R900DCTM 915 MHz Direct-Conversion Transceiver Module

Introduction

The Rockwell R900DCTM 915 MHz Direct-Conversion Transceiver Module is a complete transmitter and receiver that provides all of the necessary baseband-to-RF and RF-to-baseband signal conversion functions for 902–928 MHz digital communications. Compact form factor (3 in × 1¾ in) and low voltage requirement (3.0–5.0 V), plus lightweight, coated plastic shields make the R900DCTM ideal for portable, battery-powered wireless products. Figure 1 shows a typical system application for a Digital Cordless Telephone (DCT).

The R900DCTM is optimized for time division duplex (TDD) operation. The architecture is comprised of a quadrature down-converter with variable gain amplifier for receive, a binary phase shift keyed (BPSK) modulator and power amplifier for transmit, and a phase-locked loop (PLL) frequency synthesizer for local oscillator (LO) generation. The R900DCTM utilizes the Rockwell RF101 RF Transmitter (Data Sheet Order No. W111) and RF100 Direct-Conversion Receiver (Data Sheet Order No. W112).

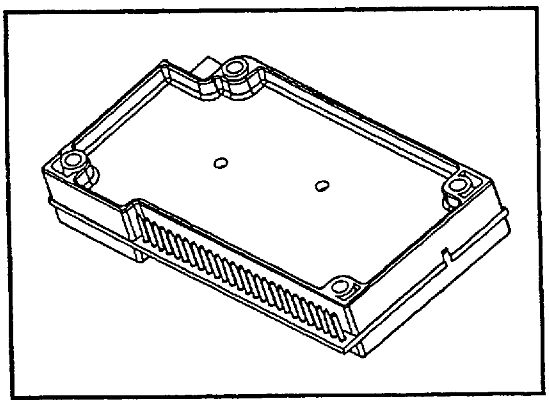
The baseband interface of the R900DCTM provides a clean connection to the baseband modem and controller for receive and transmit data and control. R900DCTM power management controls enter via the baseband interface. The RF interface is configured for matching at the antenna port. The single-supply power interface is designed for direct battery connection.

No radio tuning, other than matching the customer-selected antenna, is required.

The R900DCTM is a complete RF transceiver solution targeted to the cost, size and performance needs of voice and data communications at 902–928 MHz. For a DCT application, Rockwell's Direct-Sequence Spread Spectrum (DSSS) baseband device set (RDSSS9M), plus a few miscellaneous peripherals (keypad, LEDs, microphone, crystals, etc.) are all that is needed to produce a complete DSSS DCT system.

Features

- 902–928 MHz RF operating range.
- Conforms to FCC Part 15 requirements.
- Fast switching half-duplex architecture for time-division duplexing.
- Direct-conversion differential BPSK (DBPSK) transmit modulator.
- High-, medium- and low-power transmitter output levels.
- Direct conversion receiver with I/Q baseband outputs.
- Receiver AGC.
- Low Noise Figure: 9 dB typical.
- Large Dynamic Range: 90 dB.
- Frequency-agile UHF synthesizer with serial programming interface.
- Single supply voltage: 3.0–5.0 V.
- Small-dimension module:
  - 3.00 in × 1.75 in × 0.617 in (with shields).



