

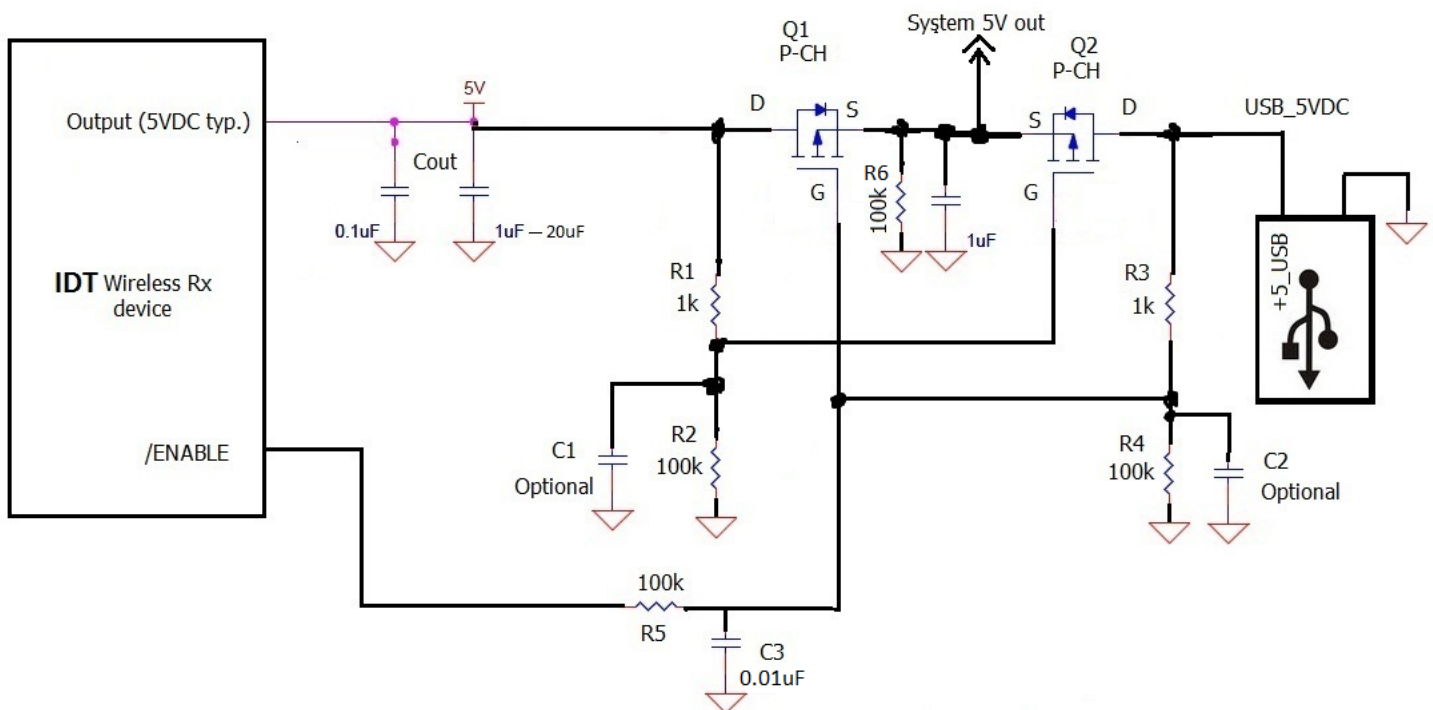
### Introduction

In many wireless charging applications it may be necessary to offer the end-user the option to charge the battery from the wireless power system or from a traditional AC adaptor or USB port. The ability to choose or use either charging method (wireless or wired) should not come with any consequence in terms of performance or loss of any energy independent of the selected charge method (during charging or when the device is running off of the battery). IDT proposes the following circuit to automatically switch between Wireless charging and standard charging on a mobile device (or any application that wireless and wired charging methods co-exist).

### Details of the Application

When charging a portable devices battery end users want flexibility; therefore, it has become common for new designs implementing wireless power receivers into portable systems to require the use of standard (wired) chargers in parallel with a wireless charger integrated circuit. This creates the need for a method to automatically switch in between wireless power transmission and charging via standard 5V (USB or AC adaptors) power by AC voltages from the wall. Additionally, some wireless power receivers may not be designed to tolerate having an external 5V supply connected directly to their output. This condition can lead to failure to startup, multiple power supplies in conflict for control of a node, or allow leakage currents in excess of 1mA to be consumed by an inactive circuit, which is undesirable from an efficiency point of view as well as in regard to battery preservation. The IDT solution is to employ two power P-CH FETs that are controlled by the power supply in use (wireless Rx IC or standard charger) and to take advantage of the /ENABLE pin of each wireless Rx IC. The following circuit diagram shows the typical discrete application circuit that is currently being recommended in order to provide seem-less power supply switching for our wireless power management products:

