

Introduction to Freescale Wireless Charging AMF-IND-T1249

Randy Ryder Product Manager

October 2013

Thereards, the Theorean's logs, ARIWs, C. S., ColeXTEST, ColeXMerras, Cablins, Cablins, C. When, the Immerge Efficient Scalarus in Equ, Niester, normalised 7466, Previous Opert, David, Colexio, Schlevinse, Hin Judykasan Ingo, Santon, Santoheng and MarxXva are trademarks of Freemak Tarekonnikases, Inc. Reg. U.S. Pat, & Tim, Off, Nichola, Bentli, Reeditarik, Camina, Felor, Santo, Yang, Marximian, K. McCarlins, J. Markawa, Inc. Reg. U.S. Pat, & Tim, Off, Nichola, Bentli, Reeditarik, Camina, Felor, Santo, Yang, Markawa, Nator, Nator



Agenda

This session introduces wireless charging, market applications, and Freescale's activities

- What is wireless charging?
- The market
- Freescale activities
- How Qi works



Presents, the Freestate logs, AVWs, D.S. Code/EBT, Code/Marco, OxfEris, Collines, No Everyy Ethiant Solutions logs, Kanta, mobileDT, PEG, Preve/GMCC, Processon Rayer, Cartil, Cartana, Earbeaues, Na: Salebauer logs, RacCare, Sprintery and Vorlib, and tasking and the conductor. Inc., Nej, U.S. Fig. ETh. OR. Antari, Salefit, Beddack, Carter, Freedow, Freedow, J. Schuller, Verol, Barton, et al. Patients, Salefit, Beddack, Salebauer, Salebauer, Salefit, Beddack, Carter, Sprinter, Salefit, Beddack, Salebauer, Saleba



Agenda

This session introduces wireless charging, market applications, and Freescale's activities

- What is wireless charging?
- The market
- Freescale activities
- How Qi works





Wireless charging is the transfer of power through nonconductive means.

Types:

- Inductive Transmitter coil that creates a magnetic field; receiver coil picks up the magnetic field and generates an electric current
- Magnetic resonance Both a transmitter and receiver coil operating at resonance
- Capacitive Transmitter plate generates an electric field via high voltage; receiver plate receives this voltage and rectifies this as a DC output





<u>Comparison:</u>

Characteristic	Inductive	Resonance	Capacitive
Efficiency	Comparable to traditional	Comparable to traditional	Comparable to traditional
Power Scalability	Highly	Slightly	Constrained by charge surface area
Operating frequency	< 500kHz	kHz – MHz range	Varies
Thermal Footprint	Dependent on efficiencies	Dependent on efficiencies	None
Multiple Devices	One to One relationship	Yes	One to One relationship
Z - Spatial Freedom	< 1cm	< 4cm	< 1cm
Cost Points	Micro & coils	Complex Rx	Electrodes, amplifiers, transformers





Agenda

This session introduces wireless charging, market applications, and Freescale's activities

- What is wireless charging?
- The market
- Freescale activities
- How Qi works



Presents: the Evenedity logs, MWay, C.S., CodyTEST, Cadolfariro, OldFire, ColdFire, ColdFire, Collars, Intellingt, Electric applications logs, Kineta, mobileDT, PEG, PreverGBCC, Processor Royer, Cord, Carlona, Electronaux in a California Systema and VordEx and statistication logs, Kineta, mobileDT, PEG, PreverGBCC, Antaria, Bankh, Cabella, Canava, Famil, Layerapa, Layerapa, Haydow, a Participa, Carlo Gonivega, Oxido Engres, Raidy MW, 2000, They and and Romas, an Extension of Freezon Sensionauxie, Int. Alt other product or serves marks for an party of their respective series. C 2013 Freezon Sensionauxie; Int. 2000, 2000

NP Market View

WIRELESS POWER

- Verizon
- •136 Members
- Complete supply chain
- Power scalability to 120W
- Resonance (via Power by Proxie & Fulton)
- Distances scalable up to 4cm
- Operating frequency 105 205kHz
- Currently supported by global telecom operators (Verizon, Orange, Docomo)
- Freescale contributing member



- Qualcomm & Samsung
- Intel member
- Magnetic Resonance @ 6.78MHz
- Distance of a few cm





- •AT&T
- Inductive Charging
- Resonance (via Witricity)
- Incompatible with Qi
- Distance up to several cm
- Operating frequency 300 350kHz
- Freescale member



Image courtesy WPC

Antari, Beefik, BeeStack, CweNer, Flaste, Layerscape, MignY, MRC, Platform + a Pachage, GorG Gorwege, GUOC Engine, Ready Play, SW007MOS, Tower, TuboLink, Vybrid and Elements are backeneers of Processons Remiconductor, Inc. All other product or solvers remote law the progenty of their respective owners. C 2011 Proceeding Remiconductor, Inc.

...deployment of wireless charging infrastructure





9

Presents, the Freenake logs, Mither, D.S., Cole/1937, Oxdelfanice, OxfErier, OxfErier, Oxferier, Dielaus, Nei Energy Ethinet, Soldieres legs, Neuts, endeld II, PEG, Preve/GMCC, Processor Rayer, Zorli, Garnas, Earlehauer, Nei Stelfanze log, StatCare, Styrpteray and Vorsilla are statienade of Freecask-Intercare Sanc, Hey U.S. Ry, E.Y., Ott Antar, Berlit, BerStack, Carelan, Earlehauer, May, WIC, Pathore is a Package, Gard Generage, GUCC Empire, Rady Ney, SMX/MOS, Tree, Tradicale, Vysnit and Stratic are balancessor Elemenonistani, for 34 Ontoir product or advisor amail are to approximate interim reproduct areas of 501 Freedox Sancharazzo, Exc.

