BS&B WIRELESS, L.L.C.

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WIRELESS INSTRUMENTATION TECHNOLOGY

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Introduction

Since the development of rupture disk pressure relief devices over 75 years ago, there has been a strong trend to complement rupture disks and other essential pressure relief technology, such as relief valves and tank vents with electrical and electronic monitoring and alarm systems. In 2002, BS&B Safety Systems, L.L.C. introduced the SmartDisk® wireless Burst Alert® Sensor monitoring system that cut out the cable between field installed sensors and centrally located monitors reducing the cost of installation typically by over 75%.

Taking this patented technology one step further, BS&B Wireless, L.L.C. has added the ability to collect data from any analog sensor (4 _ 20mA or 0 _ 5 Volt) or simple switch type sensor and send it without cable to a receiver station that may be used as a monitor or an interface to external user control systems. Compatible with hazardous (Class 1 Division 2 Groups B/C/D) and non-hazardous service conditions, the BS&B Wireless SmartSystem™ brings affordable, reliable and flexible support to instrumentation applied to both new and existing facilities.

1. System Architecture

Field installed transmitters are used to collect either "change of state" information from switch type or analog sensor output. This information is sent by radio frequency communication (RF) to a receiver station that either reports locally what is happening at each transmitter or connects to user selected external controls via Modbus or simple relay outputs.
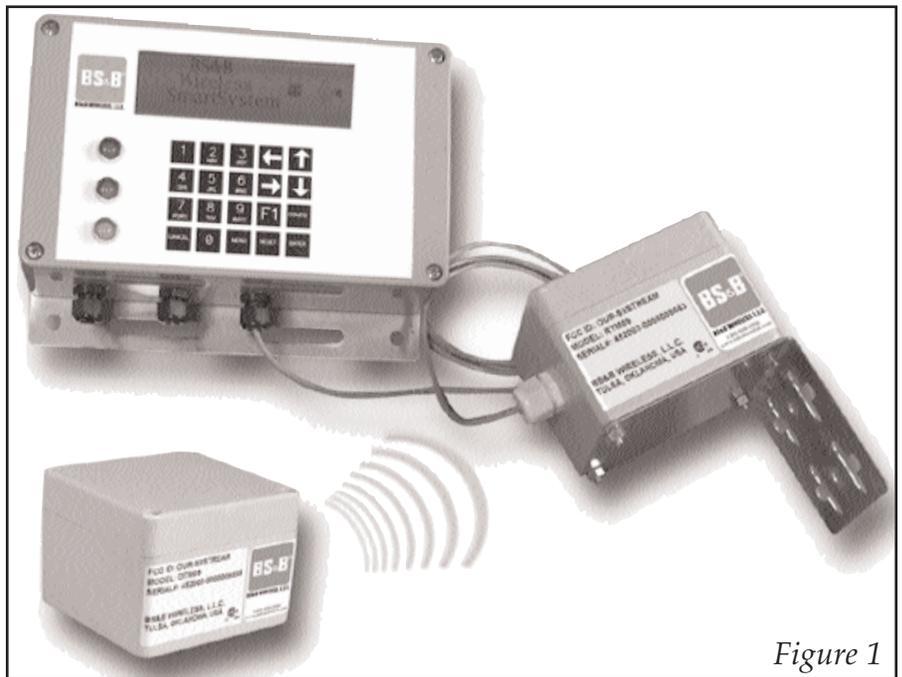

Figure 1

Identification of the SmartDisk/SmartSystem transmitter and receiver modules is by the following acronyms:

DTM - Data Transmission Module - for service with simple switch-type sensors.
ATM - Analog Transmission Module - for service with 4_20 mA or 0-5 Volt analog sensors.
DMM - Data Monitoring Module - comprising separate RF component (RTM) and system management enclosure with integral display and LEDs for programming and annunciation.
DM4 - 4-channel version of DMM
DRM - Data Receiving Module - comprising separate RF component (RTM) and system management enclosure that must be used with external control system(s).
RTM - Receiver Transceiver Module - RF communication link for DMM, DM4 and DRM.

The relationship between system components and sensors is as follows:
* One (1) Switch type sensor requires one (1) DTM transmitter
* One (1) Analog type sensor requires one (1) ATM transmitter
* Up to 32 transmitters (DTM & ATM) can be supported by one (1) DMM or one (1) DRM
* Up to 4 transmitters (DTM & ATM) can be supported by one (1) DM4

DTM/ATM communication with DMM or DRM is wireless which eliminates field wiring costs between transmitters and receivers.

