FUJITSU SEMICONDUCTOR
DATA SHEET

DS04-23509-1E

ASSP for Telephone

BIPOLAR

Quadrature Modulator IC
(With 1.0 GHz Up-converter)

MB54609

■ DESCRIPTION

The MB54609 is an intermediate-frequency (IF) quadrature modulator IC incorporating a 1.0-GHz up-converter optimized for use in digital mobile telecommunication systems such as GSM and PDC (Personal Digital Cellular).

The MB54609 incorporates a quadrature modulator for IF modulation, a transmission up-convert mixer, and a F/F type phase shifter as well, capable of handing IFs in a broad band.

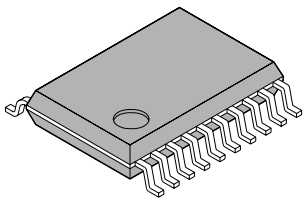
In addition, the MB54609 operates at a low power supply voltage of 3.0 V and a low power supply current of 18 mA (both as typical values), contributing to saving the power consumption of the device.

■ FEATURES

- Incorporating a high-performance transmission mixer covering the entire frequency band of up to 800 MHz used for PDC services (Maximum output frequency of 1.1 GHz)
  Maximum output frequency: 1.1 GHz, Output level: –9 dBm (typical)
- Externally connecting the quadrature modulator with the transmission mixer, allowing a bandpass filter (BPF) to be inserted in between
  The quadrature modulator output can drive a 50 Ω load.
- Flip-flop phase shifter capable of handling intermediate frequencies in the broad band (100 to 800 MHz)
- Operation at low voltage: 2.7 to 3.0 to 3.3 V
- Low current consumption
  During operating: 18.0 mA (typical)
  In power save mode: 0.6 mA (typical)
- Operating temperature range: Ta = –20 to +85°C

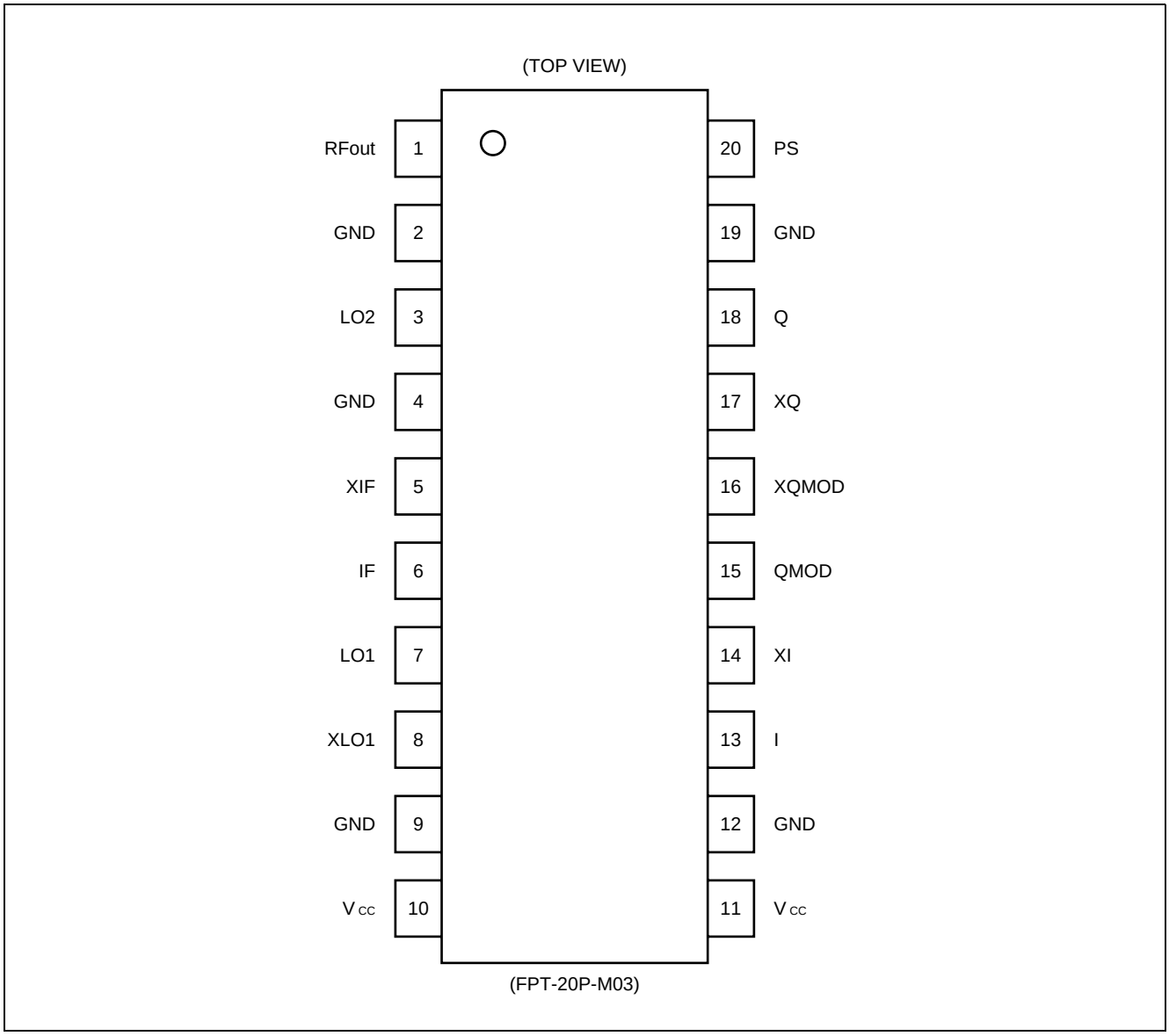
■ PACKAGE

20-pin Plastic SSOP



(FPT-20P-M03)

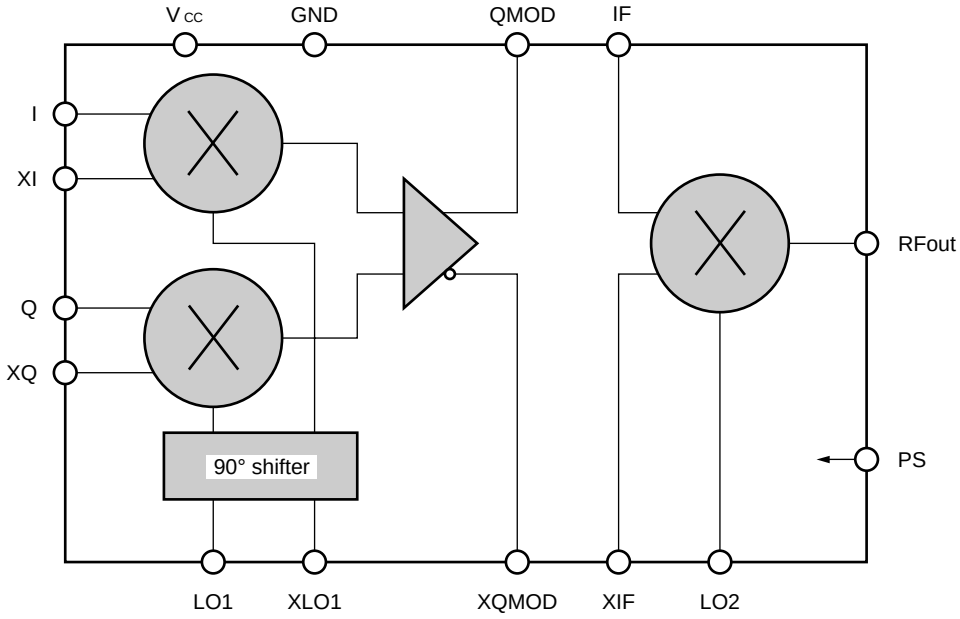
■ PIN ASSIGNMENT



■ PIN DESCRIPTION

Pin no.	Pin name	Function	
1	RFout	Up-converter output pin	
2	GND	GND pin	
3	LO2	LO input pin for mixer	
4	GND	GND pin	
5	XIF	IF input complementary pin for mixer	
6	IF	IF input pin for mixer	
7	LO1	LO input pin for quadrature modulator	
8	XLO1	LO input complementary pin for quadrature modulator	
9	GND	GND pin	
10	V_{CC}	Power supply pin	Power supply voltage must be applied to both pins.
11	V_{CC}	Power supply pin	
12	GND	GND pin	
13	I	Baseband input (I) pin	
14	XI	Baseband input (I) complementary pin	
15	QMOD	Quadrature modulator IF output pin	
16	XQMOD	Quadrature modulator IF output complementary pin	
17	XQ	Baseband input (Q) complementary pin	
18	Q	Baseband input (Q) pin	
19	GND	GND pin	
20	PS	Power save mode control pin	

■ BLOCK DIAGRAM



■ ABSOLUTE MAXIMUM RAGINGS (See WARNING)

Parameter	Symbol	Rating	Unit	Remarks
Power supply voltage	V_{CC}	–0.5 to 5.0	V	
Output voltage	V_O	–0.5 to V_{CC} + 0.5	V	
Input voltage	V_I	–0.5 to V_{CC} + 0.5	V	
Open collector applied voltage	V_{OC}	V_{CC} ± 0.3 (–0.5 to 5.0)	V	RFout pin Do not leave this pin open.
Output current	I_O	±10	mA	
Storage temperature	Tstg	–55 to +125	°C	

WARNING: Exceeding any of the above **Absolute Maximum Ratings** may cause permanent damage to the LSI. For normal operation, the device should be used under the recommended operating conditions. Exceeding any of the recommended conditions may adversely affect LSI reliability.

Note: Although the MB54609 contains an antistatic element to prevent electrostatic breakdown and the circuitry has been improved in electrostatic protection, observe the following precautions when handling the device:

- When storing or carrying the device, put it in a conductive case.
- Before handling the device, check that the jigs and tools to be used have been uncharged (grounded) as well as yourself. Use a conductive sheet on the working bench.
- Before fitting the device into or removing it from the socket, turn the power supply off.
- When handling (such as transporting) the MB54609 mounted board, protect the leads with a conductive sheet.

