P21XXCSR-EVB

P21XX Powerharvester® Chipset Reference Design
Evaluation Board

DESCRIPTION

The P21XXCSR-EVB is an evaluation board featuring PCC110 and PCC210 chips with support for six frequency bands to test and develop with the Powerharvester® Chipset Reference Design. The P21XXCSR converts radio frequency (RF) energy into DC power and stores it in a capacitor to provide an intermittent, regulated voltage output.

Frequency bands supported:

- GSM-850 uplink
- Europe RFID & GSM-850 downlink
- ISM USA & GSM-900 uplink
- GSM-1800 uplink
- GSM-1900 uplink
- WiFi 2.4GHz

ORDERING INFORMATION

The P21XXCSR can be evaluated on the P21XXCSR-EVB evaluation board. Contact Powercast for information about obtaining one of the reference designs on the P21XXCSR-EVB for integration onto your PCB. The chipset is listed under part numbers PCC110 & PCC210. Additional CSR designs are available to support different frequencies and power ranges. Send requests to: contact@powercastco.com.

ITEMS INCLUDED

1 – Evaluation Board for Powerharvester Chipset Reference Designs

Notes

1. This kit requires a user provided antenna. Contact Powercast for custom antenna designs: contact@powercastco.com.
2. This kit needs to receive power from an RF source with sufficient transmit power. Test equipment can be used to test any band. A DC block must be added if the antenna or test equipment is a DC short. Other common sources include:
    - Powercast TX91501 Transmitter
    - RFID readers
    - Cell phones
    - WiFi routers

INSTRUCTIONS

1. Connect an antenna to the SMA connector (J1 – J6) on the evaluation board, or connect J1 – J6 directly to RF test equipment. Exceeding the ratings may cause permanent damage.
2. Select the corresponding band(s) using JP2.
3. Adjust switches S2, S3, and S4 to the desired settings. See the descriptions on the next page.
4. Place the evaluation board on a flat surface and connect test meters as desired.
5. Turn on the source of RF energy (e.g. Powercaster transmitter, test equipment, other transmitter)

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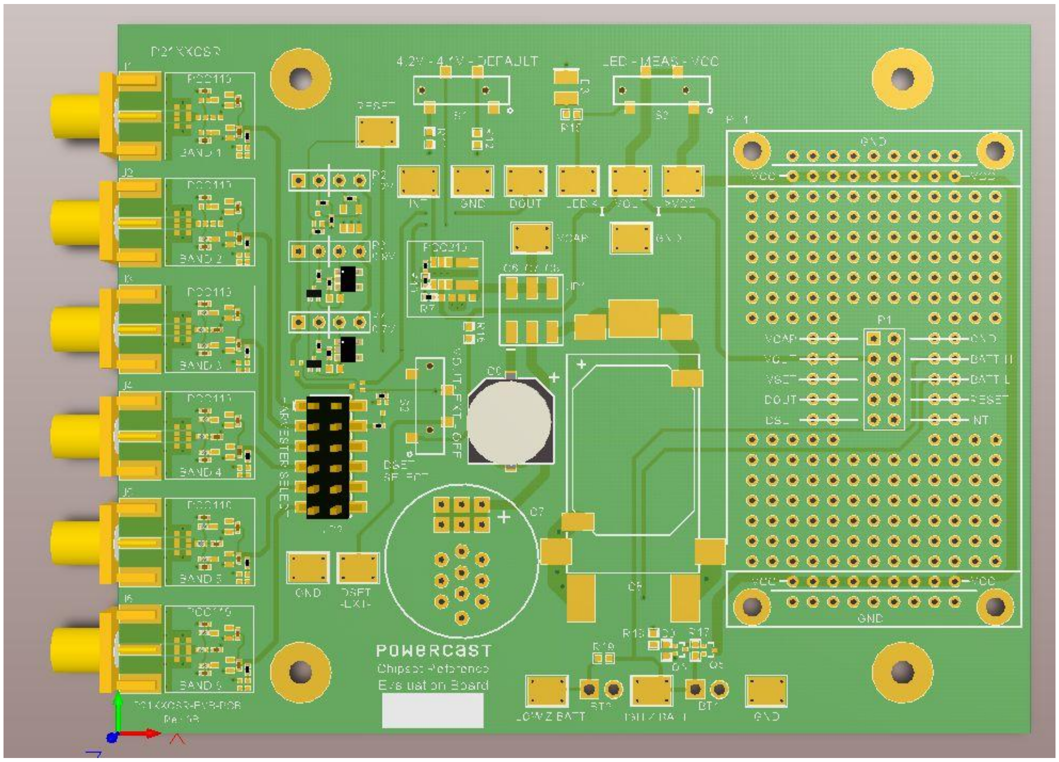
P21XXCSR-EVB EVALUATION BOARD (RENDERING)



ABSOLUTE MAXIMUM RATINGS

T_A = 25°C, unless otherwise noted.

