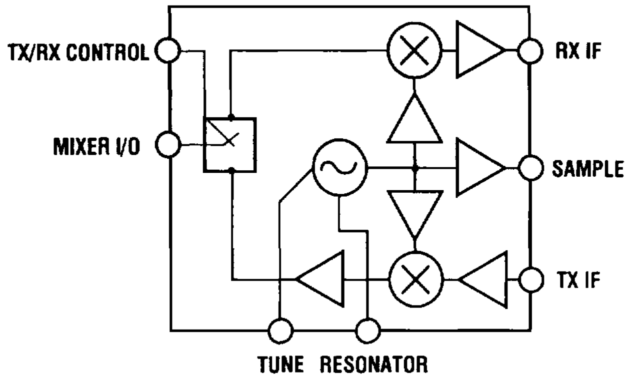
TQ9206

2.4 - 2.5 GHz Up/ Downconverter



The TQ9206 is a monolithic transmit/receive up/downconverter function designed specifically for operation in the 2.4 - 2.5 GHz bands. The transmit function consists of an I.F. amplifier, a balanced upconvert mixer, and a driver amplifier. The receive function is realized with a single-ended downconvert mixer and an I.F. amplifier. The TQ9206 also incorporates an on-chip low-side VCO capable of providing an I.F. frequency range of 200 to 400 MHz. A buffered VCO output permits the TQ9206 to be connected directly to the divider input of a PLL synthesizer. An integrated T/R switch at the mixer I/O port enables a simple, one-path connection to a single bandpass filter. Transmit or receive mode is selected by a CMOS-compatible T/R control pin. When used in conjunction with the TQ9205 power management circuitry, only one mode is active and powered at a time. A power down mode of <1 mA is also possible with TQ9205 power management. The small-sized SSOP24 plastic package is ideal for low-cost, reduced-board-space applications such as PCMCIA cards. The monolithic, internally matched design of the TQ9206 reduces development time, cost, and level of RF expertise required to acheive a high-value 2.4 GHz RF subsystem solution.

Electrical Specifications

Test Conditions: V_{DD} = 5V, T_A = 25 °C, RF = 2442 MHz, IF = 200 MHz

Parameter(1)	Min	Typ	Max	Units
Rx Noise Figure		14	16	dB
Rx Conversion Gain	-1.5	1		dB
Rx Output 3rd Order Intercept(2)		+13		dBm
Rx Supply Current		45	60	mA
Tx Conversion Gain	16	19		dB
Tx 3dB Compression Point(3)	6	9.5		dBm
Tx Supply Current		110	150	mA
Supply Voltage	4.5	5.0	5.5	V

Notes: 1. Min/max values listed are 100% production-tested.
2. Frequency separation of the two signals is 1 MHz.
3. Effectively saturated power output.

Features

- Single supply operation
- Integrated upconvert/ downconvert function
- Single RF port
- On-chip tunable oscillator
- Buffered LO output
- Digital T/R control
- 24-pin SSOP package compatible with PCMCIA card formats

Applications

- General ISM-Band spread-spectrum wireless data communications
- Wireless Local Area Networks
- Portable Data Terminals
- Remote Monitoring

Electrical Specifications

Test Conditions: T_A = 25 °C, V_{DD} = +5 V, RF = 2.442 GHz, IF = 200 MHz, unless otherwise specified

Receive Mode (TX/$\overline{RX}$ = LOW)

Parameter	Conditions	Min	Typ	Max	Units
Conversion Gain		-1.5	1		dB
Noise Figure			14	16	dB
Output 3rd Order Intercept	1 MHz frequency separation		+13		dBm
Input Return Loss	MXR I/O = input	15	20		dB
Output Impedance	RX IF = output		150		Ω
RF Frequency		2400		2500	MHz

Transmit Mode (TX/$\overline{RX}$ = HIGH)

Parameter	Conditions	Min	Typ	Max	Units
Conversion Gain		16	19		dB
Output 3dB Compression		6	9.5		dBm
Input Return Loss	TX IF = input	15	25		dB
Output Return Loss	MXR I/O = output	15	25		dB

Oscillator

Parameter	Conditions	Min	Typ	Max	Units
Center Frequency Range (1)		2000		2400	MHz
Tuning Voltage Range		0.5		5	V
Tuning Frequency Range			100		MHz
Phase Noise (2)	100 KHz offset, LO = 2150 MHz		-90		dBc/Hz
LO Sample Output Level	LO = 2150 MHz	-7	-5		dBm

