1 GENERAL DESCRIPTION

The EUT consists of three products EMTR, RMTR, and the HHTR.

All three products are capable of communicating with each other, so by necessity all RF parameters such as modulation type, data rate, channel frequencies, etc. are the same in each. During a communications session, one radio is the master and one radio is the slave. Master radios determine the hop sequence, while slave radios follow.

In the case of an EMTR <> RMTR session, the EMTR is the master. For an EMTR <> HHTR session, the HHTR is the master, and for a RMTR <> HHTR session, the HHTR is the master. In no case is the RMTR a master.

The antenna is permanently attached to the PCB and the Antenna is internal on all three EUT's. Therefore it meets the 15.203 Requirement.

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1.1 System overview

The RF link between TWACS transceivers uses a range of frequencies between 902 MHz and 928 MHz. This range is divided into 79 channels. Fifty channels are needed to satisfy the FCC's minimum channel set requirements, so 50 of the 79 were chosen for use. Five of these 50 channels are reserved for link acquisition and the other 45 are used for link maintenance (packets transmitted after a link has been acquired). The acquisition channels are spaced evenly throughout the upper end of the 50-channel set. The 45 link maintenance channels are used in a random manner while a link is active between transceivers. The radio transceivers are equipped with folded dipole antennas. Folded dipoles were chosen because of their broader radiation pattern as compared with regular dipoles, this guarantees a better radio coverage under a variety of field installation conditions utilities may find. Operationally, TWACS transceivers can play one of two roles during an RF session: A transceiver that requests a link is the *requestor* transceiver; a transceiver that replies to that request is an *acceptor* transceiver. TWACS transceivers can be characterized by their roles as shown in Table 1:

Table 1 – Roles of DCSI's Radio Transceivers

Transceiver	Type	Can request a link from	Can grant a link to
EMTR	Acceptor	None	an RMTR or an HHTR
RMTR	Requestor	an EMTR or an HHTR	None
HHTR	Both	an EMTR	an RMTR

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As can be seen, EMTRs never request a link; they are always acceptor transceivers. By contrast, RMTRs never grant a link; they are always requestor transceivers. The HHTR, since it must be able to communicate with both EMTRs and RMTRs, can act as either an acceptor transceiver (with an RMTR) or a requestor transceiver (with an EMTR). The reason this distinction is important is that the acceptor transceiver always controls the channels hop sequence. This means that an EMTR always controls the hop sequence. An HHTR controls the sequence when communicating with an RMTR. An RMTR never controls the hop sequence. Bear in mind that this distinction between acceptor and requestor transceivers is strictly operational. It is not a functional difference because the same RF transceiver and RF engine code are used on all transceivers.

The RMTR is a battery-powered device. In order to maximize battery life, the RMTR is powered off as much as possible. The requirement to maximize battery life drives a number of other factors in the system. One implication of this is that the normal Master/Slave relationship, evident throughout the design, which begins at the CCE, now ends at the EMTR. The EMTR cannot wake up the RMTR to establish a session, but can take control of a session once it is established by the RMTR. The RMTR is designed to wake up once an hour and create a session with an EMTR. Any unknown data is uploaded at that time from the RMTR to the EMTR. At any given time, the EMTR knows nearly everything the RMTR knows, plus it maintains engineering data to describe the quality of the radio link. The CCE may access this data upon demand. The EMTR maintains an "acquisition list" table. Each RMTR is categorized as belonging to a certain type of service. The various types are: Electric, Water, Gas, and Propane. A number of ports are supported for each service type. The CCE reads data from the appropriate port in order to obtain information.

The RMTR unit wakes up once an hour to take a reading from a wired encoder. The encoder's reading as well as the unit's serial number determines when the RMTR will attempt to transfer that reading via RF to an EMTR. At the calculated time interval (anywhere from 10 to 25 minutes past the above reading time), the RMTR wakes up again and attempts to contact an EMTR. If the contact is successful, the data is transferred. This occurs on multiple channels and is less than 1 second in total on-air time. The system does not have any retry capability *during* a session, so the session time can be less than 1 second total in the event of a data error in a packet.

