ITM-C-328
Manual

Release Note:
1. Jan 28, 2004 – official released v1.0

2. Feb 24, 2004 – official released v1.1
   • Fix the definition of verify code
   • Fix the bug of unable jump to power save mode
   • Fix the incorrect connection speed after wake up from power save mode
**General Description**

The C328 module is a highly integrated serial camera board that can be attached to a wireless or PDA host performing as a video camera or a JPEG compressed still camera. It provides a serial interface (RS-232) and JPEG compression engine to act as a low cost and low powered camera module for high resolution serial bus security system or PDA accessory applications.

![System block diagram](image)

**Features**

- Small in size, low cost and low powered (3.3V) camera module for high resolution serial bus security system or PDA accessory applications.
- On-board EEPROM provides a command based interface to external host via RS-232.
- UART: 115.2Kbps for transferring JPEG still pictures or 160x128 preview @8bpp with 0.75fps-6fps.
- On board OmniVision OV7640/8 VGA color sensor.
- Built-in JPEG CODEC for different resolutions.
- Built-in down sampling, clamping and windowing circuits for VGA, QVGA, 160x128 or 80x64 image resolutions.
- Built-in color conversion circuits for standard JPEG preview images.
- No external DRAM required.

**System Configuration**

1. **Camera Sensor**
   The C328-7640 module uses OmniVision OV7640/8 VGA color digital CameraChips with an 8-bit YCbCr interface.

2. **OV528 Serial Bridge**
   The OV528 Serial Bridge is a JPEG CODEC embedded controller chip that can compress and transfer image data from CameraChips to external device. The OV528 takes 8-bit YCbCr 422 progressive video data from an OV7640/8 CameraChip. The camera interface synchronizes with input video data and performs down-sampling, clamping and windowing functions with desired resolution, as well as color conversion that is requested by the user through serial bus host commands.
   The JPEG CODEC can achieve higher compression ratio and better image quality for various image resolutions.

3. **Program EEPROM**
   A serial type program memory is built-in for C328-7640 to provide a set of user-friendly command interfacing to external host.
Board Layout

Figure 2 – C328-7640 board layout and serial interface pin

Serial Interface

1. Single Byte Timing Diagram
   A single byte RS-232 transmission consists of the start bit, 8-bit contents and the stop bit. A start bit is always 0, while a stop bit is always 1. LSB is sent out first and is right after the start bit.

![Single Byte Transmission Diagram](image)

Figure 3 – RS-232 single byte timing diagram

2. Command Timing Diagram
   A single command consists of 6 continuous single byte RS-232 transmissions. The following is an example of SYNC (AA0D00000000h) command.

![SYNC Command Timing Diagram](image)

Figure 4 – RS-232 SYNC command timing diagram
Command Set

The C328-7640 module supports total 11 commands for interfacing to host as following:

<table>
<thead>
<tr>
<th>Command</th>
<th>ID Number</th>
<th>Parameter1</th>
<th>Parameter2</th>
<th>Parameter3</th>
<th>Parameter4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial</td>
<td>AA01h</td>
<td>00h</td>
<td>07h</td>
<td>07h</td>
<td>JPEG Resolution</td>
</tr>
<tr>
<td>Get Picture</td>
<td>AA04h</td>
<td>Picture Type</td>
<td>00h</td>
<td>00h</td>
<td>00h</td>
</tr>
<tr>
<td>Snapshot</td>
<td>AA05h</td>
<td>00h</td>
<td>00h</td>
<td>00h</td>
<td>00h</td>
</tr>
<tr>
<td>Set Package Size</td>
<td>AA06h</td>
<td>08h</td>
<td>Package Size Low Byte</td>
<td>Package Size High Byte</td>
<td>00h</td>
</tr>
<tr>
<td>Set Baudrate</td>
<td>AA07h</td>
<td>1st Divider</td>
<td>2nd Divider</td>
<td>00h</td>
<td>00h</td>
</tr>
<tr>
<td>Reset</td>
<td>AA08h</td>
<td>Reset Type</td>
<td>00h</td>
<td>00h</td>
<td>xxh*</td>
</tr>
<tr>
<td>Power Off</td>
<td>AA09h</td>
<td>00h</td>
<td>00h</td>
<td>00h</td>
<td>00h</td>
</tr>
<tr>
<td>Data</td>
<td>AA0Ah</td>
<td>Data Type</td>
<td>Length Byte 0</td>
<td>Length Byte 1</td>
<td>Length Byte 2</td>
</tr>
<tr>
<td>SYNC</td>
<td>AA0Dh</td>
<td>00h</td>
<td>00h</td>
<td>00h</td>
<td>00h</td>
</tr>
<tr>
<td>ACK</td>
<td>AA0Eh</td>
<td>Command ID</td>
<td>ACK counter</td>
<td>00h / Package ID Byte 0</td>
<td>00h / Package ID Byte 1</td>
</tr>
<tr>
<td>NAK</td>
<td>AA0Fh</td>
<td>00h</td>
<td>NAK counter</td>
<td>Error Number</td>
<td>00h</td>
</tr>
</tbody>
</table>

* If the parameter is 0xFF, the command is a special Reset command and the firmware responds to it immediately.

