

LMX9820 to LMX9820A Conversion Guide

National Semiconductor
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1.0 LMX9820A

The National Semiconductor® LMX9820A Bluetooth™ Serial Port module is the next generation of the current LMX9820 and is pin-to-pin compatible. The LMX9820A

includes some key changes that must be considered in the system design and implementation. Table 1-1 on page 1 summarizes differences between LMX9820 and the LMX9820A.

Table 1-1. LMX9820 vs. LMX9820A

Specification	LMX9820	LMX9820A	Action Required
Crystal Tuning Circuit		Load capacitance change - see below details	Crystal Circuit Tuning
10kΩ Pull-up resistor on Reset# to VCC	10kΩ Pull-up resistor on Reset# to VCC must be used for proper reset	1kΩ Pull-up resistor between Reset# to VCC must be used for proper reset	Place 1kΩ resistor instead of 10kΩ resistor at assembly.
Substrate	LTCC (Low Temperature Co-fired Ceramic)	FR4	None
Sensitivity	-77dBm (Typical)	-82dBm (Typical)	None
Current Consumption	62mA (Typical I _{CC-RX})	43mA (Typical I _{CC-RX})	None
Low Power Modes	32.768kHz Not Supported	32.768kHz Not Supported	None
Low Power Current Consumption	2mA (Typical)	< 500 μA	None

2.0 Crystal Circuit Tuning Scope

The LMX9820A has a new crystal circuit with a different internal load capacitance than the LMX9820. This requires possible crystal tuning. Included in this application note are the details and crystals that have been tested with the LMX9820A. This is for reference and it is highly recommended that each design is carefully reviewed and tested for overall system performance in the process of converting from LMX9820 to the LMX9820A.

The RF local oscillator and internal digital clocks for the LMX9820A Serial Port module is derived from the reference clock at the CLK+ input. This reference may either come from an external clock or a dedicated crystal oscillator. The crystal oscillator connections require an Xtal and two grounded capacitors.

It is also important to consider board and design dependent capacitance in tuning crystal circuit. Equations that follow allow a close approximation of crystal tuning capacitance required, but actual values on board will vary with capacitive properties of the board. As a result, there is some fine tuning of crystal circuit that has to be done that can not be calculated, must be tuned by testing different values of load capacitance.

Many different crystals can be used with the LMX9820A. Key requirements from Bluetooth specification is ± 20 ppm. Additionally, ESR (Equivalent Series Resistance) must be carefully considered. LMX9820A can support maximum of 230ohm ESR, but it is recommended to stay <100ohms ESR for best performance over voltage and temperature. Reference Figure 3-2 on page 2 for ESR as part of crystal circuit and Section 4.0 for more information.

3.0 Xtal Mode

The LMX9820A crystal driver circuit operates with an external crystal and capacitors to form an oscillator. (See Figure 3-1 on page 2) and Figure 3-5 on page 6. The LMX9820A also can also operate with an external TCXO (Temperature Compensated Crystal Oscillator).

3.1 CRYSTAL

The crystal appears inductive near its resonant frequency. It forms a resonant circuit with its load capacitors. The resonant frequency may be trimmed with the crystal load capacitance.

1. Load Capacitance

For resonance at the correct frequency, the crystal should be loaded with its specified load capacitance, which is the value of capacitance used in conjunction with the crystal

unit. Load capacitance is a parameter specified by the crystal, typically expressed in pF. The crystal circuit shown in Figure 3-2 on page 2 is composed of:

- C1 (motional capacitance)
- R1 (motional resistance)
- L1 (motional inductance)
- C0 (static or shunt capacitance)

