# From stem to stern, electronics drive these vessels

## Shipboard electronics offer precise control from the wheelhouse to the propeller while posing their own set of testing challenges

## Application Note

On bad days, it's enough to make an engineer wish for the old air controlled systems. But most of the time, the challenges and opportunities presented by modern marine electronics make the job worth getting up for.

On today's commercial and industrial marine vessels, massive onboard power generation systems interface not only with 20 megawatt motors, but also with new generation electronic propulsion, navigation, and communications networks that all require pure power.

Those conflicting interdependencies make for extensive power monitoring. Tuning radar receiver frequencies, designing propeller control power supplies, tracing network interferences – they all require waveform analysis. But what's 4-to-20mA current loop testing doing in the mix?

### Keeping radar ship-shape

A radar is essentially a receiver and transmitter in one box, with associated circuitry for image processing, communications, and a display. A magnetron comprises the bulk of the transmitter. It generates and transmits RF energy via its integral antenna, maximizing the signal for the greatest range.

The magnetron is actually a tube, making it a key part of the radar that needs maintenence. When a magnetron is changed, the radar has a new frequency, requiring the receiver in the radar to be tuned to that new frequency. "The best way to accomplish this is with an oscilloscope," says electronics engineer Bill Taylor of Totem Ocean Alaskan Trailer Express, a cargo shipping service. "In order to maximize the video returns for the greatest signal strength, we need to see the peak of the video signal returning to the radar."

Taylor notes that some newer radars are equipped with built-in auto tuning. "The engineer can make a coarse adjustment via onscreen indicators, but tuning the radar for optimum return requires visual observation of the return signal. That view is a huge asset, and fortunately it's a routine process with the aid of even a basic scope."

### The pitch on propulsion

Among advanced propulsion systems, controllable pitch propellers (CPPs) offer extensive maneuverability, designed to save time and reduce tugboat costs for ships with frequent port calls.

A CPP offers a fine pitch and higher rpm for acceleration and a greater pitch with reduced engine RPM once the vessel is up to speed. Moreover, if the vessel has two engines, one engine can drop off when speeds are low, and its propeller can be feathered fully to eliminate drag.

The pitch of a Controlled Pitch Propeller, or CPP, is actuated through a mechanical connection from the propeller blades to a hydraulic actuation system inside the gearbox. A correctly sized CPP can be efficient at a wide rpm range because pitch can be adjusted to absorb all the power that the engine can produce at nearly any rpm.

A CPP also permits the skipper to vary the engine rpm as needed to obtain the most favorable reduction in engine vibration and noise, as well as to vary the pitch and blade loading as a means of eliminating cavitation (formation of a vacuum around a propeller) at any rpm.

As for testing, CPPs have their own requirements. "I built a controller for a ship with a CPP that had exhibited severe power problems," said Steven Braun of Marindas, a provider of marine engineering services for large vessels. "The system before it had failed constantly. It blew out 24 V dc power supplies, as well as supplies from 15 V dc all the way down to 5 V dc. On the redesign, we went to a 24 V dc supply to power everything except pitch handles and speed control pods, which run at 10 V. It took a fair amount of design to get it right, including monitoring waveforms on a Fluke 123 ScopeMeter™ test tool, but today it runs smoothly and without incident."

## Mixed signals

A ship's power is not always clean power. Often supplied by an unregulated source, power can be wracked by undetermined noise, transients, and under-voltages. The proximity of the wires to onboard gear and systems exacerbates the problem, creating the risk of additional noise on sensitive data lines.

"In working with much of the ship's gear, we want to see a perfect square wave, but often I encounter termination problems, spurious noise, or spikes," adds Braun. "The problem is, a spike often looks like a rising edge of the intended signal, and it can create chaos with communications systems." Braun uses his ScopeMeter to deal with such predictable anomalies. "I can spot spikes or transients as short as 5ms or 10ms and take corrective measures," he says.

Instantaneous power draw is also a problem. When a deck winch or other large piece of machinery starts up, voltage can vary throughout the ship and current can drop. Therefore, certain readings must be monitored, for fear that sensitive equipment could be damaged. "We're always concerned with surges, and especially stability on ac lines," says Braun. "A scope is necessary, for example, when I turn on the radar scanner, which can draw as much as 50A instantaneously just to start the motor."

Can the instantaneous power draw of these devices compromise power quality elsewhere on the ship? "It can and it does, especially on older ships," says Seacoast's Dave Smith. "This is where I place the ScopeMeter in what I call 'babysitting mode.' "It will continue to monitor the lines over time, and I can set it to record anomalies such as spikes that may be quicker than 5ms – or, for that matter, any variations from nominal voltage."