Parameter	Rating	Unit
RF Input Power	23	dBm
RF_{IN} to GND	0	V
D_{SET} to GND	6	V
RESET to GND	6	V
V_{CAP} to GND	2.3	V
V_{OUT} to GND	6	V
VOUT Current	100	mA
Operating Temperature Range	-40 to 85	°C
Storage Temperature Range	-40 to 140	°C

Exceeding the absolute maximum ratings may cause permanent damage to the device.

ESD CAUTION

This is an ESD (electrostatic discharge) sensitive device. Proper ESD precautions should be taken to avoid degradation or damage to the component.

COMPONENT DESCRIPTION

Component	Description
BT1, BT2	External battery connection (described in detail below)
C1	Storage capacitor – 2200µF (small)
C2	Storage capacitor – not populated (user determined)
C3	Storage capacitor – 50mF (large)
C4, Q5, Q6, R17, R18	Output switch (described in detail below)
D3	LED for visual indication of power output
J1	SMA connector for antenna or RF input at 836.5 MHz (add DC block for DC short antenna)
J2	SMA connector for antenna or RF input at 879.5 MHz (add DC block for DC short antenna)
J3	SMA connector for antenna or RF input at 904 MHz (add DC block for DC short antenna)
J4	SMA connector for antenna or RF input at 1747.5 MHz (add DC block for DC short antenna)
J5	SMA connector for antenna or RF input at 1880 MHz (add DC block for DC short antenna)
J6	SMA connector for antenna or RF input at 2450 MHz (add DC block for DC short antenna)
JP1	Jumper for selecting storage capacitor C1, C2, or C3
JP2	Jumper for selecting desired band(s) of RF input
P1	Connector for add-on boards Connector on board: Sullins – P/N: SBH11-PBPC-D05-ST-BK Mating connector: Sullins – P/N: SFH11-PBPC-D05-ST-BK
JP3, JP4, JP5	Jumpers for selecting threshold voltage of boost converter
R1, R2	Resistors for setting V_{OUT} default value (changing these resistors will change the voltage set points of switch S1)
R3, R4	Resistors for adjusting V_{OUT}, selectable using S1
R5	LED bias resistor
R6	Resistor for pulling D_{SET} high using V_{OUT}, selectable using S2
R7	Resistor for limiting current to low impedance batteries
S1	Switch for selecting output voltage (described in detail below)
S2	Switch for D_{SET} selection (described in detail below)
S3	Switch for selecting V_{OUT} load (described in detail below)

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P21XX Powerharvester® Chipset Reference Design Evaluation Board

SPECIFICATIONS

T_A = 25°C, V_{OUT} = 3.3V, RF_{IN} = 0dBm, unless otherwise noted.

Parameter	Symbol	Condition	Min	Typ	Max	Unit
RF Characteristics[1]						
Input Power (836.5 MHz)	RF_{IN}		-15		15	dBm
Input Power (879.5 MHz)	RF_{IN}		-15		15	dBm
Input Power (904 MHz)	RF_{IN}		-15		15	dBm
Input Power (1747.5 MHz)	RF_{IN}		-13		15	dBm
Input Power (1880 MHz)	RF_{IN}		-12		15	dBm
Input Power (2450 MHz)	RF_{IN}		-12		15	dBm
DC Characteristics						
Output Voltage	V_{OUT}		2.0	3.3	5.5	V
Output Current	I_{OUT}				50	mA
V_{CAP} Maximum (1.2V setting)	V_{MAX}			1.25		V
V_{CAP} Minimum (1.2V setting)	V_{MIN}			1.02		V
V_{CAP} Maximum (0.9V setting)	V_{MAX}			0.945		V
V_{CAP} Minimum (0.9V setting)	V_{MIN}[2]			0.9		V
V_{CAP} Maximum (0.7V setting)	V_{MAX}			0.738		V
V_{CAP} Minimum (0.7V setting)	V_{MIN}[2]			0.64		V
Boost Efficiency		I_{OUT} = 20mA		85		%
Maximum INT Current				0.1		mA
Digital Characteristics						
RESET Input High				1		V
D_{SET} Input High			1.8			V
INT Output High			V_{MIN}[3]		V_{MAX}	V
Timing Characteristics						
D_{SET} Delay				50		µs
RESET Delay				6.6		µs
RESET Pulse Width			20			ns
1.2V INT & V_{OUT} On-time				33.7[4]		ms
0.9V INT & V_{OUT} On-time				12.6[4]		ms
0.7V INT & V_{OUT} On-time				9.4[4]		ms

[1]See typical performance graphs for operation at other frequencies or power levels. Minimum value is dependent on the JP3, JP4, or JP5 selection.
[2]Based on the on-board RC values
[3]Approximately equal to V_{MAX} for 0.9V and 0.7V settings
[4]Into on-board LED

