

Upgrading from the MB150X to National LMX1501A: Replacement Issues

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ABSTRACT

Compatibility of the LMX1501AM with the MB1501 (std, and options H, and L) and MB1502 (in the FPT-16P-M06 package option) is inspected with emphasis on issues related to dual sourcing, or replacement of the MB150X parts with the LMX1501A. The devices are fundamentally similar, with identical (1501) or compatible (1502) pin outs, and identical programming specifications. Some key differences are found, however, which require attention. These include, package size and footprint, charge pump characteristics, loop filter configuration, and programming timing. In many cases the LMX1501A will easily replace MB150X components with few or no changes at all. This will not be true in all cases, however, particularly when data sheet programming specifications of the MB150X or LMX1501A have not been followed, or when high charge pump tuning voltages are required.

SIMILARITIES

- Architecture
- Pinout
- Operating voltage (V_{CC})
- Programming content, format, and levels
- Temperature range
- RF fin sensitivity and impedance

DIFFERENCES

- Package Size/Footprint
- Charge pump magnitude, balance, deadband
- Charge pump maximum supply voltage
- Loop filter configuration
- Programming timing. (Faster, t_{ES})
- I_{CC} vs V_{CC} dependency

COMMON ELEMENTS

The LMX1501A and MB1501(H/L)—2 have a great deal in common. Both devices consist of 1.1 GHz programmable prescalers with an option of 64/65 or 128/129 dual modulus division. Both have a reference divider channel. Both have an internal phase detector and charge pump circuit, and outputs which allow use of an external charge pump circuit. The MB1501 and the LMX1501A share pinout and definitions, and the LMX1501A and MB1502 have compatible pinouts, shown in Figure 1. The components operate over the same temperature and voltage ranges (except the MB1502 operates only at 5V) and are programmed with the same information in the same format. For all these similarities, there are a number of key distinctions. This application note is focused on those issues which are relevant to replacing the MB150X with the LMX1501A. This means that certain performance improvements in the LMX1501A are not listed at length, and no effort is made to compare and contrast the parts generally. Full specifications are available in the LMX1501A data sheet—Lit. # 108500.

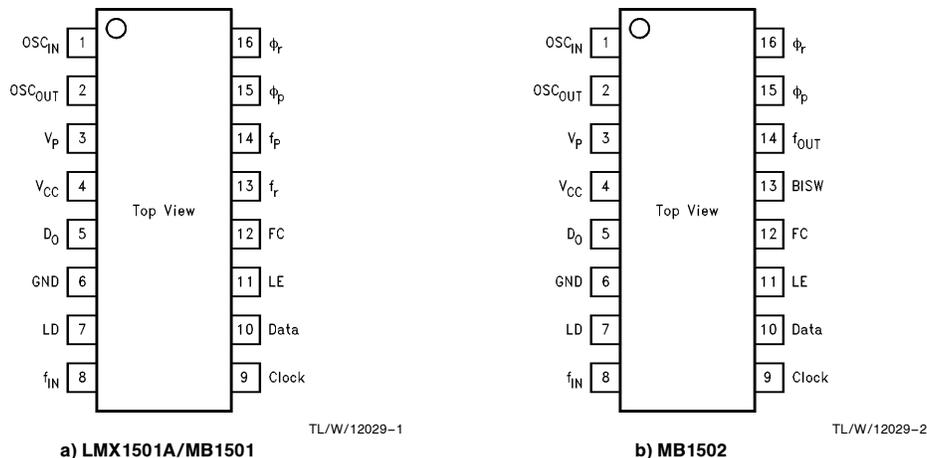


FIGURE 1. Pinouts

PHYSICAL DIFFERENCES

Footprint. The MB1501 and MB1502 are packaged in a EIAJ standard SO 16. This package has a pin to pin pitch of 0.050 in. with a **body width of 0.209"**. The NSC LMX1501A is packaged in a standard JEDEC SO 16, which has the same pin to pin pitch, but a **body width of 0.153"**. *Figure 2* shows an overlay of the JEDEC package on a PCB showing (typical) EIAJ solder pads. *Figures 3 and 4* show the dimensions of the two packages. Re-layout of the PCB is advisable, but probably not mandatory. Although not optimal, lengthening the solder pads by 0.35" will accommodate both package types. **Corrective action:** re-design the PCB using a smaller footprint.

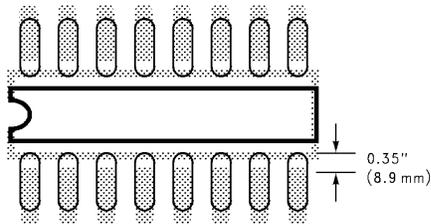


FIGURE 2. Footprint Overlay

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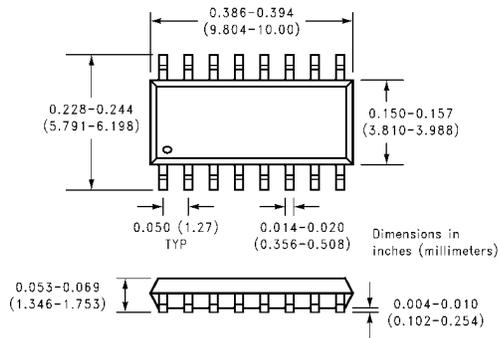


FIGURE 3. LMX1501A Outline Drawing

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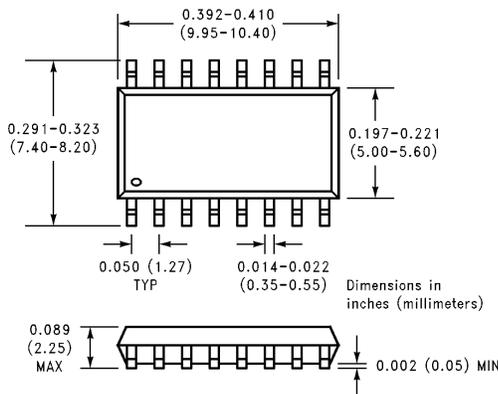


