

Electromagnetic Interference (EMI) Solutions

EMI is generated from various portions of crystal oscillation circuit. Those portions should be clarified, and EMI level can be lowered by designing printed circuit board (PCB) which includes solutions to decrease it.

1. EMI generating points

(1) The inside of IC

EMI is also emitted from the inside of IC.

(2) PCB traces

Long PCB trace which connects IC and components such as quartz crystal units and capacitors behaves as an antenna and the degree of EMI level increases, and high amount of EMI is radiated from trace *2 of the OUT pin of the inverter. Negative resistance will also unfavorably decrease if traces of IN and OUT are lengthened in parallel as shown in the figure.

(3) Quartz crystal units

The sign waveform of oscillation frequency appears on the electrode of an oscillating quartz crystal unit. Generally the waveform on the IN side of the oscillation circuit is close to sine wave and EMI level is quite low. On the OUT side, however, noise level is rather high since the waveform close to square wave which contains a lot of harmonics.

(4) The ground line of PCB

If the impedance of the ground line is high, radiated EMI level will be rather high.

(5) The power supply line of PCB

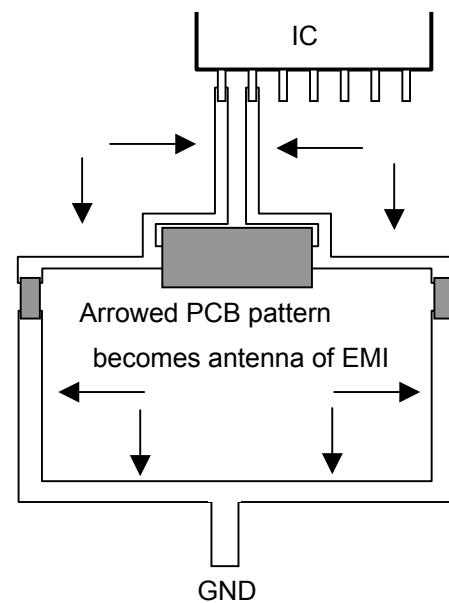
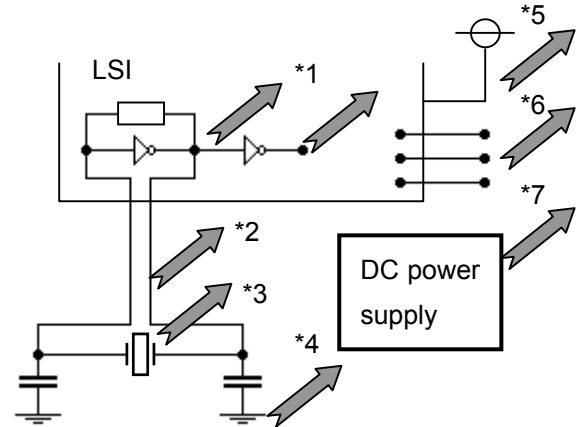
A power supply line is at the same potential with the ground line in alternating current signals. If the impedance of the power supply line becomes high, it will become an antenna which radiates EMI.

(6) The output port of LSI

The data output port of LSI also radiates EMI.

(7) Direct current power supply line

If high frequency noise is contained in the output of power supply, a crystal oscillation circuit and other functional circuits will be modulated by the noise, and EMI level generated from these circuits increases. Also, oscillation signal of crystal oscillation circuit will appear on a power line if the impedance of the power line is high, and the power line becomes an antenna and EMI will be radiated.

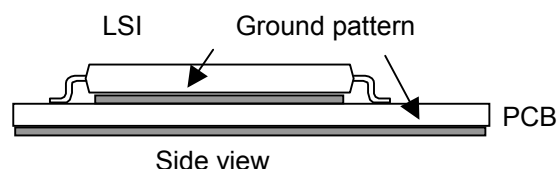


2. EMI Solutions

Since the oscillation waveform on the IN side of the Pierce crystal oscillation circuit using a C-MOS inverter exhibits a waveform similar or equal to sign wave, harmonics generated from this portion are minimal. On the other hand, the waveform on the OUT side of the inverter is square or distorted square wave, it contains a lot of harmonics. PCB trace connected to this portion becomes an antenna, and radiates EMI.

(1) EMI solution for the noise generated from the inside of LSI

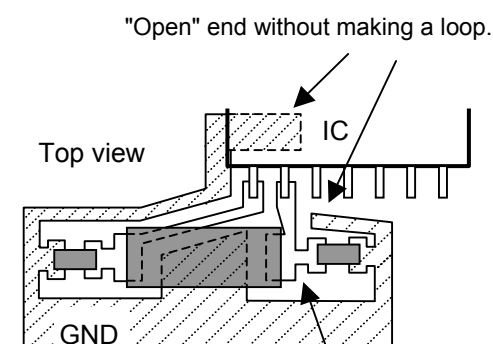
By designing a field ground under LSI, it is possible to decrease EMI radiated under LSI.



(2) EMI generated from PCB traces

As shown in the figure, PCB should be designed with the shortest trace length so that the trace connecting components such as a crystal unit and capacitors with LSI does not become an antenna which radiates EMI.

