FCC Part 15 Transmitter Certification Test Report

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FCC Rule Part: 15.247

ACS Report Number: 04-0396-15C

Manufacturer: Itron Electricity Metering, Inc.
Equipment Type: Electricity Meter With Dual RF Transmitters
Trade Name: CENTRON ™ ICARe
Model: C1A-2

Theory of Operations

Functional Specification

TITLE: CENTRON ICARe Functional Specification
AUTHOR: D.P. McConnell

REV	CCO	DESCRIPTION OF CHANGE	DATE	APPROVALS	
A		INITIAL RELEASE	23 Sep 2004	Project Leader	D. McConnell
			29 Dec 2004	Manager – Residential Metering	F. Kobbi

REVISION HISTORY

B		Update to support version 1.9.0 Firmware	13 Jul 2004	Project Leader	D. McConnell
C		Update to Itron Document	28 Dec 2004	Project Leader	D. McConnell
				(Function)	

REVISION CHART

Version	Primary Author(s)	Description of Version	Date Completed
Draft	DP McConnell	Initial draft	9/23/2002
Draft	DP McConnell	Incorporated comments from Jerome Bartier, Eric Deschamps and Vladimir Borisov	9/25/2002
Draft	DP McConnell	Updated document with management requests	9/26/2002
Draft	DP McConnell	Added R300 functionality	10/1/2002
Draft	DP McConnell	Added Interval and randomization examples	10/11/2002
Draft	DP McConnell	Added RF power consumption assumptions	10/14/2002
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Draft	DP McConnell	Updated document for company split and to address selected MCU	1/16/2002
Draft	DP McConnell	Changed CRF900 to COSMOS	3/31/2003
Draft	DP McConnell	Changed CentronCRF to ICARe	4/10/2003
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Draft	M.Peters/ P.Chiummiento	Updated Hardware and Firmware sections	12/19/2003
Preliminary	DP McConnell	Cleaned up format and made final changes from previous spec	1/15/2004
Preliminary	DP McConnell	Added display functionality	2/20/2004
Preliminary	DP McConnell	Added changes for Cellnet/RMR meter types	6/15/2004
Final	DP McConnell	Update for 1.9 Firmware separating Cellnet & RMR	7/13/2004
Final	DP McConnell	Update for Itron	12/28/2004

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INTRODUCTION

This document will describe the functional design specification for the ICARe RF electricity meter. The purpose of this project is to provide a meter module based on the COSMOS RFASIC developed in Montrouge, France and produced by Atmel. The design will allow the CENTRON meter to communicate in both the mobile and fixed network environments.

Description

The ICARe will be a transmit-only meter module that collects and transmits metering data over the 902 - 928 MHz Industrial, Scientific and Medical (ISM) RF band. The unit will contain both a Direct Sequence Spread Spectrum (DSSS) transmitter and a Frequency Hopping (FSK) transmitter.

Endpoint Function

The ICARe functions as a RF transmitter that is capable of supporting remote meter reading using mobile and fixed network protocols. The mobile network functions will be the R300 (ITRON™ protocol) or the R900 (SURF© protocol). The fixed network function will be the CellNet© electricity endpoint protocol (PID2) to maintain legacy functionality.

The endpoint will be installed in the CENTRON meter as the register board. The metrology board will provide power and energy data to the endpoint in the same manner as a normal register board.

The endpoint will provide the following data depending on configuration and firmware option:

- Cumulative energy readings using the ITRON protocol
- Cumulative energy readings using the Schlumberger SURF protocol
- Cumulative and interval readings using the CellNet by Atos Origin protocol

The endpoint will determine electrical energy data by counting pulses from the metrology board and then converting them to energy values for display and transmission. The endpoint will use a constant loaded during configuration to provide the correct energy values for the network being supported.

The endpoint will also use a serial protocol for configuration and testing using the register serial port.

It is also necessary for the endpoint to be able to be installed on previous meter bases with no modifications to the base to maintain the modularity requirement of the CENTRON meter.

References:

COSMOS RFASIC Requirements, by Gilles Picard
Schlumberger Qualification Test Specification for Solid-State Electricity Metering Products, SLB-QTS 5.0
SURF protocol Schlumberger Unlicensed Radio Frequency Protocol specifications, Version 1.0 dated June 9, 1998
Electric Interval Packet Transmission Randomization, White Paper, by Susan Stulz dated 24 June 2002
ICARe RF Protocols Specification
ICARe Product Vision
ICARe Business Case

RF NETWORK SERVICES

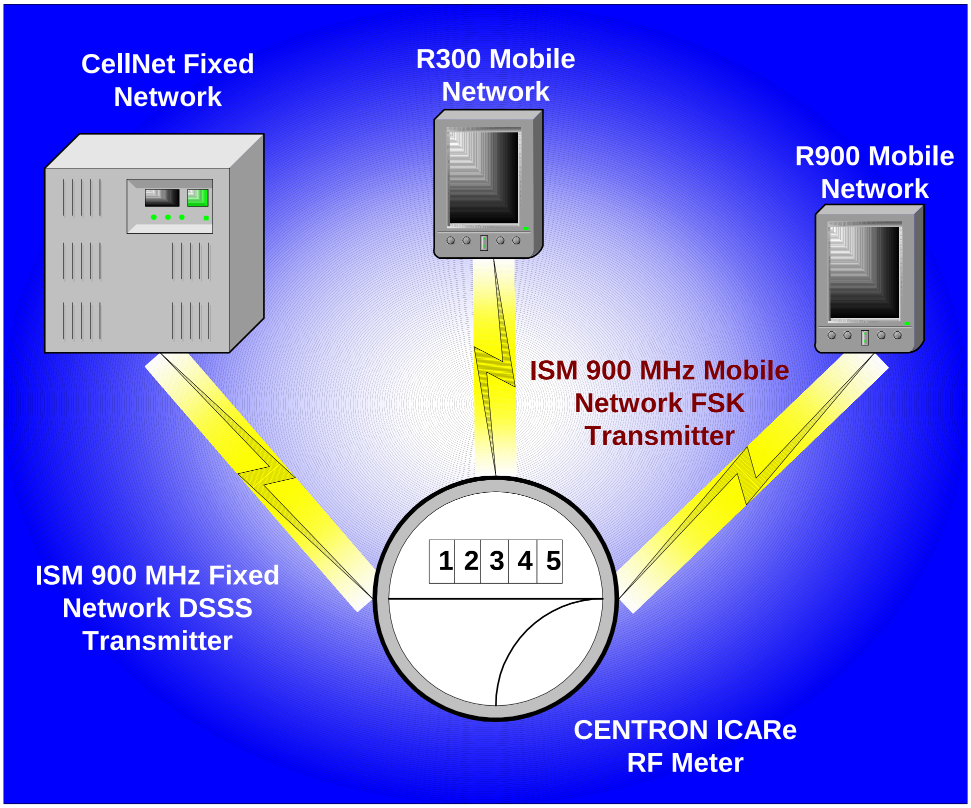

Figure 1 RF Network Interfaces

CellNet® Network System Services

The ICARe RF module will transmit a single channel of data at the 917 MHz using a Binary Phase Shift Keying (BPSK) spread spectrum transmitter. The transmitter is capable of transmitting both the On-Off-Keying (OOK) and the Cyclic Code Shift Keying (CCSK) chipping methods. The fixed network transmitter is capable of providing output power of 24 ±1 dBm to the antenna. The fixed network module transmits standard CellNet Protocol Identification 2 (PID2) packets to the network. Refer to the ICARe RF Protocols Specification for message format and details.

Information Provided

The ICARe will provide the following information to the CellNet fixed network:

- Local Area Network Identifier (LAN ID)
- Meter ID
- Register Configuration
- Cumulative Active Energy delivered daily
- 10 or 18 Active consumption data intervals
- Power fail notification
- Reverse power flow notification
- Magnet switch activation flag

FCC Regulation

The fixed network transmitter operates and meets the requirements in the US code of federal regulations (CFR) Title 47, part 15, subpart C, paragraph 247 of the FCC rules.

RF Characteristics for Fixed Network

Function	Requirement
RF Frequency	917.58 MHz
Spreading Modulation	OOK & BPSK (CCSK)
Conducted Power Output	24 dBm ±1 dB (into 50 ohm load at 25° C)
Power Output Temperature Variation	±2 dB from –40/+85°C
Effective Radiated Power (ERP)	+28 dBm minimum peak
Carrier Suppression	<+3 dB in 3 kHz RBW to adjacent spectral components
Side Lobe Suppression	-13 dB to main lobe
Data Modulation	OOK and CCSK
Symbol Data Rate	19.27 kBPS for OOK and CCSK
Chipping Code Length	63 bits for OOK and CCSK
Preamble Length	92 (93 CCSK) bits
Transmit Duration	11.0 msec to 23.5 msec
FCC Certification	Per Part 15.247

Table 1 Fixed Network (CellNet) RF Transmitter Characteristics

R300 Mobile Network System

The R300 is a frequency-hopping RF transmitter that operates in the 910 to 920 MHz band. It transmits on an average of once per second with a randomized time interval to reduce interference and collisions. The R300 module transmits an Itron standard consumption message (SCM) protocol composed of 96-bits of data. Refer to the ICARe RF Protocols Specification for message format and details.