■ RECOMMENDED OPERATING CONDITIONS

Parameter	Symbol	Value			Unit	Remarks
		Min.	Typ.	Max.		
Power supply voltage	V_{CC}	2.7	3.0	3.3	V	
Input voltage	V_I	GND	—	V_{CC}	V	
Open collector applied voltage	V_{OC}	V_{CC} – 0.2	—	V_{CC} + 0.2	V	RFout pin. Do not leave this pin open.
Operating temperature	T_a	–20	—	+85	°C	

■ ELECTRIC CHARACTERISTICS

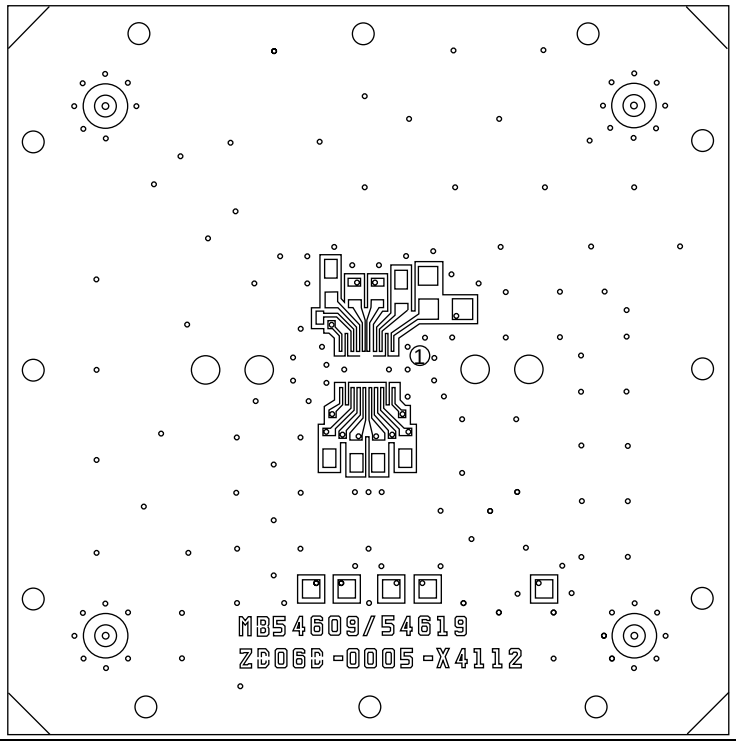
(V_{CC} = 3.0 V, Ta = +25°C)

Parameter		Symbol	Value			Unit	Remarks	
			Min.	Typ.	Max.			
Power supply current		I_{CC}	—	18.0	23.5	mA	DC current (Input with no AC signal)	
Power supply current in power save mode		$I_{CC}PS$	—	0.6	0.9	mA	DC current (Input with no AC signal)	
Shifter input LO1	Operating band	f_{LO1}	100	400	800	MHz		
	Input level	P_{LO1}	–15	—	–5	dBm		
Baseband input	Operating band	f_{BB}	DC	—	10	MHz		
	Input amplitude	V_{BB}	—	—	1.2	Vpp		
	Offset voltage	V_{OS}	1.5	1.6	1.7	V	External offset voltage value	
	Offset current	I_{OS}	—	3.0	—	µA	Input Imp. converted value = 533 kΩ	
Mixer input LO2	Operating band	f_{LO2}	—	750	1100	MHz		
	Input level	P_{LO2}	—	—	0	dBm		
Mixer output RFout	Operating band	f_{RF}	—	950	1100	MHz	$f_{RF} = f_{LO2} \pm f_{LO1}/2$	
	Output level	P_{RF}	—	–9	—	dBm	—	f_{LO1} = 400 MHz (–15 dBm) f_{LO2} = 750 MHz (–5 dBm) f_{RF} = 950 MHz output QMOD/Mix direct connection V_{BB} = 1 Vpp
Modulation precision	Amplitude deviation	A_{ERR}	—	1.3	—	%	RMS value	
	Phase deviation	P_{ERR}	—	0.82	—	deg.	RMS value	
	Vector error	V_{ERR}	—	1.9	—	%	RMS value	
Carrier suppression		CS	—	–40	–30	dBc	With external offset unadjusted	

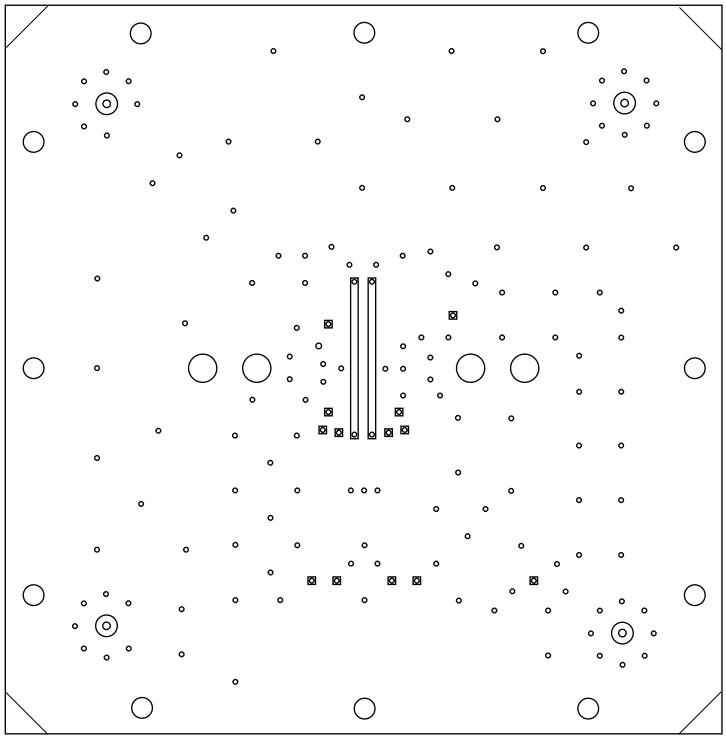
■ EVALUATION BOARD (Reference Example)

- Material: BT resin BT-HL870 (Dielectric constant [1 MHz] = 3.4 to 3.6)
- Thickness: 4 layers, 1.6 mm (Copper thickness: External layer = 18 µm, Internal layer = 70 µm)
- Plating: electroless gold plating

- **Layer 1 (front surface)**



- **Layer 2**



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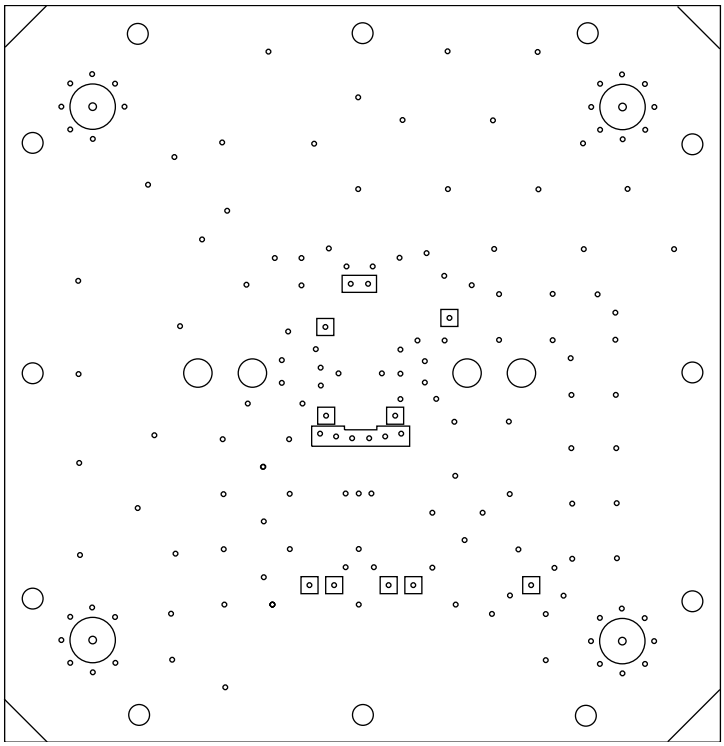
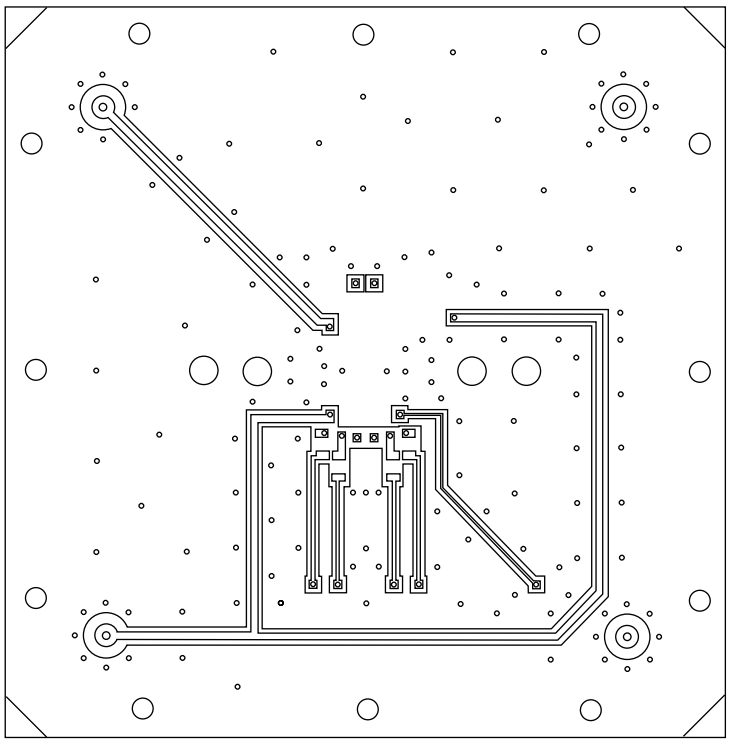
- **Layer 3**



