Measurement Guide

IQ Capture/Streaming (Option 124/126 and 125/127)

MS2090A Field Master Pro™
MS2080A Field Master™
MS2089A Site Master™
MS27201A Remote Spectrum Monitor

IQ Waveform Capture/Streaming	**Option 124/126 and Option 125/127**

Note	Not all instrument models offer every option or every measurement within a given option. Refer to the Technical Data Sheet of your instrument for available options and supported measurements.

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Chapter 1 — General Information

1-1 Introduction

This measurement guide describes the IQ capture/streaming functions of the Anritsu Field Master Pro and Remote Spectrum Monitors. Refer to Section 1-2 "Option Description" for references to discussion of the supported option. Refer to corresponding measurement guides for an overview of the measurement mode interface. Refer to Chapter 2, "IQ Capture/Streaming (Option 124/126 and 125/127)" to get started with an IQ capture or an IQ stream.

Related Manuals

For additional information and literature covering your product, visit the product page of your instrument and select the Library tab:

http://www.anritsu.com/en-US/test-measurement/products/ms2090a

https://www.anritsu.com/en-US/test-measurement/products/ms208xa

https://www.anritsu.com/en-US/test-measurement/products/ms208xa

http://www.anritsu.com/en-US/test-measurement/products/ms2720xa

Product Information, Compliance, and Safety

Read the Product Information, Compliance, and Safety Guide for important safety, legal, and regulatory notices before operating the equipment:

- Field Master Series and Site Master (MS2089A) – PN: 10100-00069
- Remote Spectrum Monitor – PN: 10100-00064

User Guide

For a complete overview of the instrument hardware and system functions, refer to your instrument user guide. The user guide provides information on the following topics:

- Instrument Care, maintenance and calibration
- External Connections to the top and side panels
- Power Requirements and Battery Information
- System settings such as Wi-Fi, GNSS/GPS, date/time, language settings, etc.
- Other advanced settings and tools such as file management, screenshot settings, port setup, and option configuration.
- Diagnostics and software updates
- Listing of all related documentation such as measurement guides, programming and maintenance manuals.

1-2 Option Description

This section provides a brief overview of the available options covered in this guide.

Note	Not all instrument models offer every option. Please refer to the Technical Data Sheet of your instrument for available options.

IQ Capture and Streaming (Options 124/126 and 125/127)

This feature attains the magnitude/phase or real/imaginary raw data components of a waveform and either saves the data to a file on internal or external USB storage media, or streams the data out of the Data, USB, or Ethernet ports.

Other Options and Features

For descriptions of other options and features not covered in this guide, refer to your instrument user guide or the product page for a comprehensive list of available documentation.

1-3 Document Conventions

The following conventions are used throughout the instrument documentation set.

User Interface Navigation

The instrument user interface consists of menus, buttons, toolbars, and dialog boxes. Elements in navigation paths are separated as follows: MARKER > PEAK SEARCH > NEXT PEAK.

Illustrations

Screen-captured images contained in this document are provided as examples. The chapters included in this measurement guide provide information on advanced measurement features, instrument settings and menu overviews, for a featured option. The actual displays, screen menus, and measurement details may differ based on the instrument, model, firmware version, installed options, and current instrument settings.

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Chapter 2 — IQ Capture/Streaming (Option 124/126 and 125/127)

2-1 Introduction

IQ capture and streaming is available in the spectrum analyzer and real-time spectrum analyzer (RTSA) modes only, for Field Master Pro and Remote Spectrum Monitors. The feature attains the magnitude/phase or real/imaginary raw data components of a waveform and either saves the data to a file on internal or external USB storage media, or streams the data out of the Data, USB, or Ethernet ports. The following sections describe details of the IQ data format and structure. Refer to Section 2-5 “IQ Capture/Streaming Measurement” on page 2-8 to get started with an IQ capture or an IQ stream.

Note	Options 126 and 127 are export license free. Option 126 limits bit depth to 8 or 10 bits when bandwidth is 110 MHz; Option 127 limits streams to 100 MHz BW or less.

2-2 IQ Capture Block Mode

This mode captures a single block of IQ data. IQ data is first stored to high speed DDR4 SDRAM buffer memory and then it can be saved to flash memory or sent to a remote user via Ethernet. The capture length (duration) is limited by the size of the buffer memory (2 GB) and IQ data rate, which is determined by the capture bandwidth. The IQ capture bandwidth must be set to one of the available values listed in the user interface. The output data rate for a single IQ data pair is depended on the selected bandwidth. The output data rate does not change, regardless of bit resolution. The maximum capture length is limited by memory, capture bandwidth and bit resolution. Refer to the instrument technical data sheet for more information.

