Texas Instruments
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Application for Experimental License
FCC File Number 0155-EX-PL-2001

Exhibit – B "Reason for Development & Description"

Texas Instruments has been developing RFID equipment globally for the last 12 years. Our interrogator development team is located in the Dallas, TX (Plano) and Attleboro, MA areas. We test the equipment under development and before FCC testing certification to verify hardware performance in application settings around continental U.S. Since other countries around the world allow different power settings, we need experimental license where we can not use marketing rule 2.803.

Currently, TI is working three technology development standardization efforts in ISO SC31 (18000 series) for RFID item management in three frequency bands. They are: 1) 125-134 kHz called DIN, 2) 13.56 MHz where FCC RM # 9375 is needed, 3) UHF with the Uniform Code Council's GTag (Global Tag). New technology variations are needed at 134 kHz in coming to joint standard resolution. TI requests to operate experimental on 13.56 MHz at power levels listed RM # 9375, which have been in operation in Canada and Europe for the last two years.

TI is participating in "GTag" 902-928 MHz technology development with four other companies being sponsored by Uniform Code Council (UCC) & European Article Numbering (EAN). This product will used in automated identification in supply chains in retail and industrial applications globally. The specification is being currently development.

Equipment Needs: 200 interrogators of each frequency in mobile and stationary interrogator formats. Note that even the stationary equipment will need the flexibility accorded mobile equipment since it will be subject to movement from location to location on a transient basis.

Technology description example for each frequency follows:

134 KHz Technology Description Example

The Radio Frequency Identification (RFID) interrogator unit (i.e. the transponder reader) is designed for use in conjunction with a battery-less data carrier transponder. It consists of the interrogator, Interface Board and the Antenna. The system operates at a single frequency of 134.2 kHz with a low radiation level. The power and read functions between the reader and the transponder are done in the inductive mode. The complete reading unit is powered by either an AC to DC power supply or battery.

<u>Basic System Operation:</u>

The interrogator has a transmitter, a data receiver, a common transmit/receive antenna tuned to the transmit-receive frequency and the control module. The transponder consists of an selective high Q tuned antenna circuit, small charge capacitor, multi-function RF and control I/C.

The reader and the transponder operate in a sequential mode with timely separated power and data transmissions cycles. The transmitter generates a single and short RF interrogation burst, which is transmitted by a ferrite- or loop- antenna, to power the remote transponder.

The powering antenna has a high Q-factor in-excess of 100 in order to serve the following purposes:

- generating a high magnetic field strength at a low energy level.
- efficient suppression of harmonics.
- providing a high selectivity in the receive mode.
- in junction with the input circuit of the data receiver for high noise immunity.

During the power burst emission, a capacitor in the transponder is charged up. After the power burst has ceased the transponder starts oscillating on the same frequency and transmits a data telegram which is stored in the EEPROM of the I/C. The modulation used in the transponder is narrowband FSK.

<u>Functions and operation modes</u>

The attached block diagram of the remote RF module shows the generation of the transmitter signal by a crystal oscillator followed by a divider which drives the power amplifier. The divider function is gated to control the emission of the power signal. This power signal is coupled to the antenna by a RF transformer.

The receiver is also coupled via the RF transformer to the antenna. The receiver is direct and non-conversion receiver with 2-pole preselector, amplifier and two band filter sections followed by the limiter, demodulator and interface functions. After decoding of the data telegram, the data signal is fed to the control module for further signal processing. The RF detector is used to identify and synchronize parallel operation of adjacent RFID system.

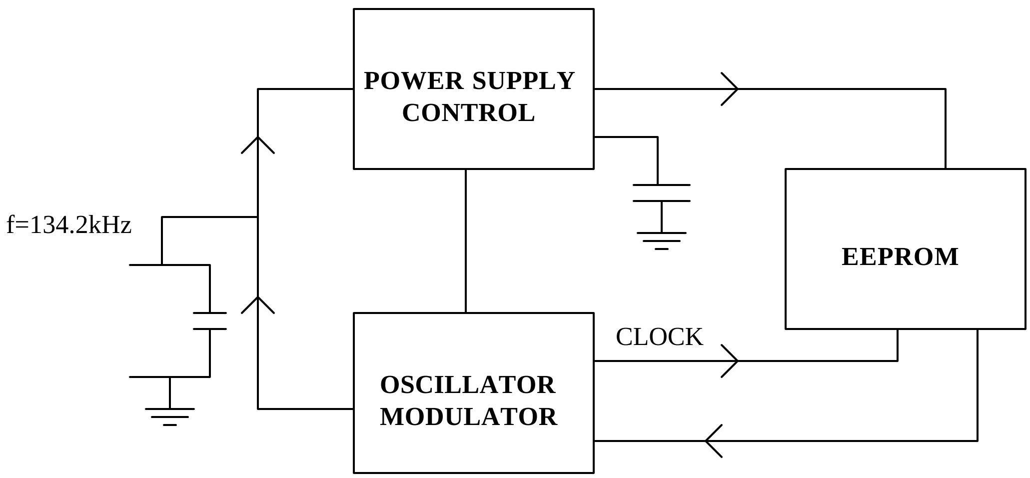
The interrogator provides the TTL serial output for RS232/422 interface, limited data storage, power control and receive/transmit functions of the STU. These functions do not cause any contribution to the radiation level.