TX/$\overline{RX}$ and Power Down Interfaces

Parameter	Conditions	Min	Typ	Max	Units
Input Logic HIGH		2.4			V
Input Logic LOW				0.7	V
Input Current	Input HIGH or LOW		10		μA

Power Supply

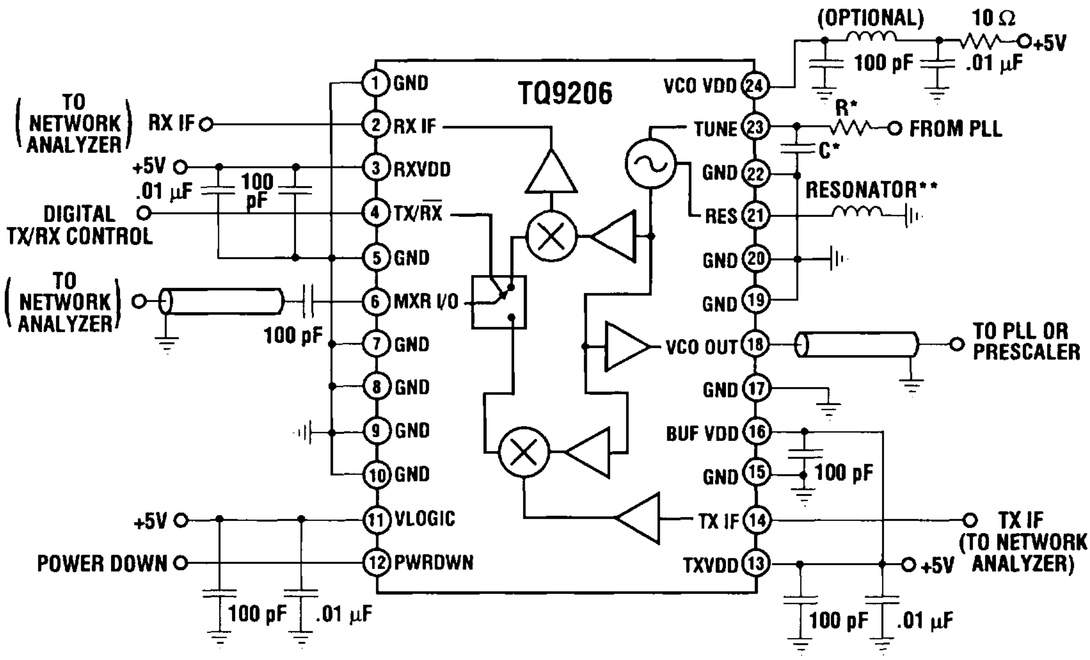
Parameter	Conditions	Min	Typ	Max	Units
Positive Supply Voltage		4.5	5.0	5.5	V
Receive Mode Current	TX/$\overline{RX}$ = LOW		45	60	mA
Transmit Mode Current	TX/$\overline{RX}$ = HIGH		110	150	mA
Power Down Mode Current	TX/$\overline{RX}$ = HIGH, PWRDWN = HIGH, VLOGIC = 5 V, VCOVDD = 5 V (3)		1		mA

Note: 1. 100 MHz tuning range, center frequency determined by external resonator.
2. External coaxial resonator.
3. RXVDD, TXVDD, BUFVDD = 0 V.

T/R Switch and Sleep Mode Control Specification

Mode	Control Signals	
Transmitter Section Active	TX/$\overline{\text{RX}}$ = HIGH	Power Down = LOW
Receiver Section Active	TX/$\overline{\text{RX}}$ = LOW	Power Down = LOW
Power Down Active	TX/$\overline{\text{RX}}$ = HIGH or LOW	Power Down = HIGH

Test Circuit

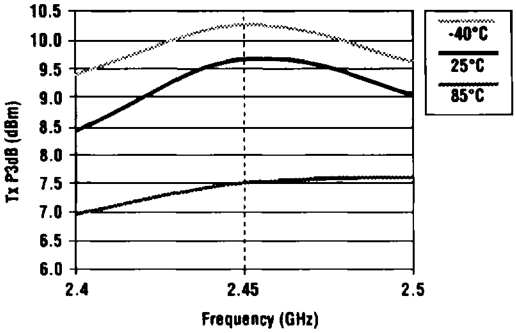


* Note: High-frequency filtering, beyond the loop filter bandwidth.

