Power Tools
Global Power Tool Market Analysis

**Market Trends & Drivers**

<table>
<thead>
<tr>
<th>Description</th>
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<tbody>
<tr>
<td>2016 global tool shipments: 200 M-units (Electric) vs. 88 M-units (Pneumatic)</td>
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<tr>
<td>Cordless power tools experiencing rapid growth: 50% of Electric Power</td>
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<td>Demand for power tools is projected to increase at a compound annual growth rate (CAGR) of over 5% to US$ 36.2B in 2020 and US$ 46.5B in 2025</td>
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<tr>
<td>Battery packs shifting from NiCd &amp; NiMH cells to Li-ion cells</td>
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<tr>
<td>Battery pack power density for given voltage is rising</td>
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<tr>
<td>Industry moving steadily towards 21700 cell form factor from 18650</td>
</tr>
<tr>
<td>Tools rapidly adopting brushless DC motor vs. brushed motor</td>
</tr>
</tbody>
</table>

Source: PressureWashr March 2018 report Tool Industry Behemoths

Global Power Tools Market Share

- Stanley Black & Decker: 23%
- Robert Bosch GmbH: 14%
- Fortive Corp: 12%
- TTI: 12%
- Hilti Corp.: 10%
- ITW: 8%
- Makita: 7%
- Snap-on: 7%
- Others: 7%

- Others: 7%

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Power Tool Battery Pack

Battery Management Unit:
- Fuse Overcurrent protection
- TVS Diode Overvoltage protection
- PPTC Sensing/Balancing Cells

Charge-Discharge:
- MOSFETS Charge–Discharge FETs

Cell Protection Module:
- NTC Sensors

Bluetooth Module:
- ESD Protection

Protect  Control  Sense
Power Tool Battery Pack Opportunities

- **Li-ion cells**
- **Battery Management Unit**
- **Cell Protection Module**
- **Charge Discharge MOSFETs**
- **ID Pin**
- **Bluetooth Module**
- **Polar HT Series**
- **Diode Array (SPA)**

<table>
<thead>
<tr>
<th>Products</th>
<th>Technology</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blade Fuse, SMD Fuse</td>
<td>Midi Fuse, BF1 Series, 881 Series(SMD), 688 Series</td>
</tr>
<tr>
<td>TVS Diode</td>
<td>SMFxxA Series</td>
</tr>
<tr>
<td>PPTC, Fuse</td>
<td>nanoSMDC016/48, 0805L010/24 PPTC</td>
</tr>
<tr>
<td>NTC Thermistor*</td>
<td>Leaded Epoxy Coated Thermistor, Surface Mount Thermistor</td>
</tr>
<tr>
<td>N Channel Power MOSFETs</td>
<td>Polar HT Series</td>
</tr>
<tr>
<td>Diode Array (SPA)</td>
<td>SP3021, chipSESD Series</td>
</tr>
</tbody>
</table>

* Thermally coupled with Li-On Cells.
Power Tool Charger

AC Input Primary Protection:
- Fuse Overcurrent protection
- MOV Lightning Surge/Induction Spikes
- NTC Thermistor Inrush current limiter

High Frequency Converter:
- MOSFET High-frequency input switch

Secondary-Side Rectification:
- Reverse Blocking Diode

Secondary-Side Protection:
- MOSFET Output DC disconnect switch
Power Tool Charger Protection Architecture

1. Input Protection Rectifier & Filter
2. High Frequency Converter
3. Step-down Transformer
4. Output Rectification & Filter

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<table>
<thead>
<tr>
<th>Technology</th>
<th>Series</th>
</tr>
</thead>
<tbody>
<tr>
<td>UL Listed AC Fuse</td>
<td>Radial Fuse, Cartridge Fuse, TR/TE Series</td>
</tr>
<tr>
<td>NTC</td>
<td>Inrush Current Limiting Power Thermistors</td>
</tr>
<tr>
<td>MOV</td>
<td>Radial Disc/10mm</td>
</tr>
<tr>
<td>N-Channel Enhancement Power MOSFETs</td>
<td>Polar 3 Series, HiPerFET Series</td>
</tr>
<tr>
<td>Reverse Blocking Diode</td>
<td>MBR Series, MBR20100CT, MBR10100CT</td>
</tr>
<tr>
<td>P-Channel Enhancement MOSFET</td>
<td>TrenchP Series</td>
</tr>
</tbody>
</table>
Cordless Power Tool

