

Servidor y cliente OPC UA usando software libre: Aplicación a un sistema fotovoltaico

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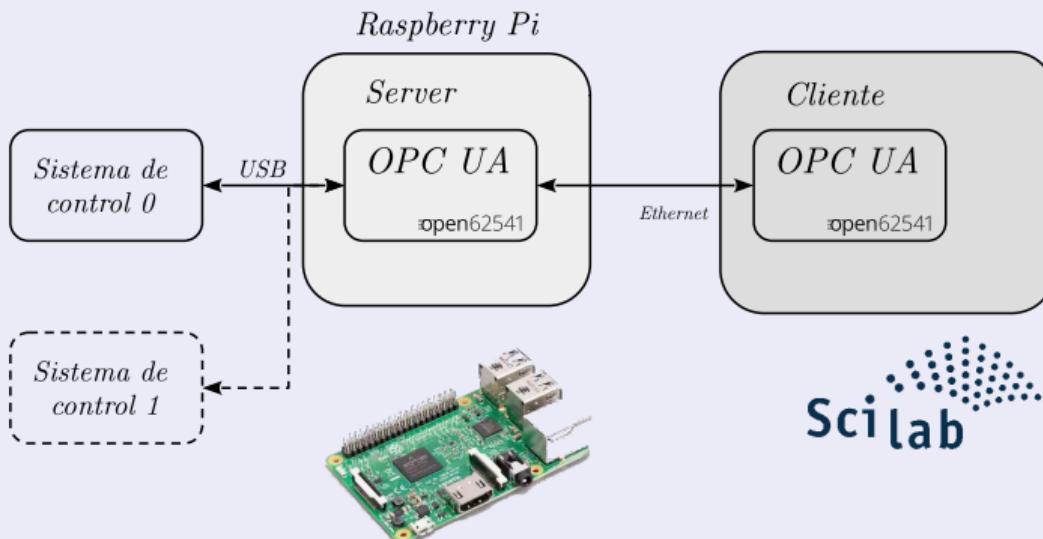
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Índice

- 1 Introducción
- 2 Desarrollo del servidor y cliente OPC UA
- 3 Aplicación a un sistema fotovoltaico
- 4 Ensayos experimentales
- 5 Conclusiones

Desarrollo

Esquema del sistema



Herramientas (Software Libre)

- Slackware Linux
<http://www.slackware.com/>
- Librería de código abierto (Open62541)
<https://www.open62541.org/>
- Scilab/Xcos <https://www.scilab.org/>

Hardware

- Raspberry pi 3b
- Microcontroladores dsPIC33FJ32MC204.
- Convertidores electrónicos de potencia, paneles solares, baterías, etc.

Desarrollo del servidor OPC UA

Herramientas

- Compilador gcc.
- Librerías open62541,etc.

Servidor OPC UA

- 1: Declaración de librerías y variables.
- 2: Configuración del puerto serie 0 – n .
- 3: Creación de variables OPC UA.
- 4: Creación de $h\text{lusb}0 - n$.
- 5: **procedure** PRINCIPAL
 - 6: Ejecuta $h\text{lusb}0$ a n .
 - 7: **while** (running) **do**
 - 8: Ejecuta el servidor OPC UA.
 - 9: Actualiza variables.
 - 10: **end while**
 - 11: Cierra 4,3,2 y finaliza.
- 12: **Return**

