

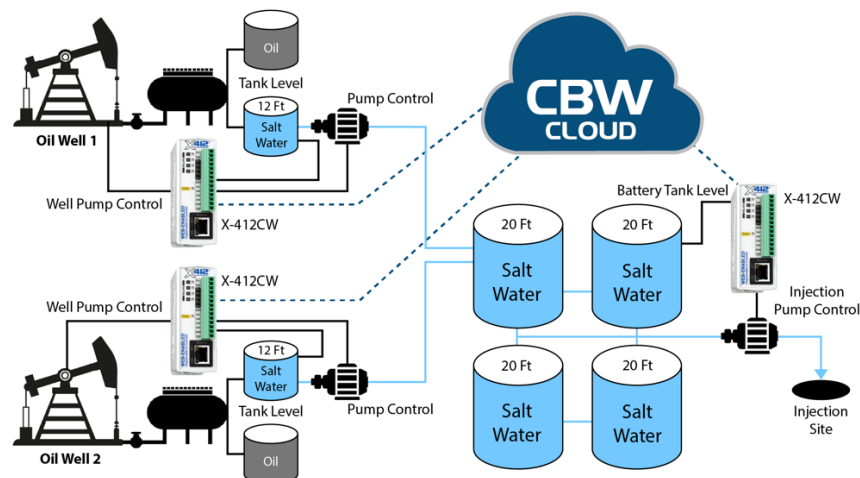
Wide Area Remote Device Control in the Oil Field (Oil & Gas SWD Instruction Guide)

Scenario – Oil & Gas Well Systems Feeding a SWD site

Oil & gas well sites move much more than just oil. Local well sites pump oil condensate from the ground and separate it into crude oil, salt water (brine), and gas. Each well site has local crude oil and saltwater storage tanks, and the gas is sent into a pipeline. It is not uncommon to have three to seven times the amount of saltwater per barrel of crude oil—in rare cases, this can approach hundreds of barrels of saltwater per barrel of crude oil. Saltwater disposal sites (SWD) receive this unnecessary saltwater either by tanker truck or through pipelines and inject it back into the ground. These pipelines connect the SWD site to the pumps within the well sites, and drain the local saltwater tanks and push the salt water to the SWD site, where it is temporarily stored before being injected into the ground. Multiple wells are feeding the SWD site, and each well site is anywhere from ½ a mile to several miles away from the SWD site.

Application – Using Cellular CBW Devices for Remote Monitoring & Control

This application example will walk you through the basic set up for using a ControlByWeb device in the Oil & Gas industry, specifically for Saltwater Disposal (SWD) sites. The 400 Series firmware allows for efficient and precise conditional logic and control of tank level and pumps. By using a peer-to-peer connection over the ControlByWeb Cloud, devices can easily coordinate across remote sites, while allowing all devices to be viewed from one dashboard.



X-412 | Oil & Gas Powerhouse

Necessary Equipment

- X-412/CW – For the Analog Inputs and the Cellular capability (with the CW model)
- 9-28VDC Power Supply (5VDC Recommended)
- Sensors and Motors needed to monitor/control
- Motor Relay Contacts (external relay)

Basic Wiring and Setup

- Wire your power supply to the Vin+ and GND pins on the X-412.
- 1 wire from your tank-level sensor to Analog Input on the X-412.
- Connect a high tank float switch to the 5V and Analog Input 2 on the X-412.
- A 5k-20k resistor between the Analog Input 2 and ground.
- Connect the Pump Jack to Relay 1.
- Connect the pump between the saltwater tank and the SWD site to Relay 2.

Adding a Cellular Device to the ControlByWeb Cloud

Note: DO NOT power on your cell device until it has been connected to the ControlByWeb Cloud and the SIM card has been activated. We recommend using Ethernet Access for initial setup and testing to avoid large amounts of cell data usage.

1. Log into your cloud account at **ControlByWeb.cloud**
2. Click on **'Devices'** in the left-hand navigation panel.
3. Click the **'New Device +'** button in the top-right corner of the device table.
4. On the New Device page, you have two tabs: **Device** or **Cell Device**.
5. Ensure the **'Cell Device'** tab is highlighted blue.
6. Enter a **device name**. Enter the **Serial Number** and **Cell ID** found on the **side** of your ControlByWeb cellular device.
7. Click **'Add'**. This will redirect to the Device Edit page.
8. On the **Device Edit** page, click **'Activate SIM Card'**. If you purchased your device and data plan separately, enter your Data Plan Code to activate the SIM.
9. Activation may take 15 minutes. Click **'Check SIM Status'** or refer to the **Summary page** to verify activation status.
10. Once activated, **power on** the cell device. It will connect to your cloud account automatically.
11. You can now access the device's **Control and Setup pages** through ControlByWeb.cloud.

