**FEATURES AND BENEFITS**
- Optimized for applications with regulated power rails
  - Operation from 2.8 to 5.5 V
- AEC-Q100 automotive qualified
- Operation up to 175°C junction temperature
- Dynamic offset cancellation
  - Resistant to physical stress
  - Superior temperature stability
- Symmetrical latch switchpoints
- Output short-circuit protection
- Solid-state reliability
- Industry-standard packages and pinouts

**PACKAGES:**
*Not to scale*
- 3-pin SOT23W (suffix LH)
- 3-pin SIP (suffix UA)

**DESCRIPTION**
The APS12205, APS12215, and APS12235 Hall-effect sensor ICs are extremely temperature-stable and stress-resistant devices especially suited for operation over extended junction temperature ranges up to 175°C. Superior high-temperature performance is made possible through dynamic offset cancellation, which reduces the residual offset voltage normally caused by device overmolding, temperature dependencies, and thermal stress.

The single silicon chip includes: a Hall plate, small signal amplifier, chopper stabilization, Schmitt trigger, and a short-circuit-protected open-drain output. A south pole of sufficient strength turns the output on; a north pole of sufficient strength is necessary to turn the output off. For applications requiring operation from greater than 5.5 V or operation directly from a battery, refer to the A1220, A1221, or A1223.

Two package styles provide a choice of through-hole or surface mounting. Package type LH is a modified 3-pin SOT23W surface-mount package, while UA is a three-pin ultramini SIP for through-hole mounting. Both packages are lead (Pb) free, with 100% matte-tin-plated leadframes.

**Functional Block Diagram**
APS12205, APS12215, and APS12235

High-Temperature Hall-Effect Latches for Low Voltage Applications

SELECTION GUIDE

<table>
<thead>
<tr>
<th>Part Number</th>
<th>Packing[1]</th>
<th>Mounting</th>
<th>Branding</th>
<th>Ambient, $T_A$</th>
<th>$B_{RP}$ (Min)</th>
<th>$B_{OP}$ (Max)</th>
</tr>
</thead>
<tbody>
<tr>
<td>APS12205ELHALX</td>
<td>13-in. reel, 10000 pieces/reel 3-pin SOT23W surface mount</td>
<td>A04</td>
<td>–40°C to 85°C</td>
<td>–40 G</td>
<td>40 G</td>
<td></td>
</tr>
<tr>
<td>APS12205LUAA</td>
<td>Bulk, 500 pieces/bag 3-pin SIP through hole</td>
<td>A18</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>APS12215LLHALX</td>
<td>13-in. reel, 10000 pieces/reel 3-pin SOT23W surface mount</td>
<td>A01</td>
<td>–40°C to 150°C</td>
<td>–90 G</td>
<td>90 G</td>
<td></td>
</tr>
<tr>
<td>APS12215LLHALT[2]</td>
<td>7-in. reel, 3000 pieces/reel 3-pin SOT23W surface mount</td>
<td>A01</td>
<td>–40°C to 150°C</td>
<td>–90 G</td>
<td>90 G</td>
<td></td>
</tr>
<tr>
<td>APS12215LUAA</td>
<td>Bulk, 500 pieces/bag 3-pin SIP through hole</td>
<td>A03</td>
<td></td>
<td></td>
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<tr>
<td>APS12235LLHALX</td>
<td>13-in. reel, 10000 pieces/reel 3-pin SOT23W surface mount</td>
<td>A35</td>
<td>–40°C to 150°C</td>
<td>–180 G</td>
<td>180 G</td>
<td></td>
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<tr>
<td>APS12235LUAA</td>
<td>Bulk, 500 pieces/bag 3-pin SIP through hole</td>
<td>A36</td>
<td></td>
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</table>

[1] Contact Allegro for additional packing options.

