45ES-1 CIRCUIT DESCRIPTION

GENERAL INFORMATION:

The 45ES-1 ERT® (Encoder Receiver Transmitter) Unit succeeds the 40ES ERT® with features that include the ability to periodically transmit an extended message necessary for advanced metering functionality.

The 45ES-1 uses a microcontroller and a custom ASIC which continues to support the features present in the current products. The meters that the 45ES-1 support include: Schlumberger J4S and J5S.

The ERT® is divided into three functional parts described in the following sections: RF, logic, and power supply.

Terms and Acronyms Used

ASIC	=	Application Specific Integrated Circuit
DCU	=	Data Command Unit - vehicle mounted reading device for the ERT®
ERT®	=	Encoder Receiver Transmitter
IDM	=	Interval Data Message (92 bytes)
IRED	=	Infrared
PI	=	Pulse Initiator
ReadOne Pro	=	Hand held reader/programming device for the ERT®
RX	=	Receive
SCM	=	Standard Consumption Message (96 bits)
TX	=	Transmit
Wake-Up	=	Signal which causes the ERT® to transmit the SCM

CIRCUIT DESCRIPTION:

RF SECTION:

Both the receiver and transmitter sections of the 45ES-1 ERT® module share the same basic oscillator circuit. The receive frequency range is 950 to 960 MHz and the transmit frequency range is 910 to 920 MHz. The normal factory preset state of an ERT® module at rest is Receive Mode. When in Receive Mode, the ERT® module continuously monitors for the presence of a coded command to transmit the current meter reading. The receiver is always ON except when commanded to transmit consumptive utility data. An optional, user programmable state of an ERT® module is IDM (Interval Data Message) Mode. When in IDM Mode, the ERT® periodically transmits an extended message containing information

necessary for advanced metering functionality. In between IDM transmissions, the ERT® module continuously monitors for the presence of a coded command to transmit the current meter reading. The receiver is always ON in IDM Mode except during IDM transmissions and when commanded to transmit consumptive utility data.

The command to transmit data is an amplitude modulated (AM) carrier in the range of 950 to 960 MHz, encoded with a 27 to 57 Hz wake up tone that is received from a handheld, mobile, or fixed station reading device. When this signal is detected, the ERT® module switches to the Transmit Mode where it transmits a 96 bit data message a programmed number of times (the factory default value is eight messages per wake up sequence). The transmit frequency of each of the eight (8) messages is pseudo-randomly selected within the ERT® module from among the 31 frequencies available between 910 and 920 MHz. The initial transmit start time is also selected pseudo-randomly. This method of operation improves the ability of the mobile, handheld, or fixed station data collection device to successfully read the consumptive utility usage data because the chance of two or more ERT® modules transmitting at the same time and at the same frequency is significantly reduced.

When the IDM Mode has been selected, a 92 byte extended data message is transmitted a programmed number of times (the factory default value is one message per IDM transmission) at a programmed rate (the factory default value is one transmission every four seconds). The transmit frequency of the extended data messages is pseudo-randomly selected within the ERT® module from among the 31 frequencies available between 910 and 920 MHz.

Oscillator:

The design is based on a Clapp Oscillator consisting of Q101, C105, C106, CR103, C115, C111, Z101, C112, CR102, C116, L103, C109, 6 dB resistive attenuator, and antenna structure. C106, C105, CR103, and C115 control the positive feedback which is necessary to sustain oscillation. Z101 provides a highly stable tank circuit inductance to resonate with the circuit capacitors. C111 provides capacitive coupling between Q101 collector/feedback capacitors to Z101. Receive frequency fine tuning is provided by laser tuning small portions of the shield of Z101. CR102 is a PIN diode which enables C112 and C116 to course tune the ERT® frequency close to the transmit band. C112 (a laser trimmable capacitor) provides the fine tuning necessary to put the ERT® exactly on the desired transmit frequency. Isolation and coupling to the antenna is through L103, C109, and a 6 dB resistive attenuator. The antenna structure is a BeCu strip.

Q101 is a PNP transistor. By using bipolar technology, the driving logic that is used in previous electric, gas, and water pit ERT® Units can be used without modification.

R102, R106, R107, R103, and CR101 provide a temperature compensated bias current into Q101 for both receive and transmit operation. C103 is a 900 MHz bypass for the base. C101 contours the current ramping of Q101 for receive operation while C102 effectively disables this ramp action to occur in the Transmit Mode. R103 and R107 control the transmit power of the unit.

Receiver Enable/Disable:

In Receive Mode, the oscillator is switched on and off by the logic of U51. When pin 17 goes low, a ground return is provided through R102 for a base voltage ramp to begin. R107 turns this changing base voltage into an increasing current through Q101. When pin 17 goes high, Q101 is disabled. R102, R106, R107, C101, and CR101 control the characteristics of the ramping current and thus the start up of Q101 oscillator transistor.

Transmit/Receive Control:

The tank circuit is changed to allow the frequency to shift from the receive band (950 to 960 MHz) to the transmit band (910 to 920 MHz). This frequency change is controlled by the opposite logic of pin 19 of U51 and pin 18 of U52. Acting differentially on CR102, these pins negatively bias CR102 with full supply voltage in receive, or forward bias CR102 through R109 and R113 in transmit. The forward biasing of CR102 enables C112 and C116 into the circuit, thus lowering the oscillation frequency of Q101 into the transmit band.