Adding Remote Devices

1. Access the master X-412 unit.
2. Select the **Devices** menu link on either device. In both cases, this link is on the **left**.
3. Click the **Add Remote Device** button. This is found on the **right** below the Device List.
4. Fill out the form for each new device. You'll need to enter the following information:

- Name
- Model
- Serial Number
- IP Address
- Port
- Password

You may specify how often you want to poll the remote device.

Repeat steps 3 and 4 for each device you need to add.


5. Next, you'll be prompted to add the **I/O** from your remote devices. Select the **I/O** you want to add and click **Add Selected I/O**.
6. Return to the **Remote Devices** page, or the **Devices** page, to confirm that your remote device is connected. The **Status** column will show a response time for connected devices, measured in milliseconds, or it will show that the connection is down.
7. Add I/O to the dashboard/control panel. You'll do this by editing the control panel. Refer to the user's manual for dashboard and control panel editing instructions.

Local SWD site Monitoring System Hardware Connections

(All numbers included will be an example and will vary per application)

The appropriate hardware must be wired to the ControlByWeb devices, and level sensors require a slope and offset set within the firmware. Each pump and sensor can be monitored and controlled by the ControlByWeb device. Signals are sent when tanks are full or empty and pumps turn on or off depending on the current need.

- **Tank Level** - Connect a tank-level sensor with a 4-20mA signal to Analog Input 1 on the X-412. A 4mA signal means the tank is empty, and a 20mA signal indicates the tank is full (with a 12 feet deep tank). Then, within the firmware of the X-412, specify an offset of 0 (4mA is 0 ft) and a slope of 0.75 (16mA x 0.75 = 12 ft). These values will be read by the remote SWD site's X-412 controller to determine when to feed the SWD's tank battery. *(The X-404 could be used with a level sensor with a Modbus RS-485 output. Contact us to learn how this can be done.)*
- **Tank High Level.** Connect a high tank float switch to 5VDC with a small resistor (to pull the analog input to ground when not in use) and Analog Input 2 to indicate a high tank level. The switch is normally closed at tank levels below 11 ft, and once the saltwater level reaches 11 ft, it will open. It is always a best practice to indicate the normal operating mode with the presence of voltage and the error condition when the voltage is removed, so the system will "*Fail False*" if a wire is cut.
- **Well Site Pump Jack.** Use Relay 1 to signal the Pump Jack to stop operating. This will be activated when the Tank High-Level signal (0 volts) is detected, indicating that the Tank is nearing capacity and pumping operations need to stop.
- **SWD Site Pump.** Use Relay 2 to control the pump between our saltwater tank and the SWD site. The SWD site's X-412 device will primarily control this, but also have a local safety that will turn Relay 2 Off if the saltwater tank goes below 1 ft to prevent draining the tank and the pump from running dry.


Programmable Web-Enabled I/O Controller

General Settings
Remote Devices
I/O Setup
Relays
Analog Inputs
Registers
Vin
Timers
Control/Logic
Logging & Cloud
Monitor & Control

I/O SETUP


ANALOG INPUTS

Name	Local Analog Input #	Mode	Edit
Tank Level (12Ft)	1	Analog 4-20mA	Edit
Tank High Level	2	Digital Input	Edit
Analog Input 3	3	Digital Input	Edit
Analog Input 4	4	Analog Single Ended	Edit

REMOTE ANALOG INPUTS

Device Name	Local Analog Input #	Device Device	Device Analog Input #	Device Mode	Device Edit
Add Remote Analog Input +					

Fig 2. Setting up the well site's inputs


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RELAYS

EDIT RELAY

Relay Name: Pump Jack Control

On Status Text: Stop Pumpjack

Off Status Text: Pumpjack Running

Output Group: No Group

Power Up State: Off

Pulse Time: 1.000 Seconds

Make Exclusive: Yes No

Save Changes Cancel

Fig 3. Setting up the well site's relays

Remote SWD Site Hardware Connections:

At the remote SWD site, similar hardware must be wired to the ControlByWeb devices. Sensors used to monitor tank battery level, and VFD's used to operate injector pumps must be correctly installed. The remote devices are connected through the ControlByWeb Cloud for easy access.