Furthermore, it is also effective to shield the signal pattern area of oscillation circuit with a ground pattern. However, one should be careful upon designing PCB, since negative resistance will decrease if these traces are routed too close. Also, it is important to design ground pattern not to make a loop by leaving the trace end open.



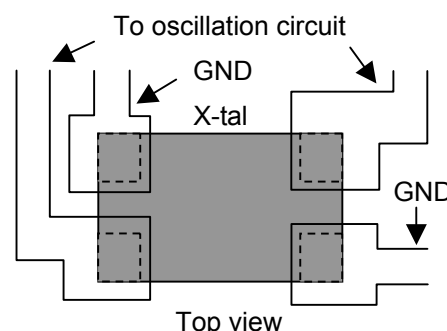
The pattern of OUT terminal needs to be designed the shortest.

Since high amount of EMI is radiated from the line connected to the OUT terminal of the inverter oscillation part, it is important to design this pattern length shortest. The waveform of the IN terminal of the inverter is a sign wave in most cases, the level of EMI is low. The increases of EMI arising by PCB pattern of the OUT terminal becoming longer than the pattern of the IN terminal is much less compared with the case when the pattern of the OUT terminal is lengthened.

Please refer to "Precautions on PCB design".

(3) EMI radiated from quartz crystal units

In SMD crystal units with metal cap (CX-2520SB, CX-3225SB, KSX-23, CX-4025S, CX-96F, KSX-35, KSX-36, CX-91F), EMI level radiated from the cap of a crystal unit can be decreased, if these terminals are connected to ground since #2 and #4 terminals are internally connected to the metal cap.



As for the leaded type quartz crystal units, oscillation signal appears in a metal case, and they are radiated as EMI.

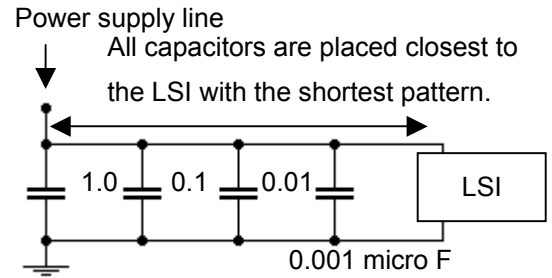
Please use crystal unit "CX-49L" equipped with a metal jacket to connect a metal case to ground decreasing radiated EMI level.

(4) EMI radiated from the ground line

If the layout of the ground pattern on the capacitor end is long and thin, it will become an antenna for the portion radiating EMI, and PCB needs to be designed so that they should be connected to the ground line with the shortest length. Please refer to (2) on the above.

(5) EMI radiated from the power supply line

It is effective to insert bypass capacitors with several values of different self-resonance frequencies so that the impedance of a power supply line shall not become high in wide frequency range. Usually, bypass capacitors are connected with the shortest length closest to the power supply terminal of LSI as shown in the right hand side figure. It is very effective to insert these capacitors in several places in PCB with long power supply line.



A bypass capacitor is required for each power supply line when LSI needs several power supply voltages. Large value capacitors such as several micro farads are usually used for low frequency noise, but the care should be taken since regulator IC itself may oscillate if capacitors with large values are connected to the output terminal of regulator IC. Furthermore, it is effective to use EMI filters to suppress EMI radiated from the power supply line.

(6) EMI radiated from the data output port

Line filters may be used depending on the form of data. If it is not possible, it is effective to shield the area of data transmission line, and shield the other side of PCB by the ground pattern. Unused ports should be terminated with adequate impedance indicated in the LSI manual.

(7) EMI radiated from the power supply unit

In order to lessen EMI radiated from a direct-current power supply circuit, it is effective to shield the circuit with a metal cover or equivalent.

3. Oscillation circuit structure and selection of circuit constants to decrease EMI.

(Measure to lessen harmonics)

The amount and level of EMI change depending on oscillation waveforms, and EMI decreases the most with sine wave. Since the oscillation waveform of the IN terminal of the inverter is close to sign wave, harmonics generated from this terminal are little in the C-MOS inverter crystal oscillation circuit. However, square wave of the OUT terminal which the sign wave of the IN terminal is amplified contains many harmonics. It is possible to decrease the distortion of the oscillation waveform of the OUT terminal and to decrease EMI by the following method.

(1) Decrease the amount of the quantity of the electric charge which is charged and discharged in C2 using Rd and Rx. It is necessary to check that it satisfies the target value of design by circuit examination while selecting proper resistance values, since negative resistance of oscillation circuit decreases and oscillation starting time becomes long.

(2) Use extremely small value compared with C1 and C2.

If the capacitance of the OUT side is made small compared with the IN side, values such as C1=22pF and C2=5pF for example, the distortion of the waveform of the OUT terminal and EMI level will decrease. However, if the capacitance of the OUT side is made excessively small, the amplitude level will become low, and it is necessary to confirm that the OUT level is sufficient to drive the circuit of the following stage.