R900DCTM Direct-Conversion Transceiver Module

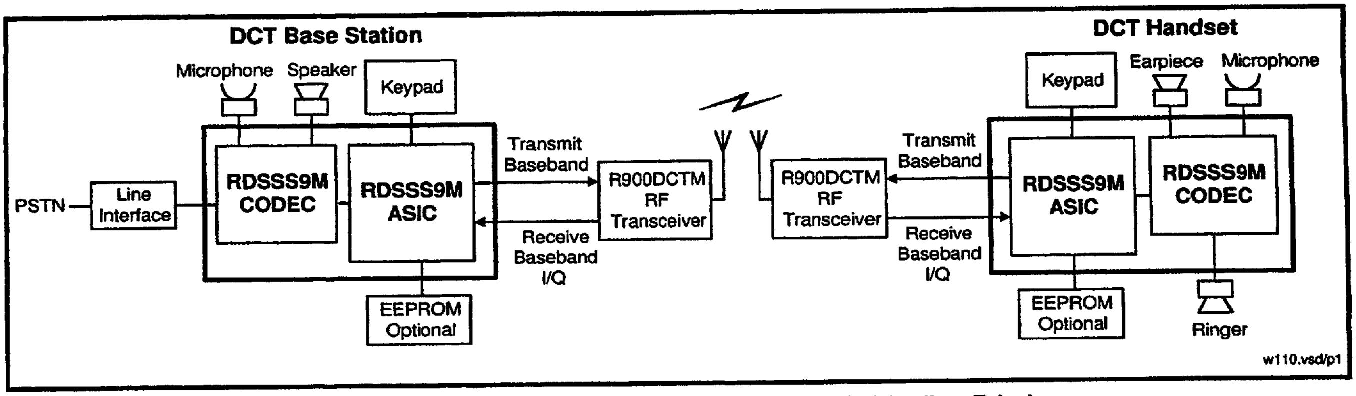


Figure 1. Typical System Application Block Diagram – Digital Cordless Telephone

Technical Description

The R900DCTM 915 MHz Direct Conversion Transceiver Module functional block diagram is shown in Figure 2. Performance characteristics, grouped by function type, are listed in Table 4.

Transmit Path

The TXDATA baseband digital data input signal is filtered and up-converted to RF by the DBPSK modulator.

High, medium, or low PA output power levels are selectable via the TXPWR control lines (2).

The PA output is lowpass filtered to remove harmonics, then routed through the transmit/receive (T/R) switch before exiting the module at the ANTENNA port.

Receive Path

From the ANTENNA port, the RF signal passes through the T/R switch, and the RF bandpass filter. Filtering before the low noise amplifier (LNA) attenuates signals outside the 902–928 MHz band.

The LNA provides two gain levels for coarse automatic gain control (AGC), which are selected via the LNAATTN control. Down-conversion to quadrature baseband signals is done using a matched pair of mixers and a 90° phase splitter for the LO.

The quadrature baseband signals are lowpass and highpass filtered to attenuate out-of-channel signals and remove low-frequency (down to DC) energy component.

A matched pair of variable gain amplifiers (VGA) provide fine AGC. The differential in-phase and quadrature baseband signals are DC-coupled to the RXIP, RXIN, RXQP and RXQN outputs, respectively.

Frequency Synthesizer

The RF LO is generated by a programmable phase-locked loop (PLL) frequency synthesizer. Synthesizer performance parameters are determined by the on-module loop filter and voltage-controlled oscillator (VCO) circuits, the external reference oscillator, and the frequency synthesizer programming. The loop filter and VCO designs are optimized for the Rockwell DCT application.

Power Management

Independent power-up/power-down control of the transmit path, receive path, and frequency synthesizer is provided by the TXEN, RXEN and SYNEN controls, respectively. When all of the functions are powered down, current drain (i.e., standby current) from the voltage supply (VBATT) is 3 mA max.

Shieldings

The coated plastic shields completely shield the transceiver module. The interior of the shields has several compartments that isolate the transmitter, receiver and synthesizer from one another. The cavity design of the bottom outer wall allows the RF module to seat on top of the baseband circuit and provides shielding for the baseband circuit as well.

Table 1. Channel Number and Frequency for 1.2 MHz Channel Spacing Using the Rockwell RDSSS9M Baseband Device Set*

Channel Number	Channel Center Frequency (MHz)	Channel Number	Channel Center Frequency (MHz)
1	903.6	11	915.6
2	904.8	12	916.8
3	906.0	13	918.0
4	907.2	14	919.2
5	908.4	15	920.4
6	909.6	16	921.6
7	910.8	17	922.8
8	912.0	18	924.0
9	913.2	19	925.2
10	914.4	20	926.4

* The synthesizer can be programmed in 200 KHz increments between 902 and 928 MHz.