Information Provided

The ICARe will provide the following services to the Itron Mobile network:

- Module ID
- Meter Type
- Cumulative Active Energy
- Tamper Information

FCC Regulation

The mobile network transmitter operates and meets the requirements in the US code of federal regulations (CFR) Title 47, part 15, subpart C, paragraph 249 and paragraph 247 of the FCC rules.

RF Characteristics for Mobile Network

Function	Requirement
RF Frequency	910 to 920 MHz
Spreading Modulation	OOK
Conducted Power Output	-8 dBm conducted (Para 249), 5 dBm conducted (Para 247)
Power Output Variation over Temperature	±3 dBm
Effective Radiated Output Power (ERP)	-13 dBm peak (94 dBuV/m) @ 3 Meters (Para 249) 4.5 dBm peak @ 3 Meters (Para 247)
On Air Transmission Time	6.71 milliseconds (SCM), 7.4 milliseconds (SURF) per channel
Data Modulation	OOK
Data Rate	16.384 kBPS (32 KHz clock, Manchester coded data)
Data Pacing	1 Packet per second typical (125 milliseconds minimum)
Number of Channels	64 or 50 Utilized, 77 Receiver channels
Channel Bandwidth	<200 KHz transmitter, 208 KHz receiver
Frequency Stability	<750 KHz/ Packet
Frequency Accuracy	±3.75 MHz Max over Temperature
FCC Certification	Per Part 15.249 and/or 15.247

Table 2 Mobile Network (R300/R900) RF Transmitter Characteristics

Schlumberger R900 Mobile Network System

The R900 is a frequency-hopping RF transmitter that operates in the 910 to 920 MHz band. It transmits on an average of once every 2 to 4 seconds with a randomized time interval to reduce interference and collisions. The R900 will operate at 0 dBm ±3 dBm to the antenna. The R900 module transmits an Schlumberger SURF consumption message protocol composed of 116-bits of data. Refer to the ICARe RF Protocols Specification for message format and details.

Information Provided

The ICARe will provide the following standard services to the CellNet fixed network:

- Module ID
- Meter Type
- Cumulative Active Energy
- Tamper Information

FCC Regulation

The fixed network transmitter operates and meets the requirements in the US code of federal regulations (CFR) Title 47, part 15, subpart C, paragraph 249 of the FCC rules.

RF Characteristics for Mobile Network

Same as defined by the R300 in section 2.2.3.

System Hardware Requirements

The ICARe will function as a transmit-only meter module that will be installed in the register board slot in the CENTRON electricity meter. It will be configurable to provide a single channel of data to the CellNet fixed network or a single channel of data to the R300/R900 mobile networks or a combination of the two mobile network.

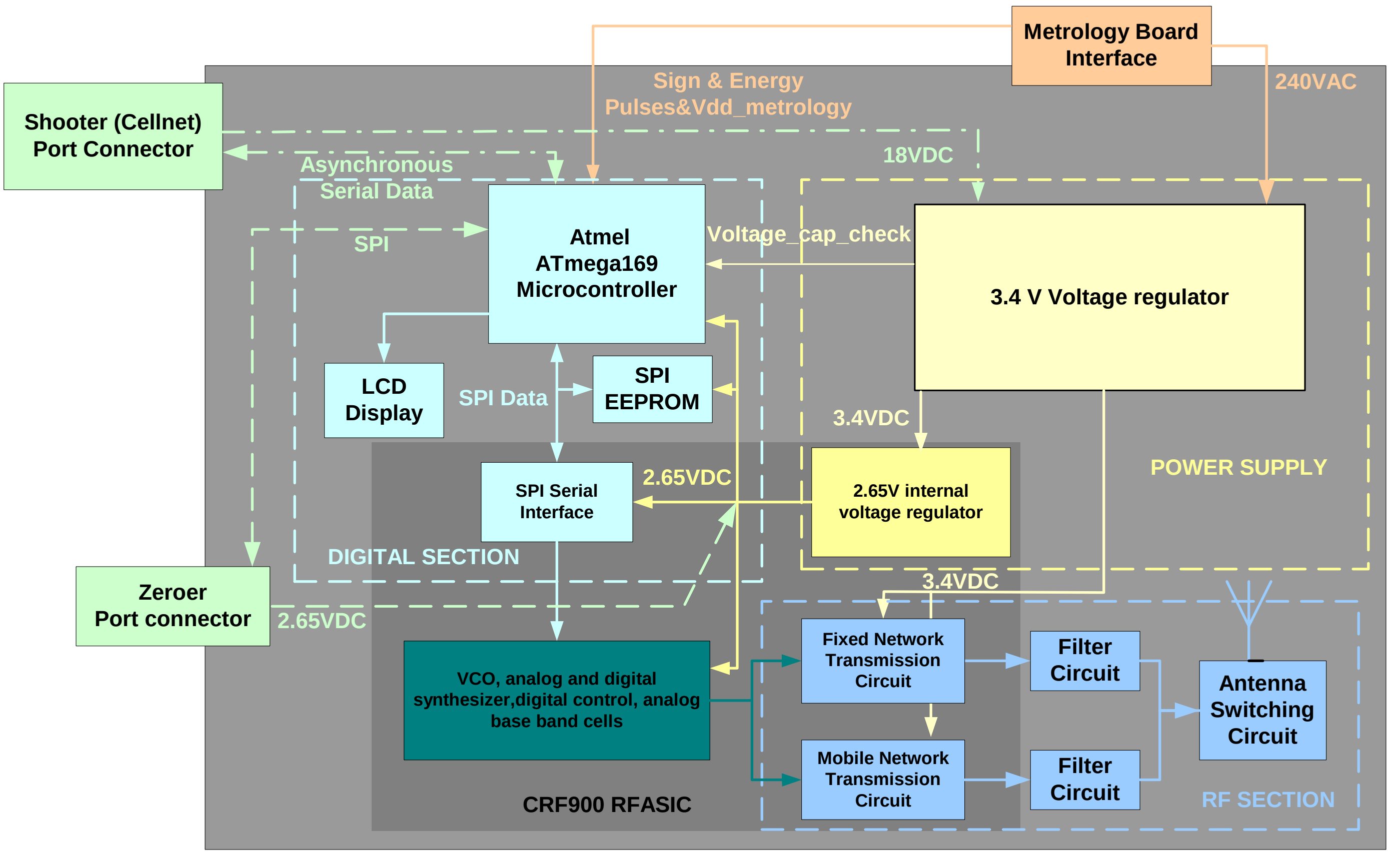

Figure 2 ICARe Block Diagram

The CENTRON meter is composed of the base, the register board and the meter cover. The base contains the metrology board and provides energy pulses and voltage via the interface connector to the register board. This section will deal with the signals coming to the register board via the interface as well as the register board.

Power Supply Specification

The power supply will be designed to meet the requirements of cost (PCB, component count, component cost), voltage regulation (normal processing, power fail detection) and current consumption (RF transmission, digital processing and voltage regulation)

Power supply inputs and outputs description

The power supply will use external discrete components to get a regulated 3.4V from the 240VAC/120VAC main. This 3.4V will then be supplied to both the internal CRF voltage regulator and the internal CRF RF Power Amplifiers. The internal CRF voltage regulator will then provide a regulated 2.65V voltage to the micro-controller, EEPROM, CRF VCO, CRF analog and digital synthesizer, CRF digital control and the analog base band cell.

Inputs:

- 120 VAC or 240 VAC from the Metrology Board Interface when the meter is plug into a base
- 18 VDC unregulated from the Serial Port Interface when it is connected

Outputs:

- Regulated 3.4 VDC for the internal CRF power amplifier and voltage regulator
- Regulated 2.65 VDC for the Digital section and the CRF internal digital and analog cells

Specification on inputs and outputs

Power grid input specification

The power supply is required to be capable of drawing power from both 120VAC and 240VAC-power line with minor changes. The power supply operational conditions are:

- The power line could have a 20% voltage variation
  - 120 VAC: 96 VAC< Power line < 144 VAC
  - 240 VAC: 192 VAC< Power line < 288 VAC
- The power supply will be capable of handling a 0 VAC potential for up to 100ms without triggering a power fail
- Power fail detection should be triggered when:
  - 120 VAC: power line voltage< 72 VAC for >100 mS
  - 240 VAC: power line voltage<144 VAC for >100 mS

Serial Port interface power input specification

The power supply will have an additional requirement of being capable to accept an unregulated 18 VDC via the serial port.