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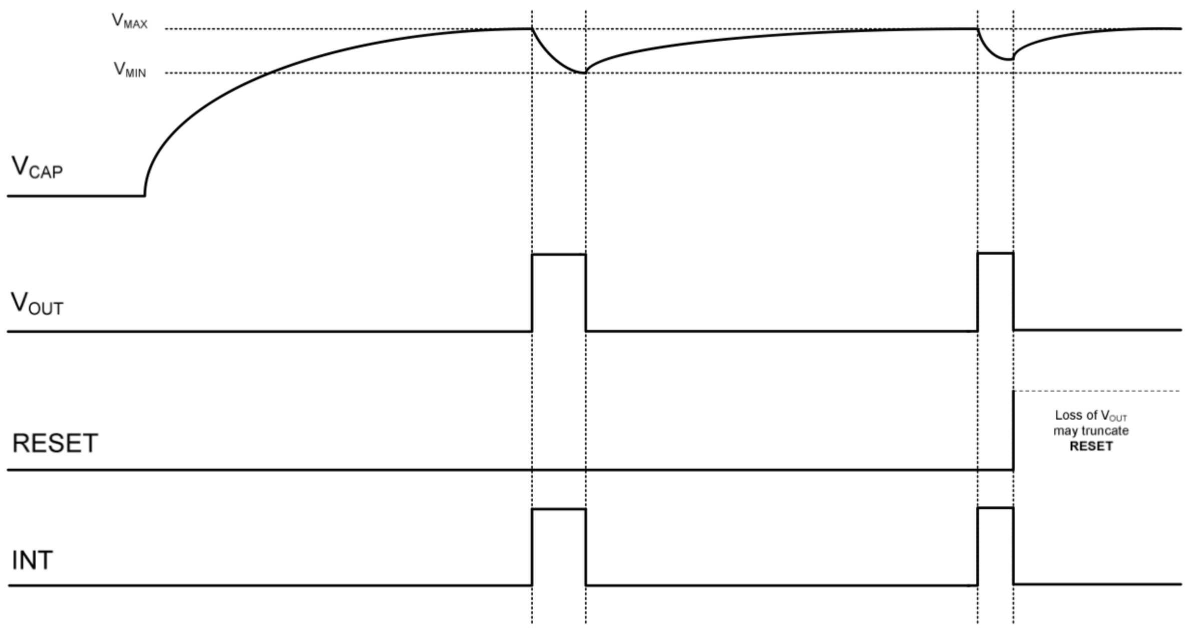
TIMING DIAGRAM



DETAILED COMPONENT DESCRIPTIONS AND OPERATING INSTRUCTIONS

Selecting RF Band

JP2 is used to select the desired band(s) of RF signal to be harvested by the system. There are six different bands, each with a corresponding SMA connector for attaching an antenna (J1-J6).

Component	Band	Band (MHz)	Center Frequency (MHz)
J1	GSM-850 uplink	824 – 849	836.5
J2	Europe RFID & GSM-850 downlink	865 – 894	879.5
J3	ISM USA & GSM-900 uplink	925 – 960	904
J4	GSM-1800 uplink	1710 – 1785	1747.5
J5	GSM-1900 uplink	1850 – 1910	1880
J6	WiFi 2.4GHz	2400 – 2500	2450

Selecting Storage Capacitor

JP1 is used to select the storage capacitor used in the system. C1 is a 2200uF electrolytic capacitor. C2 is left unpopulated but is a universal footprint so that a user can add a different capacitor to the board. C3 is a 50mF super capacitor with low ESR.

Typical Operation

The harvester circuit converts RF energy within the appropriate frequency band into DC power. This is monitored by one of three voltage detectors. The user selects 1.2V, 0.9V or 0.7V as the threshold voltage via JP3, JP4 or JP5 respectively. The storage capacitor, selected via JP1, then charges up to the selected threshold voltage. When V_{CAP} reaches its maximum value (V_{MAX}), INT is set high, the boost converter turns on, and V_{OUT} is set to the output voltage selected via S1. The storage capacitor then discharges until V_{CAP} reaches its minimum value (V_{MIN}) and then sets INT low, shutting off the boost converter until V_{CAP} charges back up to its maximum value.

RSSI Operation (D_{OUT}, D_{SET})

The RSSI functionality allows the sampling of the received signal to provide an indication of the amount of energy being harvested. When D_{SET} is driven high the harvested DC power will be directed to a resistor, and the corresponding voltage will be provided to D_{OUT}. The voltage on D_{OUT} can be read after a 50µs settling time. When the RSSI functionality is being used, the harvested DC power is not being stored. If the RSSI functionality is not used, D_{OUT} and D_{SET} should be left unconnected. D_{SET} has an on-board pull down.

