**CrystalClear™ AC '97 AMR Reference Design**

**Features**
- AMR Audio Codec add-in card designed to meet the Intel® Audio/Modem Riser Specification
- High quality, low cost, 2-layer, single sided adapter board
- CS4299 SoundFusion® Audio Codec '97
- Complete suite of Analog and Digital I/O connections:
  - Line In, Line Out, Mic In, Modem Audio connection, CD Audio In, Video In, Aux In, Headphone Out and Optical Digital Out
- Meets or exceeds Microsoft’s PC 97, PC 98, and PC 99, both required and advanced, audio performance requirements.

**Description**

The CRD4299-1 AMR add-in board reference design showcases Cirrus Logic’s Crystal Audio AC ‘97 CS4299 SoundFusion, and is Audio/Modem Riser Specification[2], compliant. The CRD4299-1 AMR card is 2.7” high by 3.6” long.

The CRD4299-1 AMR reference design includes a customer ready manufacturing kit. Included in the kit are a full set of schematic design files (OrCAD® 7.2 format), PCB job files (PADS® ASCII), PCB artwork files (Gerber), bracket drawings, and bill of materials. The design is production ready as is, or can be easily modified to incorporate specific OEM changes. Documentation source files are available to assist the OEM to quickly provide an accurate end user manual.

**ORDERING INFO** CRD4299-1 AMR
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1. GENERAL INFORMATION

The CRD4299-1 AMR is a production-grade AMR audio card reference design using the CS4299 SoundFusion Audio Codec ‘97. The design supports the functionally compatible CS4299, CS4297A, or CS4297 AC ‘97 SoundFusion Audio Codecs.

The AMR board advantage lies in the complete separation of the analog section from the noisy digital environment of a personal computer. A 5-wire digital link is all that is required to connect the audio codec to the PCI bus-based AC ‘97 controller. This allows the audio section to reach the required dynamic range of ~90 dB FS A while making the layout and placement of the audio section easier to implement. The CS4299 performs the Digital-to-Analog Conversion (DAC) for the digital audio output stream and also provides multiple analog audio inputs and outputs, analog mixing and Analog-to-Digital Conversion (ADC).

This card is designed to provide the highest possible functionality, along with industry leading audio performance at a low manufacturing cost. Care was taken with component placement and signal routing to minimize sources that can degrade audio performance. Cirrus’ analog design know-how has resulted in a board that preserves the exceptional analog performance of the CS4299.

2. REFERENCE DESIGN FEATURES

The CRD4299-1 AMR reference design illustrates a high quality, low cost two-layer add-in card layout. The card is sectioned into three main parts: the AMR bus section, the CS4299 Audio Codec ‘97 section, and the Analog I/O section.

2.1 Digital Audio Out

The AMR bus provides digital out in a format compatible with the consumer portion of IEC 958. An older version of this standard is also known as S/PDIF. Depending upon the codec, the SPDIF signal originates either from the AMR bus or the codec. Digital out is provided through a Toshiba TOTX173 optical TOS-LINK jack on the board edge. There are many advantages in using a fiber optic link versus the traditional coaxial link. Fiber optic is a non-metallic insulator thereby preventing ground loops and electromagnetic interference. For signal transmission, it offers low attenuation, high bandwidth, low propagation delay, low bit error rates, small size, and cost efficiency. The signal is IEC 958 and CP-1201 compliant.

2.2 CS4299 Audio Codec ‘97

The CS4299 is a mixed-signal serial Codec based on the AC ‘97 specification revision 2.1 [1]. It is designed to be paired with a digital controller, located on the PCI bus. The AC ‘97 Controller is responsible for all communications between the CS4299 and the rest of the system. The CS4299 functions as an analog mixer, a stereo ADC, a stereo DAC, and a control and digital audio stream interface to the AC ‘97 controller.

The CS4299 contains two distinct functional sections: digital and analog. The digital section includes the AC-link registers, power management support, SYNC detection circuitry, AC-link serial port interface logic, and the 24.576 MHz crystal master clock. The analog section includes the analog input multiplexer (mux), stereo input mixer, stereo output mixer, mono output mixer, stereo ADC, stereo DAC, and analog volume controls. For more information refer to the CS4299 Datasheet [3]. The capacitors required for the CS4299 and their placement are discussed in the CS4299 Datasheet [3]. Refer to the Grounding and Layout section of the data sheet for the recommended routing of the audio section.