## Shipboard communications

With the advance of integrated bridges comes the need for a new approach to wiring and signaling systems on commercial vessels. A case in point: voyage data recorders. With the requirements of today's recorders, engineers have a lot of data to collect and maintain. "Often, in fact, a ship's recorder has more sensors feeding it – measuring temperature, pressure, speed and liquid flow rates, for example – than in a commercial airliner." All of these analog signals need to be monitored, especially when regulations require stringent records from all corners of the ship.

According to Braun, the 4-to-20mA current loop is today ubiquitous in marine systems for mechanical monitoring and ship-wide communications, as well as for providing vital ship-wide information to recorders. A current loop is particularly useful when the information must travel a long distance to a remote location. Current-loop signals and their power can be derived from a remotely supplied voltage.

Testing ship systems in such an environment can present challenges. According to Dave Smith of Seacoast Electronics, a provider of communication, navigation, and safety equipment for commercial and military vessels, "The need in testing today is for a meter that can do double duty as a sort of 'simulation power source' – in this case a source of a 4-to-20mA signal. An advanced multimeter that provides its own 4-to-20mA signal output is a huge advantage. It allows me to simulate a signal right on the spot." For this purpose, Smith is evaluating a Fluke 789 Process Meter, which provides its own 4-to-20mA power supply.

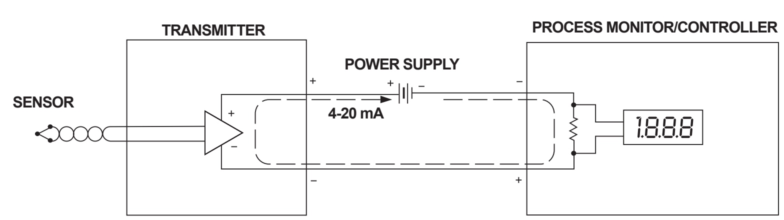


Figure 1. A 4-to-20mA current loop can be used effectively to tie multiple sensors on the ship with a controller. Low-current, low-voltage loops (voltage is typically between 12V and 24V) can be used with distances of 1,000 feet or more and are relatively insensitive to noise.

Why does a simulation function interest marine engineers? "Consider shaft RPM. It's not always practical to start turning shafts to test the integration of various ship systems and processes. To do so would require that the ship's mechanical side be working and the propeller turning, even if the ship is sitting idly at the dock. But, with an integrated 4-to-20mA simulation capability, I can place a meter right in the middle of a circuit, use it to simulate the current-loop source, and diagnose the problem – even when the ship's mechanical systems are shut down."

For Steven Braun, the use of the 4-to-20mA current loop also supports his choice of +24 V dc as a power supply voltage for commercial vessel operations. Its popularity derives from the fact that many instruments and electromechanical components found in industrial environments are rated at +24 V.

"Wherever possible, I work with 24 V dc. A ship generates its own source, and there's no ground reference available. That's an advantage over the use of 120V in a marine environment where the lack of a neutral or ground means that everything is hot."

Braun feeds 24 V dc power from the source to PLCs, instrumentation, remote I/O, and peripherals in the engine room. Wiring requirements for 24 V dc, he says, are much less severe than for 120 V; because 24 V is below the 50 V threshold, it is in the low-voltage class. "I don't have to use armored cable, and I can run most loads via 24 V dc, two-wire, 14-gauge conductors. If a line gets cut, nobody – and that usually means me! – gets hurt. Plus, the cut is easy to repair."

Still, he says, with 24 V electronics, the requirements for signal fidelity leave little room for error. "When I get onboard, the first thing I do is establish a uniform, stable, regulated 24 V dc supply. That means I usually install a fairly high-quality power supply. Then, I have to ensure that the source 120 V supply feeding it stays within range. A lot of times, that means going through a UPS or isolation transformer."

But even with the benefits of 24 V dc wiring, 24 V dc distribution is somewhat less tolerant to voltage fluctuations than 120 V. "Sometimes I'll find noise, voltage drops, etc. In fact, sometimes my only choice is to run the lines through the glands that have already been welded into the bulkhead. However, with a ScopeMeter I can monitor for degraded waveforms, noise, or induced voltages on the 24 V line."

## What lies ahead

These marine electronics engineers are constantly learning new systems and mastering their installation, integration, and maintenance inside ships of all ages. The trick will be training the next generation. Coast guard, naval and other maritime programs now generate fairly specified technicians; not the MacGyvers that keep today's ship electronics in tune.

Bill Taylor troubleshoots the radar on an Alaskan cargo ship.

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