ABSOLUTE MAXIMUM RATINGS

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Symbol</th>
<th>Notes</th>
<th>Rating</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Forward Supply Voltage</td>
<td>$V_{CC}$</td>
<td></td>
<td>6</td>
<td>V</td>
</tr>
<tr>
<td>Reverse Supply Voltage</td>
<td>$V_{RCC}$</td>
<td></td>
<td>–0.3</td>
<td>V</td>
</tr>
<tr>
<td>Output Off Voltage</td>
<td>$V_{OUT}$</td>
<td></td>
<td>6</td>
<td>V</td>
</tr>
<tr>
<td>Output Current</td>
<td>$I_{OUT}$</td>
<td>Through short-circuit current limiting device.</td>
<td>60</td>
<td>mA</td>
</tr>
<tr>
<td>Maximum Junction Temperature</td>
<td>$T_J$ (max)</td>
<td>For 1000 hours.</td>
<td>165</td>
<td>°C</td>
</tr>
<tr>
<td>Storage Temperature</td>
<td>$T_{stg}$</td>
<td></td>
<td>–65 to 170</td>
<td>°C</td>
</tr>
</tbody>
</table>
High-Temperature Hall-Effect Latches 
for Low Voltage Applications

APS12205, 
APS12215, 
and APS12235

PINOUT DIAGRAMS AND TERMINAL LIST TABLE

<table>
<thead>
<tr>
<th>Name</th>
<th>Description</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Package</td>
</tr>
<tr>
<td>VCC</td>
<td>Connects power supply to chip</td>
<td>LH 1</td>
</tr>
<tr>
<td>VOUT</td>
<td>Output from circuit</td>
<td>LH 2</td>
</tr>
<tr>
<td>GND</td>
<td>Ground</td>
<td>LH 3</td>
</tr>
</tbody>
</table>

Package LH

Package UA
## ELECTRICAL CHARACTERISTICS:

Valid over full operating voltage and ambient temperature range, unless otherwise noted.

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Symbol</th>
<th>Test Conditions</th>
<th>Min.</th>
<th>Typ.(^{[1]})</th>
<th>Max.</th>
<th>Unit(^{[2]})</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>ELECTRICAL CHARACTERISTICS</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Forward Supply Voltage</td>
<td>(V_{CC})</td>
<td>Operating, (T_J &lt; 175°C)</td>
<td>2.8</td>
<td>–</td>
<td>5.5</td>
<td>V</td>
</tr>
<tr>
<td>Supply Current</td>
<td>(I_{CC})</td>
<td>(V_{CC} = 5.5) V</td>
<td>–</td>
<td>2</td>
<td>4</td>
<td>mA</td>
</tr>
<tr>
<td>Output Leakage Current</td>
<td>(I_{OUTOFF})</td>
<td>(V_{OUT} = 5.5) V, (B &lt; B_{RP})</td>
<td>–</td>
<td>–</td>
<td>10</td>
<td>(\mu A)</td>
</tr>
<tr>
<td>Output Saturation Voltage</td>
<td>(V_{OUT(SAT)})</td>
<td>(I_{OUT} = 5) mA, (B &gt; B_{OP})</td>
<td>–</td>
<td>50</td>
<td>500</td>
<td>mV</td>
</tr>
<tr>
<td>Output Current</td>
<td>(I_{OUT})</td>
<td>Recommended value used during characterization</td>
<td>–</td>
<td>5</td>
<td>–</td>
<td>mA</td>
</tr>
<tr>
<td>Output Short-Circuit Current Limit</td>
<td>(I_{OM})</td>
<td>(B &gt; B_{OP})</td>
<td>30</td>
<td>–</td>
<td>60</td>
<td>mA</td>
</tr>
<tr>
<td>Power-On Time(^{[3]})</td>
<td>(t_{ON})</td>
<td>(V_{CC} \geq 2.8) V, (B &lt; B_{RP(min)} - 10) G, (B &gt; B_{OP(max)} + 10) G</td>
<td>–</td>
<td>–</td>
<td>25</td>
<td>(\mu s)</td>
</tr>
<tr>
<td>Power-On State, Output(^{[3]})</td>
<td>POS</td>
<td>(V_{CC} \geq V_{CC(min)}, t &lt; t_{ON})</td>
<td>Low</td>
<td>–</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Chopping Frequency</td>
<td>(f_C)</td>
<td></td>
<td>–</td>
<td>800</td>
<td>–</td>
<td>kHz</td>
</tr>
<tr>
<td>Output Rise Time(^{[3][4]})</td>
<td>(t_{r})</td>
<td>(R_{PULL-UP} = 1) k(\Omega), (C_L = 20) pF</td>
<td>–</td>
<td>0.2</td>
<td>2</td>
<td>(\mu s)</td>
</tr>
<tr>
<td>Output Fall Time(^{[3][4]})</td>
<td>(t_{f})</td>
<td>(R_{PULL-UP} = 1) k(\Omega), (C_L = 20) pF</td>
<td>–</td>
<td>0.1</td>
<td>2</td>
<td>(\mu s)</td>
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</tbody>
</table>

