ECU Functional Specification

Part Name: Wireless Charging Module	

LET																							
FR																							
LET																							
FR																							

Date	LET	FR	Revisions	DR	CK
4/3/2018			Initial Revision/v11		
8/1/2019			v12		

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STANDARD NOTES:
FOR CURRENT RELEASE STATUS, SEE THE WERS ENGINEERING NOTICE.

▽CONTROL ITEM – THE ▽ALSO IDENTIFIES CRITICAL CHARACTERISTICS DESIGNATED BY THE CROSS FUNCTIONAL TEAMS DEVELOPING THE PRODUCT. THESE, AND ADDITIONAL CRITICAL CHARACTERISTICS IDENTIFIED BY PROCESS REVIEWS, MUST APPEAR ON THE CONTROL PLANS ACCORDING TO ISO/TS 16949. THESE CONTROL PLANS REQUIRE PRODUCT ENGINEERING APPROVAL.

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1.0 INTRODUCTION

1.1 Purpose

The ECU Functional Specification (EFS) specifies the scope and the requirements of an ECU in terms of logical functions. It also defines the interfaces to the HW of the ECU.

The EFS is complemented by a ECU HW specification, which defines the details of the ECU HW.

Optionally, the EFS also defines the scope and requirements of the ECU in terms of SW components.

1.2 Scope

The following ECU is described or mentioned in this ECU specification:

Component ID	Component Name	Reference
<Add VSEM ID>	Wireless Charging Module	<Add VSEM Link>

Table 1: ECUs specified in this document

The following functions from the Global Feature & Function List are described or mentioned in this ECU Functional Specification:

Function ID	Function Name	Reference
F001046	Wireless Charging	FEA-647660
~~<Add VSEM ID>~~	~~Cellular Coupling Antenna Repeater Subsystem~~	~~<Add VSEM Link>~~

Table 2: Functions specified in this document

The allocation itself of logical functions to ECUs is not part of this document, but described within the Feature Implementation Specification.

1.3 Audience

1.3.1 Stakeholder List

1.4 Document Organization

1.1.1 Document Context

Refer to the Specification Structure page in the Ford RE Wiki to understand how the FD relates to other Ford Requirements Documents and Specifications.

1.4.1 Document Structure

The structure of this document is explained below:

Section 1 – Introduction – Giving an explanation how to use this document including responsibilities and the scope of the document. Additionally it contains the revision history and a list of unsettled but known

issues that have to be consolidated in future versions.It explains the terminology and gives a clarification of the definitions, concepts and abbreviations used in the document.

Section 2 – ECU Description - Stating briefly the background and the purpose of the ECU

Section 3 – ECU Function View – Defining the scope from functional perspective and the electrical interfaces Presenting all requirements of the functions within scope.

Section 4 – ECU Software Component View – Defining the scope from SW component perspective and the SW interfaces Presenting all requirements of the SW components within scope.

Section 5 – List of Open Concerns

Section 6 – Requirements Traceability

Section 7 – Revision History

Section 8 – Appendix – Presenting additional data mainly in a tabular form, e.g., a data dictionary, a automatically generated list of requirements or a traceability matrix

Section 4 can be considered the focal chapter of this document, containing the functional requirements related to this ECU.

1.5 References

1.5.1 Ford documents

List here all Ford internal documents, which are directly related to the feature.

Reference	Title	Revision	Date
Statement of Work (SOW)	Engineering Statement of Work (ESOW): Wireless Charging Module (WCM)	23	2018/10/16
Sharepoint	EESE NETWORK COMMUNICATIONS MULTIPLEX TECHNOLOGY STATEMENT OF WORK	2019.1	2019/03/04
Sharepoint	EESE NETWORK COMMUNICATIONS DIAGNOSTIC STATEMENT OF WORK	2019.1	2019/02/03
Wireless Charging WACM SSPS	Feature – Wireless Accessory Charging. Wireless Accessory Charging Module (WACM) Infotainment Subsystem Part Specific Specification (SPSS)	1.3	2019/04/03
Power Management WACM SSPS	Feature – Power Management. Wireless Accessory Charging Module (WACM) Infotainment Subsystem Part Specific Specification (SPSS)	1.3	2018/11/27
Info-CAN Network WACM SSPS	Feature – Infotainment Network. Wireless Accessory Charging Module (WACM) Infotainment Subsystem Part Specific Specification (SPSS)	1.0	2015/10/08
00.06.00.001	HIGH & MEDIUM SPEED - CAN (Controller Area Network) CGEA ECU LEVEL FUNCTIONAL SPECIFICATION	2017	2017/12/01
00.06.03.001	CAN (Controller Area Network) Data Link & Physical Layer Specification	BC	2019/01/18
00.06.03.002	CAN LIN Ethernet Physical Layer Transceiver, choke, and ESD components	AP	2019/03/29
00.06.15.001	Generic Global Diagnostic Specification	005	2018/10/30
00.06.15.002	Software Download Specification	007	2018/10/30
00.06.15.006	Multiplex Diagnostic Exchange Format Specification (MDX)	004	2013/05/02
FMC 1278	Electromagnetic Compatibility Specification for Electrical/Electronic Components and Subsystems.	3	2018/12/01
FAP03-145	Production Part Identification		2017/11/17
FAP03-149	Design Verification & Product Validation Process		2019/07/25
SDS, CONN	Electrical Connector SDS		2018/03/13
SDS, EDS	Electrical Distribution System SDS		2015/03/27
SDS, EESYS	E/E System SDS		2018/03/13
SDS, ELCOMP	Generic Body Module SDS		2018/03/13
SDS, ELECTRICAL	Electrical Power Supply		2018/03/13
SDS, SERVICE	Service SDS		2015/03/06
WSS-M99P9999-A1	Restricted Substance Management Standard		2019/05/23
WSS-M4D924-B1	Polycarbonate/Acrylonitrile Butadiene Styrene Blend (PC+ABS) Medium Impact Molding Compound Interior	1	2015/03/17
WSS-M9P8-C	Elastomeric Parts, Interior Performance	2	2017/09/01
19-0108	Directive E-108: Global Parts Trademarks	13	2019/04/24
FECDS E3	BRANDING, CODING AND PART MAKING	30	2018/01/31
FECDS E4	MATERIAL IDENTIFICATION	30	2018/03/31
CETP 00.00-E-412	Electrical & Electronic Component Environmental Compatibility Test		2011/11/07
FEMR	Ford Electronics Manufacturing Requirements	2012	2016/10/25
FS-0000-00001-AB	Global Start/Stop Power Supply Voltage Curve Specification	4	2016/05/26
RQT-002901-008095 (MA-154)	ELV + SUBSTANCECOMPLIANCE ACCORDING TO RSMS	12	2019/04/26
InfotainmentDiagnosticSpecification-	Infotainment Diagnostics Specification: Wireless Charging Device	5.0.1	28 March 2018

Reference	Title	Revision	Date
WACM_5_0_0-DRAFT_R1			

Table 3: Ford internal Documents

1.5.2 External documents and publications

The list of external documents should include e.g. relevant standards.

Reference	Doc. ID	Title	Revision
		SAE J2602-2 LIN	*8/16/05*
		IPC/IEA J-STD-001 C	*Latest version @ <RFQ> 19-March-2018*
		ANSI/IPC-A-610 rev.D	*Latest version @ <RFQ> 19-March-2018*
		CAN 2.0B	*Latest version @ <RFQ> 19-March-2018*
		ISO 1043-1 Plastics – Symbols	*Latest version @ <RFQ> 19-March-2018*
		ISO 26262 – Road Vehicles – Functional Safety	*Latest version @ <RFQ> 19-March-2018*
		USCAR 2, rev 4	*Latest version @ <RFQ> 19-March-2018*
		USCAR 25, rev 3	
		IEC 61508	*Latest version @ <RFQ> 19-March-2018*
		Commission Directive 95/54/EC: Function: 6C EMC Directive	*Latest version @ <RFQ> 19-March-2018*
		ICNIRP 1998 http://www.icnirp.de/PubEMF.htm	*Latest version @ <RFQ> 19-March-2018*
		Qi Specification Version http://www.wirelesspowerconsortium.com/	v1.3
		A Guide to the Safe Use of Secondary Lithium Ion Batteries in Notebook-type Personal Computers	April 20, 2007
		ISO 11898-1:2015: Road vehicles – Controller Area Network (CAN) – Part 1: Data link layer and physical signaling	December 2015

Table 4: External documents and publications

1.6 Terminology

1.1.2 Definitions

The use of the word *shall* in this document denotes a mandatory design requirement.
The use of the word *should* in this document represents a desire, but not mandatory, conformance to a WCM operational characteristic. Design verification or validation shall demonstrate that the product meets this requirement.
The use of the word *will* in this document refers to information about the performance of other components that interface to the WCM, or to the action of humans affecting the WCM which cannot be controlled by the design of these modules. Such references are used to provide information about the system components external to the WCM that may influence the context, meaning, and/or understanding of WCM requirements.

Definition	Description
Qi	Wireless charging protocol

Definition	Description

Table 5: Definitions used in this document

1.6.1 Abbreviations

Abbr.	Stands for	Description
FD	Feature Document	The document describing, collecting and developing the functional behavior of a system in a vehicle.
CAN	Controller Area Network	CAN
ARL	Attribute Requirements List	
NFC	Near Field Communication	Protocol for short-distance communications
RF	Radio Frequency	
EMC	Electromagnetic Compatibility	
PPAP	Production Part Approval Process	
PSW	Part Submission Warrant	
WCM	Wireless Charging Module	
WACM	Wireless Accessory Charging Module – legacy term describing Gen 1 wireless charger	

Table 6: Abbreviations used in this document.

1.7 Notation

1.7.1 Requirements Templates

Each requirement, use case or scenario in this specification shall follow the corresponding template given in the document template *Specification_Macros.dotm* at RE Wiki - Specification Templates.

#Hint: *The Specification_Macros.dotm template also provides macros to insert the requirement templates. Refer to "How to use the Specification Templates" on how to enable the macros and the requirements templates in this specification.*
The requirements macro and requirements templates also enable the import of the specification to VSEM (refer to "How to import specifications into VSEM as separate requirements").

1.7.1.1 Identification of requirements

The unique requirement ID given in the headline of any requirement follows the requirement throughout the development process. The requirement ID format follows a well-defined syntax.

All identifiers in an ECU Functional Spec shall be composed of 4 parts:

- A leading prefix, which indicates the type of requirement (R=Requirement, UC=Use Case, SC=Scenario, …)
- A prefix, which indicates the abstraction level (F=Feature, FNC=Function, CMP = component).
- Followed by a name, indicating the scope, which the requirement belongs to (e.g. feature or function name)
- Ending with the actual requirement number

Example:

R_CMP_LockArbitrator_00004 This is the fourth requirement on function level for the function Lock Arbitrator.

1.7.1.2 Requirements Attributes

The templates provided by *Specification_Macros.dotm* define a list of attributes for each requirement. This helps to classify the requirement. The attributes are explained at RE Wiki - Requirements Attributes.

2.0 ECU DESCRIPTION

The GEN 2 Wireless Charging Module (WCM) is an ECU that is designed to support wireless device charging of a mobile device. The WCM is located in the vehicle's passenger compartment of the vehicle and is typically packaged in the console or arm rest area. The WCM is mounted in conjunction with vehicle platforms specific implementation of Ford DNA class A surfaces and tolerances to meet charging interface requirements.

The WCM communicates with wireless power compatible devices and provides power to devices through inductive wireless charging technology. WCM runs a real time operating system and hosts the Ford Network Operating System (FNOS) with AUTOSAR Network Management for CAN sleep node operation on the HS3 bus for compliance to FNV 2. Non-volatile memory is used to store application and configuration data and the WCM has the ability to be VO EOL configurable for certain parameters. The WCM complies with Generic Global Diagnostic Specification (GGDS) 005 and Software Download Specification (SWDL) 007. WCM also supports Over The Air (OTA) software updates and meets Cyber Assurance requirements to ensure security. Charging status and other data available via the wireless power industry standards are communicated on the CAN bus. The WCM module shall be design to accommodate all module variants show in section 3.2 of this document by discontenting the base-high variant.

Key WCM functions include: (not an exhaustive list):

- Qi inductive wireless charging specification v1.3, managed by the Wireless Power Consortium (WPC) Class 0 power transmitter, supporting Extended Power Profile up to 15W of power transfer.
    - Includes authentication support with EAL 5+ rating.
- Apple Fast Charging support
- Samsung Fast Charging support
- Foreign Object Detection (FOD) (Qi compliant) to ensure metal objects between charging device and WCM do not overheat.
- Expanded 70x30 mm charge area allows easier placement of user devices
- Phone sliding robustness ensures charging continues as phone moves on surface during driving while eliminating nuisance HMI messages
- Package protected for NFC capability enables various vehicle capabilities
- Charging disable feature disables charging and emissions for users who prefer not to take advantage of charging feature
- Minimized cellular signal degradation
- Provisions to prevent AM radio band noise from WCM. Avoidance / pseudorandom frequency (TBD) mitigates interference with AM radio G1 band.
- PEPS avoidance feature disables charging during an interior key fob search
- Convective cooling with modular cooling fan capable of pulling or pushing air away from phone surface during charging to improve phone charge performance and keep device under charge cool.
- Universal snap fit features allow assembly for A or B side of console.
- Package and interface backward compatible with Ford Gen 1 WCM.
- Achieves ASIL B rating to ensure functional safety
- Note: phone does not perform arbitration between wired charging connections (i.e. USB charging) and inductive wireless charging when a phone that is charging via a cord is placed on the wireless charger. In these instances, the phone is deemed responsible to select the desired method of charging.