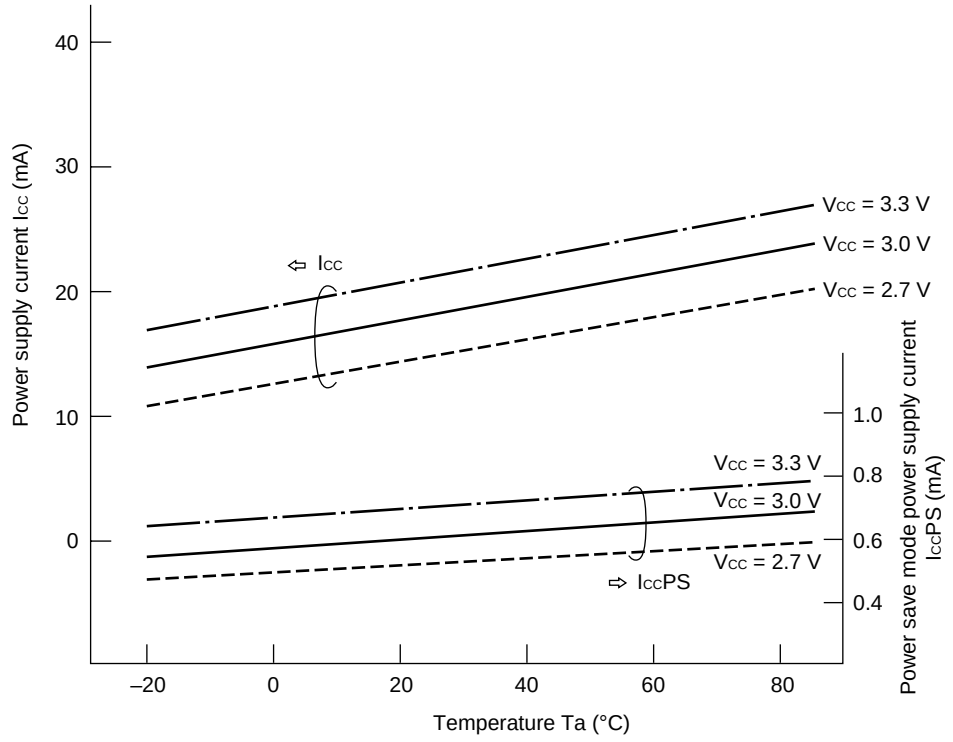
- **Layer 4**
  (rear surface)



■ MEASUREMENT DATA (Reference Values)

* : Application-common characteristics

- **DC characteristics (test circuit 1)**
  @ Input with no AC signal



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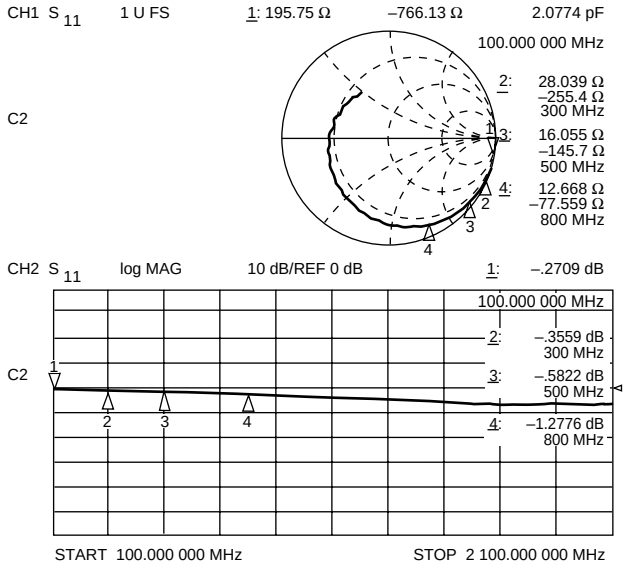
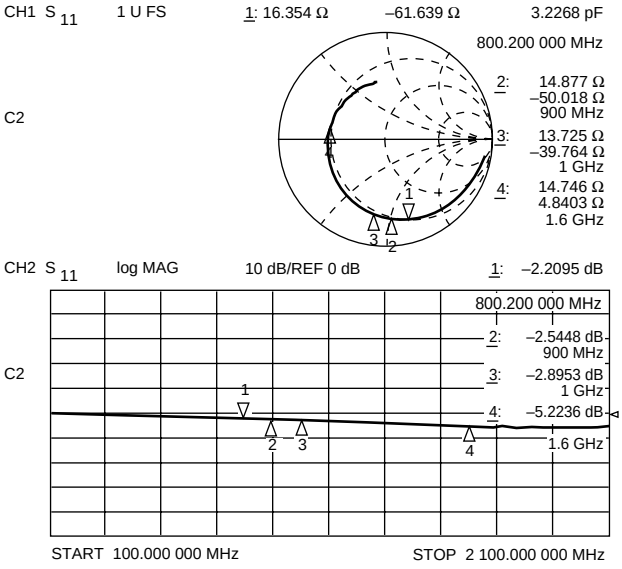
- **Input impedance (Only IC: test circuit 4)**
  @ Impedance from IC pin end

- **LO1**

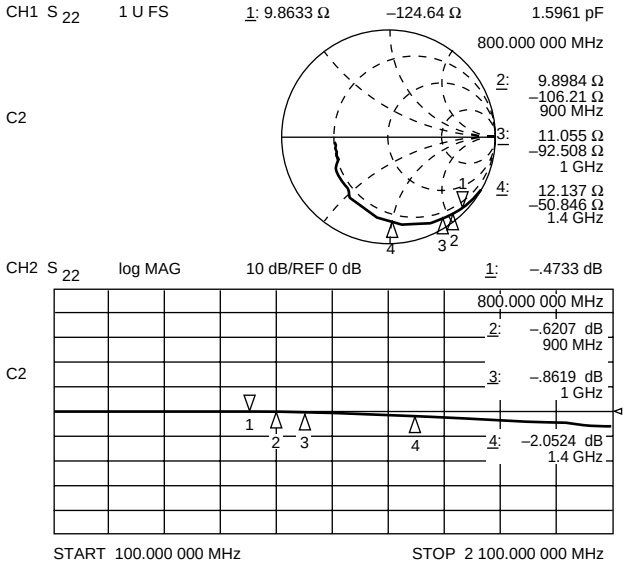


- **LO2**



- **Output impedance (Only IC: test circuit 4)**
  @ Impedance from IC pin end

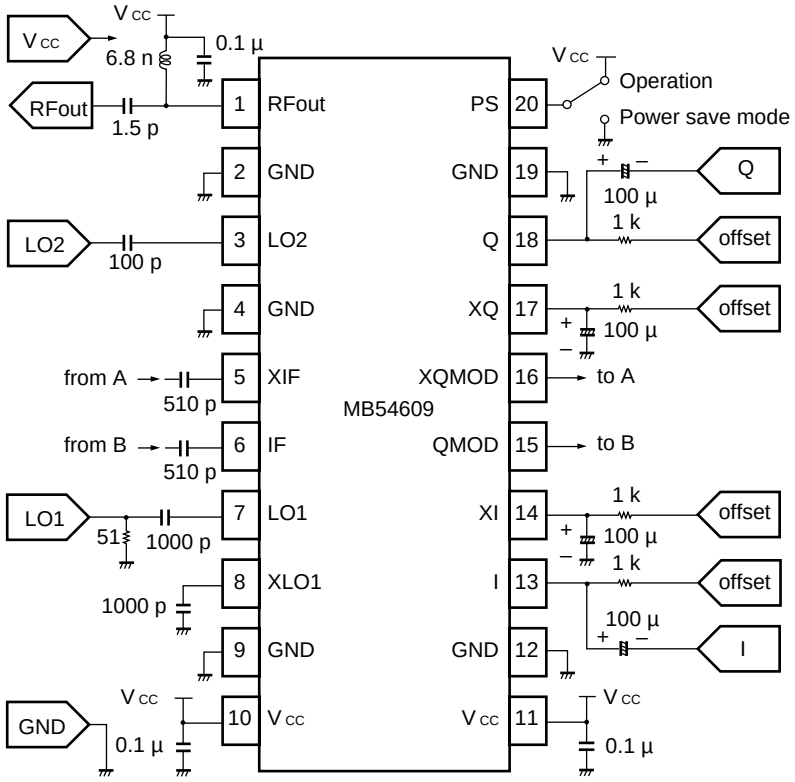
- **RFout**



■ 800-MHz PDC APPLICATION MEASUREMENT DATA (Reference Values)

Parameter	Symbol	Measurement result	Unit	Condition	Test circuit
Baseband input signal	f_{BB}	42	kbps	π/4DQPSK, Root-Nyquist filter (α = 0.5)	—
	V_{BB}	1.0	Vpp	Single-end input	—
Shifter input signal LO1	f_{LO1}	400	MHz	—	—
	P_{LO1}	–15	dBm	—	—
Mixer input signal LO2	f_{LO2}	750	MHz	—	—
	P_{LO2}	–5	dBm	—	—
Mixer output signal RFout	f_{RF}	950	MHz	$f_{RF} = f_{LO2} + f_{LO1}/2$	—
	P_{RF}	–8.4	dBm	SSB value	1
Return loss	RL_{LO1}	–17	dB	f_{LO1} = 400 MHz	3
	RL_{LO2}	–2	dB	f_{LO2} = 750 MHz	
	RL_{RF}	–12	dB	f_{RF} = 950 MHz	
Modulation precision	A_{ERR}	1.3	%	RMS Magnitude Error	2
	P_{ERR}	0.82	deg.	RMS Phase Error	
	V_{ERR}	1.9	%	RMS Vector Error	
Carrier suppression	CS	–34.5	dBc	—	2

- **External circuit constants (with the IC mounted on the evaluation board)**



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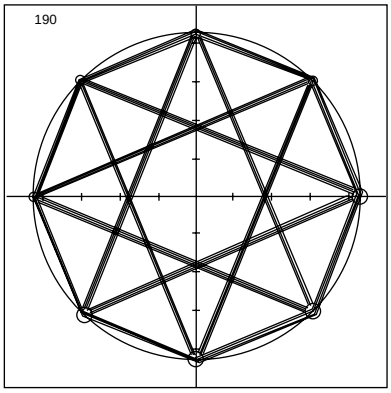
- **Modulation precision and output spectrum (test circuit 2)**
  @ Baseband signal: π/4 DQPSK, 42 kbps, 1.0 Vpp, PN 15, Root-Nyquist filter α = 0.5
  Input signals: LO1 = 400 MHz, –15 dBm; LO2 = 750 MHz, –5 dBm
  Output signal: RFout = 950 MHz