3.4V regulated output specification

The 3.4V regulated will have to meet the specification for the COSMOS internal voltage regulator as well for the COSMOS internal Power amplifier supply voltage:

Device	Minimum Voltage	Typical Voltage	Maximum Voltage
CRF Power Amplifier	2.4 VDC		3.75 VDC
CRF Voltage Regulator	3.2 VDC	3.3 VDC	3.6 VDC
Supply Ripple			20 mVpp

Table 3 COSMOS Voltage Specifications

2.65V regulated output specification

The 2.65 VDC regulated outputs from the COSMOS are the preferable voltage sources for this design since they were designed specifically for the COSMOS voltage requirements and they will reduce the overall component costs. The CRF internal voltage regulators provide:

- One source for the internal features of the CRF controllable by the MCU.
- One source for the Digital circuitry on the board that is constantly on as long as 3.4 VDC is supplied.

The 2.65V digital source meets the specification for all the major digital components in the design.

Device	Minimum Voltage	Maximum Voltage
Atmega169V Microcontroller	1.8 VDC	5.5 VDC
MicroChip 8kbit EEPROM	1.8 VDC	5.5 VDC
CRF Internal Devices	1.8 VDC	3.15 VDC

Table 4 Digital Circuit Voltage Requirements

Power Supply output current specification

Part	Descriptions	Maximum Current Value
Micro-controller Atmega169V	**16K ROM part**	
CPU	No sleep mode, run at 1Mhz on internal RC oscillator	0.7mA
Analog Digital Converter (ADC)	standby when it is not used (200uS max conversion time~40 ADC clock)(200Khz clock)	300uA active/5uA standby
EEPROM	**8Kbit part**	
	Standby mode	0.5uA
	Write 16-Byte page sequence in 5ms max	3mA
	Read sequence at 2Mhz clock	0.5mA
COSMOS RFASIC	**RF Transmitter**	
	Shutdown mode	10uA
	Serial Communication 1Mhz max	0.5mA
	Crystal and PLL stabilization in 10ms max	1.5mA
	Fix Transmission 25ms max at 23dBm	350mA
	Mobile Transmission 10ms at 8dBm	30mA
Metrology Board Interface	**Pull up to convert a +/-2.5V in 0V-2.5V logic**	**130uA low/0uA high**
	Watt hour pulse duration 10ms	130uA
	Lsync pulse	65uA
	Energy sign	130uA positive/0uA negative
Power Supply	**Power supply regulation**	
	Voltage capacitor detector	70uA
	Quiescent current in the LDO	100uA

Table 5 Component Current Requirements

From the above table the following charge quantities will be needed for each operation as well as the DC current that the Power Supply will have to provide.

Event Description	Total Charge Needed	Average Current
Each 150s-period, the algorithm will write and read (worse case) 250Khz=>250bit/ms~32byte/ms~2page/ms) 2 locations of 2 pages of the EEPROM.	Read:1.5uC Write:90uC Total:91.5uC	I_EEPROM=1.5uA @ 150s period
CRF transmission steps: COSMOS RFASIC Serial communication: 54-byte max for a CCSK plus ~10 bytes for CRF configuration and start of transmission (@250Khz~64Byte/2ms) 25.58Mhz Crystal + PLL stabilization Cellnet transmission every 300s period Mobile transmission every 1s period	Serial com:1uC Crystal+PLL:15uC Cellnet:8.75mC Mobile:300uC	I_CELLNET=(8.75+0.015+0.001)/300=30uA I_MOBILE=(0.3+0.015+0.001)/1=316uA
Analog/Digital Converter (ADC): Check the capacitor voltage every 9ms Check for Temperature Compensation every 9ms Check the metrology power supply(Vdd) every 9ms	ADC conversion:0.06uC	I_Check_Cap=15uA I_Check_RMS=15uA I_Check_Metro=15uA
Metrology board interface : 3 lines are coming from the metrology: Sign : when the energy is positive the line is at –2.5V Lsync: Squared signal between 2.5V and –2.5V @60hz Whpulse: -2.5V 10ms-pulse for one unity of 50Wh. Max frequency is 32Hz.		I_Lsync=65uA I_positive_sign=130uA I_32HzWhpulse=41.6uA

Table 6 Power Supply Current Requirements

In Normal mode without transmission, the power supply should handle the following current:

- MCU - 700uA
- Metrology Board Interface Circuitry – 240 uA (no input pulses present)
- MCU ADC – 50 uA
- COSMOS Standby Current – 500 uA

- Power Supply – 180 uA
- Total of 1.7mA DC current

Here are the criteria that the power supply is required to provide:

- Handle 1.7mA DC current
- Handle 350mA-25ms transmission every 300s
- Handle 30mA-8ms transmission every 1s
- Handle 350mA 20ms power transmission
- All requirements are valid for 15 years product life time
- Power up the board and ready to transmit in less than 8.2s (see manufacturing specification)

RF Section Specification

CRF ASIC part

CRF ASIC is handling the major functions required by the network:

- Receive data from microprocessor and modulate it following the Cellnet protocol
- Receive data from microprocessor and modulate it following the R300 or R900 or SURF protocol
- Each timing related to the RF data is handle by the CRF ASIC through a 25.48833MHz crystal

RF on board circuitry

The RF circuitry is divided in two sections:

- Antenna
- Matching between antenna and the CRF ASIC

The antenna is required to:

- Have a minimum 0dB gain at 917.58MHz for both horizontal and vertical polarization
- Be matched for 50ohms in the 910MHz-920MHz band

The matching circuit between the CRF ASIC and the antenna:

- Design a strip-line balun for both Cellnet and mobile Power amplifiers
- For Cellnet, the Power amplifiers need to matched both at the fundamental (917.58MHz) and the second harmonic (1.835GHz)
- For Mobile, the power amplifier need to matched over the band 910MHz-920MHz
- Harmonics rejecter low pass filter to be design to have a minimum 40dB attenuation for harmonics 3,4 and 5
- For Cellnet, balun and filter losses should be lower than 2dB
- For Mobile, balun and filter losses should be lower than 8dB

CENTRON Meter Metrology Interface specification

The endpoint will utilize the standard CENTRON interface for power and energy readings consisting of the following signals.

Pin Number	Signal
1	120/240 VAC
2	+2.5 VDC
3	LSYNC
4	Sign Pulse
5	Watthour Pulse
6	-2.5 VDC
7	GND

Table 7 CENTRON Interface Pinout

The two outputs of the metrology board from pins 4 and 5 are pulses that represent the watthours measured and the direction (sign) of the energy flow. The Watthour Pulse is a normally high signal with a 10 millisecond; low going pulse to represent the energy signal.

The sign pulse is either a high signal representing a negative energy flow or low signal representing a positive energy flow.

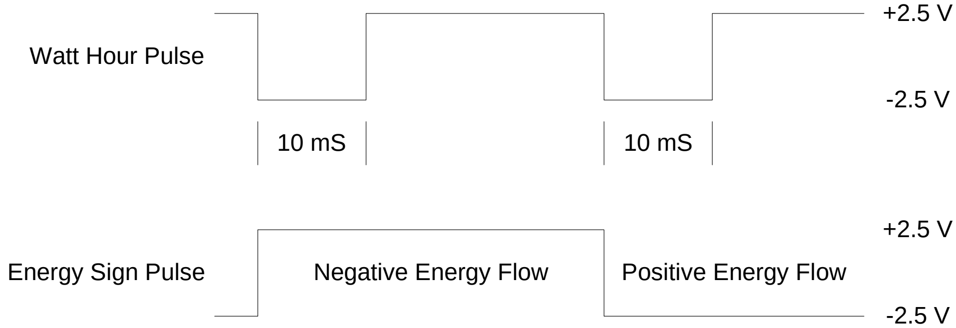

Figure 3 Metrology Energy Pulses

The LSYNC signal is a 60 Hz square wave that will be present as long as power is available on the main. This is the signal that should be monitored to calibrate in real time the internal RC oscillator of the microprocessor

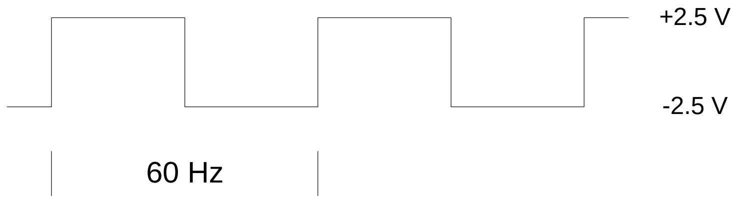

Figure 4 LSYNC Signal

For interfacing to the register board microcontroller, the signals from the metrology board will have to be level shifted to 2.65V-0V levels.