2.1 Overview

2.2 Constraints

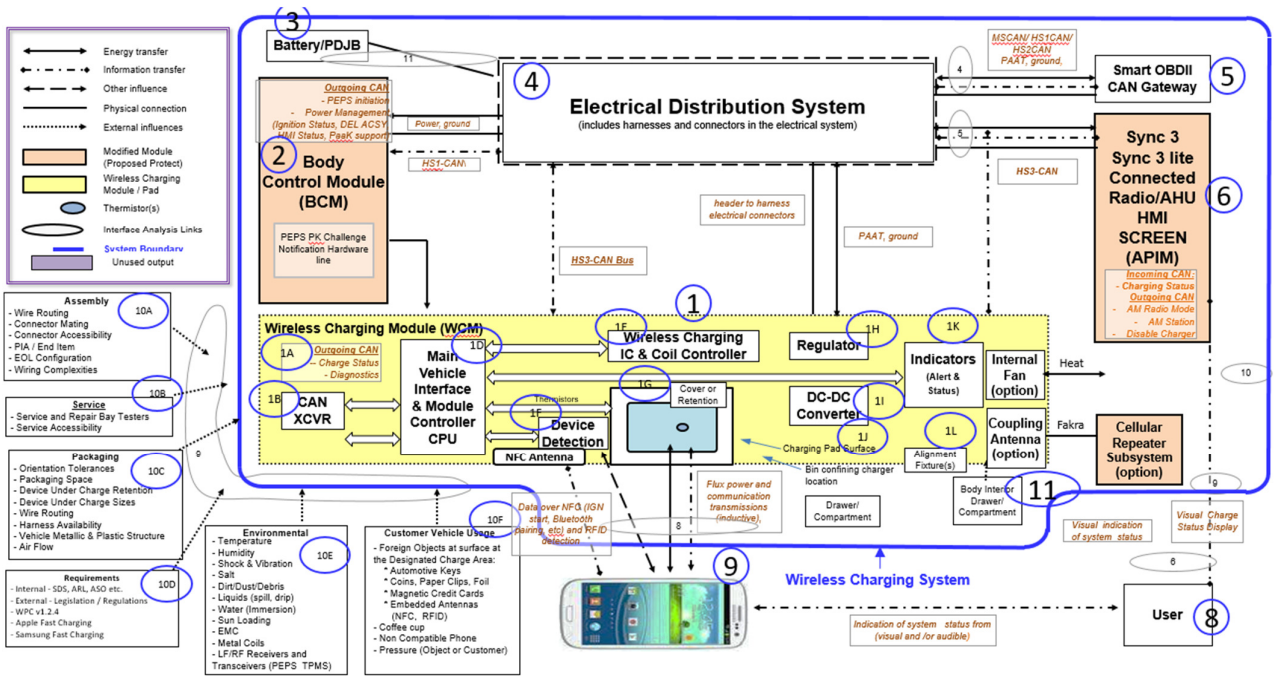
2.3 Assumptions & Dependencies

WCM is dependent on other modules for certain functions, including:

Function	Dependency
PEPS Avoidance	Hardwire from BCM & CAN signal provided through GWM to disable charging
AM Avoidance	CAN signals from ACM/APIM notifying WCM of radio status, tuned station, etc.
NFC for ignition start (TBD certain variants only)	BCM for decoding/processing
Foreign Object Detection	Receives power information from charging device
Charging enable/disable function	CAN signal from APIM

3.0 ECU HW VIEW

3.1 HW Architecture



Note: Not all features and interfaces listed in the boundary diagram above are applicable. Contact Ford Engineering prior to DV design freeze.

3.2 List of HW Modules

The WCM shall be a modular design capable of supporting each of the part variants listed below by depopulating the base-high variant.

GEN 2 WCM SCALING

		Base			
		Full	Mid	Low	
	15W Charge	X	X	X	
	Internal cooling fan	X	X	P	
	NFC	X	P	P	
	HS3 CAN	X	X	X	
	FOD	X	X	X	
	Qi spec	X	X	X	
	Charge Area 70X30	X	X	X	
	Apple Fast Charge	X	X	X	
	Samsung Fast Charge	X	X	X	
	AM Band Avoidance	X	X	X	
	PaaK Power Mgmt	X	X	X	
	PEPS Avoidance	X	X	X	
	LIN Protect				
	Message Authentication				
	Sliding Phone Robustness	X	X	X	
	Parsed	X	X	X	
	OTA (over their SW updates)	X	X	X	
	Cybersecurity	X	X	X	
	Autosar modules	X	X	X	
	High Temp Shutdown (stop charge)	X	X	X	
	ASIL B rating	X	X	X	

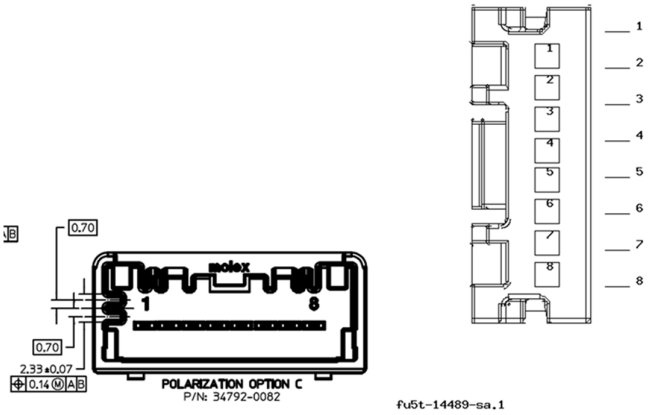
P=Design package protected

Note: For round 3 quoting purposes, please provide quote for tolling, validation and development cost for the base-mid variant with package protection for NFC feature. Then please provide incremental tooling, validation and development cost for base-full, base-low and value variants individually from the base-mid variant cost.

3.3 List of HW Connections

WCM shall use the following header connector: 107066/A, Molex PN 34792-0082 key C., Mating part FU5T-14489-SA. Contact Ford Engineer for additional information.

Component Connector Part Number		
C1:107066/A;1		
Signal Name	**Signal Abbr**	**Pin Number**
PWR01:PAAT (DEVICE TRANSMITTAL USE ONLY)	PAAT	C1-1
NC02:NO CONNECTION-02	NC02	C1-2
CRT36:CTRL MOD. - PASSIVE ANTI THEFT SEARCH STATUS	PAT SEARCH STAT	C1-3
NC04:NO CONNECTION-04	NC04	C1-4
GND02:POWER GROUND (DEVICE TRANSMITTAL USE ONLY)	PWR GND	C1-5
NC06:NO CONNECTION-06	NC06	C1-6
VDB30:CONNECTOR - DIAGNOSTIC # CAN BUS HIGH SPEED 3 (LOWER) LOW	HS 3 CAN -	C1-7
VDB29:CONNECTOR - DIAGNOSTIC # CAN BUS HIGH SPEED 3 (LOWER) HIGH	HS 3 CAN +	C1-8



Supplier shall submit a Module Device Transmittal within 4 weeks of sourcing to document key module electrical interface requirements. Contact Ford Engineering to obtain device transmittal template.

3.4 Definitions

The use of the word *shall* in this document denotes a mandatory design requirement.

The use of the word *should* in this document represents a desire, but not mandatory, conformance to a WCM operational characteristic. Design verification or validation shall demonstrate that the product meets this requirement.

The use of the word *will* in this document refers to information about the performance of other components that interface to the WCM, or to the action of humans affecting the WCM which cannot be controlled by the design of these modules. Such references are used to provide information about the system components external to the WCM that may influence the context, meaning, and/or understanding of WCM requirements.

3.4.1 Functional Importance Class

- Class A: Any function that provides a convenience.
- Class B: Any function that enhances, but is not essential to the operation and/or control of the vehicle.
- Class C: Any function that controls or affects the essential operation of the vehicle or could confuse the driver or other road users.

3.4.2 Functional Performance Status

- Status I: The function shall operate as designed (or meet specified limits) during and after exposure to a disturbance.
- Status II: The function may deviate from designed performance, to a specified level, during exposure to a disturbance but shall not affect safe operation of the vehicle, safety of its occupants and does not adversely affect customer satisfaction. The function may revert to a fail-safe mode of operation, but shall return to normal operation following removal of the disturbance either automatically or in line with the function's fail-safe recovery strategy. No effect or permanent or temporary memory is allowed. Status II performance, where applicable, is only permissible if the deviation in performance does not affect other related functions requiring Status I performance.
- Status III: The function may deviate from designed performance during exposure to a disturbance but shall not affect safe operation of the vehicle or safety of its occupants. Operator action may be required to return the function to normal operation after disturbance is removed (e.g. cycle ignition key, replace fuse). No effect on permanent type memory is allowed. Status III performance, where applicable, is only permissible if the deviation in performance does not affect other related functions requiring Status I performance.
- Status IV: The device shall not sustain damage, changes in I/O parametric values (resistance, capacitance, leakage current, etc.) or permanent reduction in functionality.

Reference RQT-191001-009906 (EC-0058) LOW/HIGH VOLTAGE GUARANTEED FUNCTION/PERFORMANCE and RQT-191001-009947 (EC-0102) EMC FUNCTIONAL CLASSIFICATION in ELCOMP SDS.

3.5 Requirements

All suppliers must adhere to Global phased PPAP requirements and Ford Motor Company Customer-Specific Requirements.

Global Phased PPAP defines the timing and methodology for meeting all 18 requirements of AIAG published Production Part Approval Process (PPAP) for single line and multiple line Tier 1 Supplier manufacturing facilities.

STA is the authorized customer representative for external Tier 1 Suppliers as defined in Ford Customer Specific Requirements to AIAG published PPAP, available through https://web.qpr.ford.com/sta/Phased_PPAP.html.

Global Phased PPAP is a Ford requirement specified in Ford PPAP Customer

WCM must meet all requirements stipulated in the latest Restricted Substance Management Standard (RSMS) Reporting Requirements and Guidelines, RQT-002901-008095 SDS MA-154.

Copies of Ford Motor Company Customer-Specific Requirements are available from Ford Motor Company at https://web.qpr.ford.com/sta/Phased_PPAP.html through the Ford Supplier Portal and International Automotive Oversight Board at www.iatfglobaloversight.org.

The WCM system must meet all requirements stipulated in the applicable FORD System design specifications (SDS) and cascaded Ford program eFvds SDS requirements. Contact Ford Engineering for latest copy of SDS requirements prior to WCM source selection and for additional program eFvds SDS requirements prior to DV design freeze.

Suppliers shall accomplish all requirements referenced in Ford Motor Company Customer-Specific Requirements

3.5.1 Electrical Input Requirements

3.5.1.1 Operational Voltage

WCM shall be powered via an unfiltered, fused link to the vehicle battery as a Powered-At-All Times (PAAT) with input power condition circuits as specified in RQT-191001-009890 (EC-0042) POWERED AT ALL TIMES AND CONDITIONED POWER CKTS in ELCOMP SDS.

WCM shall have full functionality and performance with supply voltages between 9VDC and 16VDC (Reference RQT-191001-009906 (EC-0058) LOW/HIGH VOLTAGE GUARANTEED FUNCTION/PERFORMANCE in ELCOMP SDS).
Definitions:

- Function shall be defined as: All inputs are interpreted correctly and outputs applied appropriately. However, subsystems may not meet some performance requirements (e.g. timing, illumination levels, wireless charging, NFC, etc.) as approved by the D&R engineer.
- Performance shall be defined as: All functions shall perform to all specified requirements.

WCM's Microcontroller, internal loads, and HSCAN shall be on and fully functional with supply voltages between 6VDC and 20VDC (Reference RQT-191001-009911 (EC-0063) LOAD MANAGEMENT in ELCOMP SDS).

WCM shall conform to Module Power-Up/Reset Requirements RQT-191001-009897 (EC-0049) MODULE POWER-UP/RESET REQUIREMENTS in ELCOMP SDS.

Nominal and maximum current draw shall be calculated and measured by the supplier and updated as part of the WCM Device Transmittal.

WCM is to be designed to assume a 7.5 Amp fusing from its battery supply source. The WCM's header connector and power plane connection shall tolerate over current loading for opening time-current characteristics of a 7.5Amp fuse (assume 12V MINI Blade Fuse).

