Electrical Infrastructure Research Team (EIRT) Update

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Electrical Infrastructure Research Team (EIRT)

- **The EIRT was formed in 2011 to investigate lighting infrastructure improvements that optimize power delivery and performance to airfield components that use Light Emitting Diodes (LEDs).**
- **The EIRT participants include the following:**
  - FAA Researchers
  - Lighting Manufacturer Product Design Engineers
  - Academic Researchers
  - Airfield Lighting Subject Matter Experts

EIRT Testing

- **Evaluation of architectural concept infrastructures was completed in 2018.**
- **The evaluation included testing at the FAA Cape May Research Taxiway.**

Cape May Testing

- **Testing included a series of stress conditions to assess operational margins and overall suitability for the airport environment.**

Cape May Testing

- The Fixture Centric Architecture was developed as a “Strawman” to demonstrate and gather data from this architectural approach.
- Most of the testing related to low level communications and circuit electrical characteristics to determine if the infrastructure performed well, and was robust
- A summary was presented at the 2018 IES and also in a report identifying a fixture centric architecture to be detailed in a requirements document

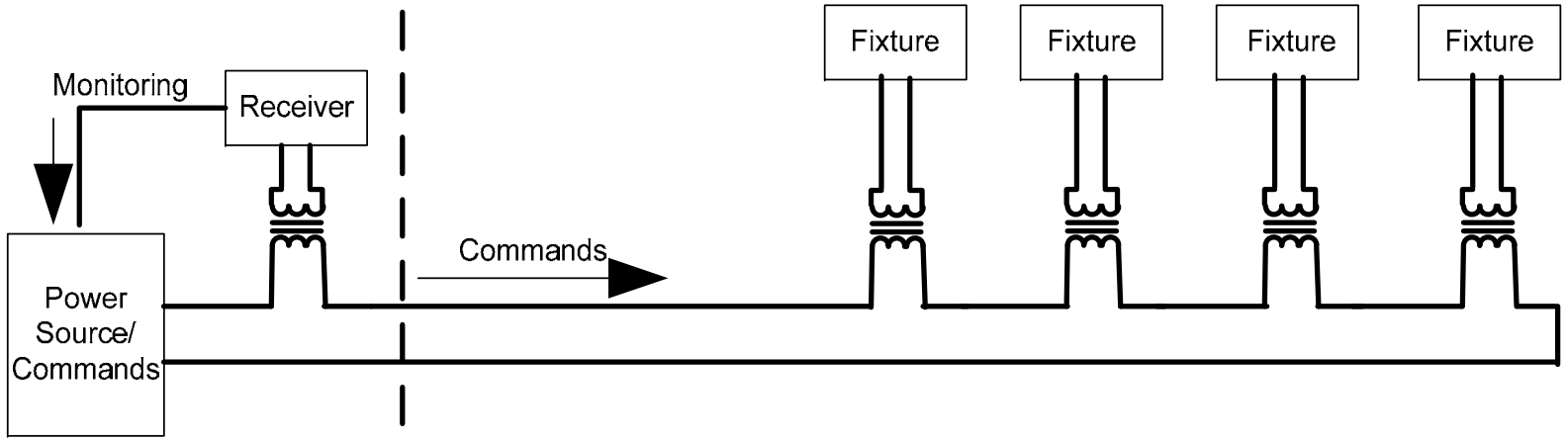
Fixture Centric Architecture

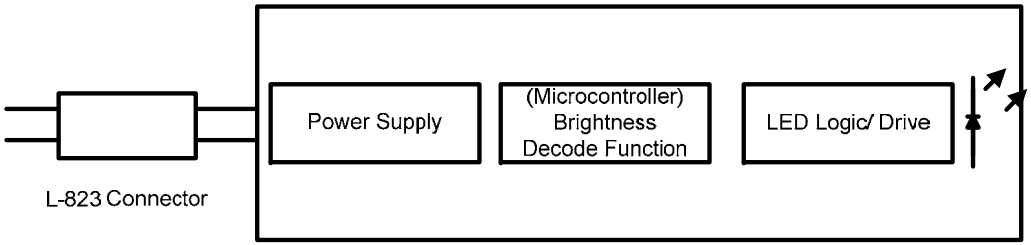
- The fixture (or field device) maintains its intensity locally.
- Not directly dependent on circuit current
- Intensity information is conveyed to the fixture digital bitstream by modulating circuit current at or near its mains frequency

