TECHNICAL SPECIFICATION: TRANSMITTER

1) RF Thermometer Overview:

The Headwaters RF Thermometer is a portable 4-channel 315 MHz telemetry system for remote indoor / outdoor temperature monitoring, with a minimum useable range of 60 meters.

2) Remote Sensor / Transmitter:

The remote sensor / transmitter is the unit consisting of the 315 MHz RF oscillator PCB and the temperature-sensing OKI 64162A microcontroller PCB. The unit transmits 885 millisecond data packets on a randomized schedule of approximately twice per minute, with no less than 30 seconds between transmissions. The average duty cycle of any 100 millisecond portion of the transmission does not exceed 50 percent, permitting a 6 dB increase in the peak output power from the transmitter. The sensor / transmitter is designed to function over a temperature range of -40 C to + 60 C, with accurate temperature measurements over a range of -40 C to + 40 C. The measurement accuracy is + / - 1.0 C or better over -40 C to +40 C range with a resolution of 0.1 C. For less critical applications (eg. indoor use) the lithium cells may be replaced by 1.5 volt alkaline cells. The unit will operate for at least 1 year on two 1.5 volt AA lithium cells.

The RF oscillator is SAW resonator -stabilized, using a one-transistor Pierce-like configuration. A loop antenna is etched on the PCB. The oscillator is turned ON by applying +3 volts to the data input (transistor base) from a CMOS output pin of the 64162A microcontroller. The microcontroller performs the functions of measuring temperature, displaying the temperature on a liquid crystal display, checking battery voltage, sensing the channel ID settings, and sending the data to the transmitter at the appropriate times. The 64162A uses a 32768 Hertz quartz watch crystal for the clock generator. A thermistor is used for temperature sensing.

The 885 millisecond transmission consists of a preamble followed by 5 identical data frames. Each frame contains a 16-bit channel ID code, a battery status flag, a Centigrade / Fahrenheit flag, and 4 BCD temperature digits. A total of 439 bits is sent. A Manchester-like encoding technique is used for the data frames.

2a) RF Oscillator PCB:

Supply voltage = 3 volts from (2) AA 1.5 volt lithium cells
Supply current = approximately 0.75 milliamps (for 50 % duty cycle transmission).
On/off keying (OOK) modulation with 315 MHz carrier.
R.F. field strength with 50% duty cycle data (averaged over a 100 mS window) will be a maximum of 2418 microvolts/metre @ 3 metres (6 dB higher than for an unmodulated continuous wave carrier) as per F.C.C. regulations.
Keying rate 496 bits/second .
Harmonic levels sufficiently low to comply with F.C.C. regulations..

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2b) Microcontroller PCB:

This board uses an OKI 64162A mask-programmed single chip CMOS 4-bit microcontroller, with a supply voltage of 3 volts and a 32768 Hz clock frequency (quartz watch crystal). The typical microcontroller supply current is 15 microamperes. A negative temperature coefficient thermistor is used for temperature sensing. The 64162A TO pin (transmit out) goes from ground to + 3 volts to activate the 315 MHz oscillator.

Production test points:
a) Force to Transmit test point - this initiates a transmission whenever activated by user.
b) 200 Hz test point - this produces a 315 MHz carrier keyed by a 200 Hz square wave from the 64162.

User Inputs:
a) Centigrade / Fahrenheit - select the units in which temperature is displayed and transmitted.
b) Channel ID - two DIP switches (containing 4 SPST switches each) allow selection between 8 preset 16-bit ID codes in 2 banks. (Each sensor uses a different ID code. The receiver can be set to look for either Bank A or Bank B. This is to minimize the problem of interference from a neighboring RF thermometer system).

Other Details:
The battery low detect function (internal to 64162A) is used to set a flag in the transmission if the batteries become weak . The low battery condition is one of several conditions which will generate an alarm condition in the receiver.
The microcontroller initiates data transmissions at random intervals (every 30 to 60 seconds). The connections between the transmitter and the 64162A are +3 V, GROUND and DATA.

Data Format for Headwaters RF Thermometer

FCC ID: NKJHWRF01TI

Transmission bit rate is 496 bits/second. Bit duration is 2.016 milliseconds. Total transmission duration is 885 milliseconds. The duty cycle is 50 percent .

The transmission begins with a preamble, followed by 5 data frames. Each frame contains a wait (low) pulse, a sync (high) pulse, a start (low) pulse, a 16-bit channel ID word (hardware set with DIP switches and PCB jumpers), a 4-bit setup word, and a 16-bit BCD temperature word. The preamble is a square-wave train, consisting of 20 high pulses and 19 low pulses. Total of 39 bit periods. b) The wait pulse is low for 2 bit periods. c) The sync pulse is high for 4 bit periods. d) The start pulse is low for 2 bit periods. e) The data is sent as (bit) followed by (complement of bit). This means that the 16-bit I.D. is represented by 32 bits , the 4-bit setup word is represented by 8 bits, and the 16-bit temperature is represented by 32 bits. The complete transmission is (80 x 5) + 39 = 439 bit periods in duration.

Data Format for Headwaters RF Thermometer

Example of Complete Transmission:

Channel ID = 1101 0011 0101 1000 = D358

Temperature = 024.7 (always transmitted in Fahrenheit) = 0000 0010 0100 0111 = 0247

Setup Word = (positive temperature, unused bit, unused bit, battery good) = 1010

The bits are converted so 0's are represented by 01 and 1's are represented by 10. Using this, the data becomes:

Channel ID = 1010 0110 0101 1010 0110 0110 1001 0101

Setup Word = 1001 1001

Temperature = 0101 0101 0101 1001 0110 0101 0110 1010

Actual Transmission:

1010 1010 1010 1010 1010 1010 1010 1010 1010 101		preamble
00	wait	FRAME 1
1111	sync	
00	start	
1010 0110 0101 1010 0110 0110 1001 0101		channel ID
1001 1001	setup data	
0101 0101 0101 1001 0110 0101 0110 1010		temperature
00	wait	FRAME 2
1111	sync	
00	start	
1010 0110 0101 1010 0110 0110 1001 0101		channel ID
1001 1001	setup data	

Data Format for Headwaters RF Thermometer

0101 0101 0101 1001 0110 0101 0110 1010 temperature

00 wait FRAME 3

1111 sync

00 start

1010 0110 0101 1010 0110 0110 1001 0101 channel ID

1001 1001 setup data

0101 0101 0101 1001 0110 0101 0110 1010 temperature

00 wait FRAME 4

1111 sync

00 start

1010 0110 0101 1010 0110 0110 1001 0101 channel ID

1001 1001 setup data

0101 0101 0101 1001 0110 0101 0110 1010 temperature

00 wait FRAME 5

1111 sync

00 start

1010 0110 0101 1010 0110 0110 1001 0101 channel ID

1001 1001 setup data

0101 0101 0101 1001 0110 0101 0110 1010 temperature

0000 0000 .....0000 0000 0000 ..... Next transmission.

The entire transmission consists of 439 bits in 885 milliseconds.