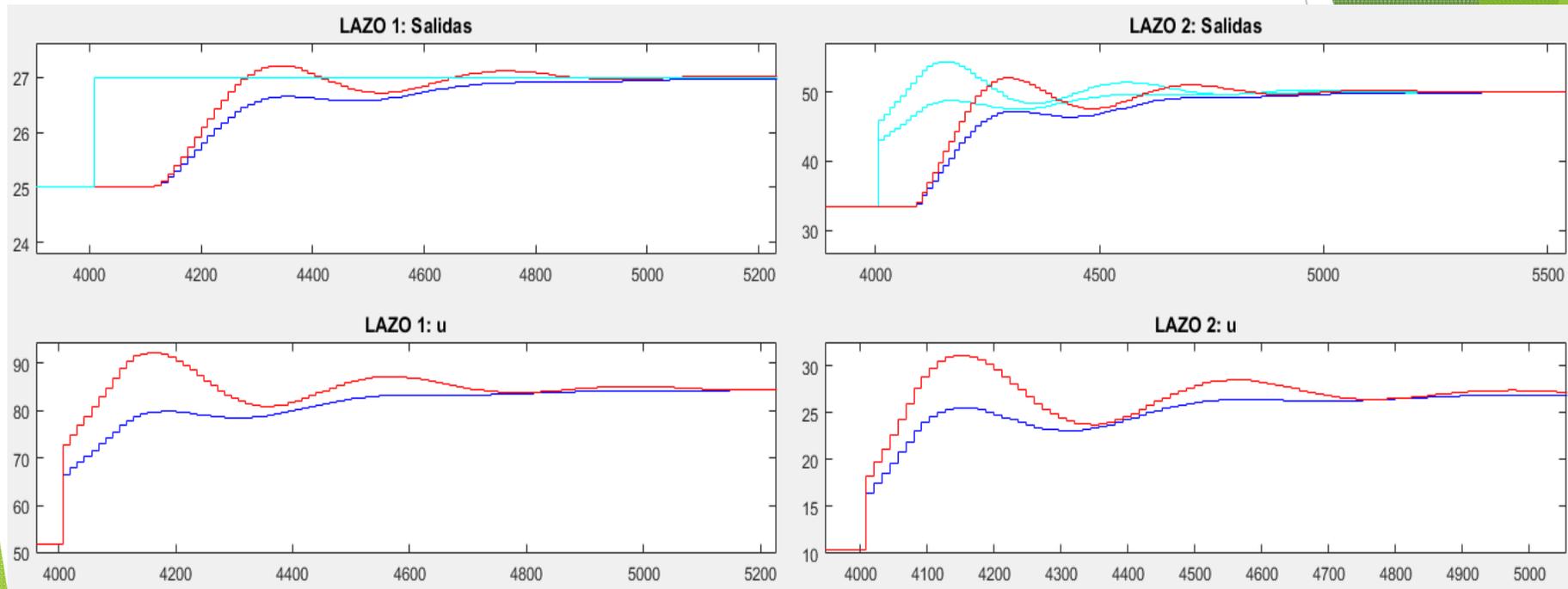
Pruebas a bordo

- Problemas por mala sintonía de parámetros



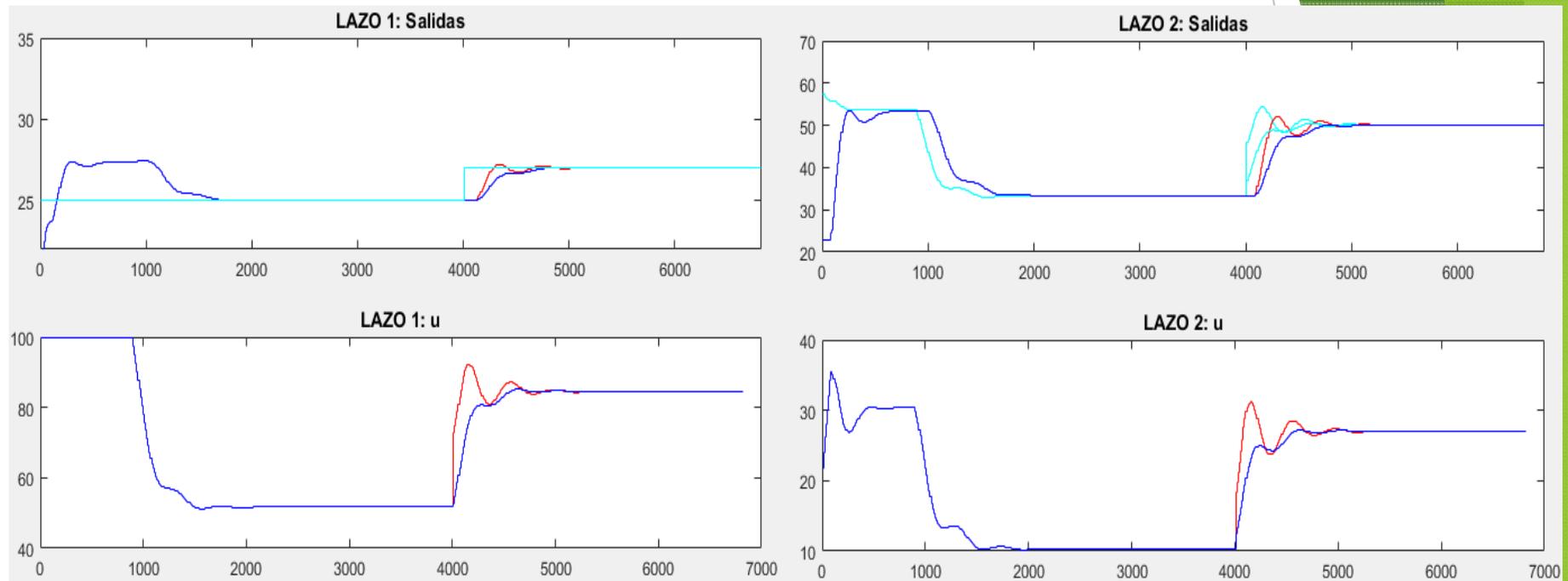
Pruebas a bordo

- ▶ Mejoras: reajuste de parámetros