2-3 IQ Data Format

The `TRAC:IQ:DATA?` query returns a modified version of the SCPI standard (IEEE 488.2) block data format. The header contains three fields with a newline delimiter separating the header from the IQ binary data:

#AXL\n: **A** is a single ASCII digit specifying the number of digits in X.

X is one or more ASCII digits specifying the number of bytes of binary IQ data and ASCII GNSS (GPS) location coordinates.

L is the ASCII string containing the GNSS (GPS) location in the form 'latitude, longitude' in decimal degrees. The coordinates record where the IQ capture was triggered.

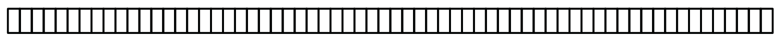
\n is a single byte newline delimiter marking the end of the GNSS (GPS) location component and start of the IQ data.

The IQ data is in binary format and is described below.

IQ Frame Structure

IQ data is organized into two levels: frame and extended frame. The lowest level is a 64-bit frame which may contain one to four IQ sample pairs depending on the selected IQ bit resolution. The second level is an extended frame which can be used for the stamp information. The first column of the IQ vector contains I and the second column contains Q.

64-bit Frame



The 64-bit frame contains one to four IQ sample pairs depending on the selected IQ bit resolution.

Table 2-1. IQ Frame Structure

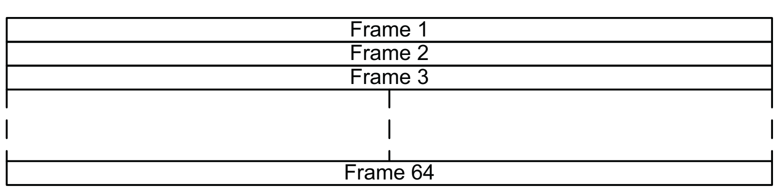
IQ Bit Resolution	Sample Pairs Per Frame	IQ Frame Structure
32	1	32-bit I, 32-bit Q
16	2	16-bit I, 16-bit I, 16-bit Q, 16-bit Q
10	3	10 -bit I, 10-bit I, 10-bit I, 0, 0, 10-bit Q, 10-bit Q, 10-bit Q, 0, 0
8	4	8-bit I, 8-bit I, 8-bit I, 8-bit I, 8-bit Q, 8-bit Q, 8-bit Q, 8-bit Q

Note	The frame structure will be modified slightly when there is a time stamp as described in “IQ Timestamps” on page 2-3.

IQ Extended Frame

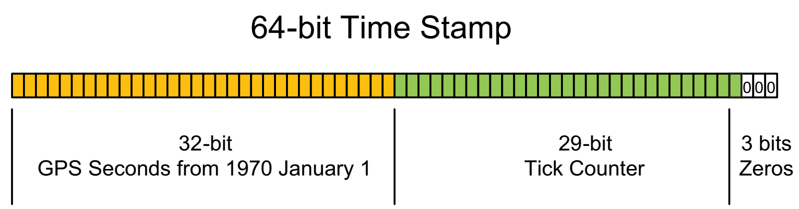
An extended frame consists of 64 frames. When time stamp information is used, each frame contains one bit of a 64-bit time stamp data. An extended frame is 64 frames that contain a time stamp.

