FEATURES:
- 64 x 9-bit organization (IDT72421)
- 256 x 9-bit organization (IDT72201)
- 512 x 9-bit organization (IDT72211)
- 1,024 x 9-bit organization (IDT72221)
- 2,048 x 9-bit organization (IDT72231)
- 4,096 x 9-bit organization (IDT72241)
- 8,192 x 9-bit organization (IDT72251)
- 10 ns read/write cycle time
- Read and Write Clocks can be independent
- Dual-Ported zero fall-through time architecture
- Empty and Full Flags signal FIFO status
- Programmable Almost-Empty and Almost-Full flags can be set to any depth
- Programmable Almost-Empty and Almost-Full flags default to Empty+7, and Full-7, respectively
- Output enable puts output data bus in high-impedance state
- Advanced submicron CMOS technology
- Available in the 32-pin plastic leaded chip carrier (PLCC) and 32-pin Thin Quad Flat Pack (TQFP)
- For through-hole product please see the IDT72420/72200/72210/72220/72230/72240 data sheet
- Industrial temperature range (−40°C to +85°C) is available
- Green parts available, see ordering information

DESCRIPTION:
The IDT72421/72201/72211/72221/72231/72241/72251 SyncFIFO™ are very high-speed, low-power First-In, First-Out (FIFO) memories with clocked read and write controls. These devices have a 64, 256, 512, 1,024, 2,048, 4,096, and 8,192 x 9-bit memory array, respectively. These FIFOs are applicable for a wide variety of data buffering needs such as graphics, local area networks and interprocessor communication.

These FIFOs have 9-bit input and output ports. The input port is controlled by a free-running clock (WCLK), and two write enable pins (WEN1, WEN2). Data is written into the Synchronous FIFO on every rising clock edge when the write enable pins are asserted. The output port is controlled by another clock pin (RCLK) and two read enable pins (RENI, REN2). The Read Clock can be tied to the Write Clock for single clock operation or the two clocks can run asynchronously of one another for dual-clock operation. An output enable pin (OE) is provided on the read port for three-state control of the output.

The Synchronous FIFOs have two fixed flags, Empty (EF) and Full (FF). Two programmable flags, Almost-Empty (PAE) and Almost-Full (PAF), are provided for improved system control. The programmable flags default to Empty+7 and Full-7 for PAE and PAF, respectively. The programmable flag offset loading is controlled by a simple state machine and is initiated by asserting the load pin (LD).

These FIFOs are fabricated using high-speed submicron CMOS technology.
PIN CONFIGURATION

Symbol | Name | I/O | Description
--- | --- | --- | ---
D0-D8 | Data Inputs | I | Data inputs for a 9-bit bus.
RS | Reset | I | When RS is set LOW, internal read and write pointers are set to the first location of the RAM array. FF and PAE go HIGH, and QF and EF go LOW. A reset is required before an initial WRITE after power-up.
WCLK | Write Clock | I | Data is written into the FIFO on a LOW-to-HIGH transition of WCLK when the Write Enable(s) are asserted.
WEN1 | Write Enable 1 | I | If the FIFO is configured to have programmable flags, WEN1 is the only write enable pin. When WEN1 is LOW, data is written into the FIFO on every LOW-to-HIGH transition WCLK. If the FIFO is configured to have two write enables, WEN1 must be LOW and WEN2 must be HIGH to write data into the FIFO. Data will not be written into the FIFO if the EF is LOW.
WEN2/LD | Write Enable 2/Load | I | The FIFO is configured at reset to have either two write enables or programmable flags. If WEN2/LD is HIGH at reset, this pin operates as a second write enable. If WEN2/LD is LOW at reset, this pin operates as a control to load and read the programmable flag offsets. If the FIFO is configured to have two write enables, WEN1 must be LOW and WEN2 must be HIGH to write data into the FIFO. Data will not be written into the FIFO if the FF is LOW. If the FIFO is configured to have programmable flags, WEN2/LD is held LOW to write or read the programmable flag offsets.
Q0-Q8 | Data Outputs | O | Data outputs for a 9-bit bus.
RCLK | Read Clock | I | Data is read from the FIFO on a LOW-to-HIGH transition of RCLK when REN1 and REN2 are asserted.
REN1 | Read Enable 1 | I | When REN1 and REN2 are LOW, data is read from the FIFO on every LOW-to-HIGH transition of RCLK. Data will not be read from the FIFO if the EF is LOW.
REN2 | Read Enable 2 | I | When REN1 and REN2 are LOW, data is read from the FIFO on every LOW-to-HIGH transition of RCLK. Data will not be read from the FIFO if the EF is LOW.
OE | Output Enable | I | When OE is LOW, the data output bus is active. If OE is HIGH, the output data bus will be in a high-impedance state.
EF | Empty Flag | O | When EF is LOW, the FIFO is empty and further data reads from the output are inhibited. When EF is HIGH, the FIFO is not empty. EF is synchronized to RCLK.
PAE | Programmable Almost-Empty Flag | O | When PAE is LOW, the FIFO is almost-empty based on the offset programmed into the FIFO. The default offset at reset is Empty + 7. PAE is synchronized to RCLK.
PFA | Programmable Almost-Full Flag | O | When PFA is LOW, the FIFO is almost-full based on the offset programmed into the FIFO. The default offset at reset is Full - 7. PFA is synchronized to WCLK.
FF | Full Flag | O | When FF is LOW, the FIFO is full and further data writes into the input are inhibited. When FF is HIGH, the FIFO is not full. FF is synchronized to WCLK.
VCC | Power | One +5 volt power supply pin.
GND | Ground | One 0 volt ground pin.
### Absolute Maximum Ratings