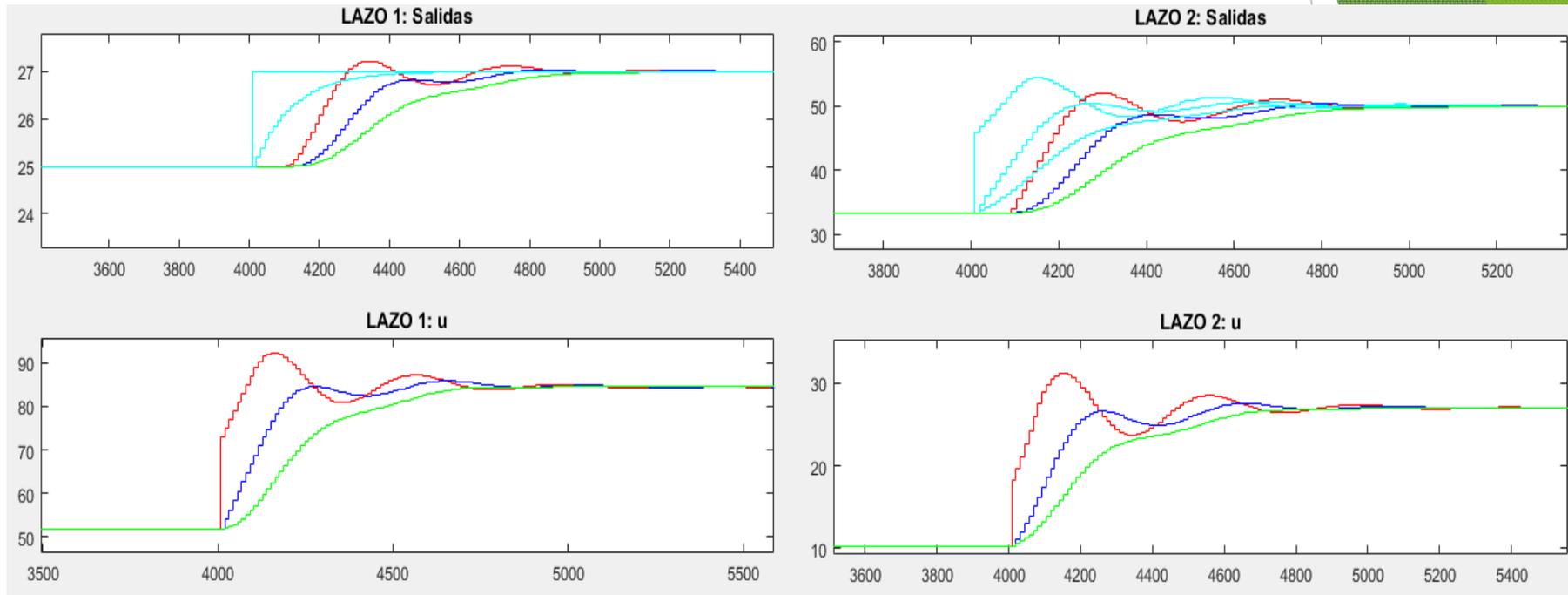
Pruebas a bordo

- ▶ Mejoras por cambio en el set-point ($b=0$)



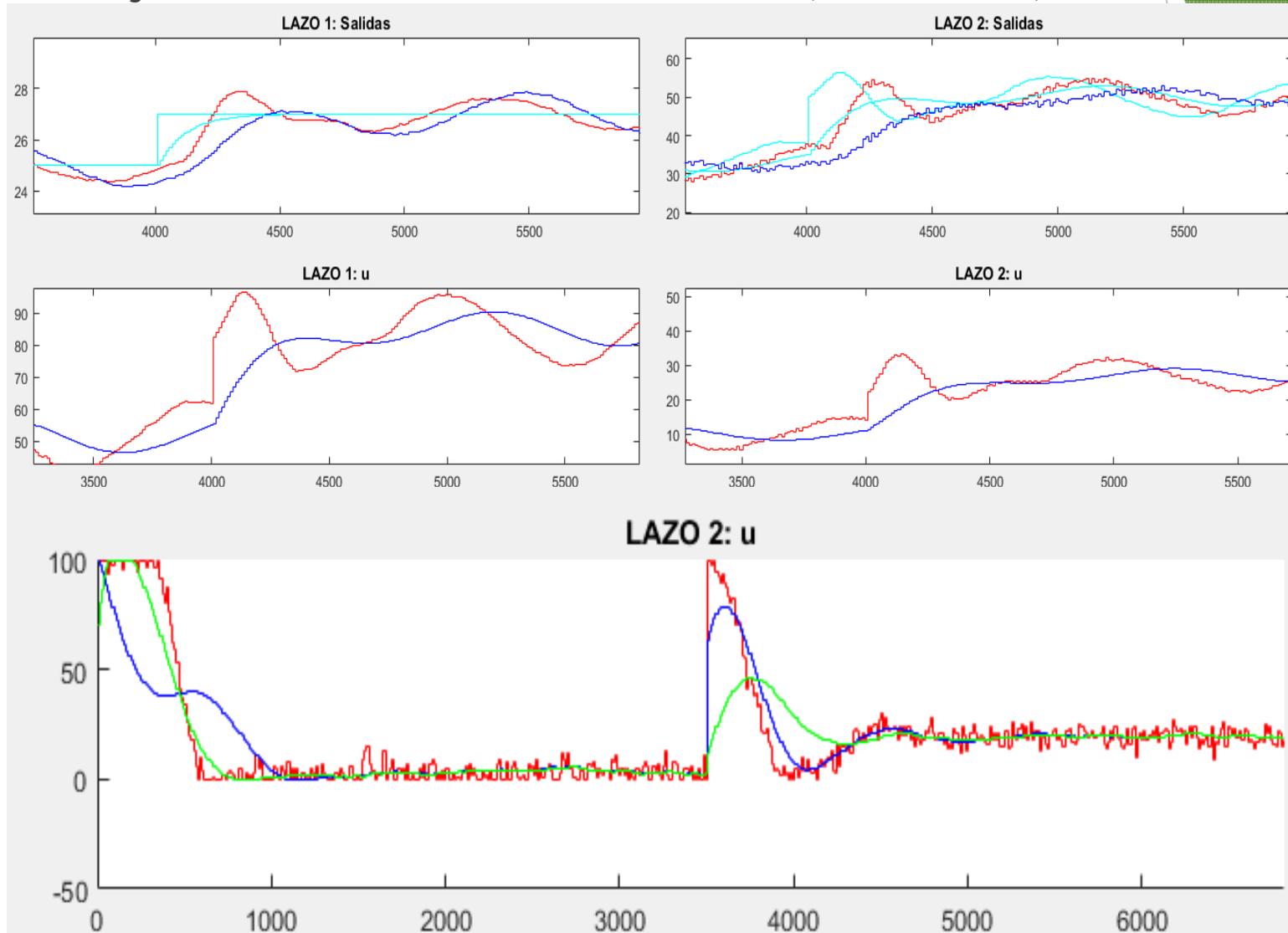
Pruebas a bordo

- Mejoras por cambio en el set-point (filtrado)