- **Modulation precision**



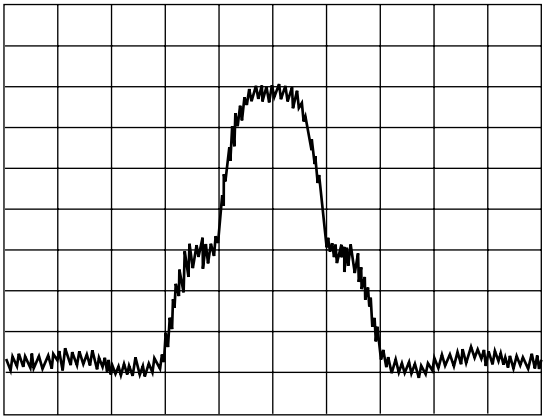
RMS Vector Error = 1.927%
Peak Vector Error = 4.234%
RMS Magnitude Error = 1.290%
Peak Magnitude Error = 3.364%
RMS Phase Error = 0.821 degs
Peak Phase Error = –2.240 degs
Carrier Freq Offset = 8.561e+03 Hz
Carrier Phase Offset = 157.455 degs

Carrier Leak = –32.429 dB

Bias Vector = (2.305, 0.634)%
Gravity Center = (–4.635, 10.356)%

VG: 5.000e-01 V / Div
Baseband Filter: RtNyq (0.5000) Rectangle Len = 64 OSR = 4.761905

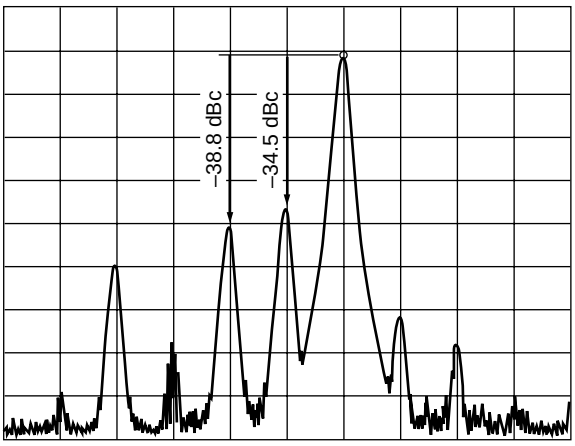
- **Output spectrum**



CENTER = 950 MHz
SPAN = 200 kHz
RBW = 3 kHz VBW = 100 Hz SWP = 3 s
ATT = 10 dB
REF = 0 dBm 10 dB / div.

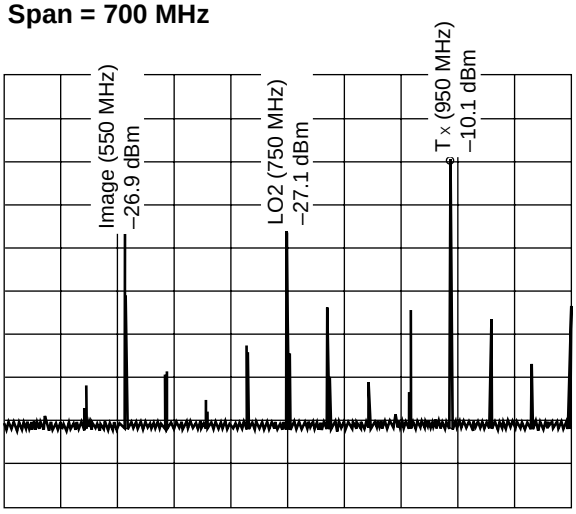
- **Spectrum (test circuit 2)**
  @ Baseband signal: π/4 DQPSK, 42 kbps, 1.0 Vpp, 0000, Root-Nyquist filter α = 0.5
  Input signals: LO1 = 400 MHz, –15 dBm; LO2 = 750 MHz, –5 dBm
  Output signal: RFout = 950 MHz

- **Span = 240 kHz**



CENTER = 950 MHz
SPAN = 26.2 kHz
RBW = 300 Hz VBW = 300 Hz SWP = 1.3 s
ATT = 10 dB
REF = 0 dBm 10 dB / div.

- **Span = 700 MHz**



CENTER = 750 MHz
SPAN = 700 MHz
RBW = 1 MHz VBW = 3 kHz SWP = 1.1 s
ATT = 10 dB
REF = 10 dBm 10 dB / div.

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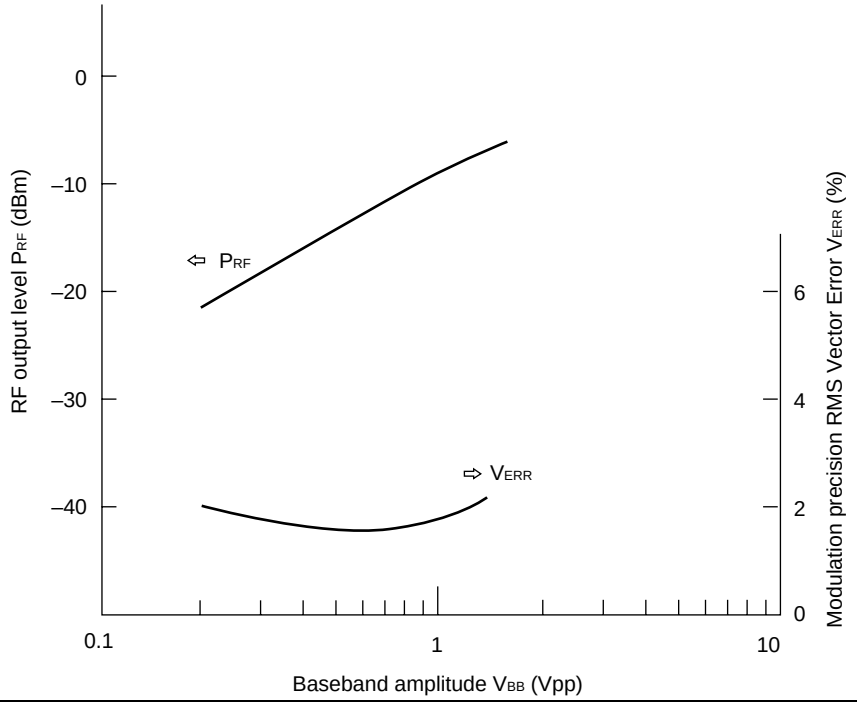
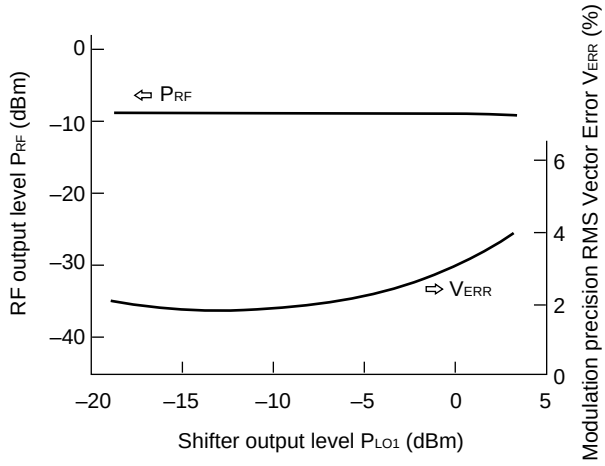
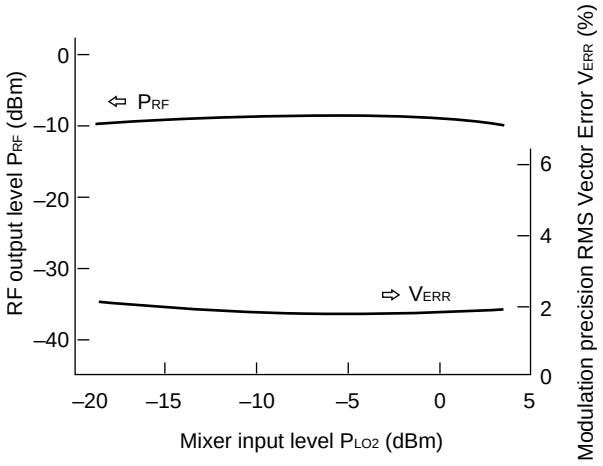
- **RF output level dependent on baseband amplitude**
  (P_{RF}: test circuit 1, Modulation precision: test circuit 2)
  @ Baseband signal of test circuit 2: π/4 DQPSK, 42 kbps, 1.0 Vpp, PN 15, Root-Nyquist filter α = 0.5
  Input signals of test circuits 1 and 2: LO1 = 400 MHz, –15 dBm; LO2 = 750 MHz, –5 dBm
  Output signal: RFout = 950 MHz



- **RF output level dependent on LO1 and LO2 input levels**
  (P_{RF}: test circuit 1, Modulation precision: test circuit 2)
  @ Baseband signal of test circuit 2: π/4 DQPSK, 42 kbps, 1.0 Vpp, PN 15, Root-Nyquist filter α = 0.5
  Input signals of test circuits 1 and 2: LO1 = 400 MHz, –15 dBm; LO2 = 750 MHz, –5 dBm
  Output signals of test circuits 1 and 2: RFout = 950 MHz
- **RF output level dependent on LO1 input level ($@P_{LO2}$ = –5 dBm)**