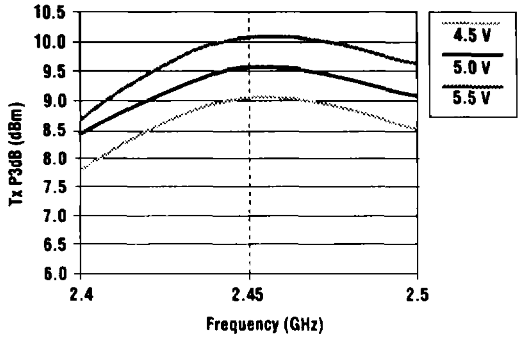
** Resonator is a printed microstrip or coaxial line. (See text for a discussion of length.)

Typical Performance

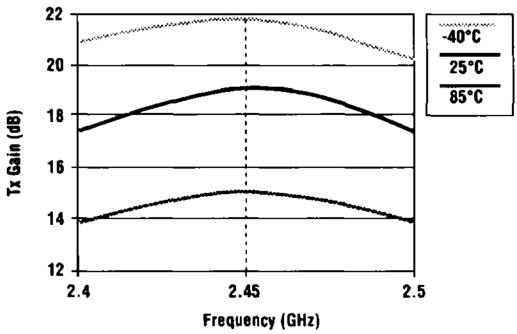
TX P_{3dB} vs. Frequency vs. Temp. (V_{DD} = 5 VDC)



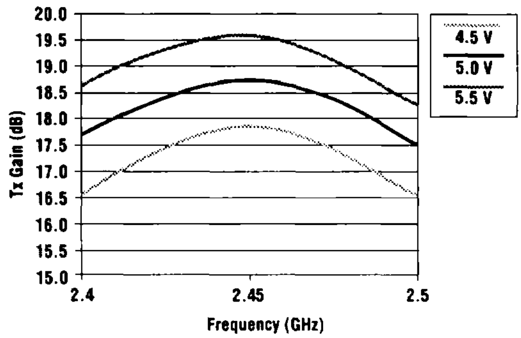
TX P_{3dB} vs. Frequency vs. V_{DD} (T = 25 °C)



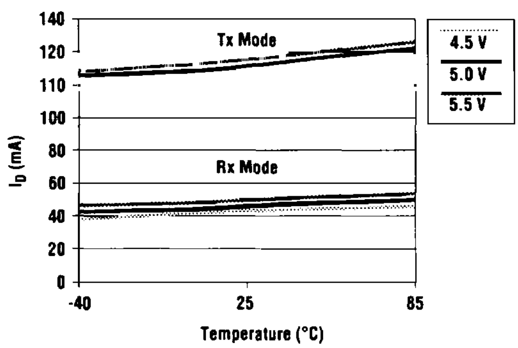
TX Gain vs. Frequency vs. Temp. (V_{DD} = 5 VDC)



TX Gain vs. Frequency vs. V_{DD} (T = 25 °C)

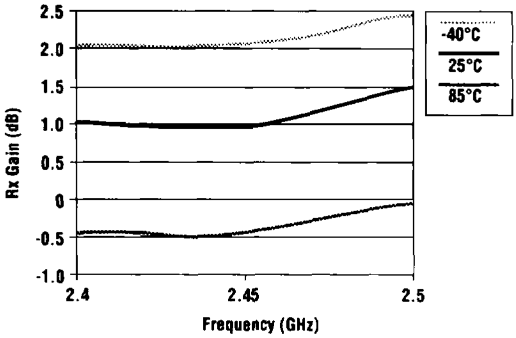


Total Supply Current vs. Temperature

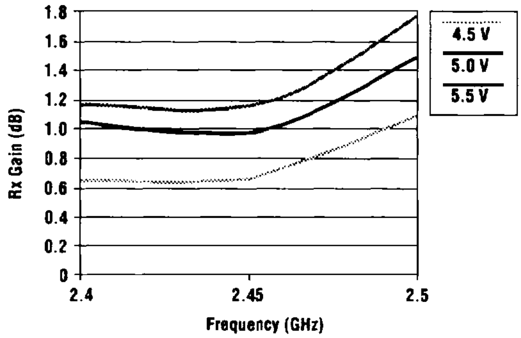


Typical Performance

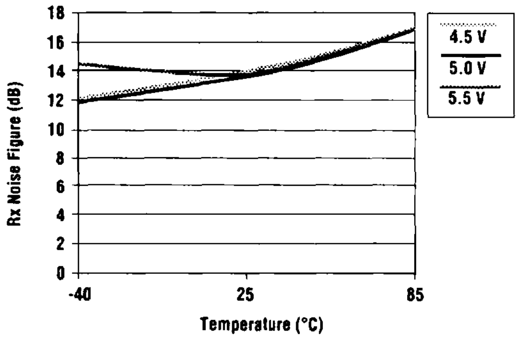
RX Gain vs. Frequency vs. Temp. (V_{DD} = 5 VDC)