Hilo 0

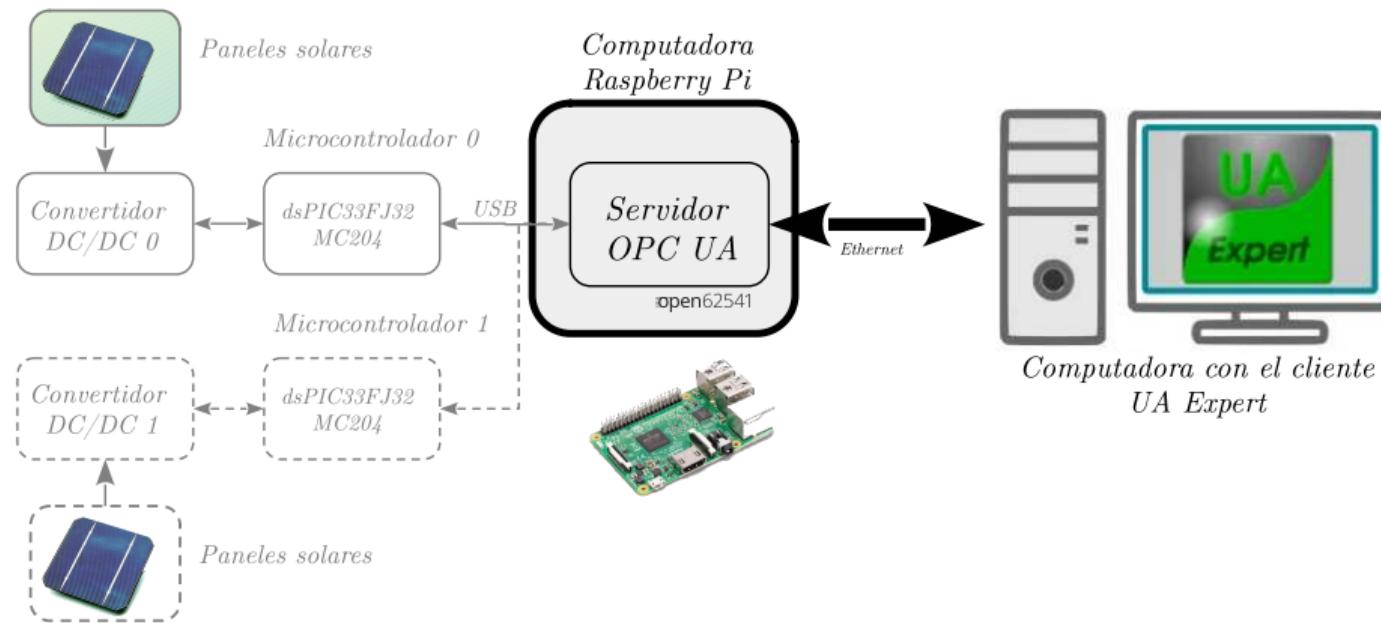
```
1: procedure HLUSB0
2:     Creación de variables
3:     while do
4:         carácter← leepuertoserie.
5:         if carácter==10 then
6:              $n_1 \dots n_4 \leftarrow buffer$ 
7:              $buffer_{pos} = 0$ ;
8:         else
9:              $buffer_{pos} = buffer_{pos} + 1$ .
10:             $buffer(buffer_{pos}) \leftarrow carácter$ 
11:        end if
12:         $/dev/ttyUSB0 \leftarrow V_{Pref}$ 
13:    end While
14: Return
```

Verificaciones con el servidor OPC UA

Verificaciones

- Servidor-Cliente
- Consumo de recursos del servidor.

Servidor-Cliente OPC UA



Servidor

Servidor OPC UA. Versión 5.0

[2025-04-01 17:03:12.806 (UTC-0300)] info/eventloop
[2025-04-01 17:03:12.807 (UTC-0300)] warn/server
[2025-04-01 17:03:12.807 (UTC-0300)] info/server
[2025-04-01 17:03:12.807 (UTC-0300)] warn/server
n leak credentials on the network.

[2025-04-01 17:03:12.818 (UTC-0300)] info/session
n. Use the default TypeDefinition for the Variable/Object
[2025-04-01 17:03:12.844 (UTC-0300)] info/session
n. Use the default TypeDefinition for the Variable/Object

[2025-04-01 17:03:12.938 (UTC-0300)] warn/userland
[2025-04-01 17:03:12.938 (UTC-0300)] warn/server
[2025-04-01 17:03:12.938 (UTC-0300)] info/server
[2025-04-01 17:03:12.938 (UTC-0300)] warn/server
n leak credentials on the network.

[2025-04-01 17:03:12.938 (UTC-0300)] warn/server
n leak credentials on the network.