**Temperature Sense:**
- NTC Thermistor Temperature Detection

**Motor Speed Sense:**
- Hall effect sensor Speed Measurement

**Trigger Input Protection:**
- Fuse Overcurrent protection
- TVS Diode Over-voltage Protection
- Reed Switch

**Power Bridge Protection:**
- NTC Thermistor Temperature Detection
- HCRTP mini Thermal Fuse
- MOSFET Bridge
BLDC Motor Protection Architecture

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<tbody>
<tr>
<td>SMD Fuse (24V/32V)</td>
<td>1206SFH, 501 Series</td>
</tr>
<tr>
<td>SMD Fuse (70V)</td>
<td>881 Series</td>
</tr>
<tr>
<td>TVS Diode</td>
<td>SMAJ, SMBJ, 5KP Series</td>
</tr>
<tr>
<td>Reed Switch</td>
<td>MDSR-10, MDSM-10</td>
</tr>
<tr>
<td>Temperature Detection</td>
<td>Ledged Epoxy Coated Thermistor, Surface Mount Thermistor</td>
</tr>
<tr>
<td>SMD Thermal Fuse*</td>
<td>HCRTP mini</td>
</tr>
<tr>
<td>N-Channel MOSFET</td>
<td>Trench T2, HiPER FET Series</td>
</tr>
<tr>
<td>Temperature Measurement</td>
<td>Ledged Epoxy Coated Thermistor, Surface Mount Thermistor</td>
</tr>
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</table>

* Suitable for large and high-power tools.
Corded Power Tool

AC Switching:
- Thyristor
Corded Power Tool Protection Opportunities

- **Input Filter**
- **AC Switching**
- **BLDC Motor**
- **Trigger**
- **Speed Control**

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<th>Technology</th>
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<tr>
<td>1</td>
<td>Thyristor Qxx25Hxx / QJxx25Hxx Series</td>
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</table>
Making Connections Can Help Open New Opportunities

- Battery-powered Appliances
- Commercial Drones
- Power Tools
- Large Battery-powered Lawnmower / Tools
- Cordless Electric Golf Cart
- Robotic Fork Lift
- E-bike
Power Tool Standards Compliance

- **IEC/UL 62841-1**: Safety standards for Transportable Hand-Held Motor Operated Electric Power Tools
  - Clause 11: Input and current
  - Clause 16: Overload protection of transformers and associated circuits
  - Sub-clause 18.8: Abnormal operation; Electronic circuits providing safety critical functions

- **IEC 62133-2**: Safety standards for Li-Ion Secondary Cells and Batteries
  - Sub-clause 7.1: Charging method
  - Sub-clause 7.2.1: Continuous charging at constant voltage
  - Sub-clause 7.3.1 / 7.3.2: External Short circuit
  - Sub-clause 7.3.4: Thermal abuse
  - Sub-clause 7.3.6: Over-charging of battery
  - Sub-clause 7.3.9: Forced Internal Short Circuit Test (cells)

- **UL 2595**: General Requirements for Battery-Powered Appliances
  - Section 11.3: Electronic circuit fault conditions
  - Section 11.4: Circuit current conditions
  - Section 11.6: Safety critical function circuits
  - Section 11.7: Li-Ion charging systems
  - Section 11.8: Li-Ion battery short circuit
  - Section 11.9: Batteries other than Li-Ion; Overcharging

* - UL 62133 is harmonized to the older edition of this standard, IEC 62133 2nd Edition

**Other Applicable Battery Regulations**

- UL 1642: Lithium Batteries
- UL 2054: Household and Commercial batteries
- UL 2271: Batteries For Use in Light Electric Vehicle Applications
- UL 2580: Batteries for use in electric vehicles.
- ANSI C18.2M: Portable Rechargeable Cells and Batteries
- IEC 62281: Safety of Primary and Secondary Lithium Cells and Batteries during transport
- UN 38.3: Recommendations on Transportation of Dangerous Goods (Li-Ion Batteries)
- JIS C8714: Safety Tests for Portable Li-Ion secondary cells and Batteries
A Strategic Supplier & Design Partner for Power Tools

- System design approach & providing product selection guidelines
- Global standards, requirements, and compliance expertise
- Testing assistance and providing system-level design support
- Single source of key power tool components
- High-volume manufacturing, and highest quality standards

Global delivery network coupled with localized customer support & distribution