<u>Two Modes have been developed</u>

- Amplitude Shift Keying (ASK) Shifts circuit current amplitude to encode a digital bit stream
- Frequency Shift Keying (FSK) Shifts circuit current frequency to encode a digital bit stream

Fixture Centric
Amplitude Shift Keying (ASK) and Frequency Shift Keying (FSK) Digital Bit Stream





Fixture Detail,
Similar to 6.6 amp Fixture

Fixture Centric

- Intensity is driven by fixture
- Intensity information is conveyed digitally
- Compensation for current variation
- Extended functionality is supported

Strawman Message Format
Limited to intensity and direction to provide proof of concept.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
PREAMBLE				SEQUENCE NUMBER					PAYLOAD					CRC								EOM	
1	2	3	4	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	6	7	8	1	2
p3	p2	p1	p0	s4	s3	s2	s1	s0	d4	d3	d2	d1	d0	c7	c6	c5	c4	c3	c2	c1	c0	e1	e0
1	1	0	1	n	n	n	n	n	x	x	x	x	x	x	x	x	x	x	x	x	x	1	0

s4:s0		
Sequence Number	00000:	initial
	11111	final
	Increment on each message	
	Roll over from 11111 to 00000	

d4:d3 light

00	reserved
01	side A
10	side B
11	Both

d2:d0 Intensity

000	off
001	b1
010	b2
011	b3
100	b4
101	b10
110	b30
111	b5/b100

Requirements Development

- The operational and functional aspects of the architecture had to be selected to fully take advantage of the capabilities inherent to the architecture.
- Message definitions had to be defined– Establish what the bits mean to support the desired functionality
- This was necessary to provide interoperability for these aspects of products from different manufacturers.
- Performance requirements also needed to be addressed so ensure compatibility between components

Requirements Development

- In late 2018 and early 2019, A series of working sessions were held with FAA, manufacturers, engineering and certification personnel.
- The details of operational, functional, and electrical characteristics of the architecture were developed, discussed and documented.
- Test procedures were also addressed so that certification details could be developed.
- These details were central to the development of a requirements document to be used as a basis for an Engineering Brief to be published by Airport Engineering