Display Specification

The ICARe display will be the same as the CENTRON ACE register. It will display the following:

- Detented kWh
- Non Detented kWh
- Net (Future addition, not in the first release)

Energy Options

The ICARe will be capable of displaying the following options for energy:

5 digit x 1 detented and nondetented

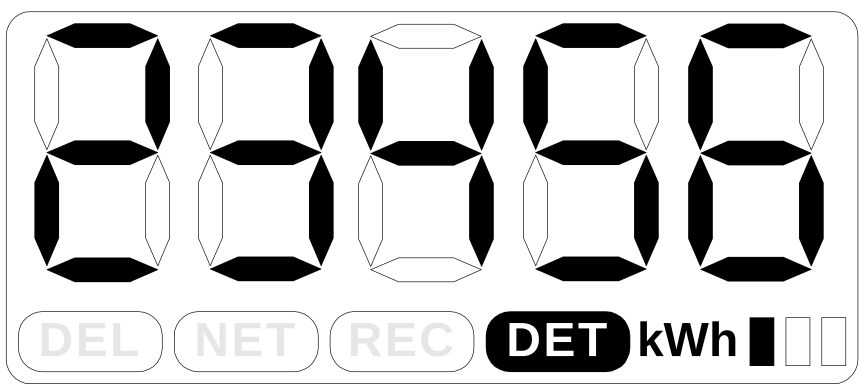

Figure 5. 5 digit X 1 display

4 digit X 1 detented and nondetented
4 digit X 10 detented and nondetented

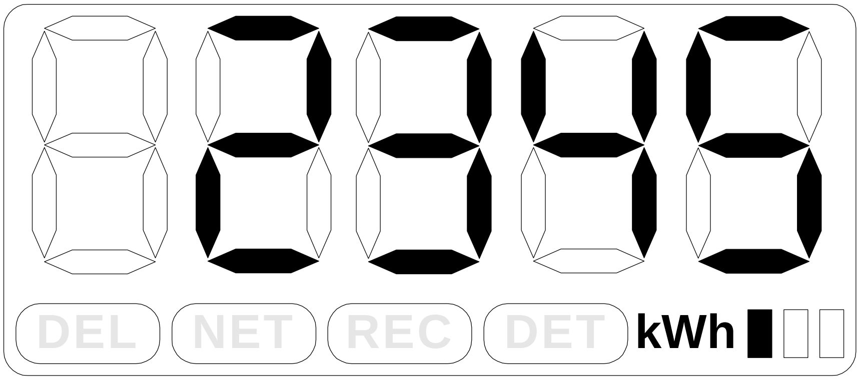

Figure 6. 4 digits X 1 and 4 digits X 10 display

Manufacturing Segment Test

The ICARe will also provide a segment display test for manufacturing when the EEPROM is not programmed as show in figure 7.

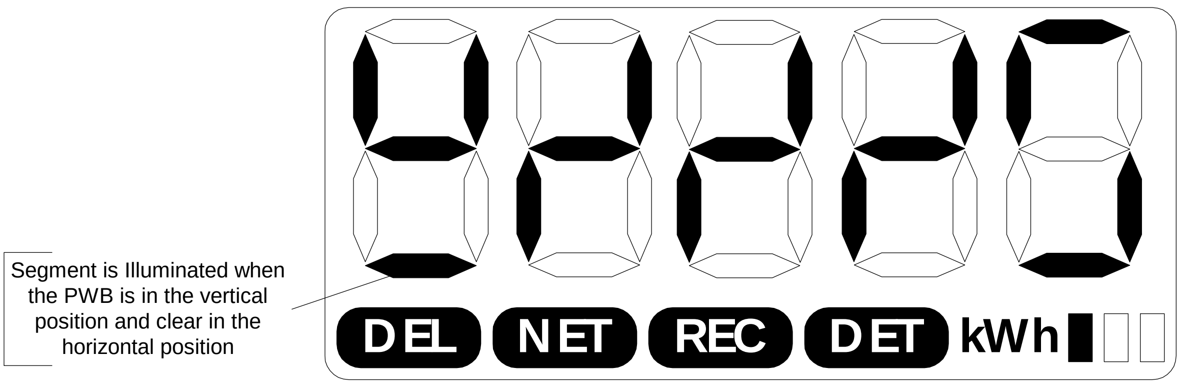

Figure 7 Unprogrammed Manufacturing Segment Test Display

Operational Segment Test

Finally, the ICARE will provide a segment test that can be configured to work with the kWh display.

Note: The watt-disk emulator should continue to operate normally during normal operation independent of the configuration.

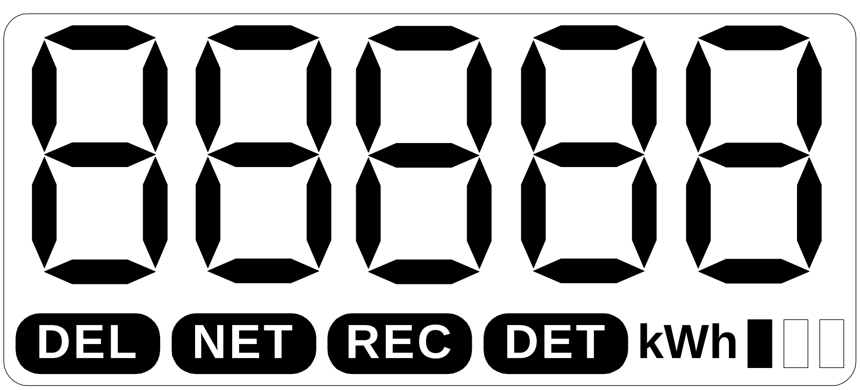

Figure 8 Operational Display Segment Test

Display Configuration Options

The display configuration utilizes one of the following programming codes to enable the energy display and the segment test display. The Upper nibble represents the display time and the lower nibble represents the segment test display time.

Program Code	Description	Display On Time	Display Off Time	Segment Test Time	Display Off Time
F0	Energy Always Displayed	Always	0	0	0
F1	Energy & Segment Test	15 Sec	1 Sec	1 Sec	1 Sec
E0	Energy	14 Sec	1 Sec	0	0
XX	Energy & Segment Test	1-14 Sec	1 Sec	1-15 Sec	1 Sec
0X	Segment Test	0	1 Sec	1-15 Sec	1 Sec

Table 9 Display Configuration Codes

For the time options for the individual program code nibbles are as follows:

Nibble	Display Time
0	0
1	1
2	2
3	3
4	4
5	5
6	6
7	7
8	8
9	9
A	10
B	11
C	12
D	13
E	14
F	15

Table 10 Program Code Display Time (Seconds)

Manufacturing specification

Test Points

The module will contain test points to support manufacturing operations as well as providing necessary access to signals for debugging both the hardware and firmware. Each node of the circuit requires a test point. All the Test points will be used in ICT test whereas only some of the test points will be use to perform the FVT test. Manufacturing is specifying that the test points should be either all on the bottom layer of the board or on the top layer of the board. The number of test point per board should be limited to 102 test points (maximum of 2048 test points available on a fixture and panel of 20 boards). The test point should also be numerated from 0 to 101.

Manufacturability

- The component count cannot exceed 150 components on the design
- The unit must have test points for ICT and FVT testing
- Increase of the number of boards per panel from 16 to 20. Note: This will reduce the total board area and with the new LCD holder it will have an impact on the size of the onboard slot antenna.
- All components have to be surface mount to eliminate any through-hole processes.
- In order to meet the present burden and overhead costs of the RMR, the power supply will have to handle a transmission within 8.2s after power up while test in process.
- During the Meter Functional Test (MFT), the meter will be fully assembled with no external access to the board. A magnet to produce a magnet packet for the CellNet fixed network application will trigger the RF transmissions.

Mechanical guidelines

- The board material structure should follow the following optimum conditions:

    - 4 layers (layer1->14mils->layer2->28mils->layer3->14mils->layer4)
    - Material will be a FR4 (permitivity close to 4.6)
    - Inner layer should be 1oz thick (start and finish), external layer should start with 0.5oz thickness and finish with 1oz thickness
- Copper should stay at 20 mils from the edge of the board after scoring operation (manufacturing cutting operation requirement)
- Use of the new board-to-board connector pads (bigger pads for GND and 240VAC)
- Use of the newest LCD pads developed by mechanical Engineer to decrease problem in manufacturing
- Keep a space for the new bar code developed by manufacturing

Qualification

The module will be able to pass all standard qualification tests per the Schlumberger Electricity Qualification Test Specification listed in the references in section 6.

SYSTEM FIRMWARE REQUIREMENTS

The firmware will be located in the MCU ROM with a maximum of 16 kBytes of code space. The firmware will encompass the functionality of the Cellnet and SURF protocols.

The firmware will be written in "C" for portability requirements. The code will be modular in nature with each unique function having it's own module. This will enhance the reuse capability of the code for future projects. The code will be maintained using version control software at all times.

The firmware should attempt to maintain commonality with existing CENTRON products as much as possible. This will reduce the risk of introducing problems that have already been resolved back into the system. Both the CENTRON and RTEMS teams should review all firmware.

Firmware Description

The firmware will operate in several states shown in figure 2. These states will be used to validate ICARe power levels, support existing serial interfaces, verify and load the static and dynamic data, process metrology and power fail signals, update the LCD, save and verify dynamic data, and create and schedule RF messages for transmissions as needed. This diagram is the "large picture" with the details of the firmware to be presented in the firmware specification document.