Requirement	*Detail*
Input Signal Names	*VBATT_01 (PAAT)*
Functional Importance Class	*Class A*
Input Current Range	*Nominal = TBD A Maximum = 4.0A*
Shared Signal	*Yes*

Table Notes:

1. Guaranteed full function between 6VDC and 20VDC as measured at the module input power and ground terminals.
2. Guaranteed full performance between 9.3VDC and 16VDC as measured at the module input power and ground terminals.
3. Limited performance between 9.0VDC and 9.3VDC as measured at the module input power and ground terminals.
4. For exceptions, please refer to RQT-191001-009906 (EC-0058) LOW/HIGH VOLTAGE GUARANTEED FUNCTION/PERFORMANCE in ELCOMP SDS (must refer to requirement detail tables).
5. Charging feature may be suspended or reduced in power (must comply with appropriate charging protocols) when input voltage continuous steady state range is not within the 9VDC and 16VDC range (but not required).

Table 7: Normal Voltage Operation (unless otherwise noted in the I/O tables)

	Class A

V_1 - Low voltage Limited Performance function	9.0V
V_3 - Low voltage Full performance	9.3V
V_4 - High voltage Full performance	16.0V
V_5 – Full Function - CAN, Microcontroller, internal loads, and HSCAN guaranteed function	6V
V_6 – Full Function - CAN, Microcontroller, internal loads, and HSCAN guaranteed function	20V
V_N – Nominal Operating Voltage	13.5V
V_N – Nominal Operating Voltage, Ign off:	12.5V

3.5.1.2 Grounding

WCM shall provide a single Power and Signal ground connection that conforms to RQT-191001-009892 (EC-0044) MODULE GROUND STRATEGIES in ELCOMP SDS.
`

Requirement	*Detail*
Input Signal Names	*GND_01 (WCM Ground)*
Functional Importance Class	*Class A*
Input Current Range	*Nominal = TBD A, Maximum = 4.0A*
Shared Signal	*Yes*

3.5.1.3 Passive Entry / Passive Start (PEPS) Input Signal

The BCM will provide a hard wired signal to WCM for the duration of the PEPS avoidance feature and will return to passive condition once it no longer requires the PEPS avoidance feature to be active. The BCM also provides a CAN signal for the PEPS avoidance feature to be used in conjunction with the input signal in the event of an external open circuit of the hard wired interface.

WCM shall have an input for a switch to battery to indicate to WCM when the PEPS avoidance feature should be activated. The WCM shall also process a CAN signal from the BCM to indicate to the WCM when the PEPS avoidance feature should be activated. WCM shall use either the hard wired signal or the CAN signal to start the PEPS avoidance feature. See Wireless Charging SPSS for additional requirments.

The PEPS Input shall be designed based on RQT-191001-009874 (EC-0026) ACTIVE HIGH MODULE INPUTS AND ACTIVE HIGH MOD-MOD INTERFACE for a Type D interface with exception of the following.

- The pull down load resistance shall ≤ 500 ohms including all component tolerances to account for BCM fault detection limits specified as follows.
    - GEN1: OC Detect Limit, >10k ohms, STG Detect Limit, > 220mA
    - GEN2: OC Detect Limit, <13mA, STG Detect Limit, > 65mA

Reference Feature – Wireless Accessory Charging. Wireless Accessory Charging Module (WACM) Infotainment Subsystem Part Specific Specification (SPSS).

3.5.1.4 Key-Off Load (KOL) Current Draw

WCM shall conform to RQT-002603-019359 (09-0501) KEY-OFF LOAD (KOL) REQUIREMENTS FOR ALL MODULES in Electrical SDS as tailored below.
Purpose: Definition of the Maximum Key-Off Load (KOL)

1. The target base key off load in sleep mode shall be: <=100 uA between -40C to 75C at 12.5 volts.
2. Key off load for CAN wake-up capability in sleep mode shall be included in the target base key off load.
3. KOL measurement time averaged. Length of time must be adequate to capture all events that will increase KOL during sleep mode. Ex. Receiving the TPMS signal every 6 hours the measurement period must be at least 6 hours long.
4. Modules to enter sleep mode as soon a feasible.
5. Modules which presently do not meet this requirement must meet after major, modified, or new design.

Notes:

a) CAN based modules must reach their final KOL current within 1 minute of bus activity terminating.
b) These current limitation apply to the total current drawn from all power connections and shall include output leakage currents for all the interfaces to the module.

3.5.1.4.1 KOL MEASUREMENT PROCEDURE CHARACTERIZATION SUMMARY

Quiescent Current shall be measured for WCM at -40°C, 25°C, and 75°C. WCM has to be in sleep mode during the test. The quiescent current shall be measured in such a way that the measurement accounts for all current flowing through WCM from the PAAT connection out the ground connections (digital and power if both are used). This includes the possible current sourcing and sinking effect of all attached devices except for power loads. Measurement shall be made with WCM connected as in the vehicle. This means that all I/Os, loads etc. shall be connected to the box. Current to external units supplied by WCM should be subtracted from the total quiescent current to WCM. The resolution of the measurement equipment used shall be no less than one micro-ampere. Current shall be measured at the WCM PAAT connection and not the vehicle battery connection.

3.5.1.5 Abnormal Voltage Operation

WCM shall withstand application of 27VDC for ≥ 60 seconds, simulating a dual battery jump start (Reference Immunity Overstress section in a Detail attached to EY-0141/RQT-002600-009624 for more details). Functions must automatically return to normal when normal operating voltages are restored.

The module shall suffer no damage from continuous vehicle voltages below 9 VDC. Functions must automatically return to normal when normal operating voltages are restored.

The module shall suffer no damage from continuous vehicle voltages between 16 VDC and 19.95 VDC. Functions must automatically return to normal when normal operating voltages are restored.

3.5.1.6 Automatic Engine Start / Stop

WCM shall be designed to be compliant to Global Power Supply Start/Stop Voltage Curve Specification FS-0000-00001-AB Revision 4 (see attachment of RQT-002600-000443 / 09-0495). The start/stop battery voltage curve defined in FS-0000-00001-AB is at the battery terminals.

WCM shall functionally operate with no perceived customer degradation while being supplied the electrical power profile defined in FS-0000-00001-AB Revision 4 with an equivalent voltage drop of 1.0V with a 4.0A load in the harness and connection systems. No perceived customer degradation when subjected to the start/stop voltage curve is defined by the following and shall be approved by FMC D&R.

- All microcontrollers are fully operational with no power-on reset or entering into any other state that would disable charging
- HS-CAN multiplex bus is fully operational and meet all performance requirements specified within.

-
- An active wireless charging session will be preserved with no disruption of the charging function by WCM. However, the ability to transfer the requested power from the receiver may deviate during the event due to the limited voltage available, but will recover automatically thereafter.

3.5.2 Electrical Output Requirements

3.5.2.1 ###R_F_Wireless Charging_00024### Charge Performance Requirement

The WCM must be capable of meeting all charge and efficiency requirements stipulated in all Qi, WPC, Apple fast charge and Samsung fast charge specifications and the charge performance requirements listed in this section.

The WCM shall be capable of meeting the following charge rate performance requirements using an Iphone X, Samsung 8, LG V30 phone when tested per conditions stipulated in this section:

	SOC after 15min		**SOC after 45min**		**Time from 5-95%**	
	Target	**Minimum**	**Target**	**Minimum**	**Target**	**Minimum**
Iphone X	17%	15%	46%	36%	120 min	142 min
Samsung Galaxy 8	18%	15%	45%	36%	115 min	130 min
LG V30	17%	13%	47%	33%	120 min	142 min

WCM must be capable of meeting the minimum values listed in the table above.

Testing shall be conducted using new phone samples and Ford standard phone samples for DV and PV testing with the latest phone software (operating system) installed at the time of test. Phone shall be tested in the minimum loading condition with airplane mode on, screen off, phone centered on charging pad, starting at 5% SOC (state of charge, read on the phone display), all test elements at 23 +/- 1C start temperature and 23 +/- 1C ambient (note: testing shall be conducted on a test bench without external active air flowing on the sample) , at 13.5 +/- 0.1VDC. SOC readings shall be taken from phone display. Contact Ford Engineer prior to DV and PV testing to obtain Ford Standard phone test samples. Supplier to contact Ford Engineering prior to DV and PV testing to obtain approval for test procedure and equipment used to validate this requirement.

WCM shall support a wireless charging rate of charge up to 15W, as governed by the specifications in section 3.5.2.3.

WCM shall limit the charging power to 5W during extended play mode in order to minimize vehicle battery drain.
Extended play mode is defined as:

- Ignition_Status = OFF
- Del_Accy = OFF
- HMI_HMIMode_St = ON

3.5.2.2 Charging Endurance

WCM shall be capable of charging for 12 hours straight with zero interrupts over the operational temperature and voltage range. An interrupt is defined as an event when charging stops, which may or not include a notification on the screen of the device. The purpose of this test is to ensure the WCM design can continue charging a phone without interruption.

3.5.2.2.1 CHARGING ENDURANCE TEST

WCM charging endurance test plan will be settled and approved by Ford Engineering prior to start of testing. The test shall include the following parameters:

- The following
  - One Qi 15W EPP receiver with Authentication support
  - One Samsung Fast Charge compatible device
  - One Apple Fast Charge compatible device
- Supply voltage must be varied during this test
- CAN will be exercised during test
- DTCs will be monitored periodically during test
- Test at three temperatures
- All coils exercised

3.5.2.3 Wireless Power Standards

WCM shall be a multimode capable wireless power transmitters designed to the below industry standard specifications, capable of charging up to 15W.

Inductive Charging:

- Qi Specification (15W EPP transmitter) version 1.3, authored and controlled by the Wireless Power Consortium (WPC)
- Apple Fast Charge
- Samsung Fast Charge

WCM's top cover charging surface material, rather purchased in assembly or customer directed, shall have no measurable degradation in the electromagnetic field and the overall system efficiency.

The supplier shall measure the overall system efficiency with and without top cover to determine the impact of the top cover to the charging function. The wireless charging function shall be Functional Importance Classification A. WCM supplier shall submit a full copy of the Qi / WPC validation test report to Ford Engineering showing conformace to the specified Qi requirements in effect during DV and PV testing.

3.5.2.3.1 ###R_F_WIRELESS CHARGING_00035### QI AUTHENTICATION

The Wireless Charging Module shall support Qi Authentication capability in compliance with Qi Specification v1.3.

3.5.2.3.2 ###R_F_WIRELESS CHARGING_00036### QI AUTHENTICATION EAL

The Wireless Charging Module's Qi Authentication cryptography security rating shall be EAL (Evaluation Assessment Level) of 5+ or higher.

3.5.2.4 Active Charge Area

WCM active charge area shall be at least 70mm x 30mm for a 5W or 15W receiver. Charge area is the area where the center of a receiver coil needs to be placed to enable charging. This charge area shall be centered around the center of the A-side surface so the charge area is approximately symmetric. Active charge area shall be defined as the area where the device under charge can be placed on the WCM and meet the minimum charge performance requriments stipulated in section 3.5.2.1 of this document unless agreed to in writing with Ford Engineering prior to PPAP approval. This area is a rectangle and Ford expects suppliers to meet the spec anywhere within this region. Efficiency is no longer included in the calculation of charge area, however, Ford expects a reasonable charge time

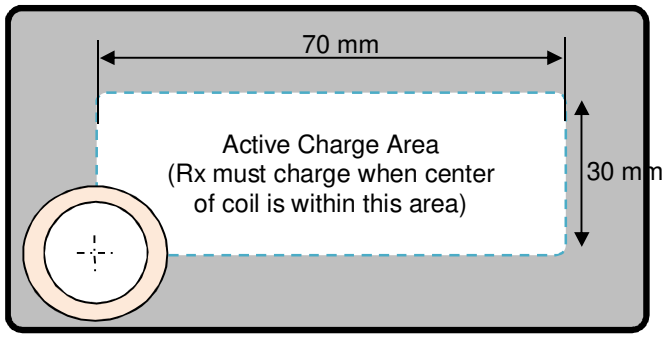
and temperature over entire charge area, and will compare performance between suppliers, and also confirm that FOD works properly.

Charge area is specified to ensure that the vast majority of phones (as small as iPhone 5 up to iPhone 8 Plus / Galaxy Note 8) are able to charge at any location within the charger bin area.

3.5.2.4.1 ACTIVE CHARGE AREA VALIDATION

Active charge area shall be measured at nominal input voltage using the 15W Avid Receiver Simulator (http://www.avid-tech.com/product/qi-receiver-simulator-v1-2/) with a 15W external load, an iPhone X supporting Apple Fast Charge, a Samsung Galaxy S9 supporting Samsung Fast Charge at the maximum rate of charge, and an LG V30 mobile device, . The test shall be performed on one receiver at -20C, room temperature, and +40C, and on at least 6 modules under nominal conditions (room temperature, nominal input voltage) to characterize the statistics. Charge efficiency measurements shall be taken in 1X1mm increments across a minimum area of 75x35mm.

WCCA shall be performed on charge area to characterize tolerances and WC expected performance.



3.5.2.5 WCM Over-Current Protection

WCM shall limit the wireless power transmitted so that no more than the maximum continuous current stipulated on the WCM device transmittal is drawn through the WCM's battery input terminals.