Development of Requirements

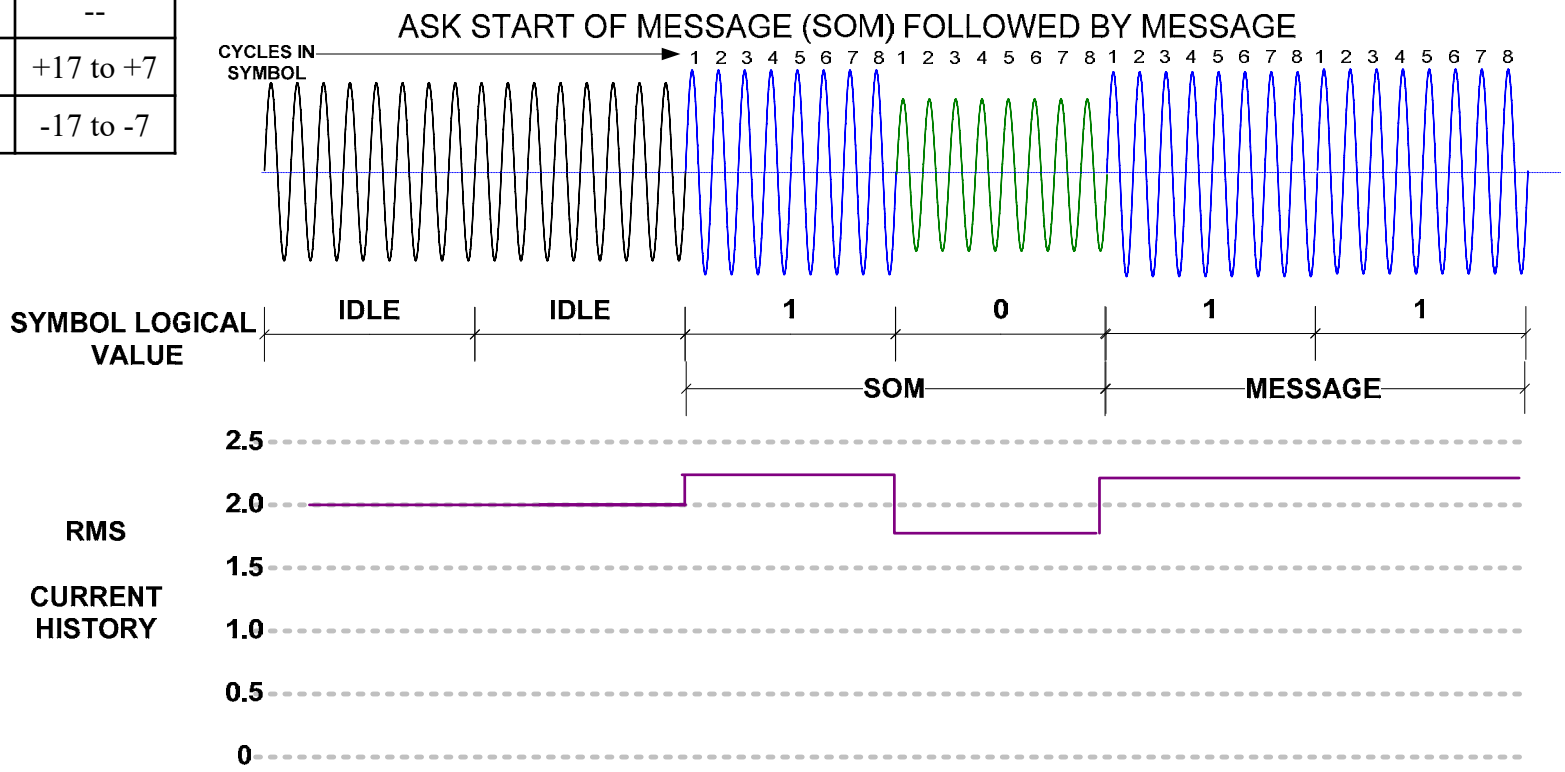
- Draft Requirements Document was developed in Spring 2019
- To validate the requirements, a test was proposed
- The purpose of the test is to update the existing fixture hardware from previous strawman testing with firmware that includes the implementation of the draft requirements document
- This testing includes two manufacturers' products on the same circuit, powered by an FAA developed power source
- Testing is underway, and will be completed in the next several weeks

Validation Test

- **Initial checkout was with 5 fixtures.**
- **The remaining fixtures, (45 from each manufacturer) will be updated with the same firmware to provide a full scale test.**
- **The tests will provide s information to make any necessary refinements to the document**