[2025-04-01 17:03:12.940 (UTC-0300)] info/network
[2025-04-01 17:03:12.942 (UTC-0300)] info/network
840

[2025-04-01 17:03:12.942 (UTC-0300)] info/server
[2025-04-01 17:03:12.942 (UTC-0300)] info/network
[2025-04-01 17:03:13.507 (UTC-0300)] info/network
[2025-04-01 17:03:13.507 (UTC-0300)] info/channel
[2025-04-01 17:03:13.607 (UTC-0300)] info/channel
A/SecurityPolicy#None and a revised lifetime of 600.00s

[2025-04-01 17:03:13.707 (UTC-0300)] warn/channel
[2025-04-01 17:03:13.838 (UTC-0300)] info/session
sion created

[2025-04-01 17:03:13.907 (UTC-0300)] info/session
ivateSession: Session activated with ClientUserId ""

[2025-04-01 17:03:14.120 (UTC-0300)] info/session
scription 1 | Subscription created (Publishing interval 100.00ms, max 1000 notifications per publish)

[2025-04-01 17:03:14.208 (UTC-0300)] info/session
scription 1 | MonitoredItem 1 | Created the MonitoredItem (Sampling Interval: 0.00ms, Queue Size: 100)

[2025-04-01 17:03:14.232 (UTC-0300)] info/session
scription 2 | Subscription created (Publishing interval 500.00ms, max 1000 notifications per publish)

[2025-04-01 17:03:14.307 (UTC-0300)] info/session

Starting the EventLoop
AccessControl: Unconfigured AccessControl. Users have all permissions.
AccessControl: Anonymous login is enabled
x509 Certificate Authentication configured, but no encrypting SecurityPolicy. This ca

TCP 0 | SC 0 | Session "Administrator" | AddNode (i=15303): No TypeDefinition

TCP 0 | SC 0 | Session "Administrator" | AddNode (i=25451): No TypeDefinition

ServerUrls already set. Overriding.
AccessControl: Unconfigured AccessControl. Users have all permissions.
AccessControl: Anonymous login is enabled
x509 Certificate Authentication configured, but no encrypting SecurityPolicy. This ca

x509 Certificate Authentication configured, but no encrypting SecurityPolicy. This ca

TCP | Listening on all interfaces

TCP 6 | Creating listen socket for "0.0.0.0" (with local hostname "rpi3") on port 4

New DiscoveryUrl added: opc.tcp://rpi3:4840

TCP 7 | Creating listen socket for ":" (with local hostname "rpi3") on port 4840

TCP 8 | Connection opened from "192.168.10.173" via the server socket 6

TCP 8 | SC 1 | SecureChannel created

TCP 8 | SC 1 | SecureChannel opened with SecurityPolicy http://opcfoundation.org/U

TCP 8 | SC 1 | ActivateSession: Session not found

TCP 8 | SC 1 | Session "urn:Ramiro.unp.edu.ar:UnifiedAutomation:UaExpert" | Ses

TCP 8 | SC 1 | Session "urn:Ramiro.unp.edu.ar:UnifiedAutomation:UaExpert" | Act

TCP 8 | SC 1 | Session "urn:Ramiro.unp.edu.ar:UnifiedAutomation:UaExpert" | Sub

TCP 8 | SC 1 | Session "urn:Ramiro.unp.edu.ar:UnifiedAutomation:UaExpert" | Sub

TCP 8 | SC 1 | Session "urn:Ramiro.unp.edu.ar:UnifiedAutomation:UaExpert" | Sub

TCP 8 | SC 1 | Session "urn:Ramiro.unp.edu.ar:UnifiedAutomation:UaExpert" | Sub

TCP 8 | SC 1 | Session "urn:Ramiro.unp.edu.ar:UnifiedAutomation:UaExpert" | Sub

TCP 8 | SC 1 | Session "urn:Ramiro.unp.edu.ar:UnifiedAutomation:UaExpert" | Sub

1

2

3

Cliente OPC UA, Ua Expert

Unified Automation UaExpert - The OPC Unified Architecture Client - NewProject*

File View Server Document Settings Help

Project

- Project
- Servers
- open62541-based OPC UA Application
- Documents
- Data Access View

1

Address Space

- No Highlight
- Root
 - Objects
 - Corriente en el inductor
 - Corriente en el inductor, convertidor
 - Corriente en los paneles solares
 - Corriente en los paneles solares
 - Current time - data source
 - Current time - value callback
 - Server
 - Auditing

2

Data Access View

#	Server	Node Id	Display Name	Value	DataType
1	open62541-based OPC UA Application	NS1[String]1p	Tensión en los paneles solares	8	Double
2	open62541-based OPC UA Application	NS0[Numeric]2257	StartTime	2025-04-01T13:00:00Z	DateTime
3	open62541-based OPC UA Application	NS0[Numeric]2259	State	0 (Running)	Int32