WPC Qi Technology Roadmap

- Current specification includes up to 5W
 - Enable mobile phone market
 - Additional features such as foreign object detection
 - Full flexibility on the device side
 - Wide range of transmitter types available
- Extending the Qi low power specification to 15 Watts
 - Enables fast phone charging
 - Align with increased power requirements of smart phones
 - Enable wireless charging for new class of devices
 - Est. spec delivery Q4'13
- Medium power: 30-120 Watt
 - Enables charging of tablets and notebook computers
- High power: up to 2000 Watt
 - Enables wireless kitchen appliances



Presents the Freesede logs, AWex, D.S., Color/EEF, Cadelhanco, Galdries, Calline, Neckergy Ethiant Soldions regi, Xiesta, mobile(2), PEG, PreveDUCC, Processor Rayer, Carl), Carlona, EstManael, Na Salekarae logs, StacCare, Spriptery and Vortila and trainistance of Freezed Earnicocolum; teo. Hey U.S. Ry: S. 71: DE. Antari, Stellit, BedStack, CarWex, Ress, Layerouga, Mayori, WicC, Pathore & Factage, Gard Gonveya, GulCC Expres Resp. Fey SMURDUS, Twaand Trainic and Indexista of Freezed Earnicocolum; for 32 other product or announces for the respective events. D 2011 Freezed Sectionauro: Extension and Trainic and Indexista (Factage), MicC, Pathore and and the system in the respective events. D 2011 Freezed Sectionauro: Ex-



Agenda

This session introduces wireless charging, market applications, and Freescale's activities

- What is wireless charging?
- The market
- Freescale activities
- How Qi works



Presents, the Freetoole logs. AVMov, D.S., Colar/EST, CadeMarcio, OxiFire, DokFire, D.Mare, No-Evergy Ethiant Solutions lags, Kireta, incluidoT, PBD, Preve/GMCC, Processor Ecsev, Confl, Sonna, EstiManan, Inschlafarar logi, SacCare, Spripting and Vorlida wir taskinata of Freezonkitzm, co., Rey, U.S. Par, Sin, OR, Antar, Selfit, Bedisch, Carlos, Flees, Layerscep, Mayri, MICC, Felforer, a Facturg, Oriol Gonverg, U/OC Empre, Ready Fer, SaMCH003, Tree, Trabolan, Vynit and Titraic are taskinating. Fleescoa Externol Action, Int. North product or annual set to property within Antaria, Solit, Fer, Solit, Carlos, SacCare, SacCare, SacCare, SacCare, SacCare, SacCare, Carlos, SacCare, Sa



Broad Flexibility - Configure and customize through easy-to-use API providing maximum flexibility

Accelerate Time-to-Market – Market-ready reference designs and productized software components

Compliant & Beyond – Leading contributor to the Qi standard, as well as providing multi-protocol support



Freescale Wireless Charging Market Segments



Freescale

Presents, the Freezenko logic, MWex, D.S., Code/EEF, CadeMarrier, Old/Frie, Cold/Frie, C. Main, No Energy Ethinet Solidions legic Xilesti, incohed II, PED, PreverQUCC, Processor Rayer, CortU, Carina, EarthAssain, the Statisfacare logic StatCare, Symptrety and Vorsibia was unalimented of Freezenko Barcconducto, the Antar, Barlie, BeeStack, Carolia, Raymong, Mayori, WRC, Pathers et al Pathog, OctO Compan, Rador Free, Statisfacare logic Theologic, Vyrail and Tamica as belandas of Freezenkaru, feix, 80 offer product or announces for a program theory hourism C2011 Freezenko Scholaros, Scholaros, Scholaros, Carolia, and Tamica as belandas of Freezenkaru, feix, 80 offer product or announces for a program theory approximate C2011 Freezenko Scholaros, Sc

WCT1000 – Single Coil Transmitter

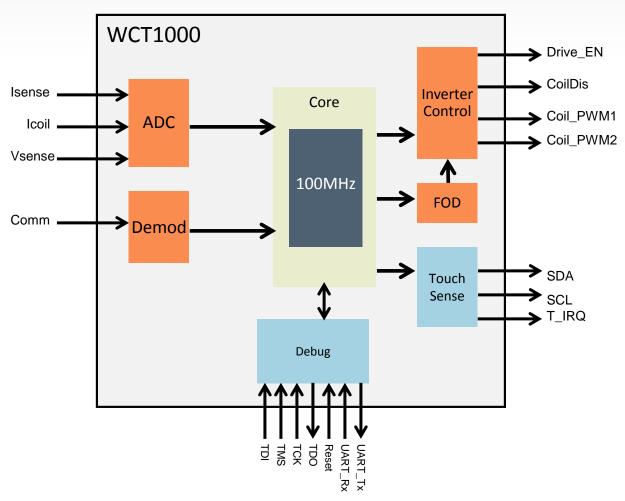
Hardware

- 100MHz core
- Support half or full-bridge power stage
- Run-time calibration capable
- Low Run power (< 30mA PID loop current)
- Ultra-low Stby power capable
- 32QFN

<u>Software</u>

- Configurable firmware library
 - Core charging functions
 - Foreign objection detection
 - Digital demodulation
- I2C for Touch Sense Interface





5W Transmitter – Premium Option

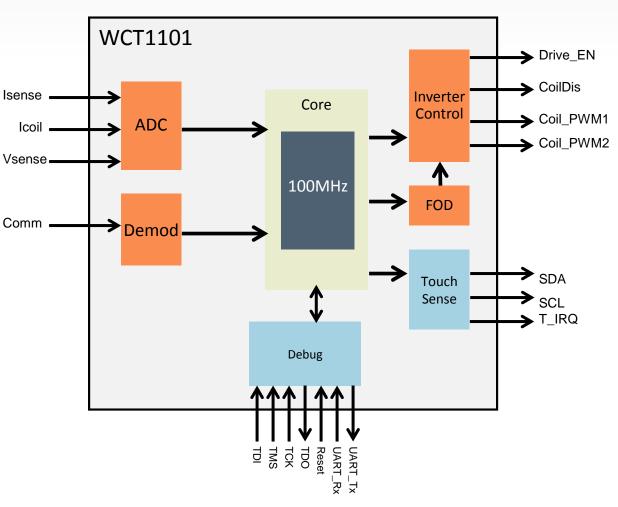
Hardware

- 100MHz core
- Support half or full-bridge control
- Run-time calibration capable
- Low Run-power (< 30mA PID loop current)
- Flash & RAM available for customization
- Support single or multi-coil systems
- 20+ Additional IOs for addon functions
- 64LQFP

Software

- Configurable firmware library
 - Core charging functions
 - Foreign objection detection
 - Digital demodulation
- Additional program memory and IOs for custom application code
- I2C for Touch Sense Interface





Presents, the Freenate logs, MMws, C.S., Code/EST, Ond-Marcin, Old/File, Oxd/File, Oxd

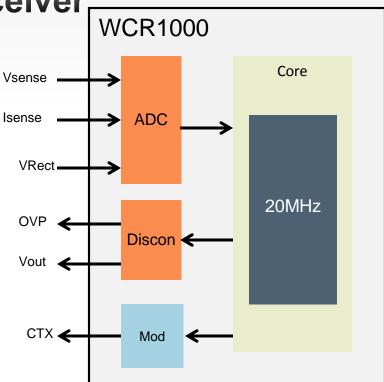
P Wireless Charging Receiver_r

Hardware

- Support s full 1A output @ 5V
- Programmable interface
- Modulation Control
- System safety monitoring
- Output disconnect control
- 4 x 4 QFN24