It is also possible to program a transponder. In this mode the ID-Code is transferred to the transponder in pulse modulation. The code has to be sent to the interrogator and the programming is done automatically. After the programming the status of the programming is sent back. A more detailed description of all function is given in the reference manual.

<u>Transponder function</u>

The tuned circuit serves as antenna for the power accumulation and for the data transmission function. It is turned to the transmit frequency of 134.2 kHz and has a high Q-factor, to provide a high efficiency during the powering as well as during the data transmission cycle. The I/C has several functions as RF burst detect, signal rectifier and limiter, oscillator, FSK modulator and the required control functions.

Block Diagram of the Transponder



13.56 MHz Technology Description Example

The Tag-it™ system is comprised of a transponder (or tags), reader(s) and its antenna(s). The reader is controlled by a host system such as a PC, a larger computer, or some other kind of intelligent device (for example a ticket printer).

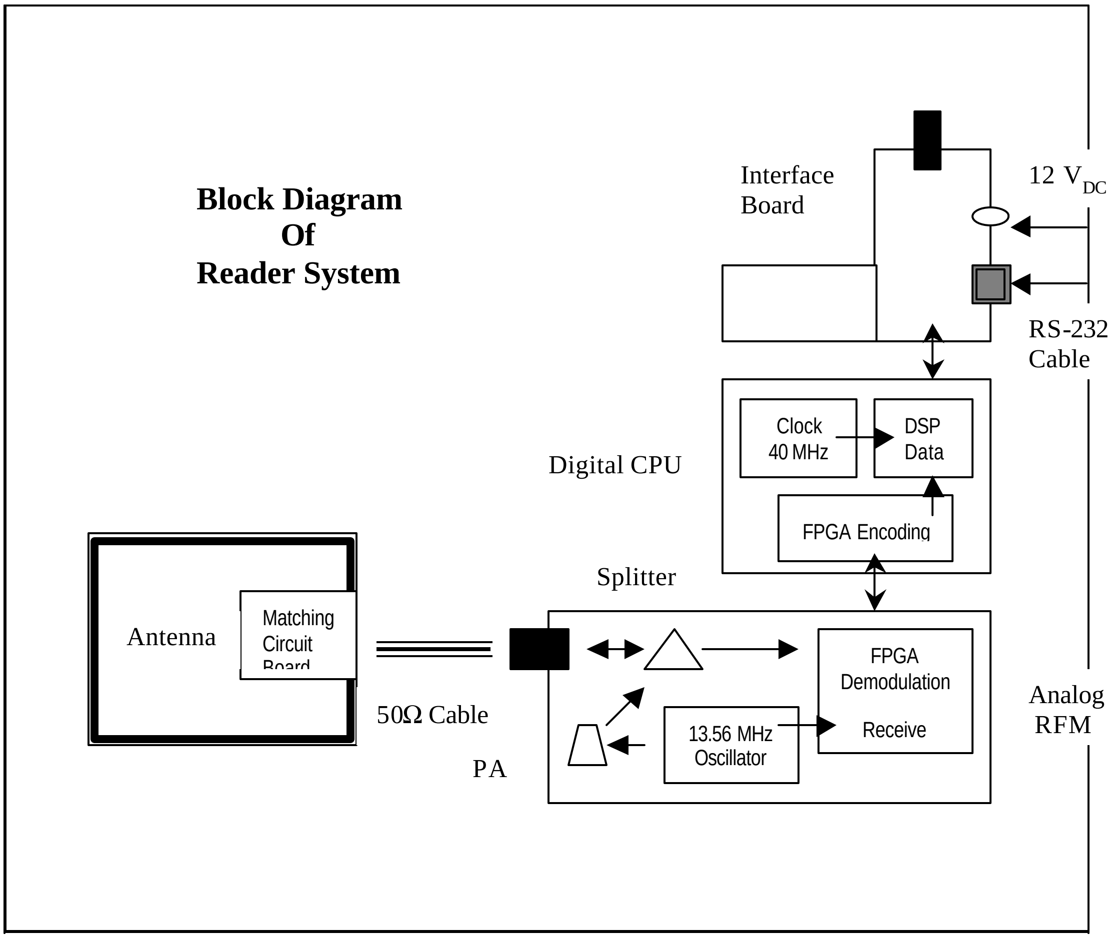
During a transaction, the transponder (tag) is permanently powered by the signal sent by the reader. This signal also provides the clock frequency to the transponder. It is amplitude modulated to transmit requests from the reader to the transponder (tag). In order to transmit responses to the reader, the transponder (tag) derives the operating energy and the clock from the reader's power signal to generate the sub-carrier frequencies. Modulation depth is 100% and is influenced by the coupling factor between the reader's antenna and the transponder, and thus by the distance between them. The emissions from transponders (tags) was not measureable and well above the regulated limit. The passive tag does not required to be FCC certified.