- **RF output level dependent on LO2 input level ($@P_{LO1}$ = –15 dBm)**



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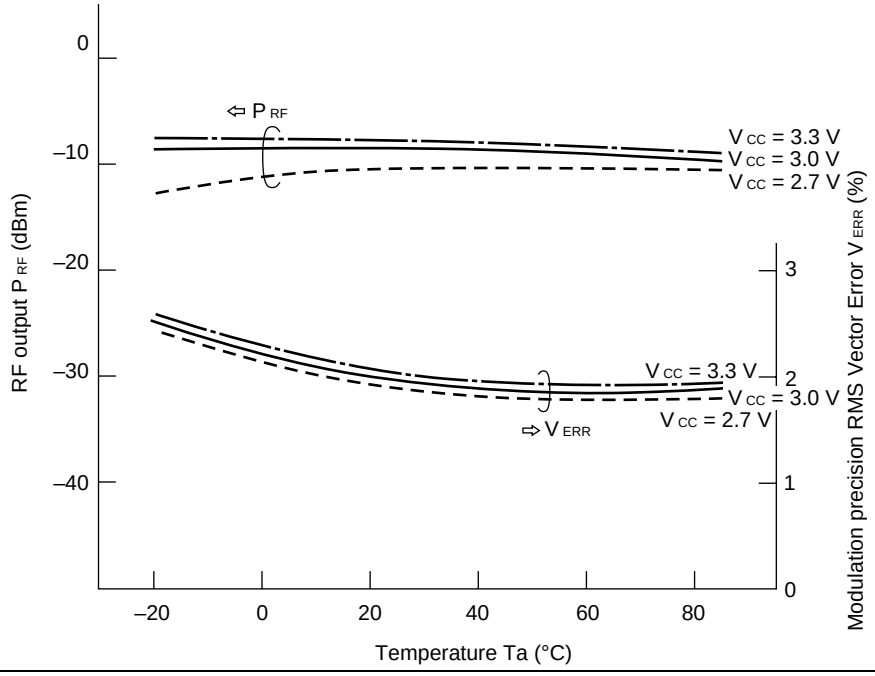
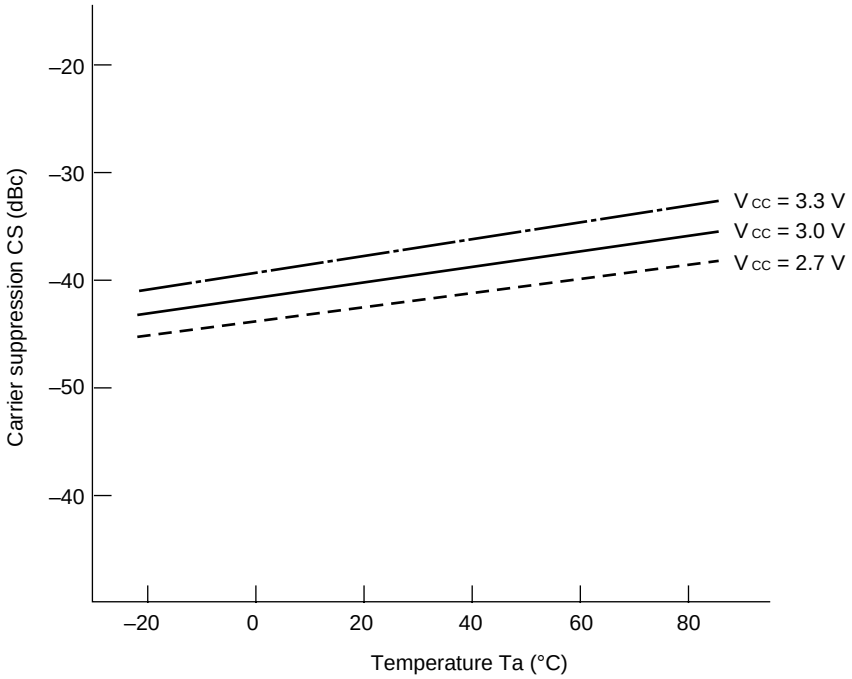
- **RF output level dependent on temperature (PRF: test circuit 1, Modulation precision: test circuit 2)**
  @ Baseband signal of test circuit 2: π/4 DQPSK, 42 kbps, 1.0 Vpp, PN 15, Root-Nyquist filter α = 0.5
  Input signals of test circuits 1 and 2: LO1 = 400 MHz, –15 dBm; LO2 = 750 MHz, –5 dBm
  Output signals of test circuits 1 and 2: RFout = 950 MHz



- **Carrier suppression dependent on temperature (test circuit 2)**
  @ Baseband signal: π/4 DQPSK, 42 kbps, 1.0 Vpp, 0000, Root-Nyquist filter α = 0.5
  Input signals: LO1 = 400 MHz, –15 dBm; LO2 = 750 MHz, –5 dBm
  Output signal: RFout = 950 MHz



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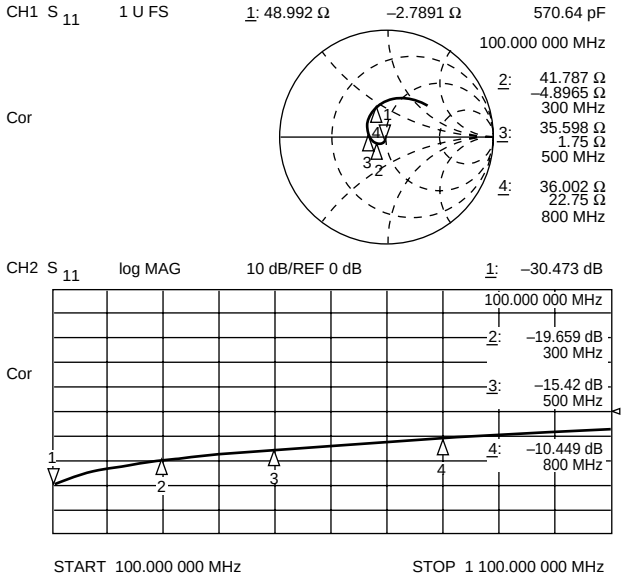
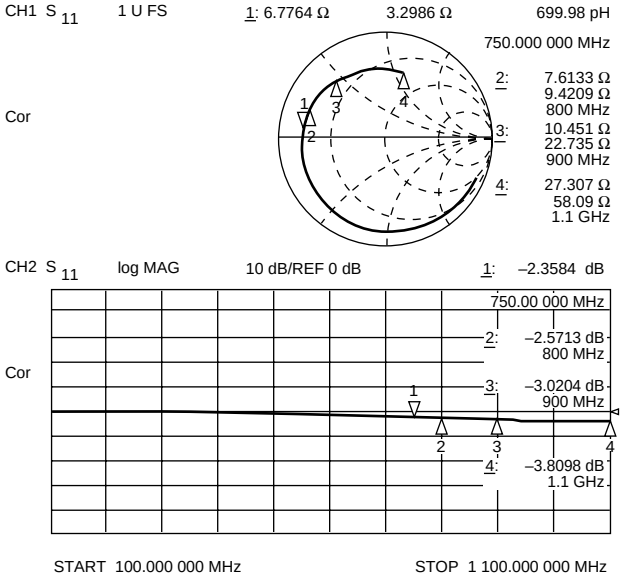
- **Input impedance (with components mounted: test circuit 3)**
  @ Impedance including external components and evaluation board

- **LO1**

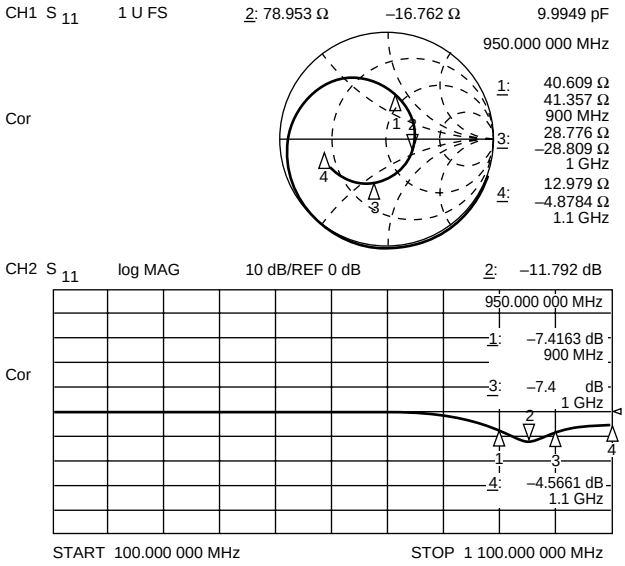


- **LO2**



- **Output impedance (with components mounted: test circuit 3)**
  @ Impedance including external components and evaluation board

- **RFout**

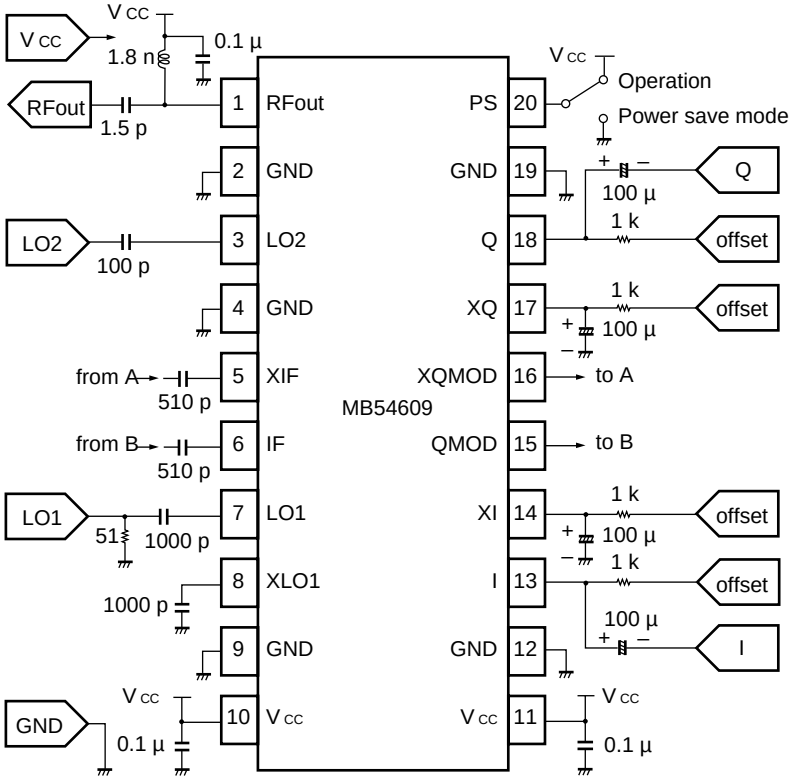


■ 1.5-GHz PDC APPLICATION MEASUREMENT DATA (Reference Values)