<u>Software</u>

- Configurable firmware library
 - Qi communications protocol
 - Battery charging algorithms (NiMH, LiION)
 - Foreign Object Detection (FOD) support



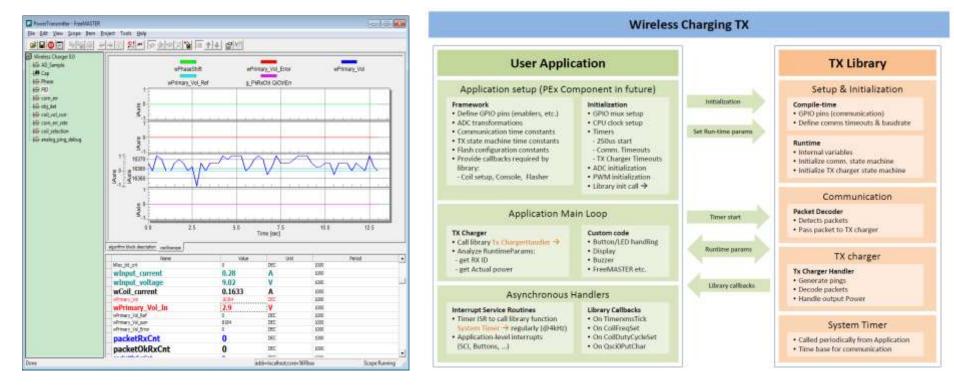


Presents, the Freerodo logs, MWex, D.S. Code/EET, Godelfanice, Dieffine, ColeFine, O Maria, No Eweyy Ethiant Soldions legs, Notas, readiaGT, PEG, PreverQUCC, Processor Riser, CodQ, Carina, Tarbasas, the Statisticane log, StatCare, Symptroty and Vorsilia are tradematic of Freezok Taroccoductor, too, Rey U.S. Pitt, Thr. Other Antary, Statist, Banklas, Anna, Layweaux, Maryol, WRC, Pathorn is a Participa, Carilla Converga, Calico Cherjine, Rady Hey, Statist, No. Antary, Statist, Banklas, Anna, Layweaux, Maryol, WRC, Pathorn is a Participa, Carilla Converga, Calico Cherjine, Rady Hey, Statist, You Markov, Statist, Carilla Converga, Carilla Converge, Cari

NP

Freescale Wireless Charging Firmware Library

- Modify parameters on-the-fly using analysis tool (e.g. FSL's Freemaster)
- Tune the system to optimize performance
- Add additional application code (via Freescale API)
- Create true differentiation by customizing your wireless charging product



17



Freescale Proof-of-Concepts

Medium-power Industrial



- Charges 4x 11.2V / 4.8Ah battery packs simultaneously
- 80% transfer efficiency
- 56F8257 / QB8 MCU

5W consumer Rx



- True 5W power delivery
- Qi-1.1
- Discreet solution offers better thermal mgt

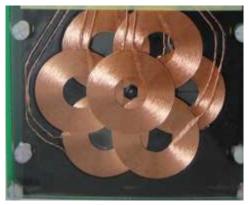


Medium-power consumer



- Provide 25W of power transfer
- 80% transfer efficiency
- Implements basic foreign-object detection
- 56F8257 / QB8 MCU

Low-power consumer



- 5W solution
- 7-coil array for free position
- 56F8006

Presents, the Freenance logit, MWex, D.S., Code/EEF, CodeRamo, Ox/Eris, CodeFais, C. Haus, No Energy Ethinet: Solidons legs, Kanta, ended CF, PEG, Preve/GMCC, Processon Rayer, Cod/Q, Carina, EarthAssan, Ha Salekaran Kog, Stachure, Symptrany and Vordia and statements of Freenance Rayer, Code, Antar, Salek, Beddack, ConAve, Ress, Layersage, Maryol, MRC, Pathors et a Package, Cord Converga, OxfCC Engen, Rayer Nat, Mark Mark, Salekaran Kog, Antar, Salek, Beddack, ConAve, Ress, Layersage, Maryol, MRC, Pathors et a Package, Cord Converga, OxfCC Engen, Rayer Nat, Salekaran Kog, Antar, Saleka, Beddackar, ConAve, Ress, Layersage, Maryol, MRC, Pathors et a Package, Cord Converga, OxfCC Engen, Rayer Nat, Salekaran Kog, Antar, Salekaran EF, Rower Remondantar, No. 80 per product or server annual and the instance in the instance of Solid Resolution Science Convergence on the instance of Solid Resolution Science Sc



5Watt Single-Coil Charger

- Rev. 2 alpha sampling now
- General board availability December '13
- Kit includes schematic, BOM & design files
- Includes configurable library file for system tuning
- Premium version silicon & library available for application layer programming
- Internal digital demodulation for major BOM cost reduction
- Supports most standard single-coils designed for 5 Watt applications

Features	Benefits	
Greater than 5W output power	Deliver full 5W to receiver	
Up to 77% transfer efficiency	Lower thermal footprint	
Supports FOD per WPC 1.1 spec	Detect foreign objects to maximize user experience	
Wide input voltage tolerance (4.25 – 5.6V)	Operates under flexible input supply voltages	
MCU run power < 30mA / Stby @ < 5mA	Achieve ultra-low power consumption during operation	
LED & buzzer for alignment options	Low-cost alignment indicators for users	
BOM cost est. < \$5.00	Highly competitive price-to-value solution	