2. Transmitter choices 902 or 928 MHz and 24 GHz

All BS&B Wireless Smart Disk/Smart System components are available with either 902 _ 928 MHz or 2.4 GHz radios. In the United States, both radio options operate at frequencies permitted for "Industrial Scientific or Medical" use (ISM bands) and have been qualified by the FCC under part 15 rules that require no user license for operation. (Check requirements for other countries)
The use of 902 _ 928MHz radios is recommended where permitted due to the slightly greater operating range of higher frequency RF systems.

Note: All components of a SmartDisk or SmartSystem application must use radios of the same frequency band.

3. RF Operating Range

BS&B Smart Disk/Smart System has been designed to operate to at least a 1 mile range in an open environment where transmitters and receivers have line of sight communication. The operating range for each wireless application is dependant upon local conditions.
Transmitting through areas with high voltage power cables or around physical obstructions requires careful attention to system component placement to ensure good RF communication. Transmission quality through trees or other vegetation may fluctuate with the seasons.

In typical industrial environments, the 902 ~ 928 MHz radio gives excellent performance up to about 1/2 mile the 2.4 GHz radio performs well to about 1/3 mile.
Following BS&B's installation and operation manuals will secure the best operating range for each application which may be well in excess of these guidance values.
For extended operating range or to by-pass obstructions, one or more of the following techniques should be used:

i.   Repeater module (RPT) placed between the field transmitters and the receiver that may be blinded by an obstruction.

ii. Elevate the receiver RF module (RTM unit) to clear low level obstructions.

iii. Elevate the transmitter RF module to clear obstructions. DTM and ATM modules can be up to 100 feet from their sensors.

To determine the RF effectiveness of BS&B Smart Disk/Smart System use the "Site Survey Kit" to verify new applications. Alternatively, use the "signal strength indicator" feature of the DMM and DM4 receivers to determine the RF quality of transmissions.

3

4. Two-way Communication

BS&B Smart Disk and Smart System DTM/ATM transmitters and the radio component of each receiver, called the "RTM," are in fact radios equipped to communicate with each other in two directions. They are more correctly called "transceivers."

This allows BS&B to provide these powerful wireless system management features:

i. Signal acknowledgement after each DTM/ATM transmission.
After receiving a signal, the receiver RTM module immediately sends a confirming message that the DTM/ATM is waiting for. The DTM/ATM radio will automatically operate in "retry mode," until it receives this acknowledgement. Should this confirming message not arrive, a 'loss of communication' alarm is generated at the receiver.

ii. Programming of transmitter function through the receiver.
The DMM, DM4 or DRM receivers are used to configure the desired DTM/ATM performance. This eliminates transmitter field programming; the DTM and ATM are simply mounted in place connected to their respective sensors. The sensor data collection and retrieval is conveniently managed at the receiver.

5. System Security

In order to protect the user programming of the SmartDisk/SmartSystem receiver modules, a password may be implemented. By managing the transmitter functions at the receiver, there is no opportunity for field alteration of DTM or ATM settings.

6. Antenna Installation

Each DTM/ATM/RTM radio module contains its own omni-directional antenna. There is no separate antenna for the user to install. By integrating the antenna into each transceiver, signal losses that arise from the use of radio to antenna cable are avoided.
Additionally the user has a simplified procedure requiring fewer parts and connections and therefore a lower installed cost.

7. Planar Omni-Directional Antenna

Each DTM, ATM or RTM transceiver module sends and receives RF signals in a complete circle*. The plane of optimum performance is parallel to the base of the DTM, ATM or RTM (the surface to which the metal mounting bracket is attached-see Figure 2). RTM performance is greatly improved by elevating above obstructions to achieve near line of sight communication with each DTM/ATM in a system.
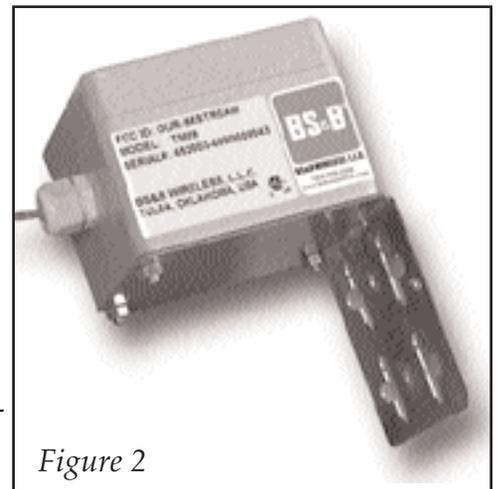
Figure 2

Note: The use of a Planar Omni-Directional antenna avoids the need to perfectly align each DTM/ATM with its system RTM. Many RF signals will reach their destination by reflection making "line of sight" unnecessary. Use the 'site survey kit' or the DMM/DM4 "received signal strength" feature to determine when each DTM or ATM is well aligned for RF service.