- **Tank battery level.** Since the tanks are equalized, a single tank-level signal can be used to monitor the battery. If they are not equalized, it could require multiple tank-level sensors. This is used to monitor the tank level and control the injection pump.
- **Tank battery high level.** It is good practice to have a secondary high-level switch monitor for each tank that will open when it reaches a critical level.
- **Injection Pump control.** A relay output will signal a contactor or VFD to operate the injector pump.

The devices need to be connected to the ControlByWeb Cloud Platform. This service comes bundled with cellular models and allows any Cloud I/O device or register on one device to be accessible on any other device as if it were a local device or register. This does not require programming or setting up REST API calls or other workarounds needed for other controllers or PLCs.

It is very easy to connect devices. The remote device's MAC address and the owner's ControlByWeb Cloud account number are used, and the device is specified and added. Options are used to specify how the device data is communicated. While data can be polled, this is often very ineffective, has latency, and can consume considerable data. ControlByWeb allows its devices to be set so they instantly report any input, output, or value changes, while having a background interval to push any changes to ensure remote devices have the correct values. With the instant send and receive, the SWD sites must be configured for the conditions that trigger sending a reading to the ControlByWeb Cloud. This is more efficient and allows control of the amount of change that needs to be monitored.

For example, if the Tank slowly fills, it may only need to send a reading for each 0.5 Ft change in Tank level, while if the Critical High-Level switch is tripped, that value needs to be sent immediately.

Edit Remote Device

① Device Name: X412-192 SWD Site

② Model: X-412 (X-412)

③ Serial Number: 000CC8035A32

④ Communication Method: Cloud

⑤ Cloud Account ID: 1.437s

⑥ Device Control Password: *****

⑦ Device Admin Password: *****

Remote Device Monitor and Control

Standard: ☐ Control and monitor I/O on remote devices (send relay commands and poll status)

⑧ Instant Receive: ☐ Remote device instantly pushes specific I/O changes to local device. (local device can send relay commands in response)

⑨ Instant Send: ☒ Local device instantly pushes specific I/O changes to remote device. (remote device can send relay command in response)

⑩ Push Interval: 300 Seconds

For Instant Receive/Send to work, make sure the remote device is configured to communicate with this device by adding it to the remote device's device table. Configure which I/O states will be pushed in the Control/Logic Conditional Task setup pages.

Save Changes Cancel

Adding remote SWD site to the well site

X412 Programmable Web-Enabled I/O Controller

REMOTE DEVICES

REMOTE DEVICE LIST

This module can monitor and control I/O from other devices. To access I/O on remote devices, first add the device to this list, then add and configure the I/O under the I/O Setup tab.

Name	Address	Model #	Serial #	Mode	Status	Edit
X412-192 SWD Site	Cloud Device	X-412	000CC8035A32	Instantly Send I/O Changes To Device	1.867s	Edit X

Find Devices Add Remote Device +

Remote Device status

Add Remote Analog Input

Analog Input Name: Tank Level (12Ft)

Device: Well 1 X412-191 (X-412)

Device's Analog Input #: 1

Local Analog Input Number: 5

Decimal Places: 1

Units: Ft.

Add Remote Analog Input Cancel

Device Name	Local Analog Input #	Device Device	Device Analog Input #	Device Mode	Device Edit
SWD Tank Level	1	Well 1 X412-191	1	Analog 4-20mA	Edit
SWD High Tank Level	2	Well 1 X412-191	2	Digital Input	Edit
Analog Input 3	3	Well 2 X412-190	1	Analog Single Ended	Edit
Analog Input 4	4	Well 2 X412-190	2	Analog Single Ended	Edit

Adding the well tank level sensor as a local analog device

Then the Tank High-Level switch sensor and the SWD Pump are added to the SWD site controller for all the oil well sites. To ensure each device's name is unique, we prefix them with the Well number and then the I/O device.