2.2.1 Power Requirements

The CS4299 requires both a digital +3.3 V and an analog +5 V supply. The digital power is supplied from the AMR bus. A voltage regulator is recommended for the analog supply. A Motorola
MC78L05 regulates the AMR +12 V supply down to provide a clean +5 V analog supply for the CS4299. The MC78L05 regulator can provide adequate current, which is enough for the CS4299 and associated analog circuitry.

2.3 Analog I/O

The CS4299 has many analog inputs and outputs that may or may not be used depending on the system’s application. Unused inputs should be tied to Vrefout (pin 28) or AC coupled via a 0.1 µF capacitor to the analog ground plane. The analog section contains the components for a headphone amplifier. The Modem Audio, CD In, Audio In, and Aux In headers are also part of the Analog I/O section. The header and its associated components may or may not be necessary depending on the audio inputs implemented.

2.4 Audio I/O

A full feature set of the CS4299’s analog I/O and digital out is represented on the reference design card through internal and external connectors:

- Line Out
- Headphone Out
- Line In
- Mic In
- CD Audio In
- Aux In
- Video In
- Modem Audio connection
- Optical Digital Out

Four external 1/8” jacks, one external TOS-LINK jack, and four internal header connections are used for analog and digital inputs and outputs.

2.4.1 Line Out

The output of the CS4299 is capable of driving impedances greater than 10 kΩ with a maximum output voltage of 1 Vrms. The Line Out connection is made via an external 1/8” jack.

• Maximum output level: 1 Vrms

2.4.2 Headphone Out

An external 1/8” jack is provided for a headphone connection. This output is driven by an amplifier for low impedance loads such as 32 Ω head phones.

• Maximum output level: 2.0 Vrms (no load); 1.5 Vrms (32 Ω load)
• Maximum output power: 70 mW/channel (32 Ω load)

2.4.3 Line In

The Line In 1/8” jack provides an input to the Line In pins of the CS4299.

• Maximum input level: 2 Vrms

2.4.4 Mic In

The Microphone In 1/8” jack provides an input to a microphone pre-amplifier circuit that applies 18 dB of gain to the signal.

• Maximum input level:
  - Microphone Boost enabled: 12.5 mVrms
  - Microphone Boost disabled: 125 mVrms
• Supports 3-pin electret (power on ring) and 2-pin dynamic microphones

2.4.5 CD Audio In

The CD Audio input provides a 4-pin (0.1 inch center) right-angled connector that is compatible with the SONY standards and ATAPI.

• Maximum input level: 2 Vrms
• Pseudo differential input using the CD Common pin as the ground
• 0.1 inch connector wired as:
  - Pin 1 : Left Channel
  - Pin 2 : Common return
- Pin 3: Common return
- Pin 4: Right Channel

**2.4.6 Aux In**
- Internal 4-pin (0.1 inch center) right-angled connector
- Wired as:
  - Pin 1: Left Channel
  - Pin 2: Analog Ground
  - Pin 3: Analog Ground
  - Pin 4: Right Channel
- Maximum input level: 2 Vrms

**2.4.7 Video In**
- Internal 4-pin (0.1 inch center) right-angled connector
  - Pin 1: Left Channel
  - Pin 2: Analog Ground
  - Pin 3: Analog Ground
  - Pin 4: Right Channel
- Maximum input level: 2 Vrms

**2.4.8 Modem Audio Connection**
The modem audio connection can be made through the internal 4-pin (0.1 inch center) right-angled connector. This connector carries both a mono input and a mono output.
- Internal 4 pin header (0.1 inch center)
  - Pin 1: Mono Out (to modem)
  - Pin 2: Analog Ground
  - Pin 3: Analog Ground
  - Pin 4: Phone In (from modem)
- Maximum input level: 1 Vrms
- Maximum output level: 1 Vrms
- Minimum load impedance: 10 kΩ

---

**3. SCHEMATIC DESCRIPTION**

Figures 11 through 17 show the schematics for the CRD4299-1 AMR card. This section will describe particular pages of the schematic that need to be discussed.