Reset (RESET)

The RESET function allows the voltage from V_{OUT} to be turned off before the storage capacitor reaches the lower threshold, V_{MIN}, thereby saving energy and improving the recharge time back to the activation threshold, V_{MAX}. The RESET function can be implemented by a microcontroller. When the function of the microcontroller is completed, driving RESET high will disable the voltage from V_{OUT}. Care should be taken to ensure that the microcontroller, especially during power-on, does not inadvertently drive RESET high. This will immediately shutdown the output voltage. If the RESET functionality is not used, RESET should be left unconnected.

Interrupt (INT)

The interrupt function provides a digital indication that voltage is present at the V_{OUT} pin. INT can be used in more sophisticated systems that contain other storage elements and can be used as an external interrupt to bring a device such as microcontroller out of a deep sleep mode. The digital high level of the INT pin will be between V_{MIN} and V_{MAX}. The INT pin can provide a maximum of 0.1mA of current. If the INT functionality is not used, INT should be left unconnected.

Selecting Turn-On Voltage

JP3, JP4 and JP5 are used to select the capacitor voltage at which the boost converter will turn on. Each is a four pin header, and the two two-pin jumpers are moved to the header corresponding to the desired threshold voltage. JP3 sets the threshold to 1.2 V, JP4 sets the threshold to 0.9 V, and JP5 sets the threshold to 0.7 V.

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Selecting/Setting Output Voltage

S1 is used to select between three output voltage options for V_{OUT}. Selecting DEFAULT sets V_{OUT} to 3.3V. Selecting 4.1V or 4.2V changes V_{OUT} to the labeled voltage. The DEFAULT setting can also be adjusted to any voltage between 2.0V and 5.5V simply by changing the resistors R1 and R2 and using the DEFAULT switch postion. The equation for determining R1 and R2 is as follows:

$$R2 = \frac{R1}{\left(\frac{V_{OUT}}{1.21} - 1\right)}$$

It is recommended that a 1MΩ be used for R1, which is connected between V_{OUT} and V_{SET}. With this in mind, some common values for V_{OUT} would result in the following R2 values:

For V_{OUT} = 3.3V, R2 = 578.9kΩ (576kΩ std)
For V_{OUT} = 4.1V, R2 = 418.7kΩ (417kΩ std)
For V_{OUT} = 4.2V, R2 = 404.7kΩ (407kΩ std)

It should be noted that changing R1 or R2 will change the voltage set by switch S1. Care should be taken to ensure the absolute maximum voltage is not exceeded.

Selecting D_{SET}

S2 is used to select how D_{SET} and D_{OUT} function on the board. Selecting OFF will allow the P21XXCSR-EVB to operate normally. If it is desired to monitor D_{OUT}, selecting V_{OUT} will tie D_{SET} to V_{OUT} through a resistor, R6. In this mode, when V_{OUT} is on, D_{SET} will be pulled high and D_{OUT} can be used to measure RSSI or to retrieve data from the RF field. Selecting D_{SET} EXT will allow D_{SET} to be controlled externally using the DSET EXT test point.

LED, Prototyping, and Measuring Current

S3 is used to control flow of current from V_{OUT}. Selecting LED will tie V_{OUT} to the on-board LED, D3, to be a visual indicator that the system working. Selecting VCC will tie V_{OUT} to the prototype area and output switch. NOTE: V_{OUT} is routed to the header P1 in parallel with S3, so V_{OUT} is present on the header pins regardless of S3 position. If using the P1 header, S3 should be in the MEAS position, as the other positions could use more power, resulting in longer charging periods on the storage cap.

Selecting MEAS allows for current to be measure by connected a current probe between test points V_{OUT} and LED or V_{OUT} and VCC. Current should be measured using an oscilloscope, as the time period of V_{OUT} being on is generally too short to be seen on a multi-meter.

Output Switch and Batteries

With S3 in the VCC position, the output switch is activated. The output switch includes C4, Q5, Q6, R17 and R18, and is necessary when using the P21XXCSR-EVB to charge a battery. The switch limits the current draw on the battery from the P21XXCSR-EVB to 10-20nA. This ensures the P21XXCSR-EVB does not discharge the battery during periods of non-harvesting.

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BT1 is a connection point used for charging a high impedance storage element (cell resistance >25 ohms) such as thin-film batteries or super capacitors. The cell impedance of these types of batteries will limit the current drawn from the P21XXCSR-EVB.

BT2 is a connection point used for charging a low impedance battery such as Li-ion or Alkaline rechargeable. Resistor R7 is in series with this connection to limit current flow between the output switch and the battery.