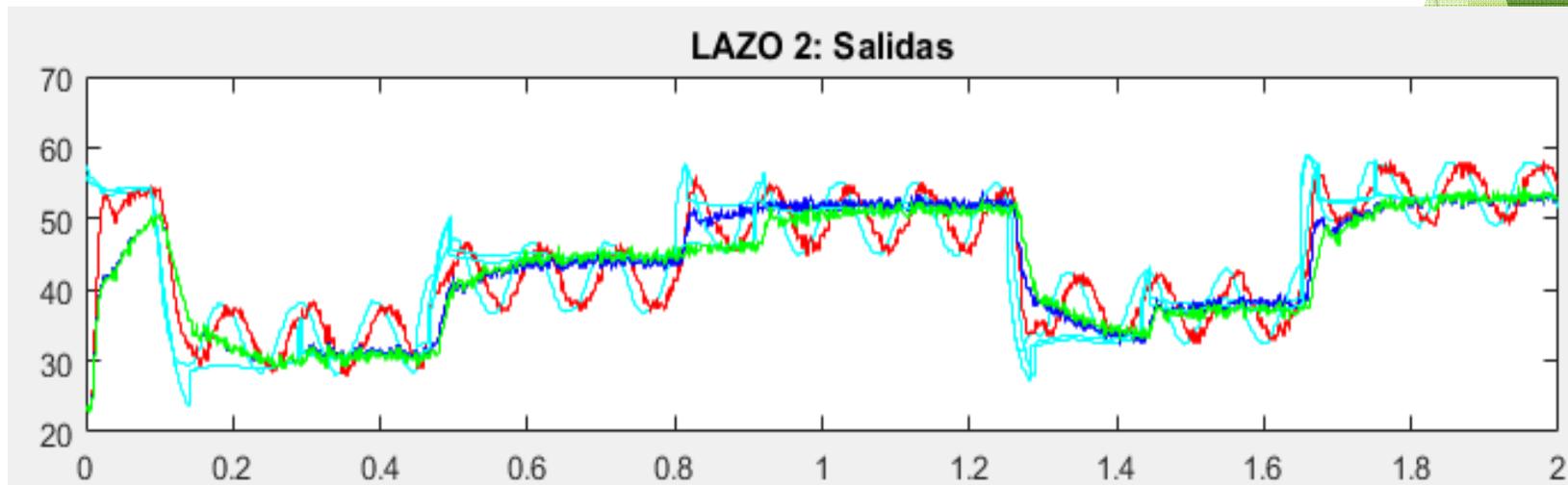
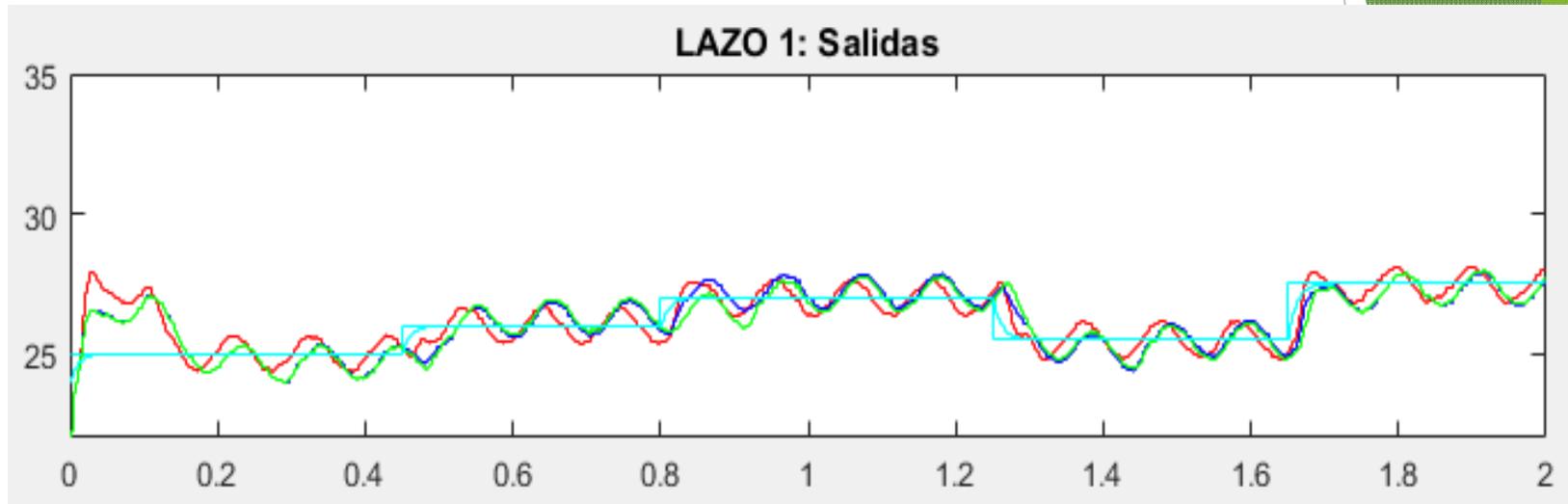
Pruebas a bordo

- ▶ Mejora de la medida señales con filtros (Butterworth)