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Rating</th>
<th>Com’l &amp; Ind’l</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>VTERM</td>
<td>Terminal Voltage with Respect to GND</td>
<td>–0.5 to +7.0</td>
<td>V</td>
</tr>
<tr>
<td>TSTG</td>
<td>Storage Temperature</td>
<td>–55 to +125</td>
<td>°C</td>
</tr>
<tr>
<td>IOUT</td>
<td>DC Output Current</td>
<td>–50 to +50</td>
<td>mA</td>
</tr>
</tbody>
</table>

**NOTE:**
1. Stresses greater than those listed under **Absolute Maximum Ratings** may cause permanent damage to the device. This is a stress rating only and functional operation of the device at these or any other conditions above those indicated in the operational sections of the specification is not implied. Exposure to absolute maximum rating conditions for extended periods may affect reliability.

### Recommended Operating Conditions

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Parameter</th>
<th>Com’l and Ind’l(1)</th>
<th>Min.</th>
<th>Typ.</th>
<th>Max.</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>VCC</td>
<td>Supply Voltage</td>
<td>Commercial/Industrial</td>
<td>4.5</td>
<td>5.0</td>
<td>5.5</td>
<td>V</td>
</tr>
<tr>
<td>GND</td>
<td>Supply Voltage</td>
<td>Com’l and Ind’l</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>V</td>
</tr>
<tr>
<td>VH</td>
<td>Input High Voltage</td>
<td>Com’l and Ind’l</td>
<td>2.0</td>
<td>—</td>
<td>—</td>
<td>V</td>
</tr>
<tr>
<td>VL</td>
<td>Input Low Voltage</td>
<td>Com’l and Ind’l</td>
<td>—</td>
<td>—</td>
<td>0.8</td>
<td>V</td>
</tr>
<tr>
<td>TA</td>
<td>Operating Temperature</td>
<td>Com’l and Ind’l</td>
<td>0</td>
<td>—</td>
<td>+70</td>
<td>°C</td>
</tr>
<tr>
<td>TA</td>
<td>Operating Temperature</td>
<td>Commercial</td>
<td>—</td>
<td>—</td>
<td>+85</td>
<td>°C</td>
</tr>
</tbody>
</table>

### DC Electrical Characteristics

(Commercial: VCC = 5V ± 10%, TA = 0°C to +70°C; Industrial: VCC = 5V ± 10%, TA = –40°C to +85°C)

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Parameter</th>
<th>IDT72421</th>
<th>IDT72201</th>
<th>IDT72211</th>
<th>IDT72221</th>
<th>IDT72231</th>
<th>IDT72241</th>
<th>IDT72251</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>tCLK = 10, 15, 25 ns</td>
<td>tCLK = 10, 15, 25 ns</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>IL(2)</td>
<td>Input Leakage Current (Any Input)</td>
<td>–1</td>
<td>–1</td>
<td>–1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>ILO(3)</td>
<td>Output Leakage Current</td>
<td>–10</td>
<td>–10</td>
<td>–10</td>
<td>10</td>
<td>10</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>VOH</td>
<td>Output Logic “1” Voltage, IOH = –2mA</td>
<td>2.4</td>
<td>2.4</td>
<td>2.4</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>VOL</td>
<td>Output Logic “0” Voltage, IOL = 8mA</td>
<td>—</td>
<td>0.4</td>
<td>—</td>
<td>0.4</td>
<td>—</td>
<td>0.4</td>
<td>—</td>
</tr>
<tr>
<td>ICC(4,6)</td>
<td>Active Power Supply Current</td>
<td>—</td>
<td>—</td>
<td>35</td>
<td>—</td>
<td>—</td>
<td>50</td>
<td>—</td>
</tr>
<tr>
<td>ICC(4,7)</td>
<td>Standby Current</td>
<td>—</td>
<td>—</td>
<td>5</td>
<td>—</td>
<td>—</td>
<td>5</td>
<td>—</td>
</tr>
</tbody>
</table>

**NOTES:**
1. Industrial temperature range product for the 15ns and 25ns speed grades are available as standard product.
2. Measurements with 0.4 ≤ VIN ≤ VCC.
3. OEE ≥ VH, 0.4 ≤ VOUT ≤ VCC.
4. Tested with outputs open (IOUT = 0).
5. RCLK and WCLK toggle at 20 MHz and data inputs switch at 10 MHz.
6. Typical ICC1 = 1.7 + 0.7*fs + 0.02*CL*fs (in mA).
   These equations are valid under the following conditions:
   - VCC = 5V, TA = 25°C, fs = WCLK frequency = RCLK frequency (in MHz, using TTL levels), data switching at fs/2, CL = capacitive load (in pF).
7. All Inputs = VCC - 0.2V or GND + 0.2V, except RCLK and WCLK, which toggle at 20 MHz.
AC ELECTRICAL CHARACTERISTICS
(Commercial: VCC = 5V ± 10%, TA = 0°C to +70°C; Industrial: VCC = 5V ± 10%, TA = –40°C to +85°C)