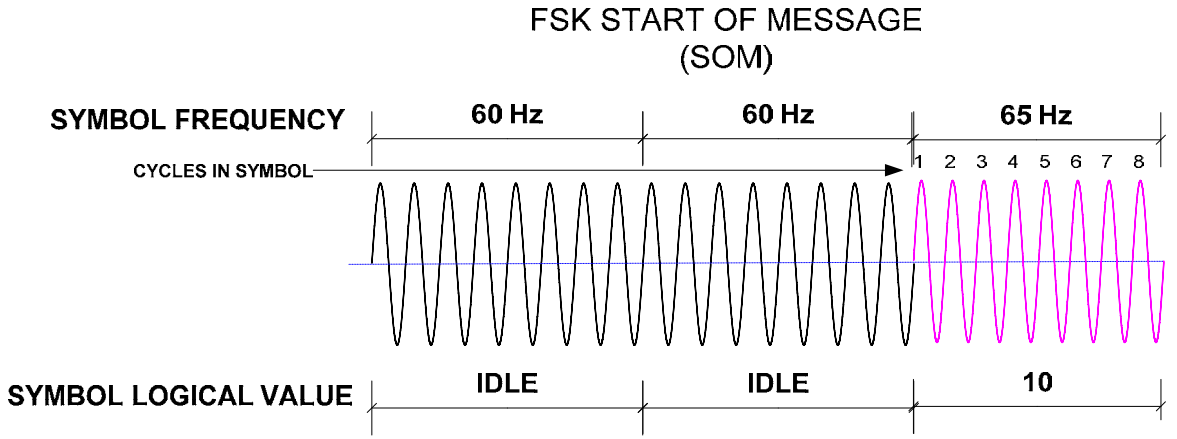
ASK
Two State Symbols Plus Idle

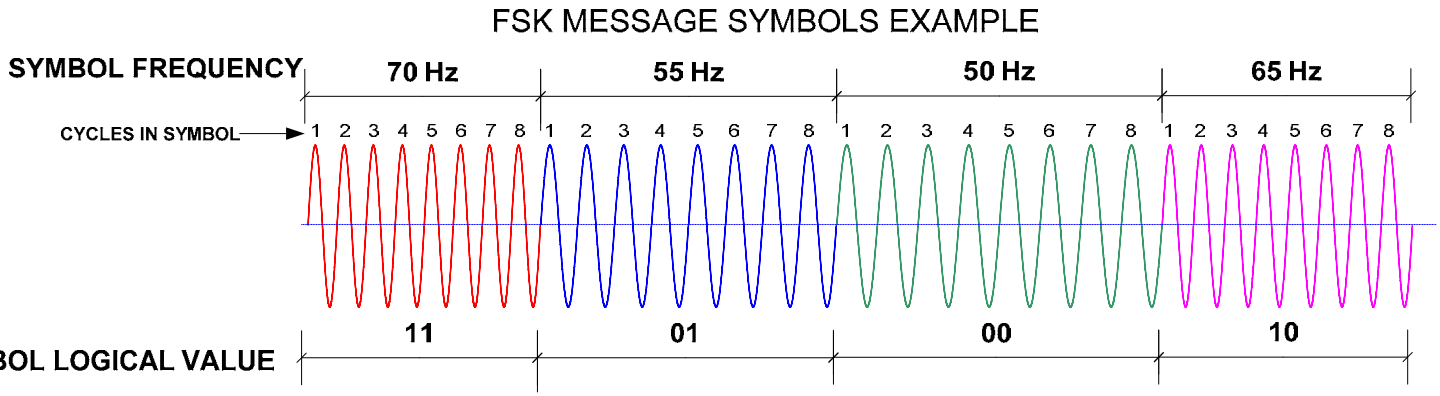
Logical Symbol	Nom. Amplitude %	Tolerance, %
Idle	--	--
1	+10	+17 to +7
0	-10	-17 to -7



Updated 2FSK Doubles ASK Speed
4 state Symbols plus idle
(2 data bits are represented in each 8 cycle period)

Logical Symbol	Frequency, Hz (+/- 1 Hz.)
Idle	60
00	50
01	55
10	65
11	70





Three Message Types Supported

- **Short Message Supports very basic Functions (12 Bits)**
- **Standard Message Supports Group Addressing More**
- **Extended Message Supports Parameter Programming and Future appications**

Short Message

- **Short Message Supports very basic Functions (12 Bits)**
  - **Fixture Direction – A, B, or Both**
  - **Intensity– B10, B30, B100, B1 through B5**

Bit #	1	2	3	4	5	6	7	8	9	10	11	12
Element	SOM		TYPE		INTENSITY			DIRECTION		CRC-3		
# of Bits in element	1	2	1	2	1	2	3	1	2	1	2	3
Bit position	s1	s0	t0	t1	i2	i1	i0	d1	D0	C2	C1	c0
Value	**1**	**0**	**0**	**0**	**x**	**x**	**x**	**0**	**0**	**X**	**X**	**x**

