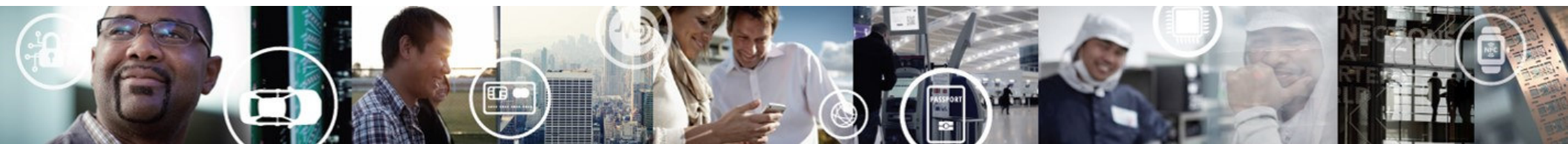


NXP车载无线充电发射端设计

DEREK WANG/王德昌
MAY 2017



EXTERNAL USE



SECURE CONNECTIONS
FOR A SMARTER WORLD

NXP 无线充电产品方案列表

200W	<div style="background-color: #FFD700; padding: 5px; display: inline-block;"> WCT-200WTX 30W - 200W </div>		<div style="background-color: #9ACD32; padding: 5px; display: inline-block;"> WPR-200WRX 30W - 200W </div>	<p>NXP type in Qi A28, MP-A4, MP-A8,MP-A9</p> <ul style="list-style-type: none"> Single-Coil Tx Multi-Coil Tx Single-Coil Rx Industrial/Auto <div style="margin-top: 10px;"> <div style="border: 1px solid black; padding: 2px; width: 60px; margin-bottom: 5px;">Production</div> <div style="border: 1px solid black; padding: 2px; width: 60px; margin-bottom: 5px;">Execution</div> <div style="border: 1px solid black; padding: 2px; width: 60px; margin-bottom: 5px;">Planning</div> <div style="border: 1px solid black; padding: 2px; width: 60px; margin-bottom: 5px;">Proposal</div> </div>
15W	<div style="border: 2px solid red; background-color: #6495ED; padding: 5px; display: inline-block;"> WCT-15WTXAUTO 15W Qi, MP-A9 5W PMA </div>	<div style="border: 2px solid red; background-color: #6495ED; padding: 5px; display: inline-block;"> WCT-15WTXAUTOS 15W Qi, MP-A9 Autosar </div>	<div style="background-color: #9ACD32; padding: 5px; display: inline-block; margin-right: 20px;"> WPR1500-BUCK 5-15W Qi </div> <div style="background-color: #9ACD32; padding: 5px; display: inline-block;"> WPR1500-LDO 5-15W Qi </div>	
	<div style="background-color: #6495ED; padding: 5px; display: inline-block;"> WCT-15WTXMULTI 15W Qi,MP-A8 </div>			
	<div style="background-color: #FFD700; padding: 5px; display: inline-block;"> WCT-15W1COILTX 15W Qi, MP-A4 5W PMA </div>			
5W	<div style="background-color: #6495ED; padding: 5px; display: inline-block;"> WCT-5WTXMULTI 5W Qi A28, 5W PMA </div>	<div style="border: 2px solid red; background-color: #6495ED; padding: 5px; display: inline-block;"> WCT-5WTXAUTO 5W Qi A13, 5W PMA </div>		
	<div style="background-color: #FFD700; padding: 5px; display: inline-block;"> NXQ1TXH5 5W Qi A11 Integrated </div>	<div style="background-color: #FFD700; padding: 5px; display: inline-block;"> WCT-5W1COILTX 5W Qi A11 Flexible </div>		
300mW	<div style="background-color: #FFD700; padding: 5px; display: inline-block;"> NFC TX </div>		<div style="background-color: #9ACD32; padding: 5px; display: inline-block;"> NFC RX </div>	
	TX		RX	

1 EXTERNAL USE

CONFIDENTIAL AND PROPRIETARY

SUBJECT TO CHANGE



控制芯片及参考设计



车载中功率发射器控制芯片

--WCT1013A

主要性能:

基于DSC 32-bit 56800EX 内核

- 100 MHz 内核工作频率 (高速模式)
- DSP 和 MCU 功能优化, 优化C语言编程支持

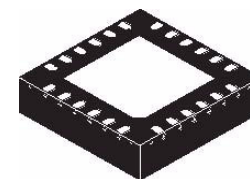
片上存储器

- 288 KB flash memory
- 32 KB data/program

封装模拟外设

- 两个 8通道, 12-bit ADCs , 带有x1, x2, and x4 可编程的增益放大器
- 3路模拟比较器, 并带有6-bit DAC 基准
- 1 12-bit 数模转换器(DAC)
- eFlexPWM 模块, 带有 12 PWM 输出, 包括 8通道高精度小数模式PWM (NanoEdge 312ps), 并有多种模式触发ADC采样
- 同时包括多个定时器可以满足无线充电控制器需求

- WCT1013A: 64PIN LQFP



车载中功率无线发射器参考设计主要性能 WCT1013A

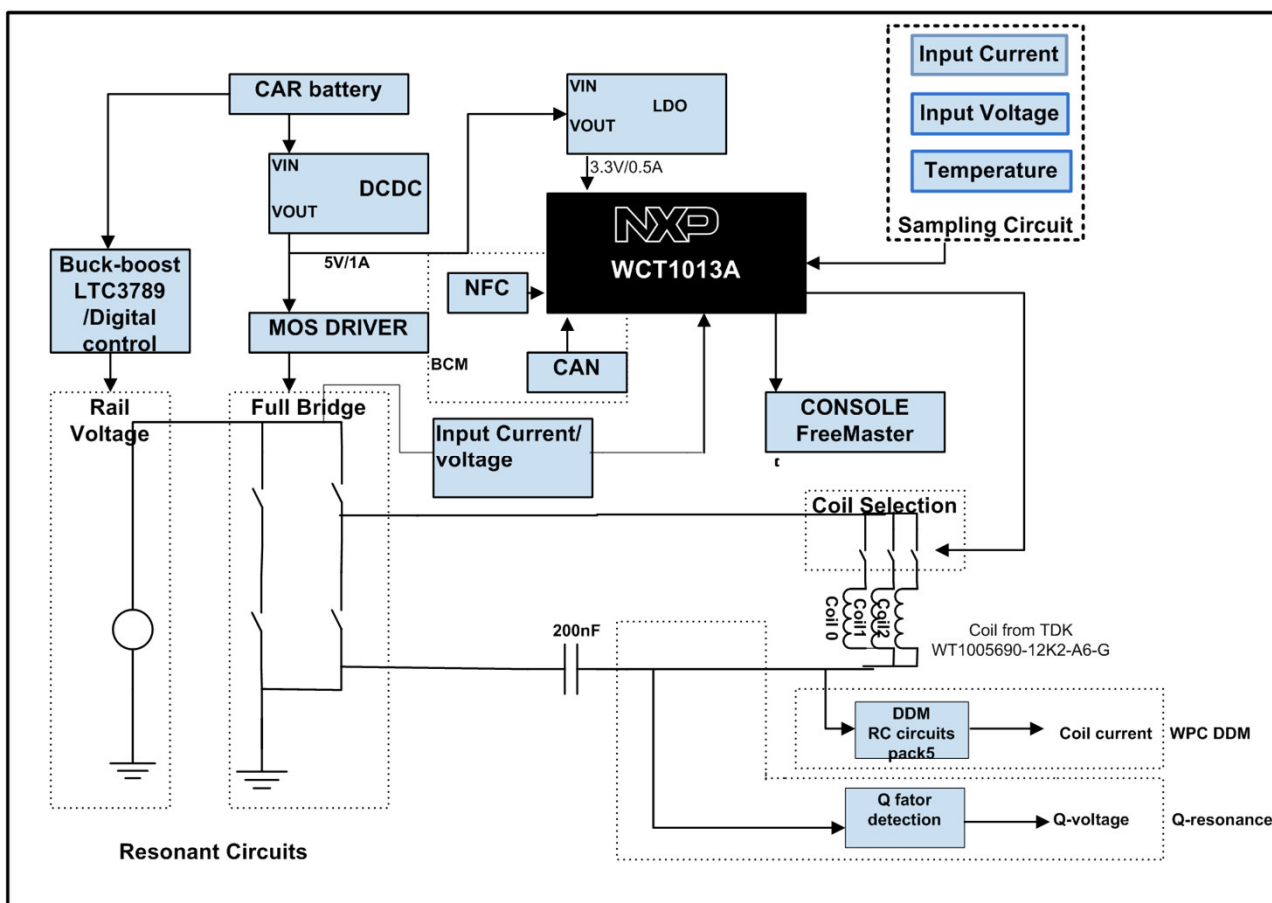
- 基于15W MP-A9拓扑(NXP 申请)
- 125K定频，多线圈解决方案
- 集成数字控制式buck-boost，降低整体成本
- 集成NFC功能，实时检测射频卡，防止损坏NFC卡
- 灵活方便的软件调试平台，方便客户快速开发产品

WCT1013A MP-A9参考设计

- 符合Qi (WPC V1.2.2) 规格书标准，支持15W功率传输
- 集成数字解调功能，可以解调接收端各种通信调制方式
- 支持基于Q值检测的FOD
- 支持基于功率损耗计算的FOD
- 安照WPC Qi 15W规格书设计，认证正在进行中
- 带有CAN，LIN通信