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Parameter</th>
<th>Commercial Min.</th>
<th>Commercial Max.</th>
<th>Com’l &amp; Ind’l(1) Min.</th>
<th>Com’l &amp; Ind’l(1) Max.</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>fS</td>
<td>Clock Cycle Frequency</td>
<td>—</td>
<td>100</td>
<td>—</td>
<td>66.7</td>
<td>kHz</td>
</tr>
<tr>
<td>tA</td>
<td>Data Access Time</td>
<td>2</td>
<td>6.5</td>
<td>10</td>
<td>15</td>
<td>ns</td>
</tr>
<tr>
<td>tCLK</td>
<td>Clock Cycle Time</td>
<td>10</td>
<td>—</td>
<td>15</td>
<td>—</td>
<td>ns</td>
</tr>
<tr>
<td>tCLKH</td>
<td>Clock High Time</td>
<td>4.5</td>
<td>—</td>
<td>6</td>
<td>—</td>
<td>ns</td>
</tr>
<tr>
<td>tCLKL</td>
<td>Clock Low Time</td>
<td>4.5</td>
<td>—</td>
<td>6</td>
<td>—</td>
<td>ns</td>
</tr>
<tr>
<td>tDS</td>
<td>Data Setup Time</td>
<td>3</td>
<td>—</td>
<td>4</td>
<td>—</td>
<td>ns</td>
</tr>
<tr>
<td>tDH</td>
<td>Data Hold Time</td>
<td>0.5</td>
<td>—</td>
<td>1</td>
<td>—</td>
<td>ns</td>
</tr>
<tr>
<td>tENS</td>
<td>Enable Setup Time</td>
<td>3</td>
<td>—</td>
<td>4</td>
<td>—</td>
<td>ns</td>
</tr>
<tr>
<td>tENH</td>
<td>Enable Hold Time</td>
<td>0.5</td>
<td>—</td>
<td>1</td>
<td>—</td>
<td>ns</td>
</tr>
<tr>
<td>tRS</td>
<td>Reset Pulse Width(2)</td>
<td>10</td>
<td>—</td>
<td>15</td>
<td>—</td>
<td>ns</td>
</tr>
<tr>
<td>tRSS</td>
<td>Reset Setup Time</td>
<td>8</td>
<td>—</td>
<td>10</td>
<td>—</td>
<td>ns</td>
</tr>
<tr>
<td>tRSR</td>
<td>Reset Recovery Time</td>
<td>8</td>
<td>—</td>
<td>15</td>
<td>—</td>
<td>ns</td>
</tr>
<tr>
<td>tRSF</td>
<td>Reset to Flag and Output Time</td>
<td>8</td>
<td>—</td>
<td>15</td>
<td>—</td>
<td>25</td>
</tr>
<tr>
<td>tOLZ</td>
<td>Output Enable to Output in Low-Z(3)</td>
<td>3</td>
<td>6</td>
<td>3</td>
<td>8</td>
<td>3</td>
</tr>
<tr>
<td>tOE</td>
<td>Output Enable to Output Valid</td>
<td>3</td>
<td>6</td>
<td>3</td>
<td>8</td>
<td>3</td>
</tr>
<tr>
<td>tOHZ</td>
<td>Output Enable to Output in High-Z(3)</td>
<td>3</td>
<td>6</td>
<td>3</td>
<td>8</td>
<td>3</td>
</tr>
<tr>
<td>tWFF</td>
<td>Write Clock to Full Flag</td>
<td>—</td>
<td>6.5</td>
<td>—</td>
<td>10</td>
<td>—</td>
</tr>
<tr>
<td>tWFE</td>
<td>Read Clock to Empty Flag</td>
<td>—</td>
<td>6.5</td>
<td>—</td>
<td>10</td>
<td>—</td>
</tr>
<tr>
<td>tWAF</td>
<td>Write Clock to Programmable Almost-Flag</td>
<td>—</td>
<td>6.5</td>
<td>—</td>
<td>10</td>
<td>—</td>
</tr>
<tr>
<td>tWAPE</td>
<td>Read Clock to Programmable Almost-Empty Flag</td>
<td>—</td>
<td>6.5</td>
<td>—</td>
<td>10</td>
<td>—</td>
</tr>
<tr>
<td>tSKEW1</td>
<td>Skew time between Read Clock &amp; Write Clock for Empty Flag &amp; Full Flag</td>
<td>5</td>
<td>—</td>
<td>6</td>
<td>—</td>
<td>10</td>
</tr>
<tr>
<td>tSKEW2</td>
<td>Skew time between Read Clock &amp; Write Clock for Almost-Empty Flag &amp; Programmable-Almost-Flag</td>
<td>14</td>
<td>—</td>
<td>15</td>
<td>—</td>
<td>18</td>
</tr>
</tbody>
</table>

NOTES:
1. Industrial temperature range product for the 15ns and 25ns speed grades are available as standard product.
2. Pulse widths less than minimum values are not allowed.
3. Values guaranteed by design, not currently tested.

AC TEST CONDITIONS

In Pulse Levels GND to 3.0V
Input Rise/Fall Times 3ns
Input Timing Reference Levels 1.5V
Output Reference Levels 1.5V
Output Load See Figure 1

CAPACITANCE (Ta = +25°C, f = 1.0MHz)

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Parameter</th>
<th>Conditions</th>
<th>Max.</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>CIN(2)</td>
<td>Input Capacitance</td>
<td>Vin = 0V</td>
<td>10</td>
<td>pF</td>
</tr>
<tr>
<td>COUT(1,2)</td>
<td>Output Capacitance</td>
<td>VOUT = 0V</td>
<td>10</td>
<td>pF</td>
</tr>
</tbody>
</table>

NOTES:
1. With output deselected (OE ≥ Vih).
2. Characterized values, not currently tested.

