Possible solutions for reducing or eliminating MLCC ringing – singing issues

- Modified PCB materials or layout (page 3)
- Lower K Dielectric MLCCs (page 4)
- SMT Film Capacitors (pages 5 ~ 16)
Piezoelectric effect in MLCCs (Multilayer Ceramic Chip Capacitors)

MLCCs (Multi Layer Ceramic Capacitor) have several advantages
- low Equivalent Series Resistance (ESR)
- low Equivalent Series Inductance (ESL)
- small size
- non-polarized

A disadvantage of the MLCC can be the piezoelectric nature of the ceramic material. MLCCs are made from ceramic dielectrics (which have ferroelectric properties), which can exhibit problematic or disruptive noise (ringing or singing) due to oscillations with PCB.

Contributors to Ringing – Singing Noise in circuits using MLCCs:
- Operating frequency of signal (or harmonics) within the audible range (20Hz – 20KHz)
- Operating voltage ... higher signal voltage produces higher SPL (sound pressure level)
- Ceramic dielectric constant (K) ... Higher K ceramics exhibit higher ferroelectric properties
- Ceramic layer thickness ... Higher voltage rated MLCVC have thicker ceramic layers and typical exhibit lower SPL

Images from EE Times - April 2012
"Reducing MLCCs’ piezoelectric effects and audible noise"
by Nicolas Guibourg, Texas Instruments Germany

www.NICcomp.com | Page 2
Piezoelectric Noise

Contributors to Ringing – Singing Noise in circuits using MLCCs:

PCB = Printed Circuit Board

- PCB material and thickness ... The thicker the PCB, more resistant it is to deformation and the lower SPL it produces
- PCB layout
  - MLCC capacitor placed at the edge of the PCB will be preferred (lower SPL) to placement away from edge of PCB.
  - Placed next to each other, MLCC capacitors generate higher overall SPL (+14 dB between a single capacitor and three placed in parallel).
  - On the contrary, when placed symmetrically on each side (opposite sides) of the PCB board as shown in below figure, MLCC capacitors tend to cancel out each other’s vibrations.

*Oscillation effects reduced when mounting MLCCs symmetrically opposite one another*

*Slit in PCB added under MLCC can help to reduce coupling to PCB and reduce SPL*

Image from EE Times - April 2012
"Reducing MLCCs’ piezoelectric effects and audible noise" by Nicolas Guibourg, Texas Instruments Germany
Potential Remedies

Goal: Reduce SPL to acceptable levels

• Use MLCC with lower dielectric constant \( (K) \)

• Replace high \( K \) dielectrics \( Y5V / X5R / X7R \) with NPO dielectric (low \( K \))

• Below table shows maximum capacitance values for 50V, 100V and 250V rating in NPO dielectric MLCCs

(3-digit capacitance code & corresponding capacitance value) for 0402 case size to 2225 case size

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<th>0402</th>
<th>0603</th>
<th>0805</th>
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<td>(0.022uF)</td>
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<td>(0.082uF)</td>
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NSPH Series - SMT Film Chip Capacitors

- Page 6 - Introduction
- Page 7 – CV Sizes
- Page 8 – Construction & Advantages
- Page 9 - Voltage Coefficient Comparison
- Page 10 - Temperature Coefficient Comparison
- Page 11 - Leakage Current Comparison
- Page 12 – Low Noise (distortion) Comparison
- Page 13 – Dielectric Absorption Comparison
- Page 14 – CV Sizes Compared to MLCCs
- Pages 15 & 16 – Applications & Replacing LDD types
NSPH series, High Capacitance SMT Film Chip Capacitors

NIC Components is pleased to announce the addition of NSPH series of High Capacitance Multilayer Polymer Film SMT Chip Capacitors. Supplied in four EIA surface mount cases sizes; 1206, 1210, 1812 & 2220 in capacitance values from 0.1uF to 22uF with voltage ratings from 16V ~ 63VDC (11V ~ 45Vrms). NSPH series is rated for operating temperatures of -55°C to +125°C with typical capacitance change within ±5% of 25°C capacitance value.

