THEORY OF OPERATION

DSC Model Series WLS916-433

February 2002

The Model Series WLS916-433 are RF wireless photoelectric smoke detectors intended for use with a compatible DSC control panel. The photoelectric detectors detect infrared light scattered by smoke particles. An infrared light emitting diode (IRED) is pulsed periodically in an optical chamber in which a photodiode is placed so that no direct radiation is sensed from the IRED. Normally, a small level of reflected light is sensed under non-smoke conditions. When smoke enters the chamber, the pulsed IR light is scattered by the smoke particles and detected at the photodiode. When this increased smoke scattered signal reaches a predetermined threshold, the detector sends an alarm signal to the control panel. When smoke clears, the unit automatically resets to the normal condition.

An available option is a 135°F fixed temperature alarm. A pair of thermistor sensors activate the unit to send an alarm signal to the control panel for high temperature. The heat alarm will reset automatically when the alarm conditions are clear. Another option is a piezo sounder, providing audible alarm and trouble annunciation.

Every WLS916-433 unit is factory programmed with a serial number to be transmitted to the control panel along with its status. Once the detector is enrolled, the communication link with the control panel is supervised. The control panel monitors the transmitted data for alarm, trouble, low battery and tamper conditions. If any of these events occur or communication is lost, the system will respond with an alarm or warning annunciation.

A series pair of CR123A lithium cells power the detector. The battery contact arrangement prevents reverse connection to the circuit. In case the contacts are bent to make a reverse connection, input diode D9 conducts to prevent damage to the detector circuits. Capacitor C1 filters the input voltage. The 3.0VDC regulator for VCC to microprocessor and RF circuits consists of U1, with C3 and C4 filtering the output.

The microprocessor U2, controls the operation of the detector. The oscillator circuit consisting of XTL1, R42, C17, C19, and VC1 produces a tuned 6.78MHz clock, also used as a frequency reference (REFREQ) for the RF transmitter circuit. Battery power is conserved by keeping U2 in sleep mode most of the time. The circuit of Q17, R64, R65 and C30 is an RC wake-up timer connected to the IRQ input of U2. The timer period is approximately 8s and it is reset by pulsing the PTA0 output to C30. Connections to CON1, R43, R44, R45, R46 are used by factory test equipment to program the FLASH memory of U2 and select factory test modes of operation.

After every six wake-up intervals (48s), red LED1 flashes if there are no trouble conditions. U2 output PTA3 is pulsed rapidly 85 times during a 9ms flash duration. The circuit of Q3, R6, R7, R66, C8 produces short pulses of about 40mA through the LED that average over the flash duration to about 1mA. The pulsed light is perceived by the human eye as being much brighter than a simple 1mA pulse, and U2 encodes measurement information in the pulsing for test purposes.

When operated, reed switch SW1 or pushbutton SW2 applies power to R9, R10, Q4, R8 to pull down U2 input PTA2 and activate a smoke sensor test. Protection from ESD is provided by SG3, D4. Tamper switch SW3 is normally held closed when the detector is on the mounting plate. When SW3 is released, R11 turns on Q5, R12 to pull down U2 input PTA1 and activate a tamper transmission. Protection from ESD is provided by SG4, D5.

The low battery detection circuit consists of Q6, Q7, R15, R16, R17, R18 and R19. It is enabled by output PTA4, and the voltage at the divider R18, R19 is measured by the A/D converter input PTD3. The battery is tested under load at the start of each RF transmission. When the batteries are below the low battery warning threshold, U2 will send low battery status to the control panel. If the piezo sounder option is included and the battery is not replaced, a low battery warning chirp every 48s begins after 7 days or immediately after an alarm.

To achieve the required sound level at a low battery voltage, a switching power supply is used to boost the supply voltage to the piezo horn driver. U2 output PTD5 pulses to C5, D1, R3, Q2, L3 produce higher voltage pulses coupled through C6, rectified by D2 and filtered by C7 at the power pin of the driver circuit U5. Feedback through R5, R4, Q1 limits the voltage by suppressing pulses at the base of Q2. U2 output PTD0 to R30, Q13, R14 applies a 3KHz square wave to the input of the driver. The circuit is protected from ESD damage by D10 and spark gaps SG5, SG6, SG7.

U2 controls the communication with the control panel. It sends periodic supervisory messages and event triggered transmissions to the control panel. Outputs PTB7 and PTB6 enable and modulate the RF transmitter circuit consisting of U3 and the associated components on page 3 of the schematic diagram. A copper trace around the perimeter of the PCB forms the transmitter antenna.