1. **Initial (AA01h)**
   The host issues this command to configure the preview image size. After receiving this command, the module will send out an ACK command to the host if the configuration success. Otherwise, an NACK command will be sent out.

   1.1 JPEG Resolution
   Since the Embedded JPEG Code can support only multiple of 16, the JPEG preview mode can support following image sizes. It is different from normal preview mode.
   
<table>
<thead>
<tr>
<th>Image Size</th>
<th>Parameter</th>
</tr>
</thead>
<tbody>
<tr>
<td>80x64</td>
<td>01h</td>
</tr>
<tr>
<td>160x128</td>
<td>03h</td>
</tr>
<tr>
<td>320x240</td>
<td>05h</td>
</tr>
<tr>
<td>640x480</td>
<td>07h</td>
</tr>
</tbody>
</table>

2. **Get Picture (AA04h)**
   The host gets a picture from C328-7640 by sending this command.

   2.1 Picture Type
   - Snapshot Picture | 01h
   - JPEG Preview Picture | 05h

3. **Snapshot (AA05h)**
   C328-7640 keeps a single frame of JPEG still picture data in the buffer after receiving this command.
4. **Set Package Size (AA06h)**
   The host issues this command to change the size of data package which is used to transmit JPEG image data from the C328-7640 to the host. This command should be issued before sending Snapshot command or Get Picture command to C328-7640. It is noted that the size of the last package varies for different image.

4.1 **Package Size**
   The default size is 64 bytes and the maximum size is 512 bytes.

<table>
<thead>
<tr>
<th>ID</th>
<th>Data Size</th>
<th>Image Data</th>
<th>Verify Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>(2 bytes)</td>
<td>(2 bytes)</td>
<td>(Package size - 6 bytes)</td>
<td>(2 bytes)</td>
</tr>
</tbody>
</table>

   ID -> Package ID, starts from zero for an image
   Data Size -> Size of image data in the package
   Verify Code -> Error detection code, equals to the lower byte of sum of the whole package data except the verify code field. The higher byte of this code is always zero. i.e. verify code = lowbyte(sum(byte[0] to byte[N-2]))

   Note: As the transmission of uncompressed image is not in package mode, it is not necessary to set the package size for uncompressed image.

5. **Set Baudrate (AA07h)**
   Set the C328-7640 baud rate by issuing this command. As the default baud rate is 14400bps, host should make connection with C328-7640 at this baud rate each time power on.

5.1 **Baudrate Divider**
   \[ \text{Baudrate} = \frac{14.7456MHz}{2 \times (2^\text{nd Divider} + 1) \times 2 \times (1^\text{st Divider} + 1)} \]

<table>
<thead>
<tr>
<th>Baudrate</th>
<th>1\text{st} Divider</th>
<th>2\text{nd} Divider</th>
</tr>
</thead>
<tbody>
<tr>
<td>7200 bps</td>
<td>ffh</td>
<td>01h</td>
</tr>
<tr>
<td>14400 bps</td>
<td>7fh</td>
<td>01h</td>
</tr>
<tr>
<td>28800 bps</td>
<td>3fh</td>
<td>01h</td>
</tr>
<tr>
<td>57600 bps</td>
<td>1fh</td>
<td>01h</td>
</tr>
<tr>
<td>115200 bps</td>
<td>0fh</td>
<td>01h</td>
</tr>
</tbody>
</table>

6. **Reset (AA08h)**
   The host reset C328-7640 by issuing this command.

6.1 **Reset Type**
   “00h” resets the whole system. C328-7640 will reboot and reset all registers and state machines.
   “01h” resets state machines only.

7. **Power Off (AA09h)**
   C328-7640 will go into sleep mode after receiving this command. SYNC command (AA0Dh) must be sent to wake up C328-7640 for certain period until receiving ACK command from C328-7640.

8. **Data (AA0Ah)**
   C328-7640 issues this command for telling the host the type and the size of the image data which is ready for transmitting out to the host.

8.1 **Data Type**
   - Snapshot Picture 01h
   - JPEG Preview Picture 05h

8.2 **Length**
   These three bytes represent the length of data of the Snapshot Picture or JPEG Preview Picture.
9. **SYNC (AA0Dh)**
   Either the host or the C328-7640 can issue this command to make connection. An ACK command must be sent out after receiving this command.