Tag-it Interrogator

A typical reader consists of three electronic boards (interface, digital CPU and analog RFM) and an antenna. The reader can be powered with 12 V_{DC} by either battery or DC source through the interface board. The interface board provides on/off switch, power and RS-232 data communication connections. The interface board has a built-in DC filter and voltage regulator. Interface board and digital CPU may not be required if the reader (analog RFM) is integrated into application peripheral such as a thermal demand printer or fixed-point identification system. The data is transmitted through the RS-232 port that is connected to its host (Application Processor) through a serial processor or a Local Area Network (LAN). It sends energy and commands to, and receives signals from the transponder through the antenna (aerial).

The basic reader includes a transmitter (with crystal oscillator), receiver and control components.   The transmitter operates at a ISM frequency of 13.56 MHz with a defined bandwidth of ±7 kHz. A magnetic field is generated and supplies energy (10 or 100% ASK) to the batteryless tag and maintains the data communication (FSK modulation) between transponder and reader. The data is transferred from the tag at 26.7 kBaud per second using one or two fixed side band sub-carrier frequencies of 13.56 MHz ± 423.75 kHz (high) and ± 484.29 kHz (low) through Manchester encoding.

The digital CPU module routes communication instruction (serial protocol) set from the computer and processes the tag data through digital signal processor (DSP). CPU module has an on-board 5V DC regulation for its logic circuitry. The analog RFM (transmitter / receiver, uses down-loadable firmware to interrogate and respond to the tag through the protocol and energy from the antenna. The firmware can not change any system's output parameters affecting regulated emissions. The antenna module is attached to the reader by 50Ω coaxial cable. The antenna module includes a loop wire and matching circuit board. The matching circuit board allows 50Ω impedance at 13.56 MHz giving maximum output.

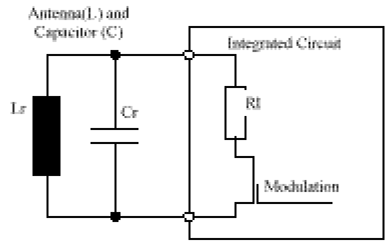


Block Diagram of Reader System

The front-end circuitry uses a power-splitter followed by a crystal filter in the receiving path and crystal based sinus wave oscillator. Transmitter generates a RF power output at an impedance of 50Ω.

<u>Transponder (Tag)</u>

A Tag-it transponder (tag inlay) comprises a flexible foil antenna, a resonance capacitor and an integrated circuit. The tag inlay can be packaged in different formats such as pressure sensitive labels and plastic cards. The transponder's IC is powered by the electromagnetic field generated by the reader's antenna, this is generally described as a passive transponder.



Block Diagram of the Transponder

The IC is flip chip mounted onto the antenna. The electrical parameters of the components: the antenna (including its inductance) and the resonance capacitor; and the layout of the antenna loops all have an effect on the transponder's performance. The L_r/C_r resonance circuit is trimmed to the required target frequency to achieve optimal performance.

The tag uses two sub-carrier AM modulation frequencies for sending its data to the Reader (up-link). The data are encoded in Manchester code by alternating between both sub-carrier frequencies, such generating an FSK modulation scheme. The emissions from transponders (tags) was not measurable and well above the regulated limit. The passive tag does not required to be FCC certified.

902.5-927.5 MHz UHF Technology Example

This device is intended for applications in the areas of identification, verification, and inventory control. The system consists of two main parts, a reader and ID tags. The reader is operated by the user to interrogate the tags, which are attached to objects in the field. Tags are small in size and have read/write capability.

The ID tags derive their power from the RF energy of the reader signal, and are not internally powered. Signaling from reader to tag is accomplished by momentarily switching off the RF transmitter in a predetermined pattern. Signaling from tag to reader is accomplished though antenna backscatter. The tag momentarily shorts its antenna terminals together, which causes the transmitted power that was being absorbed into the tag to reflect back off its antenna. This reflected signal sensed by the receiver.