Power Stage

Demod

WCT1000

Pre-Drive

Low Power

Inverter Control

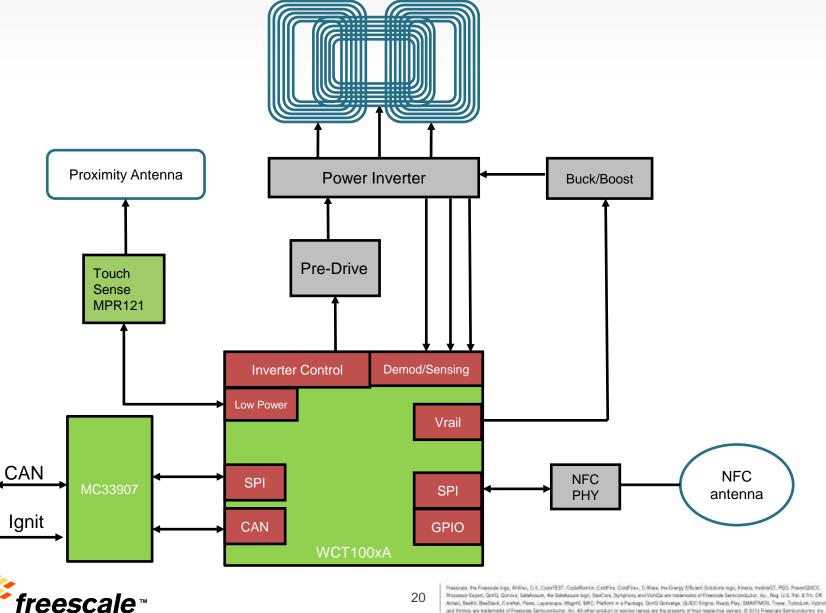
Touch MPR121 Buzzer/ LED

GPIO/

PWM

Presecute, the Freesolds Ope, MVHou, D.S., Cold FEST, Oxdolffante, OxdFine, OxdFine, O Mare, the Energy Ethiont Solutions lags, Kineta, incluid/17, PSG, Preve/QUCC, Processor Rigar, Cardia, Cardia, Eartheaue, the Salekaue logo, BacCare, Snytheira yard Vorlika was tradenated of Freesel Resolution, the JUS. Fig. 57 n. OR Antari, Saleka, BeeStack, Cardwar, Fant, Layresson, Mayrol, WBC, Parther, a Pentage, Cardia Concepta, UACC Engen, Ragi, Pay, SMA/TMOS, Trive, Turbolink, Vyteril and Strains and statements Removed and Law. In All Resolution or eavier ensure that for anogenet and their solutions and Strains School Statements and Freezel and Strains School Scho

Automotive Qi Transmitter Block Diagram



and Threads an Enderrooks of Freedom Germonductor, Inc. All other product or solvice regress are the property of their respective element. O 2011 Freedom Germonductor, Inc.



Feature Rich Automotive Reference Design

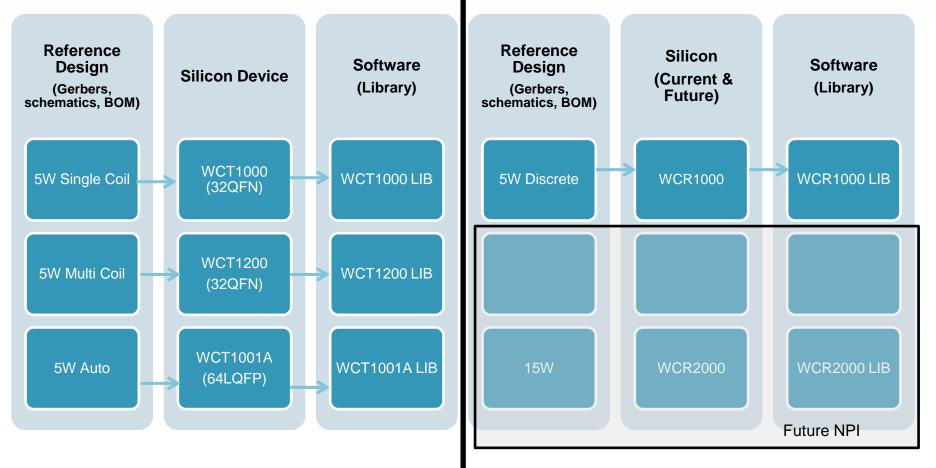
- WPC A13 Automotive Charger
 - Rev. 2 alpha sampling August'13
 - General board availability December '13
 - Kit includes schematic, BOM & design files
 - Includes configurable library file for system tuning & application layer programming

Features	Benefits
Greater than 5 Watts output power	Deliver full 5W to receiver
> 60% transfer efficiency	Lower thermal footprint
Supports FOD per WPC 1.1 spec	Detect foreign objects to maximize user experience
Low operational & Stby power using touch sense interface	Achieve ultra-low power consumption during operation
Integrated CAN bus support	Lower BOM cost
Fixed frequency operation	Avoid key FOB frequency interference
Meet CISPR 25 requirements	Improved EMI protection to meet auto standards
NFC capable (using premium version device)	Implement NFC use case & show coexistence with Qi
Dual-Mode Capable	Support both Qi & Powermat protocols
AECQ-100 Level 2 qualified	Automotive qualified



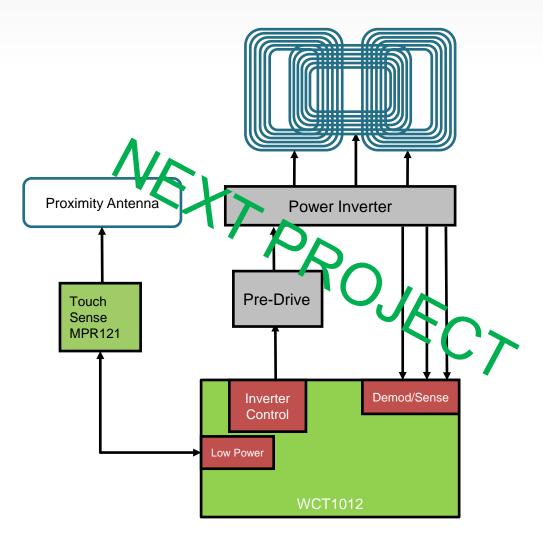
Freescale Transmitter Solutions

Freescale Receiver Solutions





5W Multi-coil transmitter for Consumer





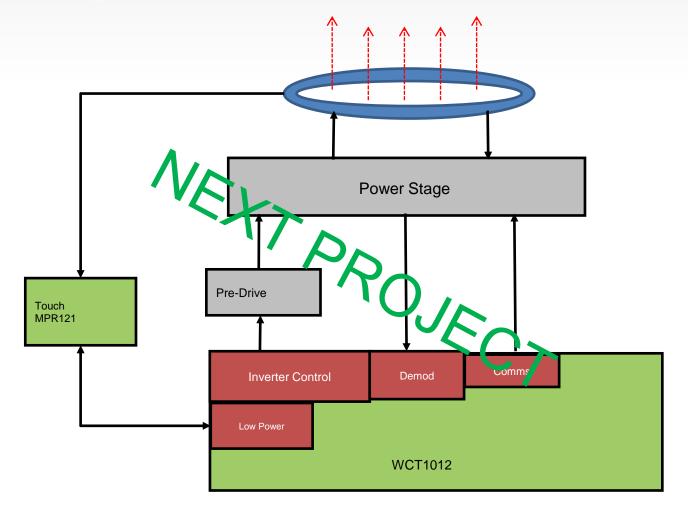
5W Multi-coil Transmitter for Consumer

- 5 Watt multi-coil to support aftermarket mobile phones
- Support both PCB & wired magnetics
- Generalized to support variety of multi-coil configurations
- Maximum flexibility via programmable solution
- Real-time debug and tuning capability
- Dual-mode support
- Internal digital demodulation for decreased BOM
- Premium configuration to add value-added differentiation
- Availability ~ Dec '13