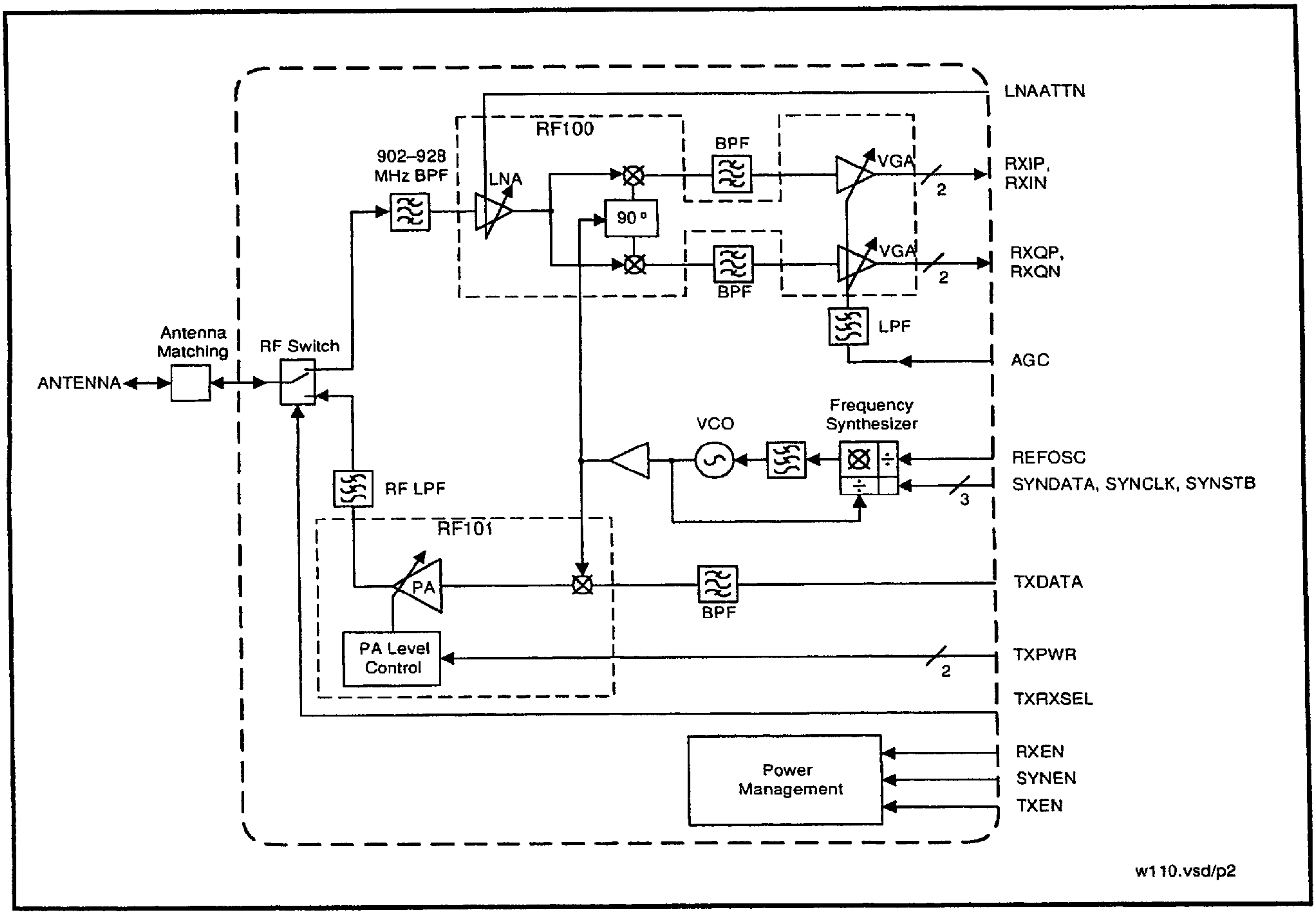


Figure 2. R900DCTM Functional Block Diagram

INTERFACE SPECIFICATIONS

The RF Modem interface defined herein is the interface to the Baseband Modem. The RF Modem interface signals are summarized in Table 5.

Digital Signals

All digital signals are CMOS levels (GND / VBATT) with a maximum current of 2 mA, except where specified.

TXRXSEL **(Transmit / Receive Select)**

This control bit toggles the RF T/R switch between the transmit and receive paths. A "1" selects the transmit path.

TXEN **(Transmit Enable)**

This active high control bit enables bias power to the transmitter circuitry.

RXEN **(Receive Enable)**

This active high control bit enables bias power to the receiver circuitry.

SYNEN **(Synthesizer Enable)**

This active high control bit enables bias power to the synthesizer circuitry.

TXPWR1, TXPWR0 **(PA Transmit Power)**

These two control bits select the PA output power according to the decoded values given in Table 2.

Table 2. TXPWR Control Word and PA Transmit Power

TXPWR0	TXPWR1	PA Transmit Power
0	0	High
0	1	Medium
1	0	Low
1	1	Undefined

LNAATTN **(LNA Attenuator)**

This control bit toggles the LNA gain between the low gain state and the high gain state. A "1" selects the low gain state of the LNA, i.e. attenuator on.

SYNCLK **(Synthesizer Programming Clock)**

This control signal, which is the programming clock signal, provides one wire of the 3-wire serial bus that programs the synthesizer. The default wave form logic and timing emulates the programming clock for a Fujitsu 1501 synthesizer or its equivalent.

SYNDATA **(Synthesizer Programming Data)**

This control signal, which is the programming data signal, provides one wire of the 3-wire serial bus that programs the synthesizer. The default wave form logic and timing emulates the programming data for a Fujitsu 1501 synthesizer or its equivalent.