FIGURE 4. MB150X Outline Drawing

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Loop Filter Configuration. *Figure 5* shows a loop filter topology which is often found with MB150X components. It is unusual in its placement of a series resistor before the integrating capacitor. This resistor effectively causes the voltage at the charge pump (CP) output to increase instantaneously as the CP delivers large current pulses. For the MB150X, since the sink current is much higher than the source current, the delivered pump up current is limited by this resistor, which makes the negative frequency lock time increase. Because of the low output of the MB150X charge pump source current, the series R does not noticeably degrade performance, and it allows an additional lowpass filter function to cope with the large spurious response caused by time and current imbalance. The LMX1501A, however, with a balanced CP design, is sensitive to this resistance. It causes current limiting in the CP output, D_O , which decreases the phase detector gain. This effect is most noticeable in large frequency steps or steps towards the high end of the tuning range. Fortunately, this resistance can be removed with no ill effect. The dramatically lower spurious content of the LMX1501A eases the filter requirement substantially. **Corrective Action:** remove and short the series resistor at D_O .

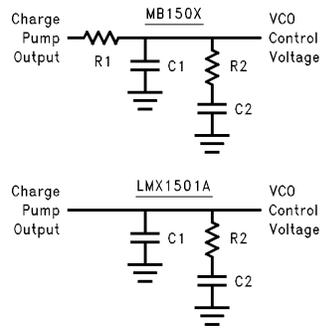
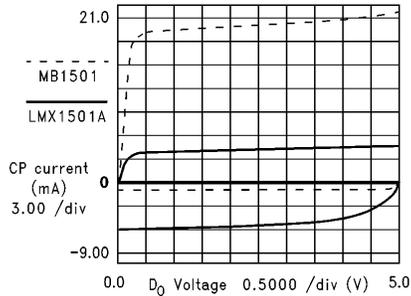


FIGURE 5. Loop Filters

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ELECTRICAL DIFFERENCES

Charge pump output magnitude and balance of the source and sink currents can be seen in Figure 6. Laboratory measurements of the LMX1501A/MB1501 sink and source currents using an HP4145A Semiconductor Parameter Analyzer are shown for $V_{CC} = V_{PP} = 5V$.



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FIGURE 6. Charge Pump Magnitude and Balance

Clearly, from the sample tested, the LMX1501A has better balance between the sink and source currents. The positive and negative lock times are therefore nearly equivalent, and the spurious energy is greatly reduced. Since the overall magnitude of the charge pump currents are markedly different, the PLL dynamics will change due to the change in the closed loop gain. In order to take full advantage of the superior performance of the LMX1501A charge pump, loop filter component values should be optimized corresponding to the LMX1501A phase detector gain. If an external charge pump implementation is used, no modification is necessary. **Corrective Action:** Optimize component values for appropriate loop gain.

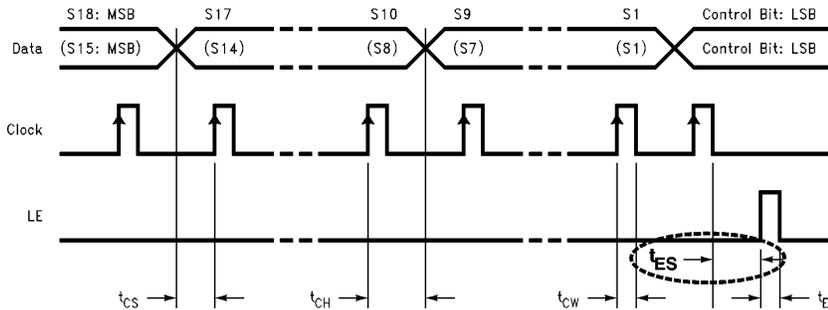
Max voltage on the internal (D_0), and external (ϕ_r , ϕ_p) charge pump of the MB150X is 10V, and 6V for the LMX1501A. Although the bulk of applications, do not require VCO tuning voltages above 5V, certain systems use higher V_{CC} 's. The LMX1501A cannot attain voltages higher than 6V because of the N-channel breakdown voltage. For the charge pump of the LMX1501A to drive voltages greater than 6V one may use an active loop filter to provide the DC gain needed. Unfortunately, this is a redesign, and reduces the tuning sensitivity of the PLL. **Corrective Action:** If $V_p < 6V$, No Action needed.

SOFTWARE COMPATIBILITY

If the specifications for the MB150X for the data timing are met, the LMX1501A will also program correctly, since the programming protocol is identical. If t_{ES} , the clock to enable set-up time, equals 0 ns, then the LMX1501A will not program correctly, while the MB15XX will continue to function out of spec. The data input timing of the LMX1501A is more than fast enough to accept MB150X programming, since the specification for setup and hold times are ≥ 50 ns, and the MB150X specification calls for setup and hold times of $\geq 1 \mu s$. **Corrective Action:** Make sure Clock returns to a low state before the rising edge of Load Enable.

ADDITIONAL NOTES

The major differences between the LMX1501AM and the MB150X that merit attention when replacing or dual sourcing have been discussed. Although the user may realize additional performance advantages from the LMX1501A, such as power dissipation, phase noise, lock time, and spurious performance, these are not discussed in depth, with the emphasis put on fundamental similarities and differences in the functional operation of the parts. With attention to the package size, loop filter, and programming, the LMX1501A will easily replace the MB150X series for many applications.



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FIGURE 7. Data Input Timing

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