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AN11097

CMMB LNA with BGU7003, 400 MHz to 800 MHz

Rev. 01 — 29 March 2012 Application note

Document information

Info	Content
Keywords	LNA, 400 MHZ - 800 MHz, BGU7003, CMMB
Abstract	The document provides the circuit, layout, Bill Of Materials (BOM) and performance information for a CMMB LNA equipped with NXP Semiconductors' BGU7003.

Revision history

Rev	Date	Description
v.1	20120329	initial version

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1. Introduction

The BGU7003 is a wideband Silicon Germanium Amplifier MMIC for high-speed, low-noise applications. It is used for Low Noise Amplifiers (LNA) applications up to 6 GHz such as GPS, satellite radios, cordless phones and Chinese Mobile Multimedia Broadcasting (CMMB). The BGU7003 contains 1 RF stage and an internal bias that is temperature stabilized. It also contains a power-down function to shut down the amplifier, using a logic signal on the enable pin.

The BGU7003 is ideal for use in portable electronic devices, such as mobile phones, Personal Digital Assistants (PDA), Personal Navigation Devices (PND).

The CMMB LNA evaluation board (EVB) is designed to evaluate the performance of the BGU7003 when it is applied as a CMMB LNA. This document provides the application diagram, board layout, bill of materials, and some typical results.

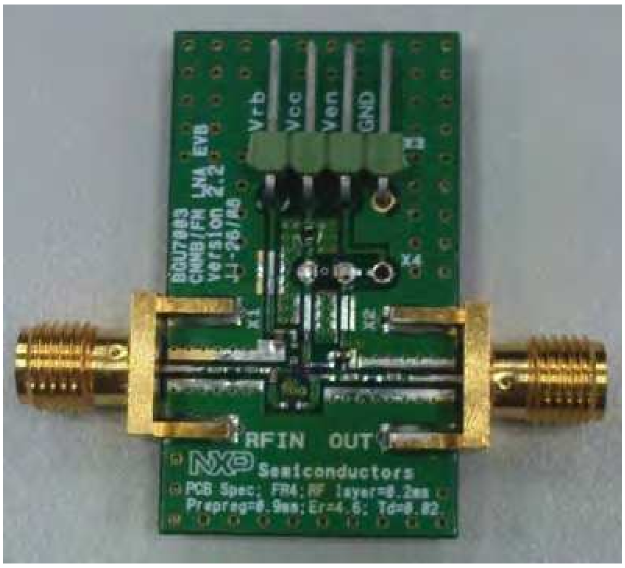

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Fig 1. BGU7003 400 MHz - 800 MHz LNA evaluation board

2. General description

The BGU7003 is a wideband Silicon Germanium SiGe transistor with an internal bias circuit. The bias circuit is temperature stabilized, which maintains a constant current during fluctuations in temperature. The bias current for the RF stage is set via an external bias resistor which provides design flexibility when choosing the bias current. The MMIC is supplied with a power-down function that allows the designer to control the MMIC via a logic signal. The power-down mode only consumes 0.4 μA. A simplified internal circuit of the BGU7003 is given in Figure 2.

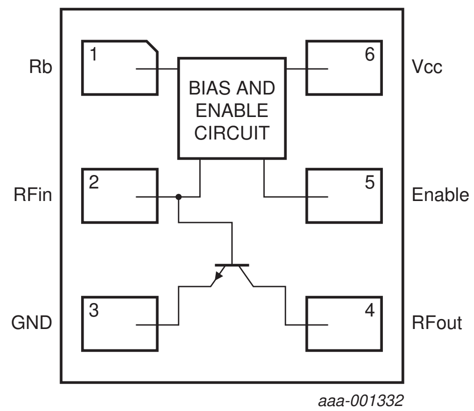

Fig 2. Simplified circuit of the BGU7003

The BGU7003 is not internally matched so a matching circuit must be designed for both input and output. The fact that no internal matching is available, makes the product suitable for various application areas.

The BGU7003, applied as a CMMB LNA, is described in the following sections.