SYNSTB **(Synthesizer Programming Strobe)**

This control signal, which is the programming strobe signal, provides one wire of the 3-wire serial bus that programs the synthesizer. The default wave form logic and timing emulates the programming strobe for a Fujitsu 1501 synthesizer or its equivalent.

Analog Signals

TXDATA **(Transmit Data)**

The TXDATA line takes a single-ended signal generated by the Baseband Modem. The data signal shall be a non-CMOS binary waveform with voltage levels of 0 V and 1.2 V. The load is 2.5 KΩ from DC to greater than 1 MHz.

RXIP **(Received In-Phase Signal, Positive),**
RXIN **(Received In-Phase Signal, Negative)**

This data signal pair from the RF Modem is the differential baseband 960 Kbps NRZ in-phase received data.

The signal is differentially driven with a maximum peak voltage of 0.25 ± 0.1 V (differential output level is 0.5 ± 0.2 V) within the AGC operating range. The common mode voltage is subject to the I/Q DC offset specification. The DC load impedance exceeds 100 KΩ. The filtered signal bandwidth is less than 1 MHz.

RXQP **(Received Quadrature Signal, Positive),**
RXQN **(Received Quadrature Signal, Negative)**

This data signal pair from the RF Modem is the differential baseband 960 Kbps NRZ quadrature received data.

The signal is differentially driven with a maximum peak voltage of 0.25 ± 0.1 V (differential output level is 0.5 ± 0.2 V) within the AGC operating range. The common mode voltage is subject to the I/Q DC offset specification. The DC load impedance exceeds 100 KΩ. The filtered signal bandwidth is less than 1 MHz.

AGC **(Auto Gain Control)**

This analog control signal from the Baseband Modem adjusts the gain of the baseband variable gain amplifiers in the RF Modem. An increase in the AGC voltage causes decreased gain (greater attenuation) in the baseband variable gain amplifiers.

The voltage range of this signal is 1.1 – 2.0 V into the RF Modem's load impedance of greater than 10 KΩ.

REFOSC **(Reference Oscillator)**

This clock signal from the Baseband Modem provides the frequency reference for the synthesizer. It should be a CMOS-level NRZ square-wave. If a 4.8 MHz reference signal is supplied and the Rockwell RDSSS9M chip set is used, the channel spacing will be 1.2 MHz. Table 1 shows the frequency and channel number for 1.2 MHz channel spacing using the Rockwell RDSSS9M chip set.

Power Supply Terminals

VBATT **(Positive Voltage Terminal)**

This is the power supply positive terminal for the RF Modem. The voltage range with respect to the ground terminal is +3.0 to +5.0 V.

GND **(Ground Voltage Terminal)**

This is the power supply ground terminal for the RF Modem. The voltage is 0.0 V.

Antenna Port

J2

This is the antenna port that transmits and receives RF signals. A proper matching circuit to the customer-selected antenna is necessary. Three additional component footprints are printed on the PCB for the customer's convenience.

Figure 3 shows a typical antenna matching circuit for a half-wavelength antenna.

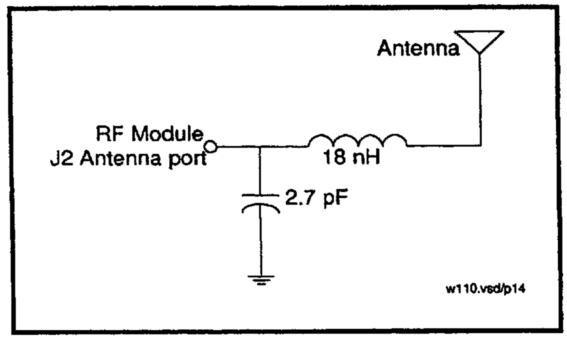


Figure 3. Typical Antenna Matching Circuit for a Half-Wavelength Antenna

RF Modem Control Timing

Figure 4 and Figure 5 show the timing relationship of TXRX, TXEN, RXEN and the baseband transmit signal (TXDATA) and received signals (RXI, RXQ). Table 3 lists the timing parameters.