3.5.2.6 ###R_F_Wireless Charging_00025### Sliding Phone Capability

WCM shall continue charging a phone after it slides across the active charge area. Foreign object detected / phone misaligned states shall not occur during this scenario if the phone's coil is still within the active charge area. It is acceptable for charging to momentarily interrupt and begin charging on another coil during this event, but the charging status signal (message 3F6 on HS3) shall remain at charging in progress if charging resumes.

This requirement also applies to the scenario where a phone slides across the charger and momentarily stops charging. If charging resumes immediately (within the minimum time needed to re-establish charging), the charging status signal (message 3F6 on HS3) shall remain at charging in progress.

The purpose of this requirement is to ensure that the phone continues to charge during driving, as long as the device's coil is still on the active charge area. For example, if a car makes a quick stop, accelerates quickly, or hits a bump in the road, the phone may slide across the charging surface.

3.5.2.6.1 SLIDING PHONE ROBUSTNESS VERIFICATION

Test plan shall be agreed upon between Ford and supplier prior to software validation testing.

3.5.3 Phone Damage Protection

WCM shall prevent damage to a charging smartphone that is moved/placed on charger. This requirement applies whether the phone is currently charging or not.

3.5.3.1.1 PHONE DAMAGE PROTECTION VERIFICATION

Test plan shall be agreed upon between Ford and supplier prior to software validation, and is expected to include testing with real smartphones.

3.5.4 RFID Damage Protection

WCM should prevent damage to nearby RFID and NFC devices in all modes of operation including charging, phone detection, digital ping, etc. WCM shall also protect against the scenario where an RFID/NFC device is moved close to the charger, or if a thin device is slipped between the phone and charger while charging.

3.5.4.1.1 RFID DAMAGE PROTECTION VERIFICATION

Test plan shall be agreed upon between Ford and supplier prior to DV and PV testing.

3.5.5 Communication and Storage

3.5.5.1 HSCAN

WCM shall use a Controller Area Networks (CAN) for serial data communication between vehicle subsystem Electronic Control Units (ECUs) and for serial data communication with the in-service and in-plant test equipment. The HSCAN interface shall conform to the requirements specified in the following documents (Reference RQT-000600-009571 (EY-0088) HIGH SPEED & MEDIUM SPEED CONTROLLER AREA NETWORK PROTOCOLS in EESYS SDS):

(1) HIGH & MEDIUM SPEED - CAN (Controller Area Network) CGEA ECU LEVEL FUNCTIONAL Requirements Specification 00.06.00.001-2017

(2) CAN (Controller Area Network) Data Link & Physical Layer Specification 00.06.03.001-BC

(3) WCM is required to integrate mandated protocol software platform (FNOS); or, shall be in possession of a Non Standard NOS Software Declaration form that has been reviewed and signed by the EESE Architecture, Systems and Advanced Engineering Manager (Dept T407). Reference the EESE NETWORK COMMUNICATIONS CAN MULTIPLEX TECHNOLOGY STATEMENT OF WORK.

Requirement	*Detail*
Interface	*HSCAN*
Signal Names	*CAN +* *CAN –*

Functional Importance Class	*Class A*
Physical Layer	*ISO 11898*
CAN Bit Rate	*500 kbps*
Network Signoff	*Prior to design freeze, the electrical PCB layout for network circuits shall be reviewed and signed off by the Ford NETCOM technical specialist.*

WCM hardware shall be designed with hardware (i.e. CAN transceiver, microprocessor, etc) that can support CAN FD, and is compliant with the following documents. The intent of this requirement is to enable CAN FD capability with a future software update.

1. ISO CAN FD 11898-1:2015, and
2. Reference RQT-000600-009571 (EY-0088) HIGH SPEED & MEDIUM SPEED CONTROLLER AREA NETWORK PROTOCOLS in EESYS SDS
3. 00.06.03.002.AP. – CAN LIN Ethernet Physical Layer Transceiver, choke, and ESD components

3.5.5.2 LIN Communication Package Protection

Not required.

3.5.5.3 Microcontroller

3.5.5.3.1 SCALABILITY

WCM control shall be microcontroller-based. The microcontroller shall be selected to be both upward and downward compatible with other members of the selected microcontroller family.

3.5.5.3.2 CLOCK SPEED AND POWER SUPPLY

The microcontroller selected shall not operate at a clock speed ≥ 70% of max capability. The microcontroller power supply shall be sized to operate at max micro clock speed + 1 short on 1 CAN line.

The microprocessor oscillatory clock speed selections should avoid speeds that match fundamentals and harmonics of the LF charging frequencies.

3.5.5.3.3 NON-VOLATILE MEMORY

The microcontroller shall contain FLASH memory for program code and calibrations to be used for development, and is the required memory type for WCM production modules.

Since WCM is required to store Diagnostic Trouble Codes (DTC's) and calibration constant data it shall meet RQT-191001-009902 (EC-0054) in ELCOMP by complying with Requirement & Expectations for Development (RED) Nonvolatile Memory (NVM)" specification.

The microcontroller shall be programmed / reprogrammed through the Diagnostic Link Connector (DLC). WCM shall not require a special service tool for programming/reprogramming (Reference RQT-19001-009903 (EC-0055) in ELCOMP).

The WCM application and diagnostic memory allocation shall provide resources as defined in RQT-191001-009915 (EC-0069) in ELCOMP.

3.5.5.3.4 POWER DROPOUT

Starting at 12 volts, a voltage dropout up to 20 milliseconds (ms) when the vehicle supply voltage (VBATT_01) drops to 0 VDC shall not cause a microcontroller/microprocessor to reset. Outputs and the wireless charging feature may dropout during this period; however, they must recover without user intervention.

Although 20mS is the requirement, it is recommended that this time be chosen such that the module can detect the dropout (minimum of 3 samples, every 2mS, total of 4mS - 6mS) and have sufficient time left to write any EEPROM data required. If a faster sampling rate is used, then the total time should still be between 4mS - 6mS (Reference RQT-191001-009891(EC-0043) in ELCOMP).

3.5.6 Concept of Operations

WCM shall operate as a sleep node on the HS3 CAN as a PAAT (powered at all times) module on the vehicle battery. WCM uses network management signals from FCDIM/APIM to enter the pre-shutdown state and proceed to a low key-Off Load (KOL) sleep state. The CAN bus is used to awake WCM from its sleep state where it will automatically proceed to the standby state and process vehicle HMI and ignition signals to determine activation of the wireless charging function. When the input battery voltage is outside of the normal operating range of 9-16V the charging function is not guaranteed and is automatically re-enabled when the voltage returns to normal.

WCM includes features to avoid interference such as AM Avoidance and PEPS avoidance, and a thermal management scheme to ensure temperatures do not exceed safe limits. WCM also protects against damage to phones.

WCM shall disable the phone charging function during transport mode. For a definition of the signaling to indicate transport mode, reference Power Management WACM SSPS.

3.5.6.1 ###R_F_Wireless Charging_00002### Wireless Charging Begins

When a compatible device is placed within the active charge area on the Wireless Charging Module, the Wireless Charging Module shall begin a wireless charging session automatically.

3.5.6.2 ###R_F_Wireless Charging_00039### Charge Complete Exit

The Wireless Charging Module shall exit charge complete state and re-enter device detection state after 20 minutes or as directed by receiver, in accordance with Qi specification. This requirement only applies when the receiver sends the End of Charging (EOC) signal.

3.5.6.3 ###R_F_Wireless Charging_00039### FOD Exit

The Wireless Charging Module shall exit FOD state and re-enter device detection state after 20 minutes.

3.5.6.4 ###R_F_Wireless Charging_00012### Driver removes device

When in the FOD state, Charge Complete, or Overheating states, the Wireless Charging Module shall exit the present state and transition to device detection state when the device is removed from the charging surface.

3.5.6.5 ###R_F_Wireless Charging_00006### Device is removed while charging

The Wireless Charging Module shall end the wireless charging session and transition to Device Detection state when a charging device is removed from the charger, while remaining compliant with applicable wireless charging protocols.

3.5.7 Thermal Management

The WCM shall be designed to allow convective cooling from air in the vehicle cabin to remove heat from the phone and WCM during a charge session using a modular internal fan to achieve optimum charge performance. The WCM shall draw air from the cabin A-side surface past the phone, primary coils, charger electronics and exit the bottom of the module. The internal fan shall be reversible to allow air to flow from the bottom to the top of the module if required. The internal fan should be a modular design for easy removal to accomdate the base-low variant (fan shall not be a serviceable item).

The module shall operate without deviation from the requirements stipulated in this specification when exposed to any fluids that may enter the module cooling system. The WCM system electronics must fail-safe if exposed to moisture. The WCM system electronics must show no evidence of a thermal event if exposed to moisture.

Any fluid entering the module cooling system shall not contact the system electrical elements (unless system electrical elements are hermetically sealed) and should pass through and exit the bottom side of the module. The module shall meet RQT-110206-021487 (CE-0104) Electrical Fire Prevention and the Fluid Ingress and Chemical/Pop Spill requirements stipulated in Ford ES-6E5H-19980 specification. Validation testing may include module immersion or dunk, fluid spray, fluid splash or drip testing. Contact Ford Engineering prior to DV design freeze to determine specific scope of testing needed for DV and PV testing.

Thermal performance is a key parameter of wireless charging. WCM has thermal management properties to ensure a robust, safe charging experience for users. It is expected that devices being charged will also have their own independent thermal management techniques. However, WCM is being specified to have its own thermal management system as a backup mechanism. WCM's temperature measuring capabilities need to be calibrated to the charging surface to meet the requirements in this section.

WCM shall have temperature sensing capabilities that are used to assess the charging surface temperature. The measurement precision of the surface temperature shall be within ±1.5°C of the actual charging surface temperature.

3.5.7.1 ###R_F_Wireless Charging_00014### Overtemperature behavior

WCM shall have a transmitter over temperature condition and disable the charging feature if the charger surface or phone reaches 58.5 +/- 1.5 degrees Celsius.

3.5.7.2 ###R_F_Wireless Charging_00015### Overtemperature recovery

WCM shall re-enable the wireless charging feature after a transmitter over temperature condition when the charging surface temperature measures a temperature ≤ 50 degrees Celsius.

3.5.8 Foreign Object Detection (FOD)

3.5.8.1 Foreign Object Detection (FOD)

An inherent issue with inductive wireless charging technology is the contribution of undesired metal objects or materials (e.g. coins, keys) to the wireless charging interface. These objects can be present before or simultaneously with a valid receiver placement, or placed during an active charge session in progress. The result of these foreign objects may cause an undesirable self-heating of the objects and reduced system efficiency as some of the energy will be transferred into heat. To mitigate these situations the wireless power industry standards implement features into the protocol to support detection schemes for determining FOD events and suspending charging.

WCM shall have the ability to detect foreign objects interfering with power transfer.

WCM shall meet industry standard verification methods for determining a FOD condition and prevent threshold temperature limits from being exceeded. Industry standards include Qi wireless power certification standards and any relevant Apple Fast Charge or Samsung Fast Charge standards.

WCM shall not allow any foreign or metal objects on or near charging surface to exceed +55degrees C. This requirement applies no matter where on surface they are placed, and both during a charging session and not during a charging session. These objects include but are not limited to coins, gum wrappers, foil, metallic rings/discs, etc. Any retry charging strategies (i.e. re-trying charge session after a defined amount of time) shall also not cause the object to exceed +55degrees C. The intent of this follow-up requirement is to prevent an occurrence where repeated re-try attempts continue to push the temperature above the +55degree C limit.

- Pass criterion: object temperature & charging surface temperature never exceed +55C. Module is permitted to stop charging to achieve spec

WCM's FOD detection scheme shall be able to distinguish FOD conditions from instantaneous coupling changes (i.e. phone moved across charging surface).

WCM's FOD detection scheme shall not trigger FOD due to a misaligned phone, provided the phone's center is within the specified 30x70mm charge area region.

FOD shall be functional over the entire specified charge area 3.5.2.4.

One common issue with certain FOD implementations is a *false FOD* occurrence. False FOD is defined as the module reaching FOD state (and therefore stopping the charge session) when there is no foreign object present.

WCM shall not experience false FOD under any circumstances (due to phone misaligned, or other reasons) with any device that supports a wireless charging protocol. These devices are defined as devices that support Apple Fast Charge, Samsung Fast Charge, Qi certified devices, and any other devices that support wireless charging that do not fall into the other categories, as long as device is located within 30x70mm active charge area.

When charging surface is covered with many coins or foreign objects (sufficient to cause intermittent charging or communication), WCM shall trigger Foreign Object Detected state, and shall not cycle between charging in progress and charging not in progress. The intent of this is to avoid issues with flickering HMI messages/icon during intermittent charging or communication scenarios.

3.5.8.1.1 METAL OBJECT IS PLACED ON CHARGER (NO DEVICE PRESENT)

When metal object(s) are placed on the charger and no compatible charging device is on the charger, the Wireless Charging Module shall not enter a charging session and shall not enter Foreign Object Detected state.

3.5.8.2 Foreign Object Detection (FOD) Verification

FOD verification shall include compliance with all relevant wireless charging standards identified in section 3.5.2.3. These tests may or may not be part of the certification process.