3. Application board

The BGU7003 EVB simplifies the evaluation of the BGU7003 wideband amplifier MMIC, for the CMMB application area. The EVB enables testing of the device performance and requires no additional support circuitry. The board is fully assembled with the BGU7003 IC, including input and output matching to optimize the performance. The board is provided with SMA connectors to connect the input and output signals to RF test equipment.

This document describes the EVB using a 2.5 V supply voltage.

3.1 Application circuit

The application diagram, as supplied on the evaluation board, is given in Figure 3.

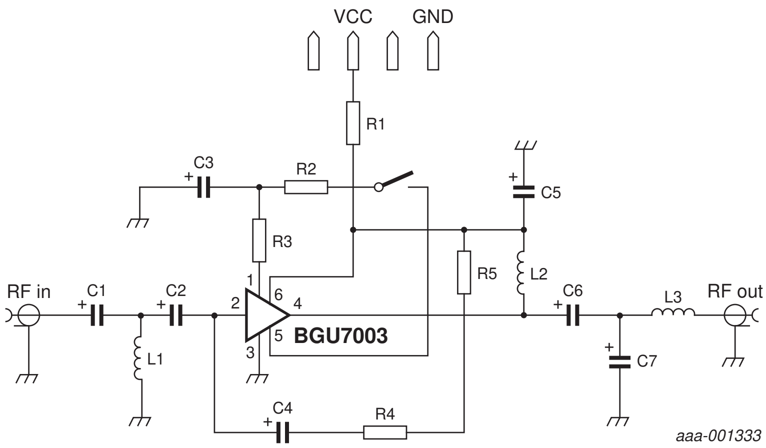

Fig 3. Circuit diagram of the evaluation board

3.2 Board layout

Figure 4 shows the board layout and components.

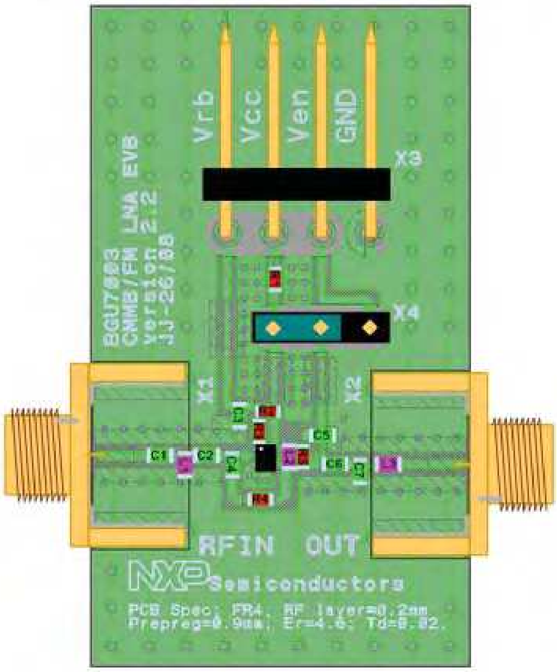

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Fig 4. Printed circuit board of the BGF7003 CMMB evaluation board

3.3 PCB layout

The PCB layout is an essential part in RF circuit design. The EVB of the BGU7003 serves as a guideline for laying out a board using the BGU7003. Controlled impedance lines are used for all high frequency inputs and outputs. Bypass VCC with decoupling capacitors located as close as possible to the device. For long bias lines, it may be necessary to add decoupling capacitors in the line farther away from the device. Correct grounding of the GND pin is also essential for the performance. The GND pin is either connected directly to the ground plane or through vias, or both.

The EVB is made of FR4 material using the stack shown in Figure 5.