基于WCT1013A系统的原理框图



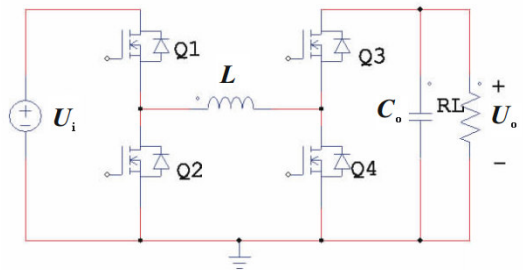
第一级DCDC转换电路

输入电压: 8~16Vdc

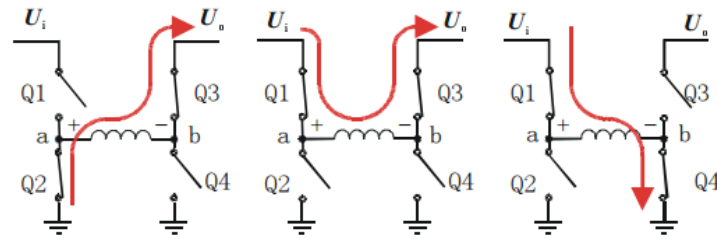
输出电压 (V_{rail}): 5~24Vdc/ 30W

拓扑选择: Buck-Boost, Sepic, Flyback

选用Buck-Boost转换器, 第一级DCDC转换效率为95%左右
模拟和数字控制方式都可以实现Buck-Boost转换

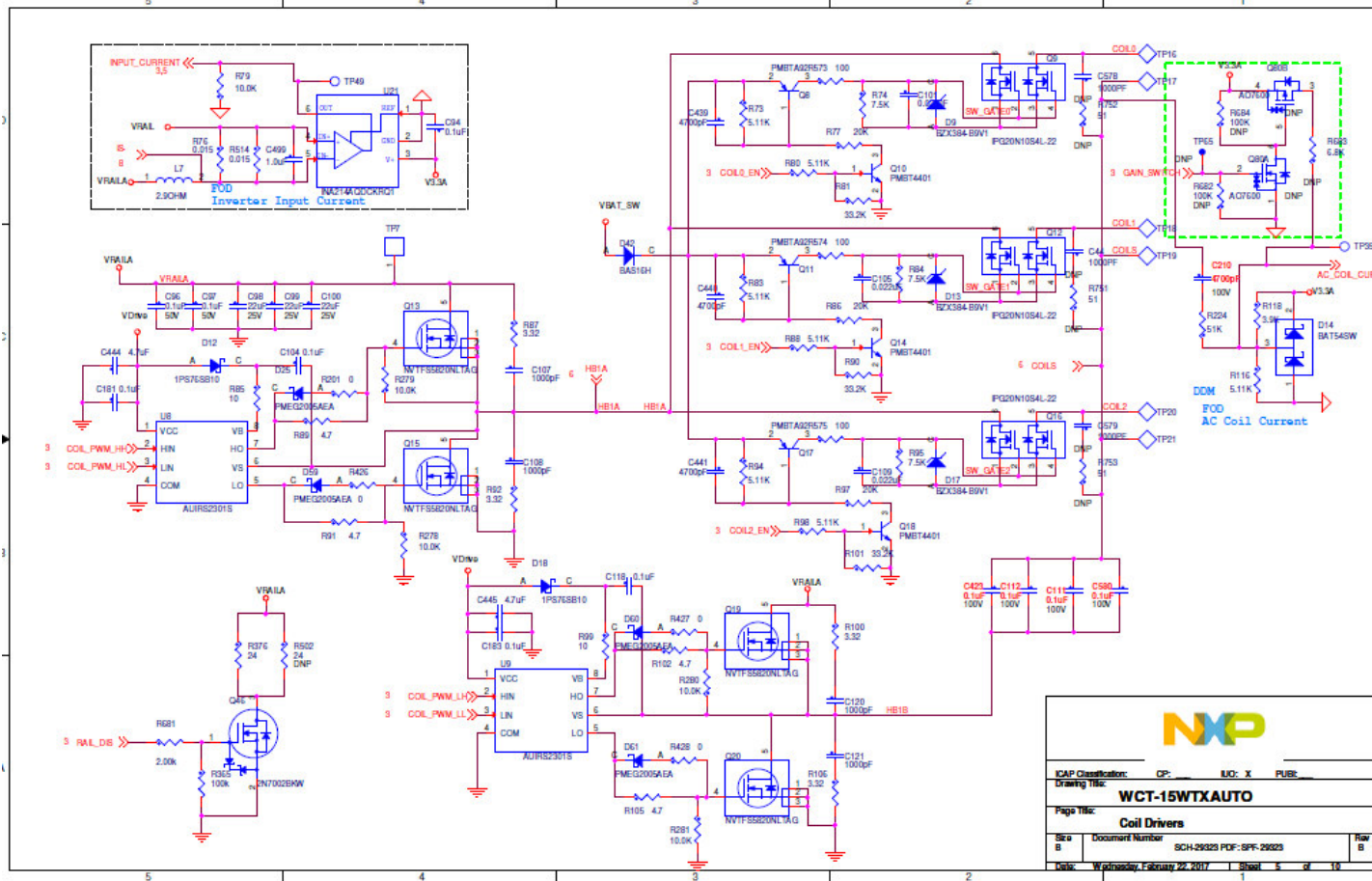


主电路拓扑



主要开关状态

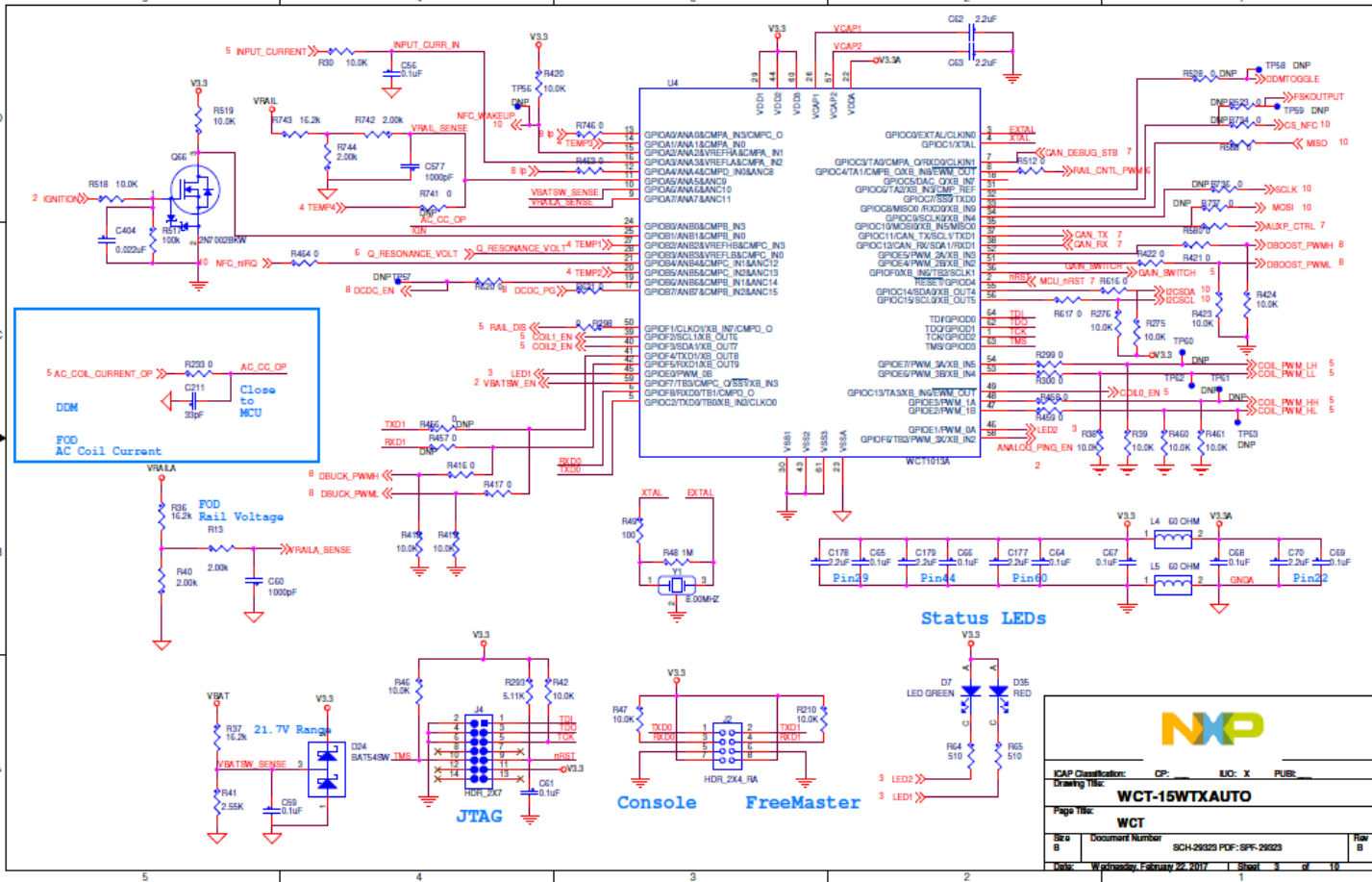
逆变功率电路原理图MP-A9



NXP			
ICAP Classification:	CP	UG: X	PUB
Drawing Title:	WCT-15WTXAUTO		
Page Title:	Coil Drivers		
Doc ID: 66000	Document Number: SCH-29229 PDF-SFF-29229	Rev: B	
Date: Wednesday, February 22, 2017	Sheet: 5	of 19	