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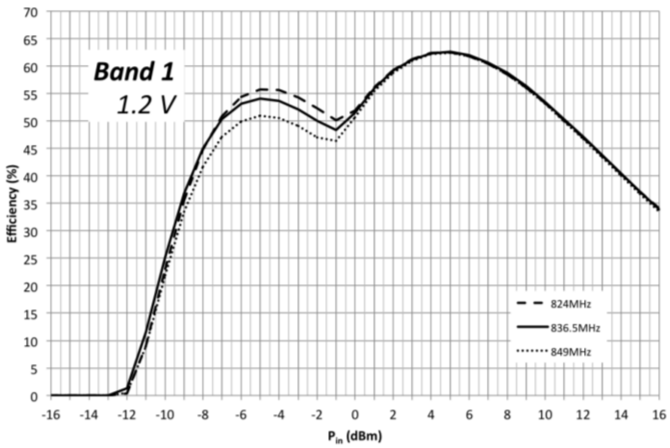
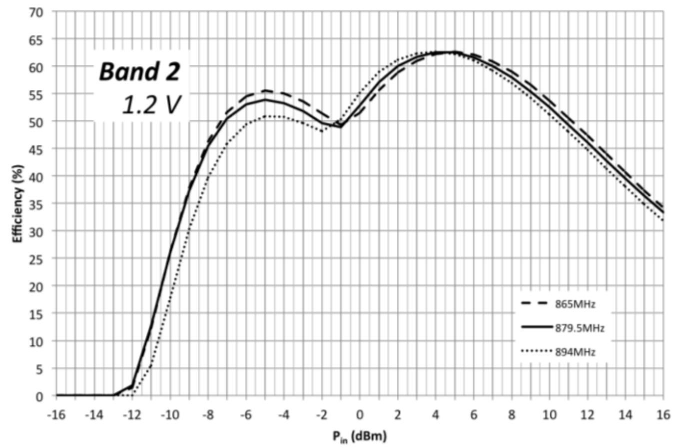
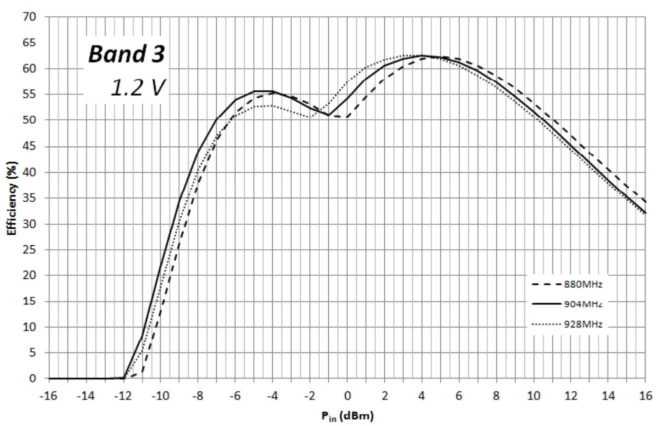
TYPICAL PERFORMANCE GRAPHS

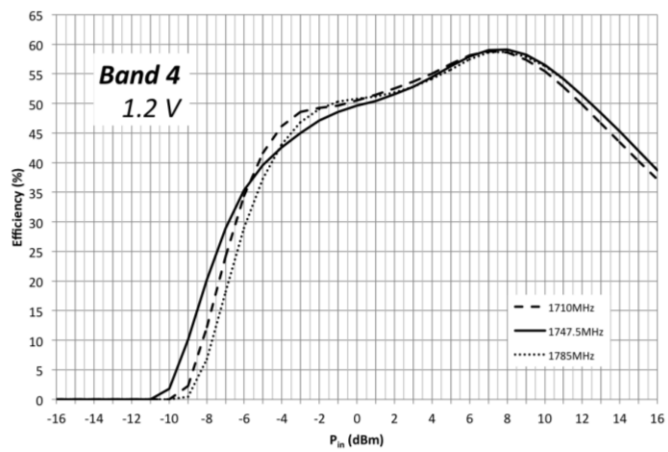
T_A = 25°C, No jumper on JP2, Keithley 2400 Sourcemeter as load, unless otherwise noted

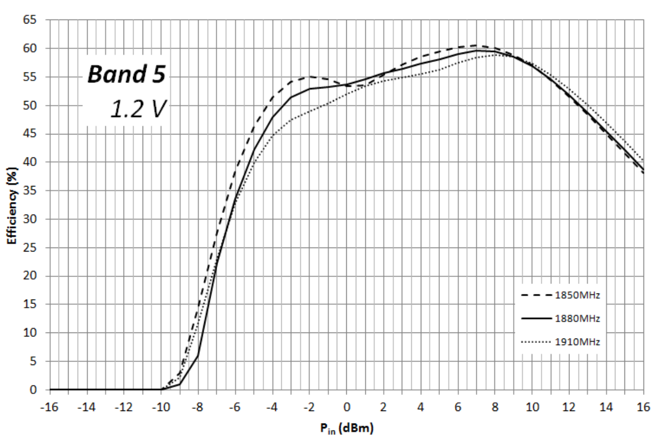
Powerharvester Efficiency vs. RF_{IN} (dBm)