10. **ACK (AA0 Eh)**
    This command indicates the success of last operation. After receiving any valid command, ACK command must be sent out except when getting preview data. The host can issue this command to request image data package with desired package ID after receiving Data command from C328-7640. The host should send this command with package ID F0F0h after receiving a package to end the package transfer. Note that the field “command ID” should be 00h when request image data package.

10.1 Command ID
    The command with that ID is acknowledged by this command.

10.2 ACK Counter
    No use.

10.3 Package ID
    For acknowledging Data command, these two bytes represent the requested package ID. While for acknowledging other commands, these two bytes are set to 00h.

11. **NAK (AA0Fh)**
    This command indicates corrupted transmission or unsupported features.

11.1 NAK Counter
    No use.

11.2 Error Number

<table>
<thead>
<tr>
<th>Error Description</th>
<th>Hex</th>
<th>Error Description</th>
<th>Hex</th>
</tr>
</thead>
<tbody>
<tr>
<td>Picture Type Error</td>
<td>01h</td>
<td>Parameter Error</td>
<td>0bh</td>
</tr>
<tr>
<td>Picture Up Scale</td>
<td>02h</td>
<td>Send Register Timeout</td>
<td>0ch</td>
</tr>
<tr>
<td>Picture Scale Error</td>
<td>03h</td>
<td>Command ID Error</td>
<td>0dh</td>
</tr>
<tr>
<td>Unexpected Reply</td>
<td>04h</td>
<td>Picture Not Ready</td>
<td>0fh</td>
</tr>
<tr>
<td>Send Picture Timeout</td>
<td>05h</td>
<td>Transfer Package Number Error</td>
<td>10h</td>
</tr>
<tr>
<td>Unexpected Command</td>
<td>06h</td>
<td>Set Transfer Package Size Wrong</td>
<td>11h</td>
</tr>
<tr>
<td>SRAM JPEG Type Error</td>
<td>07h</td>
<td>Command Header Error</td>
<td>F0h</td>
</tr>
<tr>
<td>SRAM JPEG Size Error</td>
<td>08h</td>
<td>Command Length Error</td>
<td>F1h</td>
</tr>
<tr>
<td>Picture Format Error</td>
<td>09h</td>
<td>Send Picture Error</td>
<td>F5h</td>
</tr>
<tr>
<td>Picture Size Error</td>
<td>0ah</td>
<td>Send Command Error</td>
<td>ffh</td>
</tr>
</tbody>
</table>
**Command Protocol**

1. **SYNC Command**

   ![Diagram of SYNC Command]

   - **Host**
     - **SYNC (AA 0D 00 00 00 00)**
   - **C328**
     - **ACK (AA 0E 0D xx 00 00)**
     - **SYNC (AA 0D 00 00 00 00)**
     - **ACK (AA 0E 0D xx 00 00)**

2. **Make Connection with C328-7640**
   Send the SYNC command (at 14400bps) until receiving ACK command from C328-7640 (usually an ACK command is receive after sending 25 times of SYNC command). This must be done after power up.

   ![Diagram of Make Connection with C328-7640]

   - **Max. 60 times**
   - **ACK (AA 0E 0D xx 00 00)**
   - **SYNC (AA 0D 00 00 00 00)**
   - **ACK (AA 0E 0D xx 00 00)**
   - **SYNC (AA 0D 00 00 00 00)**
   - **ACK (AA 0E 0D xx 00 00)**
3. Initial, Get Picture, Snapshot, Set Package Size, Set Baudrate, Reset and Power Off Command

4. Getting a Snapshot for RS232
   Make sure connection is made before the following communication.

   4.1 JPEG Snapshot Picture

   ![Diagram of JPEG Snapshot Picture Communication]
5. Getting JPEG preview pictures (video) for RS232
   Make sure connection is made before the following communication.
5.1 JPEG Preview Picture

![Diagram](attachment:image.png)

- Initial JPEG preview, VGA
  (AA 01 00 07 07 07)
- Set Package Size
  512 bytes size
  (AA 06 08 00 02 00)
- Get Picture
  JPEG preview picture
  (AA 04 05 00 00 00)
- ACK
  (AA 0E 01 xx 00 00)
- ACK
  (AA 0E 06 xx 00 00)
- ACK
  (AA 0E 04 xx 00 00)
- Data
  JPEG preview picture
  (AA 0A 05 --- --- ---)
- ACK
  package ID: 0000h
  (AA 0E 00 00 00 00)
- ACK
  package ID: 0001h
  (AA 0E 00 00 01 00)
- ACK
  package ID: F0F0h
  (AA 0E 00 00 F0 F0)
- 1 frame
- Image Data Package
  512 bytes, ID: 0000h
- Image Data Package
  512 bytes, ID: 0001h
- The Last Image Data Package

Note:
xx: Don’t care
~: Image size returned by C328