The LMX9820A provide some of the load with internal capacitors C_{int} . The remainder must come from the external capacitors labeled Ct1 and Ct2 as shown in Figure 3-1. Ct1 and Ct2 should have the same the value for best noise performance. Crystal load capacitance (C_L) is calculated as the following:

$$C_L = C_{int} + Ct1 // Ct2$$

The C_L above does not include the crystal internal self-capacitance C0 as shown in Figure 3-2 on page 2, so the total capacitance is:

$$C_{total} = C_L + C0$$

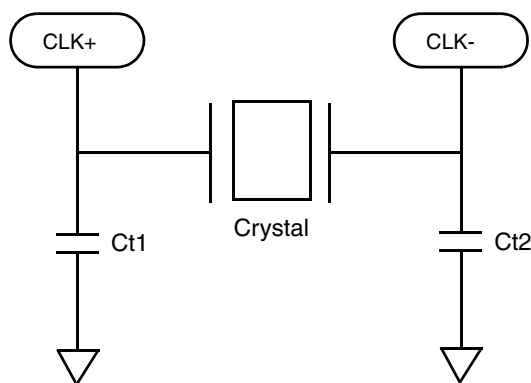


Figure 3-1. LMX9820A Crystal Recommended Circuit

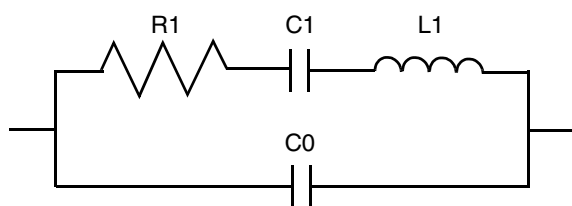


Figure 3-2. Crystal Equivalent Circuit

2. Crystal Pullability

Pullability is another important parameter for a crystal, which is the change in frequency of a crystal with units of ppm/pF, either from the natural resonant frequency to a load resonant frequency, or from one load resonant frequency to another. The frequency can be pulled in a parallel resonant circuit by changing the value of load capacitance. A decrease in load capacitance causes an increase in frequency, and an increase in load capacitance causes a decrease in frequency.

3. Frequency Tuning

Frequency Tuning is achieved by adjusting the crystal load capacitance with external capacitors. It is a Bluetooth

requirement that the frequency is always within ± 20 ppm. Crystal/oscillator must have cumulative accuracy specifications of ± 15 ppm to provide margin for frequency drift with aging and temperature.

3.1.1 Vite Crystal

The VXE4-1055 is a 12 MHz SMT crystal from Vite. National is using this crystal with the LMX9820. Table 3-1 on page 2 shows the specification of VXE4-1055.

Since the internal capacitance of the crystal circuit is 8 pF and the load capacitance is 9 pF, 10 pF is a good starting point for both Ct1 and Ct2. The 2480 MHz RF frequency offset is then tested. Figure 3-3 on page 4 shows the RF frequency offset test results.

Figure 3-3 on page 4 shows the results are 100 kHz off the center frequency, which is -4 ppm. The pullability of the crystal is 24 ppm/pF, so the load capacitance must be decreased by about 0.2 pF. By changing Ct1 or Ct2 to 9 pF, the total load capacitance is increased by 0.26 pF. Figure 3-4 on page 5 shows the frequency offset test results. The frequency offset is now zero with Ct1 = 9 pF, Ct2 = 10 pF.

Reference Table 3-2 on page 2 for crystal tuning values used on Austin Development Board with Vite crystal.

Table 3-1. VXE4-1055-12M000

Specification	Value
Package	6.0x3.5x1.1 mm - 4 pads
Frequency	12.000 MHz
Mode	Fundamental
Stability	± 18 ppm at -20 to $+70^\circ\text{C}$ (inclusive of all conditions)
Load Capacitance	9 pF
ESR	40 Ω max, 20 Ω typ
Shunt Capacitance	7 pF max
Drive Level	10 to 100 μW
Pullability	24 ppm/pF min
Storage Temperature	-40 to $+85^\circ\text{C}$

Table 3-2. VXE4-1055-12M000 on Austin Board

Reference	LMX9820	LMX9820A
Ct1	10pF	Not Recommended
Ct2	10pF	Not Recommended

3.1.2 Kinseki KSS CX-4025S

The LMX9820A has also been tested with the Kinseki KSS CX-4025S. See Table 3-3 on page 3.