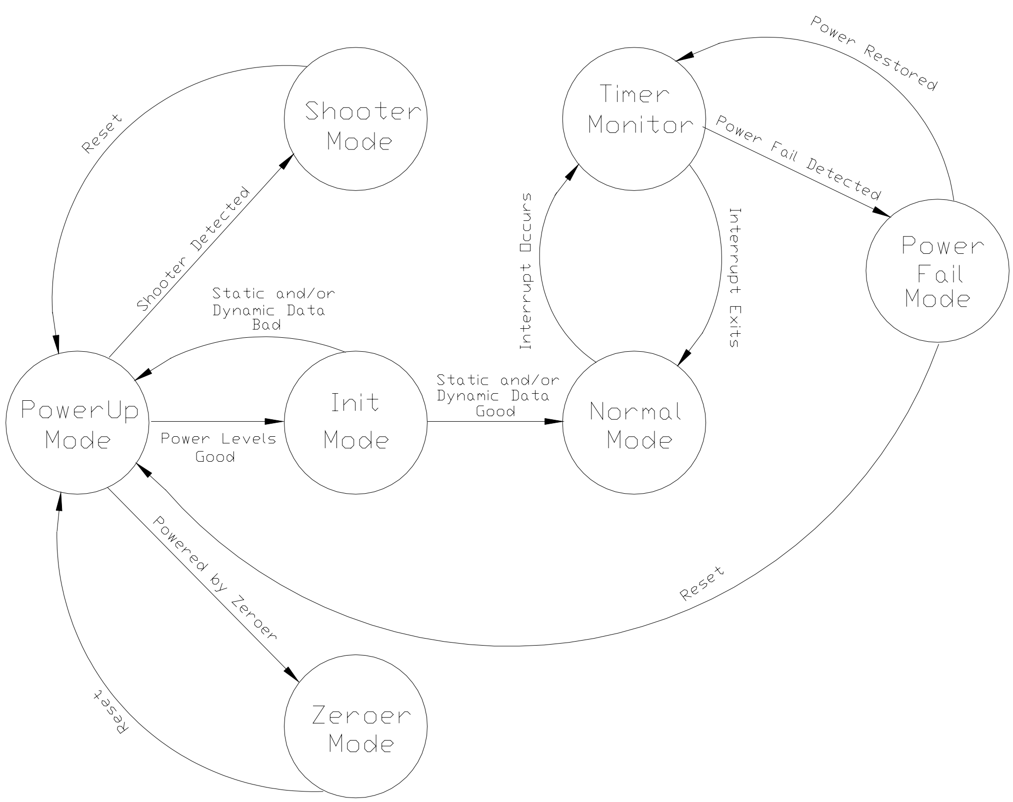

Figure 11 ICARe Modes of Operation

Mode	Description
Power Up	The Power Up mode will be the initial state of the module. It will enter this state upon a power on or watchdog reset. This mode will initialize the MCU's peripherals and then determine when the power levels are sufficient to progress to move onto the initialization mode. This state is exited when: • Shooter detected → Shooter Mode • Powered by Zeroer → Zeroer Mode • Power Levels good → Initialization Mode
Initialization	Once the module has verified that reliable supply power is present, the configuration data will be read from the nonvolatile memory and the module will initialize itself. This state is exited when one of the following conditions are met: • Invalid configuration → PowerUp Mode • Initialization successful → Normal Mode
Normal	This will be the main operating state for the module. In this state the module will update the LCD with the cumulative consumption value determine, implement the EEPROM data saving algorithm, and call functions to schedule and create RF messages for both Mobile and Fixed technologies. A pet of the watchdog is also performed in this normal mode loop. This mode is exited when: • Interruption from Timer Monitor → Timer Monitor Mode This mode is entered when: • Configuration is validated and loaded from Initialization Mode • Timer Monitor interrupt is complete
Shooter	Shooter mode is entered when it is determined that the shooter is connected to the ICARe board. This mode will be used to configure the Fixed configuration parameters as well as other test utilities to support the Fixed network. This state is exited when: • Shooter RxD low for > 1.5 msec forces watchdog reset → PowerUp Mode
Zeroer	Zeroer mode was designed to support RMR using the I2C protocol. After power is determined to come from the Zeroer device, the firmware gathers data and awaits either a read or reset energy command from the user. This state is exited when: • Zeroer voltage is removed and forces reset → Power Up mode
Timer Monitor	The mode is entered via a timed internal interrupt. This interrupt when entered will conduct all metrology signal processing and check signal levels for possible power fail mode entry. This mode also operates as the firmware's freerun timer. This state is exited when: • Power Fail Detected → Power Fail Mode • Completion of tasks → Normal Mode
Power Fail	Power fail mode commences when the Timer Monitor mode detects a possible power fail by evaluating several signals on board the ICARe. This mode is exit when: • Power Fail Detection Confirmed → Resets • Power Restored → Timer Monitor

Table 8 ICARe Firmware Modes

Firmware Requirements

The ICARe firmware will perform the following functions:

- Count energy pulses from the metrology board
- Monitor the sign line from the metrology board for energy flow and open bond detection
- Maintain module CellNet and R300/R900 configuration data in EEPROM
- Maintain module cumulative and interval counts in EEPROM
- Monitor Power Fail and Power Recovery operations
- Update LCD with cumulative consumption and perform temperature compensation
- Load and validate static configuration and dynamic data
- Schedule RF Transmissions

Interface with Serial port

- ESP serial interface capability
- Use standard Shooter interface
- Maintain MMLIB functionality as much as possible
- Support the Zeroer and I^2C functionality for the RMR version

Interface with COSMOS CRF

- SPI serial interface capability
- Provide RF configuration data to CRF
- Confirm RF messages sent

Transmit PID 2 Message Packets to CellNet fixed network

- Nominally transmitted every two native intervals (2.5 minute native interval) with a randomization period of one native interval. Packets could be transmitted from anywhere between 0 to 5 minutes minus one second.
- Consumption data packets, both CUMINT2 and CUMINT3
- Administrative packets, ADMIN3 only
- PowerFail and PowerUp packets
- Magnet Packets

Transmit R300/R900 Message Packets to mobile network

- Consumption data packet
- Nominally transmitted every 2 to 4 seconds randomized

Utilize present CENTRON algorithms in all applications

- Monitor the energy accumulation to detect the metrology bond wire failure
- Monitor the LSYNC line from the metrology board to aid in power fail detection
- Perform EEPROM backup every interval period and 91 Whr

SYSTEM RF OPERATION

RF Characteristics

The COSMOS RFASIC is designed to provide both direct sequence spread spectrum (DSSS) and frequency hopping OOK transmissions in the 902 – 928 MHz ISM band. The characteristics of the transmitters for both the fixed (DSSS) and mobile transmitters are detailed in section 3 of the COSMOS RF ASIC Requirements Specification.

Fixed Network Description

The fixed network RF transmitter is designed for integration into the Cellnet by Atos Origin Fixed RF Network. The RF transmitter specifically works within the Cellnet RF local area network (LAN) in the unlicensed 900 MHz ISM band. The transmitter complies with title 47, part 15, section 247 of the FCC rules for radio frequency devices.

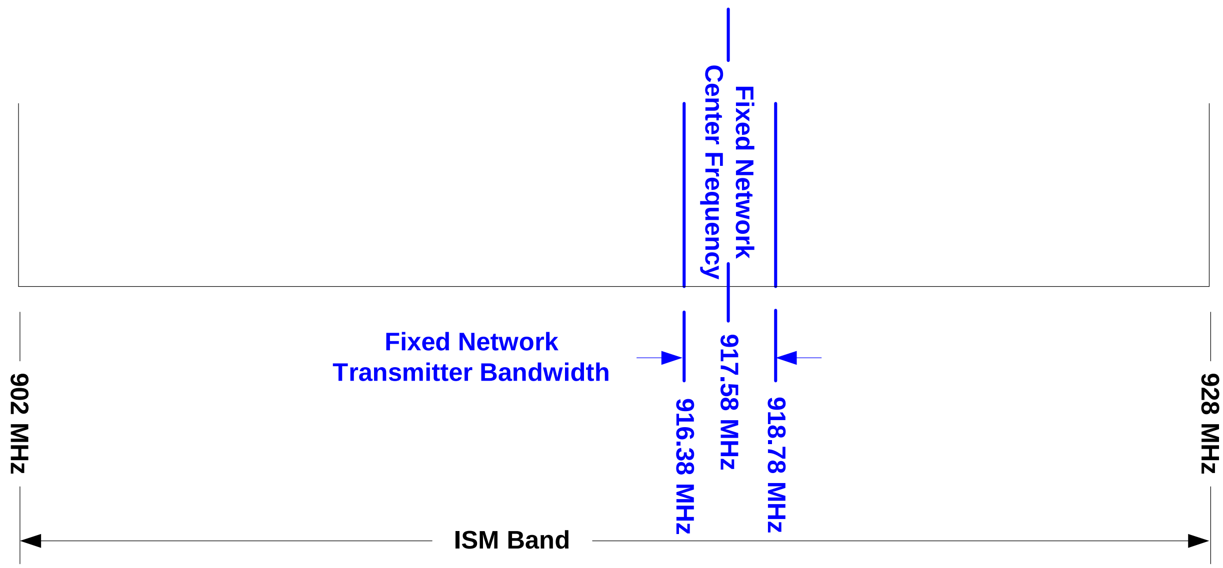

Figure 12 Fixed Network Bandwidth

Spreading Code

The COSMOS RFASIC is capable of both On-Off Keying (OOK) and Cyclic Code Shift Keying (CCSK) for RF data transmission based on the requirements of the network. The 917.58 MHz carrier is Binary Phase Shift Keying (BPSK) modulated with a 63-bit pseudorandom code sequence. This COSMOS RFASIC design contains only one DSSS RF channel. For details about the OOK and CCSK messages refer to the ICARe RF Protocols Specification.

