CrystalFree™ Oscillators: Redefining Cost and Performance of Timing Devices

Embedded World Forum
Nürnberg, Germany
Thursday, March 1, 2012

Michael S. McCorquodale, Ph.D.
General Manager, Silicon Frequency Control
Integrated Device Technology (NASDAQ: IDTI)
michael.mccorquodale@idt.com
www.idt.com/go/CrystalFree
DEVICES FOR FREQUENCY CONTROL AND TIMING
All Products Require Frequency Sources

Portable
Storage
Computing
Communications

Industrial
Medical
Security

$5B per Year Timing Investment

Companies are Seeking to Leverage New Timing Technologies to Remain Competitive
In either approach, quartz is the frequency reference.
Need for a Better Frequency Source

CHALLENGES OF QUARTZ FOR DESIGNERS

**Active (XO)**
- Expensive
- High Power Consumption
- Start-Up Issues
- Perturbation Issues
- Frequency Jumps
- Long Lead Times

**Passive (XTAL)**
- Complex Board Design
- Susceptible to Noise
- Start-Up Issues
- Low Performance
- Frequency Jumps
- Unbounded Accuracy
- Long Lead Times
CRYSTALFREE™ SOLID-STATE OSCILLATOR TECHNOLOGY
CrystalFree™ Oscillator Technology

Unprecedented RF & Analog Circuit Design
Precision Enabled by RF-CMOS

- Advent of RF CMOS enables high-Q LC oscillators
- Thin-film caps enable <10ppm freq. trimming
- Precision analog design compensates TC
- RF design enables low power and low noise
- Reference is at 4GHz and divided to app. freq.

Proprietary Wafer-Scale Faraday Shield Technology

- Proprietary Faraday shield technology enables high frequency stability (low ppm) in plastic packages over all environmental conditions by isolating the silicon from the package
- Wafer-scale process enables low cost

Test Infrastructure Including Massively Parallel Probe Technology

- Every single device must be frequency-trimmed and temperature-compensated for low ppm
- Custom-developed massively-parallel probe (126-site/touch) and software technology enables very high test throughput and negligible test cost
Over a decade of design, assembly and test development has enabled the most significant revolution in frequency control in over 5 decades: Solid-state oscillators can and are replacing quartz *en masse*.
CrystalFree™ Oscillator Solution

Surpassing Quartz on Any Dimension

LOWER COST
- Standard Semiconductor Process
- Mass Market Plastic Packages

HIGHER PERFORMANCE
- Highest Accuracy
- Low Noise and Power Usage
- Semiconductor-Grade Reliability
- Shorter Lead Times and Production Ramps

Established and Proven
- 10s of Millions of Units Shipped

Leading Worldwide Patent Portfolio
- 35+ Issued and Pending
±100ppm Total Frequency Accuracy from -20 to 70°C

2ps\text{RMS} Phase Jitter Integrated from 12kHz to 20 MHz

Unloaded Power Dissipation Is ~2mA from a 1.8–3.3 V Supply
One of the Lowest Power Broadband Frequency Sources
3C Series: Lowest Power Broadband Oscillator

Power (mA): Unloaded CMOS Output

<table>
<thead>
<tr>
<th>MHz</th>
<th>Epson TCO-710</th>
<th>Fox F130</th>
<th>SiLabs Si500</th>
<th>SiTime SiT8004</th>
<th>Epson SG-210</th>
<th>Fox F210</th>
<th>CrystalFree 3C Series</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.5-75</td>
<td>20.0</td>
<td>15.0</td>
<td>12.0</td>
<td>8.5</td>
<td>7.0</td>
<td>5.0</td>
<td>2.5 4-133</td>
</tr>
<tr>
<td>1-80</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1-200</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>125-150</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>50-80</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1-50</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4-133</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Frequency Control   CrystalFree™ Oscillators   Product Portfolio   Summary   Questions & Answers

www.IDT.com

Embedded World Forum, March 1, 2012
**3L Series: ±50ppm Differential Oscillator**

- ±50ppm Total Frequency Accuracy
- Differential Output; LVDS, LVPECL, HCSL
- <1ps$_{RMS}$ Phase Jitter Integrated from 12kHz to 20 MHz
- Unloaded Power Dissipation Is 11mA (LVDS) from a 2.5 or 3.3V Supply
3L Series: Low-Power Diff Out Oscillator

Power (mA): Unloaded LVPECL Output

- Epson EG-221: 120 mA
- Fox FXO PC-73: 120 mA
- Ecliptek E13/15: 100 mA
- Kyocera KC-7050: 90 mA
- SeRemix/Pericom PB/PX/SH: 88 mA
- TXC BB/BF Series: 82 mA
- CrystalFree 3L Series: 34-125 MHz