Table 3-3. KSS CX-4025S

Specification	Value
Package	4.0x2.5x0.75 mm - 4 pads
Frequency	12.000 MHz
Mode	Fundamental
Stability	±20 ppm at -30 to +80°C (inclusive of all conditions)
Load Capacitance	12pF
ESR	80 Ω max, 20 Ω typ
Shunt Capacitance	3 pF max
Drive Level	100 μW max
Storage Temperature	-40 to +85°C

Reference Table 3-4 on page 3 for crystal tuning values used on Austin Development Board with KSS crystal.

Table 3-4. KSS CX-4025S on Austin Board

Reference	LMX9820	LMX9820A
Ct1	30pF	6pF
Ct2	30pF	6pF

3.1.3 TEW

The LMX9820A has also been tested with the TEW crystal. See Table 3-5 on page 3.

Table 3-5. TEW

Specification	Value
Package	4.0x2.5x0.65 mm - 4 pads
Frequency	12.000 MHz
Mode	Fundamental
Stability	> ±15ppm @-40 to +85C
Load Capacitance	16pF
ESR	80 Ω max.
Shunt Capacitance	5pF
Drive Level	50 ±10uV
Storage Temperature	-40 to +85C

Reference Table 3-6 on page 3 for crystal tuning values used on Austin Development Board with TEW crystal.