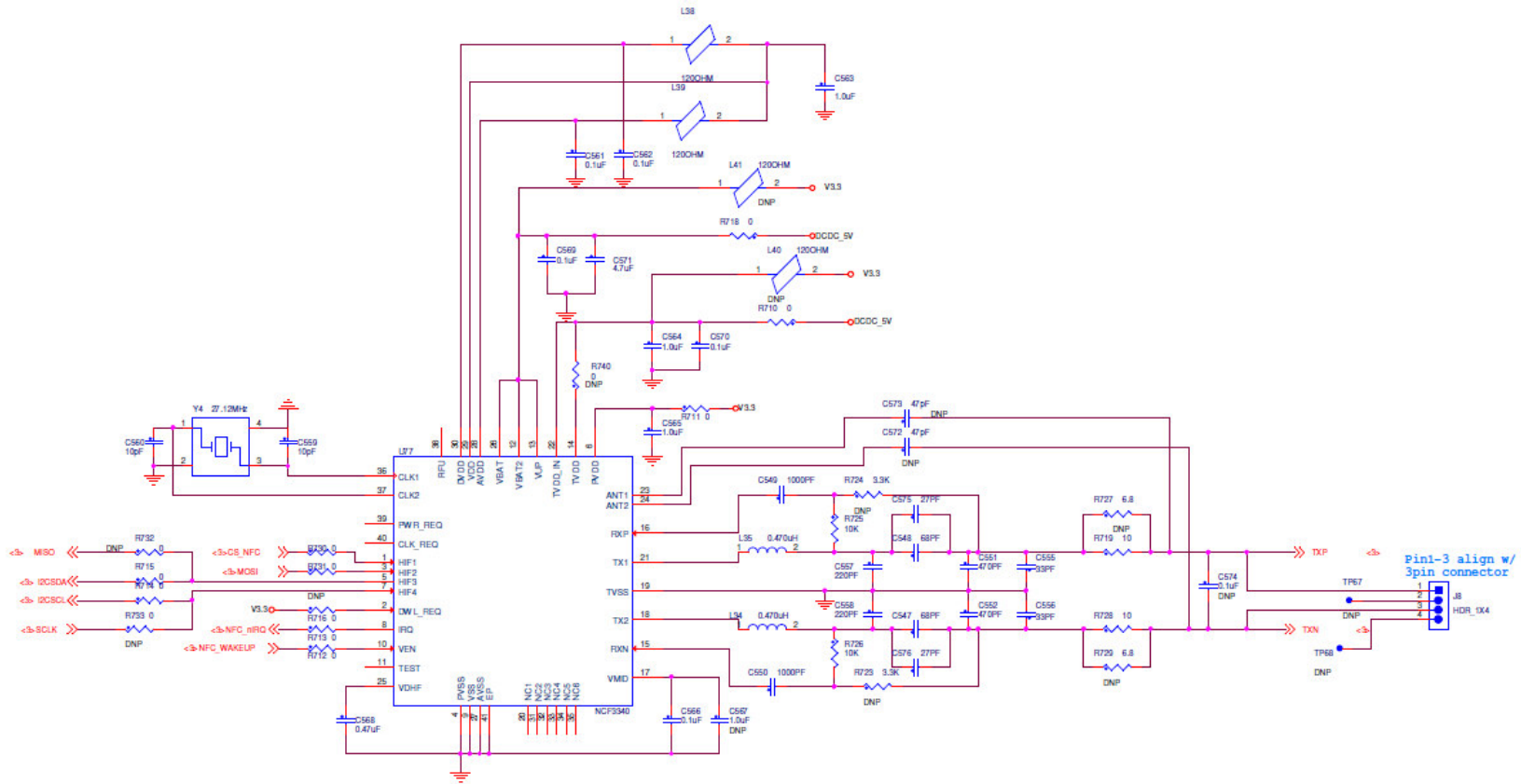


WCT1013A控制器原理图MP-A9



NXP	
ICAP Classification:	CP: X PUB:
Working Title:	WCT-15WTXAUTO
Page Title:	WCT
Doc Number	SCH-29329 PDF-6FF-2923
Date:	Wednesday, February 22, 2017 10:01 3 of 10

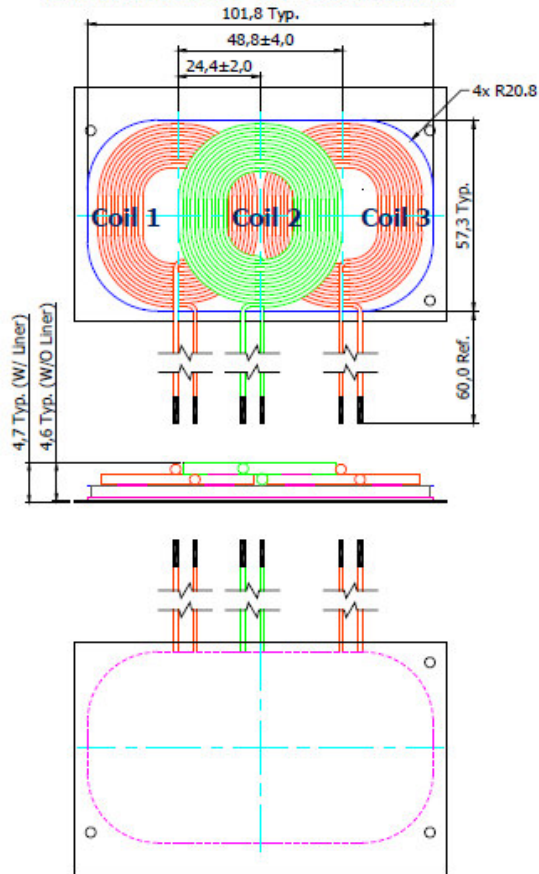
NCF3340 NFC收发器原理图



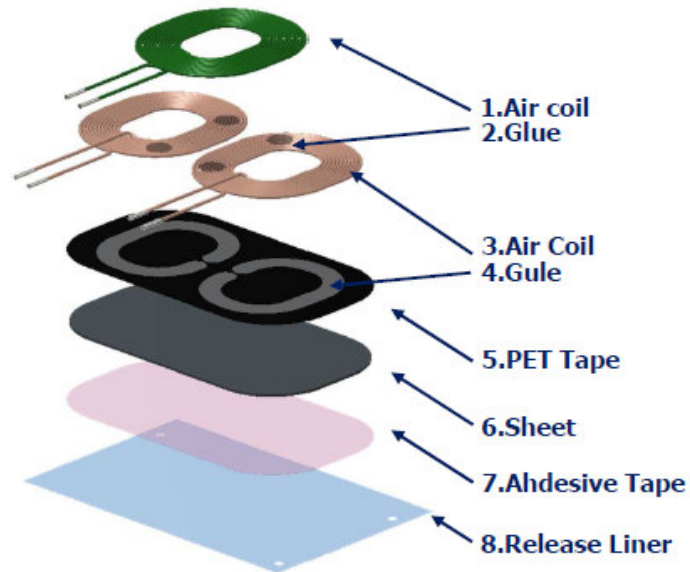
MP-A9线圈参数

--LC 谐振参数

= Dimension of coil unit =



= Coil unit Assembly =



= Electrical Characteristics =

- L_s : 9.8uH \pm 10% @100kHz(Coil1,3)
- L_s : 10.2uH \pm 10% @100kHz(Coil2)
- R_s : 0.06 Ω typ. @100kHz(Coil1,2,3)

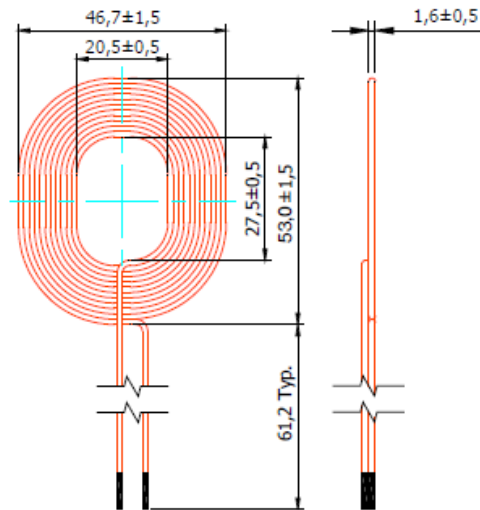
C = 400nF C0G 100V 1206

MP-A9线圈参数

--LC 谐振参数

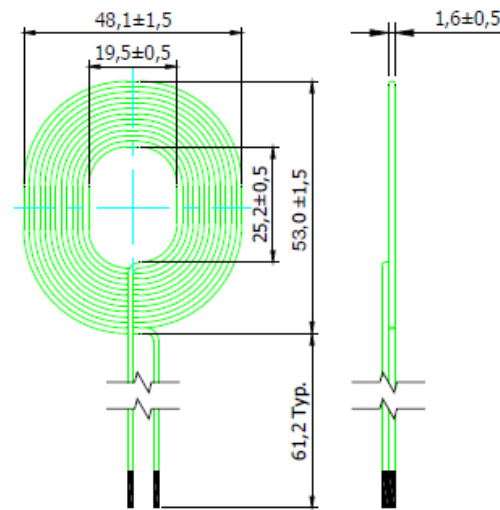
= Dimension of coil 1,3 =

- Turns of Number : 11Ts
- Wire type: 0.06mm, 200 strands (Type 2)