FOD verification shall also include the following FOD objects. A passing score is the temperature not exceeding 55°C at any time during the 60 minute tests. In the main test, the receiver will be centered on the charging surface at room temperature. The initial test will be performed with the Avid Qi FOD receiver (latest version released at start of test, which is http://www.avid-tech.com/product/qi-fod-receiver-v1-2/ at the time of the writing of this specification), but Ford may ask for certain objects & positions to be tested with other receivers (i.e. real phones) for certain objects. The final test plan will be provided by Ford prior to start of test. Ford expects suppliers to provide a robust design that goes above and beyond industry standards to identify foreign objects while avoiding false FOD.
Testing shall be conducted on objects including the following:

- All four Avid Tech FOD objects (http://www.avid-tech.com/product/qi-set-of-foreign-objects/)
- Single Coins – exact list will be determined by Ford prior to start of testing.
  - Various countries
  - Various values (1cent, 5cent, etc)
- Multiple coins
- Mat surface covered with coins
- RFIDs
  - Parking stub, credit card, passport, employment badge, etc.
- Gum wrapper
- Aluminum foil
- Metallic Rings (various materials)
- Metallic discs (various materials)
- Paper clip
- Aluminum tab (can of soda)
- Washer
- Key
- Other objects as determined by Ford prior to start of testing.

Testing shall include many use cases -> misaligned phone, misaligned coin, misaligned phone & coin, phone & coin centered. Test plan shall also include testing with real phone(s). Ford will provide the final test plan prior to start of test. Supplier shall perform and deliver, upon Ford's request, developmental tests prior to official start of FOD testing in order to refine list of objects and develop final test plan.

3.5.9 ###R_F_Wireless Charging_00019### AM Radio Band Avoidance

The AM Radio Band Avoidance Feature is the method used to mitigate possible interference between the tuned AM radio station and a harmonic output of the wireless charging. The function also provides the ability reduce radiated emissions from the wireless charging function during the seek feature.

WCM shall shift its fundamental charging frequency (and digital ping frequency, as allowed within applicable wireless charging standards) as needed to ensure none of its harmonics fall within +/-15kHz of the tuned AM frequency, including WCM frequency precision. The supplier's frequency shift strategy shall be approved by Ford Engineering prior to implementation. WCM shall shift back to the nominal default fundamental charging frequency when the AM radio station changes to a station that is not a harmonic of the fundamental frequency or the active band is no longer AM.

Note: The overall AM frequency range covering all markets is 522 to 1710 kHz. The maximum frequency shift used to achieve this performance shall not exceed +/-5% of the nominal frequency, including frequency precision.

WCM shall reduce the power being transferred during a wireless power transfer session is in progress when an AM seek/scan feature is performed for the AM band, WCM reduces the power transfer to a level that ensures no interference with the radio.

AM radio and AM seek information is provided over CAN messages. Reference Feature – Wireless Accessory Charging. Wireless Accessory Charging Module (WACM) Infotainment Subsystem Part Specific Specification (SPSS) for the full details on the entry & exit conditions for AM Avoidance.

3.5.10 PEPS Avoidance

The PEPS Avoidance Feature is the method used to mitigate possible interference of wireless charging operation with the PEPS LF antenna and passive key. The feature is event driven where the BCM provides both a hard wired and CAN signal to enable / disable the feature based on when a PEPS query is to be performed / PEPS query is complete.

WCM shall use the hardwired PEPS Input signal as the control signal for the PEPS Avoidance Feature. WCM shall stop charging and cease emissions (due to device detection, digital pinging, etc) within 7 milliseconds of the active input signal being activated. If the PEPS input signal goes active in the Power Transfer Phase while actively charging a device, the charge session shall be terminated with immediate re-engagement once the event has been completed.

WCM's charging status signal (message 3F6 on HS3) shall remain at charging in progress if charging resumes within the minimum amout of time required to re-establish charging if charging was interrupted by a PEPS event. The intention of this is to avoid unnecessary HMI messages.

WCM shall perform the required frequency clipping to be fault tolerant to erratic input events (e.g. noise, chattering input) increasing CPU utilization beyond maximum limits.

WCM shall also use a redundant CAN signal to the hardwired PEPS Input Signal to perform the PEPS Avoidance Feature as a wired "Or" condition. This redundancy is to provide additional robustness in the event the hardwired PEPS Input signal is open-circuited or behaves in an unexpected manner.

Reference Feature – Wireless Accessory Charging. Wireless Accessory Charging Module (WACM) Infotainment Subsystem Part Specific Specification (SPSS).

3.5.11 ###R_F_Wireless Charging_00003### Time to Begin Charging

A charging session shall begin within 1.5 seconds of phone being placed onto charging surface.

The intention of this requirement is to ensure the user gets quick feedback when a phone is placed on the charging surface. This lets the user know that charging has started and prevents the user from trying to reposition his or her phone. It is expected that a long delay between a device being placed on the surface and the user receiving feedback on charging status will result in confusion and dissatisfaction.

3.5.11.1 Time to begin charging verification

This requirement shall be verified on three smartphones, performed 5 times per phone. Ford Engineering must approve the phones used and the test plan prior to conducting testing.

Recommended phones (final devices selected must be approved by Ford Engineering prior to testing)

- Samsung Galaxy S9
- iPhone X
- LG V30

The timer will begin when the phone is placed down on the surface, and shall stop when either the phone's screen lights up or beeps.

3.5.12 Cellular Signal Degradation

- Degradation to cellular signal Total Radiated Power (TRP) and Total Radiated Sensitivity (TRS) when a smartphone is placed on WCM shall be no greater than 4 dB for all cellular bands and, 2 dB for GNSS band (1.16-1.61 GHz).

The intention of this requirement is to minimize degradations to cellular reception when a smartphone is placed on the module. This helps users maintain adequate cellular reception when the charger is in use. Ford expects the sourced supplier to make a legitimate attempt to meet this requirement by holding design reviews of module design(s) to meet this requirement with Ford Core Engineering and RF Engineers. This may need to be performed in parallel with module development.

3.5.12.1 Cellular Signal Degradation Verification

Three phones must be tested for this parameter. Multiple frequency bands must be tested for each phone. The phone must be tested in two orientations (normal & rotated 180 degrees), and multiple charging positions must be tested (center of charger, engaging top coil, engaging bottom coil). The tests shall be conducted according to CTIA standards. The test details are below:

The test must be performed using the proposed coil & heat sink (if applicable). Three tests shall be performed on three smartphones:

1. iPhone X
2. Samsung Galaxy S7
3. LG V30

The specified test plan is below:

			Total Radiated Power				Total Radiated Sensitivity			
Band	Phone Location	Phone Orientation	Free space	Phone on charger (charger OFF)	Phone on charger (charger radiating at max power)	WC TRP Deg.	Free space	Phone on charger (charger OFF)	Phone on charger (charger radiating at max power)	WC TRS Deg.
			dBm	dBm	dBm	dB	dBm	dBm	dBm	dB
700 MHz	Center of pad	normal								
		rotated 180deg								
	Bottom coil	normal								
		rotated 180deg								
	Top coil	normal								
		rotated 180deg								
850 MHz	Center of pad	normal								
900 MHz	Center of pad	normal								
1800 MHz	Center of pad	normal								
		rotated 180deg								
	Bottom coil	normal								
		rotated 180deg								
	Top coil	normal								
		rotated 180deg								
2500 MHz	Center of pad	normal								
		rotated 180deg								
	Bottom coil	normal								
		rotated 180deg								
	Top coil	normal								
		rotated 180deg								

Note: Tabel above shall also include GNSS frequency bands.

3.5.13 Near Field Communication (NFC) Capability (for Base-full variant only)

WCM shall support the following Near Field Communication (NFC) modes:

- Reader/Writer: ISO/IEC14443 A&B
- Peer-to-Peer (P2P): Full NFCIP-1 & NFCIP-2 compliance
- Card Emulation: ISO/IEC 14443A & FeliCa

WCM shall be capable of performing bi-directional NFC communication, including the operating scenario while the device is being charging at maximum power without interruption. Wireless charging and NFC shall occur together in the presence of harmonics and emissions from the deice being charged.

WCM shall process the key fob identification bytes over NFC from either smartphone or key card and transmit data on CAN bus to support ignition start for processing.

3.5.13.1 Near Field Communication (NFC) Area

WCM shall be able to communicate over NFC to a phone anywhere in the charging bin. The intention of this requirement is to ensure that the driver/passenger does not need to move the phone to the center of the charging surface in order to enable an NFC feature. The charging bin dimensions are targeted to be 188.3mm by 88.6mm.

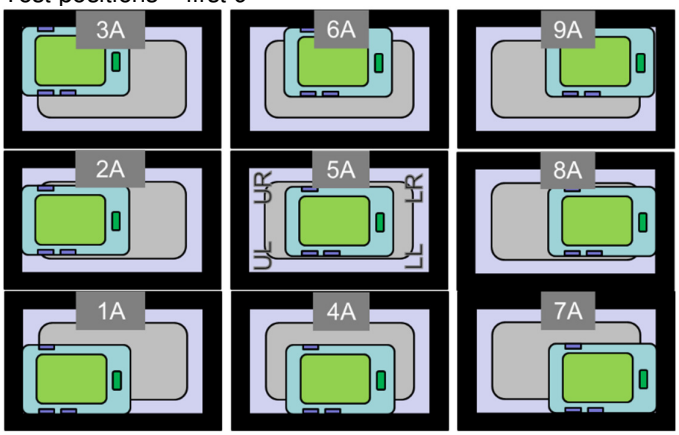
3.5.13.1.1 NEAR FIELD COMMUNICATION (NFC) AREA VERIFICATION

NFC Area shall be verified using multiple phones and multiple phone positions within the bin.

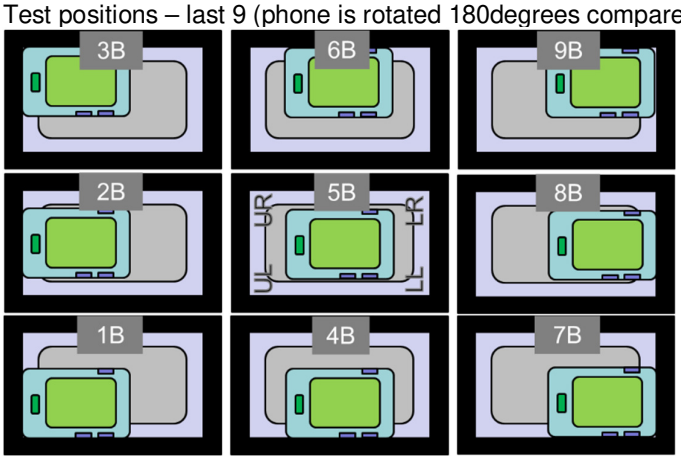
Recommended phones (final devices selected must be approved by Ford Core Engineering prior to testing):

- Samsung Galaxy S9
- iPhone X
- LG V30

Test positions – first 9



Test positions – last 9 (phone is rotated 180degrees compared to first nine)



3.5.14 EMF Emissions

WCM shall not exceed 20% of the ICNIRP 1998 EMF exposure limits during all operating modes within 5cm of the charger, in any direction.

The intent of this requirement is to ensure sufficient margin to the INCIRP 1998 EMF exposure limits during all operating modes. The 20% requirement means that for a theoretical spec of 5.0 units, the maximum acceptable performance would be 1.0 units.

3.5.14.1 EMF Emissions Verification

EMF Emissions must be verified in all operating modes (i.e. device detection, phone charging, etc). The smartphone and test plan used for the test shall be approved by Ford Core Engineering and Ford EMC prior to testing.

3.5.15 ###R_F_Wireless Charging_00026### Disable Charging Function

WCM shall accept a CAN signal that disables the charging function. WCM shall remember the last state of this signal during sleep & wake-up.

The intent of the requirement is to allow users to disable the wireless charger to prevent emissions.

3.5.16 HVAC interface

Not required.

3.5.17 Integrated Cooling

The WCM shall include an integrated cooling system per requirements stipulated in section 3.5.7 of this document.

The WCM shall be designed to avoid customer complaints from excessive nose emission when the integrated cooling system is active. Integrated cooling mechanism noise emissions shall be below ambient vehicle noise level during all modes of vehicle operation unless agreed to in writing with Ford Engineering prior PPAP approval.

Unless agreed to in writing with Ford Engineering prior to PV testing, the integrated cooling mechanism shall not exceed a noise limit of maximum 22 dBA when tested at the component level in a quiet chamber with a microphone positioned 18 inches from the module in the worst-case direction.

Component validation shall be conducted for DV and PV. Vehicle validation shall be conducted on DCV level vehicles. Ford Engineering to approve component and vehicle validation set up and test procedure prior to DV and PV testing.

See section 3.5.7 of this document for additional requirements.

3.5.18 Integrated Cellular Coupling Antenna (certain variants only)

NFC variant of WCM module may be package protected to accommodate a coupling antenna. Supplier to review coupling antenna package protection design concepts with Ford Engineer during sourcing phase to determine applicability to package protect for this feature.