U2 performs the smoke detection circuit timing, measurements and IRED driver pulse level control. Output PTD4 is a factory calibrated PWM (pulse width modulation) signal, filtered by R34, C11 to produce the control voltage for the IRED D12. When enabled by a pulse at output PTD2 to R35, the emitter follower circuits of Q12, Q14 apply a controlled voltage across R48 that determines the emitter current of Q14. The slightly lower collector current of Q14 is the IRED current that determines the intensity of the IR light pulse in the smoke sensor. The IRED pulse current is nominally 75mA.

U2 output PTD7 controls the power of the photodiode amplifier circuit via the R31, C13 filter. The emitter-base voltage of Q16 provides an analog ground reference of about 1V, filtered by R37, C49. The reference voltage is measured at A/D input PTD1. Reference changes resulting from the temperature coefficient of Q16 are used by U2 to calculate temperature compensation for the smoke signal level.

Photodiode D2 detects the IR light from reflections in the sensor and from scattering by smoke particles. Load resistor R38 converts the photodiode current to a voltage signal going into the opamp circuit of U4, R39, R40. The amplified signal is measured at A/D input PTB5 of U2 twice, immediately before the start and end of the 200μs IR pulse. The calculated difference between the 'dark' and 'light' measurements is the smoke signal.

If the 135°F temperature alarm option is included, a 250μs pulse from output PTD6 is applied to R20 in series with the two thermistors THM1, THM2 and the voltage on the thermistors is measured by A/D input PTB4. The input is protected from ESD damage by R21, D6, varistors MV1, MV2 and spark gaps SG8, SG9, SG10. A factory calibrated offset is subtracted from the temperature measurement.

In normal operation, a set of measurements is done at every 8s wake-up interval. Each A/D measurement is compared with circuit fault thresholds and any error found will result in a repeat of all the measurements after a 2s delay. If an error persists after two repeats, a trouble condition is flagged for transmission to the control panel.

To avoid false alarms, smoke and temperature measurements are compared with previous values and any large change detected will cause a repeat of measurements after a 2s delay. A large change that is verified by two repeats is accepted. When either smoke or temperature reaches its alarm threshold, the detector flags the alarm for transmission to the control panel.

In alarm operation, the red LED flash rate is increased to once per second. If the piezo option is included, an alarm is sounded. At the beginning of alarm operation, the alarm transmission to the control panel is repeated 16 times. Additionally, a single alarm message is transmitted every 32s for the entire duration of the alarm. The LED flashes, piezo beeps and RF transmissions are timed such that they always occur separately to minimize the peak battery loading. Measurements are done once in each 4s temporal alarm period to check for the end of alarm conditions. A set of 16 alarm restore messages is transmitted to the panel after the alarm ends.

If the piezo sounder option is included, a warning chirp occurs every 48s as an early warning if the smoke level exceeds 75% of the alarm threshold for 16 or more consecutive smoke measurements (128s). Smoke alarm, early warning, heat alarm and low battery restore thresholds all include hysteresis to improve stability of detector operation.

During normal operation, if the test switch is activated and held for 5 seconds a smoke sensor test is performed. U2 switches to a higher factory set PWM value for the smoke measurement. The higher background reflected light signal passes the test threshold to put the unit into alarm for two repeats of the temporal pattern or longer if the test switch is still activated. This procedure checks the whole smoke detection circuit. If any part of the circuit has a problem, the smoke signal will not increase and the detector will fail to alarm. The WLS916-433 optical chamber's low reflectivity provides a low background signal level with tight dispersion such that a controlled relationship exists to the smoke scattering efficiency.

The optical chamber is a round shape vented around its full periphery for easy and uniform smoke access. It is designed for minimum reflectivity to set into the design a superior Signal to Reflected Background Light Ratio. Additionally the chamber has reticulated surfaces to hide dust. These features combine to provide exceptional immunity to false alarms from dust over the years of service. The IRED and photodiode are arranged in a scattering angle geometry with the photodiode placed on the printed circuit board in a virtually leadless format for maximum RFI immunity. Surface mounted components and ground shielding are used appropriately to achieve exceptional immunity to false alarms from RFI.

The detector stores its serial number, date of manufacture, model identification and all the calibration information in its FLASH memory. A second copy of this information is kept and compared periodically to detect errors. It tracks its background reflected light signal routinely and will do drift compensation every 7 days based on a long-term average to keep the smoke sensitivity at the factory setting. It will signal high or low compensation trouble if the background signal change reaches its upper or lower limit of compensation.