= Dimension of coil 2 =

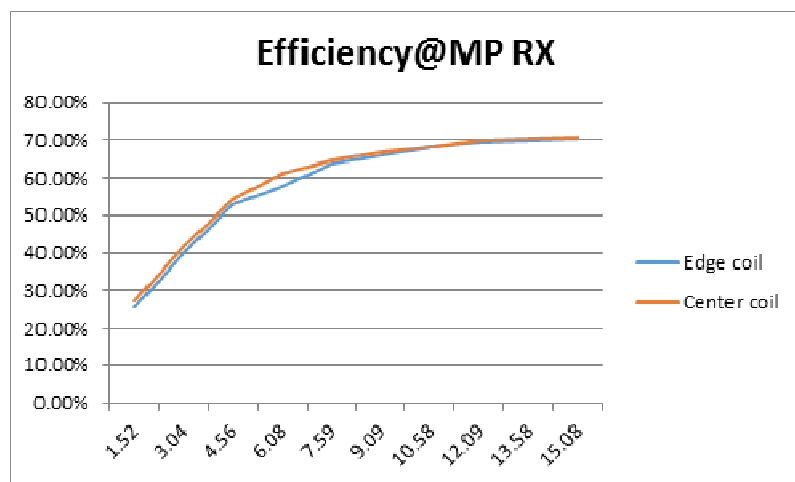
- Turns of Number : 12Ts
- Wire type: 0.06mm, 200 strands (Type 2)



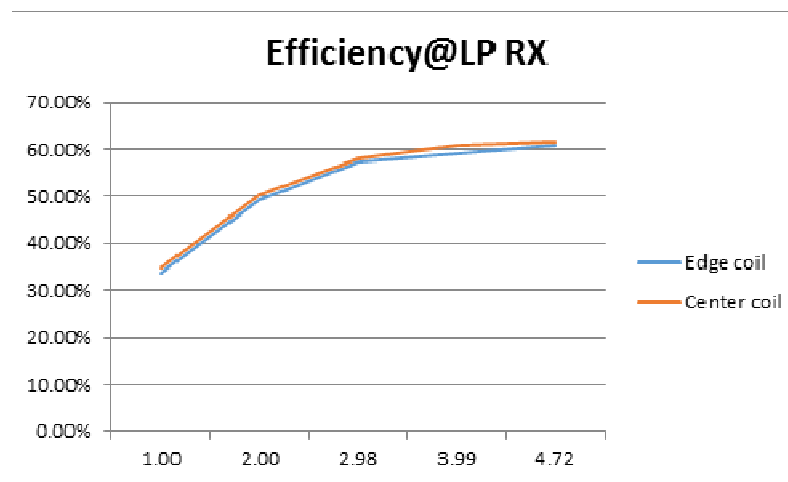
= Shielding information =

- Shielding material: FK2(Ni-Zn) or equivalent
- Shielding thickness: 0.9mm typ.