### MAGNETIC CHARACTERISTICS

<table>
<thead>
<tr>
<th></th>
<th>(B_{OP})</th>
<th>(B_{RP})</th>
<th>(B_{HYS})</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operate Point</td>
<td>APS12205</td>
<td>5</td>
<td>40</td>
</tr>
<tr>
<td></td>
<td>APS12215</td>
<td>15</td>
<td>90</td>
</tr>
<tr>
<td></td>
<td>APS12235</td>
<td>100</td>
<td>180</td>
</tr>
<tr>
<td>Release Point</td>
<td>APS12205</td>
<td>–40</td>
<td>–5</td>
</tr>
<tr>
<td></td>
<td>APS12215</td>
<td>–90</td>
<td>–15</td>
</tr>
<tr>
<td></td>
<td>APS12235</td>
<td>–180</td>
<td>–100</td>
</tr>
<tr>
<td>Hysteresis</td>
<td>APS12205</td>
<td>10</td>
<td>45</td>
</tr>
<tr>
<td></td>
<td>APS12215</td>
<td>30</td>
<td>100</td>
</tr>
<tr>
<td></td>
<td>APS12235</td>
<td>200</td>
<td>300</td>
</tr>
</tbody>
</table>

\(^{[1]}\) Typical data are at \(T_A = 25°C\) and \(V_{CC} = 5\) V, and are for initial design estimations only.

\(^{[2]}\) 1 G (gauss) = 0.1 mT (millitesla).

\(^{[3]}\) Guaranteed by device design and characterization.

\(^{[4]}\) \(C_L\) = oscilloscope probe capacitance.
THERMAL CHARACTERISTICS: May require derating at maximum conditions; see application information

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Symbol</th>
<th>Test Conditions</th>
<th>Value</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Package Thermal Resistance</td>
<td>$R_{θJA}$</td>
<td>Package LH, 1-layer PCB with copper limited to solder pads</td>
<td>228</td>
<td>°C/W</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Package LH, 2-layer PCB with 0.463 in$^2$ of copper area each side connected by thermal vias</td>
<td>110</td>
<td>°C/W</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Package UA, 1-layer PCB with copper limited to solder pads</td>
<td>165</td>
<td>°C/W</td>
</tr>
</tbody>
</table>

Power Derating Curve

- $T_{J(max)} = 175°C$; $I_{CC} = I_{CC(max)}$, $I_{OUT} = 0 mA$ (Output Off)

Package Power Dissipation versus Ambient Temperature
CHARACTERISTIC PERFORMANCE
Electrical Characteristics

Average Supply Current versus Supply Voltage

Average Supply Current versus Ambient Temperature

Average Low Output Voltage versus Supply Voltage for $I_{out} = 5\, mA$

Average Low Output Voltage versus Ambient Temperature for $I_{out} = 5\, mA$
CHARACTERISTIC PERFORMANCE (continued)
APS12205 Magnetic Characteristics

Average Operate Point versus Supply Voltage

\[ B_{\text{op}} (G) \]

\[ V_{\text{CC}} (V) \]

Average Operate Point versus Ambient Temperature

\[ B_{\text{op}} (G) \]

\[ T_{A} (°C) \]

Average Release Point versus Supply Voltage

\[ B_{\text{rp}} (G) \]

\[ V_{\text{CC}} (V) \]

Average Release Point versus Ambient Temperature

\[ B_{\text{rp}} (G) \]

\[ T_{A} (°C) \]