Standard Message

- **Standard Message Supports Core Functions (20 Bits)**
  - **Fixture Direction – A, B, or Both**
  - **Intensity– B10, B30, B100, B1 through B5**
  - **Fixture Flash**
  - **Heater Control On/off**
  - **Alternate Device– For additional Light Device if implemented, i.e. IR**
  - **Group address– up to 16 groups of lights on a circuit**

Bit #	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Element	SOM		TYPE		INTENSITY			DIRECTION		FLASH	HEATER	ALT DEV	GROUP				CRC-4			
# of Bits in element	1	2	1	2	1	2	3	1	2	1	1	1	1	2	3	4	1	2	3	4
Bit position	s1	s0	t1	t0	i2	i1	i0	d1	d0	f0	h0	a0	g3	g2	g1	g0	c3	c2	c1	c0
Value	**1**	**0**	**1**	**0**	**x**	**x**	**x**	**x**	**x**	**x**	**x**	**x**	**x**	**x**	**x**	**x**	**x**	**x**	**x**	**x**

Extended Message

- **Extended Message Supports Advanced Functions (32 – 542 Bits) Parameter Programming to modify the fixture behavior, grouping, or future functions**
  - **Parameter Programming to modify the fixture behavior, grouping, or future functions**

Bit #	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	
Element	SOM		TYPE		DATA LENGTH								CRC-4				MESSAGE IDENTIFIER						Continued Below
# of Bits in element	1	2	1	2	1	2	3	4	5	6	7	8	1	2	3	4	1	2	3	4	5	6	
Bit position	s1	s0	t1	t0	l7	l6	l5	l4	l3	l2	l1	l0	c3	c2	c1	c0	n5	n4	n3	n2	n1	n0	
Value	**1**	**0**	**1**	**1**	**x**	**x**	**x**	**x**	**x**	**x**	**x**	**x**	**x**	**x**	**x**	**x**	**x**	**x**	**x**	**x**	**x**	**x**	

n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n
DATA								CRC-8								EOM	
1	2	3	4	5	6	7	8	1	2	3	4	5	6	7	8	1	2
dn	dn	dn	dn	dn	dn	dn	dn	c7	c6	c5	c4	c3	c2	c1	c0	e1	e0
x	**x**	**x**	**x**	**x**	**x**	**x**	**x**	**x**	**x**	**x**	**x**	**x**	**x**	**x**	**x**	**1**	**0**

Message Speed

Message Type	Length	ASK Transmission time, Seconds	FSK Transmission time, Seconds	Typical Function
Operational Messages				
Short	12	1.6	0.8	Intensity
Standard	20	2.6	1.3	Group Message

Configuration Messages				
Extended	32	4.26	2.13	
Extended	48	6.37	3.18	Fixture Parameter
Extended	132	17.6	8.8	
Extended	232	31	15.5	
Extended	352	46.7	23.4	All Fixture Parameters

Fixture Centric Architectural Characteristics

- Interoperability
- Uses existing infrastructure of cables and transformers
- Reduced power consumption and nominal circuit current– 2 amps
- Robust performance in poor electrical environment
- Precise intensity control at all levels-- Fixture controls its light engine, not impacted by circuit or circuit components
- Supports Higher Power Loads such as HIRLs
- Retains support for shared signs, windcones or similar components
- Current can be changed for larger light or heater load
- Addressable in groups– Selecting direction and/or groups of lights
- Eliminates selector switch requirement
- Compatible with Power Line Carrier Products
- Heater control is independent of fixture intensity
- Can support Legacy Mode for 6.6 amp operation

Interoperability

- **Interoperability is key requirement**
- **Uses existing infrastructure of cables and transformers**
- **Fixtures and power source will operate the same regardless of manufacturer**

Group Addressing

- Each Fixture Can be a member of up to 16 groups
- 16 group numbers are supported per circuit