**3.1 Figure 11: Block Diagram**
The block diagram is an interconnection overview between schematic pages.

**3.2 Figure 12: AMR Bus Interface**
The +5 V power pin is decoupled through C1 and supplies power for the SPDIF_OUT circuit. All ground pins are tied to digital ground except for B2, which is tied to analog ground.

The AC-link, which consists of ASDOUT, ARST#, ASYNC, ASDIN, and ABITCLK, transfers digital audio data between the audio codec and the host. PC_BEEP_BUS routes the beep/speaker signal from the motherboard to the audio subsystem, for use in hearing POST codes (refer to the Intel Audio/Modem Riser Specification [2]).

The PRIMARY_DN# signal indicates the presence or the absence of a primary codec on the motherboard. The MSTRCLK is the 24.576 MHz master clock for the AC ‘97 link. Populate R51 when the Codec is the primary codec. Populate R50 when the Codec is the secondary codec.

The CS4297 does not support S/PDIF. In this case, R3 should be populated so the S/PDIF signal originates from the AMR bus. For a CS4297A/99, by populating R2 instead of R3, the S/PDIF signal originates from the codec, bypassing the AMR bus.

**3.3 Figure 13: Power Supply**
The CS4299 requires both a digital +3.3 V and an analog +5 V supply. The digital power is supplied from the AMR bus. A separate regulator is recommended for the analog voltage supply to provide good audio signal quality. A Motorola MC78L05 regulates the +12 V supply from the AMR bus.
down to a clean +5 V analog supply. Two packaging options are supported, where U5 is an SO8 surface mount package and U4 is a TO-92 pin-in-hole package. The -12 V power pin is decoupled through C73/C74, and supplies power to the headphone circuit.

3.4 Figure 14: CS4299 AC ‘97 Audio Codec

For the best audio performance, the analog voltage regulator, an MC78L05, is located near the CS4299. A 10 µF electrolytic capacitor should be added next to pins 25 and 26 if the capacitor connected to the output of the power regulator is located far away from the CS4299. All filtering capacitors of audio signals are NPO-type to ensure minimal added distortion. Two footprints are provided for the crystal: a CA-301 pin-in-hole footprint, Y1, for miniature crystal; and a short height HC-49S package, Y2. R47 is a termination resistor in the serial AC-link between the CS4299 and the AMR bus.

3.5 Figure 15: Analog Inputs

The inputs for AUX, VIDEO, CD, and LINE are passed through voltage dividers that reduce the levels by 6 dB to allow connection of line level sources up to 2 Vrms. The 220 pF capacitors are provided on Line_In, Mic_In, CD_In, Aux_In, Video_In, and Internal Modem connection for EMC suppression. These may be removed if EMC testing determines they are not required. 1 µF AC coupling capacitors are used on the Line_In, Mic_In, CD_In, Aux_In, Video_In, and Internal Modem circuit to minimize the low frequency roll-off. The internal CD audio connection utilizes a pseudo-differential interface with CD_GND as the common return path for both the left and right channels. Therefore, the input impedance of this block is half of that of the other inputs.

The modem connection is both a mono input and output. The output is fed from the CS4299’s MONO_OUT pin through a divider made of R22/23. The divider ratio is preset to 0 dB for an output voltage of 1 Vrms. If a lower output voltage is desired, the resistors can be replaced with appropriate values, as long as the total load on the output is kept greater than 10 kΩ. The input is not divided to accommodate line level sources up to 1 Vrms.

3.6 Figure 16: Audio Outputs

The line out is driven directly by the CS4299. The headphone out amplifier, a Motorola MC1458, is capable of driving stereo headphones with impedances greater than 32 Ω or powered speakers. R37/38 are added for short-circuit protection. An optical S/PDIF (IEC 958 consumer) output is also supported.