Figure 1. Circuit Diagram Showing the Typical Discrete Application Circuit



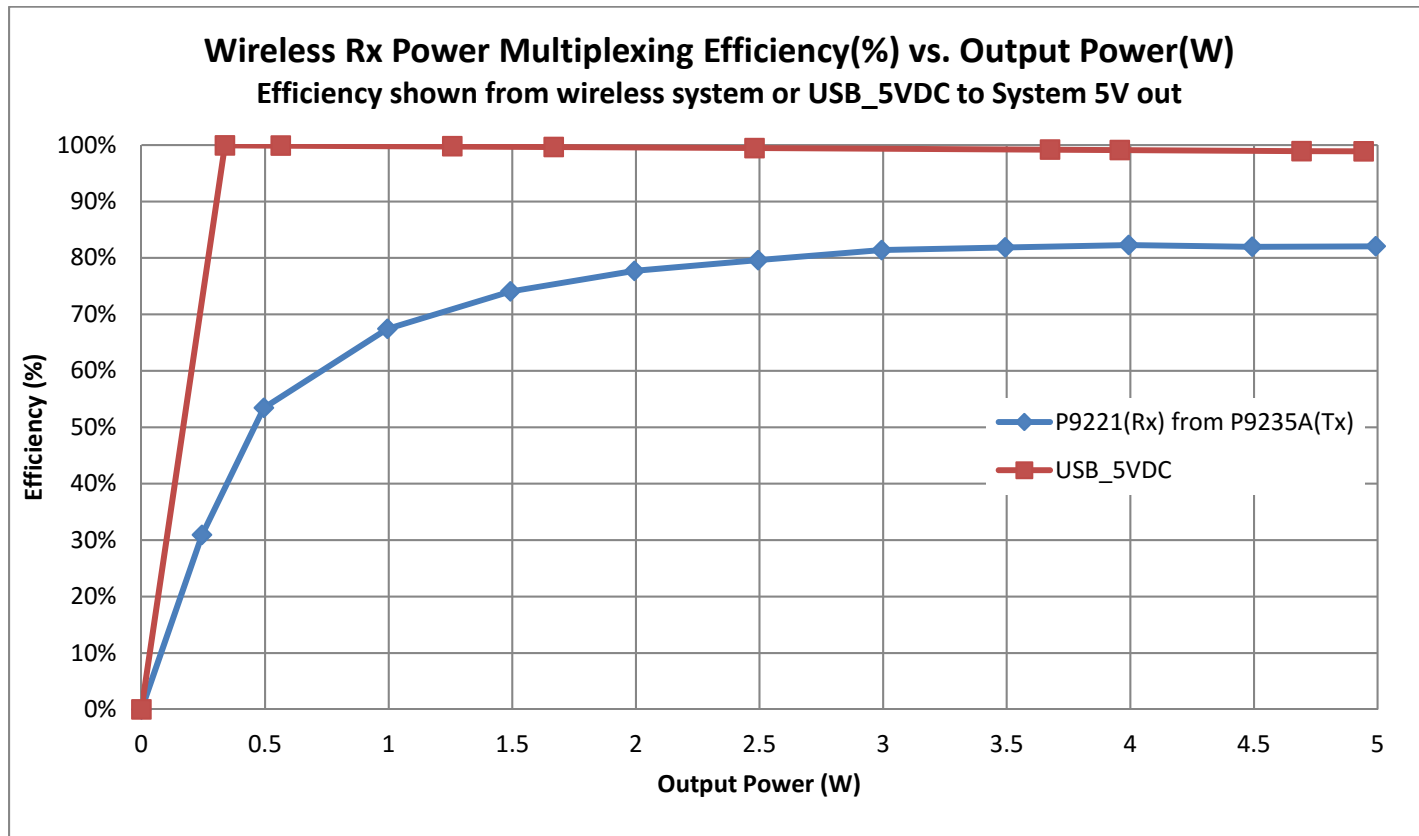
- Wireless Power – '5V' node connects to 'System 5V Out' (saturate Q1); Q2 blocks DC from 'USB\_5VDC'.
- USB Power – 'USB\_5VDC' connects to 'System 5V Out' (saturate Q2) and disables Wireless Rx IC; Q1 blocks DC from '5V'.
- Not Charging state – 'System 5V Out' should not be powered by battery; for USB OTG, connect to directly to 'USB\_5VDC' node.

