

Understanding the GP-22050

Key Performance Figures

1 Scope

As a **USB 2.0 multipurpose device**, the **GP-22050** can be used for numerous data transfer applications. As for any PC-based instrumentation device, actual performances may vary according to the used elements.

This technical note is of purpose to review the key figures that should be examined in order to check if the GP-22050 fits any application needs.

2 GP-22050 at a glance

The table hereafter summarises the GP-22050 key figures.

Parameter	Description	Value	Unit
USB 2.0 high speed maximum throughput	Maximum overall bandwidth available on a USB 2.0 high speed connection.	480	Mbps
USB 2.0 full speed maximum throughput	Maximum overall bandwidth available on a USB 2.0 full speed connection	12	Mbps
USB 1.1 maximum throughput	Maximum overall bandwidth available on a USB 1.1 connection	12	Mbps
GP-22050 target connector number of data pins	The GP-22050 target connector is divided into 'data pins', 'control pins', 'special purpose pins' and 'power pins'.	16	-
GP-22050 target connector number of control pins	The GP-22050 target connector is divided into 'data pins', 'control pins', 'special purpose pins' and 'power pins'.	6	-
GP-22050 target connector number of power pins	VCC and GND	10	-
GP-22050 target connector individual pin max frequency	Each pin of the GP-22050 target connector (data and/or control pin) can toggle at this frequency.	50	MHz
GP-22050 maximum data throughput at the target connector	This is the maximum throughput that can be reached at the target connector, if all the data pins toggle at the maximum frequency. This throughput can be sustained for a maximum burst length of 16k words.	800 (= 100	Mbps MByte/s)
GP-22050 continuous throughput	This is the maximum continuous throughput that the GP-22050, coupled with a PC running the 8PI Control Panel software can sustain to transfer data in any direction to/from the PC.	88 (= 11	Mbps MByte/s)
GP-22050 control throughput	This is the maximum throughput available on the GP-22050 target connector control pins	300 (= 37.5	Mbps MByte/s)
GP-22050 embedded memory	Memory available on the GP-22050 device to buffer incoming and outgoing data	16	kByte
GP-22050 total memory	Total memory available to a GP-22050 connected to a PC to store incoming / outgoing data samples.	Unlimited	MByte

3 Target connector clock frequency

The GP-22050 device holds a clock divider unit based on a 16 bits register that defines 2 clocks signals, using a 50 MHz reference clock:

- The **system clock**, used to generate/sample the data / controls on the target connector;
- The **output clock**, optionally generated on a dedicated target connector control line.

The system clock achievable frequencies are defined by the following formula:

$$F_{sys} = F_{ref} / (\text{ClockDiv} + 1) = F_{ref} / M$$

Where: Fref = 50 MHz and ClockDiv is the value of the clock divider register.

Hence, the maximum frequency corresponds to $M = 1 \rightarrow F_{sys} = 50 \text{ MHz}$
The minimum frequency corresponds to $M = 2^{16} \rightarrow F_{sys} = 50.10^6 / (65.536) = 763 \text{ Hz}$

The clock frequency defines the rate at which the data is sampled from / put on the GP-22050 target connector¹.

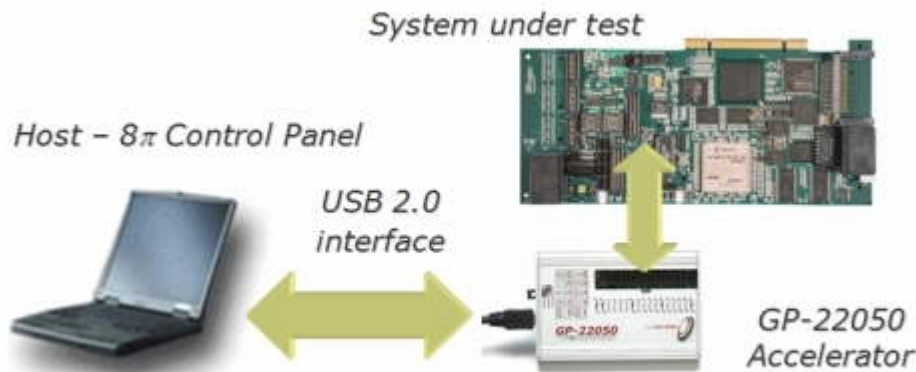
The output clock frequency is defined with another dividing factor:

$$F_{out} = F_{ref} / (M \times N) = F_{sys} / N$$

4 Data throughput

4.1 Overview

Figure 1: GP-22050 setup overview



This section is dedicated to the transfer of data from/to the host PC to/from the system under test. The following setup used:

- **A PC running the 8PI Control panel software;**
- **A GP-22050 device, connected one of the USB ports of the PC;**
- **The 16 data lines of the GP-22050, connected to the system under test.**

¹ In some modes of operation, for this to be true, please make sure that the 'hole clock' option is not selected and the 'continuous mode' option is selected. These options affect the way the clock and output data are generated and have as result to 'relax' the actual throughput. Please refer to the corresponding modes of operation documentation.