NSPH series is RoHS compliant and is halogen free. Supplied tape and reel packaged, for high speed automated placement and compatible with high temperature Pb-Free alloy soldering (+260degC soldering heat rated). NSPH unit pricing range from $0.39 ~ $1.09 with production lead times of 8 to 10 weeks. Please contact NIC today for Free component samples and to review your requirements.

Features:
- High Capacitance in Small Case Sizes
- Stable Cap Value over Voltage, Temperature & Time
- Low Noise for Digital Audio Streamer applications
- Reduce or eliminate MLCC Piezoelectric Effects
  - Capacitor singing or ringing effects
- Low Dielectric Absorption for use in A to D applications (10X ~ 20X improvement over X7R MLCCs)
- Self healing construction (open mode failure)
  - Free of component cracking failures (MLCC weakness)
- High IR; low leakage current performance (compared to high cap X5R MLCCs)
- Replace large leaded film capacitors with small low profile (low ESL) SMT chip
- RoHS compliant and Halogen Free
### SMT Film Chip Capacitors; Series & Case Sizes

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<thead>
<tr>
<th>Voltage Rating (VDC)</th>
<th>NSWC 1206~1210</th>
<th>NSWC 1913</th>
<th>NSWC 2416</th>
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<th>NSWC 2820</th>
<th>NSWC 3022</th>
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</table>

#### NSPH series
High Capacitance SMT Film Chip Capacitors

- High Capacitance
- Reduced Case Sizes
- High Voltage @ >1μF

### Capacitance Value

- < 0.01uF
- 0.01uF
- 0.022uF
- 0.047uF
- 0.1μF
- 0.22μF
- 0.47μF
- 0.68μF
- 1.0μF
- 1.5μF
- 2.2μF
- 3.3μF
- 4.7μF
- 6.8μF
- 10μF
- 15μF
- 22μF

NSPH - High Capacitance SMT Film Chip Capacitors

**CONSTRUCTION**

<table>
<thead>
<tr>
<th>Part</th>
<th>Materials</th>
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<tbody>
<tr>
<td>1  Capacitor Element</td>
<td>Acrylic base polymer film</td>
</tr>
<tr>
<td>2  Internal Electrode</td>
<td>Vapor deposited aluminum</td>
</tr>
<tr>
<td>3  First Termination Layer</td>
<td>Copper alloy</td>
</tr>
<tr>
<td>4  Second Termination Layer</td>
<td>Conductive paste</td>
</tr>
<tr>
<td>5  Third Termination Layer</td>
<td>100% Sn (tin) plating</td>
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</tbody>
</table>

NSPH is ideal for use in green power, network infrastructure, instrumentation, high-end audio, digital audio streaming equipment and audio DAC applications.

**NSPH** series have many advantages over high capacitance MLCCs (X5R & X7R) capacitors:

- Higher voltage ratings (15uF & 22uF)
- **Stability over voltage, temperature** and time
- The low loss film construction is **free from piezoelectric noise** (MLCC distortion)
- Free from MLCC cracking failures
- Superior **low leakage current characteristics** for green power applications (high efficiency)
- **Low dielectric absorption** characteristics, *10X ~ 20X improvement over X7R MLCCs*
- **Open-mode failure** advantage of NSPH series, compared to short-circuit failure mode of MLCC capacitors.
NSPH - High Capacitance SMT Film Chip Capacitors

NSPH stability advantage over high capacitance MLCCs capacitors

- Stable Capacitance value with applied VDC
- NSPH
- Stable Capacitance value with applied VDC
- NSPH
- 70% Capacitance decrease due to applied VDC
- X7R MLCC

Specifications:
NSPH105M35V1210TRF
1.0uF / 35V SMT Film Capacitor / 1210 Case Size

Ceramic Capacitor
1.0uF / 50V SMT X7R MLCC / 1210 Case Size
NSPH advantage over high capacitance MLCCs capacitors

Typical Capacitance vs. Temperature (NSPH vs. MLCC)

- Capacitance Increase with Increasing Temperature
- Capacitance Decrease with Increasing Temperature
**NSPH** lower leakage current advantage compared to high capacitance MLCCs capacitors