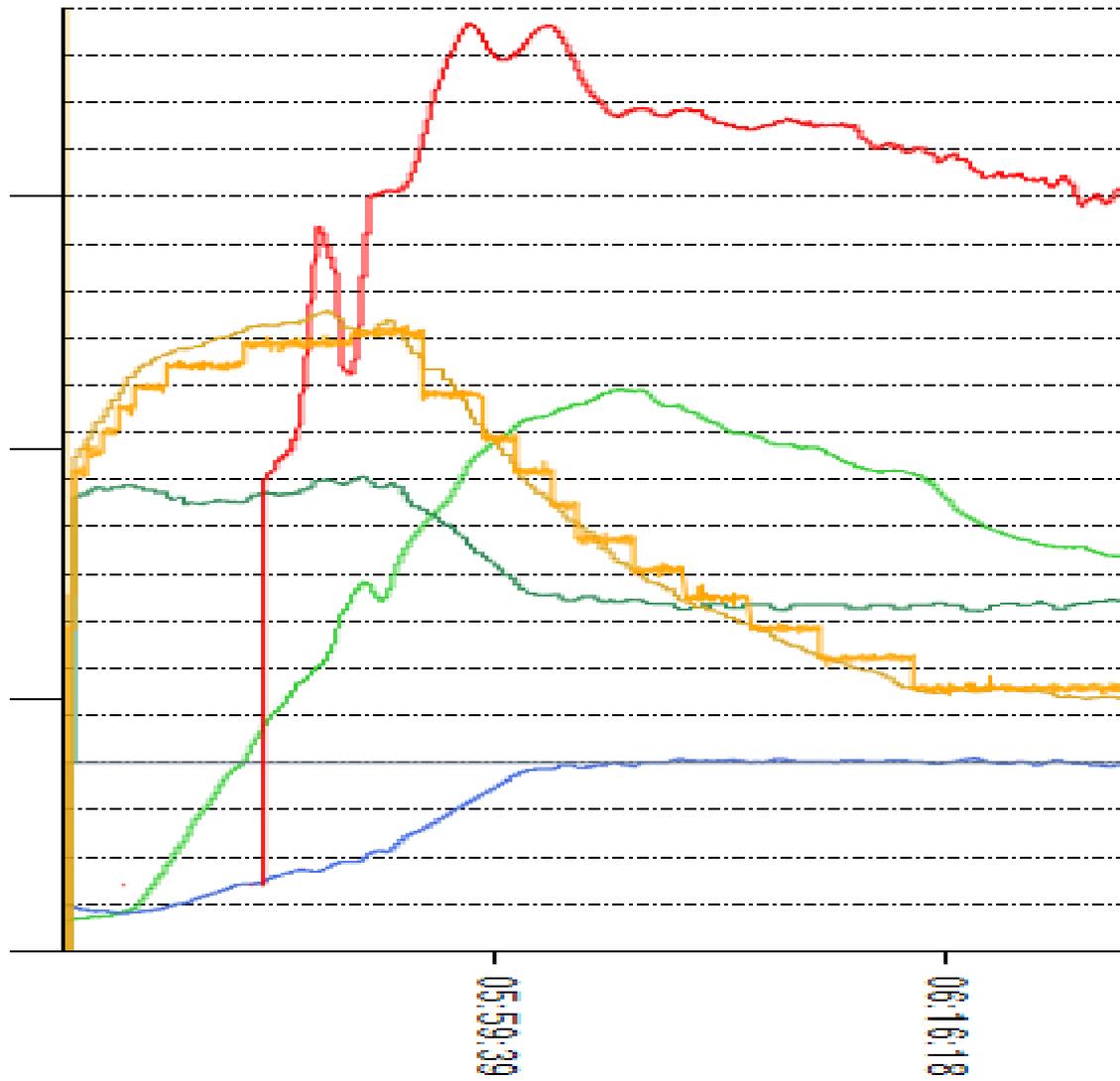


Pruebas a bordo

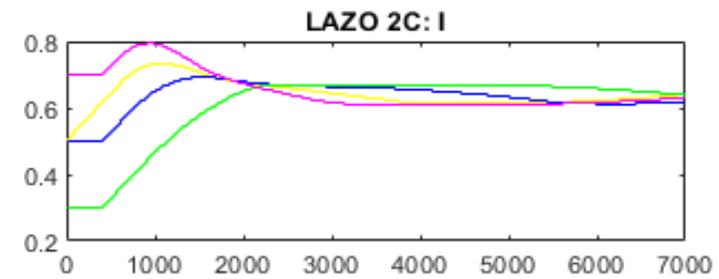
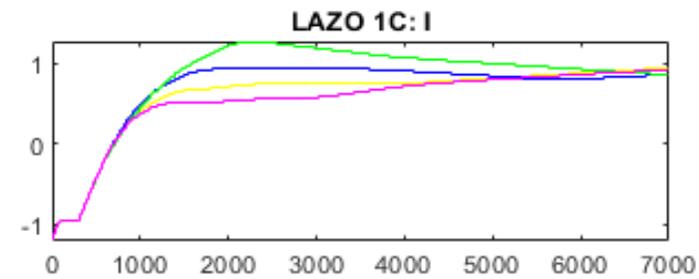
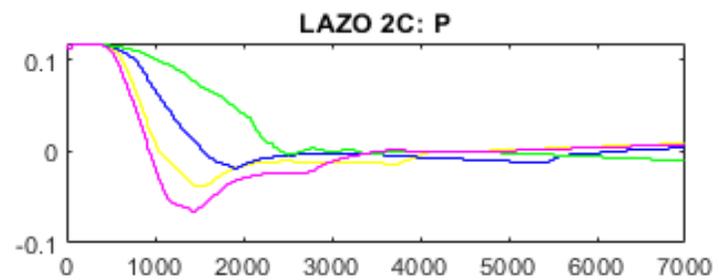
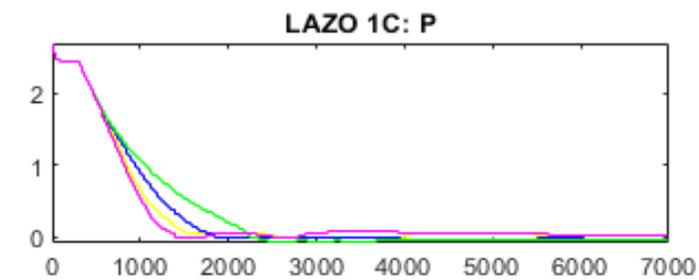
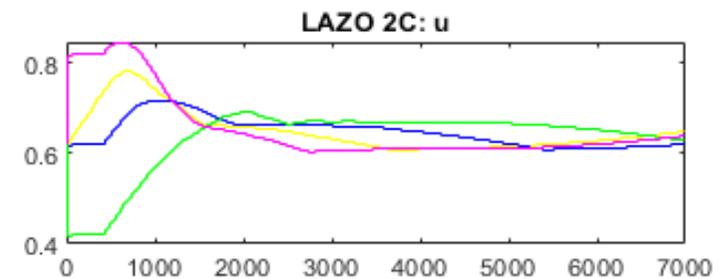
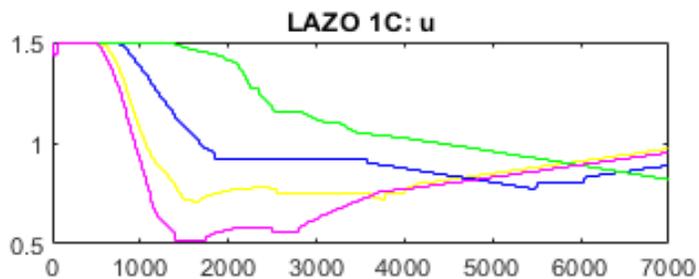
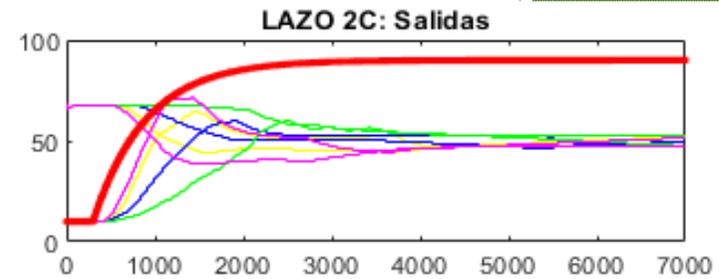
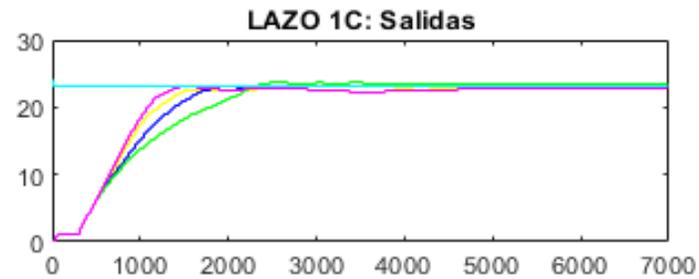
► Histéresis