<u>Applications</u>

- Bidirectional fixture– select A, B or Both sides–
- Runway Centerline Direction
- Taxiway Centerline Direction

- Can remove the need for a Selector Switch
- Control Segments of taxiways from same circuit
- Controls Taxiway Centerlines for SMGCS operation
  - Closer Light Spacing for SMGCS would not require separate circuit

Legacy Mode Support

- Operation on a 2.8 to 6.6 amp Circuit
- Provides migration Path
- Timeout after circuit power up allows for entering Legacy Mode
- Timeout also allows for entering Fixture Centric Mode

Heater Control Support

- Heater now operates only with fixture thermostat, and is most effective with higher current steps
- Fixture centric supports control of the heater– heaters can be enabled when needed, and circuit current can be increased to provide adequate power, without impacting fixture intensity
- Heater can be off on cold days if not needed with low circuit current

Configurable Current Levels

- Circuit current can be as low as 2 amps
- During operation, current can be increased if heaters are in operation, or for very large loads
- Maximum is 6.6 amps
- Power source capabilities can determine range of operating current

Fail Safe Operation

- Normal operation includes periodic intensity messages
- If messages stop, the fixture can enter fail safe state
- Failsafe timeout and behavior is set in parameters
- Behavior can be last commanded, a preset intensity or flash. (A or B side)

Power Up State Support

- Similar to Failsafe, when power is applied fixture can power on and enter a power up state
- After a configurable time out, (or immediate) power up state is set.
- Behavior can be last commanded, a preset intensity or flash. (A or B side)

Flash Functionality

- **Settable Parameters for flashing—**
- **Flash Rate**
- **Duty Cycle**
- **Initial Flash State (on or off)**
- **Intensity Ramp up**
- **Intensity Ramp Down**

Alternate Device

- **Alternate Device is a control mechanism to support an additional light source (if present) in the fixture (like IR)**

- **Support includes the same intensity control, power up, failsafe, and flash timeout, as the primary light source in the fixture**

Transient Current Gap Support

- If a brief gap in power is present, the fixture behavior can be configured
- A timeout value is configured. Less than this value, the gap is considered a transient. (could be an ATS transfer from commercial to generator power)
- If within the timeout, the fixture will stay at its last commanded state
- If the current gaps beyond the timeout, the fixture will enter a power up state when power returns

Degraded Current Operation

- If circuit insulation leakage results in current reduction, the fixture can maintain its intensity as long as it is provided with enough current to achieve its set intensity
- If the fixture is not able to make intensity it will turn off its light

Parameter Programming

- Fixtures contain configuration tables in memory that define its behavior
- Function parameters control items like timeouts, power up and fail safe state, flashing parameters and operational modes
- Group parameters store the group addresses that the fixture is a member of.
- The architecture currently provides 16 group addresses. The fixture can be a member of up to 16 groups
- Currently this parameters total 320 Bits (40 Bytes)
- These parameters can be programmed in circuit using extended messages
- Fixtures can optionally support alternate means of parameter programming such as Bluetooth or similar if manufacturer implements this support