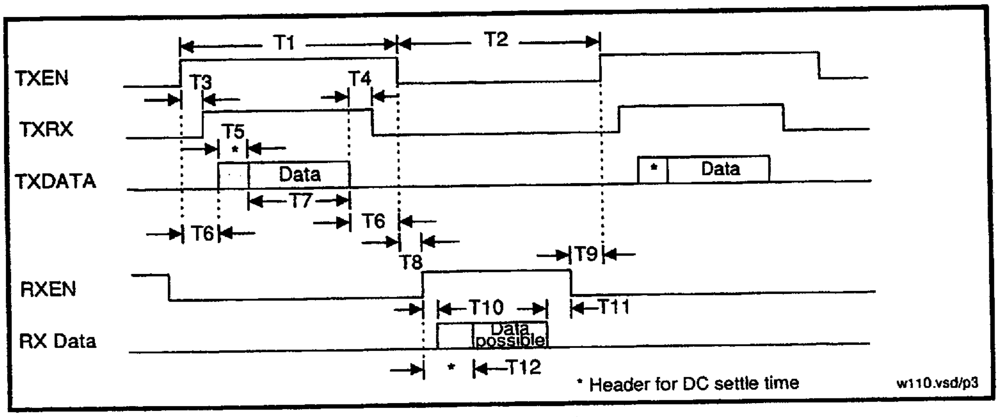


Figure 4. RF Timing Diagram

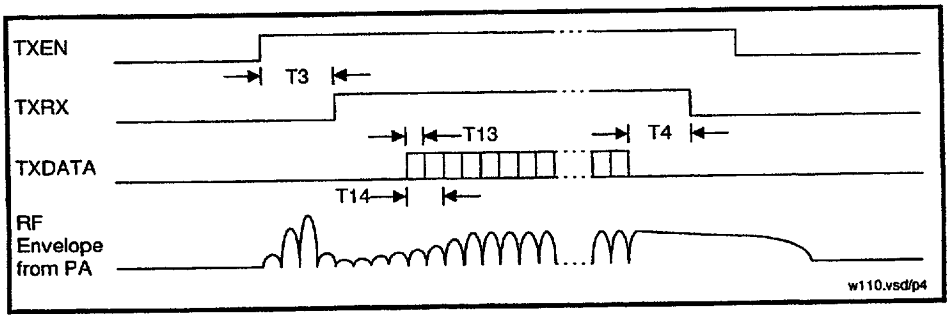


Figure 5. RF Envelope Timing Diagram

Table 3. RF Modem Timing Parameters

Name	Description	Value
T1	TXEN-On Time	1.975 ms
T2	TXEN-Off Time	2.025 ms
T3	TXEN-On to TXRX-On	8.3 μs
T4	Data-Off to TXRX-Off	8.3 μs
T5	DC Settling Time	23 × 12.5 μs
T6	TXEN-On to Data-On and Data-Off to TXEN-Off	12.5 μs
T7	Data Frame Time	133 × 12.5 μs
T8	TXEN-Off to RXEN-On	12.5 μs
T9	RXEN-Off to TXEN-On	> 0 μs
T10	RXEN-On to Expected RX Data	≥ 12.5 μs
T11	RX Data-Off to RXEN-Off	12.5 μs
T12	RXEN-On to RX Data DC and Gain Settle	< 300 μs
T13	Chip Time	1.041 μs (1/960 KHz)
T14	TX Settling	< 300 μs*

* T12 includes settling of TX data from other transmitter (T13). Total settling must occur during settle bit header in RX data stream.

Table 4. Performance Characteristics

Parameter	Condition[1]		Min	Typ	Max	Unit
General						
RF Frequency Range Baseband Frequency Range LO Frequency Range				902 – 928 30 – 700 903.6 – 926.4		MHz KHz MHz
T/R Switch Time					10	µsec
Transmit Path						
Peak Output Power	50 Ω load, VBATT = 3.6 V					
	TXPWR0	TXPWR1				
High Medium Low	0 0 1	0 1 0		19 7 –1		dBm dBm dBm
Emission on Adjacent channel (For 1.2 MHz channel spacing)				Refer to plot in Figure 6.		
Output Power Flatness			–1.5		1.5	dB
Harmonic Output	Output Power = High				–40	dBm
Modulator LO Suppression			–15	–25	–40	dBc
Baseband Lowpass Filter Bandwidth	3 dB			700		KHz
Baseband Highpass Filter Bandwidth	3 dB			20		KHz
LO Reradiation					–44	dBm
Receive Path						
RF Filter Passband	3 dB			902 – 928		MHz
Frequency Flatness			–1.5		1.5	dB
Noise Figure	Maximum Gain			9		dB
Minimum Received Signal	BER = 10^{-3}				–104	dBm
Maximum Received Signal					–15	dBm
Baseband Gain Control Range (VGA)				66		dB
LNA Gain-State Difference				22		dB
Input 3rd-Order Intercept Point	Minimum Gain Maximum Gain		–9 –15	–6 –12		dBm dBm
LO Reradiation					–44	dBm
I / Q Gain Imbalance[2] Gain Imbalance Tracking[3] Phase Imbalance[4]				0.5 0.5 ±2	3 2 ±5	dB dB degrees
Baseband Lowpass Filter Cutoff Rejection at 3.6 MHz	3 dB			700 60		KHz dB
Baseband Highpass Filter Cutoff	3 dB			27		KHz
Frequency Synthesizer						
Tuning Range				902 – 928		MHz
Reference Frequency				4.8		MHz
Channel Spacing	REFOSC = 4.8 MHz			1200		KHz
Settling Time	Δf = 10 MHz, settle to f_{FINAL} ±1KHz				2	msec
Phase Noise	30 KHz carrier offset			–95	–85	dBc/Hz
RMS Phase Jitter	30 – 700 KHz				5	degrees rms
Power Consumption						
RX Mode High Gain Low Gain				90 90		mA mA
TX Mode Low Power Medium Power High Power				95 115 220		mA mA mA
Sleep Mode					3	mA