~~3.5.18.1 Integrated Cellular Coupling Antenna RF output (certain variants only)~~

~~Variants of WCM with an integrated coupling antenna shall have a Fakra RF output connector.~~

~~The return loss looking into the module through the Fakra connector shall be no less than TBD dB. Suppliers shall provide return loss data over the band 700MHz to 3 GHz.~~

~~3.5.18.2 Integrated Cellular Coupling Antenna Fault Detection Capability (certain variants only)~~

~~Variants of WCM with an integrated coupling antenna shall have the capability to detect an open circuit or a short to ground on the RF~~

3.5.19 Pseudorandom Frequency

WCM supplier shall investigate the feasibility of using a pseudorandom frequency instead of a fixed frequency in order to minimize interference with the AM radio.

- Charging frequency would be pseudorandom selection over a 4 kHz bandwidth (fcenter +/- 2 kHz). Frequency must be switched every 500 microseconds.
- Is Qi certification possible?
- Will this cause interrupts in phone charging? How will phone react to the instantaneous change in power when frequency is changed?

3.5.20 Over The Air software update

WCM shall comply with Ford Over The Air (OTA) Software Update requirements as specified in the RFQ Package. WCM shall support ABA OTA capability. This is known as “Fast OTA”.

3.5.21 Cyber Assurance Requirements

WCM shall comply with Cyber Assurance/security software requirements as specified in the relevant applicable requirements.

3.5.22 Software Health and Reporting Requirements

WCM shall comply with Software Health and Reporting (SWHM&R)/PARSED requirements as specified in the RFQ package.

3.5.23 Message Authentication

Not required.

~~Ford has requested suppliers provide for the cost for WCM to support Message Authentication. Message Authentication requirements can be found in the file “Message Authentication FSMS Requirements 1.0.docx” in the Software folder -> Message Authentication.~~

3.5.24 Multiplexed Incoming / Outgoing Messages

WCM shall process state variables received over the CAN bus and perform state model changes within 50 milliseconds of receiving the signal (i.e. ACC, RUN, Delayed Accessory, Load Shed HMI Audio On).

WCM shall report wireless charging Status over the CAN bus within 50 milliseconds of the state change.

For definition of incoming and outgoing signals, reference the following subsystem specifications.

Feature – Wireless Accessory Charging. Wireless Accessory Charging Module (WACM) Infotainment Subsystem Part Specific Specification (SPSS)

Feature – Power Management. Wireless Accessory Charging Module (WACM) Infotainment Subsystem Part Specific Specification (SPSS)

Feature – Infotainment Network. Wireless Accessory Charging Module (WACM) Infotainment Subsystem Part Specific Specification (SPSS)

3.5.25 Test Mode

WCM shall implement a test mode that enables charging when the input voltage is between 9 and 16V without the need for CAN messages. This mode shall only be configurable by the supplier in order to prevent battery drain. The intent of this requirement is to facilitate bench D&R testing.

3.5.26 Diagnostics

3.5.26.1 Part 1 Specification

WCM shall implement embedded (on-board) diagnostics and interfaces with the dealership test tools, generic scan tool, or the vehicle assembly plant test equipment via CAN. WCM shall comply with the requirements specified in the "Generic Global Diagnostic Specification" (00.06.15.001 Issue Index 005) and in the “Software Download Specification” (00.06.15.002 Issue Index 007). Subsystem Specific Diagnostic Specifications (i.e., Part 2 Diagnostic specifications) shall comply with the requirements specified in the “Multiplex Diagnostic Specification” (00.06.15.006 Issue Index 004). Reference RQT-000600-009536 (EY-0053) in EESYS SDS.

3.5.26.2 Part 2 Specification

The supplier shall create and maintain the Diagnostics Part 2 specification for the life of the product, with Ford Motor Company input and approval. The Subsystem Specific Diagnostic Specifications (i.e., Part 2 Diagnostic specifications) shall comply with the requirements specified in the “Multiplex Diagnostic Specification” (00.06.15.006 Issue Index 004). Reference RQT-000600-009536 (EY-0053) in EESYS SDS.

3.5.26.3 Diagnostics Support

WCM shall support the mandatory diagnostic services defined in "Generic Global Diagnostic Specification" (00.06.15.001 Issue Index 005) and to be defined in the Subsystem Specific Diagnostic Specifications (i.e. Diagnostics Part 2 Specification).

3.5.26.3.1 REQUIRED DIAGNOSTICS

WCM shall include (but is not limited to) the following diagnostic information via DIDs (accessible via OBD-2 connector). Reference Infotainment Diagnostics Specification: Wireless Charging Device for more information.

- FOD information – relevant information determined by supplier

- Charging surface temperature(s)
- Operational state (device detection, charging in progress, FOD, etc)
- Coil in use
- Operational frequency
- Charging Surface temperature – one of each thermistor and one for the "max" temperature of all thermistors
- FOD counter (counts number of times FOD has occurred over the part's lifetime)
- WCM over temperature counter – counts number of times a WCM over temperature condition has occurred over the part's lifetime (needs to be able to be cleared)
- Device over temperature counter – counts number of times a charging device has ended a charge session due to over temperature (based on communication msg from device)
- Test Mode Enabled/Disabled
- Module input voltage
- Module input current (optional)
- Coupling antenna subsystem status – fault detection – open circuit and short to ground (integrated cellular coupling antenna variant only). Not required
- Charge Level Indication (###R_F_Wireless Charging_00031###).
    - The Wireless Charging Module shall provide charge level indication information on the CAN bus
- (TBD) Fan RPM
- (TBD) Fan status (performance, failures, etc.)
- PEPS Event counter – records number of PEPS events on this ignition cycle. This is used to support testing to confirm that module has correctly interpreted a PEPS event request.
- Active charging coil
- Charging protocol in useRx reported power
- Tx power estimate

3.5.27 EOL/Service

WCM shall be capable of writing of ECU configurable parameters in vehicle assembly plant or in service (dealership) via the HS-CAN network in conformance to the requirements specified in "ECU Configuration Specification" (00.06.15.003 Issue Index 004).

3.5.27.1.1 CHARGING POWER

WCM's maximum charging power shall be configurable between 5W and 15W in 2.5W steps:

- 5W
- 7.5W
- 10W
- 12.5W
- 15W

3.5.27.1.2 CHARGING STANDARDS

WCM's inductive wireless charging standards shall be configurable on/off (1 = ON, 0 = OFF). The Qi protocol does not need to be configurable. The intention of this requirement is to allow a capability to turn off Samsung or Apple Fast Charge at vehicle EOL.

- Samsung Fast Charge
- Apple Fast Charge

3.5.27.1.3 WCM OUTPUT CAN SIGNALS

WCM shall be able to enable/disable the following CAN states. For example, if Charge Complete CAN message is enabled, WCM will send Charge Complete signal when in the charge complete state. If Charge Complete CAN

message is disabled, WCM will never send charge complete signal. For all signals, 1 = ENABLED, 0 = DISABLED.

- Charging Not In Progress signal
- Charging In Progress signal
- Charging Complete signal
- Metal/Foreign Object Detected signal
- Over Temperature signal
- Charge Level Indication (%) signal

3.5.27.1.4 TRANSMITTER TEMPERATURE CONFIGURATION

This DID is used to enable/disable WCM's transmitter over temperature detection feature. The over temperature feature has two parameters, the first being the threshold limit at which a transmitter detect and over temperature condition. The second is the hysteresis temperature at which the transmitter will resume the wireless charging feature. If Over Temperature Limit = 0, the over temperature feature is disabled and Over Temperature Hysteresis is a don't care. When Over Temperature Limit = 1, the Over Temperature Hysteresis bit can be set to enable a hysteresis temperature for re-enabling the wireless charging feature, otherwise, the re-enabling of the feature is performed around the over temperature limit.

- Over Temperature Limit
- Over Temperature Hysteresis

3.5.27.1.5 FREQUENCY AVOIDANCE CONFIGURATION

This DID is used to enable/disable WCM's frequency avoidance features. The two features are the PEPS avoidance and the AM avoidance. When PEPSEN = 1, WCM will disable the wireless charging feature and any pinging/intentional emissions for the duration of the PEPS query event.

The AMAEN bit is used to enable/disable the AM avoidance feature. When AMAEN = 1, WCM will use CAN signals to determine when this feature should be performed and shift the fundamental frequency. If AMAEN = 0, WCM will ignore the tuned band information from the CAN bus and maintain the nominal charging frequency.

The AMSEEK bit is used to enable/disable the reduction of charging power during an AM seek function. If AMSEEK = 1, the charging power will reduce to a level that mitigates AM radio interference.

PEPSEN

- 0 – PEPS avoidance feature disabled
- 1 – PEPS avoidance feature enabled

AMAEN

- 0 – AM avoidance feature disabled
- 1 – AM avoidance feature enabled

AMSEEK

- 0 – Transmit power is not reduced during AM seek
- 1 – Transmit power is reduced during AM Seek

3.5.27.1.6 LOST COMMUNICATION DTC ENABLE/DISABLE

Enable/Disable Lost Comm with Radio DTC

- 0 – Lost Comm with Radio DTC is disabled

- 1 – Lost Comm with Radio DTC is enabled

Enable/Disable Lost Comm with APIM DTC

- 0 – Lost Comm with APIM DTC is disabled
- 1 – Lost Comm with APIM DTC is enabled

3.5.27.1.7 COOLING FAN CONTROL

Ability to control max fan RPM – details TBD (i.e. limit max RPM to 1000 RPM, 2000 RPM, etc).

3.5.28 Mechanical

3.5.28.1 WCM Thermal Performance

See section 3.5.7 of this document.

3.5.28.1.1 THERMAL PERFORMANCE CHARACTERIZATION

WCM's system thermal performance (temperature on phone surface, charger surface, temperature sensors) shall be measured during charge performance testing. Contact Ford Engineering prior to DV or PV testing to obtain approval for test method.

3.5.28.2 Connector

See section 3.3 of this document for module connection system requirements.

The connector and pinouts will be specified by Ford Motor Company Engineering prior to the start of development. All connectors must be Ford approved connectors. Reference RQT-180107-008726 (EL-0173) in CONN SDS and RQT-002600-000434 (09-0486) in Electrical SDS.

The module connector shall mate with the vehicle harness connector defined and/or approved by Ford Motor Company. All connections must meet the Connector Insertion Force requirements detailed in CONN SDS RQT-180107-008726 (EL-0173) for a 75N max insertion force. Where applicable, surrogate data from connector supplier should be used to prevent retest.

Per Electrical Connector SDS Requirement EL-0032, improper harness connector attachment to the wrong module connector header shall be prevented by using mechanical keying. Connector housing polarization must prevent mating with similar connectors or the mating of connectors in an incorrect orientation when a force less than or equal to 220 N is applied. Identical or similar connectors with differing polarizations should be clearly distinguished. Where applicable, surrogate data from connector supplier should be used to prevent retest.

Connector implementations shall meet requirements of USCAR 2, rev 4 (Performance Standard for Automotive Electrical Connection Systems) and USCAR 25, rev 3 (Ergonomics Specification for Electrical Connections).

Header or molded in connectors must mate to the Ford specified connector.

For all connectors there must be a cavity numbering to identify the different positions on WCM that can be determined by visual inspection. There shall also be pin outs in the connector cavities. 1st pin and last pin shall be identified at a minimum.

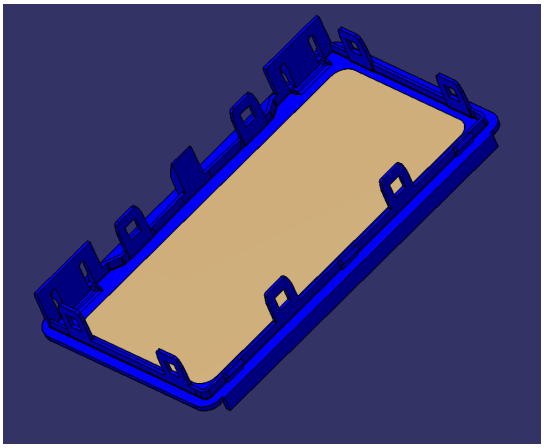
Supplier shall be responsible for conducting all connection system interface validation testing to verify acceptable performance of the complete connection system. Contact Ford Engineering 4 weeks prior to start of validation testing to obtain connection system test samples. WCM supplier shall provide 50 connection system header samples for DV and PV testing by EDS connector supplier.