<table>
<thead>
<tr>
<th>Type</th>
<th>IR Insulation Resistance</th>
<th>22uF Capacitor Leakage Current @ 5VDC Operation</th>
<th>Using 4 Capacitors Energy Loss due to Capacitor LC</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>NSPH Film Cap</strong></td>
<td>&gt; 300MΩ • μF</td>
<td>0.37 uA</td>
<td>up to 1.5 uA</td>
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<tr>
<td>MLCC X5R &amp; X7R</td>
<td>“&gt; 50Ω • F”</td>
<td>2.2uA</td>
<td>up to 8.8uA</td>
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</table>
**NSPH** - High Capacitance SMT Film Chip Capacitors

**NSPH** lower distortion advantages over high capacitance MLCCs capacitors

**NSPH**

1uF, 35V, 1210 size **NSPH** SMT Film Capacitor

Signal to Noise

THD+N (%)

Class D Audio Amplifier

Low Pass Filter Application

Yellow = 1 Watt

Blue = 10 Watt

Green = 50W

Red = 100W

Ultra Low Noise < 0.01%

INCREASED noise >0.1%

**X7R MLCC**

1uF, 50V, 1210 size **X7R** MLCC Ceramic Capacitor

THD+N is a sum of harmonic distortion components and noise
**NSPH** lower dielectric absorption advantages over high capacitance MLCCs capacitors

**Dielectric Absorption Comparison**
Typical Performance 0.47uF & 10uF X7R MLCC compared to NSPH series 1.0uF & 10uF Film Chip Capacitors

- **MLCC 10uF / X7R**
- **MLCC 0.47uF / X7R**
- **NSPH Film Cap 10uF**
- **NSPH Film Cap 1.0uF**

**10X ~ 20X improvement**
### SMT Ceramic MLCC Capacitors; TCs & Case Sizes

<table>
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<th>Voltage Rating (VDC)</th>
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### Capacitance Value

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<tr>
<td>47uF</td>
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<tr>
<td>100uF</td>
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</table>

Please review to assure NSPH meets circuit voltage and current requirements of circuit.
NSPH - High Capacitance SMT Film Chip Capacitors

NSPH series, SMT Film capacitors contribute to “excellent sound reproduction and very low distortion” ... in Audio Streamer products, decoding FLAC, WAV, MP3 and Ogg Vorbis digital audio files using ARM Cortex-M4 embedded processor

100nF (0.1uF) / 1206 / NSPH/20% / 50V = PN: NSPH104M50V1206TRF

10uF/1812/NSPH/20%/16V = PN: NSPH106M16V1812TRF

Applications:
- High-End Audio
- Digital audio streaming and audio DAC applications
- Battery Powered: Handheld & Portable Devices
- Green Power
- Test & Instrumentation
- Network Infrastructure
NSPH - High Capacitance SMT Film Chip Capacitors

Circuit Redesign & Downsize

Small SMT type NSPH series can replace large leded polypropylene film capacitors
* Please review to assure NSPH meets circuit voltage and current requirements of circuit

EIA surface mount cases sizes
- 1206 (3.2mm x 1.6mm x 1.6mm)
- 1210 (3.2mm x 2.5mm x 2.2mm)
- 1812 (4.5mm x 3.2mm x 2.8mm)
- 2220 (5.7mm x 5.0mm x 2.8mm)

Downsize from large radial leaded film capacitor in **18mm x 18mm x 9mm size**
  to small SMT film capacitor in **5.7mm x 5.0mm x 2.8mm size**

![Capacitor Image]
- Capacitance = 10µF
- Voltage Rating AC = 40V (63VDC)
- Dielectric Material = Polyester
- Package / Case = Radial Box Type
- Size / Dimension L x W = **18.0mm x 9.0mm**
- Height (Max) H = **17.5mm**
- Lead Spacing LS = **15.00mm**
Additional Information Needed?

Need Samples?

Technical Support: tpmg@niccomp.com
Sales Support: sales@niccomp.com

NIC Components offers unique performance passive components that provide advantages to design engineers to create high performance end products in smaller and lower total cost formats

• Surface Mount SMT formats (high speed auto placement)
• Pb-Free Reflow Compatible (high temperature reflow)
• Performance advantages over competing technologies