The material supplier is ISOLA DURAVER; $\varepsilon r = 4.6 - 4.9$: $T\delta = 0.02$

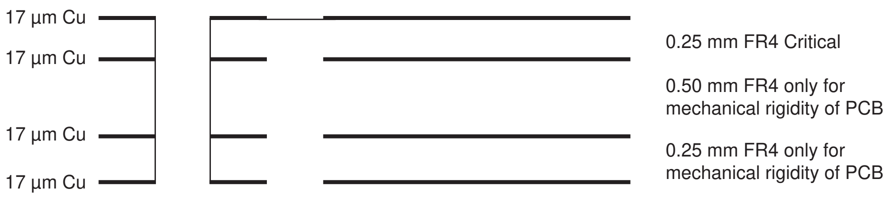

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Fig 5. Stack of the PCB material

3.4 Bill Of Materials (BOM)

Table 1. BGU7003 400 MHz band LNA EVB parts List

Part reference	Description	Comment	Footprint	Vendor	Value
C1	Capacitor	Input matching	0402	MurataGRM1555	10 pF
C2 and C6	Capacitor	DC blocking	0402	MurataGRM1555	100 pF
C3	Capacitor	LF decoupling	0402	MurataGRM1555	0.1 μF
C4	Capacitor	Feedback	0402	MurataGRM1555	470 pF
C5	Capacitor	LF decoupling	0402	MurataGRM1555	0.1 μF
C7	Capacitor	Output matching	0402	MurataGRM1555	1.0 pF
L1	Inductor	Input matching	0402	Murata/LQW15A, high Q, low Rs	22 nH
L2	Inductor	DC bias	0402	Murata/LQW15A	120 nH
L3	Inductor	Output matching	0402	Murata/LQW15A, high Q, low Rs	15 nH
R1 and R2	Resistor	Backup tune pads	0402	Various	0 Ω
R3	Resistor	Bias setting	0402	Various	3.3 kΩ
R4	Resistor	Feedback	0402	Various	1.2 kΩ
R5	Resistor	Stability	0402	Various	560 Ω
X1 and X2	SMARF connector	RF input/output	-	Johnson, End launch SMA 142-0701-841	-
X3	DC header	Bias connector	-	Molex, PCB header, Right Angle, 1 row, 3 way 90121-0763	-

4. Equipment required

The following equipment is necessary to measure the evaluation board:

- DC power supply up to 5 mA at 2.5 V (up to 15 V for bias control).
- RF signal generator capable of generating an RF signal at the operating frequency of CMMB.
- RF spectrum analyzer that covers the operating frequency of 400 MHZ to 800 MHz as well as a few of the harmonics. 6 GHz is sufficient. A version with the capability of also measuring the noise figure is useful.
- Ammeter to measure the supply current (optional).
- Network analyzer for measuring gain, return loss and reverse Isolation.
- Noise figure analyzer.

5. Connections and setup

The BGU7003, CMMB EVB is fully assembled and tested. For a step-by-step guide on how to operate the EVB and test the device functionality, proceed with the following steps:

1. Connect a 2.5 V DC power supply to the VCC and GND terminals.
2. Connect the RF signal generator to the RF input of the EVB and the spectrum analyzer to the RF output.
   - **Do not turn on the RF output of the signal generator yet**
3. Set the signal generator to –30 dBm output power at 600 MHz.
4. Set the spectrum analyzer to 600 MHz center frequency with a reference level of 0 dBm.
5. Turn on the DC power supply and it should read approximately 5 mA.
6. Enable the RF output of the generator - the spectrum analyzer displays a tone of 600 MHz at approximately –11 dBm.
7. An alternative to using the combination of the signal generator and spectrum analyzer, is to use a Network Analyzer (NWA). The NWA can measure gain as well as input and output return losses.
8. For noise figure evaluation, it is possible to use either a noise figure analyzer or a spectrum analyzer with noise option. Use a 5 dB noise source, such as the Agilent 364A. Do not use any form of adaptor or cable between the noise source and the EVB when measuring the noise figure of the evaluation board. Using adaptors and cables, affects the noise performance.