Table 3-6. TEW on Austin Board

Reference	LMX9820	LMX9820A
Ct1	56pF	10pF
Ct2	56pF	10pF

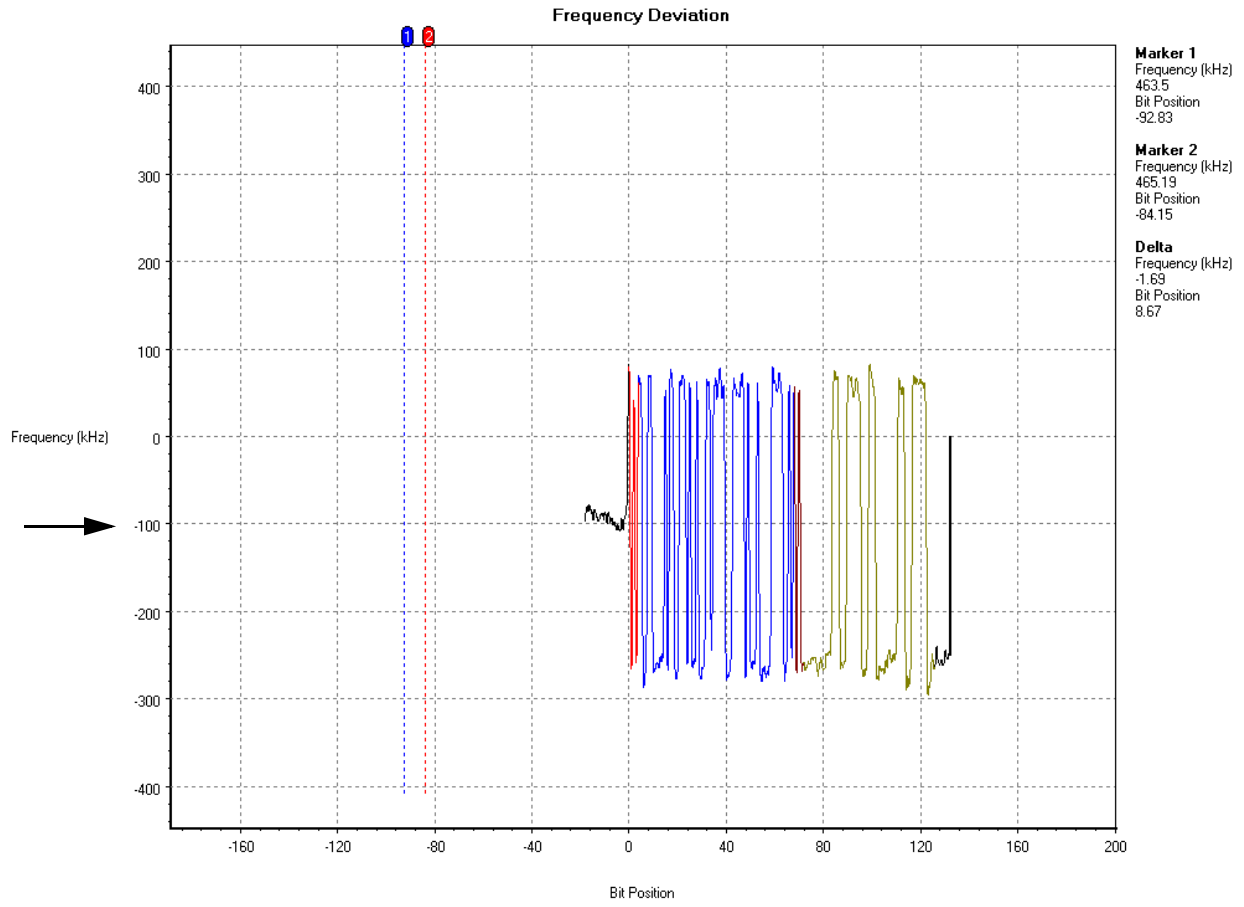


Figure 3-3. Frequency Offset with 10 pF Capacitors

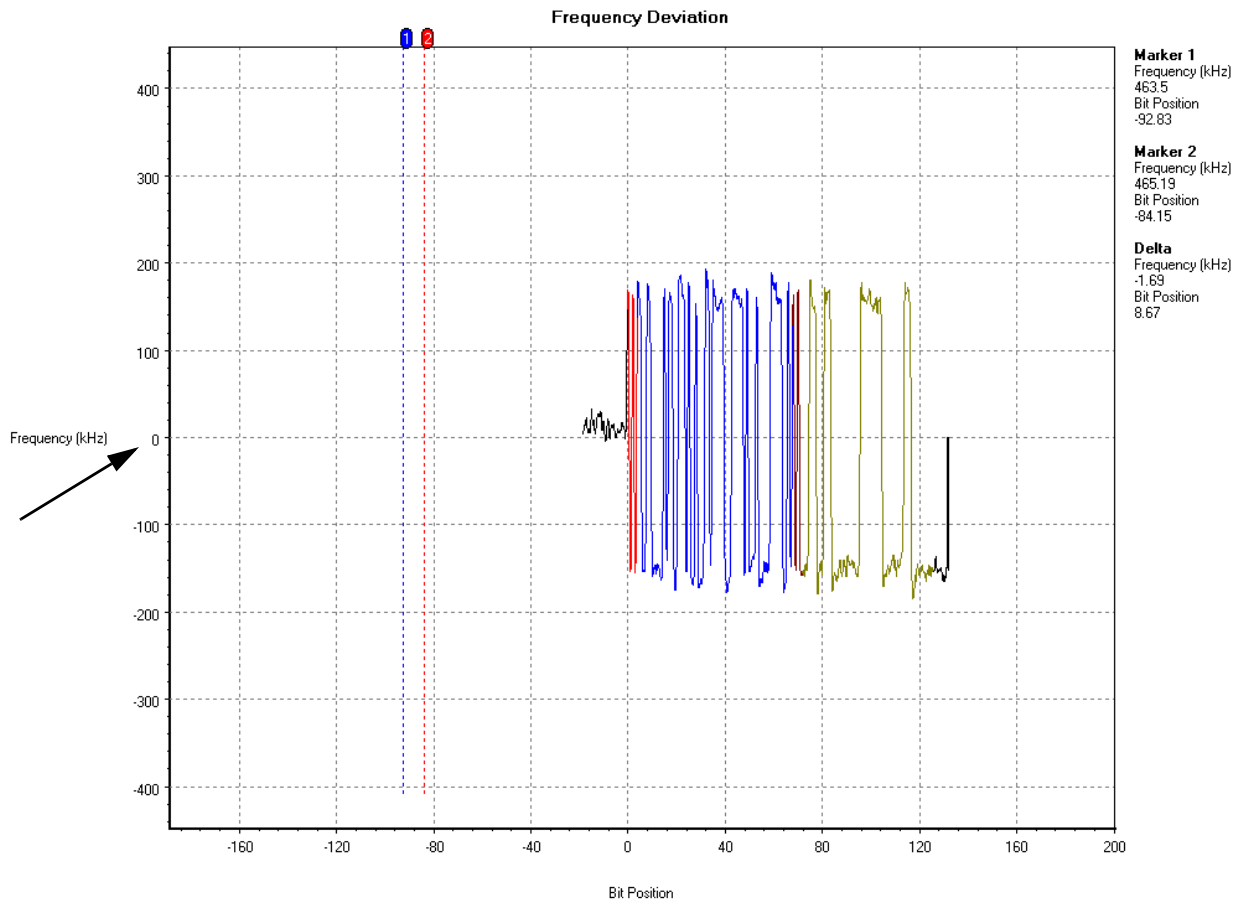
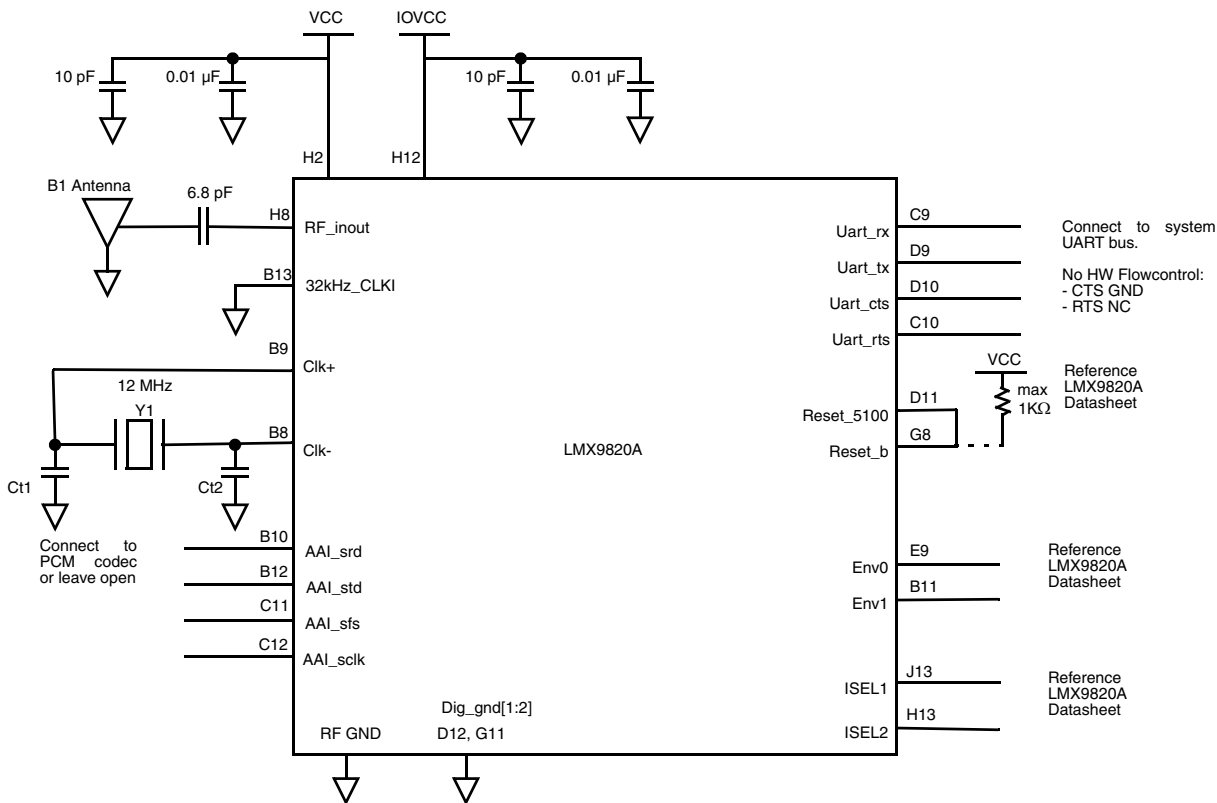


Figure 3-4. Frequency Offset with 9 pF//10 pF Capacitors



Notes:
 Capacitor values, Ct1 and Ct2 may vary depending on board design crystal manufacturer specification.
 Single ground plane is used for both RF and digital grounds.