© 2019 Renesas Electronics Corporation
**SIGNAL DESCRIPTIONS**

**INPUTS:**

**DATA IN (D0 - D8)**  
Data inputs for 9-bit wide data.

**CONTROLS:**

**RESET (R$S$)**
- Reset is accomplished whenever the Reset (R$S$) input is taken to a LOW state. During reset, both internal read and write pointers are set to the first location. A reset is required after power-up before a write operation can take place. The Full Flag (FF) and Programmable Almost-Full flag (PAF) will be reset to HIGH after tRSF. The Empty Flag (EF) and Programmable Almost-Empty flag (PAE) will be reset to LOW after tREF. During reset, the output register is initialized to all zeros and the offset registers are initialized to their default values.

**WRITE CLOCK (WCLK)**
- A write cycle is initiated on the LOW-to-HIGH transition of the Write Clock (WCLK). Data setup and hold times must be met in respect to the LOW-to-HIGH transition of WCLK. The Full Flag (FF) and Programmable Almost-Full flag (PAF) are synchronized with respect to the LOW-to-HIGH transition of WCLK.
- The Write and Read Clocks can be asynchronous or coincident.

**WRITE ENABLE 1 (WEN1)**
- If the FIFO is configured for programmable flags, Write Enable 1 (WEN1) is the only enable control pin. In this configuration, when Write Enable 1 (WEN1) is LOW, data can be loaded into the input register and RAM array on the LOW-to-HIGH transition of every Write Clock (WCLK). Data is stored in the RAM array sequentially and independently of any ongoing read operation.
- If the FIFO is configured to have two write enables, when Write Enable 1 (WEN1) is HIGH, the input register holds the previous data and no new data is allowed to be loaded into the register.
- If the FIFO is configured to have two write enables, when Write Enable 1 (WEN1) is HIGH, the input register holds the previous data and no new data is allowed to be loaded into the register.
- The Write Enable 1 (WEN1) and Write Enable 2/Load (WEN2/LD) pin HIGH, the FIFO is returned to normal read/write operation in this configuration.

**READ CLOCK (RCLK)**
- Data can be read on the outputs on the LOW-to-HIGH transition of the Read Clock (RCLK). The Empty Flag (EF) and Programmable Almost-Empty flag (PAE) are synchronized with respect to the LOW-to-HIGH transition of RCLK.
- The Write and Read Clocks can be asynchronous or coincident.

**READ ENABLES (REN1, REN2)**
- When both Read Enables (REN1, REN2) are LOW, data is read from the RAM array to the output register on the LOW-to-HIGH transition of the Read Clock (RCLK).
- When either Read Enable (REN1, REN2) is HIGH, the output register holds the previous data and no new data is allowed to be loaded into the register.
- When all the data has been read from the FIFO, the Empty Flag (EF) will go LOW, inhibiting further read operations. Once a valid write operation has been accomplished, the Empty Flag (EF) will go HIGH after tREF and a valid read can begin. The Read Enables (REN1, REN2) are ignored when the FIFO is empty.

**OUTPUT ENABLE (O$E$)**
- When Output Enable (O$E$) is enabled (LOW), the parallel output buffers receive data from the output register. When Output Enable (O$E$) is disabled (HIGH), the Q output data bus is in a high-impedance state.

**WRITE ENABLE 2/LOAD (WEN2/LD)**
- This is a dual-purpose pin. The FIFO is configured at Reset to have programmable flags or to have two write enables, which allows depth expansion. If Write Enable 2/Load (WEN2/LD) is set HIGH at Reset (R$S$ = LOW), this pin operates as a second write enable pin.
- If the FIFO is configured to have two write enables, when Write Enable 2/Load (WEN2/LD) is set HIGH and Write Enable 2/LD is LOW, data can be loaded into the input register and RAM array on the LOW-to-HIGH transition of every Write Clock (WCLK). Data is stored in the RAM array sequentially and independently of any ongoing read operation.
- In this configuration, when Write Enable 2/LD is HIGH and/or Write Enable 2/Load (WEN2/LD) is LOW, the input register holds the previous data and no new data is allowed to be loaded into the register.
- To prevent data overflow, the Full Flag (FF) will go LOW, inhibiting further write operations. Upon the completion of a valid read cycle, the Full Flag (FF) will go HIGH after tWFF, allowing a valid write to begin. Write Enable 1 (WEN1) and Write Enable 2/Load (WEN2/LD) are ignored when the FIFO is full.
- The FIFO is configured to have programmable flags when the Write Enable 2/Load (WEN2/LD) is set LOW at Reset (R$S$=LOW). The IDT72421/72201/72211/72221/72231/72241/72251 devices contain four 8-bit offset registers which can be loaded with data on the inputs, or read on the outputs. See Figure 3 below for details of the size of the registers and the default values.
- If the FIFO is configured to have programmable flags when the Write Enable 1 (WEN1) and Write Enable 2/Load (WEN2/LD) are set LOW, data on the inputs D is written into the Empty (Least Significant Bit) Offset register on the first LOW-to-HIGH transition of the Write Clock (WCLK). Data is written into the Empty (Most Significant Bit) Offset register on the second LOW-to-HIGH transition of the Write Clock (WCLK), into the Full (Least Significant Bit) Offset register on the third transition, and into the Full (Most Significant Bit) Offset register on the fourth transition. The fifth transition of the Write Clock (WCLK) again writes to the Empty (Least Significant Bit) Offset register.
- However, writing all offset registers does not have to occur at one time. One or two offset registers can be written and then by bringing the Write Enable 2/Load (WEN2/LD) pin HIGH, the FIFO is returned to normal read/write operation. When the Write Enable 2/Load (WEN2/LD) pin is set LOW, the Write Enable 1 (WEN1) is LOW, the next offset register in sequence is written.