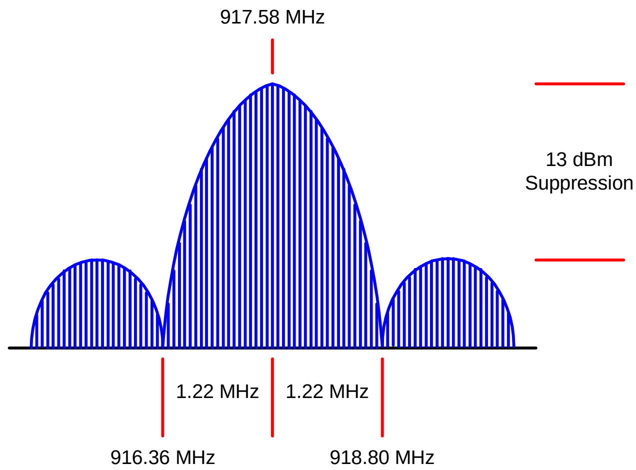

Figure 13 Fixed Network DSSS Pattern

Mobile Network Description

The mobile network works within the 900 MHz ISM band using an OOK transmitter. The COSMOS RF is capable of providing 50 channels with 196.5 kHz channel spacing, 64 channels with 131.072 kHz channel spacing or 128 channels with 65.536 kHz channel spacing.

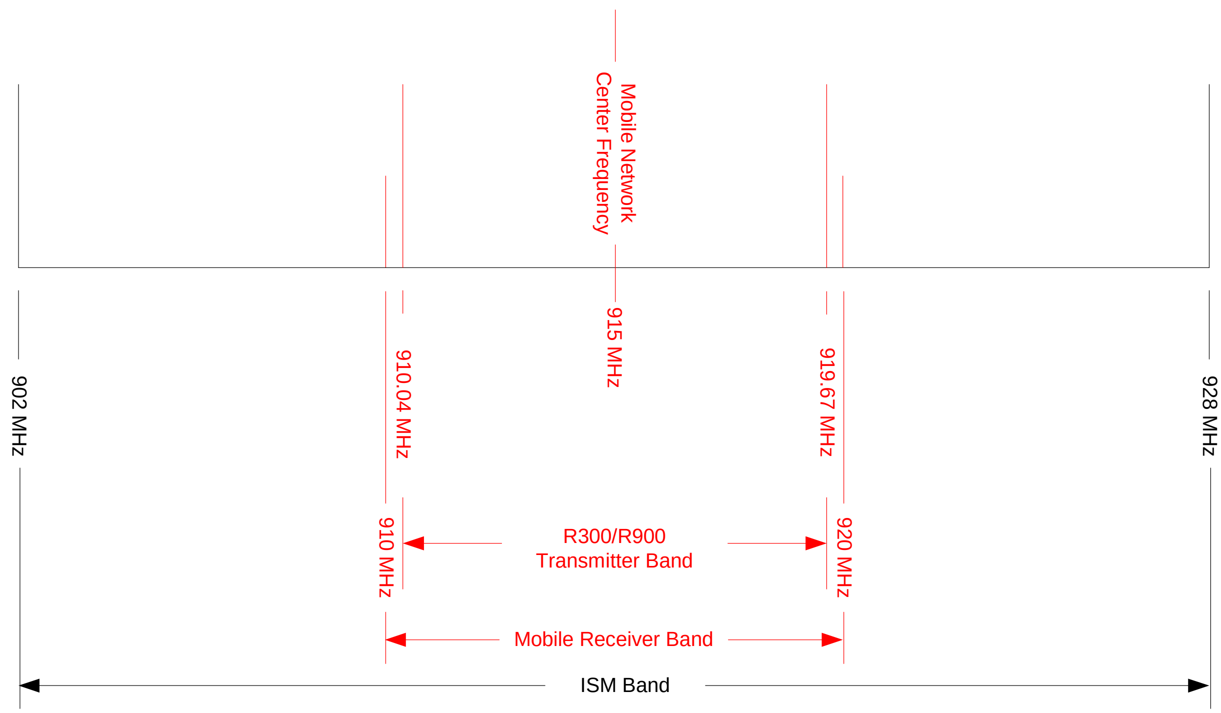

Figure 14 Mobile Network Transmission Bandwidth

R300 / R900 Transmissions

The R300 and R900 use two different transmission methods that should be noted. The R900 transmissions are standard On-Off-Keying (OOK) while the R300 is a Manchester encoded signal. The R900 transmitter basically turns the amplifier on and off to represent a 1 and a 0 respectively for the OOK. The R300 Manchester encoded signal actually is a double chipset that has a 1 to 0 transition to represent a 1 and a 0 to 1 transition to represent a 0.

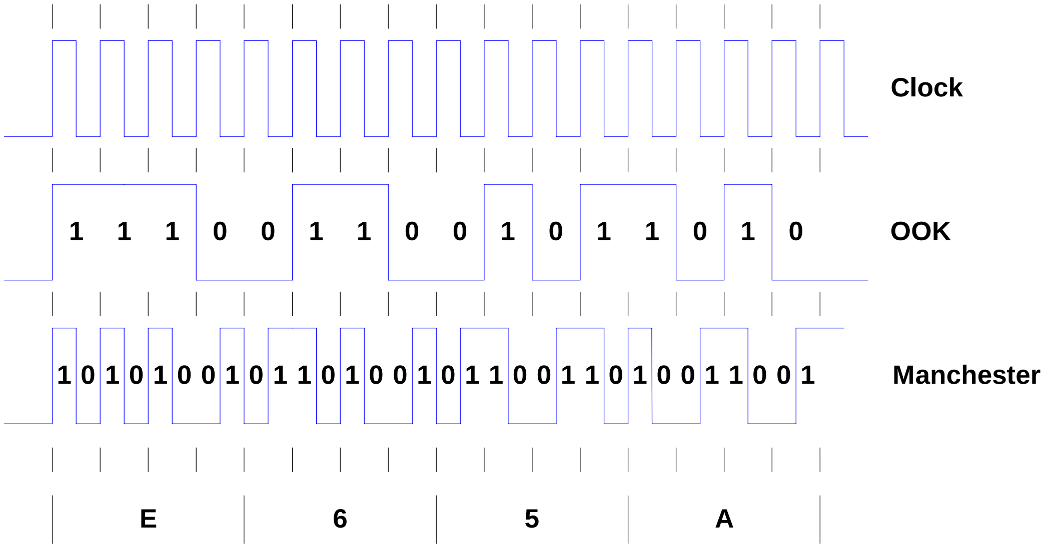

Figure 15 Mobile OOK versus Manchester Encoding

Transmission Randomization

The ICARe will have the ability to transmit multiple data protocols from the same meter. The data will be converted to the proper protocol and then transmitted on an interval period loaded during configuration.

Fixed Network Randomization

The randomization of the fixed network takes place over a 150 second native interval from the EOI which is the default setup. The normal operation for most deployed residential fixed network endpoints are two native intervals of data per transmission. That means that while 150 seconds of interval data is collected, transmissions occur every 300 seconds. The randomization values will be between minimum of 1 second and a maximum of 140 seconds to allow for an additional clearance time of the message transmission.

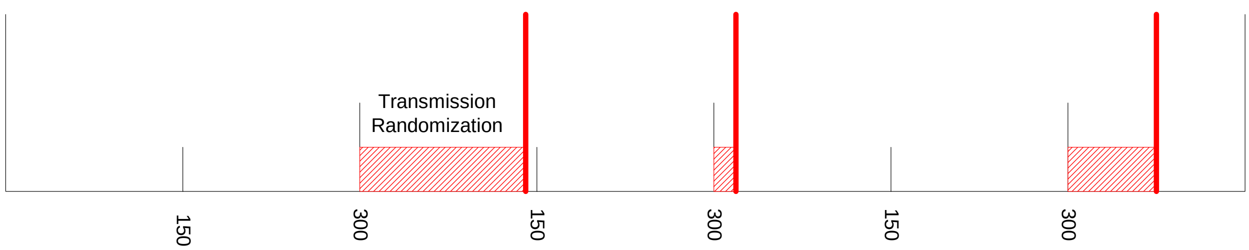

Figure 16 Fixed Network Interval Randomization

Fixed Network Intervals

The fixed network transmissions include cumulative and interval data. There are two formats for the messages that can be transmitted. The first format is a Cumulative 2 (CumInt2) message that has 18 bytes of interval data that is transmitted along with the total energy cumulative count. Since the normal setup for the residential transmitter is to transmit every other native interval each transmission will include 2 intervals (300 seconds) of data. For the residential meter the data is the total energy accumulated during the interval.

