



How the system works.

A fully digital, North American manufactured SCADA control and monitoring solution for fresh and wastewater utilities, on a private plant radio, supported from engineering through implementation.



DIGITAL WITHOUT CELLULAR

Off the shelf

A long-term replacement for defunct analog Zetron or PLC RTU and MTU equipment, and for aging analog ModBus systems.

Private digital radio

NXDN very narrow band digital radio. No cellular network in the loop, so the link belongs to the utility.

Browser based

Every product is managed from a standard browser on a low-level computer. No proprietary software.

12 V on battery and solar

Sites run from a 12 VDC battery with solar charging, so a mains outage arrives as a reading.

We work with manufacturers representatives, dealers, integrators and self-maintained clients to provide a long-term solution for your company.

The case for digital

Analog served its time

Analog radio and SCADA products are obsolete: atmospheric noise levels have risen to the point where their effective range keeps shrinking. **Cellular is the first thing to fail during catastrophic events**, as the past years have shown numerous times. Only a fully digital system can provide reliable service for the future.

If you are looking for an off-the-shelf product to replace a defunct analog Zetron or PLC RTU and MTU, or another antiquated analog ModBus system, this document walks through that solution: what each component does, how the pieces talk to each other, and what a deployed system looks like.

What the experts know about very narrow band

+20%

Range increase from NXDN very narrow band digital modulation.

>40%

More coverage area, because coverage grows faster than range.

20 dB

Receiver sensitivity gained by eliminating analog noise: from -95 dBm to -115 dBm, a 100 times improvement.

Most very narrow band NXDN radios receive at **-120 dBm** or better, which is nearly 200 times more sensitive than the analog equipment they replace.

Why NXDN digital

Repeater compatibility	Kenwood, ICOM, Ritron	Manufactured	In the USA, in Indiana
Built to	SM specifications	Encryption	Military level, optional
Cost and availability	Stable during unstable markets	Extended range	Off-the-shelf repeaters

Many clients already operate compatible repeaters, so extended coverage is often available without new infrastructure.

The link

The SM digital radio

Made in the USA since 1977. NXDN digital, compatible with major brand repeaters for extended coverage, running firmware built to SCADA MASTERS specifications.

The proprietary firmware provides the fastest data delivery on the channel, with **anti-collision and retry algorithms** that assure a command gets through the first time it is sent. An encryption option is now available for systems that require it.

Because the radio is compatible with Kenwood, ICOM and Ritron repeaters, a utility that outgrows a direct path can add coverage with standard equipment rather than replacing its network.

SCADA MASTERS also delivers engineered radio propagation studies, from P25 911 systems to digital trunked radio to water and wastewater systems, along with FCC licensing expertise and high-level dipole antennas. The RF engineering pages at the end of this document show what a study looks like.

On the bench

Modulation	NXDN very narrow band
Receive sensitivity	-120 dBm class
Data delivery	Anti-collision, with retries
Complete command	12 bits
Receive current	100 mA
Transmit current	2-7 A, short bursts
Encryption	Optional

Why it matters. The radio is the part of a SCADA system that cannot be improvised. A digital link that is 20 dB more sensitive than the analog one it replaces keeps reporting through conditions that used to mean silence.

A short history

The 4-20 mA loop is older than you think

Most sensors used in automation today, a tank level transducer first among hundreds of types, deliver a **4-20 milliamp current loop**, the international standard that SM-NEURO analog inputs are calibrated against. That standard did not appear with modern electronics. It has been carrying alarms for nearly two centuries.

1837	Samuel Morse develops the current-loop concept behind 4-20 mA, and the code, for a single-wire telegraph. Implemented coast to coast along the railroad, it carries its first transcontinental message in 1861.
1845	William Channing and Moses Farmer present the fire alarm telegraph to the city of Boston: call boxes on street corners, wired on the loop.
1859	John Gamewell purchases the patents for \$30,000 (about \$1.2 million today). The US government seizes them for the war effort during the Civil War; John Kennard later buys them back and returns them to Gamewell.
1862	Boston installs the system with 40 call boxes on street corners.
1886	Installed in 250 cities. By 1890, in 500 cities .
2018	A fire call box notifies Boston of a major fire during a 911 outage .

The loop never left. Many locations still run fire alarms on 4-20 mA today. Central station security companies still use it: the loop runs on a 6 V battery, so a cut line sets off the alarm. Teletype, military Morse traffic and the original stock tickers all ran on the same idea.