Frequency Control | CrystalFree™ Oscillators | Product Portfolio | Summary | Questions & Answers
--- | --- | --- | --- | ---
www.IDT.com
PAGE 15 of 32
Embedded World Forum, March 1, 2012
PRODUCT PORTFOLIO
CrystalFree™ Solid-State Oscillator Portfolio

PACKAGED PRODUCTS

Active (XO Replacement)

±100ppm CMOS to ±50ppm Differential

Passive (XTAL Replacement)

±50ppm (initial) to ±30ppm (initial)

INTEGRATED DIE PRODUCTS
Active (Crystal Oscillator (XO) Replacement)

- 3C Series with ±100ppm frequency accuracy and CMOS outputs
- 3L Series with ±50ppm frequency accuracy and differential outputs

Lower Power, Better Performance, Best Price
Ease of XO Replacement

CrystalFree™ Oscillators Are Drop in Replacements for Industry-Standard XOs

STANDARD 4 PIN
- 7 x 5mm
- 5 x 3.2mm
- 3.2 x 2.5mm
- 2.5 x 2mm
- 2 x 1.6mm

STANDARD 6 PIN
- 7 x 5mm
- 5 x 3.2mm

CrystalFree™ Oscillators in Plastic Packages are Pin-to-Pin Compatible with All Listed XO Packages
## Replacing XO for Better Performance

<table>
<thead>
<tr>
<th>Feature</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Replacement Ease</td>
<td>Pin-to-Pin Compatible with Industry Standard 4-Pin and 6-Pin XOs</td>
</tr>
<tr>
<td></td>
<td>Supporting Wide Range of Frequencies Up to 200MHz</td>
</tr>
<tr>
<td></td>
<td>Excellent Phase Jitter from $&lt;1$ to $2\text{ps}_{\text{RMS}}$ Integrated from 12kHz to 20 MHz</td>
</tr>
<tr>
<td></td>
<td>Up to 90% Lower in Power Compared to Competition</td>
</tr>
<tr>
<td></td>
<td>Down to 2.0 x 1.6 mm</td>
</tr>
<tr>
<td></td>
<td>$&lt;$400us</td>
</tr>
</tbody>
</table>
## CrystalFree™ XO Replacement Products

<table>
<thead>
<tr>
<th>Part</th>
<th>*PKGs</th>
<th>Freq. (MHz)</th>
<th>Accuracy (ppm)</th>
<th>Temp. (°C)</th>
<th>Output</th>
<th>Status</th>
<th>Production</th>
</tr>
</thead>
<tbody>
<tr>
<td>3CN</td>
<td>5032, 2520</td>
<td>4-133</td>
<td>±100</td>
<td>0 to 70 / -20 to 70</td>
<td>CMOS</td>
<td>Production</td>
<td>NOW</td>
</tr>
<tr>
<td>3CL</td>
<td>5032, 2520</td>
<td>26, 27, 54</td>
<td>±100</td>
<td>0 to 70 / -20 to 70</td>
<td>CMOS</td>
<td>Sampling</td>
<td>Q1 CY12</td>
</tr>
<tr>
<td></td>
<td>7050, 3225, 2016</td>
<td>1-200</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Q4 CY12 / Q1 CY12</td>
</tr>
<tr>
<td>3CJ</td>
<td>2520</td>
<td>24-125</td>
<td>±100</td>
<td>0 to 85</td>
<td>CMOS</td>
<td>Samples</td>
<td>Q4 CY11 / Q2 CY12</td>
</tr>
<tr>
<td>3CG</td>
<td>7050-6pin</td>
<td>24-125</td>
<td>±100</td>
<td>0 to 70 / 0 to 85</td>
<td>LVDS / LVPECL / HCSL</td>
<td>Samples</td>
<td>Q4 CY11 / Q2 CY12</td>
</tr>
<tr>
<td></td>
<td>5032-6pin</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3LG</td>
<td>7050-6pin</td>
<td>24-125</td>
<td>±50</td>
<td>0 to 70</td>
<td>LVDS / LVPECL / HCSL</td>
<td>Sampling</td>
<td>Q2 CY12</td>
</tr>
<tr>
<td></td>
<td>5032-6pin</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*All packages are 0.85mm thick

---

Ideal for Replacing XOs Where High-Accuracy, Low-Noise and Low-Power Are Required
CrystalFree™ Solid-State Oscillator Portfolio