- **Measurement result**

Parameter	Symbol	Measure-ment result	Unit	Condition	Test circuit
Baseband input signal	f_{BB}	42	kbps	π/4 DQPSK, Root-Nyquist filter (α = 0.5)	—
	V_{BB}	1.0	Vpp	Single-end input	—
Shifter input signal LO1	f_{LO1}	356	MHz	—	—
	P_{LO1}	–5	dBm	—	—
Mixer input signal LO2	f_{LO2}	1619	MHz	—	—
	P_{LO2}	–5	dBm	—	—
Mixer output signal RFout	f_{RF}	1441	MHz	$f_{RF} = f_{LO2} + f_{LO1}/2$	—
	P_{RF}	–13.4	dBm	SSB value	1
Return loss	RL_{LO1}	–18	dB	f_{LO1} = 356 MHz	3
	RL_{LO2}	–6	dB	f_{LO2} = 1619 MHz	
	RL_{RF}	–14	dB	f_{RF} = 1441 MHz	
Modulation precision	A_{ERR}	1.6	%	RMS magnitude error	2
	P_{ERR}	0.90	deg.	RMS phase error	
	V_{ERR}	2.2	%	RMS vector error	
Carrier suppression	CS	–39.0	dBc	—	2

- **External circuit constants (with the IC mounted on the evaluation board)**



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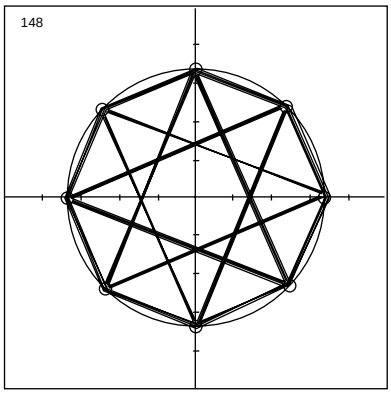
- **Modulation precision and output spectrum (test circuit 2)**
  - @ **Baseband signal: π/4 DQPSK, 42 kbps, 1.0 Vpp, PN 15, Root-Nyquist filter α = 0.5**
    Input signals: LO1 = 356 MHz, –5 dBm; LO2 = 1619 MHz, –5 dBm
    Output signal: RFout = 1441 MHz

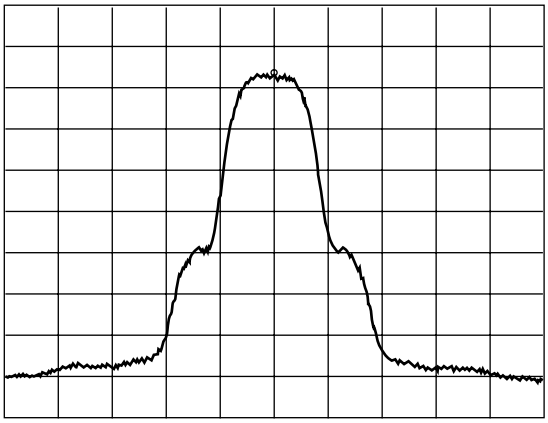
- **Modulation precision**



RMS Vector	Error =	2.243%
Peak Vector	Error =	4.552%
RMS Magnitude	Error =	1.597%
Peak Magnitude	Error =	3.756%
RMS Phase	Error =	0.902 degs
Peak Phase	Error =	–1.977 degs
Carrier Freq	Offset =	–1.454e+03 Hz
Carrier Phase	Offset =	7.417 degs
Carrier Leak	=	–33.001 dB
Bias Vector	=	(1.839, 1.275) %
Gravity Center	=	(–1.295, 0.833) %

VG : 7.000e-02 V / Div
Baseband Filter: RtNyq (0.500) Rectangle Len = 64 OSR = 4.761905

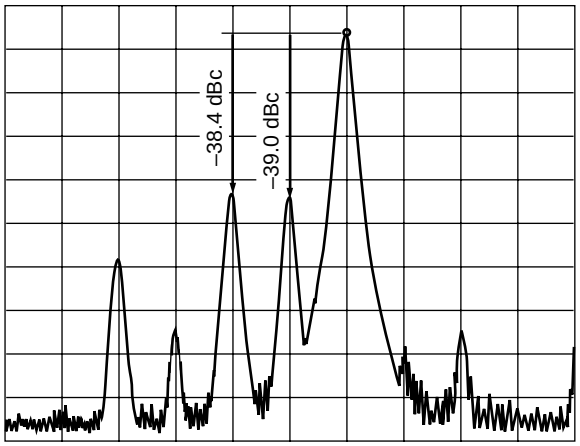
- **Output spectrum**



CENTER = 1441 MHz
SPAN = 200 kHz
RBW = 3 kHz VBW = 3 kHz SWP = 100 ms AVG = 128
ATT = 10 dB
REF = –10 dBm 10 dB / div.

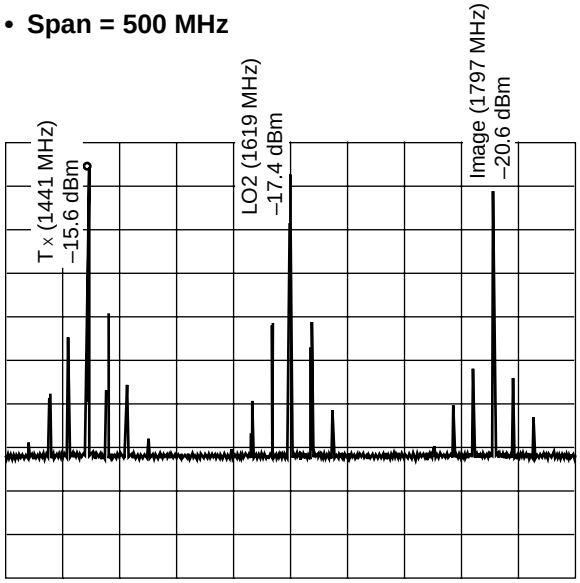
- **Spectrum (test circuit 2)**
  - @ **Baseband signal: π/4 DQPSK, 42 kbps, 1.0 Vpp, 0000, Root-Nyquist filter α = 0.5**
    Input signals: LO1 = 356 MHz, –5 dBm; LO2 = 1619 MHz, –5 dBm
    Output signal: RFout = 1441 MHz

- **Span = 26.2 kHz**



CENTER = 1441 MHz
SPAN = 26.2 kHz
RBW = 300 Hz VBW = 100 Hz SWP = 4 s
ATT = 10 dB
REF = –10 dBm 10 dB/div.

- **Span = 500 MHz**

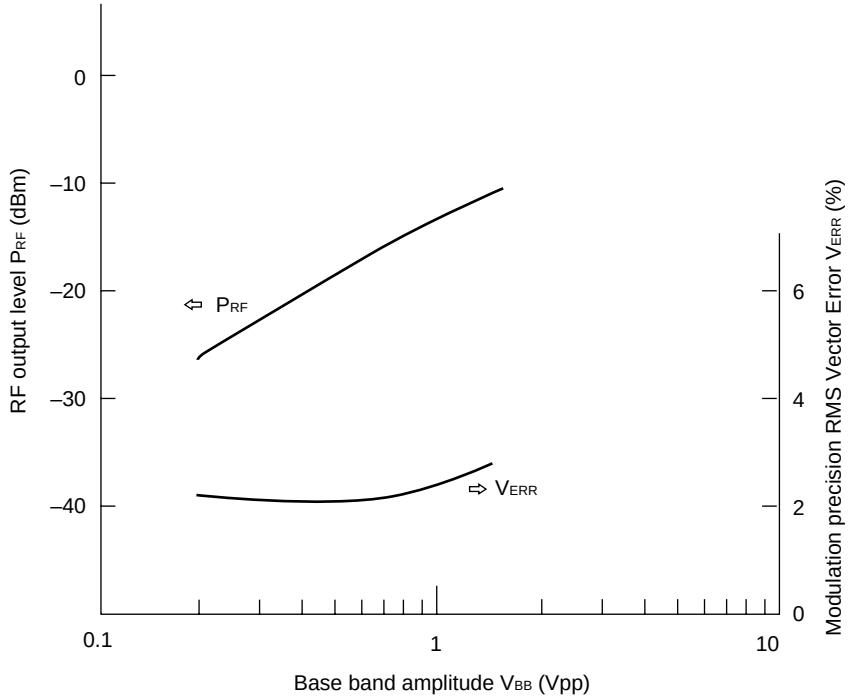


CENTER = 1619 MHz
SPAN = 500 MHz
RBW = 1 MHz VBW = 1 kHz SWP = 3 s
ATT = 10 dB
REF = –10 dBm 10 dB/div.