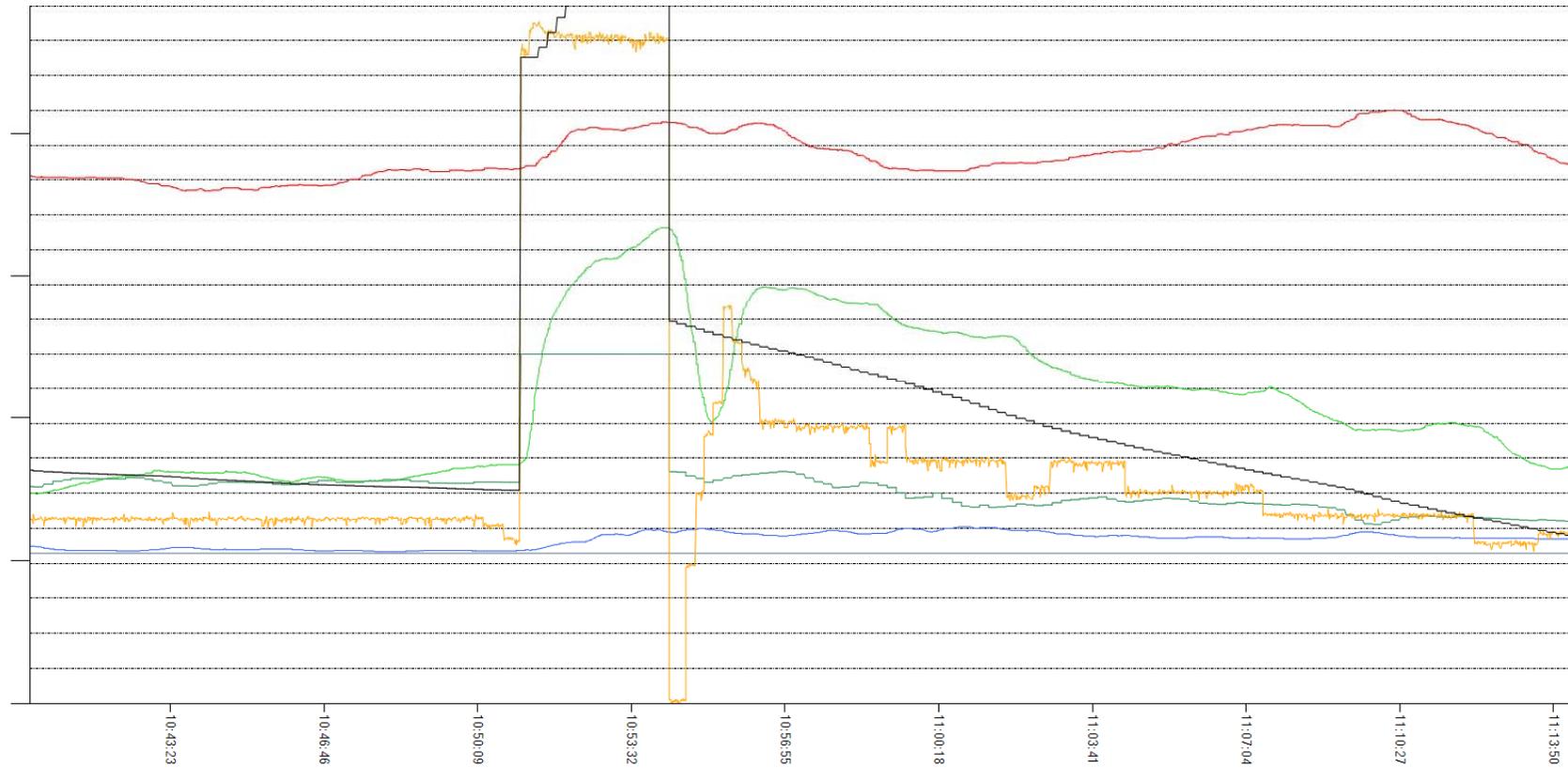
Pruebas a bordo: inicialización



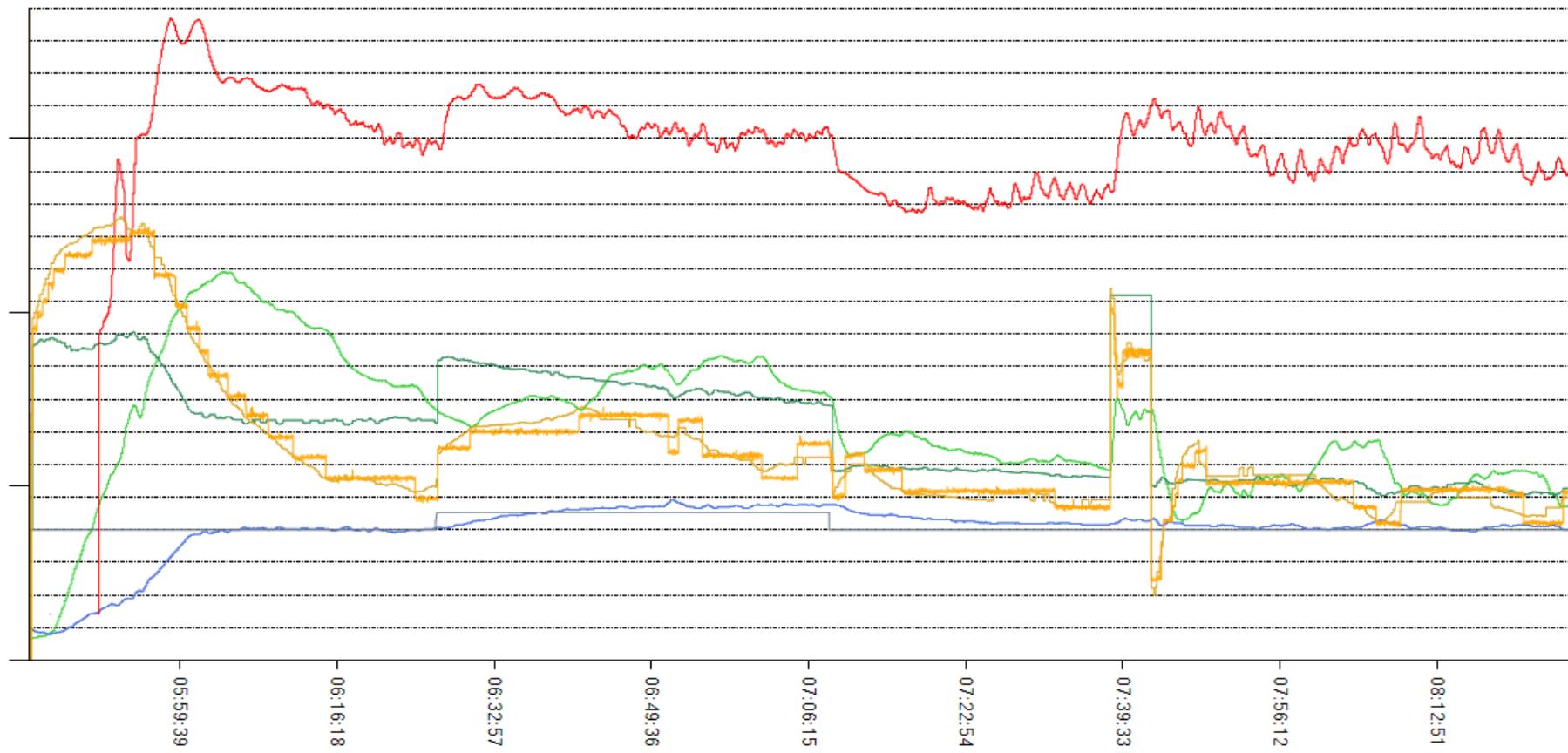
Pruebas a bordo: inicialización



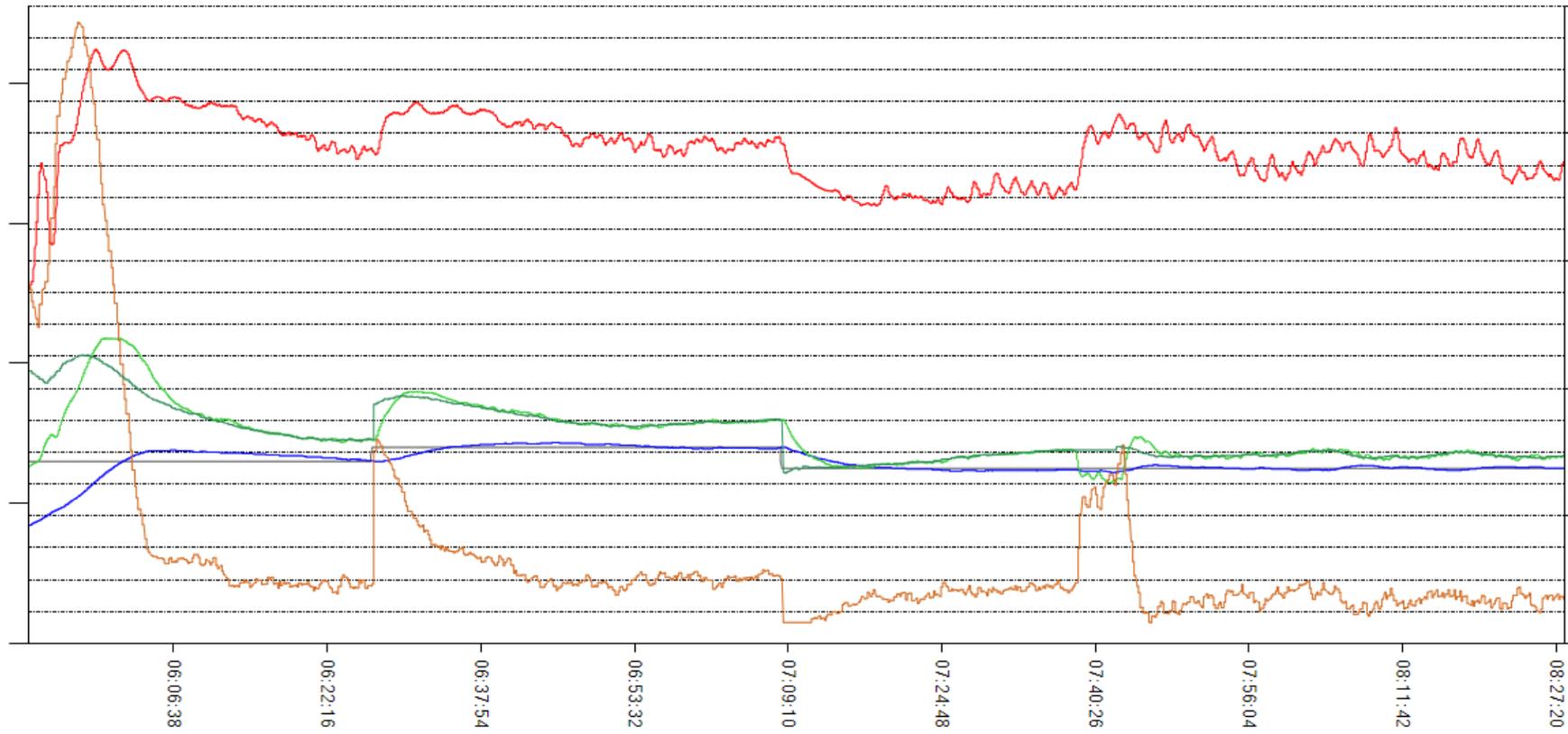