效率测试MP-A9



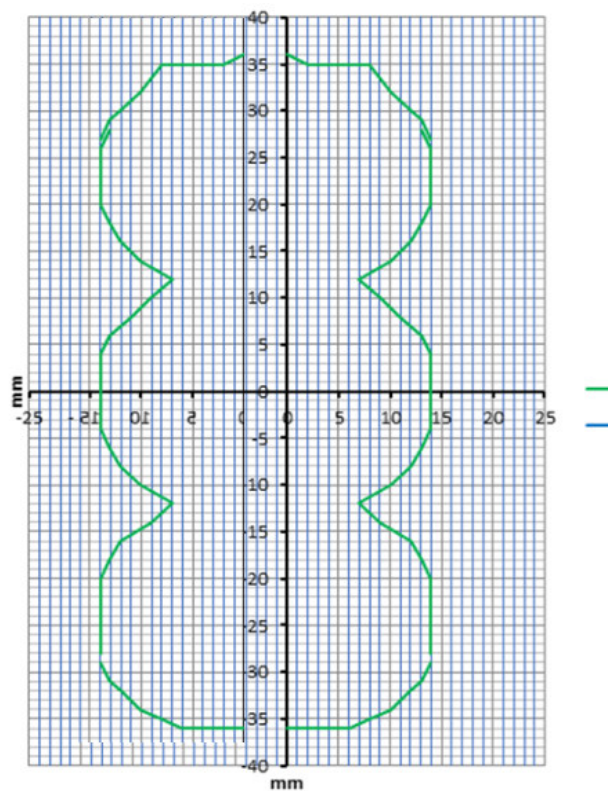
中功率接收器



低功率接收器

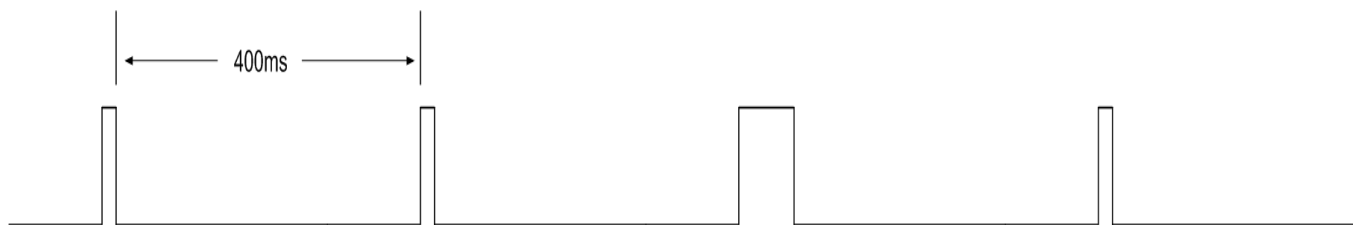


充电面积测试MP-A9



WPR1500 buck RX

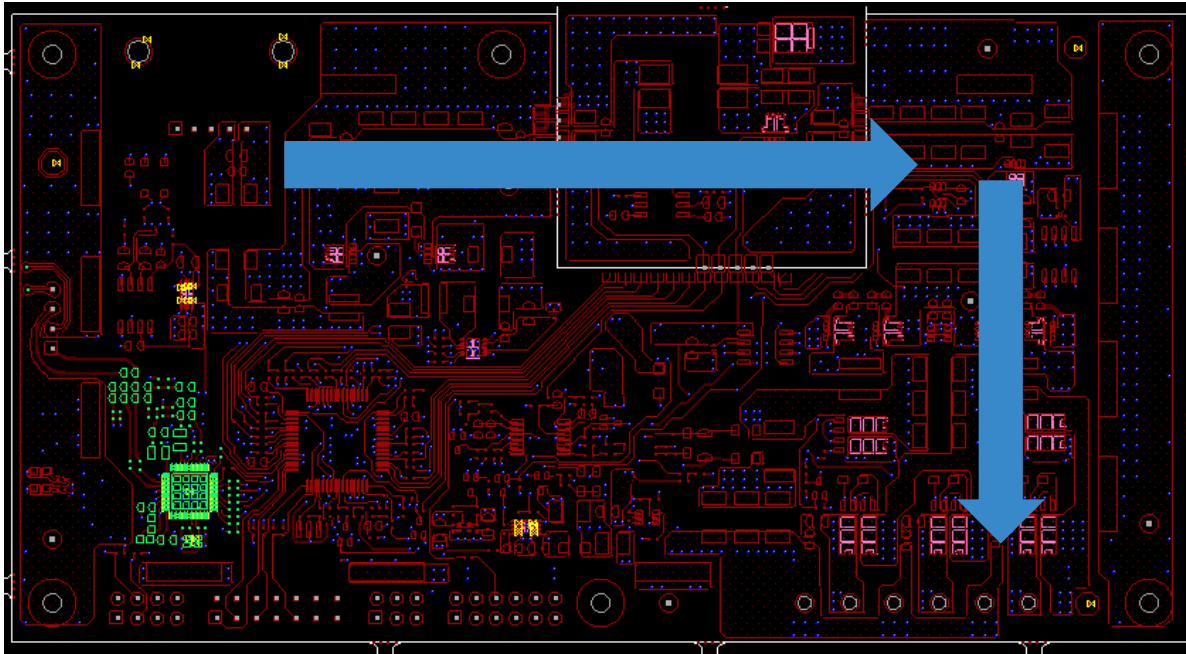
待机功耗MP-A9



低功耗待机模式： 15mA

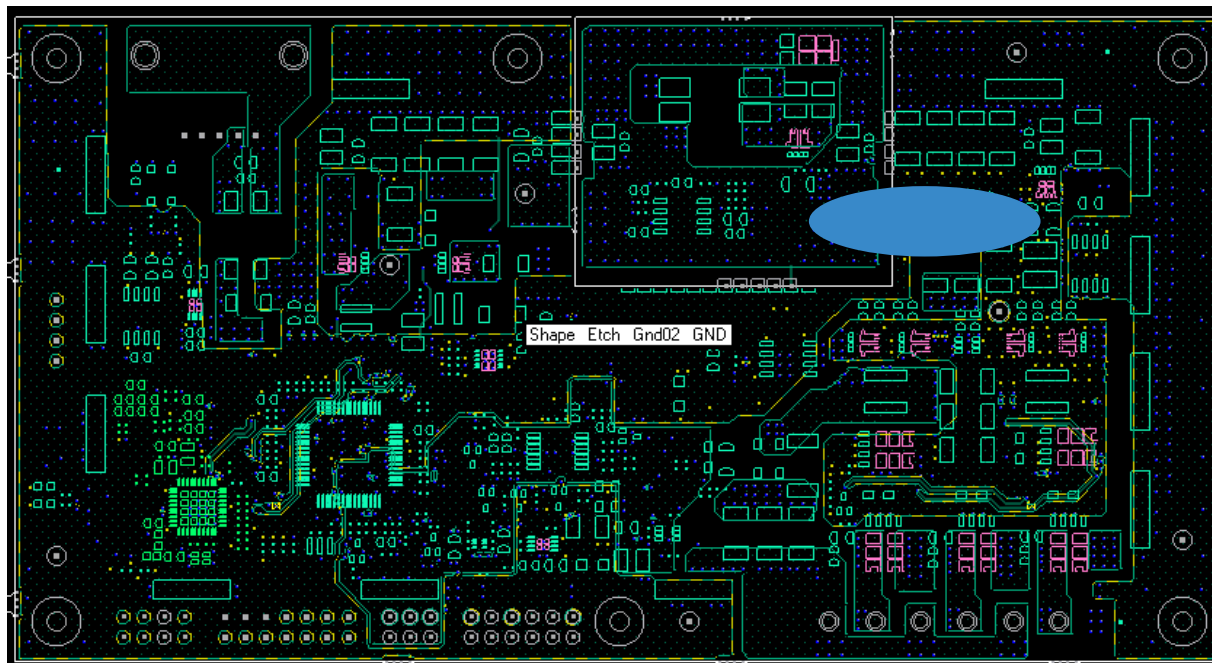
启动信号关闭状态： < 100uA

PCB布局 and 功率走线



- 1, 板子布局, 输入滤波器, 功率电路和控制电路的分离.
- 2, 信号较弱的输入电流信号, 输入电压信号, 线圈电流信号的走线尽量远离功率谐振电路.

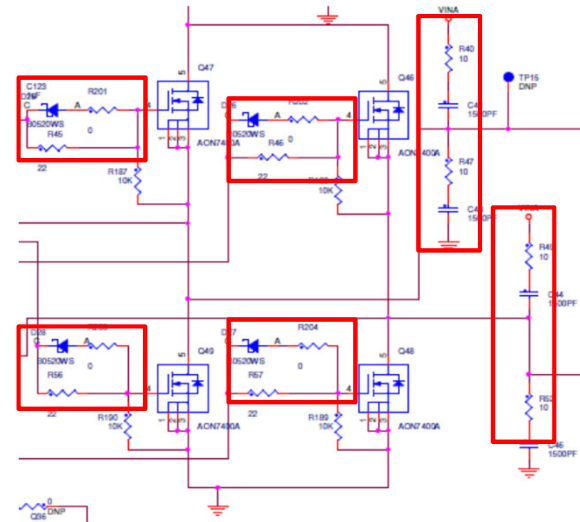
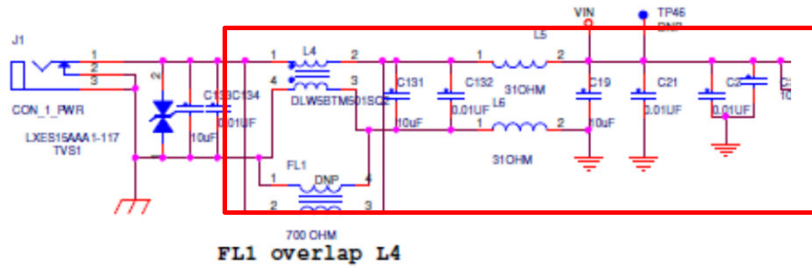
PCB GND走线注意事项



PGND
DGND
AGND

功率地和控制地在滤波电容处连接，同时单点连接数字地GND和模拟地AGND，可以用0ohm电阻或磁珠短接

EMC调试

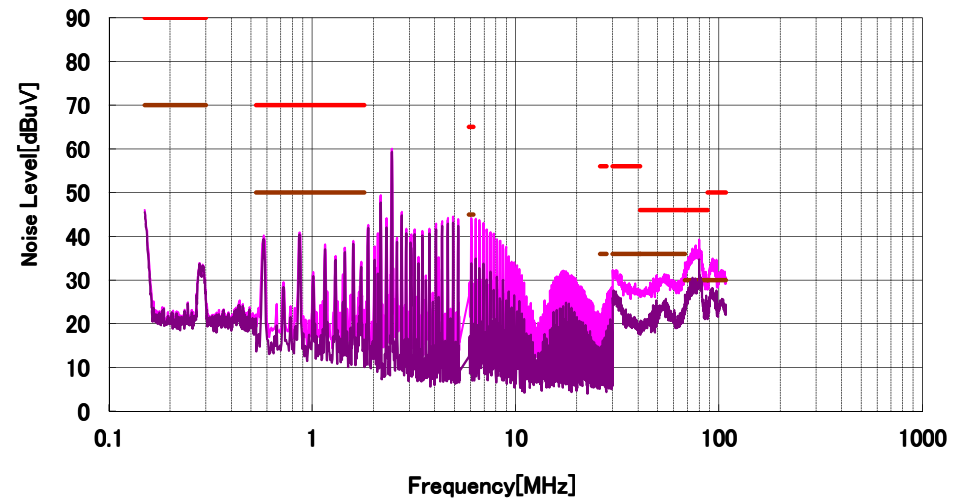


无线充电系统EMI注意事项:

- A, 端口的输入滤波器.
- B, DCDC转换器和逆变器的Mosfet的开关速度
- C, mosfet吸收电路
- D, PCB板和线圈的屏蔽

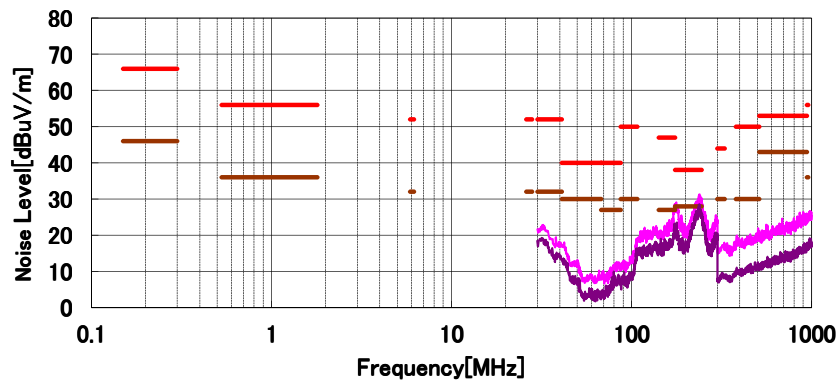
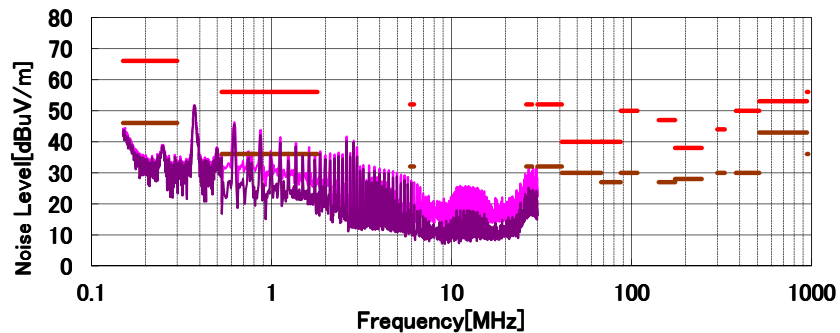
测试标准 CE

CISPR25 class3		
Frequency[MHz]	pk	av
0.15	90	70
0.3	90	70
0.53	70	50
1.8	70	50
5.9	65	45
6.2	65	45
26	56	36
28	56	36
30	56	36
41	56	36
41	46	36
68	46	36
68	46	30
88	46	30
88.00	50.00	30
108.00	50	30