3.7 Figure 17: Microphone Pre-amp and Bias

A Motorola MC33078D low noise dual op-amp provides an +18 dB gain stage for the microphone and buffers the phantom power supply for the mic. The phantom power is derived from the +5 V analog supply and buffered by U1A to provide a maximum of 4.2 V with no load and a minimum of 2.0 V under a 0.8 mA load on the ring. Hardware rolloffs were implemented at 60 kHz and 15 kHz as recommended by the PC 99 System Design Guide, Chapter 17, Audio Components [5].
3.8 Component Selection

Great attention was given to the particular components on the CRD4299-1 AMR board with cost, performance, and package selection as the most important factors. Listed are some of the guidelines used in the selection of components:

- No components smaller than 0805 package
- Use single package components, no resistor packs
- Right-angled headers for all internal connections to provide sufficient headroom for the jacks
- Dual footprint for XTAL, HC-49S, and small circular CA-301 pin-in-hole package
- Dual footprint for +5 V regulator. Surface mount and pin-in-hole package are supported.

3.9 EMC Components

A number of capacitors and inductors are included to help the board meet EMC compliance tests, such as FCC Part 15. Modifying this selection of components without EMC testing could cause EMC compliance failure.

4. GROUNDING AND LAYOUT

4.1 Partitioned Voltage and Ground Planes

The pinout of the CS4299 allows the ground split to completely separate digital signals on one side and analog signals on the other. This split is located very close to the CS4299 so analog and digital ground return currents originating from the CS4299 may flow through their respective ground planes. A bridge is made across the split to maintain the proper reference potential for each ground plane.

The area around the crystal oscillator and the two XTAL signals is filled with copper on the top and bottom sides and attached to digital ground. This ground plane serves to keep noise from coupling onto these pins. All data converters are highly susceptible to noise on the crystal pins.

A separate chassis ground provides a reference plane for all of the EMC components. The chassis ground plane is connected to the analog ground plane at the external jacks.

4.2 CS4299 Layout Notes

Please refer to the CS4299 Datasheet [3] on how the area under the chip should be partitioned and how the bypass capacitors should be placed. Pay close attention to the suggestions for the bypass capacitors on REFFLT, AFLT1, AFLT2, and the power supply capacitors. The pinout of the CS4299 is designed to keep digital and analog signals from crossing when laying out the board.

5. AUDIO PERFORMANCE EVALUATION

In the below reference designators, the letters in parenthesis designate the full-scale value for that particular I/O. These reference designators are used in the following tables to help clarify which full-scale value applies to the particular measurement. Values referenced to digital numbers on the PC are listed with the (d) suffix.

5.1 Plots

In the following plots, stereo measurements have two sets of data per plot and two vertical axes. Above each vertical axis is a label indicating a channel that relates to that axis. The data set extends beyond the vertical axis to indicate its association with that axis. Using Figure 1 as an example, the top set of data extends beyond the right vertical axis, which is labeled at the top “RIGHT”, indicating that the top set of data is the right channel and associated with the right vertical axis. Likewise, the bottom set of data extends beyond the left vertical axis which is labeled at the top “LEFT”, indicating that the bottom set of data is the left channel and associated with the left vertical axis.
<table>
<thead>
<tr>
<th>Signal Name</th>
<th>Connector</th>
<th>Maximum Voltage</th>
<th>Reference Designator</th>
<th>Imp. (kΩ)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Line In (A-D-PC-D-A)</td>
<td>Jack</td>
<td>2.376 (V_{\text{RMS}})</td>
<td>0 dB FS (li)</td>
<td></td>
</tr>
<tr>
<td>Line In (A-A)</td>
<td>Jack</td>
<td>2.142 (V_{\text{RMS}})</td>
<td>0 dB FS (li)</td>
<td></td>
</tr>
<tr>
<td>Mic In</td>
<td>Jack</td>
<td>0.128 (V_{\text{RMS}})</td>
<td>0 dB FS (mi)</td>
<td></td>
</tr>
<tr>
<td>Line Out</td>
<td>Jack</td>
<td>1.021 (V_{\text{RMS}})</td>
<td>0 dB FS (lo)</td>
<td>N/A</td>
</tr>
</tbody>
</table>