**Table 1: Write Offset Register**

<table>
<thead>
<tr>
<th>LD</th>
<th>WEN</th>
<th>WCLK</th>
<th>Selection</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
<td></td>
<td>Empty Offset (LSB)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Empty Offset (MSB)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Full Offset (LSB)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Full Offset (MSB)</td>
</tr>
<tr>
<td>0</td>
<td>1</td>
<td></td>
<td>No Operation</td>
</tr>
<tr>
<td>1</td>
<td>0</td>
<td></td>
<td>Write Into FIFO</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td></td>
<td>No Operation</td>
</tr>
</tbody>
</table>

**NOTE:**
1. For the purposes of this table, WEN2 = V$h$.
2. The same selection sequence applies to reading from the registers. REN1 and REN2 are enabled and read is performed on the LOW-to-HIGH transition of RCLK.
The contents of the offset registers can be read on the output lines when the Write Enable 2/Load (WEN2/LD) pin is set LOW and both Read Enables (REN1, REN2) are set LOW. Data can be read on the LOW-to-HIGH transition of the Read Clock (RCLK).

A read and write should not be performed simultaneously to the offset registers.

---

Figure 3. Offset Register Location and Default Values
OUTPUTS:

FULL FLAG (FF)

The Full Flag (FF) will go LOW, inhibiting further write operation, when the device is full. If no reads are performed after Reset (RS), the Full Flag (FF) will go LOW after 64 writes for the IDT72421, 256 writes for the IDT72201, 512 writes for the IDT72211, 1,024 writes for the IDT72221, 2,048 writes for the IDT72231, 4,096 writes for the IDT72241, and 8,192 writes for the IDT72251.

The Full Flag (FF) is synchronized with respect to the LOW-to-HIGH transition of the Write Clock (WCLK).

EMPTY FLAG (EF)

The Empty Flag (EF) will go LOW, inhibiting further read operations, when the read pointer is equal to the write pointer, indicating the device is empty.

The Empty Flag (EF) is synchronized with respect to the LOW-to-HIGH transition of the Read Clock (RCLK).

PROGRAMMABLE ALMOST-FULL FLAG (PAF)

The Programmable Almost-Full flag (PAF) will go LOW when the FIFO reaches the almost-full condition. If no reads are performed after Reset (RS), the Programmable Almost-Full flag (PAF) will go LOW after (64-m) writes for the IDT72421, (256-m) writes for the IDT72201, (512-m) writes for the IDT72211, (1,024-m) writes for the IDT72221, (2,048-m) writes for the IDT72231, (4,096-m) writes for the IDT72241, and (8,192-m) writes for the IDT72251. The offset “m” is defined in the Full offset registers.

If there is no Full offset specified, the Programmable Almost-Full flag (PAF) will go LOW at Full-7 words.

The Programmable Almost-Full flag (PAF) is synchronized with respect to the LOW-to-HIGH transition of the Write Clock (WCLK).

PROGRAMMABLE ALMOST-EMPTY FLAG (PAE)

The Programmable Almost-Empty flag (PAE) will go LOW when the read pointer is “n+1” locations less than the write pointer. The offset “n” is defined in the Empty Offset registers. If no reads are performed after Reset the Programmable Almost-Empty flag (PAE) will go HIGH after “n+1” for the IDT72421/72201/72211/72221/72231/72241/72251.

If there is no Empty offset specified, the Programmable Almost-Empty flag (PAE) will go LOW at Empty+7 words.

The Programmable Almost-Empty flag (PAE) is synchronized with respect to the LOW-to-HIGH transition of the Read Clock (RCLK).

DATA OUTPUTS (Q0 - Q8)

Data outputs for a 9-bit wide data.

