W. H. BRADY CO.
RFID SYSTEMS GROUP

RADIO FREQUENCY WAND READER
THEORY OF OPERATION

MAY 20, 1998

- INTRODUCTION:

This design note includes information regarding the electronic design of the RF wand reader developed by the RFID Systems Team. Of special note is the circuitry designed to obtain an Intrinsically Safe (IS) product rating.

- DESCRIPTION:

The RF wand reader is a micro-controller based transciever designed to read from and write to passive RF transponders, or tags.

The absolute maximum operational parameters of the RF reader are as follows:

Input Voltage (V_{in})	$12V_{dc(MAX)}$
Input Current (I_{in})	$300mA_{(MAX)}$
Operating Temperature (T_A)	$-40^oC \leq T_A \leq +85^oC$

- FUNCTIONAL DESCRIPTION:

The design of the RF wand reader is divided into the following circuit functions.

- DC Power Supply

(refer to schematic H1102 sheet 2)

The DC power supply generates the regulated +5V supply voltage required by the RF reader circuitry.
Input power is provided from either an external source, such as an external AC to DC converter, or a 5V supply line from a handheld PC.
CB1 is a Positive Temperature Coefficient (PTC) resettable device used to protect the reader circuitry against any overcurrent condition.
ZD1 is a 1W zener diode used to limit the amount of input voltage to +12V.
VR1 is a low-dropout +5V voltage regulator. This device provides the regulated +5V supply voltage. The LM2940 has a dropout voltage of approximately 0.2V @300mA. This allows the reader to operate with a minimum input voltage of 5V. Due to the thermal dissipation required by this device, a heatsink is provided to maintain an acceptable device temperature. The output capacitor C1 is required to maintain regulator stability. Diode D3 is provided to protect the regulator against C1 discharging through the device in the event of the regulator input being shorted to ground. In addition, zener diodes ZD2 and ZD3 limit the output

voltage to 5.6V in the event of a short between the input and the output of the voltage regulator. The LM2940 also provides internal short circuit and thermal overload protection.

- Controller

(refer to schematic H1102 sheet 1)

The controller section consists of the microcontroller and the external memory. The microcontroller, U1, is an 80C32 operating at 14.75MHz. U2 is a PSD611 programmable peripheral device. This device provides 32K bytes of external memory, as well as 26 I/O pins.
U5 is a supervisory chip that provides both a power-on reset, as well as a watchdog timeout function. The reset is an active high open-collector output used to reset the microcontroller. The RESET line is also inverted to provide an active low reset that is required by the PSD611.
The X25045 protects the system from low voltage conditions by asserting the RESET line high whenever the VCC supply voltage drops below the reset trip point voltage (nominally 4.4V). The RESET line will remain high until VCC returns to +5V.
The watchdog timer will reset the system in the event of a system failure. If the WDOG line is not strobed by the program within a selected time interval, the X25045 will respond by asserting the RESET line high, resetting the system.
In addition to the reset and watchdog functions, the X25045 contains 4Kbits of EEPROM memory organized as 512 x 8. A simple 3-wire bus is used to interface between the X25045 memory and the PSD611.

- Operator Input / Output

(refer to schematic H1102 sheet 1)

The operator I/O is in the form of a pushbutton input device, and visual, audible and force-feedback output devices.
The READ pushbutton S1 is a tactile feedback switch requiring an actuating force of 230g. The READ line is normally high due to the pull-up resistor R1, but goes low when S1 is activated. S1 is buffered by the inverters U4B and U4C to provide a sharp transition signal to the INT1 input of the microcontroller.
There are two LED outputs, one red and the other green. The red LED indicates that the reader is active, either reading from or writing to a tag. The green LED indicates that the operation being performed has been completed successfully.
The speaker LS1, and the motor M1 are also used to signal an operation was completed.
LS1 is a small audio transducer that provides a tone when activated.
The feedback motor M1 is a pager motor that causes the wand to vibrate when activated. This feature is advantageous in noisy environments where the beeper tone may not be heard.
The motor is a small (12mm x 6.6mm) DC motor mounted to the PC board. The motor is rated at 1.3V with a maximum rated current of 80mA. The vibration is caused by the motor rotating a counter weight about its shaft when the motor is driven. This vibrating motion is transferred through the PCB to the case of the wand reader.

- RF Control

(refer to schematic H1102 sheet 3)

The RF reader IC ,U3, is used to communicate with 125KHz transponders using amplitude modulation for the write operation, and AM/PM for the read operation. The reader IC consists of the antenna driver/modulator, demodulator, oscillator, and the microcontroller interface.
The antenna drivers deliver a square shaped voltage to the series resonant antenna circuit. The full bridge configuration of the antenna drivers provides a peak-to-peak driver voltage of approximately 10V. This corresponds to a peak voltage of 5V. The current through the antenna is sinusoidal with a peak amplitude of approximately 5V / 22ohm = 290mA (peak). The RMS value of antenna current is thus I_{Ant} / 1.414 = 204mA.
The demodulator senses the absorption modulation from a transponder. The voltage divider formed by RV1 and an internal resistor divide the signal at the RX-pin to a level below 8V (peak) with respect to QGND. This signal is filtered internally and demodulated.
The microcontroller interface is a three-wire bus used for programming the reader IC as well as communicating with the transponders.
The crystal oscillator frequency is divided internally to get the 125KHz carrier frequency.

- Communication

(refer to schematic H1102 sheet 4)

The communication section employs the LTC1387 IC (U6) which allows for RS-232, RS-422 and RS-485 communication protocols. The transient suppression network consisting of the 18V transient suppression diode and the 22ohm resistor, is designed to suppress any high voltage spikes that may be induced on lengthy transmission lines. The EMI filters are feedthrough capacitor types designed to filter out high frequncy noise on the digital I/O lines. The WDOUT line is a wand emulation output line emulating a bar code-type reader.