Pruebas a bordo



Pruebas a bordo: lazo conductor

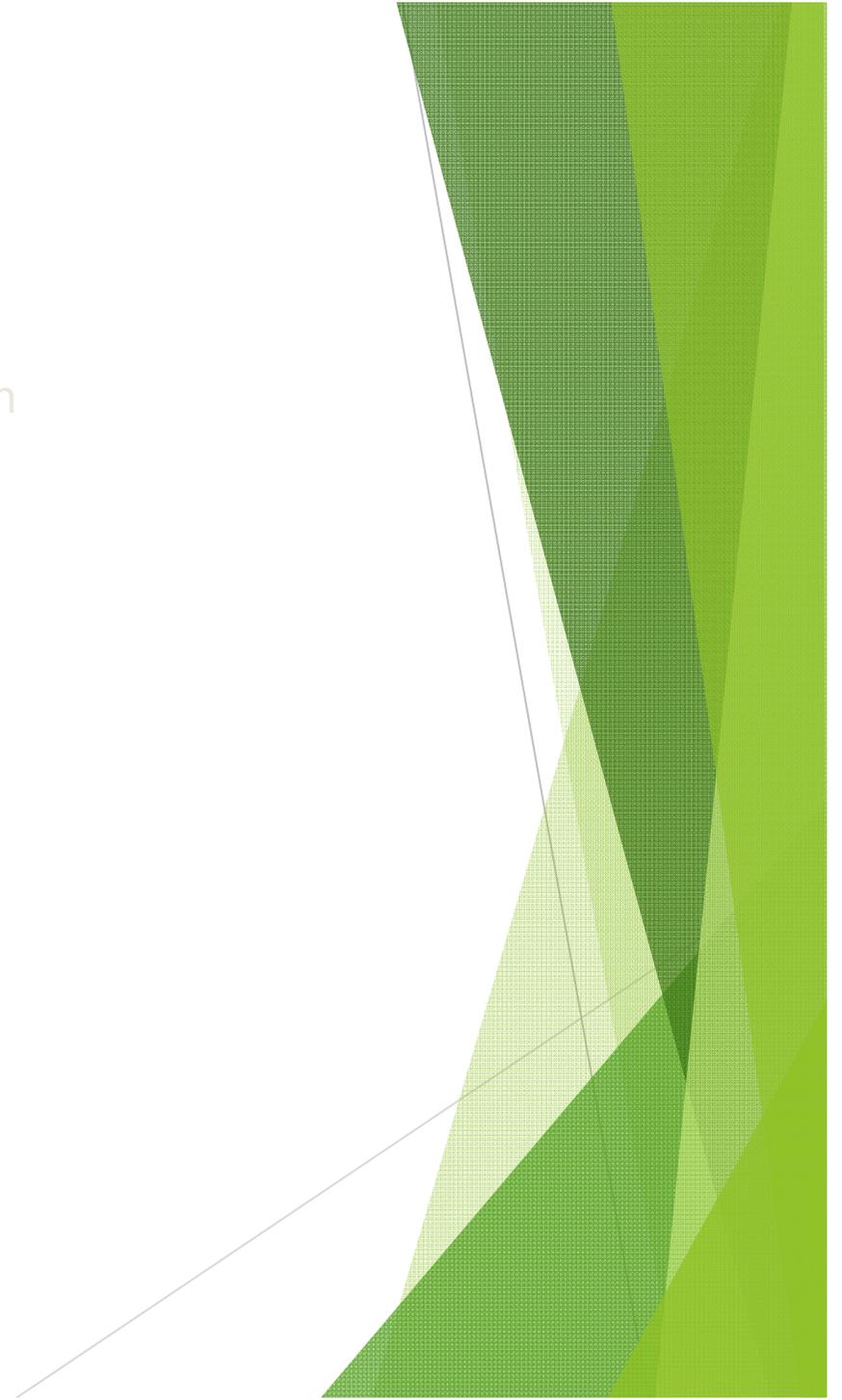


Pruebas a bordo: lazo pasajeros



INDICE