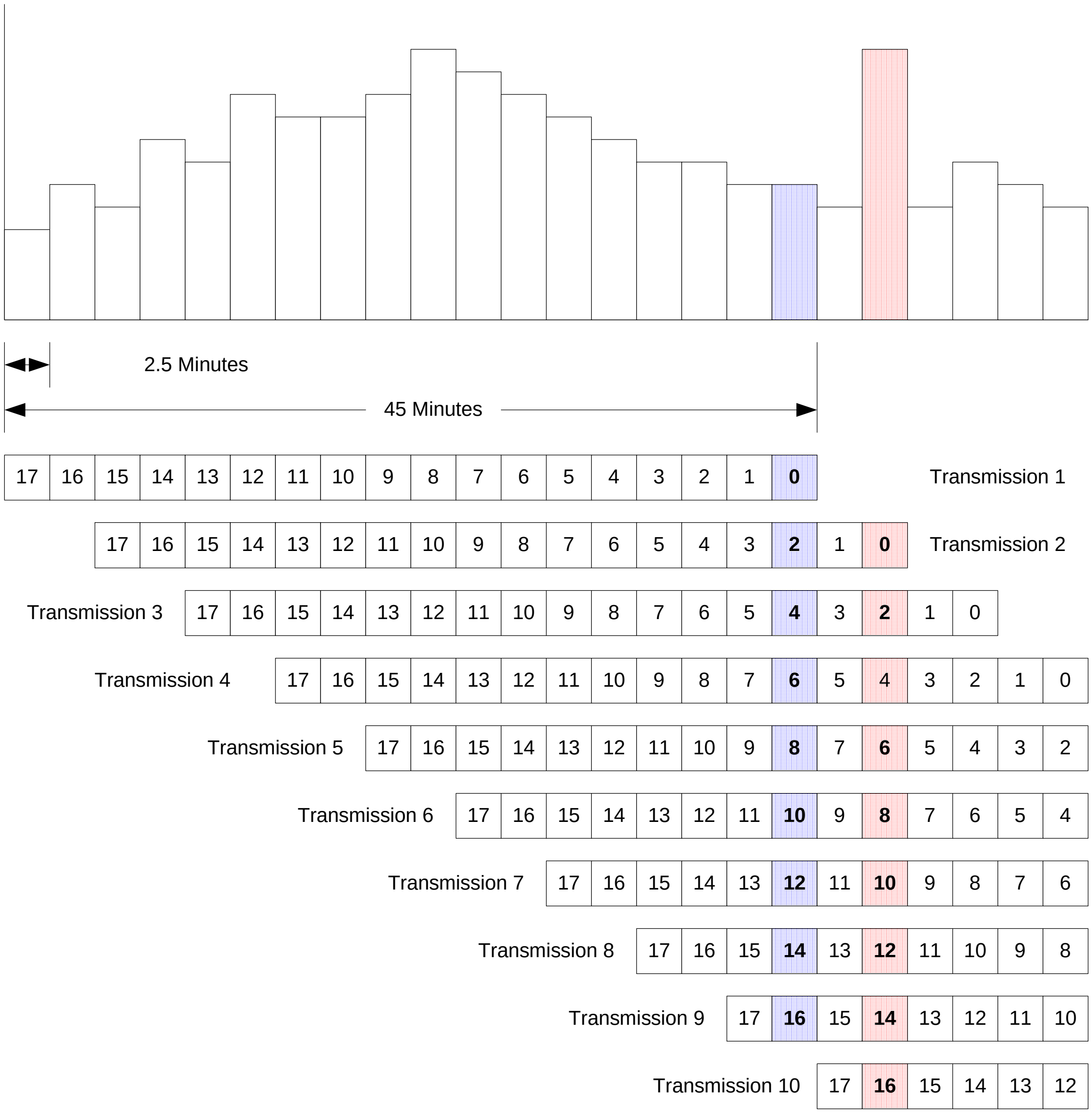

Figure 17 Cumulative 2 with 18 Intervals

The second format is a Cumulative 3 (CumInt3) message that has 10 15-bit intervals of data that is transmitted along with the total energy cumulative count. This message operates in a similar fashion to the cumulative 2 message.

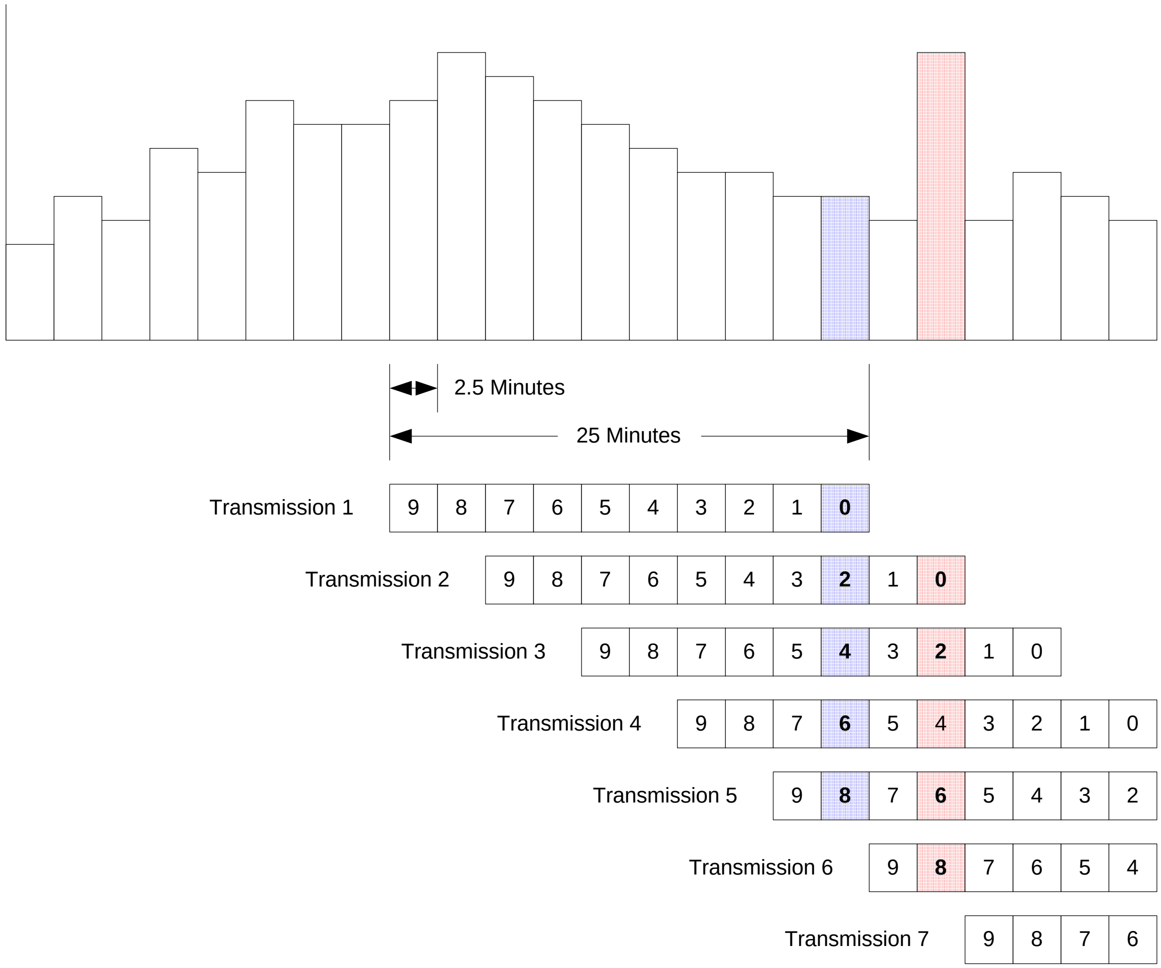

Figure 18 Cumulative 3 with 10 Intervals

R300 / R900 Mobile Network Randomization

The randomization of the R300 / R900 mobile network takes place over a 1 second interval. The normal operation for the mobile network is one transmission per second randomized. The mobile transmitter will transmit the cumulative data as it is updated as opposed to the native interval method of the fixed network.