PACKAGED PRODUCTS

Active (XO Replacement)

±100ppm CMOS to ±50ppm Differential

Passive (XTAL Replacement)

±50ppm (initial) to ±30ppm (initial)

INTEGRATED DIE PRODUCTS
CrystalFree™ Resonator Replacement

Passive (XTAL/Resonator Replacement)

- 3F Series: ±50ppm, E-Temp
- 3D Series: ±50ppm, I-Temp
- 3G Series: ±30ppm, E-Temp
- 3N Series: ±30ppm, I-Temp

Active Oscillator Performance at the Price of Passive Crystals
Replacing XTALs for Better Performance

- **High Value**
  - Active Oscillator Performance at Price of Crystals

- **High Performance**
  - ±30/50ppm Initial Frequency Accuracy @ 25C Just Like Crystals
  - Bounded Total Error
  - Excellent Phase Jitter of $2ps_{RMS}$ Integrated from 12kHz to 20MHz

- **Ultra Small Size**
  - Down to 2.0 x 1.6 x 0.55mm

- **Fast Start Up**
  - <400us
>100x Improvement in Bit-Error-Rate

CrystalFree™ Oscillator Exhibits >100x Better BER in USB

10^-6.2 at 0.1UI

10^-8.5 at 0.1UI

Improvement in BER Provides an Effective Communications Channel
<table>
<thead>
<tr>
<th>Part</th>
<th>*PKGs</th>
<th>Freq. (MHz)</th>
<th>Accuracy (ppm)</th>
<th>Temp. (C)</th>
<th>Output</th>
<th>Status</th>
<th>Production</th>
</tr>
</thead>
<tbody>
<tr>
<td>3FN</td>
<td>2520LP 5032, 2016LP</td>
<td>4-133</td>
<td>Ini=±50 Temp=±100</td>
<td>0 to 70 -20 to 70</td>
<td>CMOS</td>
<td>Production</td>
<td>Now</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Samples Q4 CY11</td>
<td>Q1 CY12</td>
</tr>
<tr>
<td>3DN</td>
<td>2520LP 5032, 2016LP</td>
<td>4-133</td>
<td>Ini=±50 Temp=±400</td>
<td>-40 to 85C</td>
<td>CMOS</td>
<td>Production</td>
<td>Now</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Samples Q4 CY11</td>
<td>Q1 CY12</td>
</tr>
<tr>
<td>3GL</td>
<td>2016LP 2520LP 5032</td>
<td>1-200</td>
<td>Ini=±30 Temp=±100</td>
<td>0 to 70 0 to 85 -20 to 70</td>
<td>CMOS</td>
<td>Sampling</td>
<td>Q1 CY12</td>
</tr>
<tr>
<td>3NL</td>
<td>2016LP 2520LP 5032</td>
<td>1-200</td>
<td>Ini=±30 Temp=±400</td>
<td>-40 to 85C</td>
<td>CMOS</td>
<td>Sampling</td>
<td>Q1 CY12</td>
</tr>
</tbody>
</table>

*LP packages are 0.55mm thick. All other packages are 0.85mm thick.

Active Oscillator Performance at the Price of Passive Crystals
CrystalFree™ Solid-State Oscillator Portfolio

PACKAGED PRODUCTS

Active (XO Replacement)

±100ppm CMOS to ±50ppm Differential

Passive (XTAL Replacement)

±50ppm (initial) to ±30ppm (initial)

INTEGRATED DIE PRODUCTS
CrystalFree™ Die Integration

**REMOVE CRYSTAL ON THE BOARD**
- Integrate Die into SOC

**BENEFITS TO SOC VENDOR**
- Higher ASP
- Differentiation
- Easier PLL Design
- Faster Time to Market
- Better Performance

**BENEFITS TO OEM**
- Simple Board Design
- Lower Cost/BOM
- Better Performance
- Easier Commodity Management

**MILLIONS SHIPPED**
- Detailed Design Guide
- FAE Support

---

**Packaged Device with Both Die**

**Dissolved Package**

**CrystalFree™ Oscillator**

---

**SoC**
SUMMARY
CrystalFree™ Solid-State Oscillators

- Now achieve and exceed the performance of crystals and crystal oscillators
- Leverage semiconductor economies of scale to enable high-performance, low price and short lead time
- Are the only technology and product capable of replacing active XOs and passive XTALs as both packaged devices and die
- Are robust products with millions of units shipped
Thank You for Your Interest in CrystalFree™ Oscillators

For More Information Visit
www.idt.com/go/CrystalFree