测试标准 RE

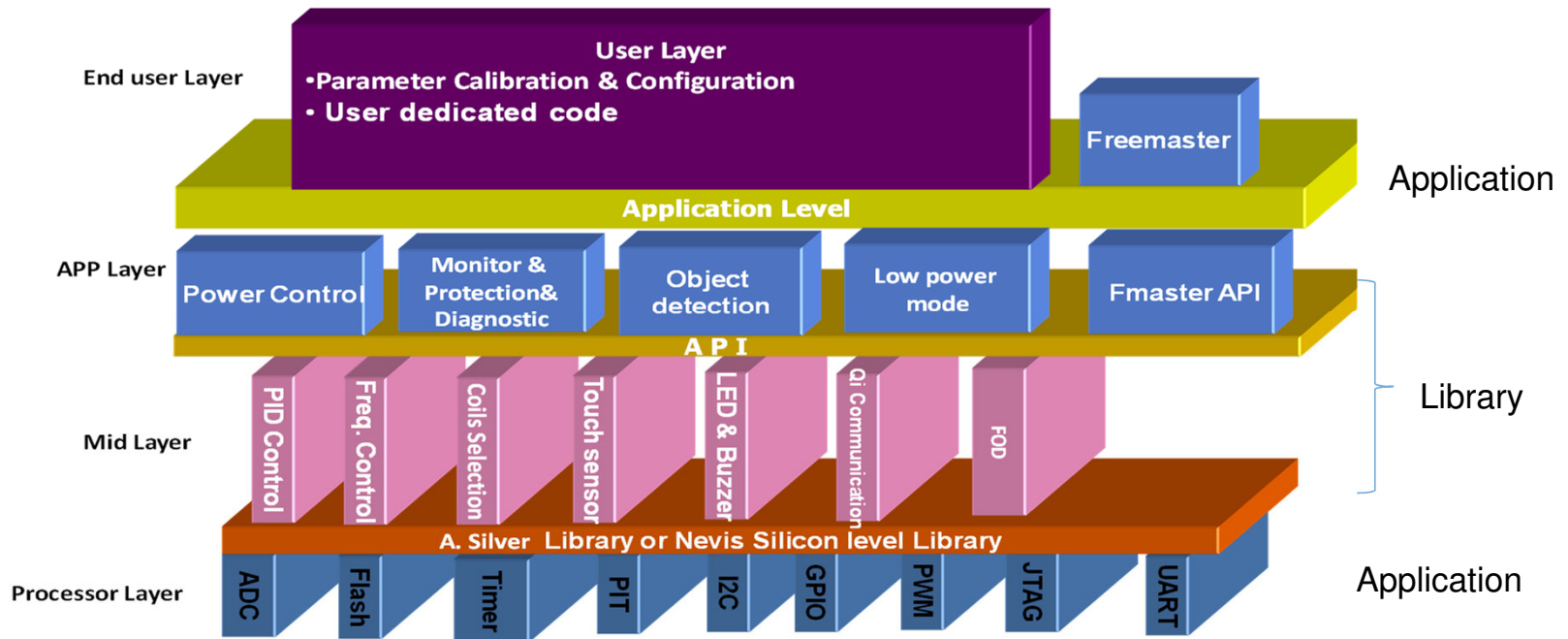
CISPR25 class3		
Frequency[MHz]	pk	av
0.15	66	46
0.3	66	46
0.53	56	36
1.8	56	36
5.9	52	32
6.20	52	32
26.00	52.00	32
28.00	52	32
30.00	52	32
41.00	52	32
41.00	40	30
68.00	40	30
68.00	40	27
87.00	40	27
87.00	50	30
108.00	50	30
142.00	47	27
175.00	47	27
175.00	38	28
245.00	38	28
300.00	44	30
330.00	44	30
380.00	50	30
512.00	50	30
512.00	53	43
944.00	53	43
944.00	56	36
960	56	36



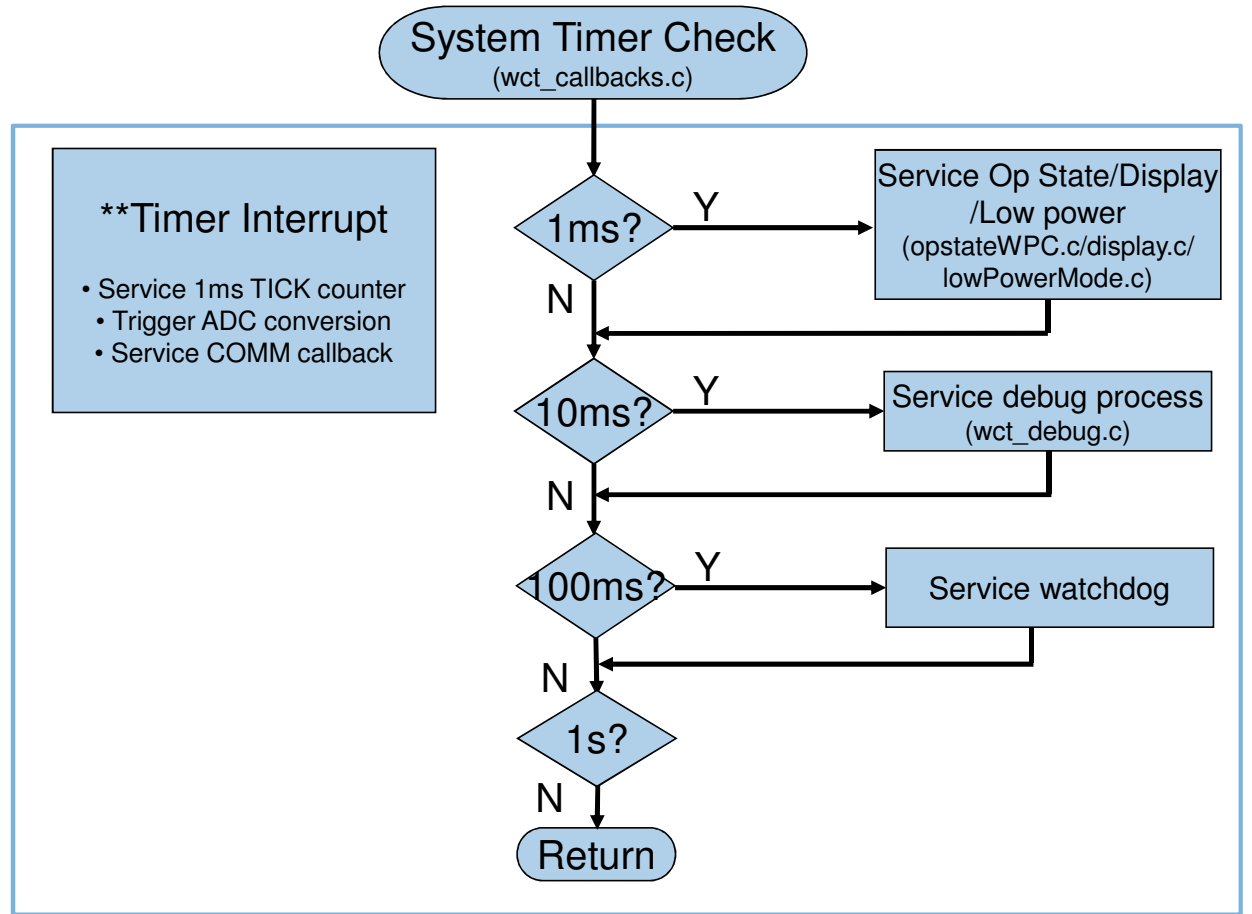
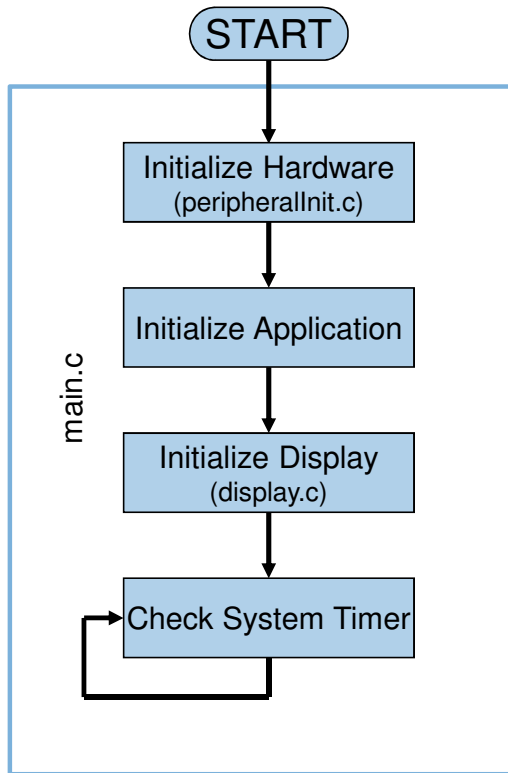
软件平台简介