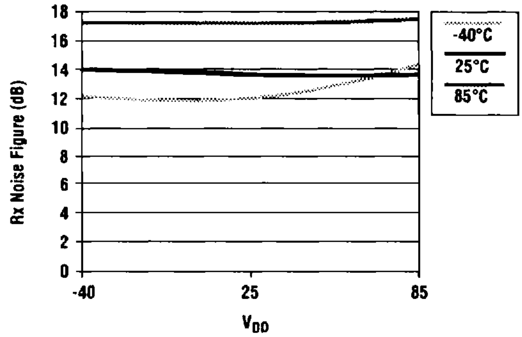
RX Gain vs. Frequency vs. V_{DD} (T = 25 °C)



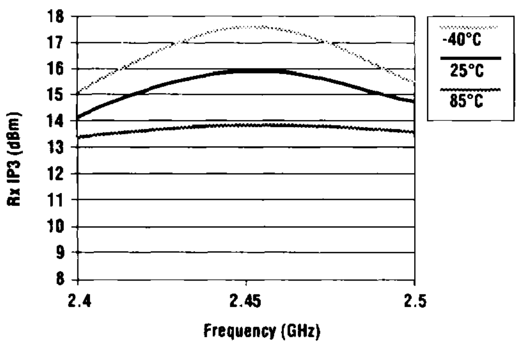
RX Noise Figure vs. Temperature vs. V_{DD}



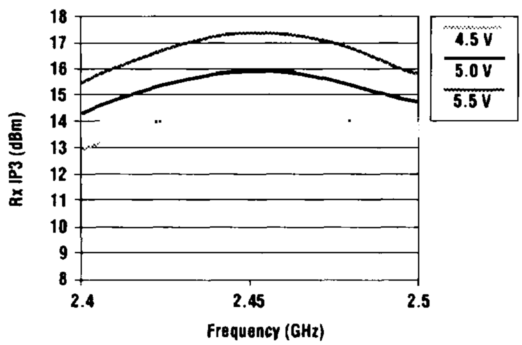
RX Noise Figure vs. V_{DD} vs. Temperature



RX Input IP3 vs. Frequency vs. Temperature



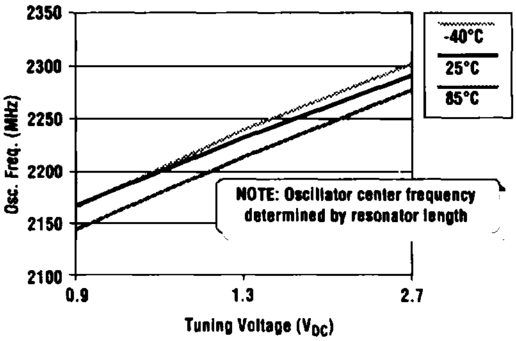
RX Input IP3 vs. Frequency vs. V_{DD}



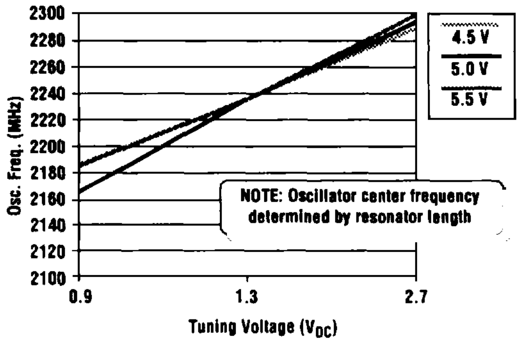
ICs

Typical Performance

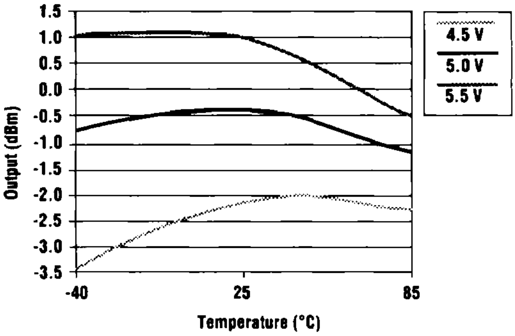
Osc. Frequency vs. Tuning Voltage vs. Temp.