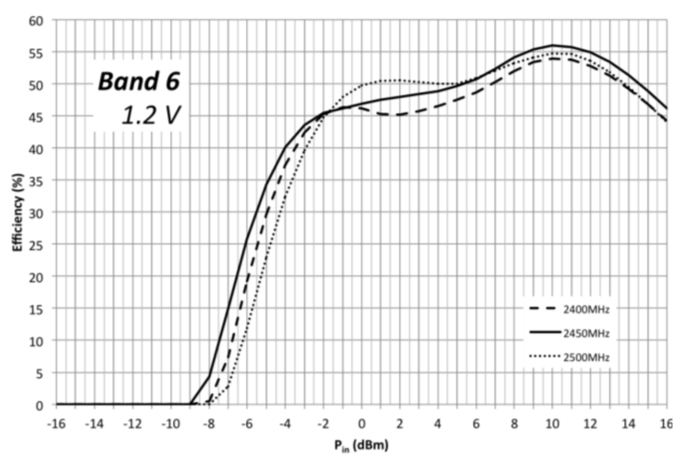


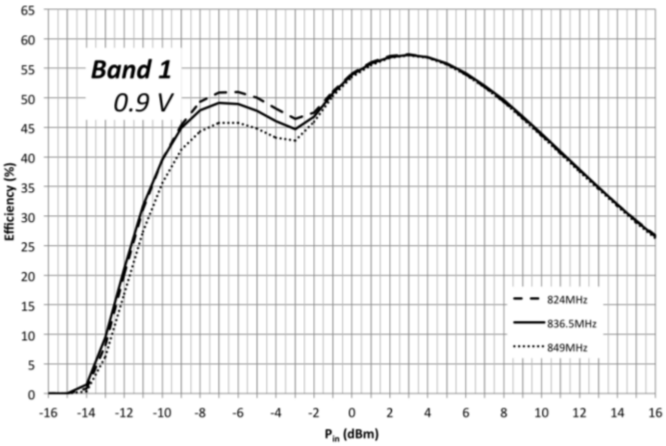




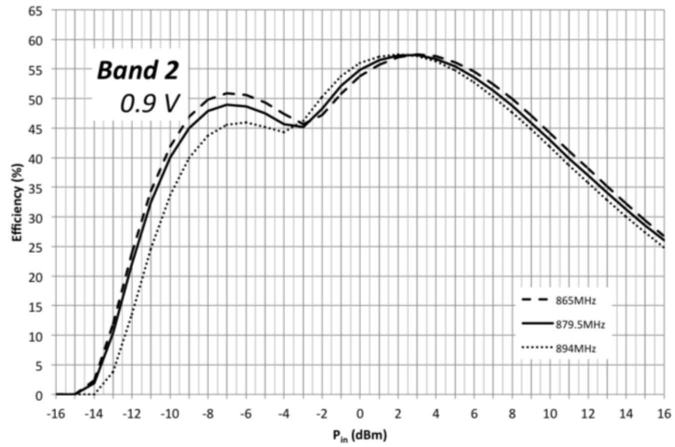




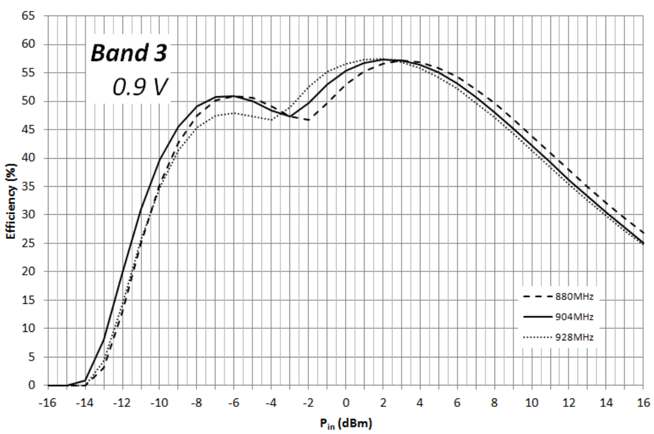




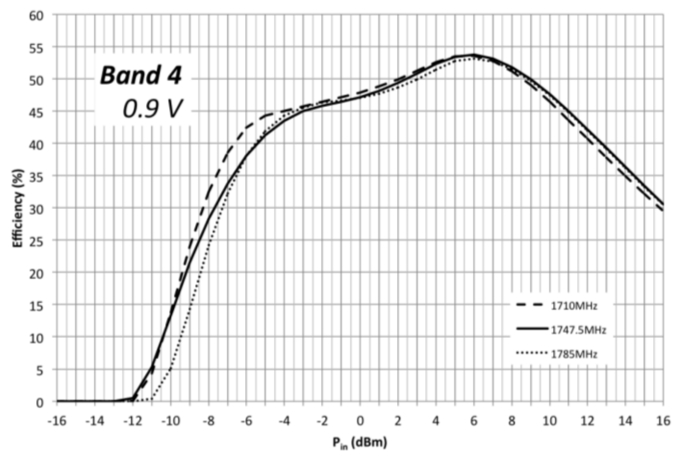
Band 1
0.9 V
Efficiency (%)
P_{in} (dBm)
824MHz
836.5MHz
849MHz