3

Attributes

Attribute	Value
NodeId	i=2259 [Server]
NamespaceIndex	0
IdentifierType	Numeric
Identifier	2259 [Server]
NodeClass	Variable
BrowseName	0, "State"
DisplayName	"State"
Description	
Value	
DataType	ServerState
ValueRank	-2 (Any)

4

References

Reference	Target DisplayName
HasTypeDefinition	BaseDataVariableType

Log

Timestamp	Source	Server	Message
4/1/25 10:59:5...	DA Plugin	open62541-ba...	Found existing subscription for ServerId 0
4/1/25 10:59:5...	DA Plugin	open62541-ba...	Item [NS0[Numeric]2257]: SamplingInterval=250, QueueSize=1, DiscardOldest=1, ClientHandle=3
4/1/25 10:59:5...	DA Plugin	open62541-ba...	CreateMonitoredItems succeeded [ret = Good]
4/1/25 10:59:5...	DA Plugin	open62541-ba...	Item [NS0[Numeric]2257] succeeded : RevisedSamplingInterval=250, RevisedQueueSize=1, MonitoredItemId=2 [ret = Good]
4/1/25 11:00:0...	Attribute Plugin	open62541-ba...	Read attributes of node [NS0[Numeric]2259] succeeded [ret = Good].
4/1/25 11:00:0...	Reference Plu...	open62541-ba...	Browse succeeded.
4/1/25 11:00:0...	AddressSpace...	open62541-ba...	QosAddressSpaceModel:mimeTypeData
4/1/25 11:00:0...	DA Plugin	open62541-ba...	QosDataModel:dropMimeData
4/1/25 11:00:0...	DA Plugin	open62541-ba...	Found existing subscription for ServerId 0
4/1/25 11:00:0...	DA Plugin	open62541-ba...	Item [NS0[Numeric]2259]: SamplingInterval=250, QueueSize=1, DiscardOldest=1, ClientHandle=5
4/1/25 11:00:0...	DA Plugin	open62541-ba...	CreateMonitoredItems succeeded [ret = Good]
4/1/25 11:00:0...	DA Plugin	open62541-ba...	Item [NS0[Numeric]2259] succeeded : RevisedSamplingInterval=250, RevisedQueueSize=1, MonitoredItemId=3 [ret = Good]

Consumo de recursos del servidor OPC UA

```
root@rpi3:/home/ramiro# pgrep shyps45b_raspi
960
root@rpi3:/home/ramiro# pidstat -p 960 -t 10
Linux 6.6.16-v7-sarpi3 (rpi3) 06/04/2025 _armv7l_ (4 CPU)

05:27:35 PM  UID      Tgid      TID  %usr  %system  %guest  %wait  %CPU   CPU  Command
05:27:45 PM  0        960       -  0.40   0.70    0.00    0.00   1.10   2  shyps45b_raspi
05:27:45 PM  0        -        960  1.00   0.00    0.00    0.00   1.00   2  |__shyps45b_raspi
05:27:45 PM  0        -        961  0.00   0.20    0.00    0.00   0.20   2  |__shyps45b_raspi
05:27:55 PM  0        960       -  0.50   0.80    0.00    0.00   1.30   2  shyps45b_raspi
05:27:55 PM  0        -        960  0.90   0.10    0.00    0.00   1.00   2  |__shyps45b_raspi
05:27:55 PM  0        -        961  0.10   0.20    0.00    0.10   0.30   2  |__shyps45b_raspi
05:28:05 PM  0        960       -  1.10   0.50    0.00    0.00   1.60   2  shyps45b_raspi
05:28:05 PM  0        -        960  1.30   0.00    0.00    0.00   1.30   2  |__shyps45b_raspi
05:28:05 PM  0        -        961  0.00   0.20    0.00    0.10   0.20   1  |__shyps45b_raspi
05:28:15 PM  0        960       -  0.00   1.20    0.00    0.00   1.20   2  shyps45b_raspi
05:28:15 PM  0        -        960  1.00   0.00    0.00    0.00   1.00   2  |__shyps45b_raspi
05:28:15 PM  0        -        961  0.00   0.20    0.00    0.10   0.20   2  |__shyps45b_raspi
05:28:25 PM  0        960       -  0.10   1.10    0.00    0.00   1.20   2  shyps45b_raspi
05:28:25 PM  0        -        960  1.00   0.10    0.00    0.00   1.10   2  |__shyps45b_raspi
05:28:25 PM  0        -        961  0.00   0.30    0.00    0.20   0.30   2  |__shyps45b_raspi
^C
Average:    0        960       -  0.42   0.86    0.00    0.00   1.28   -  shyps45b_raspi
Average:    0        -        960  1.04   0.04    0.00    0.00   1.08   -  |__shyps45b_raspi
Average:    0        -        961  0.02   0.22    0.00    0.10   0.24   -  |__shyps45b_raspi
root@rpi3:/home/ramiro#
```