Presents the Freenance logs, AlWex, D.S., Code/EES, CadeRearce, Oxferine, Caderine, Tordina, Ino Energy Ethiant Societions logs, Keesta, Incolad/JL, PES, Preve/QUCC, Processor Rayer, Caroli, Carolina, Earbanauk, Int Sathanaur Kog, StarCare, Styratory and Vorsilla and statematics of Freezok Elemiconductar, Inc., Reg. U.S. Park, Stark, Stark, Tank, Tank

15W Single-coil Transmitter for Consumer





15W Single-coil Transmitter for Consumer

- 15 Watt single-coil transmitter solution
- Targets high-end smartphone & tablet applications
- Reduce battery charge time & increased battery capacities
- Maximum flexibility via programmable solution
- Real-time debug and tuning capability
- Internal digital demodulation for decreased BOM
- Premium configuration to add value-added differentiation
- Availability ~ Q1 '14



Presents: the Freesede logs, AWex, D-5, Code/EES CadeMarine, Oxferine, CodeFree, Cadema, Ino Energy Ethiane Sociations legs, Keeta, Incode/CE, PEG, PreverQUCC, Processor Rayer, Corell, Carina, Earbhanas, Na Salekarar Kog, StarCane, Styratory and Ventilla versional and consecute Tencconductor, too, Hey U.S. Rys. Rev. Ok. Annae, Stellit, BedStah, Careker, Rest, Layersona, Mayer, WIC, Pathore in a Factory, Cale Company, OxfoC Engine, Ready Rev. Coll. Rev. Sci. Annae, Stellit, BedStah, Careker, Rest, Layersona, Mayer, WIC, Pathore in a Factory, Careke, Colling III, Reide Rev. Coll. Freesenaities and Ethica and State Conductor Law. A Core product or server name and the sequence at the sequence and the Sci. Careker, Stellit, BedState Conductor Law. Coll. Conductor Science Colling Conductor Law.



Broad Flexibility

- Generalized solutions to support a wide range of magnetics options
- Configurable hardware for added features
- Ability to add differentiating features via software add-ons

Application-Specific Technology

- DSC core technology optimized for wireless charging transmitters
- Software IP focused on efficiency & X/Y/Z freedom

Speed Time-to-Market

- Market-focused solutions
- Productized software components
- Wireless charging expertise



Presents: the Eventskie logs. AVWex, D.A. Code/EER, CodeRamon, OxfErie, CodEries, OxfEries, D. Hava, No Everyy Ethioms Solidons legs. Knots, modeleDL PGS, PreverQUCC, Processor Rayer, CodU, Carlona, Earbhauar, Ins Salekauar Iog, Stachur, Shyatrony and Vorsilla are statematic of EvenceN lancoch lancoch data Artini, Saleki, DerStat, Carlow, Existin, Layersona, Mayori, WC, Patrices a Fantage, Carlo Compan, Budy Pay, Saleki Par, Statu, Par, Saleki Pay, Saleki Pa



Agenda

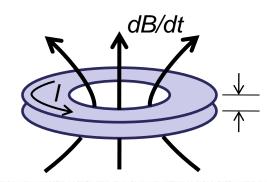
This session introduces wireless charging, market applications, and Freescale's activities

- What is wireless charging?
- The market
- Freescale activities
- How Qi works





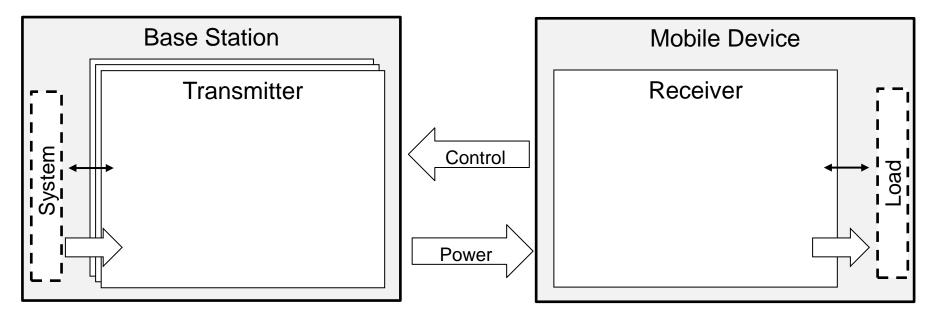
- Main application
 - Battery charging, or other suitable loads
 - For wide range of mobile devices
 - Mobile phone, camera, mp3 player, headset, ...
- Up to 5W of power delivery
 - More power at later versions
- Power transfer via magnetic induction
 - Loosely coupled transformer
 - At short distance (few mm)





System Overview (Top View)

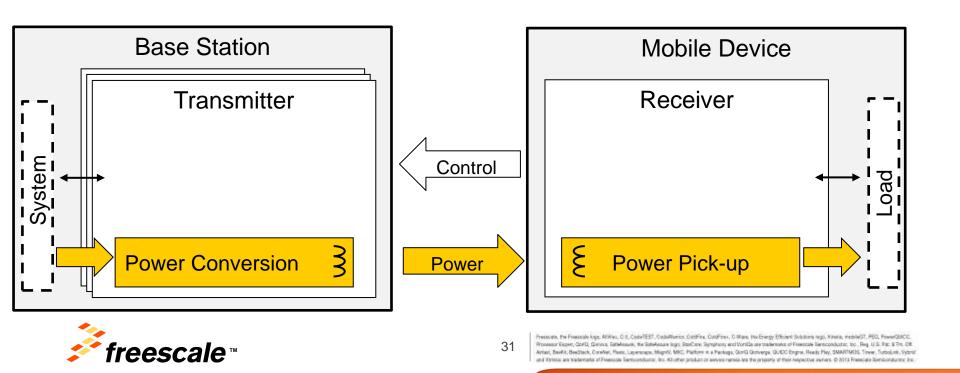
- Base Station
 - Contains one, or more transmitters
 - Transmitter provides power to receiver
- Mobile Device
 - Contains a receiver that provides power to a load (e.g. a battery)
 - Receiver provides control information to transmitter