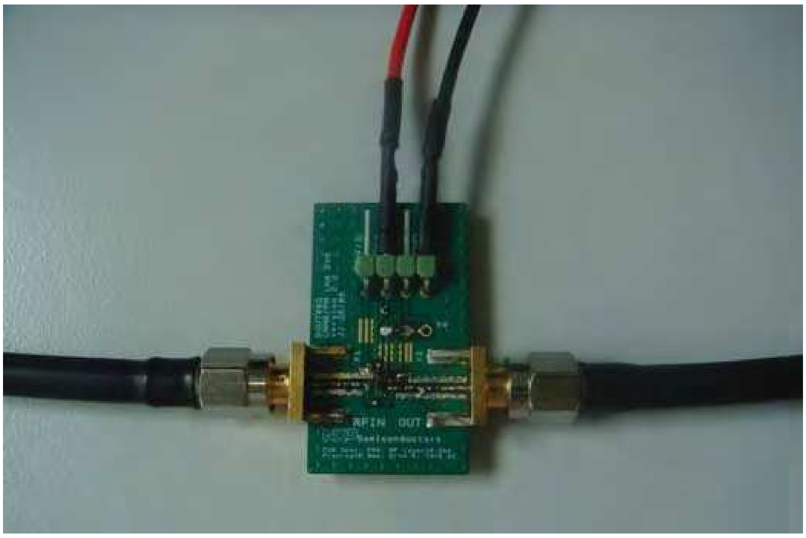

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Fig 6. Evaluation board and connectors

6. Summary of typical evaluation board test results

Table 2. Typical results measured on the evaluation board

Testing made at 600 MHz unless otherwise specified, Temp = 25 °C

Symbol	Description	Value	Unit
NF	noise figure[1]	1.2	dB
G_p	power gain[1]	19.5	dB
RL_{in}	input return loss	10.2	dB
RL_{out}	output return loss	17.9	dB
$\alpha_{isol(r)}$	reverse isolation	24.2	dB
$P_{i(1dB)}$	input power at 1 dB gain compression	−19.7	dBm
$P_{L(1dB)}$	output power at 1 dB gain compression	−1.0	dBm
$IP3_I$	input third-order intercept point	−3.3	dBm

[1] The NF and gain figures are measured at the SMA connectors of the EVB. The losses of the connectors and the PCB are not subtracted, improving the NF by approximately 0.1 dB.

6.1 Noise figure plot

Figure 7 is a plot of the noise figure in the 400 MHz to 800 MHz frequency band. The center of the plot (x-axis) is 600 MHz.

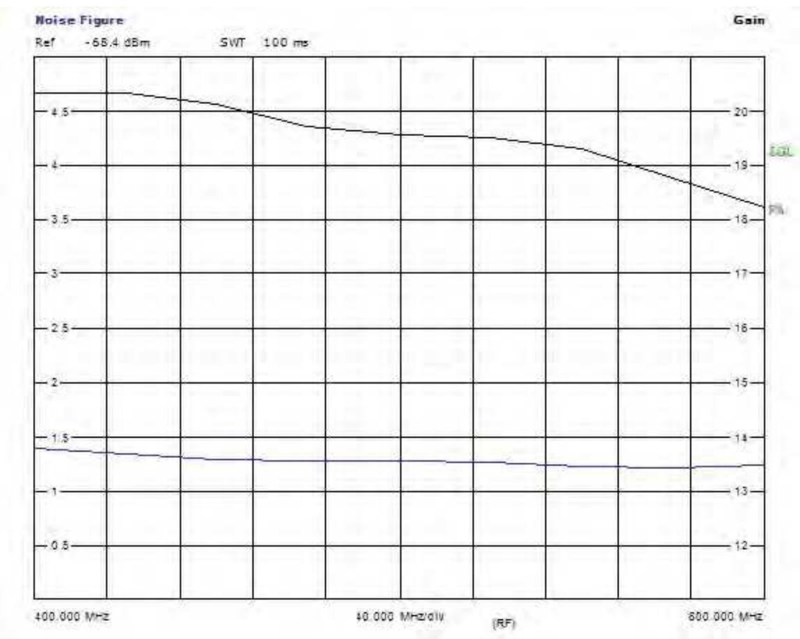

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Fig 7. Plot of noise figure

6.2 Noise figure tabular data

Rohde & Schwarz FSU supplies the data for the noise figure and it is shown in tabular form in Figure 8.