---

TABLE 1 — STATUS FLAGS

<table>
<thead>
<tr>
<th>NUMBER OF WORDS IN FIFO</th>
<th>IDT72421</th>
<th>IDT72201</th>
<th>FF</th>
<th>PAF</th>
<th>PAE</th>
<th>EF</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
<td>0</td>
<td>H</td>
<td>H</td>
<td>L</td>
<td>L</td>
</tr>
<tr>
<td>1 to n</td>
<td>0</td>
<td>0</td>
<td>H</td>
<td>H</td>
<td>L</td>
<td>L</td>
</tr>
<tr>
<td>(n+1) to (64-(m+1))</td>
<td>(n+1)</td>
<td>(n+1)</td>
<td>H</td>
<td>H</td>
<td>L</td>
<td>L</td>
</tr>
<tr>
<td>(64-(m)^2) to 63</td>
<td>(256-(m)^2) to 255</td>
<td>H</td>
<td>L</td>
<td>H</td>
<td>H</td>
<td></td>
</tr>
<tr>
<td>64</td>
<td>256</td>
<td>512</td>
<td>L</td>
<td>L</td>
<td>H</td>
<td>H</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>NUMBER OF WORDS IN FIFO</th>
<th>IDT72221</th>
<th>IDT72231</th>
<th>IDT72241</th>
<th>IDT72251</th>
<th>FF</th>
<th>PAF</th>
<th>PAE</th>
<th>EF</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>H</td>
<td>H</td>
<td>L</td>
<td>L</td>
</tr>
<tr>
<td>1 to n</td>
<td>1 to n</td>
<td>1 to n</td>
<td>1 to n</td>
<td>1 to n</td>
<td>H</td>
<td>H</td>
<td>L</td>
<td>L</td>
</tr>
<tr>
<td>(n+1) to (1,024-(m+1))</td>
<td>(n+1)</td>
<td>(n+1)</td>
<td>(n+1)</td>
<td>(n+1)</td>
<td>H</td>
<td>H</td>
<td>H</td>
<td>H</td>
</tr>
<tr>
<td>(1,024-(m)^2) to 1,023</td>
<td>(2,048-(m)^2) to 2,047</td>
<td>(4,096-(m)^2) to 4,096</td>
<td>(8,192-(m)^2) to 8,192</td>
<td>L</td>
<td>L</td>
<td>H</td>
<td>H</td>
<td></td>
</tr>
<tr>
<td>1,024</td>
<td>2,048</td>
<td>4,096</td>
<td>8,192</td>
<td>8,192</td>
<td>L</td>
<td>L</td>
<td>H</td>
<td>H</td>
</tr>
</tbody>
</table>

NOTES:

1. n = Empty Offset (n = 7 default value)
2. m = Full Offset (m = 7 default value)
COMMERCIAL AND INDUSTRIAL
TEMPERATURE RANGES

IDT72421/72201/72221/72241/72251 CMOS SyncFIFO™
64 x 9, 256 x 9, 512 x 9, 1,024 x 9, 2,048 x 9, 4,096 x 9 and 8,192 x 9

NOTE:
1. tSKEW1 is the minimum time between a rising RCLK edge and a rising WCLK edge for FF to change during the current clock cycle. If the time between the rising edge of RCLK and the rising edge of WCLK is less than tSKEW1, then FF may not change state until the next WCLK edge.

Figure 5. Write Cycle Timing

NOTES:
1. Holding WEN2/Ł HIGH during reset will make the pin act as a second write enable pin. Holding WEN2/Ł LOW during reset will make the pin act as a load enable for the programmable flag offset registers.
2. After reset, the outputs will be LOW if OE = 0 and tri-state if OE = 1.
3. The clocks (RCLK, WCLK) can be free-running during reset.

Figure 4. Reset Timing

NOTE:
1. tsKEW1 is the minimum time between a rising RCLK edge and a rising WCLK edge for FF to change during the current clock cycle. If the time between the rising edge of RCLK and the rising edge of WCLK is less than tsKEW1, then FF may not change state until the next WCLK edge.

Figure 5. Write Cycle Timing
NOTE:
1. \( t_{SKEW1} \) is the minimum time between a rising WCLK edge and a rising RCLK edge for \( EF \) to change during the current clock cycle. If the time between the rising edge of RCLK and the rising edge of WCLK is less than \( t_{SKEW1} \), then \( EF \) may not change state until the next RCLK edge.

Figure 6. Read Cycle Timing

NOTE:
1. When \( t_{SKEW1} \geq \) minimum specification, \( t_{FRL} = t_{CLK} + t_{SKEW1} \)

\( t_{SKEW1} < \) minimum specification, \( t_{FRL} = 2t_{CLK} + t_{SKEW1} \) or \( t_{CLK} + t_{SKEW1} \)

The Latency Timings apply only at the Empty Boundary (\( EF = LOW \)).

Figure 7. First Data Word Latency Timing
NOTE:
1. Only one of the two write enable inputs, WEN1 or WEN2, needs to go inactive to inhibit writes to the FIFO.

Figure 8. Full Flag Timing

NOTE:
1. When tSKEW1 ≥ minimum specification, tFRL maximum = tCLK + tSKEW1
   
   tSKEW1 < minimum specification, tFRL maximum = 2tCLK + tSKEW1 or tCLK + tSKEW1
   
   The Latency Timings apply only at the Empty Boundary (EF = LOW).

Figure 9. Empty Flag Timing
NOTES:
1. \( n = \text{PAE} \) offset.
2. \( 64-m \) words in FIFO for IDT72421, \( 256-m \) words for IDT72201, \( 512-m \) words for IDT72211, \( 1,024-m \) words for IDT72221, \( 2,048-m \) words for IDT72231, \( 4,096-m \) words for IDT72241, and \( 8,192-m \) words for IDT72251.
3. \( t_{SKEW2} \) is the minimum time between a rising \( \text{WCLK} \) edge and a rising \( \text{RCLK} \) edge for \( \text{PAE} \) to change during that clock cycle. If the time between the rising edge of \( \text{RCLK} \) and the rising edge of \( \text{WCLK} \) is less than \( t_{SKEW2} \), then \( \text{PAE} \) may not change state until the next \( \text{WCLK} \) rising edge.
4. If a read is performed on this rising edge of the Read Clock, there will be Empty + (\( n-1 \)) words in the FIFO when \( \text{PAE} \) goes LOW.