8. Local Environment: Effect on RF performance

Seasonal factors such as trees and other vegetation can produce variation in RF performance. A system installed in summer will work well in winter. A winter installed system may show signs of interruption as trees grow. Several years later as vegetation increases in size, RF performance may alter. With the ability to place DTM and ATM modules up to 100 feet from their respective sensors, the portability of a wireless system allows for future adjustments to be made.

Weather conditions will not influence system performance. All DTM, ATM, RTM and DRM modules are designed for outdoor use with Nema 4 enclosures. As for other electrical devices, protection from lightning strikes is required together with the use of shielded cable and the grounding of equipment or structures.

Buildings and other fixed structures may impact RF performance. Significant new construction within a SmartDisk/SmartSystem application might interrupt RF activity. This can be checked using the integral 'radio signal strength' indicator on the DMM and DM 4 or using the 'site survey kit'. Repositioning of the affected transceiver(s), or the installation of an RPT module (repeater) provide for future remedy to RF environment changes.

Temporary RF interruption may occur if occasional presence of large moveable structures, such as rail cars, blocks a line of sight application. Care in planning Smart Disk / Smart System applications can typically account for this.

9. License Free Radio System

Both the 902~928 MHz and 2.4 GHz versions of Smart Disk/Smart System meet the US requirements for license free operation according to FCC part 15 regulations. The primary design features that allow this are:

i. **Frequency hopping spread spectrum RF transmission.**
    Within the allowed frequency band, each transmission is of short duration and at a different frequency from the one before.

ii. **Effective radiated power < 36dBm.**
    This low power requirement contributes to the ability to operate DTM and ATM modules using internal batteries.

10. Electrical Power

All of the receiver hardware (DMM, DM4, DRM and RPT) is designed for operation on a DC power supply operating between 8 and 32 Volts. (The RTM receives its power through the cable connecting it to the DMM, DM4 or DRM.)

All DTM and ATM modules are supplied with an integral long-life lithium battery. External 5-32 Volt DC power can also be used and is recommended for ATM units programmed to update frequently or where sensors are powered through the ATM. The frequency of signal transmission for DTM and ATM modules is set at a default of two minutes. Using battery power, this will typically offer battery life of about two years.

Where battery power is used, a warning is generated when about 20% of the electrical energy remains. Prompt battery replacement is recommended to avoid loss of RF signals.

DTM and ATM modules operated by external DC power use the integral battery for back up in the event of external DC power loss. (ATM powered sensors do not benefit from this battery back-up feature).

11. External Communication from SmartDisk/SmartSystem

Each DMM and DM4 receiver has an integral backlit LCD screen with 8 lines/40 characters in normal operating mode, and three colored LED's. The DMM and DM4 can be used as a system monitor with annunciation capability. All receivers can communicate externally through one or more of the following:

i. **External Relays**
    Two SPDT relays are provided and they can be independently programmed to activate when DTM changes of state (NC to NO, or NO to NC) occur, or at user selected ATM alarm thresholds (up to 4 per ATM; 2 high & 2 low).

ii. **RS232/RS485**
    DMM, DM4 and DRM receivers can be integrated into external systems using Modbus protocol. All Smart Disk / Smart System receivers are "slave" units and can be addressed by the user "master" device during system set up. Up to 32 system components may be linked together (receiver units + user device(s)).

12. DTM/ATM Transmission Interval

The default transmission interval is two minutes. It is recommended that this not be altered for DTM modules; long periods may elapse between the "change of state" events that cause a DTM to transmit instantly - this two-minute "heartbeat" message verifies that the DTM remains active in the system (the receiver is expecting this periodic transmission and will generate a loss of communication alarm after a short period is allowed for transmission retries).