Frequency List Results			
RF	NF	Noise Temp	Gain
400.000 MHz	1.395 dB	109.843 K	20.332 dB
450.000 MHz	1.336 dB	104.488 K	20.347 dB
500.000 MHz	1.298 dB	101.033 K	20.113 dB
550.000 MHz	1.273 dB	98.818 K	19.694 dB
600.000 MHz	1.270 dB	98.496 K	19.576 dB
650.000 MHz	1.260 dB	97.627 K	19.507 dB
700.000 MHz	1.228 dB	94.746 K	19.304 dB
750.000 MHz	1.224 dB	94.405 K	18.760 dB
800.000 MHz	1.241 dB	95.951 K	18.227 dB

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Fig 8. Table of noise figure

6.3 Stability

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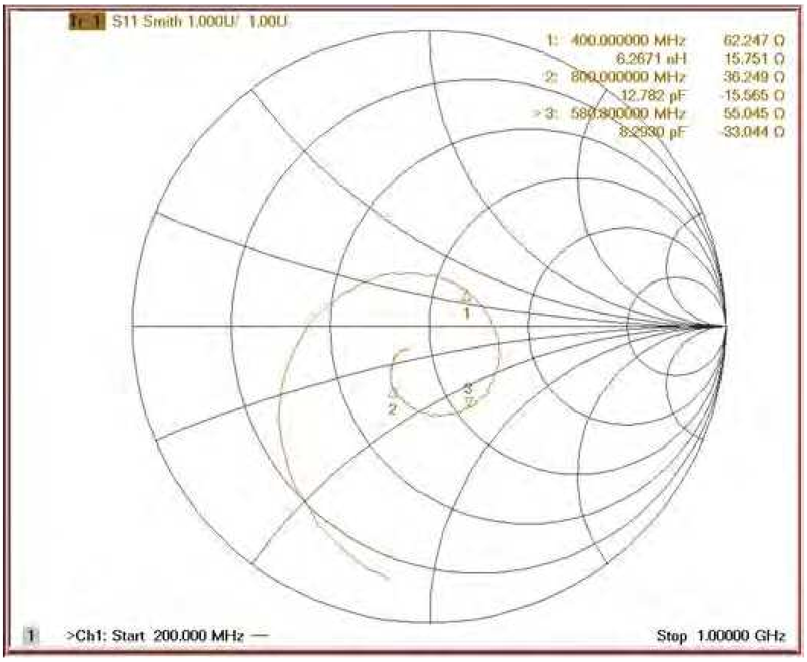
K-factor, Line mag (10 MHz - 10 GHz)

Fig 9. Plot of stability performance

6.4 Input return loss - Smith chart



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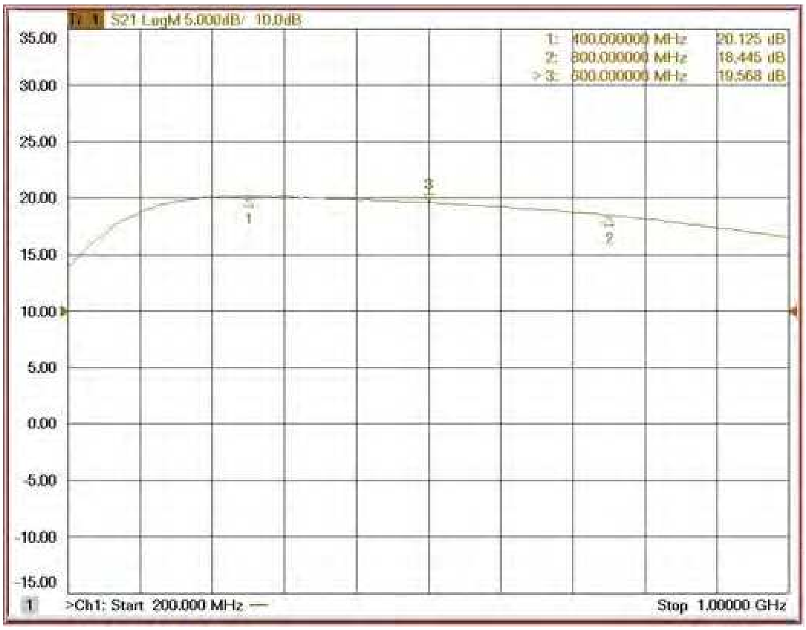
200 MHz - 1 GHz