The transmitter produces a phase locked CW signal, which is modulated by momentarily switching off the output power. In the transmitter, the phase locked loop output is amplified and then modulated by an RF switch, which is also controlled by the microprocessor. It then passes through the final amplifier, low pass filter, switch, and ultimately is transmitted from the antenna.

The received signal from the antenna comes through the switch, through a circulator, to a power divider. The two signals from the power divider are quadrature down converted (to base band) using an LO derived from the transmitter. The two baseband signals are amplified and filtered, the absolute values are taken, and the two resultant signals are summed. This composite baseband signal goes to a comparator circuit, which provides an input signal to the microprocessor.

Antenna port power is less than 28.5 dBm. With an antenna gain of 7.5 dBi, the effective radiated output power is rated at less than 36 dBm (4 Watts). The 20 dB bandwidth of the modulated signal power is less than 500 KHz.

There are 50 hopping channels with center frequencies located at 0.5 MHz intervals starting at 903 MHz and continuing to 927.5 MHz. The hopping dwell time is 300msec. The frequencies - numbered 1 through 50 - are chosen pseudorandomly. The frequency number is modulo 50 of the contents of a 7-bit maximum length feedback shift register.

The linear feedback shift register (counter) operates continuously as soon as power is switched on. However, power is not applied to the final amplifier (to begin transmitting) until a command is received by the scanner from the operator via the host computer. The starting frequency (time) at which the transmit command occurs will generally be uniformly distributed across the 50 channels. The shift register (counter) continues to operate which should guarantee a uniform distribution of restart frequencies. (equal use of all channels §15.247(a)(1)).

The interrogator uses frequency hopping as a method of meeting the FCC requirement for spread spectrum operation. The frequency hopping is completely independent of the modulation used to communicate with the RF ID labels. Both functions are described below.

The RF frequency is generated using a phase locked loop (PLL) and a voltage controlled oscillator (VCO). At power up the microprocessor begins sending the PLL integrated circuit the serial information to the set frequency. The PLL uses a 20 MHz crystal oscillator as a reference frequency. The PLL generates a voltage for the voltage-controlled oscillator (VCO). The VCO generates the RF signal, which is then fed back to the PLL. The PLL divides this signal down, and compares it to the 20 MHz reference. In the closed control loop, the PLL's output voltage is adjusted to precisely maintain the set frequency.

The frequency hopping timing is maintained by the microprocessor in the Tag-it UHF Reader (RI-RU1-001A-00). When it is time to hop, the microprocessor sends serial data to the PLL to change the frequency. There are 50 hopping channels with center frequencies located at 0.5 MHz intervals starting at 903 MHz and continuing to 927.5 MHz. The hopping dwell time is 300msec. The frequencies - numbered 1 through 50 - are chosen pseudorandomly. The frequency number is modulo 50 of the contents of a 7-bit maximum length feedback shift register. The linear feedback shift register (counter) operates continuously as soon as power is switched on. However, power is not applied to the final amplifier (to begin transmitting) until a command is received by the scanner from the operator via the host computer. The time at which the transmit command occurs will generally be uniformly distributed across the 50 channels. The shift register (counter) continues to operate which should guarantee a uniform distribution of restart frequencies.

The RI-RU1-001A-00 Transceiver uses an RF on/off modulation scheme. The RF signal powers the ID tag in the field, and then communicates with the tag by briefly turning off the RF power at the proper time. The waveform timing and duty cycle depend on the transmitted symbol. There are 3 transmitter waveforms. The transceiver is either sending just a clock, sending a logic "0", or sending a logic "1". Figure 1 shows the timing for each of these waveforms. The range of time for the next frame of data or clock varies as a function of the interrupt latency of the microprocessor. The modulation either has the RF at full strength in the "on" state, or attenuated by at least 20 dB in the "off" state. Any time the scanner is normally operating, the RF signal is continuously being modulated. The commands being sent and the frequency of these commands is user dependant. The system is operating unmodulated only when the transceiver is instructed to operate as such, via operator command. Even when not modulated, the scanner is still frequency hopping at 300 ms intervals. The sequence of clock, logic "0" and logic "1" information being transmitted is completely dependent on the commands issued by the processor, and by the tag responses.

The modulation of the signal is controlled with a digital pulse sequence from the FPGA. This signal is RC filtered to limit the transmission bandwidth, and then is sent to the analog gain control of an RF amplifier. The RF amplifier attenuates the RF signal by a minimum of 20 dB when in the "off" state.