Any data transfer proceeds as follows, according to its direction:

- Data acquisition from the system under test:
 - Data is sampled from the system under test at the clock rate defined for the GP-22050 target connector. This data is temporary stored into the GP-22050 embedded memory.
 - The data is transferred to the PC through the USB link. The 8PI Control Panel software communicates with the GP-22050 USB controller to collect the data. The data is stored into the PC memory. It can be saved onto another support (e.g. the PC hard disk) when necessary².
- Data transmission from the PC: same as above, the other way round. The GP-22050 embedded memory is always used as a temporary buffer.

4.2 Burst throughput

The GP-22050 maximum clock frequency and the target connector width define the **maximum burst throughput**:

$$16 \text{ data bits @ maximum frequency} = \\ \mathbf{16 \text{ bits} \times 50 \text{ MHz} = 800 \text{ Mbps} = 100 \text{ MByte/s}}$$

This throughput can be sustained for bursts that do not exceed the embedded memory depth. Over this burst size, the PC won't be able to provide/collect the data in time over the USB link.

4.3 End-to-end throughput

According to the PC hardware used, the USB link can be of the following types:

- USB 2.0 high speed → **480 Mbps**
- USB 2.0 full speed / USB 1.1 → **12 Mbps**

These maximum throughputs are defined for their respective USB standards. Please go to www.usb.org for further information on USB.

Of course, it is always preferable to use a USB 2.0 high speed connection if you wish to benefit from the GP-22050 capabilities.

Defining the **actual data throughput** that you'll end up with is not straightforward: the following elements have to be taken into account:

- The total USB bandwidth dedicated to data transfer is somewhat lower than the theoretical figures: a part of the total bandwidth is reserved to control information for the USB protocol. As a consequence, the total maximum bandwidth actually available for data transfers is about: 380 Mbit/s on a USB 2.0 high speed link – that is about 80% of the total bandwidth.
- The USB port is managed from a PC, run with a non-real time OS. Through the provided 8PI Control Panel host software, the PC will process interrupts or periodically query the USB port. As a consequence, the USB transfer will occur in bursts. If the total data transfer exceeds one 'USB burst', the total burst size and latency between burst affect the actual throughput.

Failure from the host PC to be quick enough to process interrupts or query the port will result in data **underflow error** or **overflow error** from the GP-22050 device:

- **Underflow error** occurs when the PC fails to provide sufficient data to the GP-22050 device. Practically, the GP-22050 buffer memory encounters a 'data shortage' and no new data can be brought to the GP-22050 target connector. This can happen with the GP-22050 in ADWG mode of operation.

² Therefore, the maximum storage memory of a GP-22050 device connected to a PC is virtually unlimited.

- **Overflow error** occurs when the PC fails to fetch the data available in the GP-22050 buffer memory. The GP-22050 embedded buffer memory is full and the host PC can't sustain the incoming data throughput. This can happen in anayser mode of operation.

When the data quantity to transfer with the GP-22050 exceeds the GP-22050 embedded memory size and one USB single frame size, it is possible to quantify **the maximum continuous throughput** of the GP-22050. This quantity measures the overall **sustainable end-to-end throughput** of the system. Its bottleneck is located at the USB link management level – and mainly comes from the USB port latencies³. As a consequence, the maximum continuous throughput is not uniquely defined by the GP-22050 device or by the 8PI Control Panel software and is not guaranteed.

Evaluating the maximum continuous throughput requires testing with different PC types. Standard 3 GHz Pentium 4 PCs reach about up to **11 MByte/s**.

5 Control throughput

The GP-22050 target connector holds 6 control pins. These pins can be used for:

- Generating an output clock signal;
- Getting an external signal as clock input;
- Defining patterns to trigger events;
- Generating repetitive output patterns;
- Setting constant levels.

The essential difference between the target connector control and data lines is that the data lines are used for all informations starting from or ending in the host PC. In other words, the GP-22050 control lines are totally 'hardware controlled' and autonomous. Once programmed, the PC does not affect these control lines any more; as a consequence, the actual performances that can be reached on these control line do not depend of the PC nor the USB link characteristics. As a consequence, the control lines show better rough throughput performance; it is important to note, however that there are many restrictions to the use of the control lines.

The **GP-22050 control throughput** is defined as the maximum throughput that can be achieved on the control lines. This throughput can be found as follows:

6 control lines, maximum frequency: 50 MHz → **control throughput = 6 x 50 = 300 Mbps**.

This supposes that the control lines are used to generate patterns, or to check pre-programmed patterns occurrence (triggers). The generated pattern total length is limited to 250.

³ It is important to note that this latency mostly comes from the host system OS.