Average Switchpoint Hysteresis versus Supply Voltage

\[ B_{\text{hys}} (G) \]

\[ V_{\text{CC}} (V) \]

Average Switchpoint Hysteresis versus Ambient Temperature

\[ B_{\text{hys}} (G) \]

\[ T_{A} (°C) \]
CHARACTERISTIC PERFORMANCE (continued)
APS12215 Magnetic Characteristics

Average Operate Point versus Supply Voltage

Average Operate Point versus Ambient Temperature

Average Release Point versus Supply Voltage

Average Release Point versus Ambient Temperature

Average Switchpoint Hysteresis versus Supply Voltage

Average Switchpoint Hysteresis versus Ambient Temperature
High-Temperature Hall-Effect Latches for Low Voltage Applications

CHARACTERISTIC PERFORMANCE (continued)
APS12235 Magnetic Characteristics

Average Operate Point versus Supply Voltage

![Graph showing Average Operate Point versus Supply Voltage]

Average Operate Point versus Ambient Temperature

![Graph showing Average Operate Point versus Ambient Temperature]

Average Release Point versus Supply Voltage

![Graph showing Average Release Point versus Supply Voltage]

Average Release Point versus Ambient Temperature

![Graph showing Average Release Point versus Ambient Temperature]

Average Switchpoint Hysteresis versus Supply Voltage

![Graph showing Average Switchpoint Hysteresis versus Supply Voltage]

Average Switchpoint Hysteresis versus Ambient Temperature

![Graph showing Average Switchpoint Hysteresis versus Ambient Temperature]
High-Temperature Hall-Effect Latches for Low Voltage Applications

OPERATION
The output of these devices switches low (turns on) when a magnetic field perpendicular to the Hall element exceeds the operate point threshold, B_{OP} (see Figure 1). After turn-on, the output voltage is V_{OUT(SAT)}. The output transistor is capable of continuously sinking up to 30 mA. When the magnetic field is reduced below the release point, B_{RP}, the device output goes high (turns off). The difference in the magnetic operate and release points is the hysteresis, BHYS, of the device. This built-in hysteresis allows clean switching of the output even in the presence of external mechanical vibration and electrical noise.

Removal of the magnetic field will leave the device output latched on if the last crossed switchpoint is B_{OP}, or latched off if the last crossed switch point is B_{RP}.

POWER-ON BEHAVIOR
Device power-on occurs once t_{ON} has elapsed. During the time prior to t_{ON}, and after VCC ≥ V_{CC(min)}, the output state is V_{OUT(SAT)} (Low). After t_{ON} has elapsed, the output will correspond with the applied magnetic field for B > B_{OP} or B < B_{RP}. See Figure 2 for an example.

Powering-on the device in the hysteresis range (less than B_{OP} and higher than B_{RP}) will give an output state of V_{OUT(SAT)}. The correct state is attained after the first excursion beyond B_{OP} or B_{RP}.

FIGURE 1: SWITCHING BEHAVIOR OF LATCHES

On the horizontal axis, the B+ direction indicates increasing south polarity magnetic field strength, and the B- direction indicates decreasing south polarity field strength (including the case of increasing north polarity.

FIGURE 2: POWER-ON TIMING DIAGRAM
APPLICATIONS

It is strongly recommended that an external bypass capacitor be connected (in close proximity to the Hall element) between the supply and ground of the device to guarantee correct performance under harsh environmental conditions and to reduce noise from internal circuitry. As is shown in Figure 3, a 0.1 µF capacitor is typical.

Extensive applications information on magnets and Hall-effect sensors is available in:

• Hall-Effect IC Applications Guide, AN27701,
• Hall-Effect Devices: Guidelines for Designing Subassemblies Using Hall-Effect Devices AN27703.1
• Soldering Methods for Allegro’s Products – SMD and Through-Hole, AN26009

All are provided on the Allegro website:

www.allegromicro.com
CHOPPER STABILIZATION
A limiting factor for switchpoint accuracy when using Hall-effect technology is the small signal voltage developed across the Hall plate. This voltage is proportionally small relative to the offset that can be produced at the output of the Hall sensor. This makes it difficult to process the signal and maintain an accurate, reliable output over the specified temperature and voltage range. Chopper stabilization is a proven approach used to minimize Hall offset.