Notes:
1. Unless otherwise noted: VBATT = 3.6 V; T_A = 25°C; TXDATA = 1.2 V square wave
2. Maximum imbalance anywhere in AGC dynamic range.
3. Maximum gain imbalance delta over AGC dynamic range.
4. In 100 – 500 KHz band.

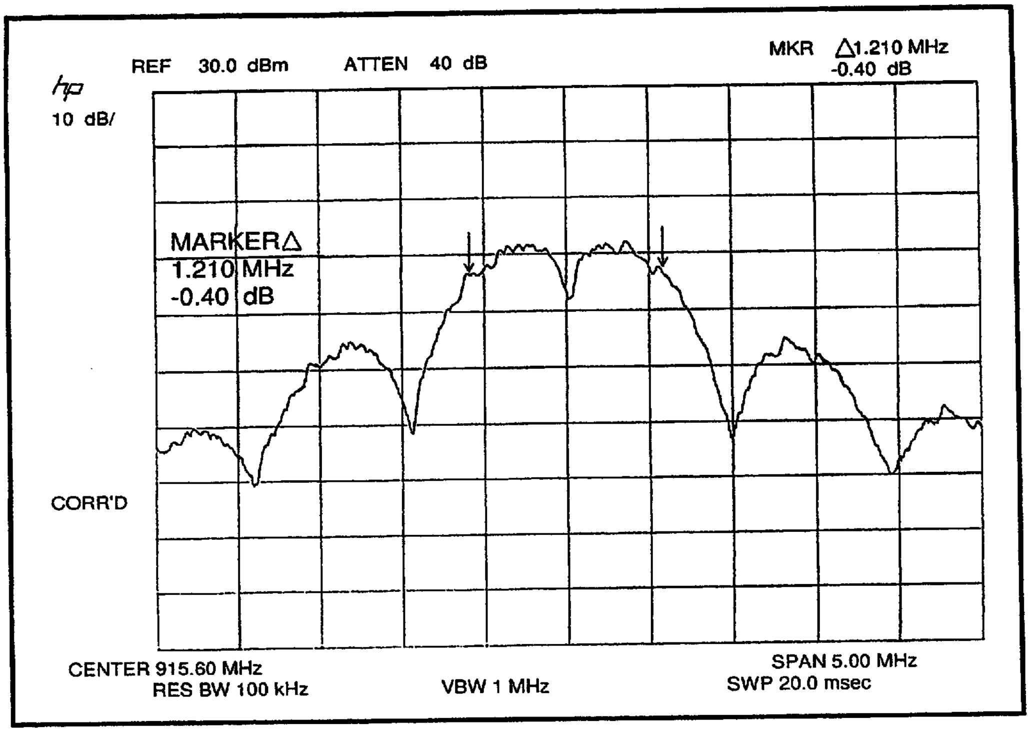


Figure 6. Typical Transmitter Output Spectrum

Test Conditions: TxD level: 1.2 V_{P-P}
High Power Mode
VBATT: 3.6 V

Interface Description

The R900DCTM interface signal diagram is shown in Figure 7, and the corresponding interface signals are described by functional group in Table 5.

The signal pinout diagram for the R900DCTM is shown in Figure 8. Absolute maximum ratings are given in Table 6.