Promedio

Proceso	% usr	% system	% CPU
960	1,04	0,04	1,08
961	0,02	0,22	0,24

Desarrollo del cliente OPC UA para Scilab/Xcos

Función computacional (Cliente OPC UA)

```

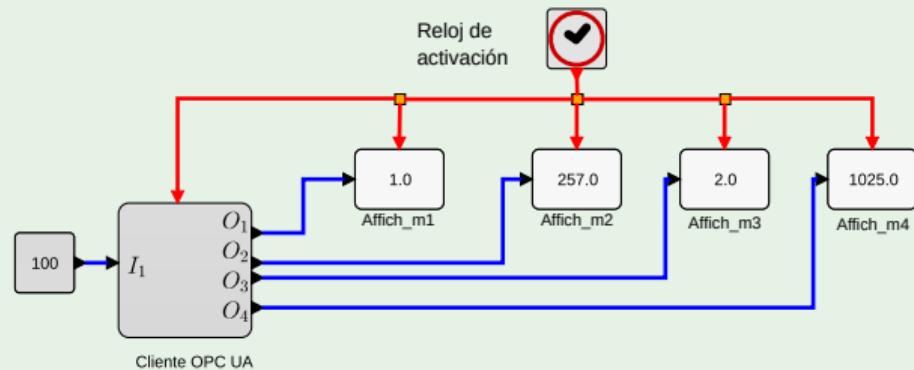
1: procedure CLIENTEOPCUA(IP,PUERTO)
2:   Carga librerías.
3:   Definición de variables.
4:   if flag == 4 then           ▷ Ini sim.
5:     | Inicia conexión OPC UA.
6:   else if flag == 5 then      ▷ final.
7:     | Cierra la conexión OPC UA.
8:   else if flag == 1 then      ▷ Calc. Salida.
9:     | Lee y escribe variables OPC UA.
10:  end if.
11: Return

```

Implementación

- Compilación con gcc.
- Enlace de la función computacional a Scilab.
- Creación de una nueva paleta de componentes para Xcos con el bloque nuevo.

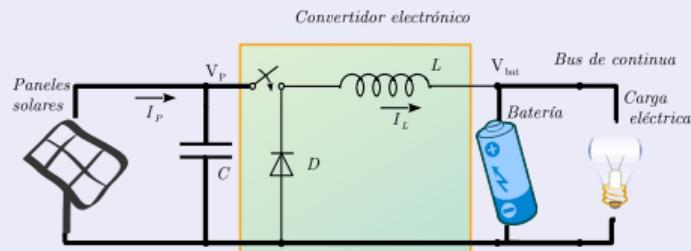
Esquema en Xcos con el cliente OPC UA diseñado



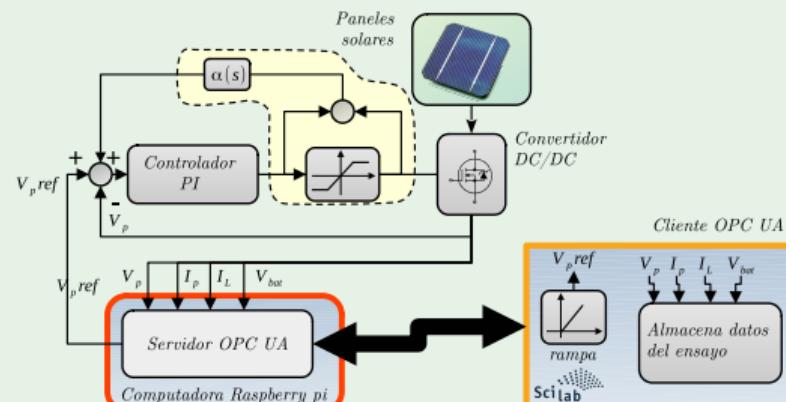
Ejecución del servidor OPC UA y el registro de mensajes.