软件架构

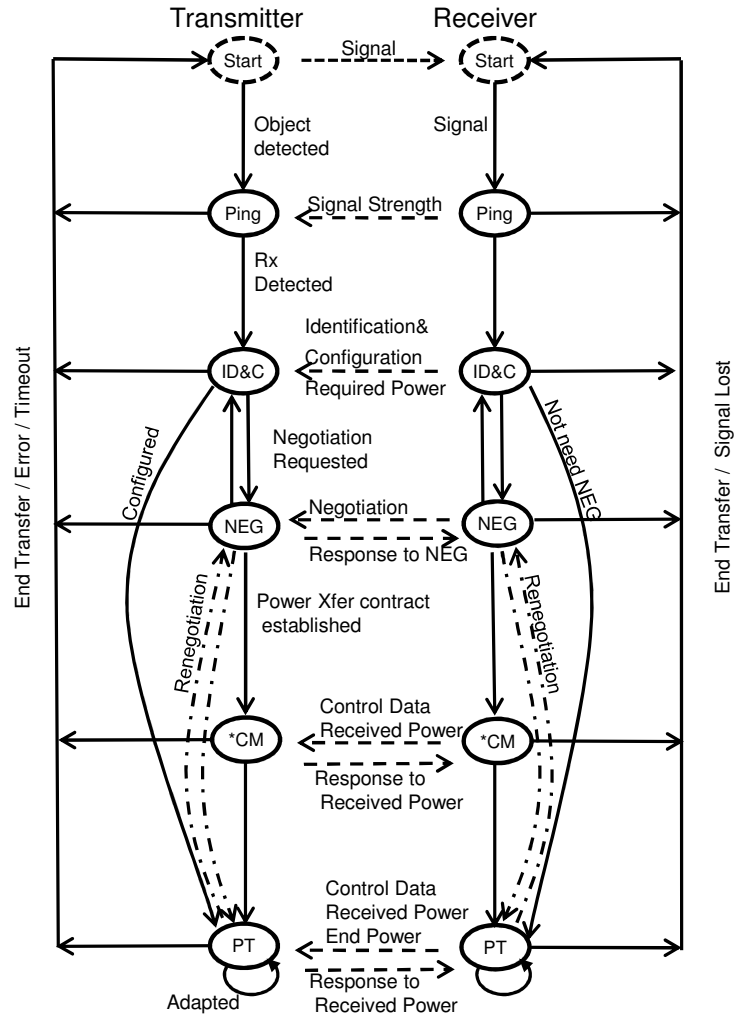


软件流程图



主要状态机

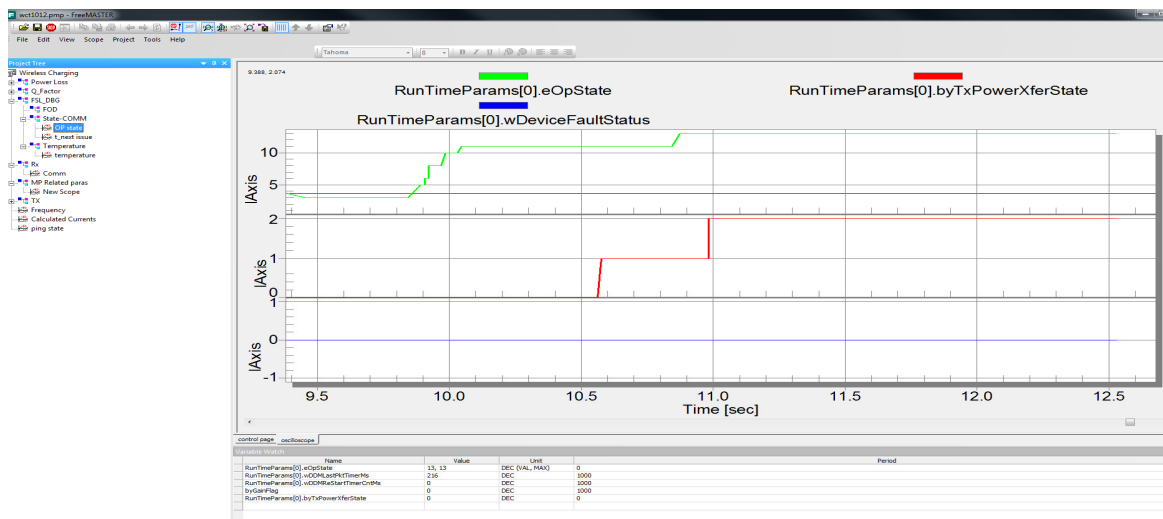
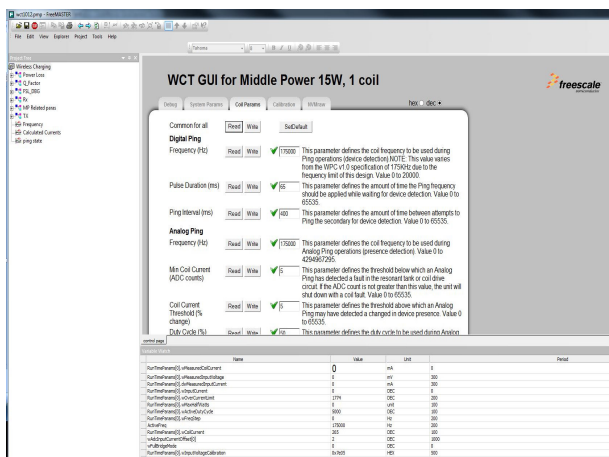
- ❖ **Start**
TX 发出信号检测是否有物体在表面
- ❖ **Ping**
RX 发包表示其存在
- ❖ **Identification & Configuration**
RX提供配置信息
- ❖ **Negotiation**
TX 和RX协商建立功率传输协议
- ❖ **Calibration**
FOD校准
- ❖ **Power Transfer**
RX输出功率，TX根据其输出调整工作状态



*CM: calibration mode



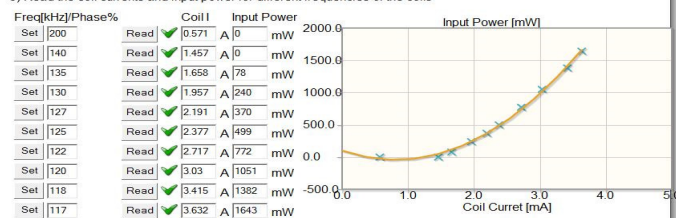
开发调试工具FreeMASTER



系统参数设置和校准

FOD Calibration

- 1) Set Device ID: and Coil ID: and Control Type: (0-half bridge frequency control, 1-full bridge phase control, 2-full bridge frequency control) (frequency is between 110kHz and 205kHz, phase percent is between 26% and 100%)
- 2) Set the calibration constant to default before calibration:
- 3) Enter to debug mode:
- 4) Turn On desired coil:
- 5) Read the coil currents and input power for different frequencies of the coils



- 6) Turn off desired coil:
- 7) Tune calculated constants: C5 , C5 Exp , C6 , C6 Exp , C7
- 8) Move FOD Calibration Constants to NVM:
- 10) Save final calibration constant to FLASH:
- 11) Disconnect FreeMASTER and reset CPU

实时系统调试



NFC 功能集成



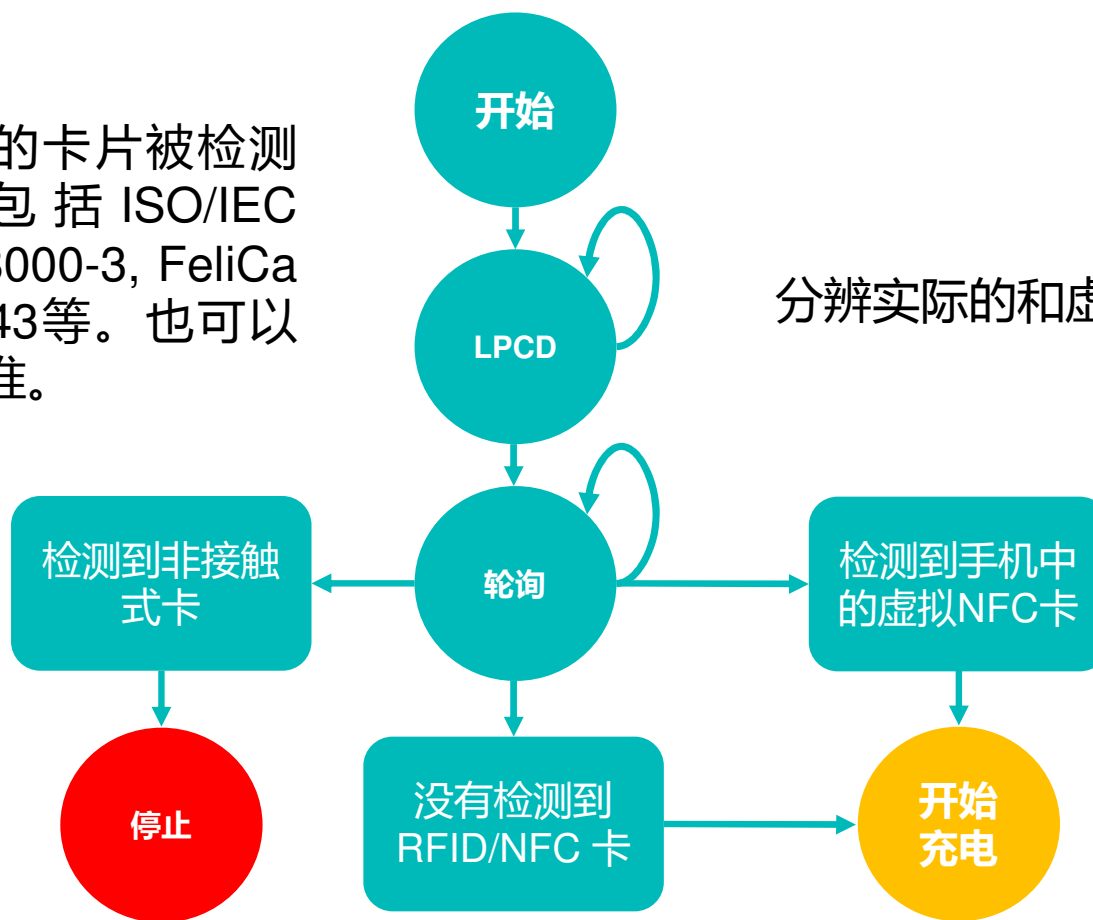
NFC检测在无线充电系统中的集成

- Qi FOD 检测
 - Qi 的无线充电器利用Power Loss来检测其表面的金属异物，可以准确检测出硬币及其他的金属元件
 - 但是不能检测到非接触式的Card, 这样在充电时这些卡片会被损坏
- RFID HF tag /NFC card 检测
 - LPCD 是基于天线回路阻抗变化的检测，利用了低功率唤醒的技术
 - 在LPCD唤醒之后，会查询是否有RFID/NFC卡；如果收到回复，NFC TX 会决定是否阻止下一步充电
 - 有具体的轮询方案来分别是实际的或者虚拟的RFID/NFC 卡