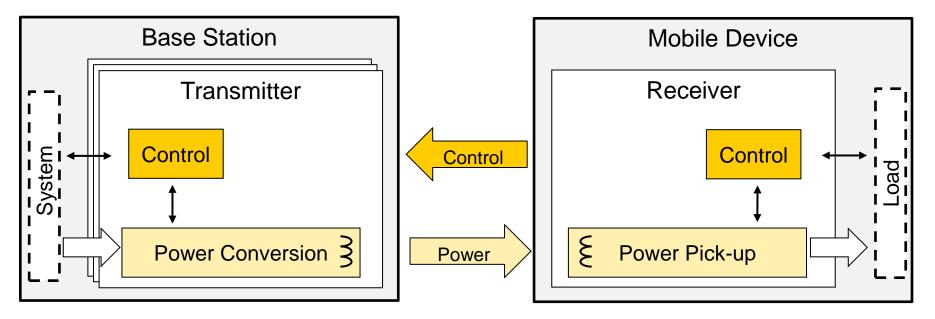
System Overview (Power Conversion)

- Power Conversion Unit converts electrical power to wireless power signal
- Power Pickup Unit converts wireless power signal to electrical power



System Overview (Control)

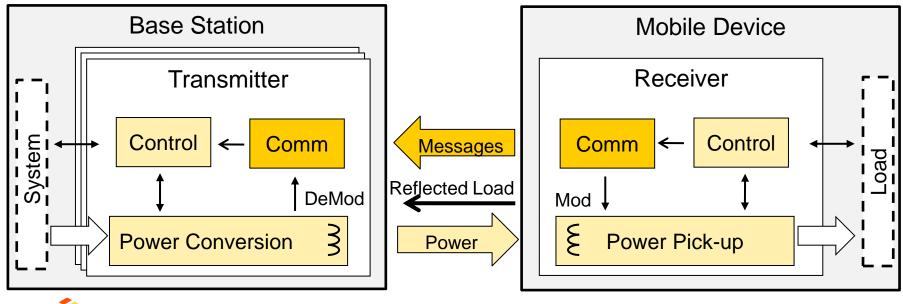
- Receiver controls the power to the output load
 - To the need of the mobile device (required power)
 - To the desired operation point (e.g. output current, voltage)
- Transmitter adapts power transfer
 - To the need of the receiver (required power)
 - To the desired operation point (e.g. primary coil current)





System Overview (Communication)

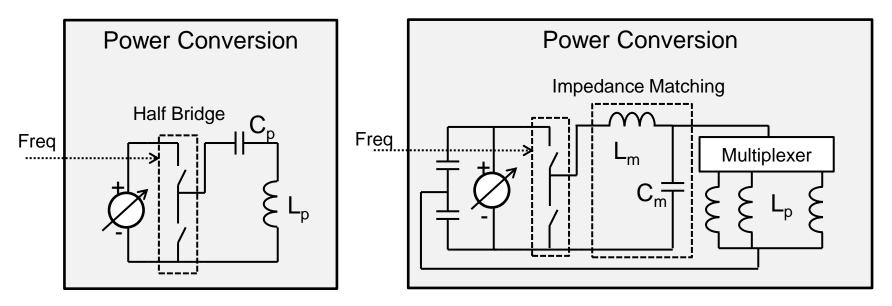
- Receiver sends messages
 - To provide control information to the transmitter
 - By load modulation on the power signal
- Transmitter receives messages
 - To receive control information from the receiver
 - By de-modulation of the reflected load





Power Conversion (Transmitter)

- Primary coil (L_p) + serial resonance capacitor (C_p)
- Inverter: e.g. half bridge
- Coil array implementation
- · Controlled by e.g. frequency or voltage

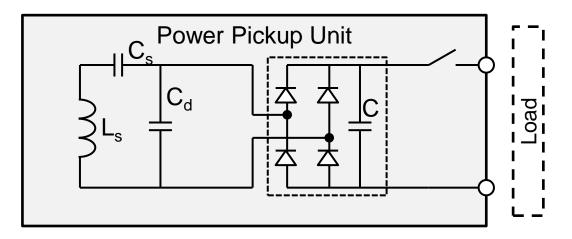


16 October 2013



Power Pick Up (Receiver)

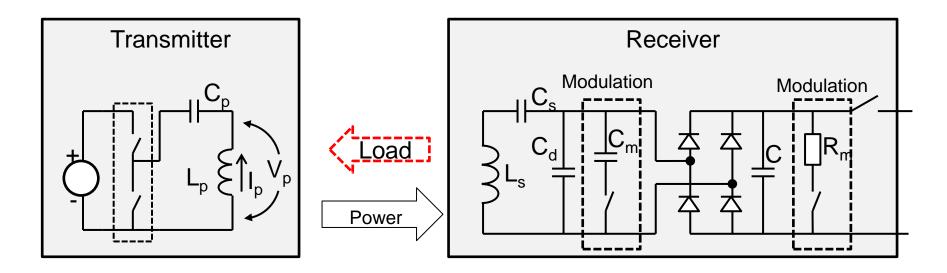
- Secondary coil (L_s)
- Serial resonance capacitor (C_s) for efficient power transfer
- Parallel resonance capacitor (C_d) for detection purposes
- Rectifier: full bridge (diode, or switched) + capacitor
- Output switch for (dis-)connecting the load





Communication (Modulation)

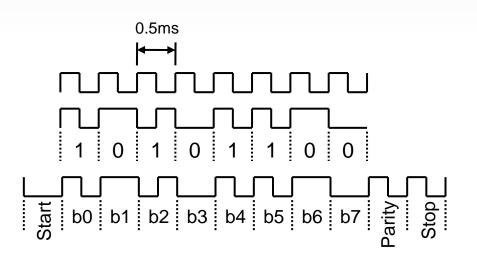
- · Receiver modulates load by
 - Switching modulation resistor (R_m), or
 - Switching modulation capacitor (C_m)
- · Transmitter de-modulates reflected load by
 - Sensing primary coil current (Ip) and/or
 - Sensing primary coil voltage (V_p)





Communication (Data-Format)

- Speed: 2 Kbit/s
- Bit-encoding: bi-phase
- Byte encoding: Start-bit, 8bit data, parity-bit, stop-bit
- Packet Structure
 - Preamble (>= 11bit)
 - Header (1 Byte)
 - Indicates packet type and message length
 - Message (1 .. 27 Byte)
 - One complete message per packet
 - Payload for control
 - Checksum (1 Byte)