Extended Frame



IQ Timestamps

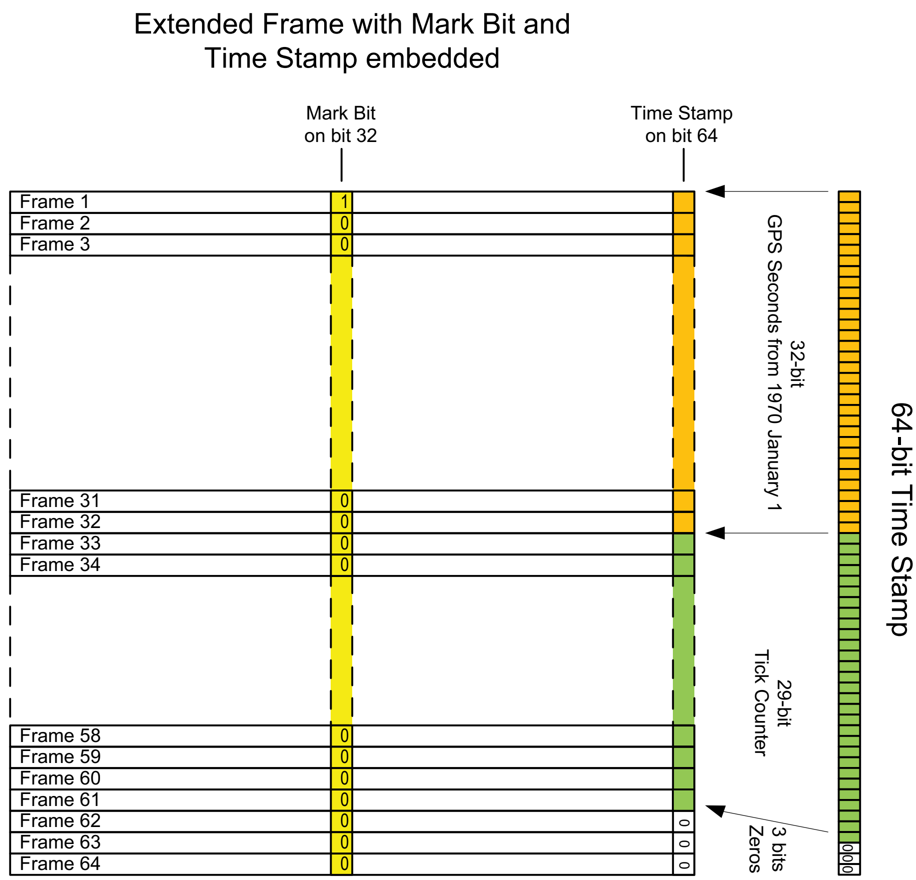
IQ timestamps are available for IQ capture. This section describes how the time stamp is embedded into the IQ data. Within each 64-bit frame, only the first four extended frames contain time stamp information (see the 64-bit time stamp frame diagram below).



The GNSS (GPS) seconds is the time in seconds from January 1, 1970. The tick counter counts at a rate of 270 MHz and it is reset to 0 on every second, triggered by the GPS PPS signal. The time stamp records the time at the beginning of each extended frame. The elapsed time between each frame is calculated with the following formula:

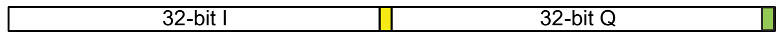
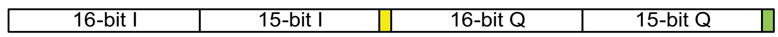
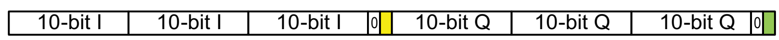
$$\text{Elapsed Time Between Each Frame} = \frac{1}{\text{Output Data Rate}} \times \text{IQ Sample Pairs per Frame}$$

To insert the time stamp without interrupting the IQ data sequence, the 64-bit time stamp is rotated and inserted into the extended frame by using bit 64 from each frame. To indicate the beginning of an extended frame with a time stamp, a mark bit is set to '1' for the first frame and '0' for the remaining 63 frames. The mark bit uses bit 32 of each frame.



Embedding the time stamp requires using two bits from each frame, which requires modifying the IQ frame structure as shown below:

Table 2-2. IQ Frame Structure with Time Stamps

IQ Bit Resolution	IQ Frame Structure
32	 Each frame contains only one IQ sample pair (one I and one Q). The first column of the IQ vector contains I and the second column contains Q. All the frames will have 32 bits each for I and Q. Each I and Q sample is followed the mark or time stamp bit. Within each super frame, only the first four extended frames contain time stamp information. The remaining extended frames will have a zero valued mark and a time stamp bit.
16	 Each frame contains two IQ sample pairs (two I and two Q). The first I and first Q sample in the frame will always have 16 bits; the second I and second Q sample will have 15 bits followed by the mark and a time stamp bit.
10	 Each frame contains three IQ sample pairs (three I and three Q). All of the frames will have 10 bits each for I and Q. Each I and Q sample is followed by one zero, then the mark or time stamp bit. Within each super frame, only the first four extended frames contain time stamp information. The remaining extended frames will have a zero valued mark and a time stamp bit.
8	 Each frame contains four IQ sample pairs (four I and four Q). The first three I and first three Q samples in the frame will always have eight bits. The fourth I and fourth Q sample will have seven bits if the frame is in the first four extended frames, which uses one bit for mark and one bit for the time stamp. Having only seven effective bits instead of eight bits on every fourth sample will slightly increase the noise floor.