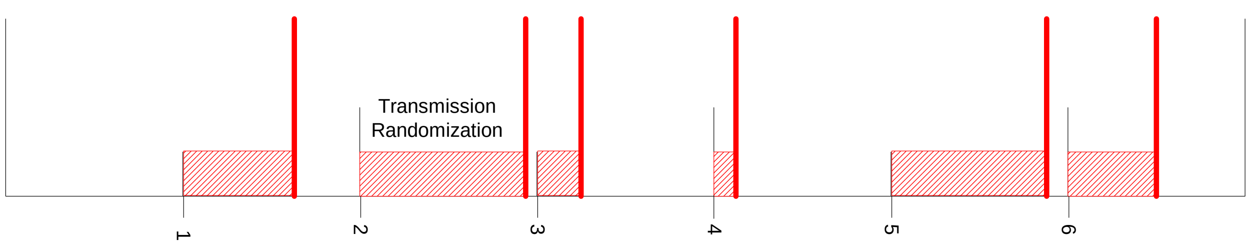

Figure 19 Mobile Network Randomization

Mobile Channel Selection

Based on the equation given in the COSMOS RF specification version 2.4 the following table should give the correct N & M values to correspond with one of the allocated frequencies.

Value	Channel Frequency	Channel No.	Value	Channel Frequency	Channel No.	Value	Channel Frequency	Channel No.
1615	910962087	1	1657	913714041	22	1699	916465994	43
1617	911093133	2	1659	913845086	23	1701	916597040	44
1619	911224178	3	1661	913976132	24	1703	916728085	45
1621	911355224	4	1663	914107177	25	1705	916859130	46
1623	911486269	5	1665	914238222	26	1707	916990176	47
1625	911617314	6	1667	914369268	27	1709	917121221	48
1627	911748360	7	1669	914500313	28	1711	917252267	49
1629	911879405	8	1671	914631359	29	1713	917383312	50
1631	912010451	9	1673	914762404	30	1715	917514357	51
1633	912141496	10	1675	914893449	31	1717	917645403	52
1635	912272541	11	1677	915024495	32	1719	917776448	53
1637	912403587	12	1679	915155540	33	1721	917907493	54
1639	912534632	13	1681	915286586	34	1723	918038539	55
1641	912665678	14	1683	915417631	35	1725	918169584	56
1643	912796723	15	1685	915548676	36	1727	918300630	57
1645	912927768	16	1687	915679722	37	1729	918431675	58
1647	913058814	17	1689	915810767	38	1731	918562720	59
1649	913189859	18	1691	915941813	39	1733	918693766	60
1651	913320905	19	1693	916072858	40	1735	918824811	61
1653	913451950	20	1695	916203903	41	1737	918955857	62
1655	913582995	21	1697	916334949	42	1739	919086902	63
						1741	919217947	64

Table 9 Mobile 64 Channel Selections

Value	Channel Frequency	Channel No.	Value	Channel Frequency	Channel No.	Value	Channel Frequency	Channel No.
1601	910044770	1	1652	913386427	18	1703	916728085	35
1604	910241338	2	1655	913582995	19	1706	916924653	36
1607	910437906	3	1658	913779563	20	1709	917121221	37
1610	910634474	4	1661	913976132	21	1712	917317789	38
1613	910831042	5	1664	914172700	22	1715	917514357	39
1616	911027610	6	1667	914369268	23	1718	917710925	40
1619	911224178	7	1670	914565836	24	1721	917907493	41
1622	911420746	8	1673	914762404	25	1724	918104062	42
1625	911617314	9	1676	914958972	26	1727	918300630	43
1628	911813882	10	1679	915155540	27	1730	918497198	44
1631	912010451	11	1682	915352108	28	1733	918693766	45
1634	912207019	12	1685	915548676	29	1736	918890334	46
1637	912403587	13	1688	915745244	30	1739	919086902	47
1640	912600155	14	1691	915941813	31	1742	919283470	48
1643	912796723	15	1694	916138381	32	1745	919480038	49
1646	912993291	16	1697	916334949	33	1748	919676606	50
1649	913189859	17	1700	916531517	34			

Table 10 Mobile 50 Channel Selections

Rcvr Chan	Rcvr Chan Frequency	Rcvr Chan	Rcvr Chan Frequency	Rcvr Chan	Rcvr Chan Frequency
102	910032474	76	913440346	50	916848218
101	910163546	75	913571418	49	916979290
100	910294618	74	913702490	48	917110362
99	910425690	73	913833562	47	917241434
98	910556762	72	913964634	46	917372506
97	910687834	71	914095706	45	917503578
96	910818906	70	914226778	44	917634650
95	910949978	69	914357850	43	917765722
94	911081050	68	914488922	42	917896794
93	911212122	67	914619994	41	918027866
92	911343194	66	914751066	40	918158938
91	911474266	65	914882138	39	918290010
90	911605338	64	915013210	38	918421082
89	911736410	63	915144282	37	918552154
88	911867482	62	915275354	36	918683226
87	911998554	61	915406426	35	918814298
86	912129626	60	915537498	34	918945370
85	912260698	59	915668570	33	919076442
84	912391770	58	915799642	32	919207514
83	912522842	57	915930714	31	919338586
82	912653914	56	916061786	30	919469658
81	912784986	55	916192858	29	919600730
80	912916058	54	916323930	28	919731802
79	913047130	53	916455002	27	919862874
78	913178202	52	916586074	26	919993946
77	913309274	51	916717146	25	920125018

Table 11 Receiver Channels

SPECIFICATIONS & STANDARDS

Specifications

Electrical

Voltage Ratings: 120V & 240V ± 20%

- Frequency: 60 Hz ± 5%

Operating Environment

- Temperature: -40° C to +85° C
- Humidity: 0 to 95% relative humidity, noncondensing
- Accuracy: ± 0.5%
- Transient/Surge Suppression: ANSI C37.90.1-1994
  IEC 61000-4-4
  ANSI C62.45-1992
- High Voltage Surge: ANSI C62.41
- Electrostatic Discharge (ESD): ANSI C12.1-2001,
  10 pulses of 15kV direct contact to meter enclosure per IEC 61000-4-2
- Radio Frequency Interference (RFI): EMI/RFI fields of between 15 V/m for all frequency ranges between 14 kHz and 10 GHz.

Meter Base Requirements

The ICARe will be required to work in CENTRON meter with the following form, class, and voltage ratings:

Class	Volts	Form
20	120	3S
20	240	3S
20	240	4S
100	120	1S
200	120	12S
200	120	25S
200	240	2S
320	240	2S

Table 12 Meter Specification Types

External Standards

ANSI Standards

The system will be required to meet the following standards.

- ANSI C12.1 - 2001
- ANSI C12.20 (Class 0.5) – 1998 as a minimum requirement since the present metrology/base unit was certified under this standard. If at all possible, the meter should strive to qualify under the newer ANSI C12.20 (Class 0.5) –2002 specification where possible.

FCC Regulations

These regulations will be required to be verified using the in-house RF test facility for verification and a

FCC certified RF OATS test facility for certification.
CFR Title 47,Part 15, Subpart C, Paragraph 247

Applicable section for 902-928 MHz include:

Field strength of fundamental: 500 mV/m @ 3m
Field strength of harmonics: 1.6 mV/m @ 3m

"Frequency hopping systems shall have channel frequencies separated by a minimum of 25 KHz or 20 dB bandwidth of the hopping channel whichever is greater. Hopping channels are selected at the system hopping rate from a pseudorandomly ordered list of hopping frequencies. Each frequency must be used equally on the average by each transmitter."

"If the 20 dB bandwidth of the hopping channel is less that 250 KHz, the system shall use at least 50 hopping frequencies and the average time of occupancy on any frequency shall not be greater than 0.4 seconds within a 20 second period; if the 20 dB bandwidth is 250 KHz or greater, the system shall use at least 25 hopping frequencies and the average time of occupancy on any frequency shall not be greater that 0.4 seconds within a 10 second period. The maximum allowed 20 dB bandwidth of the hopping channel is 500 KHz."

"The maximum peak output power of the intentional radiator shall not exceed 1 watt for systems employing at least 50 hopping channels; and, 0.25 watts for systems employing less than 50 hopping channels."

"If transmitting antennas of directional gain greater that 6 dBi are used the peak output power from the intentional radiator shall be reduced below the stated values above as appropriate, by the amount in dB gain of the antenna exceeds 6 dBi."

CFR Title 47,Part 15, Subpart C, Paragraph 249

Applicable sections include:

Field strength of fundamental: 50 mV/m @ 3m
Field strength of harmonics: 500 uV/m @ 3m

"Emissions radiated outside of the specified frequency bands, except for harmonics, shall be attenuated by at least 50 dB below the level of the fundamental or to the general radiated emission limits whichever is the lesser attenuation."

Internal Standards

The following internal quality standards will apply to this project.

- N-Q001 : Quality Manual
- N-Q017 : Documentation & Control of Changes
- N-Q034 : ECN
- N-Q043 : Calibration, Traceability of Electronic Measuring Equipment
- N-Q050 : ESD Control
- N-Q057 : Identifying the Latest Revision of Engineering Drawings
- N-Q071 : Initiating & Releasing New Engineering Drawings
- N-Q075 : Control of Software
- N-B010 : IPO Management