Aplicación a un sistema fotovoltaico

Círculo eléctrico del sistema fotovoltaico



Esquema del sistema fotovoltaico



Controlador PI

$$G_c(s) = kp \left(1 + \frac{1}{T_i s} \right). \quad (1)$$



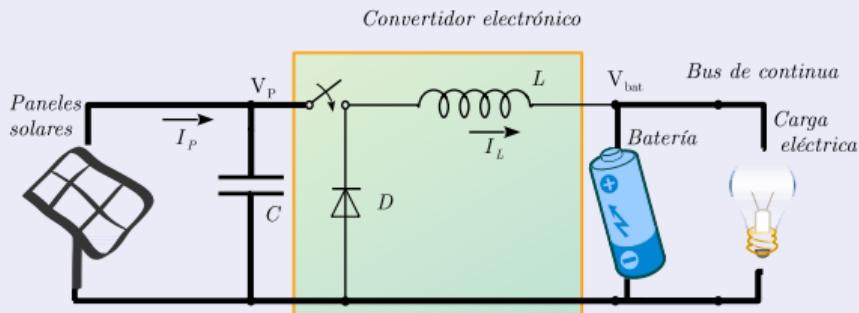
Fotografía del sistema.

Ensayos experimentales

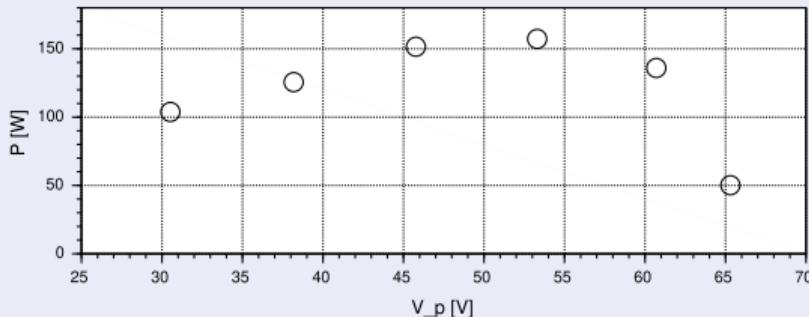
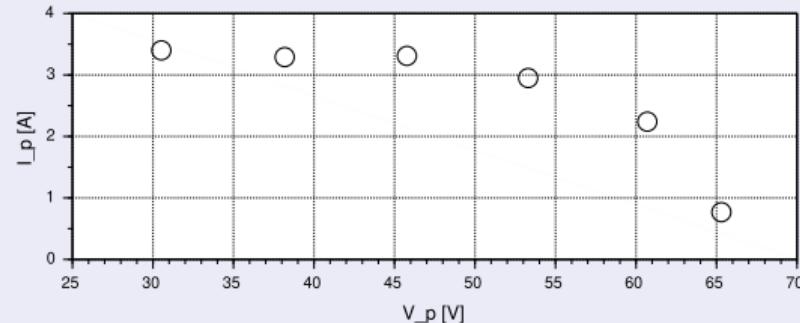
Ensayos

- Ensayos de las etapas de medición.
- Ensayos con Scilab/Xcos.

Sistema fotovoltaico

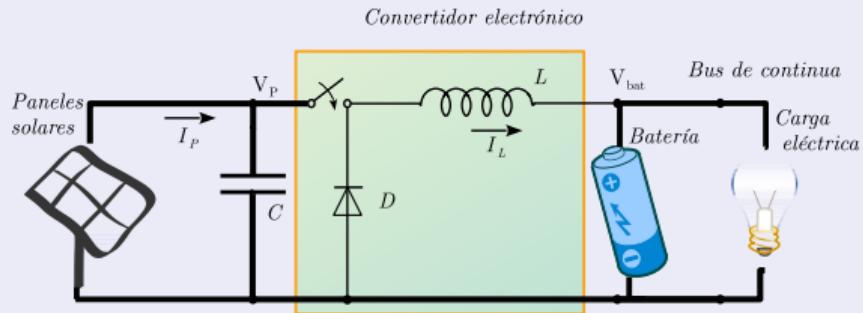


Esquema en Xcos y datos experimentales.