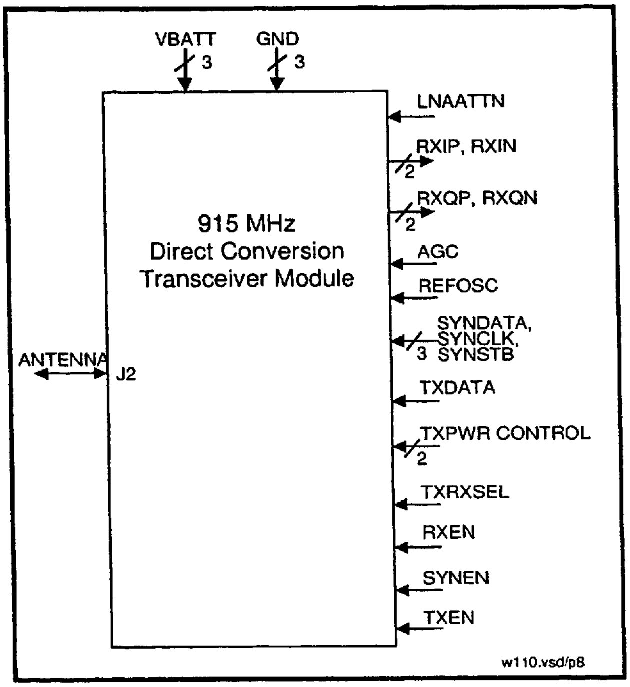


Figure 7. R900DCTM Interface Signal Diagram

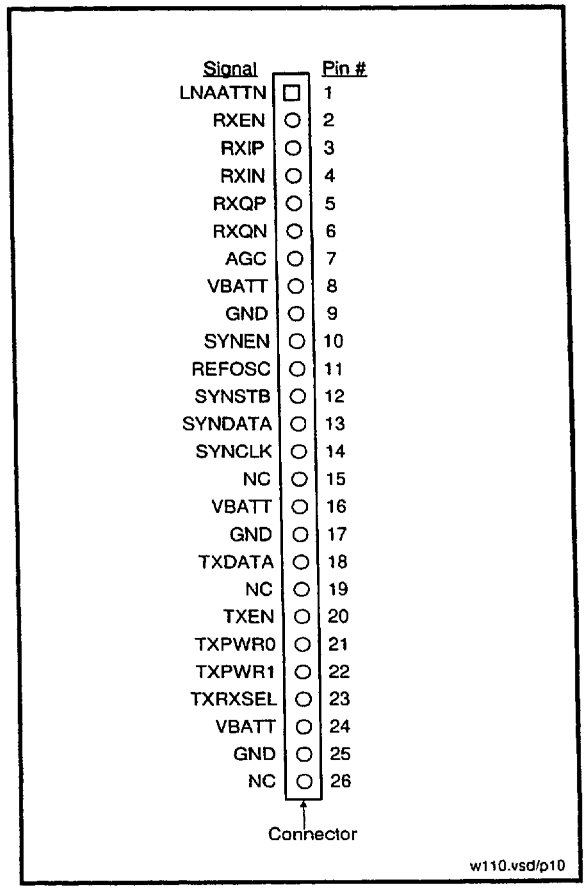


Figure 8. DCT Radio Module Connector Pin-Out Diagram

Table 5. Interface Signal Descriptions

Pin	Pin Name	Signal Type[1]	Function	Comments
Baseband Interface				
1	LNAATTN	I-D	LNA gain-state select	1: Low gain 0: High gain
4 3	RXIP RXIN	O-A O-A	Differential in-phase baseband signal	RXIP: positive RXIN: negative
6 5	RXQP RXQN	O-A O-A	Differential quadrature baseband signal	RXQP: positive RXQN: negative
7	AGC	I-A	Automatic Gain control voltage for baseband VGA	1.1 – 2 V
11	REFOSC	I-A	Frequency reference signal for frequency synthesizer	4.8 MHz
13	SYNDATA	I-D	Synthesizer programming serial data	Serial bus specification
14	SYNCLK	I-D	Synthesizer programming clock	Serial bus specification
12	SYNSTB	I-D	Synthesizer programming strobe	Serial bus specification
18	TXDATA	I-A	Single-ended baseband transmit signal	960 Kbps NRZ
21 22	TXPWR1 TXPWR0	I-D I-D	PA output power control bit PA output power control bit	00: High output power 01: Medium output power 10: Low power 11: Undefined
23	TXRXSEL	I-D	T/R switch control	1: Tx selected 0: Rx selected
2	RXEN	I-D	Receive enable	1: Rx powered 0: Rx off
10	SYNEN	I-D	Synthesizer enable	1: Synthesizer powered 0: Synthesizer off
20	TXEN	I-D	Transmit enable	1: Tx powered 0: Tx off
RF Interface				
J2	ANTENNA	I/O-A	Antenna port	Antenna impedance match at port for 2 antenna types (i.e. base station and handset)
Power Supply				
8, 16, 24	VBATT	S	Positive voltage supply	3.0 – 5.0 V
9, 17, 25	GND	S	Common ground	0.0 V
Other				
15, 19, 26	NC	–	No connect	