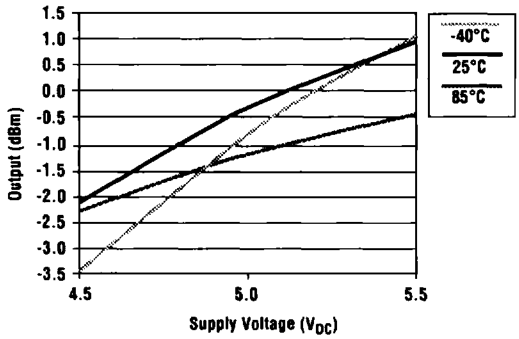
Osc. Frequency vs. Tuning Voltage vs. V_{DD}



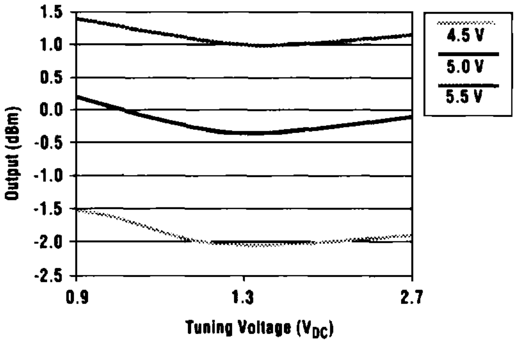
Osc. Buffer Output vs. Temperature at Center Frequency



Osc. Buffer Power Output vs. V_{DD} at Center Frequency

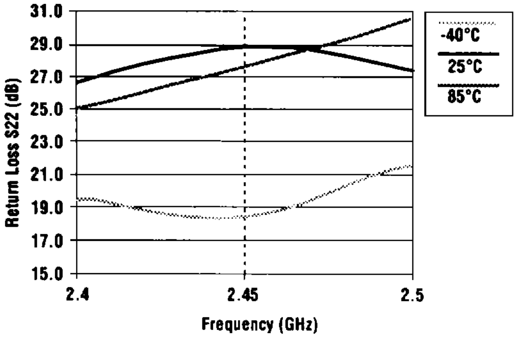


Osc. Buffer Output vs. Tuning Voltage (T = 25 °C)

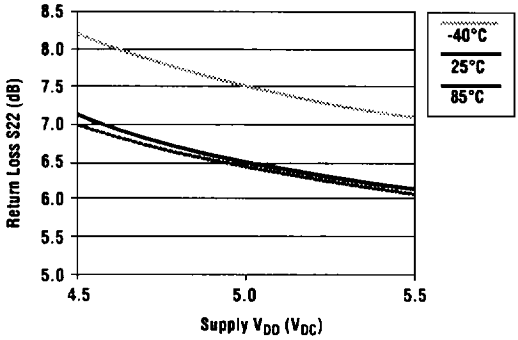


Typical Performance

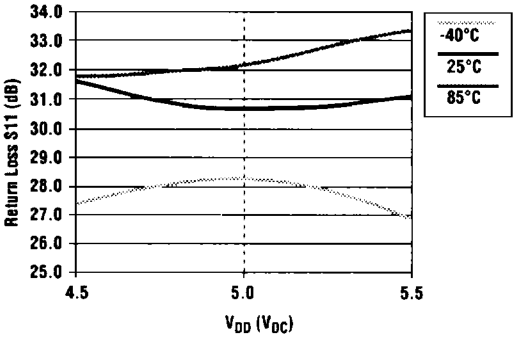
TX Output Return Loss vs. Frequency



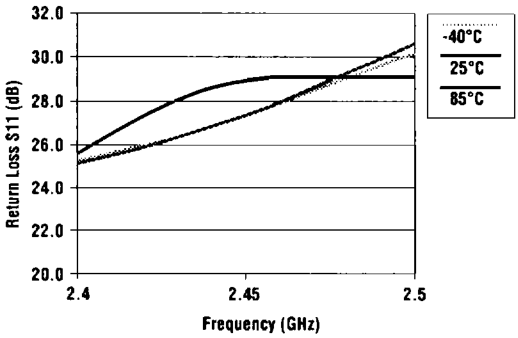
RX Output IF Return Loss



TX IF Input Return Loss vs. V_{DD} (200 MHz IF)



RX Input Return Loss vs. Freq. (V_{DD} = 5 VDC)