Table 1. Reference Designators

<table>
<thead>
<tr>
<th>Microphones Supported</th>
<th>Support</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>3-Pin Phantom Power (power on ring)</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td>2-Pin Dynamic</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td>2-Pin Phantom Power (power on tip)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 2. Microphone Support Specifications

<table>
<thead>
<tr>
<th>Full Duplex (A-D-PC-D-A): Line In to Line Out</th>
<th>Reference</th>
<th>Left</th>
<th>Right</th>
<th>Units</th>
<th>Figures</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dynamic Range</td>
<td>-91.4</td>
<td>-91.4</td>
<td>dB FS A (lo)</td>
<td>99 - 1NXL</td>
<td></td>
</tr>
<tr>
<td>THD+N</td>
<td>-85.2</td>
<td>-85.2</td>
<td>dB FS (lo)</td>
<td>99 - 1DXL</td>
<td></td>
</tr>
<tr>
<td>Frequency Response</td>
<td>(A_c = -0.4) dB</td>
<td>20-20k</td>
<td>20-20k Hz</td>
<td>99 - 1MXL</td>
<td></td>
</tr>
</tbody>
</table>

NOTE: TM004: combined test used in lieu of TM002 and TM003

Table 3. Full Duplex Specifications

<table>
<thead>
<tr>
<th>Analog Mixer (A-A): Line In to Line Out</th>
<th>Reference</th>
<th>Left</th>
<th>Right</th>
<th>Units</th>
<th>Figures</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dynamic Range</td>
<td>-95.8</td>
<td>-95.7</td>
<td>dB FS A (lo)</td>
<td>99 - 1NAL</td>
<td></td>
</tr>
<tr>
<td>THD+N</td>
<td>-92.9</td>
<td>-92.9</td>
<td>dB FS (lo)</td>
<td>99 - 1DAL</td>
<td></td>
</tr>
<tr>
<td>Frequency Response</td>
<td>(A_c = +0.2) dB</td>
<td>20-20k</td>
<td>20-20k Hz</td>
<td>99 - 1MAL</td>
<td></td>
</tr>
<tr>
<td>Crosstalk</td>
<td>(f = 10) kHz</td>
<td>-66.8</td>
<td>-66.5  dB FS (lo)</td>
<td>99 - 1CAL</td>
<td></td>
</tr>
</tbody>
</table>

Table 4. Analog Mixer, Line In to Line Out Specifications

<table>
<thead>
<tr>
<th>Analog Mixer (A-A): Mic In to Line Out</th>
<th>Reference</th>
<th>Left</th>
<th>Right</th>
<th>Units</th>
<th>Figures</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dynamic Range</td>
<td>(\text{Gain} = 0) dB</td>
<td>-94.1</td>
<td>N/A</td>
<td>dB FS A (lo)</td>
<td>99 - 1NAM</td>
</tr>
<tr>
<td>THD+N</td>
<td>(\text{-3 dB FS (mi)})</td>
<td>-91.3</td>
<td>N/A</td>
<td>dB FS (lo)</td>
<td>99 - 1DAM</td>
</tr>
<tr>
<td>Frequency Response</td>
<td>(A_c = -3) dB</td>
<td>50-15k</td>
<td>N/A</td>
<td>Hz</td>
<td>99 - 1MAM</td>
</tr>
</tbody>
</table>

NOTE: Mic In is Mono

Table 5. Analog Mixer, Mic In to Line Out Specifications
Figure 1. Full Duplex (A-D-PC-D-A): Line In/Out Frequency Response

Figure 2. Full Duplex (A-D-PC-D-A): Line In/Out Dynamic Range
Figure 3. Full Duplex (A-D-PC-D-A): Line In/Out THD+N vs. Frequency

Figure 4. Analog Mixer (A-A): Line In/Out Frequency Response
Figure 5. Analog Mixer (A-A): Line In/Out Dynamic Range

Figure 6. Analog Mixer (A-A): Line In/Out THD+N vs. Frequency
Figure 7. Analog Mixer (A-A): Mic In/Line Out Frequency Response

Figure 8. Analog Mixer (A-A): Mic In/Line Out Dynamic Range
Figure 9. Analog Mixer (A-A): Mic In/Line Out THD+N vs. Frequency