(Continued)

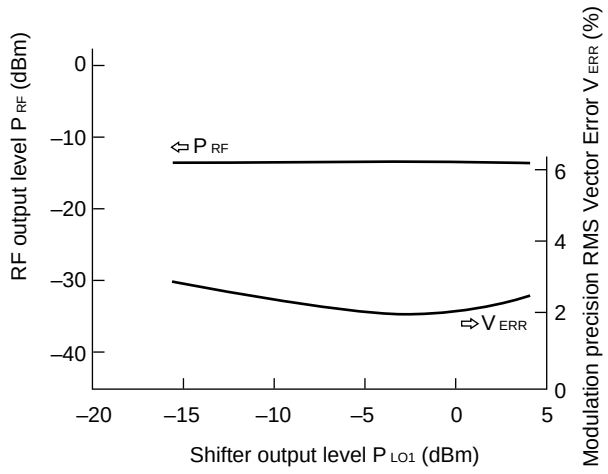
(Continued)

- **RF output level dependent on baseband amplitude**
  (P_{RF}: test circuit 1, Modulation precision: test circuit 2)
  @ Baseband signal of test circuit 2: π/4 DQPSK, 42 kbps, 1.0 Vpp, PN 15, Root-Nyquist filter α = 0.5
  Input signals of test circuits 1 and 2: LO1 = 356 MHz, –5 dBm; LO2 = 1619 MHz, –5 dBm
  Output signals of test circuits 1 and 2: RFout = 1441 MHz

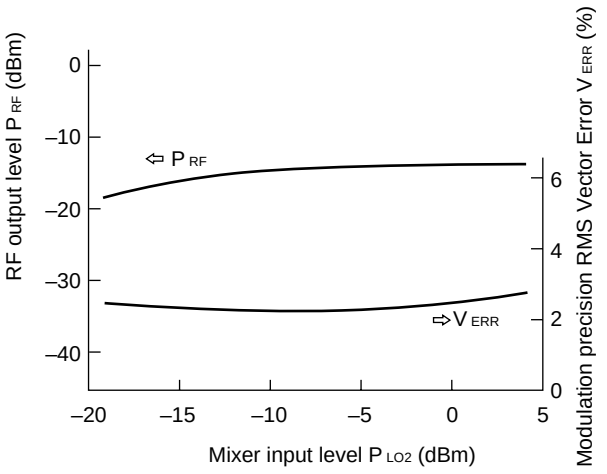


- **RF output level dependent on LO1 and LO2 input levels**
  (P_{RF}: test circuit 1, Modulation precision: test circuit 2)
  @ Baseband signal of test circuit 2: π/4 DQPSK, 42 kbps, 1.0 Vpp, PN 15, Root-Nyquist filter α = 0.5
  Input signals of test circuits 1 and 2: LO1 = 356 MHz, –5 dBm; LO2 = 1619 MHz, –5 dBm
  Output signals of test circuits 1 and 2: RFout = 1441 MHz

- **RF output level dependent on LO1 input level ($@P_{LO2}$ = –5 dBm)**



- **RF output level dependent on LO2 input level ($@P_{LO1}$ = –5 dBm)**



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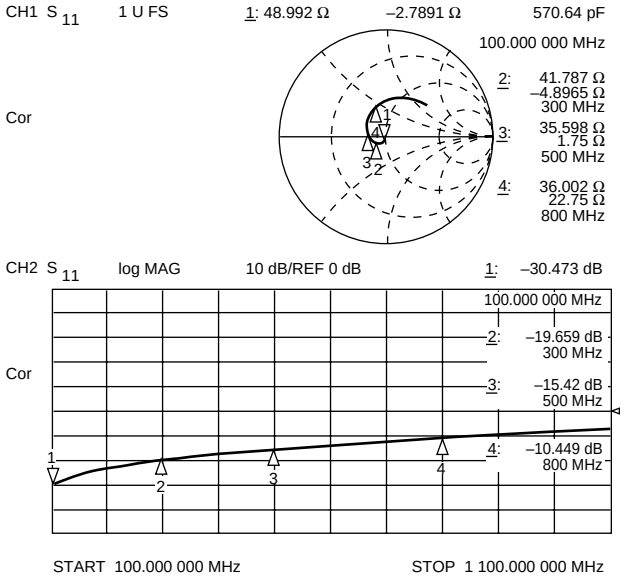
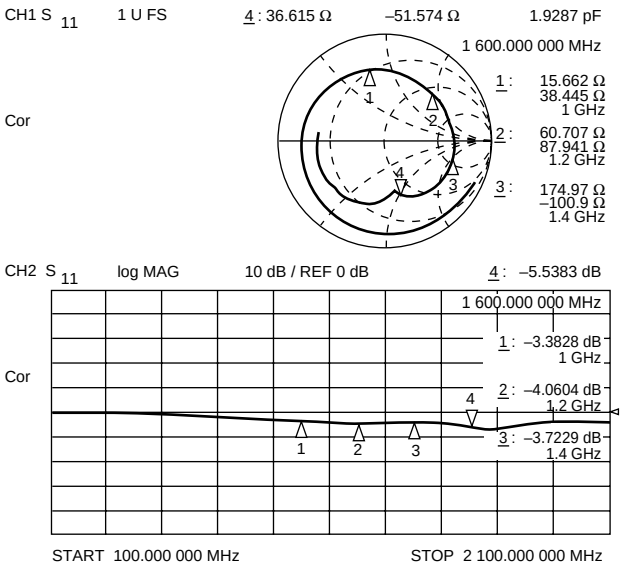
- **Input impedance (with components mounted: test circuit 3)**
  @ Impedance including external components and evaluation board

- **LO1**

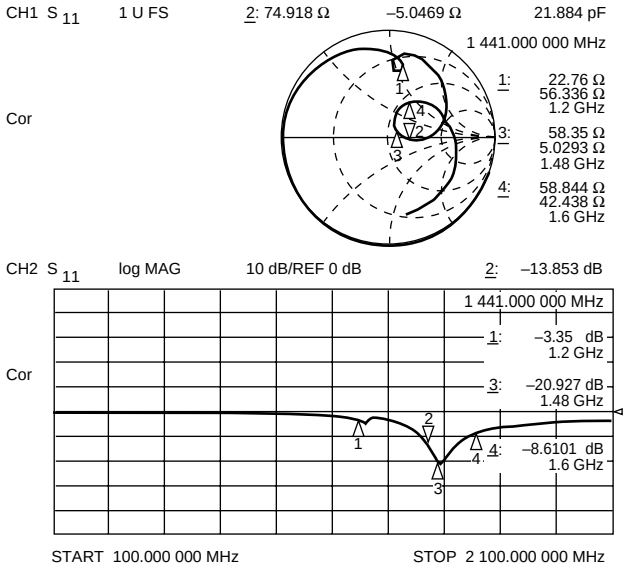


- **LO2**



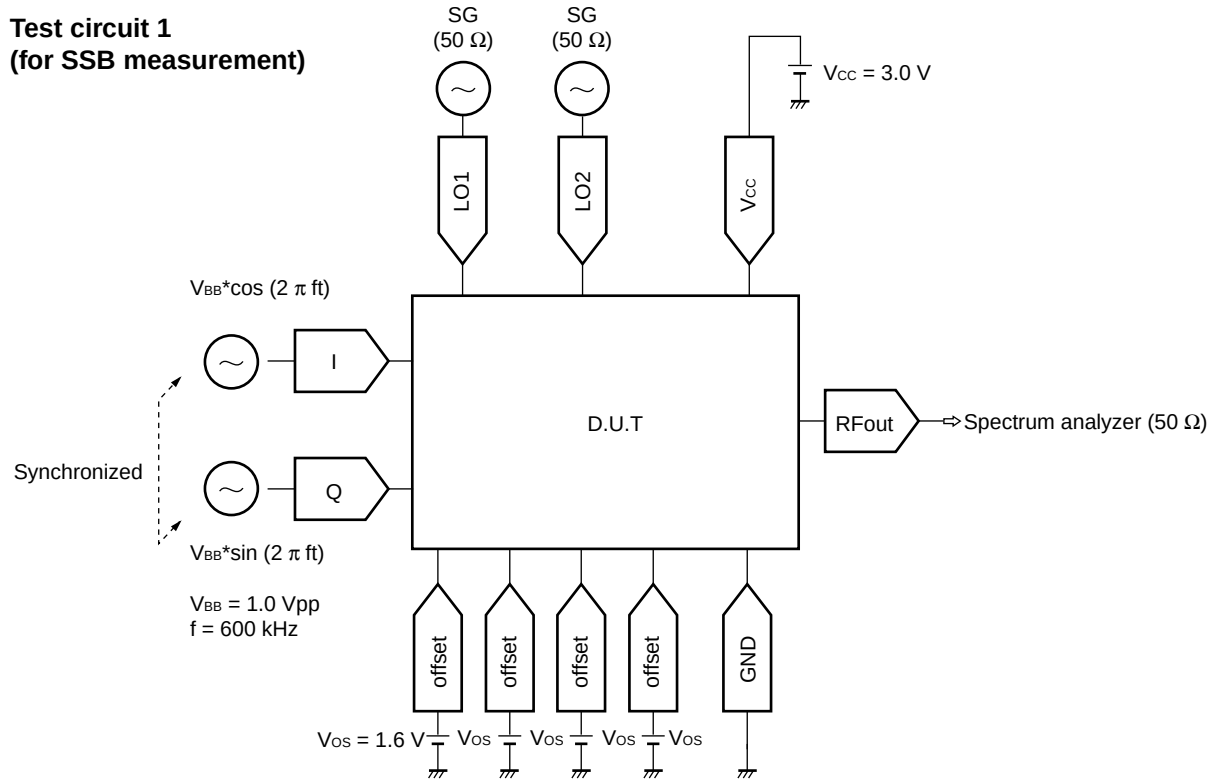
- **Output impedance (with components mounted: test circuit 3)**
  @ Impedance including external components and evaluation board