Figure 3

The ATM transmission interval depends upon the sensor update cycle time desired by the user and can be selected between 5 seconds and 255 seconds. Each ATM transmission reflects the output of the sensor it is supporting by taking 1000 readings, which takes a few milliseconds, then analyzing the data using a proprietary averaging algorithm.
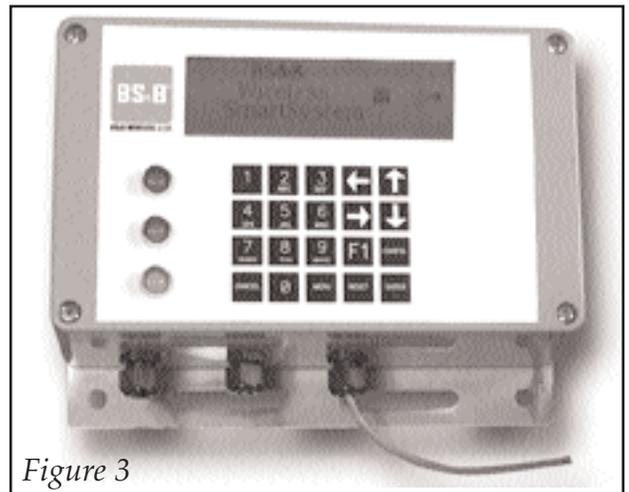
Use of a 12-bit A/D converter means the resolution of data within SmartDisk/SmartSystem is excellent. The overall accuracy of information generated through this wireless system is determined by:

i. The accuracy of the sensor selected for the application.

ii. The accuracy of calibration of the sensor into SmartDisk/SmartSystem.

13. DMM/DM4 and DRM Receiver Programming

The DMM and DM4 have an integral keypad that allows the user to access programming menus as well as data on all 32 (or 4 in the case of the DM4) sensor communication channels. All receivers can be programmed via a temporary connection to a laptop or PC whose "hyperterminal" facility is used for programming. Hyperterminal is present in all Windows® based operating systems.

14. Interference

BS&B Smart Disk and Smart System are designed within the requirements of FCC part 15 to be tolerant of and allow for interference. The following system design features protect the users wireless communication system:

i. **Unique Transceiver Identity**
    Each DTM and ATM has a unique identity number or address embedded at time of manufacture and marked on the product label. This identity number is logged into the Smart Disk / Smart System receiver when the user is setting up a system. The users system is only going to respond to the logged identity numbers.
    This approach provides security of information to the user.

ii. **Unique RF Signal Preamble**
    BS&B Smart Disk / Smart System components have a unique message as the preamble to each RF transmission. This means that time is not lost listening to all complete transmissions occurring within the 902~928 MHz or 2.4 GHz bands.
    This approach maximizes the sensitivity of the system.

iii. **Acknowledgment & Retry**
    Each DTM and ATM transmission requires acknowledgement right away. If this is not received, the DTM/ATM "retries." A retry algorithm developed by BS&B optimizes the opportunity for the RF signal to reach the receiver before a 'loss of communication' alarm is generated.
    This approach ensures both reliability & accuracy of communication.

Caution: RF equipment always requires a short time between transmission and reception of information. Do not use RF devices where "real time" data exchange is required.

15. Temperature

BS&B Smart Disk/Smart System DTM/ATM/RTM/DRM modules have been designed and tested for operation over a temperature range from -40 °F to +185 °F (-40 °C to +185 °C). Operation outside of these limits may cause permanent damage. Operation below -40 °F (-40 °C) will require warming to at least -25 °F (-31 °C) to determine whether the module can be further used.
The DMM and DM4 modules are designed for operation over a temperature range from -4 °F to +140 °F (-20 °C to +60°C). This is the range over which the LCD screen will function.

16. "Flexible Wireless Platform"

BS&B Smart Disk/Smart System is designed to operate with any simple switch, two-wire analog or four- wire analog sensors. (Analog 4_20 mA and 0-5 Volt sensors are supported).

The receiver software allows the user to operate in any technical parameter such as psi, bar, MPa, °F, °C, Hz, PH, %, cP, ppm, etc. (Upper case characters must be used to identify technical units.) Any combination of technical units and switch/analog sensors can be supported within the 32 channel capacity of the DMM and DRM (4 channels for the DM4).

BS&B Wireless, L.L.C. is continuously advancing the design and features of SmartDisk and SmartSystem RF instrumentation technology. For the latest information consult our website www.bsbwireless.com or your SmartDisk/SmartSystem distributor.