Figure 3-5. Example system schematic with crystal

4.0 ESR (Equivalent Series Resistance)

LMX9820A can operate with a wide range of crystals with different ESR ratings. Reference Table 4-1 on page 6 and Figure 4-1 on page 7 for more details.

Table 4-1. System Clock Requirements

Parameter	Min	Typ	Max	Unit
External Reference Clock Frequency		12MHz		MHz
Frequency Tolerance (over full operating temperature and aging)		±15	±20	ppm
Crystal Serial Resistance			230	Ω
External Reference Clock Power Swing, pk to pk	100	200	400	mV
Aging			±1	ppm per year

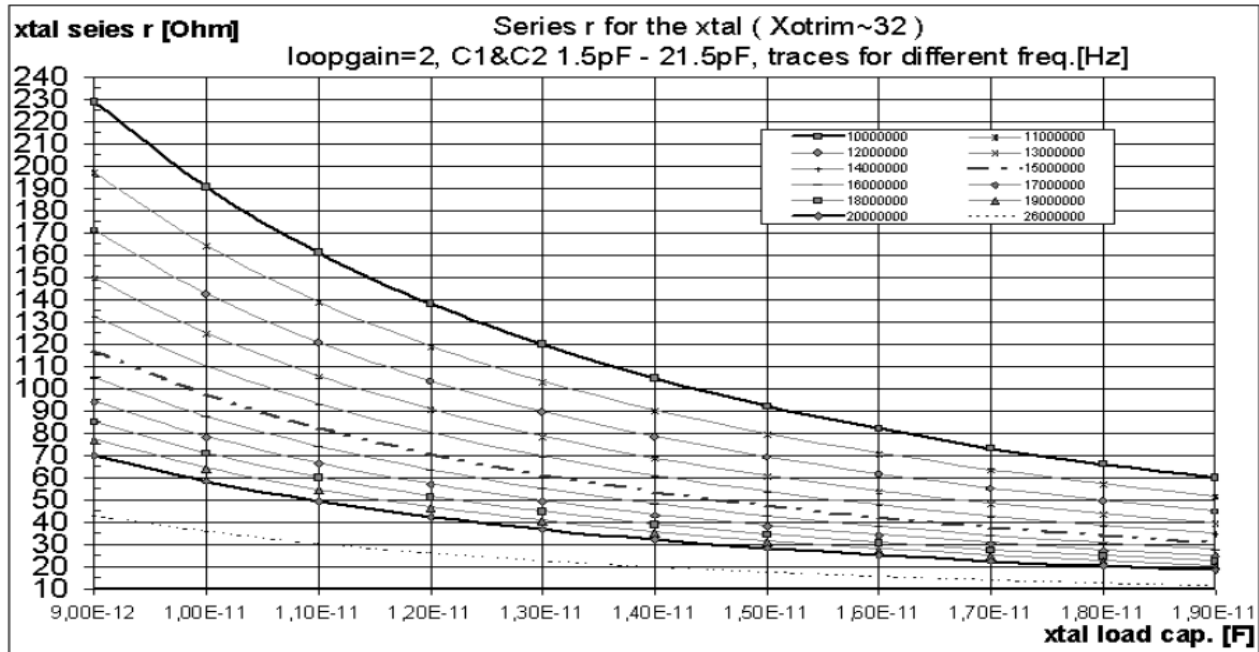


Figure 4-1. ESR vs. Load capacitance for the crystal circuit

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