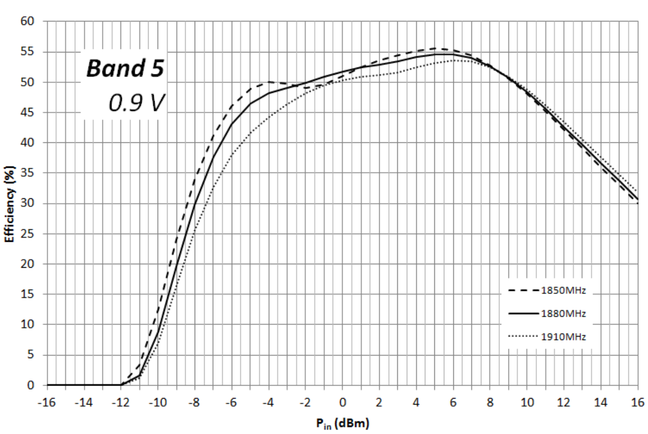
Band 2
0.9 V
Efficiency (%)
P_{in} (dBm)
865MHz
879.5MHz
894MHz



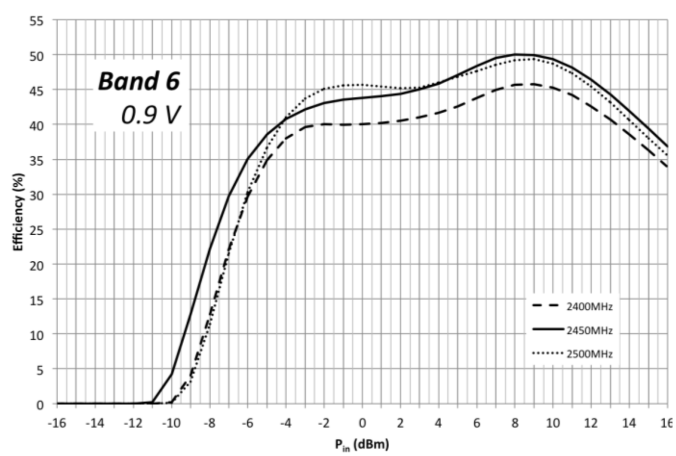
Band 3
0.9 V
Efficiency (%)
P_{in} (dBm)
880MHz
904MHz
928MHz



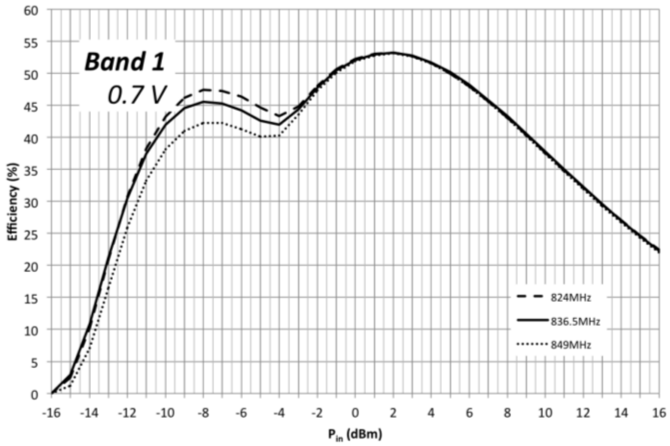
Band 4
0.9 V
Efficiency (%)
P_{in} (dBm)
1710MHz
1747.5MHz
1785MHz