ANALOG INPUTS

Name	Local Analog Input #	Mode	Edit
SWD Tank Level	1	Analog 4-20mA	Edit
SWD High Tank Level	2	Digital Input	Edit
Analog Input 3	3	Analog Single Ended	Edit
Analog Input 4	4	Analog Single Ended	Edit

REMOTE ANALOG INPUTS

Device Name	Local Analog Input #	Device Device	Device Analog Input #	Device Mode	Device Edit
Well1-Tank Level (12Ft)	5	Well 1 X412-191	1	Analog 4-20mA	Edit X
Well1-Tank High Level	6	Well 1 X412-191	2	Digital Input	Edit X
Well2-Tank Level (12Ft)	7	Well 2 X412-190	1	Analog 4-20mA	Edit X
Well2-Tank High Level	8	Well 2 X412-190	2	Digital Input	Edit X

Add Remote Analog Input +

List of well 1 and 3 remote inputs at the SWD site

Logic on the ControlByWeb device at the SWD site

(All numbers included will be an example and will vary per application)

With all the necessary hardware in place, the logic will need to be implemented on the firmware of each device. This is done through the drop-down menus on the 400 Series Firmware. When thresholds within the tank batteries are met, pumps are turned off or on to reach the desired levels.

- The SWD site will remotely control the oil well sites. Each oil well site's SWD pump should turn ON if the level is above 9 ft (75%) unless water shouldn't be sent to the SWD site. This is to avoid sending water if the SWD site tank battery is full, the Injection pump is not working, or it is down for service.
- To indicate this "do not send" flag, use one of the local registers named "OkToSend". If its value is 1, water will be allowed to come from the well sites; otherwise, the remote SWD pumps will not turn on. If the register is set to OFF, this will ensure the remote SWD pumps are also turned OFF.
- When the SWD site's 20-ft. equalized tank battery reaches 50% (10 ft), it will turn on the injection pump and turn it off when it reaches 10% capacity (2 ft). The SWD site must ensure sufficient capacity to accept salt water at any time and understand that the injection pump may be down for periodic maintenance.
- If the SWD site critical high tank level switch turns on, it must set the "OkToSend" flag to 0, telling the remote oil well sites to stop sending salt water to the disposal. When the tank battery level goes down, wait until the tank battery level is below 15 Ft before setting "OkToSend" back to 1 before filling the tanks again. This prevents the Injection pump from immediately cycling ON and OFF.
- For a backup, if the SWD site Tank battery reaches 19 ft, this as a critical high tank level, even if the switch has not changed state.

X412

General Settings
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Tasks/Functions
Logging & Cloud
Monitor & Control

CONTROL

TASKS/F

SCHEDULE

CONDITION

AUTOMATI

OVERRI

OVERRI

TRIGGER

Triggers ONLY occur when conditions change to true. The logic operations are event driven, and are not combinational. Conditions must change to false and back to true to re-trigger.

Condition 1: Well1-Tank Level (12Ft)

Value: Ft

Deadband: Ft

And

Condition 2: OKToSend

Status Is:

During: ☒ Always ☐ Set Time

Then:

ACTIONS

Actions only occur at the moment the trigger status changes to true. Note that you MUST create a second task if the condition must change when the trigger status becomes false.

Set Action 1: Well1-SWD Pump

Set To:

Set Action 2: None (Optional)

Set Action 3: None (Optional)

Log: ☒ Enable

Send Email: ☐ Enable

Setting well site pump control logic

Logic on the ControlByWeb device at remote sites

(All numbers included will be an example and will vary per application)

The logic must be created for the devices set to monitor/control the remote sites, which will be conditional tasks in this case. Since the devices are connected to the ControlByWeb Cloud, they can easily communicate via a peer-to-peer connection.

- Start the well site's SWD pump once the level reaches 9 ft and continue running until it drops below 25% or 3 feet. On the trigger signal, set a deadband to prevent the pump from cycling on and off. It will be set the deadband to 1 ft, which is the amount of change the system ignores.
- To support the ControlByWeb Cloud Platform instant Send and Receive functionality, specify the amount of change sensed to trigger a data push to the cloud.
- If the oil well site's Tank reaches a critically high level, shut down the pump jack's operation. This is detected by either the high-level float switch or the tank level

reaching 90% (11 ft). A condition will need to be added to clear this when the Tank float switch is not tripped, and the Tank level is less than 11 feet.