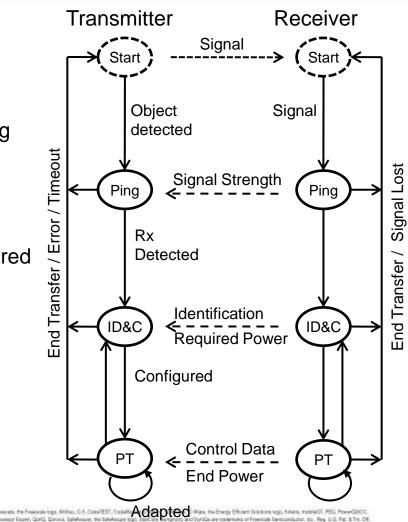
Preamble Header Message Checksum



heacain, the Francelo login AMNo, C.S., Color EES, Codolfanto, Califfrin, Coloffrin, C.Main, Inv Energy Efficient Solutions legin, Minuta, incolor/OT, PEG, FranceOUCC, Possiering Esperi, Colf, Damina, Establicature logi, SeaCain, Sprathary and World's are tradematic of Francesh Renconductor, Inc., Rey, U.S. France, Ren Interas, Berlin, Berdack, Conniver, Franci, Layersages, Mayriv, MRC, Parther in a Pantage, Cont Gonweg, COCC Engine, Read Pari, Statisticature, Color and Strate, and Statistic and Pancesh Berlin Color. In: A Strate postular or every entrois and the amports and encoded Pari, Scholane, Vand and Strate, and Statisticature Color. Encoded Encoded and Inc. and Statisticature of the Inspective and encoded Strate Resonance for the

Communication & Control

- Start
 - Transmitter provides signal and senses for presence of an object (potential receiver)
 - Receiver waits for signal
- Ping
 - Receiver indicates presence by communicating received signal strength
 - Transmitter detects response of receiver
- Identification & Configuration
 - Receiver communicates its identifier and required power
 - Transmitter configures for power transfer
- Power Transfer
 - Receiver communicates control data
 - Transmitter adapts power transfer



ach, CareWar, Peans, Layverarge, MagnV, MRC, Platform in a Package, GardG Gonwege, GUICC Empre. Ready Play, SURUTIVOS, Traver, Tabolank, Vybrit marks of Presences Remicrochaster, Inc. 42 other product or sorvice names are the property of their respective averant. O 2013 Presence Remicroadoxter, Inc.



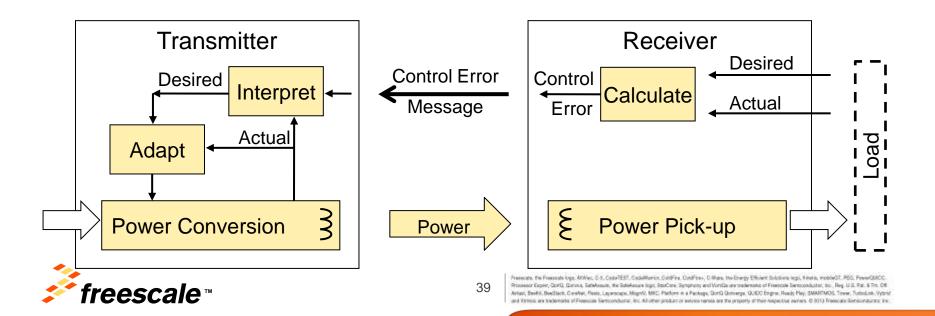
NP Power Transfer Control

Transmitter

- Interpret desired control point from
 - Control error message
 - Actual control point
- Adapt power towards zero difference between
 - Desired control point
 - Actual control point

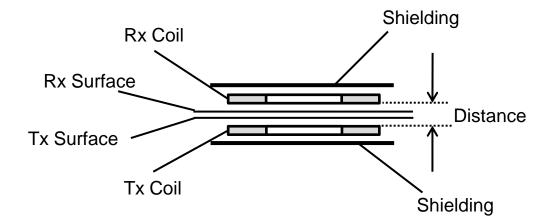
Receiver

- Calculate control error
 - = difference between
 - Desired control point
 - Actual control point
- Communicate control error message



Coupling between Coils

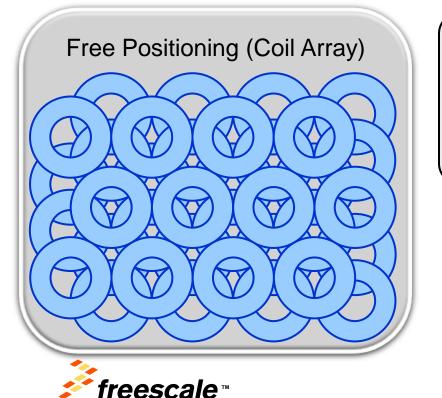
- · Good Coupling between coils is achieved by
 - Choosing appropriate dimensions of coils (matching size)
 - Keeping the distance between coils small (flat interface surface)
 - Adding magnetic permeable material (shielding)
 - Aligning the coils (next page)

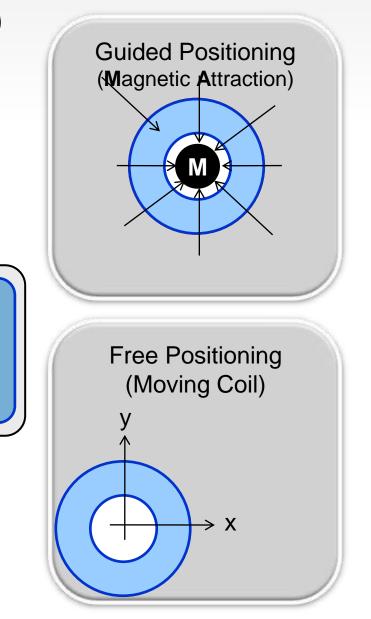


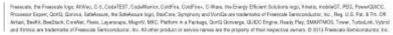


Coil Alignment (Design Freedom)

- Guided positioning with tactile feedback
- Free positioning with moving coil
- Free positioning with selective activation of coils in coil array