Notes:
1. Signal Type Description:
   - I-D Input - Digital
   - I-A Input - Analog
   - O-A Output - Analog
   - I/O-A Bidirectional - Analog
   - S Supply

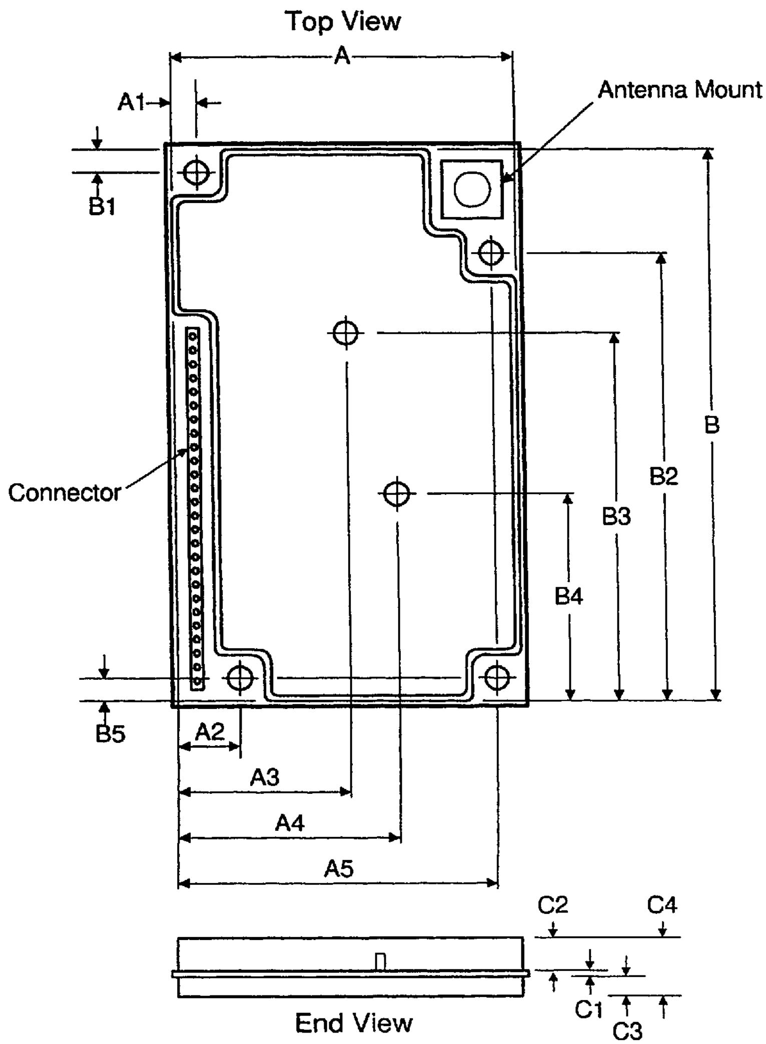
Table 6. Absolute Maximum Ratings – Non-operating

Parameter	Symbol	Limits	Units
Supply Voltage[1]	VBATT	0 to +5.0	V
Input Voltage[1]	V_{IN}	0 to +5.0	V
Operating Temperature Range	T_A	0 to +70	°C
Storage Temperature Range	T_{STG}	–65 to +150	°C
Relative Humidity	H_{REL}	Up to 90% noncondensing, or a wet bulb temperature of up to 35 °C, whichever is less.	–

Notes:
1. Voltages are referenced to ground (GND).

Module Dimensions

R900DCTM module dimensions are shown in Figure 9.



Dim.	Inches	Millimeters*
A	1.730	43.94
B	2.980	75.69
A1	0.187	4.75
A2	0.285	7.24
A3	0.865	21.97
A5	1.543	39.19
B1	0.187	4.75
B2	2.430	61.72
B3	1.985	50.42
B4	1.175	29.85
B5	0.187	4.75
C1	0.062	1.57
C2	0.340	8.64
C3	0.215	5.46
C4	0.617	15.67

* Metric values (mm) are converted from English values (inches) and may contain round-off errors.

w110.vsd/p9

Figure 9. R900DCTM Module Dimensions