Sometimes, the first mark bit does not always begin at the start of the IQ capture. There could be a number of IQ samples recorded before the first time the mark bit is set to one. In the example below, there are five frames before the first timestamp, which doesn't start until the sixth frame. The first column of the IQ vector contains Q and the second column contains I.

Table 2-3. IQ Frame Structure with Time Stamps

N	Frame Data (one I and one Q sample per frame)
0	[I-------TQ-------0]
1	[I-------TQ-------0]
2	[I-------TQ-------0]
3	[I-------TQ-------0]
4	[I-------TQ-------0]
5	[I-------TQ-------0] <- first mark bit, 'T' is the MSB of the timestamp
6	[I-------TQ-------0] <- 'T' is MSB - 1 bit of the timestamp
7	[I-------TQ-------0] <- 'T' is MSB - 2 bit of the timestamp
8	[I-------TQ-------0] <- etc.

To get the timestamp for frames N=0 though N=4, you must extrapolate the timestamp from frame five backward. To get the timestamps for frames 6 through 68, you must extrapolate the timestamp forward. The time between each frame is equal to (1/Output Data Rate) x (Number of I or Q samples per frame).

IQ Bit Resolution	Time Between Each Frame
32	1/(Output Data Rate)
16	2/(Output Data Rate)
10	3/(Output Data Rate)
8	4/(Output Data Rate)

Once the 64 bits of timestamp is put together, you get a number that looks like:

[S-------T-----0000]

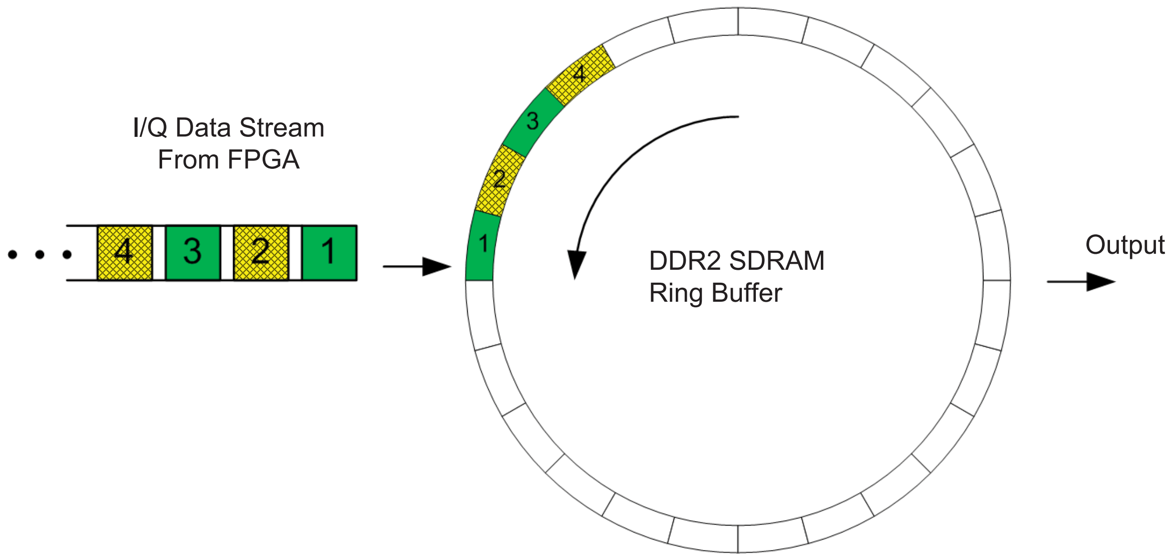
Where 'S-------' is 32 bits specifying the timestamp in seconds since 1970 (time_t), 'T-----' is 28 bits specifying the offset from that second (in clock ticks at 270 MHz), and '0000' are four unused bits.

Note	There could be some frames at the very end of the capture that have an incomplete timestamp because the capture stops before there is a complete group of 64 frames to make an extended frame. In that case you would extrapolate from the previous timestamp.