Fixture Function Parameters

PARAMETERS		BITS							
		7	6	5	4	3	2	1	0
POWER-UP STATE	SIDE A	NO CHANGE	FLASH				A SIDE, 0 TO 7		
	SIDE B	NO CHANGE	FLASH				B SIDE, 0 TO 7		
FAILSAFE STATE	SIDE A	NO CHANGE	FLASH				A SIDE, 0 TO 7		
	SIDE B	NO CHANGE	FLASH				B SIDE, 0 TO 7		
POWER-UP TIMEOUT	SECONDS	0 to 255							
FAILSAFE TIMEOUT	MSB SECONDS	MSB							
	LSB SECONDS	LSB							
LEGACY MODE	SECONDS	0 to 255							
FLASH RATE, FPM		Start on or off	1 TO 127						
FLASH DUTY CYCLE	1 TO 100	Ramp	0 T0 100%						
FLASH RAMP ON	0 TO 255, 0.1 SEC	0 TO 255							
FLASH RAMP OFF	0 TO 255 0.1 SECONDS	0 TO 255							
ALT OUTPUT POWER-UP STATE		NO CHANGE	FLASH				0 TO 7		
ALT OUTPUT FAILSAFE STATE		NO CHANGE	FLASH				0 TO 7		
POWER-UP TIMEOUT	SECONDS	0 to 255							
FAILSAFE TIMEOUT	MSB SECONDS	MSB							
	LSB SECONDS	LSB							
ALT OUT P/U TIMEOUT	SECONDS	0 TO 255							
ALT FLASH RATE, FPM		Start on or off	1 TO 127						
ALT FLASH DUTY CYCLE	1 TO 100		0 T0 100%						
ALT OUTPUT FS TIMEOUT	MSB SECONDS	MSB							
	LSB SECONDS	LSB							
TRANSIENT TIMEOUT, LAST COMMANDED STATE	1. SECONDS 0= IMMEDIATE 255 = DISABLED	0 to 255							
SIGN MODE		1 enables, 0 disables						FS	PU

Fixture Group Address Parameters

PARAMETERS		BITS							
		7	6	5	4	3	2	1	0
GROUP ADDRESS 1	gggg== Group num ffff===function	f	f	f	f	g	g	g	g
GROUP ADDRESS 1	gggg== Group num ffff===function	f	f	f	f	g	g	g	g
GROUP ADDRESS 3	gggg== Group num ffff===function	f	f	f	f	g	g	g	g
GROUP ADDRESS 4	gggg== Group num ffff===function	f	f	f	f	g	g	g	g
GROUP ADDRESS 5	gggg== Group num ffff===function	f	f	f	f	g	g	g	g
GROUP ADDRESS 6	gggg== Group num ffff===function	f	f	f	f	g	g	g	g
GROUP ADDRESS 7	gggg== Group num ffff===function	f	f	f	f	g	g	g	g
GROUP ADDRESS 8	gggg== Group num ffff===function	f	f	f	f	g	g	g	g
GROUP ADDRESS 9	gggg== Group num ffff===function	f	f	f	f	g	g	g	g
GROUP ADDRESS 10	gggg== Group num ffff===function	f	f	f	f	g	g	g	g
GROUP ADDRESS 11	gggg== Group num ffff===function	f	f	f	f	g	g	g	g
GROUP ADDRESS 12	gggg== Group num ffff===function	f	f	f	f	g	g	g	g
GROUP ADDRESS 13	gggg== Group num ffff===function	f	f	f	f	g	g	g	g
GROUP ADDRESS 14	gggg== Group num ffff===function	f	f	f	f	g	g	g	g
GROUP ADDRESS 15	gggg== Group num ffff===function	f	f	f	f	g	g	g	g
GROUP ADDRESS 16	gggg== Group num ffff===function	f	f	f	f	g	g	g	g

Simple Operating Defaults

- For many installations simple control is adequate
- Basic control of intensity, and direction
- Uses short message
- No programming or handling of parameters is needed

Power Source Requirements

- Some Requirements from AC 150/5345-10

- Operational settings such as
  - Mode—ASK or FSK (if both supported)
  - Fixed or configurable current mode (if supported)
  - Message update rate—how often to refresh the circuit on the commanded state
  - Group information—if groups supported, the last commanded groups must be stored so that a refresh table is available for the power source
  - Failsafe behavior—last commanded state or no action, with a timeout value
  - Loss of Power behavior—last commanded stat or no action with a timeout value

Power Source Operational Settings

- Nominal Circuit Current
- Circuit Maximum VA
- Maximum and minimum current for configurable current control mode
- Maximum voltage
- Heater load, VA
- Heater Current
- Alternate Load VA
- Number of intensity Steps
- Retransmission attempts before fault

Remaining Schedule

Activity	
Validation Testing	Underway
Validation test report (followed by Final Requirements Document to Airport Engineering)	December 31, 2019 (Happy New Year)

Thank you!

Questions?

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