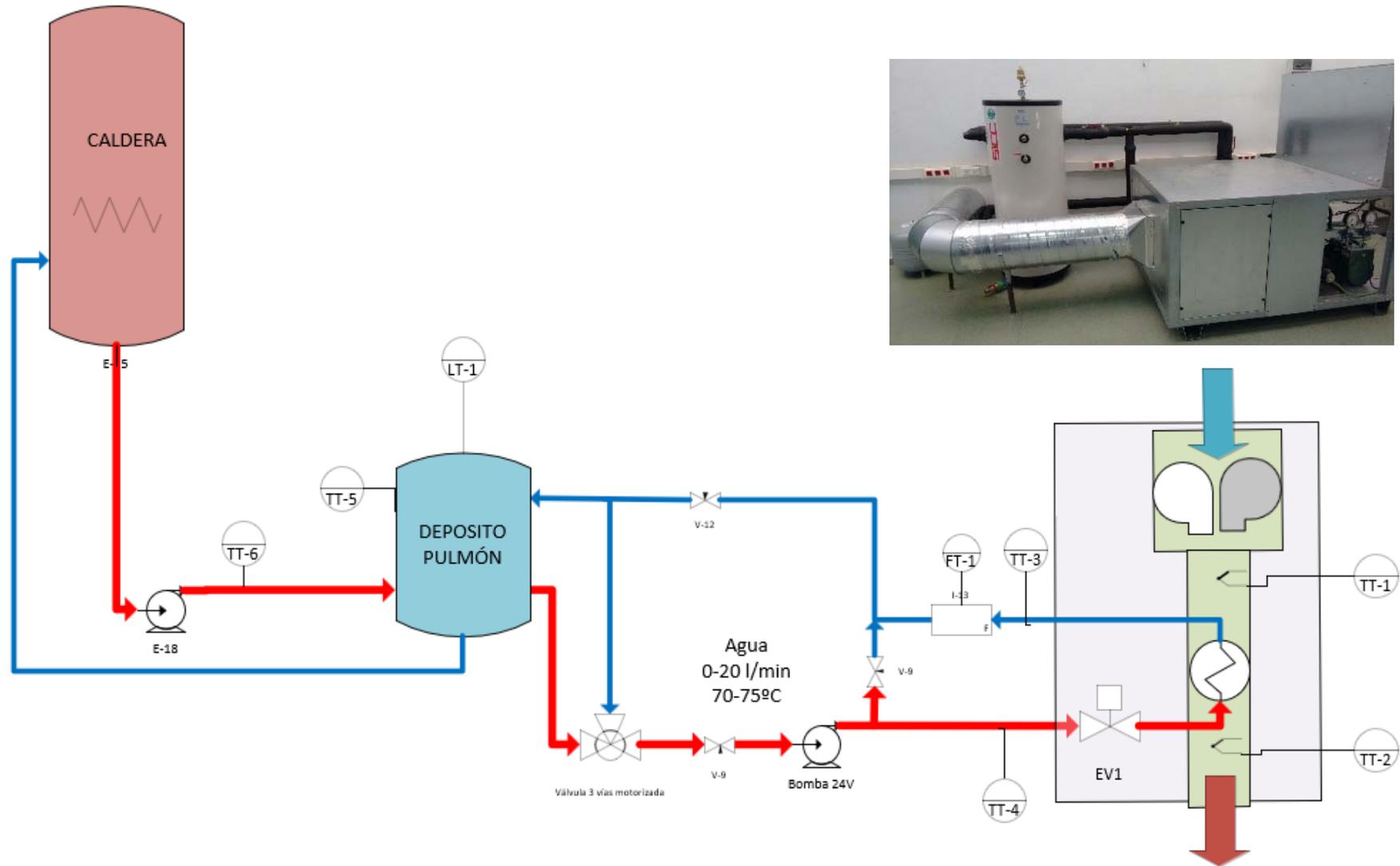
- ▶ Presentación del Grupo
- ▶ Introducción
- ▶ Componentes del sistema de calefacción
- ▶ La válvula de control
- ▶ Ensayos a bordo
- ▶ Trabajo actual