Output voltages other than 5V are supported with proper FET and resistor selection, Since it can be destructive or simply a waste of energy to have two power sources connected directly together, this circuit solves the issues of multiplexing between the standard charging method and wireless charging safely and automatically while preventing leakage currents greater than a few microamps. The ohmic value of resistors R1, R2, R3, and R4 should be set such that the divided value of the respective voltage rail they are connected to will guarantee that the FET they control does not have enough gate voltage to begin turning on (conducting) and the actual resistances may be increased for further energy savings. The two resistors R2 and R4 may also have a capacitor of 1nF to 1uF (C1 and C2) used to control the timing of the ON-OFF sequencing and to help hold the gate voltages in higher noise environments. The value of the disable resistor (R5) and capacitor (C3) may be varied in order to comply with required switching time constants for the system. Care should be taken with the Q1 gate connection and the /Enable circuit to be sure that the voltage stays low enough during operation to fully saturate the transistor in order to maintain the highest possible efficiency.

When selecting the P-CH MOSFETs the following guidance should be used:

- The  $V_{DS}$  (Voltage Drain-to-Source) rating should be at least 5 to 10 V greater than the highest Voltage expected out of either power supply.
- The  $V_{GS}$  (Voltage Gate-to-Source) should be at least 5 V greater than the highest Voltage expected out of either output.
- The  $R_{DS(ON)}$  (Resistance Drain-to-Source) must be considered (cost compared with expected power loss due to typical value) and guaranteed at all output Voltages that can be present from either power supply.

Figure 2. Wireless Rx Power Multiplexing Efficiency (%) vs. Output Power (W)



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## Details of Circuit Operation

### Co-Existence Scenarios:

**Scenario 1:** Charger not connected state (USB = WC = 0 V).

Q1 is off (body diode prevents reverse current flow):  $V_{gate} = V_{source} = 0\text{ V}$ .

Q2 is off (body diode prevents reverse current flow):  $V_{gate} = V_{source} = 0\text{ V}$ .

**NOTE:** System 5V Out should be floating or pulled to GND to satisfy  $V_{source} = 0\text{ V}$  condition.

*Voltages on System 5V Out during Scenario 1 will place Q1 and Q2 on the brink of conduction due to voltage on FET Sources and pull-downs on FET Gates (the FETs will start turning on, but turning on will start turning them off).*

**Scenario 2:** Wireless Charger powering the device state (USB = 0 V, WC = 5 V).

Q1 is on: Gate pulled to ground thru R4.

Q2 is off: Gate pulled up thru R1.

**NOTE:** Q1 body diode starts powering System 5V Out, as voltage increases Q1 saturates via R4 and Q2 is turned off via R1.

**Scenario 3:** USB plugged-in during Wireless Charging (USB = 0  $\rightarrow$  5 V, WC = 5 V  $\rightarrow$  0V).

/Enable is pulled high thru R3/R5, turning off the WC output.

Q2 is initially off, then starts turning on: Gate pulled to GND by R2 as WC shuts down.

Q1 is initially on but turned off when USB is applied: Gate pulled high thru R3.

**NOTE:** When USB is connected, Q1 is saturated and USB 5V source pulls up C3 disabling WC. C3 changes the time-delay to disable after USB insertion. As WC voltage decreases to 0V, System 5V Out, switches from WC to USB via Q1/Q2 body diodes, Q1 is turned off via R3 and Q2 is saturated via R2. C1 and C2 can be used to adjust this transition timing.

**Scenario 4:** USB powering the device state (USB = 5V, WC = 0V).

Q1 is off: Gate pulled up thru R3.

Q2 is on: Gate pulled to ground thru R2.

**NOTE:** Q2 body diode starts powering System 5V Out, as voltage increases Q2 saturates via R2 and Q1 is turned off via R3.

**Scenario 5:** Placed onto WC while USB power is connected state (USB = 5V, WC placed).

Q2 is on: Gate pulled to ground thru R2.

Q1 is off and stays off since /Enable is high via R3/R5.

**Scenario 6:** USB (unplugged) while placed on WC Pad state (USB = 5 V  $\rightarrow$  0V, WC placed).

Q2 is on: Gate pulled to ground thru R2.

Q1 is initially off: Gate pulled high thru R3. WC is disabled off.

When USB power is removed WC becomes Enabled via R4, Q1/Q2 turn off, WC power becomes available upon the next Tx PING, see **Scenario 2**.

## Revision History

Revision Date	Description of Change
January 31, 2017	Application Note 956 Published. US Patent pending, Consult IDT Sales/Marketing for use. V1.0
February 2, 2017	Added Detailed Circuit operation and Scenario table. V1.1



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