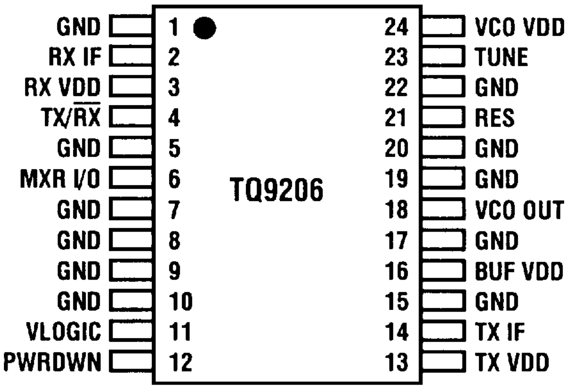
ICs

Pin Descriptions

Pin Name	Pin #	Description
RX IF	2	Receiver IF output. Nominal 150 Ω impedance. DC-blocked.
RXVDD	3	Supply voltage for receive circuitry. Local bypass cap. required. Permits power management.
TX/$\overline{RX}$	4	Transmit/Receive control line. CMOS logic-compatible.
MXR I/O	6	Transmit output and receive input. 50 Ω interface to filter or TQ9205. Not DC-blocked. External blocking cap required.
VLOGIC	11	Supply voltage for T/R switch and power down. Local bypass cap. required. Always ON.
PWRDWN	12	Power down control line. Active HIGH.
TXVDD	13	Supply voltage for transmit circuitry. Local bypass cap. required.
TX IF	14	Transmit IF input. 50 Ω interface. DC-blocked.
BUF VDD	16	Supply voltage for oscillator buffer. Local bypass cap. required.
VCO OUT	18	Oscillator buffer output. 50 Ω interface. DC-blocked.
RES	21	External resonator connection.
TUNE	23	Oscillator voltage-controlled frequency tuning line. 0.5 V to 3 V range.
VDD VCO	24	Supply voltage for oscillator. High-quality isolation and bypass required.
GND	(1)	Ground connections. Keep lengths physically short for stability and best performance. Use multiple ground vias close to pins.

Note: 1. GND Pins are: 1, 5, 7-10, 15, 17, 19, 20, 22.

TQ9206 Pinout



DC Power and Ground Connections

The TQ9206 was designed to operate from a single +5V supply voltage. A range of 4.5V to 5.5V is permissible for normal operation. The TQ9206 uses separate Vdd pins for delivering the supply voltage to different sections of the overall circuit. This is done for isolation and power management. Each pin should be locally bypassed with a high frequency ceramic capacitor. The TQ9206 application circuit shows the location and typical values for the bypass capacitors.

As with most RF circuits, a good local connection to ground is very important. The TQ9206 requires a top surface ground with multiple via hole connections to the backside ground plane for best thermal and electrical performance. These via holes should be located underneath the package and adjacent to the package ground pins.

RF Connections

The TQ9206 operates at microwave frequencies. Controlled impedance transmission lines are required for connection to the RF ports. Best results have been obtained with 50 Ω coplanar waveguide connections to the VCO, RES, and MXR I/O ports. Coplanar waveguide requires a top surface ground which serves to orient the E field component of the RF energy in the plane of the circuit board. This provides a ground-signal-ground connection to the TQ9206 which yields minimum discontinuities and best SWR.

Control Signals

TX/$\overline{RX}$

The TX/$\overline{RX}$ control line selects the transmit or receive signal paths. On-chip logic controls the mode of operation through the internal T/R switch and optional external PMOS switches. The T/R switches establish the RF signal path by connecting the mixer I/O to the appropriate transmit or receive converter. Power management is accomplished via TQ9205-controlled external PMOS switches, are used to power down the unused TQ9206 converter function. The on-chip control logic of the TQ9205 provides two logic outputs which enables gate control for the external PMOS switches.

Power Down

The TQ9206 contains on-chip power down circuitry for the VCO and buffer amplifier circuitry. The power down function is an extension of the TX/RX control logic. Power down simultaneously shuts down both the transmit and receive amplifiers via the TQ9205-controlled PMOS power switches. The TQ9206 VCO is also shut down via on-chip power switching. The RF T/R switch goes to a high-impedance state in power down mode. Bias must be supplied to the logic V_{DD} at all times. Power consumption in the power down mode is on the order of 1 mA. Both transmit and receive circuits can be simultaneously powered if power down is not required.

Transmit (TX) Operation

In the transmit mode, TX/$\overline{RX}$ is HIGH and PWRDWN is LOW. The signal path flows through the switch and the transmit mixer and amplifiers. The IF signal is applied to TX IF. upconverted with the LO signal, producing the RF signal, which is available at MXR I/O. The full +9 dBm output is produced with a drive level of -7 dBm applied at the TX IF input. Only the transmit side is active via external power control of TXVDD.

Receive (RX) Operation

In the receive mode, TX/$\overline{RX}$ is LOW and PWRDWN is LOW. The signal path flows through the switch and the receive mixer and amplifiers. The RF signal is applied to ANT I/O and is available at MXR I/O. The full gain and low noise figure is produced up to input levels of -20 dBm at the ANT I/O port. Only the receive side is active via external power control of RXVDD.

