**ChatGPT specifying components w.r.t. the TIDM-02013 Design Guide:**

**In the Totem Pole PFC converter section** of the TIDM-02013 circuit, here’s a breakdown of the primary components to include in your simulation, along with key specifications:

1. **High-Frequency Switches (GaN FETs)**:
   * **Type**: GaN FET (e.g., **LMG3522R030-Q1**)
   * **Switching Frequency**: 120 kHz
   * **Role**: Operates in high-frequency switching mode for efficient power factor correction.
2. **Low-Frequency Switches (MOSFETs)**:
   * **Type**: Si MOSFETs for the line-frequency operation
   * **Switching Frequency**: 50-60 Hz
   * **Role**: Acts as synchronous rectifiers to minimize conduction losses.
3. **Boost Inductor**:
   * **Inductance**: 126 µH
   * **Current**: Designed to handle up to **12 A RMS** for optimal ripple control​(7.4-kW EV or HEV Bidire…).
4. **Input AC Components**:
   * **Fuse and EMI Filter**: Designed to handle a maximum input current of **32 A RMS**.
   * **AC Voltage Sensing**: Differential voltage sensing using resistive dividers and an RC filter.
5. **DC Bus Capacitor**:
   * **Capacitance**: 1410 µF (e.g., three 470 µF capacitors in parallel)
   * **Purpose**: Smooths out ripple at the output of the PFC to maintain a stable DC voltage of approximately **400 V**​(7.4-kW EV or HEV Bidire…)​(7.4-kW EV or HEV Bidire…).
6. **Controller**:
   * **Microcontroller**: **TMS320F280039C C2000 MCU**
   * **Function**: Controls PWM signals for the Totem Pole PFC, voltage, and current regulation loops.
7. **Current and Voltage Sensors**:

* **Current Sensors**:
  + **Type**: Hall-effect sensors such as the ACS733KLATR-40AB-T.
  + **Purpose**: Used to measure total input current and balance current between interleaved phases.
  + **Signal Conditioning**: Use an amplifier circuit (e.g., based on OPA320-Q1) to scale the sensor’s output voltage to match the MCU’s ADC input range.
* **Voltage Divider for DC Bus**:
  + **Resistor Divider Network**: Use high-value resistors (e.g., 10kΩ and 16.5kΩ) to safely scale down the DC bus voltage.
  + **RC Filtering**: Include an RC filter with small capacitance (e.g., 100 pF) to ensure stable DC voltage readings without excessive noise​

1. **AC Voltage Sensing**:
   * **Sensing Mechanism**: Use differential resistive dividers with an RC filter.
   * **Resistor Divider**: High-value resistors (e.g., 365kΩ) are typically used in the divider network to step down the input AC voltage to a safe level.
   * **RC Filter**: Capacitance of about 470 pF and resistance of around 7.15kΩ are typical for filtering purposes before feeding the signal to the microcontroller

**For the CLLLC Resonant Converter** in the TIDM-02013 design, here are the essential components and specifications based on the design guide:

**1. Resonant Tank Components:**

* **Primary Resonant Inductor (Lrp)**:
  + **Value**: Determined based on the ratio Lm/LrpL\_m / L\_{rp}Lm​/Lrp​ to control the gain and efficiency. In this design, an inductance value that supports a gain variation of about 10% is chosen.
  + **Selection**: Choose an inductor that matches the target Ln value (14 in this design) to achieve desired gain and soft-switching characteristics.
* **Secondary Resonant Inductor (Lrs)**:
  + **Value**: Typically chosen to meet the resonance frequency with Lrp and Crp.
  + **Selection**: Ensure compatibility with high-frequency operation and peak current requirements.
* **Primary and Secondary Resonant Capacitors (Crp and Crs)**:
  + **Value**: These capacitors determine the series resonant frequency of the converter.
  + **Frequency Tuning**: Select values that keep the converter operating within the specified range of 200 kHz to 800 kHz for different load conditions. Component availability may influence the final choice, so choosing the closest standard values is recommended.
* **Magnetizing Inductor (Lm)**:
  + **Value**: Around 14 µH in this design, chosen to ensure Zero Voltage Switching (ZVS) across the operating range.
  + **Purpose**: Stores sufficient energy to maintain ZVS, critical for reducing switching losses in the primary FETs.

**2. Switching Devices:**

* **Primary and Secondary Switching FETs**:
  + **Type**: GaN FETs (e.g., LMG3522-Q1) for high-speed switching and efficient power transfer.
  + **Switching Frequency**: The nominal frequency is 500 kHz, with a range from 200 to 800 kHz to allow flexible operation.
  + **Configuration**: Full-bridge arrangement with complementary PWM pulses at 180° phase shifts for balanced power transfer between the primary and secondary sides​(7.4-kW EV or HEV Bidire…).

**3. Current and Voltage Sensing Components:**

* **Primary and Secondary Current Sensing**:
  + **Type**: Rogowski coil-based sensing for high-frequency tank current, paired with amplifiers for precise current measurement.
  + **Placement**: Located on the primary and secondary sides to monitor bidirectional current flow and ensure proper synchronous rectification.
* **Voltage Sensing (Primary and Secondary)**:
  + **Primary Voltage Sensing (Vprim)**: Sensed by a resistor divider and buffered with an operational amplifier to the ADC of the MCU.
  + **Secondary Voltage Sensing (Vsec)**: Sensed in an isolated manner using AMC3330-Q1, which provides galvanic isolation and feeds voltage information to the MCU for regulation.