Figure 10. Analog Mixer (A-A): Line In/Out Crosstalk vs. Frequency
6. REFERENCES


2) Intel, Audio/Modem Riser Specification, Revision 1.01, Sep 10, 1998.
   http://developer.intel.com/pc-supp/platform/ac97/INDEX.HTM


4) Steve Harris, Clif Sanchez, Personal Computer Audio Quality Measurements, Ver 1.0

5) Intel and Microsoft, PC 99 System Design Guide
   http://www.microsoft.com/hwdev/desguid/

Figure 11. Block Diagram
Figure 12. AMR Bus

- Populate R2 for CS4299 board
- Populate R3 for CS4297 board
- Populate R51 if primary codec.
- Populate R50 if secondary codec.

**AMR BUS**

- **B1**
  - PC_BEEP_BUS
  - PRIMARY_DN#
  - +3.3VDC
  - +5VDC
  - +12VDC
  - AUDIO_MUTE# +12VDC
  - MONO_OUT/PC_BEEP +5VDC
  - RSVD GND
  - PRIMARY_DN# +3.3VDC
  - GND
  - 12V +5V dual/+5VSB
  - GND
  - 12V
  - RSVD
  - KEY
  - 12V
  - KEY
  - GND
  - KEY
  - GND
  - KEY
  - GND
  - KEY
  - 12V
  - AUDIO_PWRDN
  - MONO_PHONE
  - RSVD
  - RSVD
  - RSVD

- **B2**
  - GND
  - +12V
  - RSVD
  - RSVD
  - RSVD
  - PRIMARY_DN#
  - +3.3VDC
  - +5VDC
  - +12VDC
  - PRIMARY_DN#
  - +3.3VDC
  - +5VDC
  - +12VDC
  - PRIMARY_DN#
  - +3.3VDC
  - +5VDC
  - +12VDC
  - PRIMARY_DN#
  - +3.3VDC
  - +5VDC
  - +12VDC
  - PRIMARY_DN#
  - +3.3VDC
  - +5VDC
  - +12VDC

- **R2**
  - 0
  - S/PDIF_CODEC
  - S/PDIF_OUT

- **R3**
  - 0
  - S/PDIF_CODEC
  - S/PDIF_OUT

- **R51**
  - 47
  - ASIN

- **R50**
  - 47
  - ASIN

- **C1**
  - 1uF
  - Z5U
  - C3
  - 10uF
  - ELEC
  - C2
  - 0.1uF
  - Z5U
  - M1
  - HOLE
  - M2
  - TOOLHOLE
  - M3

- **C3**
  - 10uF
  - ELEC

- **M1**
  - HOLE

- **M2**
  - TOOLHOLE

- **M3**
  - HOLE
Connect AGND to DGND with a 50 mil trace near the 4297.
Connect CGND to DGND with a 50 mil trace near the finger edge of the board.

Figure 13. Power Supplies
Figure 14. CS4299
Figure 15. Audio In
Figure 16. Audio Out
**Figure 17. Mic Pre-Amp**

- Connect CGND to AGND at the jack.
- Digital Output
  - SPDIF_OUT
  - LINE_OUT_JACK
  - HEADPHONE JACK
Figure 18. Assembly Drawing
Figure 19. Top Layer
Figure 20. Bottom Layer
Figure 21. Bracket Drawing

NOTES:
1. APPLICABLE STANDARDS/SPECIFICATIONS:
   ASME Y14.5M-1994, DIMENSIONS AND TOLERANCES
   MIL-STD-12, ABBREVIATIONS
2. REMOVE ALL BURRS AND SHARP EDGES.
3. MATERIAL: .035 THK 6.003 #1010 CRS
4. SILK SCREEN CHARACTERS .05 HIGH AND MARKINGS
   LOCATED APPROXIMATELY AS SHOWN USING BEST
   SHOP PRACTICE.
## 8. BILL OF MATERIALS

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<th>Item</th>
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<th>Value</th>
<th>Type</th>
<th>PCB Footprint</th>
<th>Mnfr</th>
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<th>Description</th>
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**Do Not Populate**

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