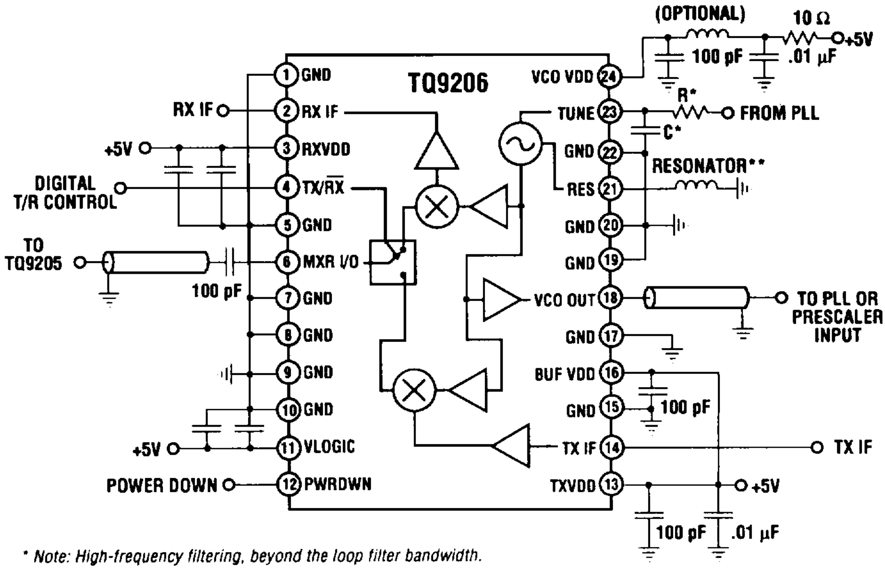
DC Blocking

The TQ9206 MXR I/O port (pin 6) is DC coupled and biased at the Vlogic potential. *RF connections to this port must be DC blocked.*

Selecting the VCO Resonator

The TQ9206 incorporates an on-chip Colpitts VCO for both up and down conversion. The center frequency is set by an off-chip $^1/_4$-wave shorted-stub resonator, while fine tuning is accomplished with an on-chip varactor. Resonator selection will impact oscillator stability and phase noise performance.

TQ9206 Application Circuit



* *Note: High-frequency filtering, beyond the loop filter bandwidth.*
** *Resonator is a strip line*

Adequate performance may be realized with a simple printed line or coaxial line resonator, but the best performance is obtained with a high-Q coaxial ceramic resonator. Typical phase noise performance of better than -105 dBc/Hz at a 100 KHz offset can be obtained with a ceramic resonator. Resonator length must be determined experimentally due to board layout parasitics. Connection length between the resonator and the TQ9206 pin will tend to lower the resonate frequency. By selecting a ceramic resonator's self-resonant frequency slightly above the desired VCO frequency, the connection length can be adjusted via resonator placement to bring the VCO on frequency. Printed line or coaxial line resonators can be designed deliberately long, and shortened to the appropriate length for the desired VCO frequency.

Using the TQ9206 with an External Oscillator

Some applications may require the use of an external oscillator. This can be accomplished by applying typically 0 dBm of external oscillator power into the resonator port (pin 21) of the TQ9206 via a series 50-ohm resistor. The 50-ohm resistor serves to stabilize the on-chip oscillator by canceling its negative resistance. As a result, the on-chip oscillator stage behaves as a buffer to the external oscillator input. Note that both the VCO V_{DD} (pin 24) and the BUF V_{DD} (pin 16) must still be energized during operation with an external oscillator.