NFC检测状态机

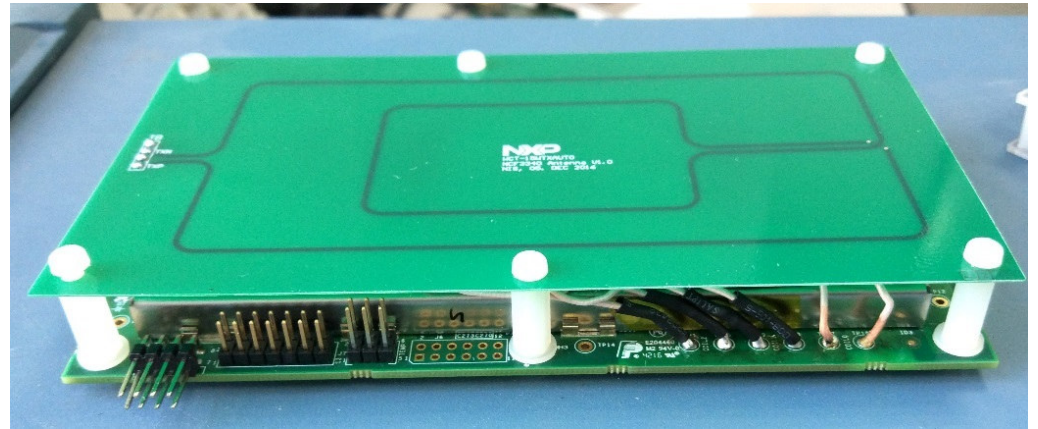
有符合RFID 标准的卡片被检测到，这些标准包括 ISO/IEC 15693, ISO/IEC 18000-3, FeliCa and ISO/IEC 14443等。也可以添加一些专有的标准。

分辨实际的和虚拟的 RFID/NFC卡



无线充电和NFC卡检测技术的集成

- 在现有的无线充电参考设计的基础上扩展添加NFC 控制芯片 NCF3340，来实现NFC 卡的保护
- 使用NFC控制器的LPCD 技术检测物体
- NFC天线布置在Qi的线圈上，可以实现有效的NFC卡检测和解耦

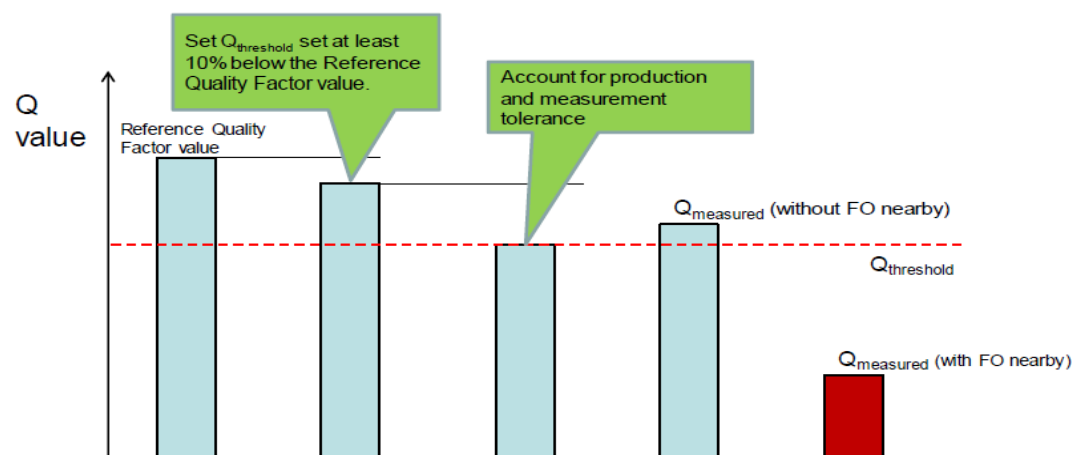
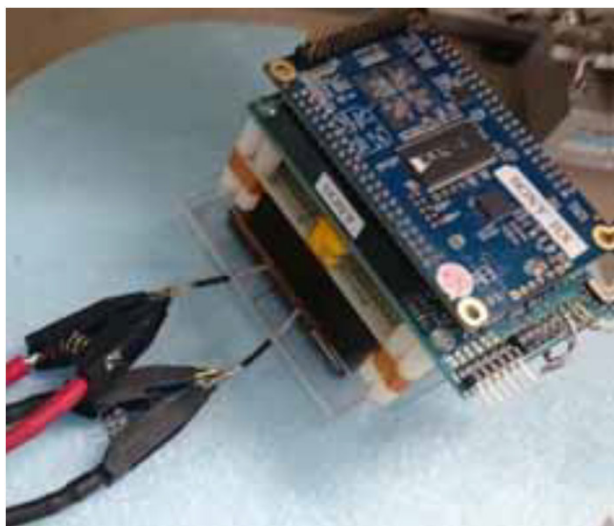


Q值检测方法



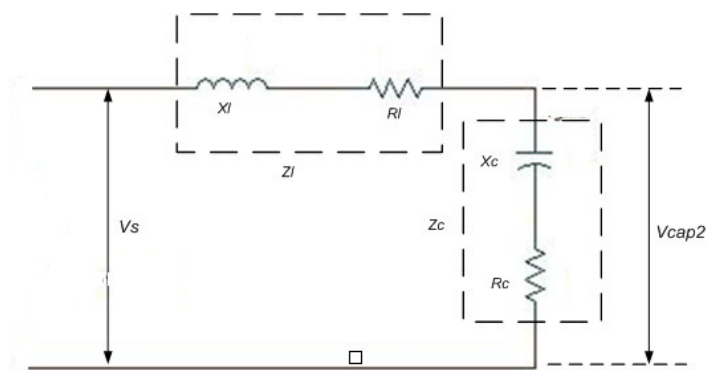
接收端RX Q值的定义

在Qi规格书中，中功率接收端线圈的Q值定义为：MP-A1线圈跟RX放置耦合在一起，此时MP-A1线圈工作在100K频率时测得的Q值为RX线圈品质因数的参考值。

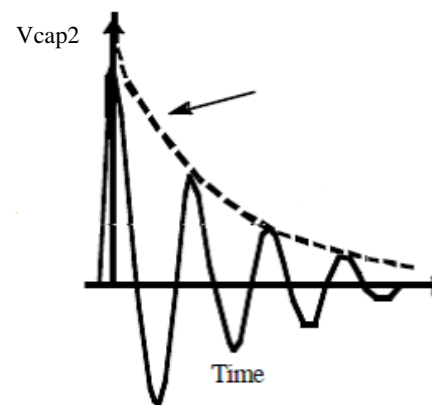


自由谐振法测LC回路的Qlc值

- 使用自由谐振的方法得到LC回路的Qlc值；
- $Q_{lc} = \pi / (-\ln(\text{Rate}))$
- 如下图所示，Rate 是LC回路中谐振信号的衰减率；为了得到衰减率，需要检测信号Vcap2，计算需要得到谐振信号的峰值。

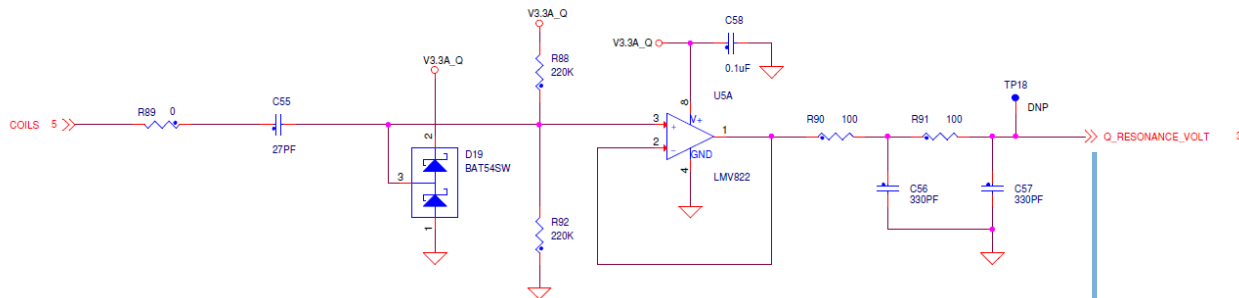


等效电路

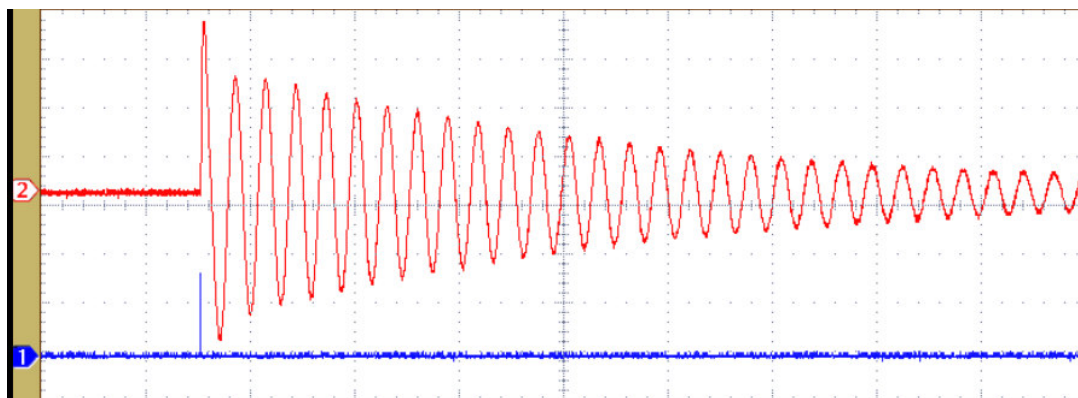


谐振波形

Q值采样电路和波形分析



加激励信号在LC回路中产生谐振信号



通过对LC回路的自由震荡波形进行分析，得到LC回路的谐振频率和衰减率Rate。

自由谐振Q值检测

采得到谐振信号的峰值点后，衰减率Rate可以计算出来；

LC回路的Q值可以计算： $Q_{lc} = \pi / (-\ln(\text{Rate}))$

通过计算可以得到谐振回路中线圈的Qcoil值，用测得的Qcoil值跟RX发送的Q值进行比较，从而判断有没有异物。



SECURE CONNECTIONS
FOR A SMARTER WORLD