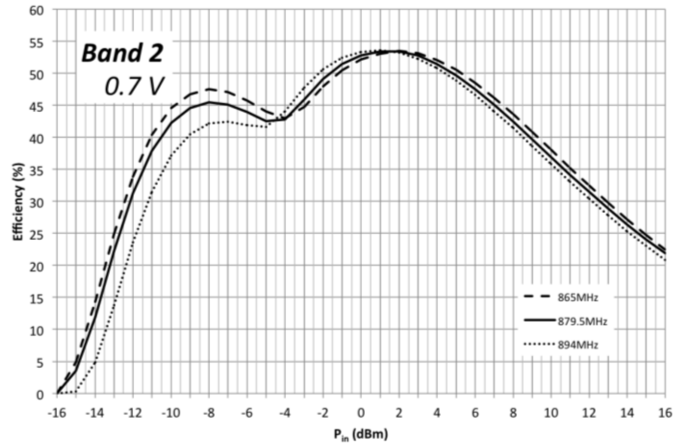


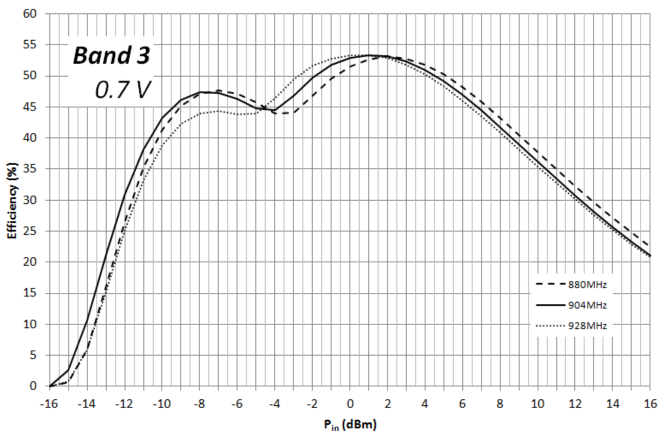
Band 5
0.9 V
Efficiency (%)
P_{in} (dBm)
1850MHz
1880MHz
1910MHz

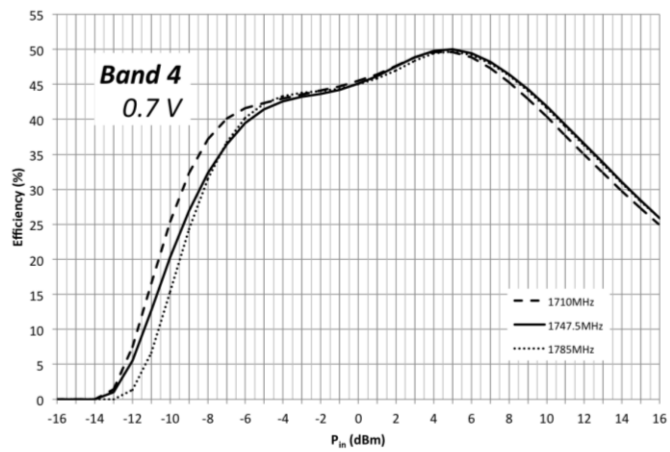


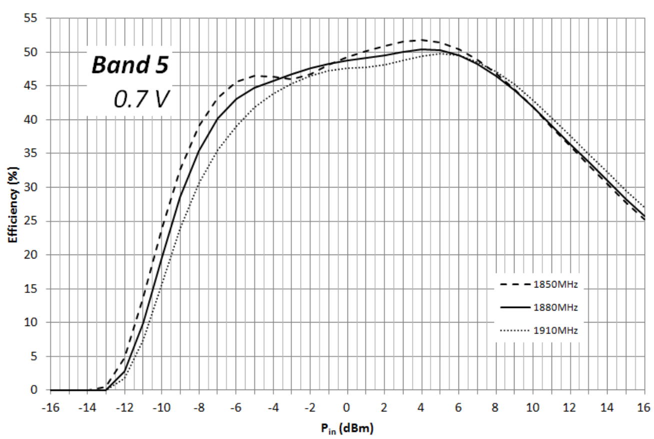
Band 6
0.9 V
Efficiency (%)
P_{in} (dBm)
2400MHz
2450MHz
2500MHz


Band 1
0.7 V
Efficiency (%)
P_in (dBm)
824MHz
836.5MHz
849MHz


Band 2
0.7 V
Efficiency (%)
P_in (dBm)
865MHz
879.5MHz
894MHz


Band 3
0.7 V
Efficiency (%)
P_in (dBm)
880MHz
904MHz
928MHz


Band 4
0.7 V
Efficiency (%)
P_in (dBm)
1710MHz
1747.5MHz
1785MHz


Band 5
0.7 V
Efficiency (%)
P_in (dBm)
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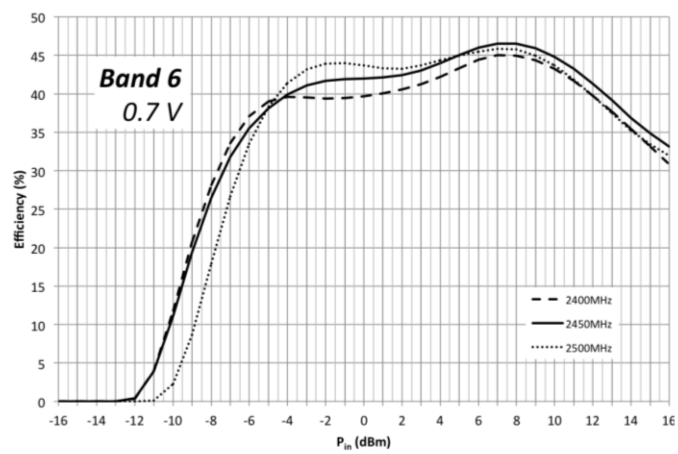
1880MHz
1910MHz


Band 6
0.7 V
Efficiency (%)
P_in (dBm)
2400MHz
2450MHz
2500MHz