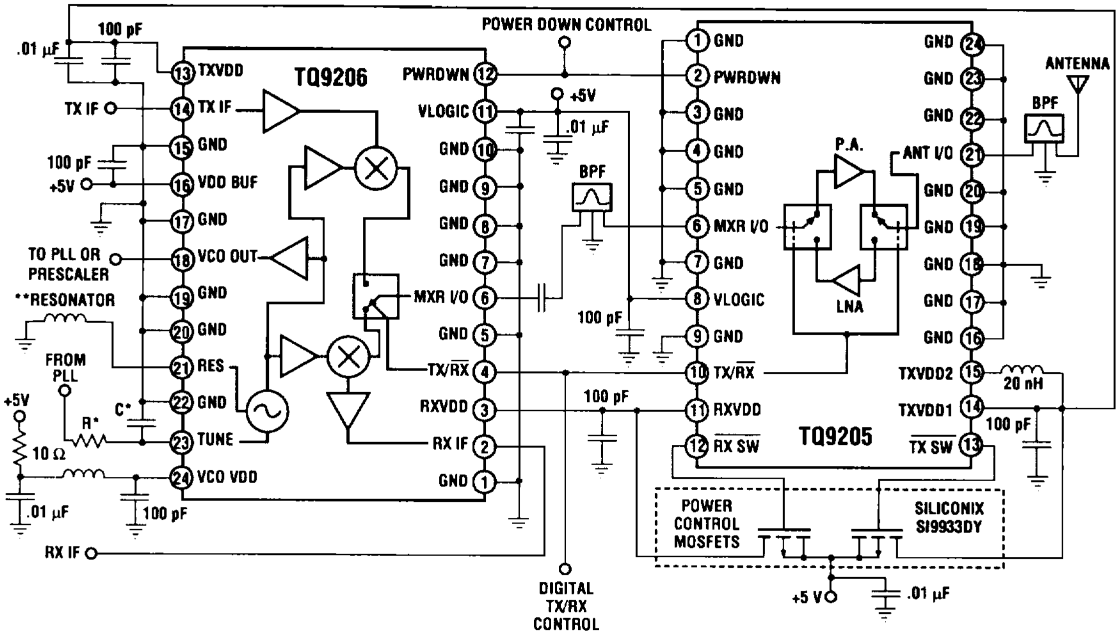
Matching the Rx IF port to 50 ohms

The Rx IF port has the typical output impedance shown in table 1. This impedance eases the matching requirements to a SAW filter which typically follows the TQ9206. In situations where a 50-ohm match is desired, a simple two-element match can be accomplished off-chip. A shunt 4.7 pF capacitor at the TQ9206 RxIF (pin 2) followed by a series 39 nH inductor will provide a match at 250 MHz with a 100 MHz bandwidth.

Table 1 - Typical TQ9206 Rx IF Port Impedance

Frequency	R ohms	X ohms
100 MHz	130	-j18
200 MHz	125	-j32
300 MHz	113	-j41
400 MHz	105	-j46
500 MHz	97	-j47

Application Circuit – TQ9205 and TQ9206



** Resonator is a strip line.

Interfacing with the TQ9205

The TQ9205 2.4 GHz Amplifier/Switch Front-End is specifically designed to interface to the TQ9206 2.4 GHz RF Up/downconverter to form a complete RF transceiver chip pair. The two chips are connected in the manner shown in the Application Circuit figure. A bandpass filter is required between the chips, and often required at the antenna port, in order to meet FCC regulations for spurious emissions.

Proximity

The TQ9205 and TQ9206 each have interfaces designed for direct connection to 50 ohms and, as such, can be connected to each other via 50-ohm transmission lines of arbitrary length. However, it is recommended that the two be separated by only a few cm to keep transmission line losses to a minimum. The minimum spacing will usually be set by the physical dimensions of the filter which is connected between the two.

Filtering

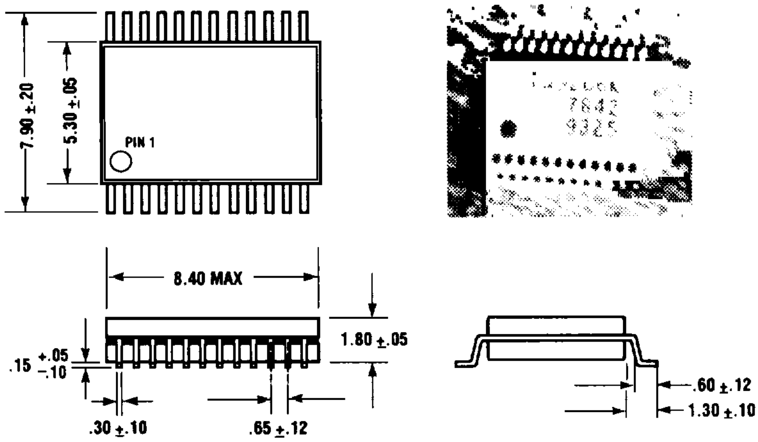
A bandpass filter is required between the TQ9205 and TQ9206 for proper operation. This filter has the dual purpose of acting as the image frequency filter for downconversion on the receive side and for upconversion on the transmit side. By combining the transmit and receive paths in this way, the 9205/06 architecture eliminates a second filter. Additional filtering may be required at the antenna port in order to meet FCC regulations.

Absolute Maximum Ratings

Parameter	*Min.*	*Typ.*	*Max*	*Units*
+ DC Supply Voltage			8	V
Power Dissipation			0.4	W
Input Power			+10	dBm
Storage Temperature	-55		155	°C
Operating Temperature	0		70	°C

ESD-sensitive device - Class 1

24-Pin SSOP Package



TriQuint SEMICONDUCTOR

Revision D.1, June 21, 1995