Transmit Frequency Control:

The transmit frequency is varied from 910 to 920 MHz by the DC voltage on pin 22 of U51. This voltage can be changed in 31 steps from approximately 0 to 2.5 volts. The voltage on pin 22 is applied to the anode of varactor diode CR103 through R111. The voltage to the cathode of varactor diode CR103 is the emitter voltage of Q101 which is about 5.0 volts. The voltage swing on the varactor in the Transmit Mode is thus the difference between the cathode and anode voltages, or 2.5 to 5.0 volts. This voltage differential results in a nominal 3.5 MHz overall frequency shift. Higher voltages on the anode of the varactor results in a lower frequency in the transmit band.

Transmit Data:

SCM data messages are Manchester-encoded and contain the unit ID number, electric meter reading in 1/100th kilowatt-hours, and other information. IDM data messages are Manchester-encoded and contain the unit ID number, differential electric meter reading consumption data, electric meter reading in 1/100th kilowatt-hours, and other information. The data is transmitted using on and off keying (OOK) of oscillator Q101. The transmit data output is pin 16 of U51. When this output goes low, oscillator Q101 is enabled by establishing a base voltage through the base circuit components. When pin 16 goes high, the oscillator is disabled. Therefore, a logic 0 output on pin 16 represents presence of carrier, and a logic 1 by the non-existence of carrier.

Receive Audio Detection:

In the Receive Mode this circuit functions as a super-regenerative detector. The principal of detection is to mark the time that it takes the oscillator to start up. With in-band RF energy present on the antenna, this energy will promote the starting up of the ERT® oscillator. This will cause the oscillator to turn on at a lower current level. Since throughout the RX enable time frame the current through Q101 is ever increasing, starting up at a lower current level equates to starting up sooner. The time to oscillator startup is monitored by the electronics in U51. If this timing varies at a rate equal to the programmed wake up tone, the ERT® will go into its transmit routine.

LOGIC SECTION:

The RF section above is controlled by ERT® ASIC U51. This ASIC device was designed specifically for the ERT®. It includes EEPROM memory for the ERT® Unit type and 26 bit ERT® ID number, RAM for storing programmed parameters, tone demodulator circuitry, Manchester data encoding circuitry, three logic level output ports, a digital-to-analog converter to provide the tuning voltage for the RF transmit frequency, and additional functions. For more detailed information on the operation of U51 consult specification A544-9020-012.

U51 is controlled and provides internal status via a 'micro-wire interface' (uWire I/F) to microcontroller U52, a masked ROM device containing 45ES-1 ERT® firmware. U52 receives additional parallel status from U51 externally to the uWire I/F.

The clock of U52 is set by crystal Y1. The 32.768 KHz clock for U51 is driven from a U52 microcontroller output.

Serial EEPROM U2, also tied to microcontroller U52 though the uWire I/F, provides non-volatile memory for storage of programmed parameters, tamper data, and consumption data in the event of loss of power.

U1 monitors the regulated DC power supply, holding U52 inactive, if there's inadequate voltage for proper microcontroller execution.

Mercury tilt switch S1, an input to microcontroller U52, is used to detect tilt tamper and tilt on loss of power, functionally differentiated, recorded, and reported by microcontroller firmware.

The optoelectronic reflective pulse initiator (PI) monitors directional rotation of the electric meter disc enabling the microcontroller firmware to register the accumulation of kilowatt-hour consumption data. The infrared (IRED) PI is comprised of drive circuitry (Q301, Q302, C305, C300, CR300, CR302, R300, R301, R302, R303, R304, R305, R309, R322, RT300 and a LED housing) a two stage ac-coupled trans-impedance amplifier for the silicon photodiode (SiPD) output (C5, C302, C303, C304, CR301, R9, R315, R317, R318, R319, R320, R321, and U300) a threshold and reference bias circuitry (C301, R313, R314, R315) and a comparator integrated into microcontroller U52. Firmware initiates a periodic sequence of IRED pulses at a 1024 Hz repetition rate and uses state machine logic for processing, tracking, and decoding the comparator results amplified from the SiPD. The difference between the shiny disk and infrared absorbing stripe is detected by the PI and used by the microcontroller to count disk rotations.

POWER SUPPLY:

The power supply for the ERT® is comprised of a sub-miniature power transformer, a bridge rectifier, a filtering capacitor and a zener diode. Transient protection of the AC power supplied from the secondary is provided by the bi-directional zener CR200. This protected low voltage AC is then rectified to DC by bridge CR201/CR202, limited to 12VDC by a zener diode CR203, smoothed by capacitive input filter C205, and finally DC regulated to 5 VDC by U200. The zener diode CR203 limits the DC output voltage to 12V so that the voltage does not exceed the maximum voltage rating of C205 and U200. The aluminum electrolytic capacitor C205 also act as an energy storage device when a loss of power occurs. This capacitor must provide sufficient storage time to save non-volatile information in U2, the Serial EEPROM, described above. Voltage divider R200 and R201 scales down the unregulated DC input voltage and provides an indication to microcontroller U52 when a change of input power is occurring.