CONDITIONAL

Add Conditional Task

Name	Trigger	Actions	Edit
<div></div> <div>Tank Level</div>	If Tank Level (12Ft) changes by 0.5	<div>Push I/O State To Remote Receiver Devices</div> <div>Send Device State To Remote Services Server</div> <div>Log</div>	<div>Edit</div> <div>X</div>
<div></div> <div>Tank High level</div>	If Tank High Level Changes	<div>Push I/O State To Remote Receiver Devices</div> <div>Send Device State To Remote Services Server</div> <div>Log</div>	<div>Edit</div> <div>X</div>
<div></div> <div>Vin Monitoring</div>	If Supply Voltage changes by 2.0	<div>Push I/O State To Remote Receiver Devices</div> <div>Send Device State To Remote Services Server</div> <div>Log</div>	<div>Edit</div> <div>X</div>
<div></div> <div>Critical High Tank Level</div>	If Tank High Level is High Tank Level or Tank Level (12Ft) >= 11.0	<div>Set Pump Jack To Stop Pumpjack</div> <div>Set Tank Level (12Ft) Color To Red</div> <div>Log</div>	<div>Edit</div> <div>X</div>
<div></div> <div>CriticalHighTank Clear</div>	If Tank High Level is Normal Level and Tank Level (12Ft) < 11.0	<div>Set Pump Jack To Pumpjack Running</div> <div>Set Tank Level (12Ft) Color To Blue</div> <div>Log</div>	<div>Edit</div> <div>X</div>

Conditional Tasks for each oil well site

Failsafe Setup:

Start talking about timers, what the register values are, etc.

In safety-critical applications such as oil and gas production, it's imperative that there is no loss of control. Wide-area remote device systems add an additional layer of complexity with potential loss of communications. This system is structured so the SWD site controls when the remote oil well sites send saltwater to the site to ensure it does not overflow. One obvious problem is if the SWD site tells an oil well site to start its SWD pump and communications are lost between the SWD site and the oil well site, salt water will continue to flow and potentially overflow the SWD site tanks. To prevent this from happening, add a fail-safe timer to each oil well site.

The failsafe timer will count down from 180 seconds; every 60 seconds, the SWD site will reset the failsafe timer to 180 seconds. If the oil well site misses three transmissions from the SWD site, the timer will expire, and the well site will turn off the SWD pump feeding saltwater to the SWD site. It will remain off, and if the saltwater level in the local tank rises to a critical level, then the logic to turn off the pumping operations will be activated. Once the connection is restored, the SWD site controller will remotely start the failsafe timer operating, and the oil well site will begin to turn the SWD pump on.

The ControlByWeb Controllers do not share Timers with remote devices, but registers are shared. Add a 180-second timer and a register to each oil field controller. If the register is set to a value that isn't 0, the controller will restart the 180-second timer and clear the

register to be triggered again. If the timer expires, the local oil well controller will turn off the pump at the SWD site.

TIMERS			
Name	Local Timer #	Trigger(s)	Edit
SWD Loss Connection	1	Start Timer For 180 Sec. On Reset Connection Timer	Edit X
Reset Connection Timer	If Register 1 > 0	Start SWD Loss Connection For 180 Sec. Set Register 1 To 0 Push I/O State To Remote Receiver Devices Log	Edit X
Connection Timer Timeout	If SWD Loss Connection Expires	Set SWD Pump To SWD Pump Off Push I/O State To Remote Receiver Devices Send Device State To Remote Services Server Log	Edit X

Defining Timers and Tasks to manage the timer at the well site

On the SWD site, Scheduled Tasks are added to increment the remote register by one on the oil well site. This also requires us to push this change to the remote device so it sees the register value change and resets the timer.

SCHEDULED ⓘ							Add Scheduled Task +
Name	Start Date/Time	Repeat	Actions	Next Occurrence	Run Mode	Edit	
Reset Well 1 Timer	Mon, 16 Sep 2024 08:00:00	Every Minute	Increment Well 1 X412-191 Register 1 By 1 Log	Mon, 16 Sep 2024 17:31:00	Always	Edit X	
Reset Well 2 Timer	Mon, 16 Sep 2024 08:00:00	Every 59 Seconds	Increment Well 2 X412-190 Register 1 By 1 Log	Mon, 16 Sep 2024 17:30:20	Always	Edit X	
Well 1 X412-190 Reg 1	If Well 1 X412-191 Register 1 = 1		Push I/O State To Remote Receiver Devices Log			Edit X	
Well 2 X412-190 Reg 1	If Well 2 X412-190 Register 1 > 0		Push I/O State To Remote Receiver Devices Log			Edit X	

Scheduled Tasks at the SWD site to reset the remote timers

Additional Helpful Features

- X-400 Series Firmware Demo
- How to Add Remote Devices
- Cell Device setup Guide
- Backup and Duplicate ControlByWeb Device Settings

Similar Applications and Case Studies

- Level & Flow Monitoring in Oil & Gas
- Fuel Tank Monitoring