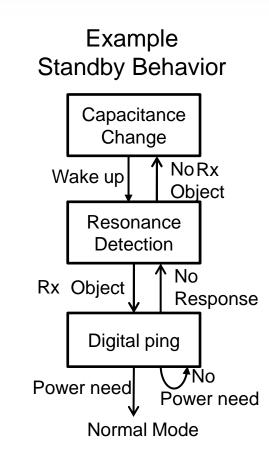






Standby Power

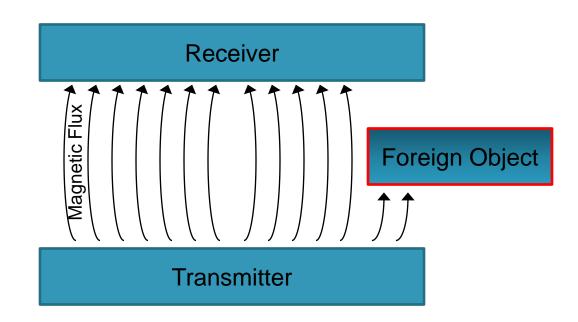
- Transmitter can enter standby power mode when
 - No device is present, or
 - present devices need no power (battery charged)
- Transmitter can apply various methods to react on a receiver
 - Capacitance change
 - To detect the placement of a potential receiver
 - E.g. 0.1 mW
 - Resonance detection , or
 - Resonance change
 - To detect the presence and location of a potential receiver
 - E.g. 5 mW per primary coil when applied every 0.5s
 - Digital ping
 - To detect the presence and location of a receiver
 - To check for power need of a receiver







- The presence of foreign objects can absorb energy from the magnetic field, causing heating of the object.
- The system must account for all power to detect the presence of a foreign object.





Presents, the Freerede logs, AlVier, D.S., Cole/TEST, ColeManno, Carlfins, ColeFins, C.Mara, Into Every Different Solutions logs, Kitera, incolled's, PEG, Pereed/UCC. Processor Garrie, Cardi, Qamina, Barkauania in Salakkauar logs, Barchin, Spratny and Vorlia variasilinatos of Freeresa Interconducts, the U.S. Rei, S. R. 19, D. A. Antar, Berlik, Berlack, Carleker, Freet, Layersage, Mayriv, MRC, Parther in a Pantage, Gind Gonorega, UADC Empire, Ready Pey, Stad/MoloS, Triver, Turbolich, Vystal 42 and Empire, and Empired and Freecow Bentrochecture, Nacionary control and the graphic term Appendix events 2011 Prevende Advications in the

General Power Loss Equations

• The overall power loss in the system can be calculated using the following equation:

 $P_{loss} = P_{transmittal} - P_{received}$

• Further, the transmitted power can be calculated using the following equation:

 $P_{transmittel} = P_{in} - P_{txlosses}$

• And the received power can be calculated as follows:

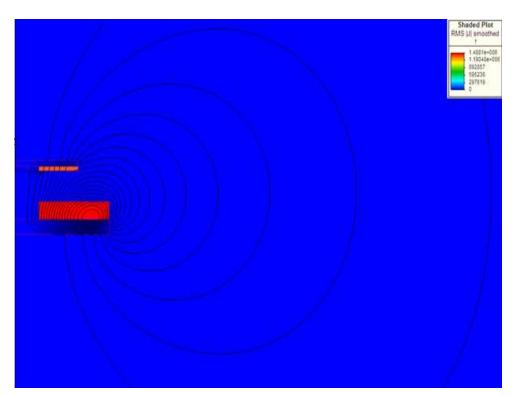
$$P_{received} = P_{load_{meas}} + P_{rxlosses}$$

 Characterization of "expected" system losses make foreign objects easily identifiable --- NOT!!



Magnetics Introduction

- Air Core Transformer
 - TX Create Local Magnetic Flux
 - RX Convert Coupled
 Flux into Current
- Shielding Materials Keep flux out of other subsystems
 - Batteries
 - Housing
 - PCB Planes, etc





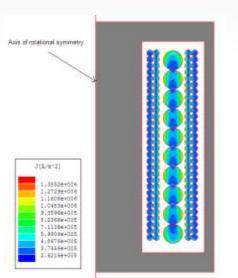
45

Presents, the Freezele logs, AlVier, D.S., Cole/EEF, Codultarion, OartFrei, C.Mare, Ine Energy Efficient Solutione logs, Kinata, incolad/T. PEG, PrevedUICC. Processor Equine, Caroli, Caronia, EsteManae, Inis SateManae logs, BanCine, Sprylamp and Vorlaw are satematical of Freezele Interconductor, inc., Ing. U.S. Par, E.T. Ott. Annae, Seeffit, BerSteck, Caroline, Layrences, Migrel, MIGC, Parlom in a Panlang, Carol Generage, DUCC Empire, Ready Per, StatMCMOS, Trave, Thodant, Versit 45. State at Entrice are statematical and Freezele Interconductor, Inc. All Onto productor or an engineering of their Inspective animatics 05.011 Freezele Sectionae Device Caroline and Statematics 20.012 Freezele Sectionae Device Caroline 20.002 Freezele 20.002 Free

NP

Power Loss Considerations

- Switching losses
 - WPC operates ~100kHz 210kHz
 - Regulated as Unintentional Radiator
 - Higher Frequencies (6.78MHz, 13.56MHz) increase losses in inverter stage
- AC resistance increases with frequency
 - Proximity effect (current crowding from multiple turns, core material)
 - Skin effect (current crowding from internal magnetic fields)
- PCB coils useful in RX coil
 - Balance ohmic losses vs. current needed
 - Good choice >~400mA
 - High gauge FPWB, PCB needed
 - Wire coils may be more cost effective for high current (>~400mA)









heacoas, the Freezele Kop, MWex, D.S., Color/EBT, ColoRheiro, OxtEre, Collere, Cillian, IncEnergy Ethient Solutions lags, Kitela, includedT, PED, PoweGUCC, Possess Roser, 2010, Sama, Satkauas, its Satkauar kog, Satura (Synghony and Vorla) are traininated of Freezela Banccookutta, to, Hei U.S. Ru. Sith, Sith Inter, Sevilla, Bandlack, Carelin, Fassi, Layenapa, Mayri, M.C., Pathon e A Parting, Card Schwarg, OxCO Engin, Rash (My, SMARTON), Trave, Turbolini, Vystal and Transa are Mannesia of Freezela Banccookutta, Vol. 2010, Pathon e A Parting, Card Schwarg, OxCO Engin, Rash (My, SMARTON), Trave, Turbolini, Vystal and Transa are Mannesia of Freezela Banccookutta, Vol. 2010, Pathon e A Parting, Card Schwarg, OxCO Engin, Rash (My, SMARTON), Trave, Turbolini, Vystal and Transa are Mannesia and Freezela Banccookutta, Vol. 2010, Pathon e A Parting, Card Schwarg, OxCO Engin, Rash (My, SMARTON), Trave, Turbolini, Vystal