If the contact is not successful or a data error occurs, the RMTR sleeps for 10 minutes and tries again. There are at most 4 attempts to contact an EMTR during any given hour. There are no ongoing sessions. All sessions are less than one second in length, and always occur over multiple channels. It is not possible to violate the 400mS in 20 second rule because the hop sequence never repeats during a session.

1.2 System Receiver Input Bandwidth

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System Receiver Input Bandwidth: The receiver employs a ceramic filter to limit the receive noise bandwidth to approximately 1.5 times the width of the transmitted signal. This is a practical value based on component tolerances and allowances for drift.

1.3 System Receiver Hopping Capability

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System Receiver Hopping Capability: Every transmitted packet from a master radio has a byte reserved for "next channel". The receiver uses this value to shift frequencies (channels) in synchronization with the master radio.

1.4 Section 15.247(g) and (h) Hopping Requirements

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The synthesizer in the units is capable of tuning 79 channels in the 902-928 band, but only fifty channels are defined for communications (see the attached "DCSI Channel Allocation" table). Five of these are defined as acquisition channels (shown as "acquisition" on the attached "DCSI Channel Allocation" table).

A session begins by the transmission of a small "RTS" packet on the acquisition channel with the lowest RSSI. If no response is heard, the next acquisition channel is attempted. This is continued until acquisition occurs but stops prior to violation of the "400 milliseconds in 20 seconds rule" on any channel.

Initial hop_index for the hop sequence is computed by the master with the following algorithm:

Hop_index = Current_Time MOD Max_Frequency

Where Current_Time increments by one every 2.5 seconds of real time, and Max_Frequency is a constant and defined as 45. This computation results in a hop index of between 0 and 44, which is used as an index into the hop table (see the attached "Hop Table" definition). Once this initial point in the hop table is computed, subsequent packet exchanges simply increment this index by one for each exchange. Since a session can occur at any time, Current_Time can be any value.

In practice there is never a session that is long enough to cause the hop_index to roll back around to where it started. In fact, most complete sessions are less than a second long.

DCSI Channel Allocation

Channel	Frequency (Hz)	Usage	Channel	Frequency (Hz)	Usage
3	903275806.45161	session	65	923275806.45161	session
4	903598387.09677	session	66	923598387.09677	session
5	903920967.74194	session	67	923920967.74194	session
6	904243548.38710	session	68	924243548.38710	acquisition
7	904566129.03226	session	69	924566129.03226	session
8	904888709.67742	session	70	924888709.67742	session
9	905211290.32258	session	71	925211290.32258	session
10	905533870.96774	session	72	925533870.96774	session
11	905856451.61290	session	73	925856451.61290	session
12	906179032.25807	session	74	926179032.25807	session
13	906501612.90323	session	75	926501612.90323	session
41	915533870.96774	acquisition	76	926824193.54839	session
42	915856451.61290	session	77	927146774.19355	acquisition
43	916179032.25807	session	78	927469354.83871	session
44	916501612.90323	session	79	927791935.48387	session
45	916824193.54839	session			
46	917146774.19355	session			
47	917469354.83871	session			
48	917791935.48387	session			
49	918114516.12903	session			
50	918437096.77419	acquisition			
51	918759677.41936	session			
52	919082258.06452	session			
53	919404838.70968	session			
54	919727419.35484	session			
55	920050000.00000	session			
56	920372580.64516	session			
57	920695161.29032	session			
58	921017741.93548	session			
59	921340322.58065	acquisition			
60	921662903.22581	session			
61	921985483.87097	session			
62	922308064.51613	session			
63	922630645.16129	session			
64	922953225.80645	session			

DCSI Hop Table

Index	Channel
0	42
1	52
2	11
3	5
4	72
5	76
6	64
7	79
8	47
9	74
10	10
11	67
12	7
13	78
14	4
15	49
16	43
17	51
18	48
19	66
20	6
21	44
22	65
23	12
24	71
25	8
26	57
27	13
28	73
29	45
30	60
31	63
32	3
33	75
34	61
35	46
36	70
37	58
38	9
39	53
40	56
41	62
42	54
42	69
44	55