Reference plane = input SMA connector on PC board

Fig 10. Smith chart of input return losses

6.5 Forward gain, wide sweep



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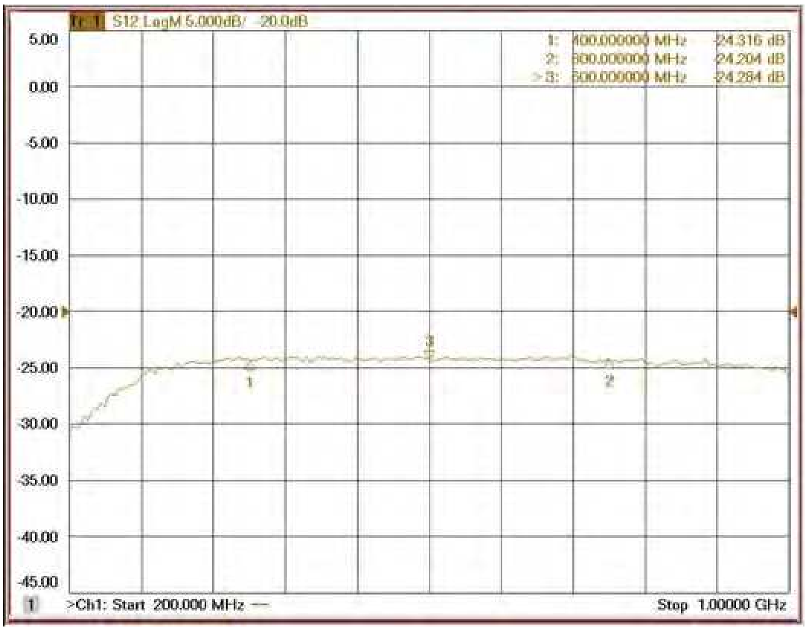
200 MHz - 1 GHz

Fig 11. Plot of forward gain

6.6 Reverse isolation



aaa-001343

200 MHz - 1 GHz

Fig 12. Plot of reverse isolation

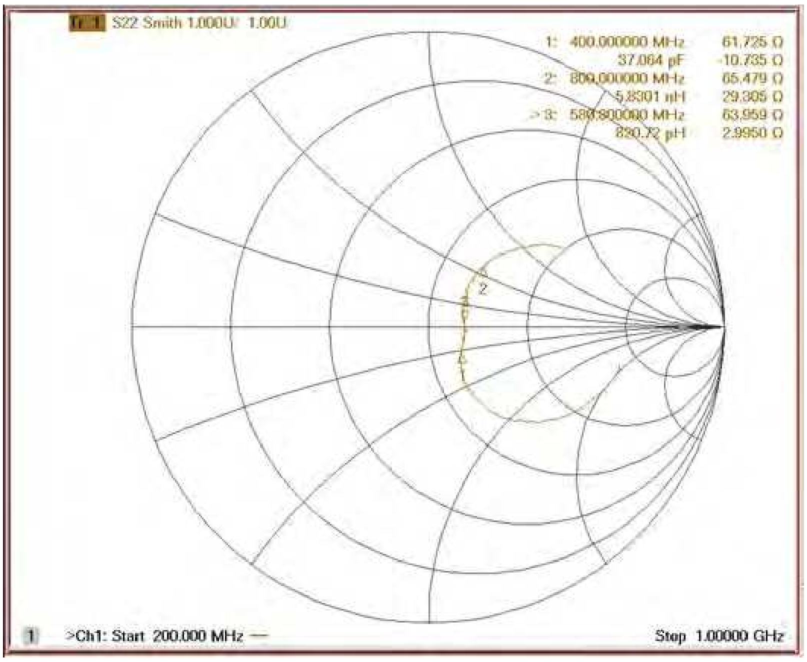
6.7 Output return loss - log magnitude

aaa-001344

200 MHz - 1 GHz

Fig 13. Plot of output return losses

6.8 Output return loss - Smith chart



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200 MHz - 1 GHz

Reference plane = input SMA connector on PC board

Fig 14. Smith chart of output return losses

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8. Tables

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