*Figure 10. Programmable Full Flag Timing*

NOTES:
1. \( m = \text{PAF} \) offset.
2. \( 64-m \) words in FIFO for IDT72421, \( 256-m \) words for IDT72201, \( 512-m \) words for IDT72211, \( 1,024-m \) words for IDT72221, \( 2,048-m \) words for IDT72231, \( 4,096-m \) words for IDT72241, and \( 8,192-m \) words for IDT72251.
3. \( t_{SKEW2} \) is the minimum time between a rising \( \text{RCLK} \) edge and a rising \( \text{WCLK} \) edge for \( \text{PAF} \) to change during that clock cycle. If the time between the rising edge of \( \text{RCLK} \) and the rising edge of \( \text{WCLK} \) is less than \( t_{SKEW2} \), then \( \text{PAF} \) may not change state until the next \( \text{WCLK} \) rising edge.
4. If a write is performed on this rising edge of the Write Clock, there will be Full - (\( m-1 \)) words in the FIFO when \( \text{PAF} \) goes LOW.

*Figure 11. Programmable Empty Flag Timing*
**Figure 12. Write Offset Registers Timing**

**Figure 13. Read Offset Registers Timing**
OPERATING CONFIGURATIONS

SINGLE DEVICE CONFIGURATION

A single IDT72421/72201/72211/72221/72231/72241/72251 may be used when the application requirements are for 64/256/512/1,024/2,048/4,096/8,192 words or less. When these FIFOs are in a Single Device Configuration, the Read Enable 2 (REN2) control input can be grounded (see Figure 14). In this configuration, the Write Enable 2/Load (WEN2/LD) pin is set LOW at Reset so that the pin operates as a control to load and read the programmable flag offsets.

WIDTH EXPANSION CONFIGURATION

Word width may be increased simply by connecting the corresponding input controls signals of multiple devices. A composite flag should be created for each of the endpoint status flags (EF and FF). The partial status flags (AE and AF) can be detected from any one device. Figure 15 demonstrates a 18-bit word width by using two IDT72421/72201/72211/72221/72231/72241/72251s. Any word width can be attained by adding additional IDT72421/72201/72211/72221/72231/72241/72251s.

When these FIFOs are in a Width Expansion Configuration, the Read Enable 2 (REN2) control input can be grounded (see Figure 15). In this configuration, the Write Enable 2/Load (WEN2/LD) pin is set LOW at Reset so that the pin operates as a control to load and read the programmable flag offsets.

DEPTH EXPANSION - The IDT72421/72201/72211/72221/72231/72241/72251 can be adapted to applications when the requirements are for greater than 64/256/512/1,024/2,048/4,096/8,192 words. The existence of two enable pins on the read and write port allow depth expansion. The Write Enable 2/Load pin is used as a second write enable in a depth expansion configuration thus the Programmable flags are set to the default values. Depth expansion is possible by using one enable input for system control while the other enable input is controlled by expansion logic to direct the flow of data. A typical application would have the expansion logic alternate data access from one device to the next in a sequential manner. These devices operate in the Depth Expansion configuration when the following conditions are met:

1. The WEN2/LD pin is held HIGH during Reset so that this pin operates a second Write Enable.
2. External logic is used to control the flow of data.

Please see the Application Note "DEPTH EXPANSION OF IDT’S SYNCHRONOUS FIFOs USING THE RING COUNTER APPROACH" for details of this configuration.
### ORDERING INFORMATION

<table>
<thead>
<tr>
<th>Device Type</th>
<th>Power</th>
<th>Speed</th>
<th>Package</th>
<th>Process/ Temperature Range</th>
<th>Clock Cycle Time (tCLK)</th>
<th>Speed in Nanoseconds</th>
</tr>
</thead>
<tbody>
<tr>
<td>PLCC, J32-1</td>
<td></td>
<td></td>
<td></td>
<td>BLANK</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TQFP, PR32-1</td>
<td></td>
<td></td>
<td></td>
<td>BLANK</td>
<td></td>
<td></td>
</tr>
<tr>
<td>J</td>
<td></td>
<td></td>
<td></td>
<td>G</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PF</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>L</td>
<td></td>
<td></td>
<td></td>
<td>Low Power</td>
<td></td>
<td></td>
</tr>
<tr>
<td>72421</td>
<td>64 x 9</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>72201</td>
<td>256 x 9</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>72211</td>
<td>512 x 9</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>72221</td>
<td>1,024 x 9</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>72231</td>
<td>2,048 x 9</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>72241</td>
<td>4,096 x 9</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>72251</td>
<td>8,192 x 9</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### NOTES:
1. Industrial temperature range product for the 15ns and 25ns speed grades are available as standard product.
2. Green parts are available. For specific speeds and packages contact your sales office.

**LEAD FINISH (SNPB) PARTS ARE IN EOL PROCESS. PRODUCT DISCONTINUATION NOTICE - PDN# SP-17-02**

### DATASHEET DOCUMENT HISTORY

<table>
<thead>
<tr>
<th>Date</th>
<th>Pages</th>
</tr>
</thead>
<tbody>
<tr>
<td>10/03/2000</td>
<td>2, 3, 4 and 14.</td>
</tr>
<tr>
<td>05/01/2001</td>
<td>1, 2, 3, 4 and 14.</td>
</tr>
<tr>
<td>02/08/2006</td>
<td>1 and 14.</td>
</tr>
<tr>
<td>10/22/2008</td>
<td>14.</td>
</tr>
<tr>
<td>08/08/2013</td>
<td>1, 3, 13 and 14.</td>
</tr>
</tbody>
</table>
Notice

1. Descriptions of circuits, software and other related information in this document are provided only to illustrate the operation of semiconductor products and application examples. You are fully responsible for the incorporation or any other use of the circuits, software, and information in the design of your product or system. Renesas Electronics disclaims any and all liability for any losses and damages incurred by you or third parties arising from the use of these circuits, software, or information.