Today, SCADA MASTERS takes this time-proven technology to its ultimate level: a totally digital solution for potable and wastewater SCADA.



The remote site

Three components, sized to the site

In essence, a SCADA solution has only three kinds of components at an RTU: **analog inputs, digital inputs and relay outputs**. SCADA MASTERS has simplified the hardware to fit the smallest through the largest system, so you buy only what you need.

Analog inputs

Continuous measurements: levels, flows, temperatures, power.

Digital inputs

Anything with a logic shift: intrusion, power failure, pulses.

Relay outputs

Anything you wish to command: pumps, valves, lights, channels.



The SM-NEURO intelligent RTU, based on the Davicom NEURO, made in North America for more than 40 years.

The SM-NEURO is in effect **multiple programmable intelligent RTUs in a single package**, delivered already 90 percent programmed: adjust the inputs and outputs to match each site and it is ready for service. Whether you need two sites or hundreds, it works stand-alone or peer to peer, and it may be polled and manually controlled by the SM-CORTEX master for total management, displays, logs, alarms and notifications.

One small package

Boards per unit	Up to 5
Per board	5 relays, and 8 analog or 8 digital inputs
Typical build	Analog, digital and relay boards
Local site management	Runs without a master

With local site management, the SM-NEURO is the only required component at a co-located pump, valve or tank site.

Built-in intelligence

Every event logged

Stop and think about **what you really need at a site**, instead of what your current limitations allow. The SM-NEURO provides hundreds of features with a built-in calendar, timers, counters, math functions, sunrise and sunset calculations, event logging, pump and valve rotation management, and remote control.

Analog ports

12 bit resolution: 2048 levels against 256 at 8 bit. Up to 40 in one SM-NEURO.

- Water levels, by transducer
- Water flow
- Temperature and humidity
- Battery and power levels, with automatic switching to backup
- Solar charging levels
- Lightning detection
- Radio power output and antenna efficiency
- HVAC monitoring and efficiency
- Control of relays, locally or at other sites

Digital ports

Negative or positive logic switching. Up to 40 in one SM-NEURO.

- AC power failure, where AC is present
- Security and entry
- Pulse counters
- Control relays or relay outputs driving digital inputs
- Monitoring functions, such as radio keying and time in use
- Anything that has a logic shift; you will think of a lot more

Relay outputs

5 available, in NO-C-NC (SPDT) configuration.

- Valves, pumps, lights, security, or any other on-off function
- Actuated locally or remotely, by an SM-NEURO or by the CORTEX master
- Switching radio channels or backup power
- Pulse counting and monitoring functions
- Anything you wish to command

Every input and output can participate in local rules, so a level, a switch and a relay become a working control loop without any master in the path.


Peer to peer

The intelligence is in the field

Each operation in your system is a **stand-alone sub-system**. Why send a request to the commander at headquarters and wait for its decision, when the intelligence is in the field and can work efficiently and autonomously, even if every other sub-system were down?

Worked example

A tank needs water, or a sewage level is running too high. The tank requests its peer, in the same or a remote location, to open a valve or start pumps to fill the tank. **Completed in seconds**, with no master in the path.



Peer distances are typically closer than the path back to a master, so radio signals are stronger and commands travel as **short bursts of digital traffic**, acknowledged without multiple repeats or channel collisions. The digital radios carry a purpose-built algorithm to prevent collisions, and a complete command travels in just 12 bits of data.

12
bits

One complete peer
command on the air.

<2 s

Typical time for a
command to be sent
and acknowledged.

The SM-NEURO also calls the SM-CORTEX master with any alarms or anomalies, so call-out procedures and handling efficiency stay centralized even while control stays local.

Power and management

A whole site on a 12 V battery

Low power consumption allows the SM-NEURO, the digital radio and the SCADA components to be powered from a **12 VDC battery**. Solar power and battery can be configured to completely power a SCADA MASTERS RTU site, with no mains connection at all.

Load	Draw at 12 VDC
SM-NEURO	150-300 mA maximum
Radio, receive	100 mA
Radio, transmit	2-7 A, short bursts
SM-CORTEX 320	275 mA

Browser based, end to end

All SCADA MASTERS products are browser based, so total management and changes are made with a low-level computer, using the browser you already run. On-site monitoring, adjusting and management are at your fingertips.