The Allegro technique, dynamic quadrature offset cancellation, removes key sources of the output drift induced by temperature and package stress. This offset reduction technique is based on a signal modulation-demodulation process. Figure 4 illustrates how it is implemented.

The undesired offset signal is separated from the magnetically induced signal in the frequency domain through modulation. The subsequent demodulation acts as a modulation process for the offset, causing the magnetically induced signal to recover its original spectrum at baseband while the DC offset becomes a high-frequency signal. Then, using a low-pass filter, the signal passes while the modulated DC offset is suppressed. Allegro’s innovative chopper stabilization technique uses a high-frequency clock. The high-frequency operation allows a greater sampling rate that produces higher accuracy, reduced jitter, and faster signal processing. Additionally, filtering is more effective and results in a lower noise analog signal at the sensor output. Devices such as the APS12205, APS12215, and APS12235 that use this approach have an extremely stable quiescent Hall output voltage, are immune to thermal stress, and have precise recoverability after temperature cycling. This technique is made possible through the use of a BiCMOS process which allows the use of low offset and low noise amplifiers in combination with high-density logic and sample-and-hold circuits.
POWER DERATING
The device must be operated below the maximum junction temperature of the device, $T_J(max)$. Under certain combinations of peak conditions, reliable operation may require derating supplied power or improving the heat dissipation properties of the application. This section presents a procedure for correlating factors affecting operating $T_J$. (Thermal data is also available on the Allegro MicroSystems website.)

The Package Thermal Resistance, $R_{θJA}$, is a figure of merit summarizing the ability of the application and the device to dissipate heat from the junction (die), through all paths to the ambient air. Its primary component is the Effective Thermal Conductivity, $K$, of the printed circuit board, including adjacent devices and traces. Radiation from the die through the device case, $R_{θJC}$, is relatively small component of $R_{θJA}$. Ambient air temperature, $T_A$, and air motion are significant external factors, damped by overmolding.

The resulting power dissipation capability directly reflects upon the ability of the device to withstand extreme operating conditions. The junction temperature mission profile specified in the Absolute Maximum Ratings table designates a total operating life capability based on qualification for the most extreme conditions, where $T_J$ may reach 175°C.

The silicon IC is heated internally when current is flowing into the VCC terminal. When the output is on, current sinking into the VOUT terminal generates additional heat. This may increase the junction temperature, $T_J$, above the surrounding ambient temperature. The APS12205, APS12215, and APS12235 are permitted to operate up to $T_J=175°C$. As mentioned above, an operating device will increase $T_J$ according to equations 1, 2, and 3 below. This allows an estimation of the maximum ambient operating temperature.

For example, given common conditions such as: $T_A=25°C$, $V_{CC}=5\,V$, $I_{CC}=2.5\,mA$, $V_{OUT}=185\,mV$, $I_{OUT}=2\,mA$ (output on), and $R_{θJA}=165°C/W$, then:

$$P_D = (V_{CC} \times I_{CC}) + (V_{OUT} \times I_{OUT}) = (5\,V \times 2.5\,mA) + (185\,mV \times 2\,mA) = 12.5\,mW + 0.4\,mW = 12.9\,mW$$

$$ΔT = P_D \times R_{θJA} = 12.9\,mW \times 165°C/W = 2.1°C$$

$$T_J = T_A + ΔT = 25°C + 2.1°C = 27.1°C$$

A worst-case estimate, $P_D(max)$, represents the maximum allowable power level ($V_{CC}(max)$, $I_{CC}(max)$), without exceeding $T_J(max)$, at a selected $R_{θJA}$.

For example, given the conditions $R_{θJA}=228°C/W$, $T_J(max)=175°C$, $V_{CC}(max)=5.5\,V$, $I_{CC}(max)=4\,mA$, $V_{OUT}=500\,mV$, and $I_{OUT}=5\,mA$ (output on), the maximum allowable operating ambient temperature can be determined.