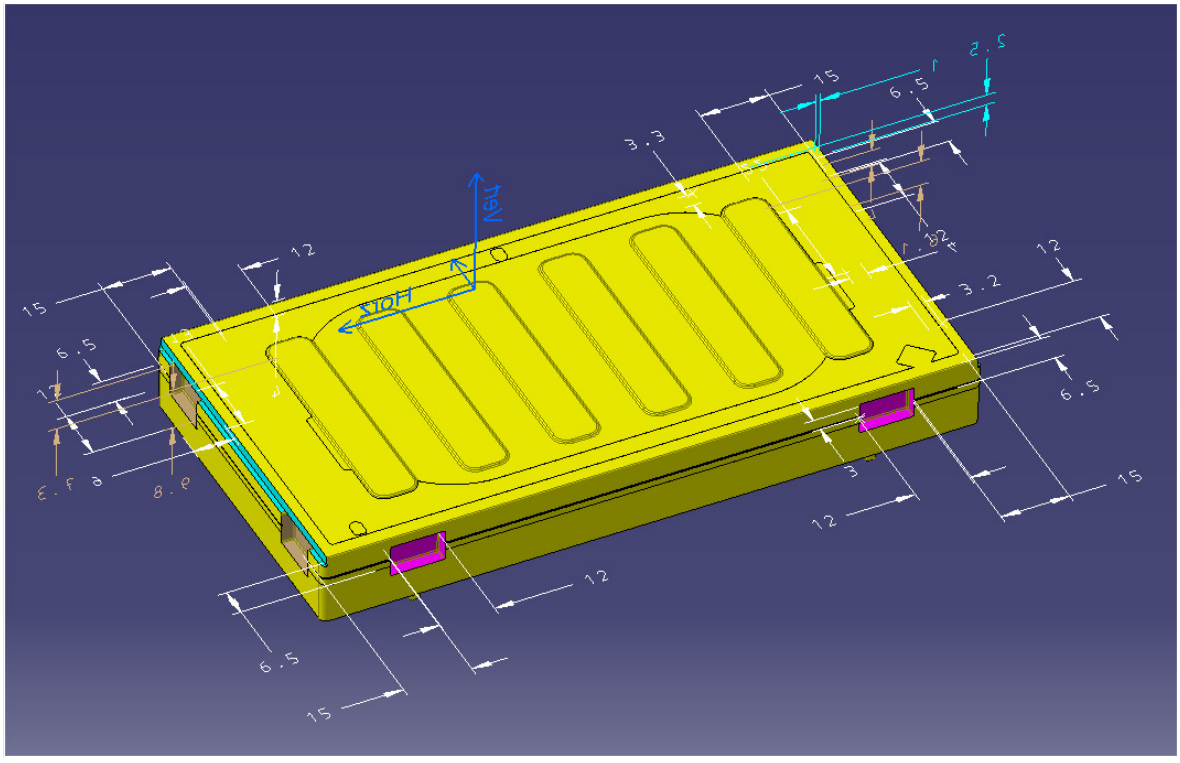
All internal WCM connection systems and wire shall meet Ford SDS ED-1481.

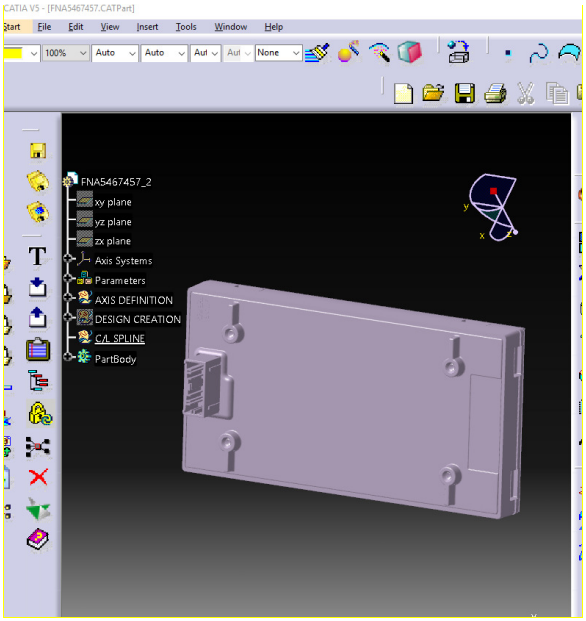
3.5.28.3 Mechanical Dimensions

WCM shall be backward compatible with Ford Gen 1 WCM. The Gen 2 WCM shall plug and play into existing Gen 1 applications. Contact Ford Engineering to obtain Gen 2 WCM CAD packaging and interface model.

The WCM shall be capable of mounting using a traditional Gen 1 bracket or snap fit mounting from the A or B side per requirements stipulated in the Ford Engineering Gen 2 WCM CAD packaging and interface model.



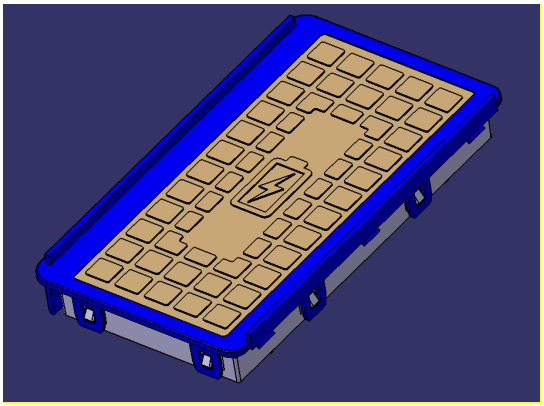




WCM's charging surface shall be a two-shot material using the following two materials:

1. Shot 1: WSS-M4D924-B1 (harder surface around material #2)
2. Shot 2: Recommending TPE 63 Durometer Shore A (soft, grippy surface touching phone)
    a. Trade name: Trinseo Pulse GX70NA. YoungWay Starprene 350A2
    b. Final material selected must meet WSS-M9P8-C.

Ford's intends the orange surface to be a sticky material the user centers their phone on top of. The blue material around the edge is a harder material around the charging surface that is used to support A-side loading. Refer to the CAD file attached in the Design Assumptions folder.



3.5.28.4 Weight

Note: Weight requirements include the weight of the charging surface mat. A requirement without the mat will be generated prior to the start of development.

Variant	Max Weight Spec

Base-high	350g
Base-Mid	340g
Base Low	320g

3.5.28.5 Materials

3.5.28.5.1 EVL + SUBSTANCE COMPLIANCE

Shall meet EVL + Substance Compliance According to specification listed in section 1.5.1.

3.5.28.5.2 RESTRICTED SUBSTANCE MANAGEMENT STANDARD

Shall meet Restricted Substance Management Standard listed in section 1.5.1.

3.5.28.6 Permanent Part Marking

3.5.28.6.1 BRANDING AND CODING.

Shall meet Branding and Coding per FECDS E-3 listed in section 1.5.1.

3.5.28.6.2 MATERIAL IDENTIFICATION & MATERIAL CODE PARTS MARKING.

Shall meet Material Identification & Material Code Parts Marking per FECDS E4 listed in section 1.5.1.

3.5.28.6.3 PRINTED LABELING

3.5.28.6.3.1 Printed Label Content

Part Labeling shall include all applicable regional regulatory information. See Supplier on Board Agreement (SOBA) for regional details. Contact Ford Purchasing or Ford Engineering for confirmation.

3.5.28.6.3.2 Regulatory Requirements

Part Labeling shall include all applicable regional regulatory information. See Supplier on Board Agreement (SOBA) for regional details. Contact Ford Purchasing or Ford Engineering for confirmation.

3.5.28.7 PC Board Assembly and Layout

Any Logic Printed Circuit Boards (PCB) will be of FR-4, CEM-3, or better material. All copper foil, connectors and cables shall be dimensioned to manage the worst case load according to ELCOMP in all temperature conditions, special attention should be made regarding ELCOMP RQT-191001-009986 (EC-0238) Maximum PCB Temperature and RQT-191001-009987 (EC-0239) Module PCB Trace Widths and Spacing requirements. Internal module temperatures shall not promote the relaxation of connector and fret terminal interfaces. Traces shall be designed to handle both the application current as well as the heat dissipation from the PCB mounted relays & subcomponents and other heat generating devices. There shall be no uncontrolled thermal event for un-fused circuit tracks in any possible situation including all loads and tests described in the Engineering Specification for Electrical Tests (i.e. Continuity Test, Thermal Map Test, Power dissipation test, voltage drop test, quiescent current, overload test (1.5x fuse rating), current step, 135% fuse test, Overload of circuits not protected by Fuses, FET overload test).

Cleanliness test of PCBs before solder mask is applied shall be done and documented for each batch of PCBs. Moisture Sensitivity Level (MSL) needs to be established and documented for PCBs. This needs to be done every time PCB manufacturing process/PCB sub supplier has changed.

Guidelines and rules for PCB layout shall be presented to FMC at an early stage in the project.

3.5.28.7.1 LEAD FREE MANUFACTURING

WCM and all BOM devices shall be Lead free (Pb) according to RoHS directive. DV or PV testing of WCM shall not be considered as a verification of a Lead free solder process. The printed circuit assembly shall be designed and manufactured in accordance with IPC/IEA J-STD-001 and ANSI/IPC-A-610 rev. D. (Class III devices). Special attention shall be paid to the choice of solder fluxes used in the PCB manufacturing and assembling processes. Special attention shall also be paid to effects of flux residues since the PCB will be used in moist environment.

The supplier shall reference the document Lead-free Requirement Guidelines To Consider for Engineering Change Request dated 5/13/2008 for material specification on lead free manufacturing. Compliance with this specification is recommended but any deviation must be justified by the supplier.

The supplier shall reference Ford Electronics Manufacturing Requirements (Release 2012 or later) for minimum electronics manufacturing requirements for printed circuit assembly processes.

3.5.28.7.2 CONFORMAL COATING

The PCBs shall have a protective coating not including area dedicated for coil(s), fully covering the surface in order to withstand corrosion and electro migration during the service life of WCM. The material and method of any surface treatment and coverage/inspection shall be specified on the drawing and approved by Ford Engineering. The surface treatment method is to be chosen so that satisfactory protection is provided with reference to the installation and its external and internal environment in the vehicle. Reference RQT-191001-009923 (EC-0078) in ELCOMP.

3.5.28.7.3 PCB TEMPERATURE, TRACE WIDTHS, AND SPACING

WCM's PCB traces shall be sized according to a current capacity chart for given copper thickness and allowable temperature rise. The maximum permissible temperature rise is the delta between the maximum ambient temperature and the maximum allowable temperature for the laminate. Rule of thumb is to keep the trace temperature rise at or below 20C. WCM's PCB traces shall be sized based on worst-case maximum currents, voltage drops, temperature rise. WCM's PCB minimum trace thickness should be large enough so that variations in manufacturing, copper thickness, etc. do not cause traces to open. The separation (spacing) between adjacent conductors must be sufficient to insure electrical isolation. This separation needs to take into account manufacturing tolerances, internal vs. external traces, polymer coating, and elevation. The separation for Battery and Ground shall be a minimum of 0.5mm (preferably 1.0mm). Signals considered as Battery, are signals able to source 1A or greater and can be active for > 10 minutes at a time (e.g. Key, Run, Battery Saver, etc.). Reference RQT-191-001-009987 (EC-0239) MODULE PCB TRACE WIDTHS AND SPACING in ELCOMP SDS.

WCM's maximum PCB temperature shall not exceed the glass transition temperature (Tg) of the substrate material with a 10% derating applied. For example, FR-4 substrate is available with many choices of Tg (135, 155 , 170 deg C, etc.). If using an FR-4 substrate with a Tg of 155deg C, then the substrate must not exceed 140 deg C. WCM's PCB vias, plated through holes (PTH) and solder joint temperatures shall not exceed their maximum temperatures (typically 135C). Circuit traces may go higher (do not violate maximum PCB temperature mentioned above), but must not cause vias, PTH's or solder joints to exceed their ratings. Reference RQT-191-001-009986 (EC-0238) MAXIMUM PCB TEMPERATURES in ELCOMP SDS.

3.5.28.8 Reliability

3.5.28.8.1 KLT WORST CASE CIRCUIT ANALYSIS.

The supplier shall ensure that the thermal budget for individual components is managed in such a way so as to guarantee 10yr/150,000mi reliability performance for the WCM design over the standard vehicle warranty period. Reference RQT-001100-002489 (18-0037) in DURABILITY SDS. This is done by successfully completing the Worst Case Circuit Analysis.

3.5.28.8.2 VALIDATION REQUIREMENTS

Refer to ES-6E5H-19980-AP for validation requirements, appearance approval procedure, and other requirements, with the following exceptions that supersede the document.

- WCM shall be tested to Class III mechanical Shock/Drop test..

3.5.28.8.3 IN-PROCESS (IP) REQUIREMENTS

In-Process (IP) tests are used to further understand the relationship between significant design and process characteristics and to establish a basis for continuing improvement. Supplier shall complete Special Characteristics Communication and Agreement Form (SCCAF) FAF03-111-2. Supplier shall obtain approvals supporting milestones shown on the form and per FAP 03-111.

Tests must be completed with production parts on an ongoing basis.

Sampling plans for both IP testing and evaluation of the significant process characteristics must be included in the Control Plan.

When the process is found to be out of control or the test acceptance criteria are not met, the reaction plan approved in the Control Plan shall be invoked.

3.5.28.8.4 EMC

The Component's design performance shall meet the electromagnetic compatibility requirements delineated in FMC 1278 Revision 3: Electromagnetic Compatibility Specification for Electrical/Electronic Components and Subsystems.

The Supplier shall work with FMC D&R to perform the following steps to assure compliance for the Component.

- Support FMC D&R with definition of Functional Importance Classification and get agreement from FMC EMC.
- Identify which tests are applicable and document in the below table.
- Identify operating modes and acceptance criteria
- Develop EMC test plan and get Ford EMC sign-off prior to start of test
    - Recommend submitting EMC Test Plan 4 weeks prior to start of test

The Component EMC Design Verification testing shall be performed with production hardware ready / production intent software code. Any software strategies / techniques used for EMC mitigation should be applied. This software shall be verified / approved via the FORD Software development process.