Configuration you can hold

Each RTU and MTU site keeps its configuration in a file that may be stored on a PC, or even a thumb drive, and reloaded in a few seconds. One backup NEURO can be programmed for a specific site and put into service rapidly if disaster strikes.

Deployable backup solution

NEURO, radio, power supply and battery, ready to connect to sensors and an antenna at any site, or powered from a vehicle. Load the site configuration and go. Waterproof case with wheels and a pull handle, airplane carry-on size.

Together these mean the recovery plan is not a service call: it is a file, a spare unit and a case that rolls.

The master

SM-CORTEX 320, the master station

The SM-CORTEX is the complete master remote site management solution, with central monitoring, polling and remote web access. It receives alarms and notifications **directly from the SM-NEUROs**, polls them for status, and gives an operator full control over every NEURO RTU in the system. Polling requirements are determined by system size.

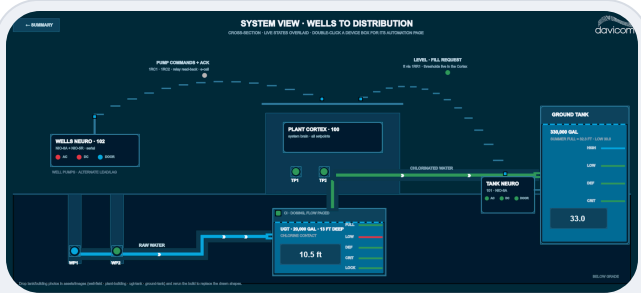


The SM-CORTEX 320 master (MTU), built on Davicom hardware.

Alarms and access

- | | |
|---------------------|---------------------------------|
| Voice announcements | Over radio or PA |
| Email alarms | Multiple users |
| Logging | Events easily recalled |
| Remote access | Via internet, built-in graphics |
| Polling | Programmable timing |

Displays range from simple meter and bar graphics to industry graphics of water tanks, pumps, valves and flow metering. A complete graphics manager is built in, or a library of graphics can be added to match your old system.



Evidence: the operator workspace of a deployed system, wells to distribution in cross-section, live states overlaid on every device.

Polling retrieves current data and confirms each site is awake and working, and it **does not stop** when a site fails to answer.

Specification

SM-CORTEX 320, inside the box

Hardware

Versatile inputs **12, analog or digital**

Analog inputs **4**

Relays **6: 3 Type C, 3 Type A/B**

Aux outputs **5 VDC and 12 VDC**

Audio **Input or output**

Serial ports **Yes, plus internal modem**

USB **2 port hub**

Network **RJ-45 port**

Real-time clock **10 year battery**

DC current **Only 275 mA**

Logic and alarming

Virtual logic gates **128**

Virtual relays **128**

Event schedulers **64, trigger or mask**

I/O counters **16, with limits and resets**

Activity monitors **16, logged**

Math functions **16 built in**

SNMP **Agent and manager, optional**

Phone apps **iOS and Android**

Alarm modes

Voice, SMS, email with TXT and XML attachments, SNMP trap, smartphone notification, pager, fax, and DavNet over dial-up and IP. Activity monitoring and cumulative run time are kept on all inputs, so a pump that is drifting toward failure shows up in its hours before it shows up as an alarm.

Warranty. SM-NEURO, SM-CORTEX and the digital radios provided by SCADA MASTERS carry a two-year limited factory warranty against defects in manufacturing, per published specifications. Details at scadamasters.com.

System overview

What a deployed system looks like

Each RTU field site

Site unit	SM-NEURO, ports to suit the site
Link	Digital radio
Power	Supply, battery, solar as desired
Mounting	DIN rail is the norm

Typical RTU sites include water tanks of any style, valve pits and stations, pump stations, and flow measurement locations. Additional sensors are available as an option from SCADA MASTERS.

Each master control location

Master	SM-CORTEX 320 or 360
Link	Digital radio
Power	Supply, battery, solar as desired
Internet	Required for remote alarms

The client provides sensors, AC power, network, existing cabinetry and antenna systems in accepted and proper order. SCADA MASTERS and the client determine the graphical display interface and the polling requirements together.

Access and security

The SM-CORTEX provides a variety of alarm methods and remote access for management, with **multi-level security**. The system is browser based and allows access to anyone permitted, either locally on the internal network or remotely via app or VPN.