The power dissipation required for the output is shown below:

$$P_D(V_{OUT}) = V_{OUT} \times I_{OUT} = 500\,mV \times 5\,mA = 2.5\,mW$$

The power dissipation required for the IC supply is shown below:

$$P_D(V_{CC}) = V_{CC} \times I_{CC} = 5.5\,V \times 4\,mA = 22\,mW$$

Next, by inverting using equation 2:

$$ΔT = P_D \times R_{θJA} = [P_D(V_{OUT}) + P_D(V_{CC})] \times 228°C/W = (2.5\,mW + 22\,mW) \times 228°C/W = 24.5\,mW \times 228°C/W = 5.6°C$$

Finally, by inverting equation 3 with respect to voltage:

$$T_A(est) = T_J(max) – ΔT = 175°C – 5.6°C = 169.4°C$$

In the above case there is only sufficient power dissipation capability to operate up to $T_A(est)$. This particular result indicates that, at $T_J(max)$, the application and device can only dissipate adequate amounts of heat at ambient temperatures ≤ $T_A(est)$; the APS12205, APS12215, and APS12235 performance is not guaranteed above $T_A=150°C$ for the “L” temperature variant and $T_A=85°C$ for the “E” temperature variant.
High-Temperature Hall-Effect Latches for Low Voltage Applications

APS12205, APS12215, and APS12235

Package LH, 3-Pin (SOT-23W)

For Reference Only; not for tooling use (reference DWG-0000628)
Dimensions in millimeters
Dimensions exclusive of mold flash, gate burns, and dambar protrusions
Exact case and lead configuration at supplier discretion within limits shown

Active Area Depth, 0.28 ±0.04 mm
Reference land pattern layout
All pads a minimum of 0.20 mm from all adjacent pads; adjust as necessary to meet application process requirements and PCB layout tolerances
Branding scale and appearance at supplier discretion
Hall element, not to scale
High-Temperature Hall-Effect Latches for Low Voltage Applications

APS12205, APS12215, and APS12235

Package UA, 3-Pin SIP

For Reference Only; not for tooling use (reference DWG-0000404, Rev. 1)
Dimensions in millimeters
Dimensions exclusive of mold flash, gate burrs, and dambar protrusions
Exact case and lead configuration at supplier discretion within limits shown

- Dambar removal protrusion (6×)
- Gate and tie bar burr area
- Active Area Depth, 0.50 ± 0.08 mm
- Branding scale and appearance at supplier discretion
- Hall element (not to scale)

Dimensions in millimeters
Dimensions exclusive of mold flash, gate burrs, and dambar protrusions

Standard Branding Reference View

A18
APS12205LUAA

A03
APS12215LUAA

A36
APS12235LUAA
High-Temperature Hall-Effect Latches
for Low Voltage Applications

Revision History

<table>
<thead>
<tr>
<th>Number</th>
<th>Date</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>–</td>
<td>June 3, 2016</td>
<td>Initial release</td>
</tr>
<tr>
<td>1</td>
<td>June 20, 2016</td>
<td>Updated Functional Block Diagram (page 1); Updated Selection Guide (page 2) and package outline drawing brand information (pages 14-15).</td>
</tr>
<tr>
<td>2</td>
<td>September 23, 2016</td>
<td>Updated Title (all pages), Selection Guide (page 2), Absolute Maximum Ratings (page 2); Electrical Characteristics (page 4); added Characteristic Performance Data (pages 6-9); updated Functional Description (page 6), Chopper Stabilization (page 12), and Power Derating sections (page 13).</td>
</tr>
<tr>
<td>3</td>
<td>July 5, 2018</td>
<td>Updated $T_J$ (max) notes (page 2), Typical Application Circuit (page 11), Power Derating section (page 13), Package Outline Drawings (pages 14-15), and other minor editorial updates.</td>
</tr>
<tr>
<td>4</td>
<td>June 18, 2019</td>
<td>Updated Selection Guide (page 2), Power Derating section (page 13), and Package Outline Drawing branding (page 14).</td>
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</tbody>
</table>

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