2. Renesas Electronics hereby expressly disclaims any warranties against and liability for infringement or any other claims involving patents, copyrights, or other intellectual property rights of third parties, by or arising from the use of Renesas Electronics products or technical information described in this document, including but not limited to, the product data, drawings, charts, programs, algorithms, and application examples.

3. No license, express, implied or otherwise, is granted hereby under any patents, copyrights or other intellectual property rights of Renesas Electronics or others.

4. You shall not alter, modify, copy, or reverse engineer any Renesas Electronics product, whether in whole or in part. Renesas Electronics disclaims any and all liability for any losses or damages incurred by you or third parties arising from such alteration, modification, copying or reverse engineering.

5. Renesas Electronics products are classified according to the following two quality grades: "Standard" and "High Quality". The intended applications for each Renesas Electronics product depends on the product's quality grade, as indicated below.

   - "Standard": Computers; office equipment; communications equipment; test and measurement equipment; audio and visual equipment; home electronic appliances; machine tools; personal electronic equipment; industrial robots; etc.
   - "High Quality": Transportation equipment (automobiles, trains, ships, etc.); traffic control (traffic lights); large-scale communication equipment; key financial terminal systems; safety control equipment; etc.

   Unless expressly designated as a high reliability product or a product for harsh environments in a Renesas Electronics data sheet or other Renesas Electronics document, Renesas Electronics products are not intended or authorized for use in products or systems that may pose a direct threat to human life or bodily injury (artificial life support devices or systems; surgical implantations; etc.), or may cause serious property damage (space system; undersea repeaters; nuclear power control systems; aircraft control systems; key plant systems; military equipment; etc.). Renesas Electronics disclaims any and all liability for any damages or losses incurred by you or any third parties arising from the use of any Renesas Electronics product that is inconsistent with any Renesas Electronics data sheet, user's manual or other Renesas Electronics document.

6. When using Renesas Electronics products, refer to the latest product information (data sheets, user's manuals, application notes, "General Notes for Handling and Using Semiconductor Devices" in the reliability handbook, etc.), and ensure that usage conditions are within the ranges specified by Renesas Electronics with respect to maximum ratings, operating power supply voltage range, heat dissipation characteristics, installation, etc. Renesas Electronics disclaims any and all liability for any malfunctions, failure or accident arising out of the use of Renesas Electronics products outside of such specified ranges.

7. Although Renesas Electronics endeavors to improve the quality and reliability of Renesas Electronics products, semiconductor products have specific characteristics, such as the occurrence of failure at a certain rate and malfunctions under certain use conditions. Unless designated as a high reliability product or a product for harsh environments in a Renesas Electronics data sheet or other Renesas Electronics document, Renesas Electronics products are not subject to radiation resistance design. You are responsible for implementing safety measures to guard against the possibility of bodily injury, injury or damage caused by fire, and/or danger to the public in the event of a failure or malfunction of Renesas Electronics products, such as safety design for hardware and software, including but not limited to redundancy, fire control and malfunction prevention, appropriate treatment for aging degradation or any other appropriate measures. Because the evaluation of microcomputer software alone is very difficult and impractical, you are responsible for evaluating the safety of the final products or systems manufactured by you.

8. Please contact a Renesas Electronics sales office for details as to environmental matters such as the environmental compatibility of each Renesas Electronics product. You are responsible for carefully and sufficiently investigating applicable laws and regulations that regulate the inclusion or use of controlled substances, including without limitation, the EU RoHS Directive, and using Renesas Electronics products in compliance with all these applicable laws and regulations. Renesas Electronics disclaims any and all liability for damages or losses occurring as a result of your noncompliance with applicable laws and regulations.

9. Renesas Electronics products and technologies shall not be used for or incorporated into any products or systems whose manufacture, use, or sale is prohibited under any applicable domestic or foreign laws or regulations. You shall comply with any applicable export control laws and regulations promulgated and administered by the governments of any countries asserting jurisdiction over the parties or transactions.

10. It is the responsibility of the buyer or distributor of Renesas Electronics products, or any other party who distributes, disposes of, or otherwise sells or transfers the product to a third party, to notify such third party in advance of the contents and conditions set forth in this document.

11. This document shall not be reprinted, reproduced or duplicated in any form, in whole or in part, without prior written consent of Renesas Electronics.

12. Please contact a Renesas Electronics sales office if you have any questions regarding the information contained in this document or Renesas Electronics products.

(Note1) "Renesas Electronics" as used in this document means Renesas Electronics Corporation and also includes its directly or indirectly controlled subsidiaries.

(Note2) "Renesas Electronics product(s)" means any product developed or manufactured by or for Renesas Electronics.

(Rev.4.0-1 November 2017)

Corporate Headquarters

TOYOSU FORESIA, 3-2-24 Toyosu,
Koto-ku, Tokyo 135-0061, Japan
www.renesas.com

Contact Information

For further information on a product, technology, the most up-to-date version of a document, or your nearest sales office, please visit:
www.IDT.com/go/support

Trademarks

Renesas and the Renesas logo are trademarks of Renesas Electronics Corporation. All trademarks and registered trademarks are the property of their respective owners.