**4. Controller and PWM Modulation:**

* **Microcontroller**: TMS320F280039C (or TMS320F28P650).
* **PWM Configuration**: Uses high-resolution PWM for precise control. Primary legs are centered on the period event with an up-down count, while the secondary legs have a phase shift to account for isolation delays.
* **Synchronous Rectification**: Enabled by the Comparator Subsystem (CMPSS) and controlled based on tank current feedback for optimal timing​(7.4-kW EV or HEV Bidire…).

**5. Protection and Control Mechanisms:**

* **Comparator Subsystem (CMPSS)**: Handles overcurrent protection and trips PWM signals when currents exceed set thresholds.
* **X-Bar (Crossbar)**: Routes various trip signals to the PWM for immediate shutdown during fault conditions.
* **Blanking Window**: Suppresses CMPSS output during noisy switching events, especially important for ZVS/ZCS transitions​.

**Remaining parts** and any specific values or configurations from the design guide:

1. **DC Output Filter Components**

* **Purpose**: The DC output filter is used to smooth out any remaining ripple on the DC side after the CLLLC resonant converter, ensuring a stable DC output voltage suitable for charging or powering other components.
* **Components**:
  + **Output Capacitor(s)**:
    - **Value**: As per the guide, you might see values around **470 µF** each. For example, three 470 µF capacitors in parallel would yield a total of **1410 µF**, suitable for smoothing the output ripple.
    - **Voltage Rating**: Ensure these capacitors are rated for at least **400 V DC**, as the output voltage of the PFC stage is around this level.
* **Current Sensor** (if applicable):
  + **Purpose**: To measure the output current for control and monitoring purposes, especially if this is part of a charging application.
  + **Type**: Hall-effect current sensor is recommended for non-invasive measurement.
  + **Rating**: Should handle the maximum expected output current, which could be around **15-20 A** depending on the converter’s rated power.

1. **Control Circuitry and Sensing Components**

* **Microcontroller / Digital Signal Controller (DSC)**:
  + **Type**: The TMS320F280039C C2000 MCU is recommended in the guide.
  + **Function**: Controls PWM signals for the Totem Pole PFC and CLLLC resonant converter, performs voltage and current regulation, and handles fault protection.
* **Voltage Sensing**:
  + **Purpose**: To provide feedback for the control loop, allowing the controller to adjust the PWM for accurate output voltage.
  + **Configuration**:
    - **DC Bus Voltage Sensing**: Typically uses a resistive voltage divider and an RC filter to step down the DC bus voltage (400 V) to a range suitable for the MCU’s ADC input (0-3.3V).
    - **Example Values**: If the ADC reference voltage is 3.3V, a divider ratio of approximately **1:122** would be needed to step down from 400 V to this level.
* **Current Sensing**:
  + **Purpose**: For closed-loop control and protection, measuring both the input current (for PFC) and output current (for load regulation).
  + **Configuration**:
    - **AC Input Current Sensor**: Hall-effect current sensor for input current, suitable for handling **32 A RMS**.
    - **DC Output Current Sensor**: Hall-effect sensor as well, designed to handle the maximum DC output current.

1. **Protections**

* **Over-Voltage Protection (OVP)**:
  + Uses the voltage sensing on the DC bus to detect if the output voltage exceeds a certain limit (e.g., 420 V). If it does, the MCU can shut down or reduce power to prevent damage.
* **Over-Current Protection (OCP)**:
  + Based on current sensing at both the input and output, over-current protection can trigger if currents exceed specified limits, protecting components from thermal stress or damage.
* **Temperature Sensors** (if not already placed):
  + Typically mounted near high-power components like GaN FETs, MOSFETs, and inductors.
  + Can connect to the MCU to provide feedback for temperature-based shutdown or derating.

1. **Gate Driver Circuitry**

* **High-Frequency GaN FET Drivers for Totem Pole PFC**:
  + **Part**: Use compatible GaN FET drivers (e.g., LMG3522R030-Q1).
  + **Configuration**: Ensure that they are configured for appropriate high-frequency switching at **120 kHz** with minimal dead-time for efficient PFC operation.
* **Half-Bridge Driver for CLLLC Converter**:
  + **Type**: Use half-bridge gate drivers compatible with your chosen MOSFETs for the CLLLC primary and secondary stages.
  + **Switching Frequency**: Should match the resonant frequency, now set at **500 kHz**.
  + **Dead-Time**: Configure adequate dead-time to avoid shoot-through but minimize it to maintain efficiency.

1. **Miscellaneous Components**

* **Fuse and EMI Filter at Input**:
  + **Fuse Rating**: Choose a fuse rated for **32 A RMS** to protect against over-current.
  + **EMI Filter**: Include differential-mode and common-mode filtering stages to meet EMI standards. Values depend on design constraints but typically involve **inductors and capacitors** tailored for the 50-60 Hz input frequency range.
* **Snubber Circuits** (if applicable):
  + Used across high-frequency switches (e.g., GaN FETs) to dampen voltage spikes due to parasitics.
  + **Typical Components**: RC snubber circuit with resistor and capacitor values optimized based on switching node characteristics.