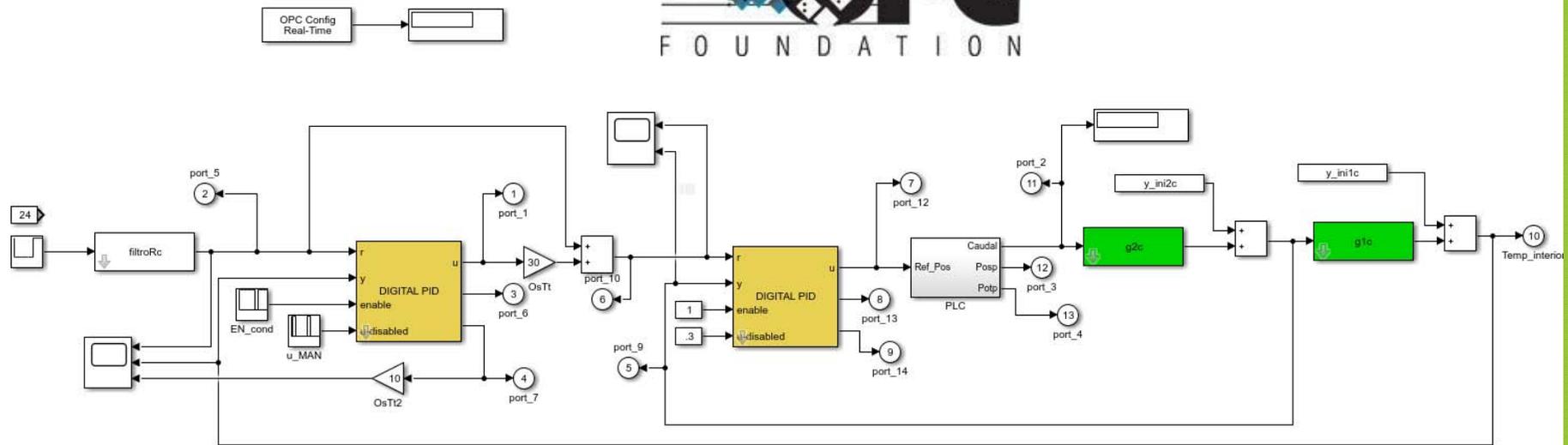
Trabajo actual



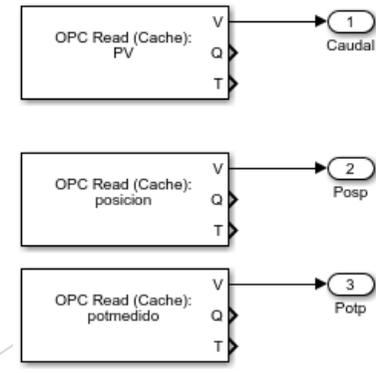
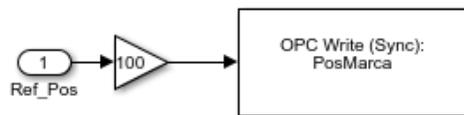
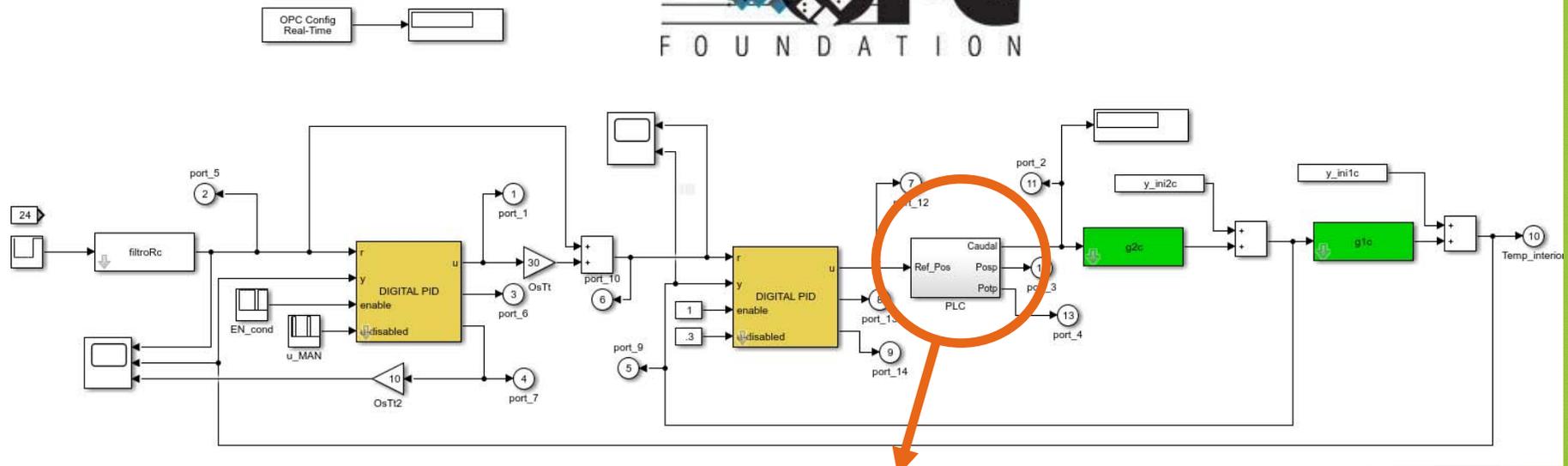
Trabajo actual



Trabajo actual: Ensayos híbridos



Trabajo actual: Ensayos híbridos



Agradecimientos

- ▶ Proyecto P18-TP-2040: Diseño de estrategias de control de calefacción en vehículos de transporte público
 - Modalidad Colaboración Tejido Productivo. 2020-22

JUNTA DE ANDALUCÍA

**CONSEJERÍA DE TRANSFORMACIÓN ECONÓMICA, INDUSTRIA,
CONOCIMIENTO Y UNIVERSIDADES**

Secretaría General de Universidades, Investigación y Tecnología