Exact components for every site are listed in the quotation and in any contract, so what is delivered is what was written down, line by line.



The channel

Value added for integrators

SCADA MASTERS works with manufacturers representatives, dealers, integrators and self-maintained clients. Here is what an integrator gains from the partnership.

Easy-to-program, browser-based software

Built-in configuration tools. No proprietary software to license, install or train around.

RF engineering expertise

Designed and supported by experienced radio engineers.

FCC licensing support

Guidance through licensing requirements and compliance.

High-performance dipole antennas

Optimized for reliable long-range communications.

Radio systems built to perform when cellular fails

Mission-critical communications without cellular dependency, which is the reason this product line exists.

Antennas

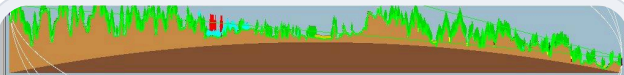
SCADA MASTERS delivers rugged, broad-bandwidth **folded dipole antennas** at a very competitive price, with free shipping on orders over \$500.

For the reseller. The system you sell is the system you can support: browser-based configuration, documented I/O, and an engineering partner on the radio side.

RF engineering

Point to point, and point to multipoint

RF engineering and analysis supports VARs, dealers and end users in designing radio systems that meet standards and work properly, using **low-cost, reliable, geo-based propagation**. Multiple studies are run for the same sites, proving the required antenna height and power for the desired location before anything is bought or built.

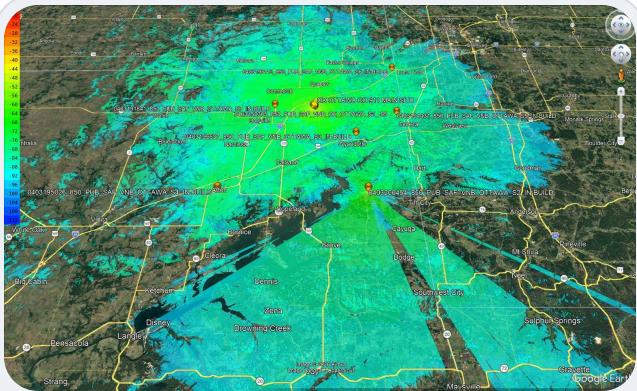


PAT WP to Oak Valve 33' Ant*		(2) Oakland City Valve	
Latitude	38.412004 °	Latitude	38.342820 °
Longitude	-86.730778 °	Longitude	-87.334479 °
Ground elevation	204.0 m	Ground elevation	137.1 m
Antenna height	15.0 m	Antenna height	10.0 m
Azimuth	261.87 TN 266.65 MG °	Azimuth	81.50 TN 85.85 MG °
Tilt	-0.32 °	Tilt	-0.16 °

Radio system		Propagation	
TX power	43.98 dBm	Free space loss	111.70 dB
TX line loss	1.00 dB	Obstruction loss	30.65 dB
TX antenna gain	10.20 dBi	Forest loss	2.48 dB
RX antenna gain	3.00 dBi	Urban loss	1.00 dB
RX line loss	0.00 dB	Statistical loss	19.23 dB
RX sensitivity	-108.88 dBm	Total path loss	165.06 dB

Performance	
Distance	53.184 km
Precision	26.6 m
Frequency	173.375 MHz
Equivalent Isotropically Radiated Power	207.941 W
System gain	189.20 dB
Required reliability	95.000 %
Received Signal	-108.88 dBm
Fade Margin	24.14 dB

A path study at a 33 ft antenna: terrain profile, both endpoints, losses, and the fade margin the design must clear.



A coverage prediction rendered over terrain for a county 911 system: the same discipline SCADA MASTERS applies from P25 to water SCADA.

The same studies serve fresh and wastewater utilities, and they are what turns an antenna quotation into an engineering answer: this height, this power, this margin.



SCADAMASTERS, LLC

Locally represented, coast to coast

With representatives across the United States, Puerto Rico and the Virgin Islands.

Engineering and consulting

LeRoy Shipley

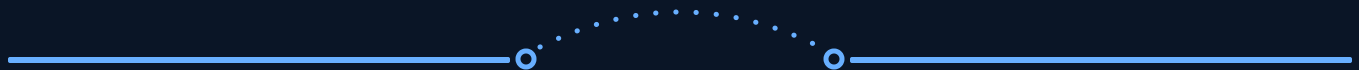
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