- **RFout**

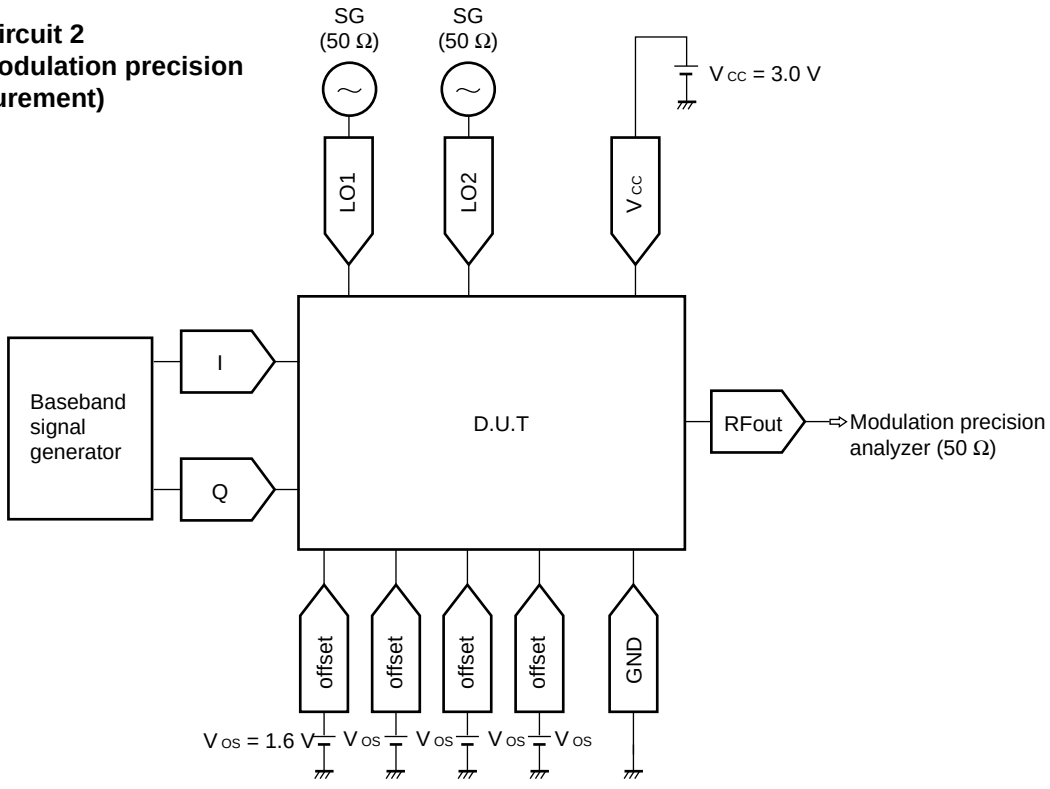


■ TEST CIRCUITS (Reference Examples)

- **Test circuit 1**
  (for SSB measurement)



- **Test circuit 2**
  (for modulation precision measurement)



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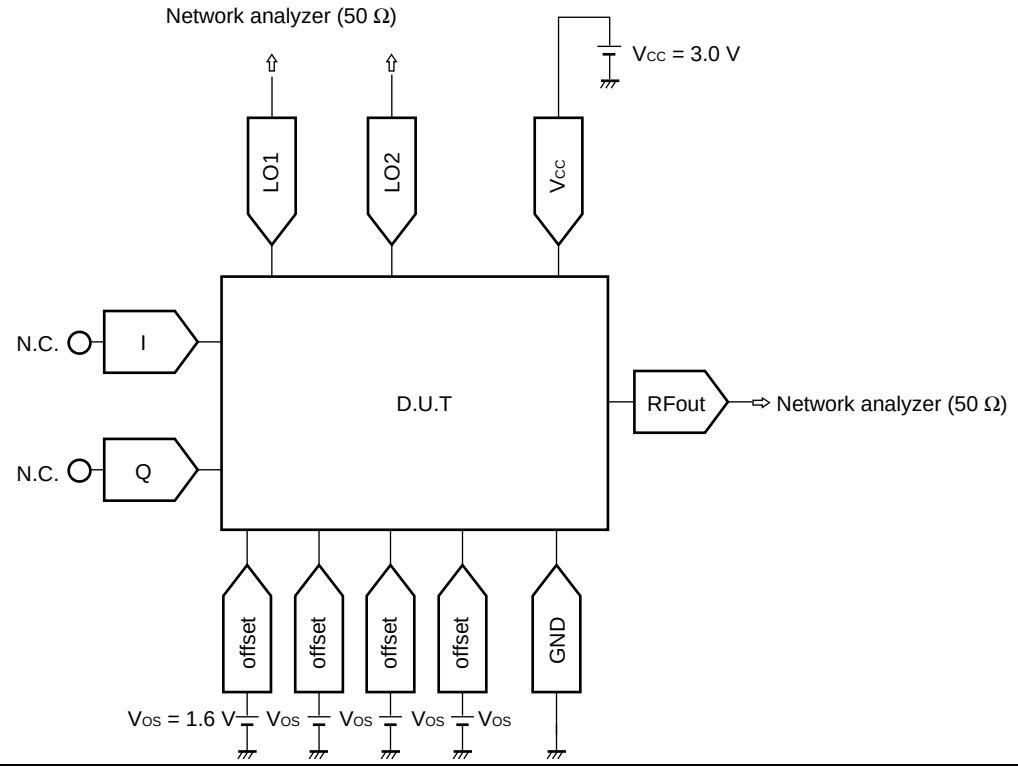
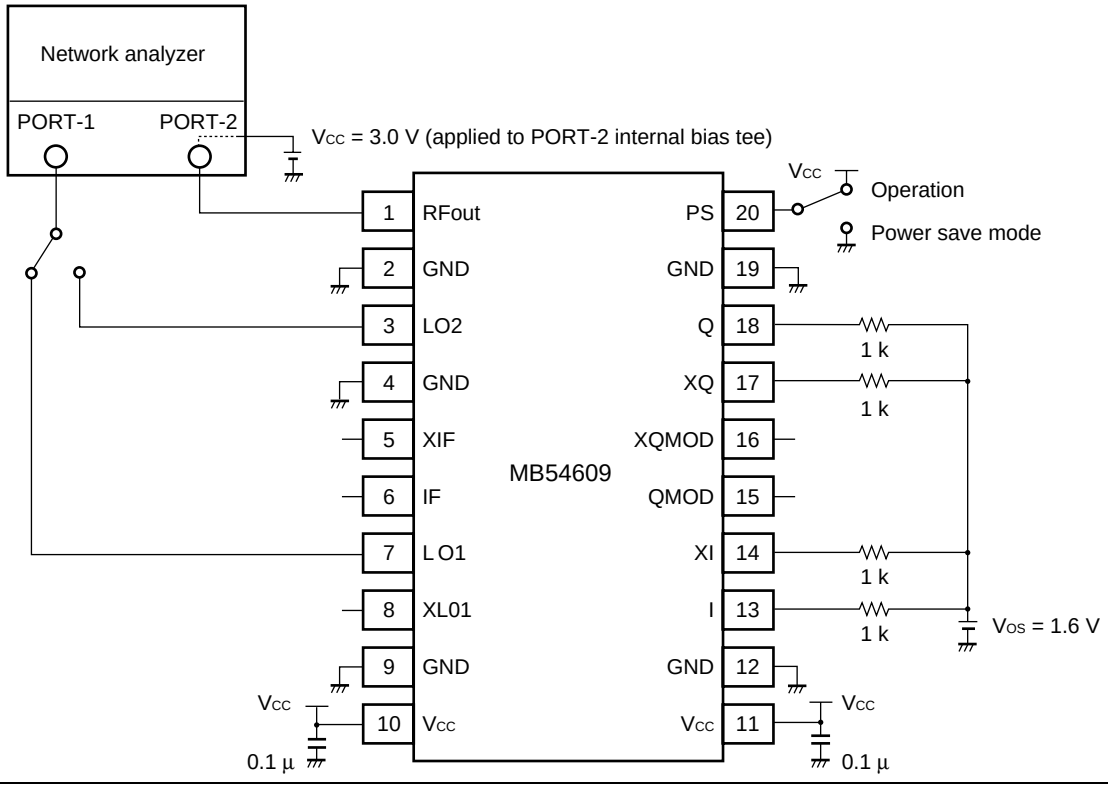
- **Test circuit 3 (for impedance measurement with components mounted)**



- **Test circuit 4 (for measurement of impedance of only IC)**



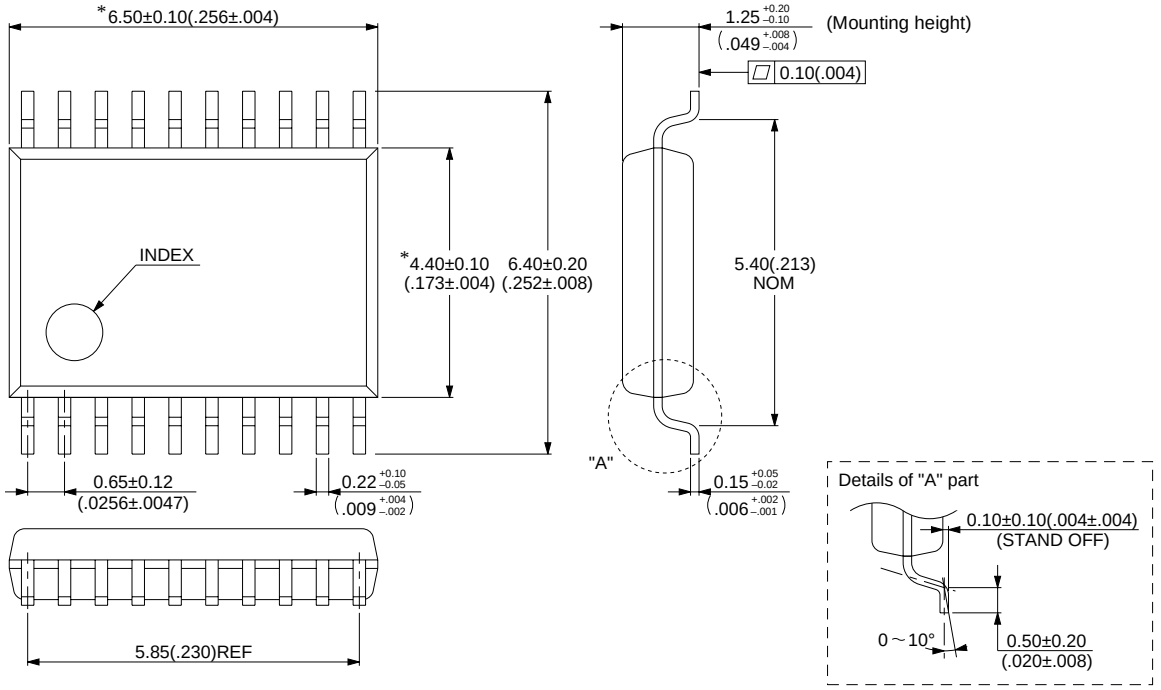
■ ORDERING INFORMATION

Part number	Package	Remarks
MB54609PFV	20-pin Plastic SSOP (FPT-20P-M03)	

■ PACKAGE DIMENSION

20-pin Plastic SSOP
(FPT-20P-M03)

*: These dimensions do not include resin protrusion.



Dimensions in mm (inches)

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