EMC Design verification testing shall be performed in accordance to FMC 1278 Revision 3: Electromagnetic Compatibility Specification for Electrical/Electronic Components and Subsystems.

The WCM supplier shall submit a component EMC validation test report, per Ford EMC team requirements, within two weeks of component EMC DV or PV test completion. DV or PV test results must be reviewed and approved by the Ford EMC team. The WCM supplier shall submit a component test summary within one week of the completion of EMC testing.

3.5.28.8.5 ENVIRONMENTAL DURABILITY (NON-EMC)

The WCM shall meet all requirements stipulated in the Ford Electrical and Electronic Component Compatibility Test Specification, CETP 00.00-E-412.

The Supplier and Ford Engineering shall develop an Electrical Validation Test Plan that shall define the test procedure and test sequence necessary to demonstrate conformance to all requirements listed in this specification. Supplier shall submit an Electrical DV test plan to Ford Engineering for review and approval, at least 4 weeks prior to the start of DV or PV testing.

In addition to validation testing stipulated in this specification, WCM supplier shall conduct all component and module level validation testing, design analysis and design reviews necessary to demonstrate conformance to all requirements stipulated in this document, applicable Ford SDS and eFVDS requirement documents.

Supplier shall submit final validation test reports for review and approval within two weeks of test completion.

The WCM supplier shall provide all required test collateral and tools required for testing the modules in the production facility.

WCM shall meet the climatic, mechanical, chemical resistance, and demonstrated life requirements listed in RQT-002600-009611 (SDS EY-0128) E/E System Environmental (Non-EMC). The WCM shall show compliance with these environmental requirements by testing in accordance with Ford Corporate Engineering Test Procedure CETP 00.00-E-412, Electrical and Electronic Component Environmental Compatibility Test and relevant requirements in this specification.

The Environmental CETP 00.00-E-412 is a generic test procedure for all electronic components. Section 3.5.30.1: Environmental Validation Test Requirements, specifies what unique WCM operational sequences shall be required, if any, during specific environmental test procedures.

Each type of evaluation (Performance Evaluation, Functional Check, Monitored Operation, Functional Evaluation, Visual Check, and Internal Inspection) procedure and acceptance criteria shall be agreed upon between the supplier and Ford Infotainment Core Engineering as part of approval of the WCM DVP.

Any proposed changes to the requirements, test flow and/or test conditions listed in the referenced WCR, CETP or this specification shall be discussed and agreed upon prior to supplier submission of the WCM DVP, and must be approved by Ford Infotainment Core Engineering in writing.

3.5.29 Appearance Approval Procedure

Supplier is responsible to submit the 1st shot parts and Material Color/Durability Compliance Certification to Design Quality engineering for pre-grain approval prior to final appearance approval. This includes daytime color, texture and perfection of the class A area and Interior Parts Painter Approval Process (AVP-T113-016). Supplier must conform to DCAP manual for the detail processes. Additional information can be found in ES-6E5H-19980-AP.

3.5.30 Environmental Validation Test Requirements

3.5.30.1 Environmental Validation Test Requirements

The Supplier and Ford Engineering shall develop an Electrical Validation Test Plan that shall define the test procedure and test sequence necessary to demonstrate conformance to all requirements listed in this specification. Supplier shall submit an Electrical DV test plan to Ford Engineering for review and approval, at least 4 weeks prior to the start of DV or PV testing.

The following environmental test sequences shall be required for DV and PV testing per CEPT 00.00 E-412 requirements (section 6.4 p.55):
1) Subgroup A (No salt mist test required, high temp exposure to meet paint oven requirement max temp)
2) Subgroup D (Thermal shock testing from 125 to -40C.)
   Supplier shall x-ray and micro section select solder joints before and after thermal shock endurance testing. Supplier to obtain approval for solder joint inspection plan prior to start of DV and PV testing.
3) Subgroup E (Note: this group shall be required in additional to WCCA completion)
4) Subgroup F
5) Module Ignition cycling test.
   Six samples shall be tested to 60,000 ignition on/off cycles. 15K cycles at -40C, 30K cycles at 23C, 15K cycles at 85C. Parts shall be cycled and the minimum time needed to cycle the module form the off to run state. Samples shall be fully powered and monitored for proper operation during testing. Samples shall meet all requirements before, during and after exposure to this test. This test can be conducted at the start of Subgroup A or can be conducted on six stand-alone samples. This test is intended to verify that the module will properly start up and shut down as designed for 1X life ignition cycling and shall be conducted in addition to PTC testing.
6) Additional fluid ingress and compatibility testing.
   Additional testing may be need to verify requirements stipulated in this document. Supplier and Ford Engineering to determine scope of additional testing (if any) upon review of proposed DV design.

The Vehicle E/E System's subsystems and components shall achieve their functional performance targets, while operating under the influence of the real world environment specified by the vehicle program, and the environmental conditions induced by the vehicle specific component interactions, installation locations (regions), and packaging.

(1) The subsystem/component functional performance targets and associated acceptance criteria are defined in their System Design Document (SDS) or Component Design Document (CDS).
(2) The specified environmental noise factor metrics define the generic environmental requirements baseline for all the Vehicle E/E System's subsystems and components. The generic target values provided represent the generic minimum target ranges for the environmental noise factor metrics. ALL ACTUAL TARGET VALUES MUST BE DEFINED, VALIDATED & CASCADED BY THE VEHICLE PROGRAM TEAM, in accordance with, program specific real world operating environment and component packaging/installation constraints.

In addition to validation testing stipulated in this specification, WCM supplier shall conduct all component and module level validation testing, design analysis and design reviews necessary to demonstrate conformance to all requirements stipulated in this document, applicable Ford SDS and eFVDS requirement documents.

The WCM assembly shall meet the following requirements after exposure to the environmental testing stipulated in CETP 00.00-E-412

Physical, Plastic: No cracks, dents, chips, or nicks that impede assembly operation.
Physical, Metal: No bends, dents or visible corrosion, which will impede assembly operation or will directly cause assembly failure.
Physical, solder: No cracks, dents, chips or nicks, corrosion, delaminating of coating material.
Wire bonds: no corrosion, lifting of bonds, coating material delaminating,
Functional: The assembly shall meet all requirements as specified.

The WCM module shall withstand the paint oven temperature without damage. Materials used in all systems shall withstand a paint repair oven temperature of 130 ° C for 25 minutes without deformation, functional damage, or loss of specified physical characteristics, or shall be capable of being protected, e.g., with shielding, during repair oven processing of the vehicle.

WCMs shall be tested in compliance with CETP 00.00-E-412, Electrical and Electronic Component Environmental Compatibility Test, which defines the test procedures for each test in each leg of the subgroups. Additional details relevant to these requirements are outlined in ES-6E5H-19980-AP. Supplier shall comply with all applicable requirements in ES-6E5H-19980-AP: Global Mechanical Design Specification for Climate Control Modules (CCM) & Electronic Control Panel (ECP). A list of applicable requirements can be found in the file ES Check List_CX0134.

3.5.30.1.1 CLASSIFICATIONS

The DUTs shall be tested to the relevant environmental classifications included in Ford Corporate Engineering Test Procedures, CETP 00.00-E-412 shown below:

Temperature:	Class I
Water/Fluid Ingress:	Class II
Salt Mist:	Class I
Dust:	Class I
Chemical Resistance:	Class III
Vibration:	Class I
Mechanical Shock/Drop:	Class III

3.5.30.1.2 TEST TEMPERATURES

The following test temperatures shall be used where applicable within Ford Corporate Engineering Test Procedures, CETP E-412:

T_1 = Minimum Operating Temperature = -40°C
T_2 = Maximum Operating Temperature = +75°C
T_3 = Low Temperature for Performance Evaluation = -20°C
T_4 = High Temperature for Performance Evaluation = +40°C
T_5 = Minimum Storage Temperature = -40°C
T_6 = Maximum Storage Temperature = 85°C
T_7 = High Temperature for Functional Evaluation = +75°C
T_N = Nominal Temperature = 20°C

3.5.30.1.3 TEST VOLTAGES

The following test voltage levels shall be used where applicable within Ford Corporate Engineering Test Procedures, CETP 00.00-E-412:

V_1 = Low Voltage of Guaranteed Function= 9.0 V ± 200 mV
V_2 = High Voltage of Guaranteed Function = 16.0 V ± 200 mV
V_3 = Low Voltage of Guaranteed Performance = 9.3 V ± 200 mV
V_4 = High Voltage of Guaranteed Performance = 16.0 V ± 200 mV
V_N = Normal or Nominal Voltage = 13.5 V
V_5 = Function Check Test Voltage = V_N ± 1.5V
V_6 = Monitored Operation Test Voltage = V_N ± 0.5V

3.5.30.1.4 PERFORMANCE/FUNCTIONAL EVALUATIONS

Evaluation shall be accomplished per Section 1.3 and Section 6.2 of CETP 00.00-E-412
DUT with Class A Surface shall include Functional Evaluation of the charging surface frictional coefficient per ASTM D1894. (Purpose is to identify degradation by recording pre-test and post-test values)

3.5.31 Regulatory Requirements

WCM must comply with the regulatory RF operating requirements (allowed frequencies, power output, occupied bandwidth, etc.), as well as, follow the certification procedures, if any, laid out in each market in which the product is sold.

Regulatory requirements for local markets change frequently and must be monitored continuously. It is the responsibility of the supplier to find a local country representative when required for certification purposes unless the regulation indicates an OEM.

3.5.32 ISO 26262 Function Safety Requirements

ASIL B minimum rating. Final ASIL rating will be based on FMEA and ISO2626 review of supplier's design prior to DV design freeze.

Supplier shall support reviews required to determine and establish WCM function safety recruitments to meet ISO 26262 specification.

3.5.33 Worst Case Circuit Analysis

A worst-case circuit analysis (WCCA) shall to be completed and submitted for each circuit block to the Ford Design and Release Engineer for approval prior to DV design freeze. WCM shall meet all requirements stipulated in the FORD Electrical hardware review checklists. Supplier to submit checklists for Ford Engineering for approval prior to DV design Freeze. Contact Ford Engineering to obtain latest Electrical hardware review checklists within 2 weeks of source selection. WCM shall meet Ford SDS EC-0240.

WCCA is a rigorous mathematical evaluation of circuit performance attributes against performance tolerance limits, under simultaneous existence of all the most unfavorable conditions being at realizable limits. The WCCA shall include the following: Circuit Description, system schematic, bill of materials, theory of operation, description of functionality provided by each component, specifications, environmental conditions (temp, voltage, EMC, ground shifts, interface), component specifications/assumptions, analysis schematic, worst case analysis, stress analysis, A/C analysis (if required), transient analysis, summary, and bench test results.

Note: Regardless of the temperature stated for the EMC test plan, all circuits must be designed and analyzed for all known transients, over the entire operational range of the module. Additionally, if the EMC specification calls out any tolerances or ranges for transients, the module must be designed and analyzed for the worst-case condition.

The preferred format for this report is a Mathcad document. P-spice or Saber simulation tools are acceptable. However, if a simulator is used, Worst Case models must be verified and provided. All equations should be visible in the document.

If the circuit does not meet WCCA requirements, a Monte Carlo analysis may be conducted. Depending on the results of the Monte Carlo analysis, the Ford Design and Release Engineer shall determine if the circuit in questions is acceptable.

Any device that has results within 10% of the parts temperature rating should be thermal coupled during DV/PV testing and verify the temperature of the device is acceptable.

Note 1, for outputs that are PWM'd, make sure to include switching losses in the output driver analysis.
Note 2, make sure to include reverse battery power dissipation in the output driver analysis. Reverse battery is to be done over the entire temperature range.

Additional Requirement based on lessons learned:
Specific requirements on wire bonding: material combination (wire bond / pad) must be selected in a way, that no impact on signs of fatigue, corrosion, bond adhesion, etc will be observed. Material selection and supporting documents must be reported / made available to the Ford D&R engineer. The usage of silver / aluminum combination requires Ford approval.

Suppliers must provide a copy of WCM circuit schematics and WCCA prior to DV design freeze.

4.0 OPEN CONCERNS

#Hint: The following list presents open concerns, which have to be discussed or clarified over the course of the on-going requirements engineering.

ID	Concern Description	e-Tracker Reference	Status	Solution

5.0 REVISION HISTORY

#Hint: *A new version number is assigned to a document with a given revision each time it is checked in to Team Center (TCSE). After release of a revision, the document can not be edited and no new versions can be created on that revision. When updating the document after that, a new revision has to be created and new versions on that revision will be created upon checking in.*

Rev. (revision)	Vers.	Date	Description	Approved by	Responsible
001		*3/19/2018*	*Initial version*		*bgrifka*
002	*v10*	*7/26/2018*	*Final RFQ Quotation Clarification*		*bgrifka*
003	*V11*	*9/28/2018*	*Round 3 RFQ Updates*		*Pgianni1*
004	*V12*	*9/20/2019*	*Updates*		*bgrifka*