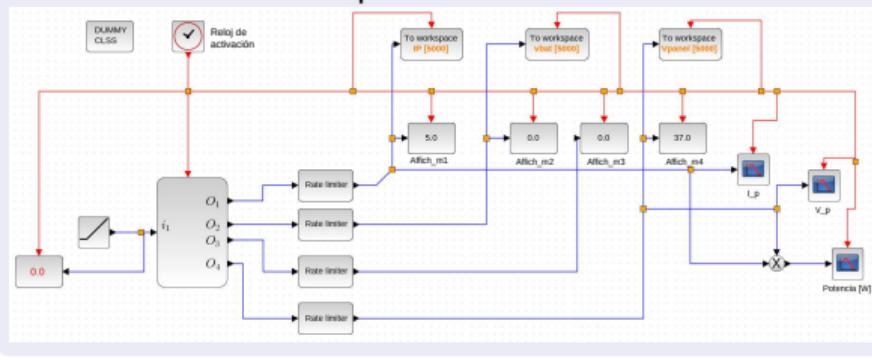


Ensayos experimentales

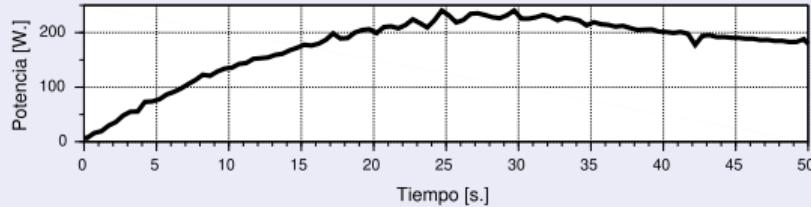
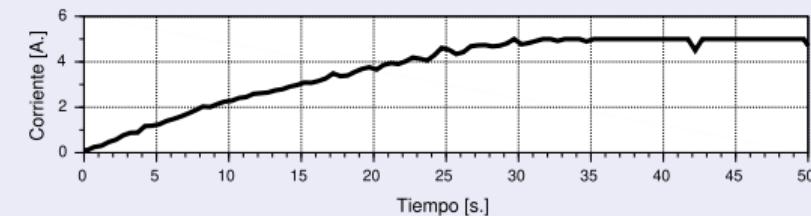
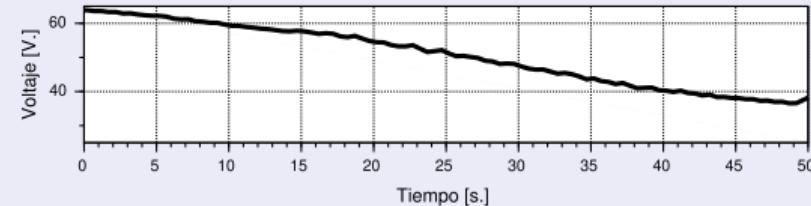
Sistema fotovoltaico y esquema en Xcos



Esquema en Xcos



Esquema en Xcos y datos experimentales.



Conclusiones

En este trabajo se presenta un servidor y un cliente para el protocolo de comunicación industrial OPC UA aplicado a un sistema fotovoltaico para la supervisión y control del sistema. El cliente OPC UA para el entorno gráfico Xcos puede tener múltiples aplicaciones, como por ejemplo la supervisión de sistemas, análisis de datos en tiempos real, etc. De esta forma, se agrega una nueva funcionalidad a Scilab/Xcos.

Por otra parte, el servidor OPC UA también está construido empleando la librería de código abierto open62541. Esto permite, una implementación económica del protocolo OPC UA en diferentes arquitecturas. Esto posibilita realizar la supervisión y control de más de un convertidor DC/DC conectado al sistema.

Los trabajos futuros incluyen la aplicación del cliente OPC UA en diferentes sistemas para tomar datos, implementación de algoritmos, aplicaciones en educación, etc.

¿Preguntas?



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¡Muchas gracias!