2-4 IQ Streaming

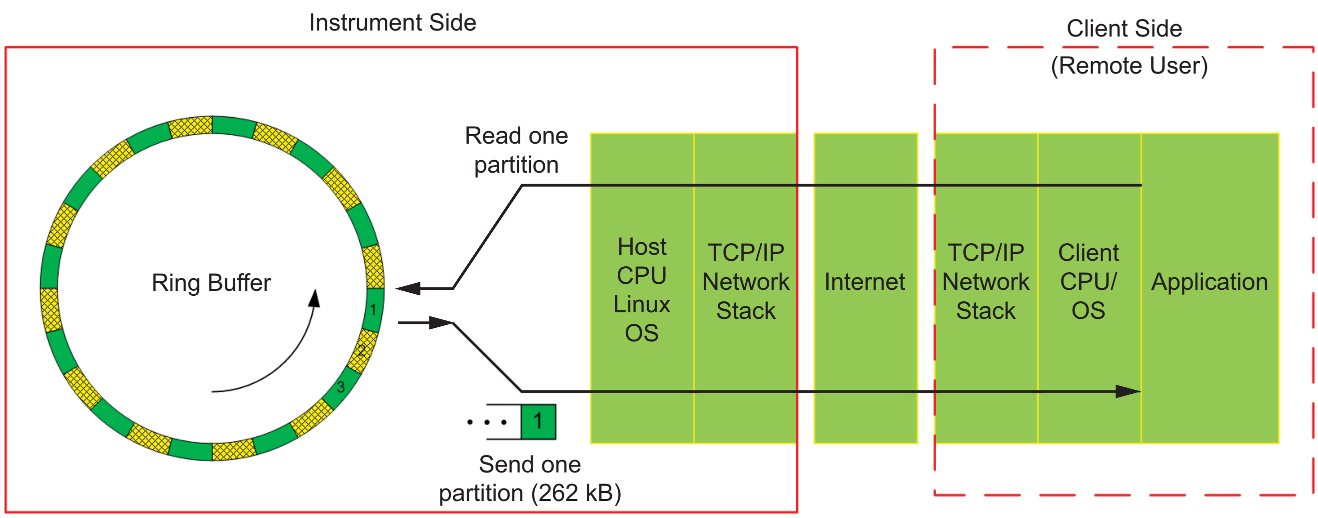
In streaming, the IQ data uses the same frame and extended frame structure as in block mode.

IQ data is captured to high speed DDR4 SDRAM memory, configured as a ring buffer. The buffer memory is 2 GB. The data stream rate to memory is determined by the selected IQ bandwidth. When the buffer is full, new IQ data is stored from the first partition again.



Data Transmission to Remote User

When the IQ is sent out from the memory to the remote user, the data flow rate has to be managed. The simplest way to manage the data flow is to send out one partition and wait for a read command from the remote user before sending another partition. The user may not be able to receive all the partitions if the read command for each partition is delayed due to latency in the CPU, OS, network, and user application. The IQ data is continuously filling the memory partitions at a rate proportional to the selected IQ capture bandwidth. If the read command arrives after the start of a partition, that partition is skipped and will not be sent. The next partition will be sent instead.



To read the IQ data, use the `TRAC:IQ:DATA?` SCPI command. This returns the partition with the most recently captured IQ data. During streaming, the client has to continuously send `TRAC:IQ:DATA?` SCPI command to another partition's IQ data.

The capture of IQ data and filling of partitions will continue until it is aborted with the `:ABORT` command or other commands that change frequency or attenuation settings. To determine if the capture was aborted, check the output of `STATus:OPERation?`.

The `STATus:OPERation?` query responds with an integer. Convert this integer to binary.
Bit 9 is set to 1 when the `MEAS:IQ:CAPT` command is issued.
Bit 9 is set to 0 if the capture is aborted by the `:ABORT` command or other command that invalidates the capture.

2-5 IQ Capture/Streaming Measurement

Setting up an IQ capture/streaming measurement begins with setting up the basic measurement parameters:

- For spectrum analyzer measurement setup, refer to Spectrum Analyzer measurement guide (10580-00447).
- For real-time spectrum analyzer measurement setup, refer to RTSA measurement guide (10580-00448)
- For optimal dynamic range, noise floor, and residual spurs, set the reference level to just above the peak signal level when performing 16-,10-, or 8-bit captures. Otherwise, high level spurs may be present.
- Turn on the preamp when the reference level is set to –40 dBm or lower. With signal levels at –40 dBm and preamp off, spurs may be –15 dB from the signal level with 8-bit captures.

Note	When capturing IQ data from spectrum analyzer mode, the analyzer stops sweeping to start the capture. When the span is wider than the capture bandwidth or the RBW is very narrow, the LO will have to be tuned to the center frequency before the capture starts.

Once your basic measurement is configured, access the IQ CAPTURE menu from the main MEASURE menu. Refer to the measurement guide for the measurement mode you are using for information about using the menus.

2-6 Setting Up the Data Out Port and MA25424A

Set up the instrument and MA25424A for IQ streaming to IQC5000B as shown below:

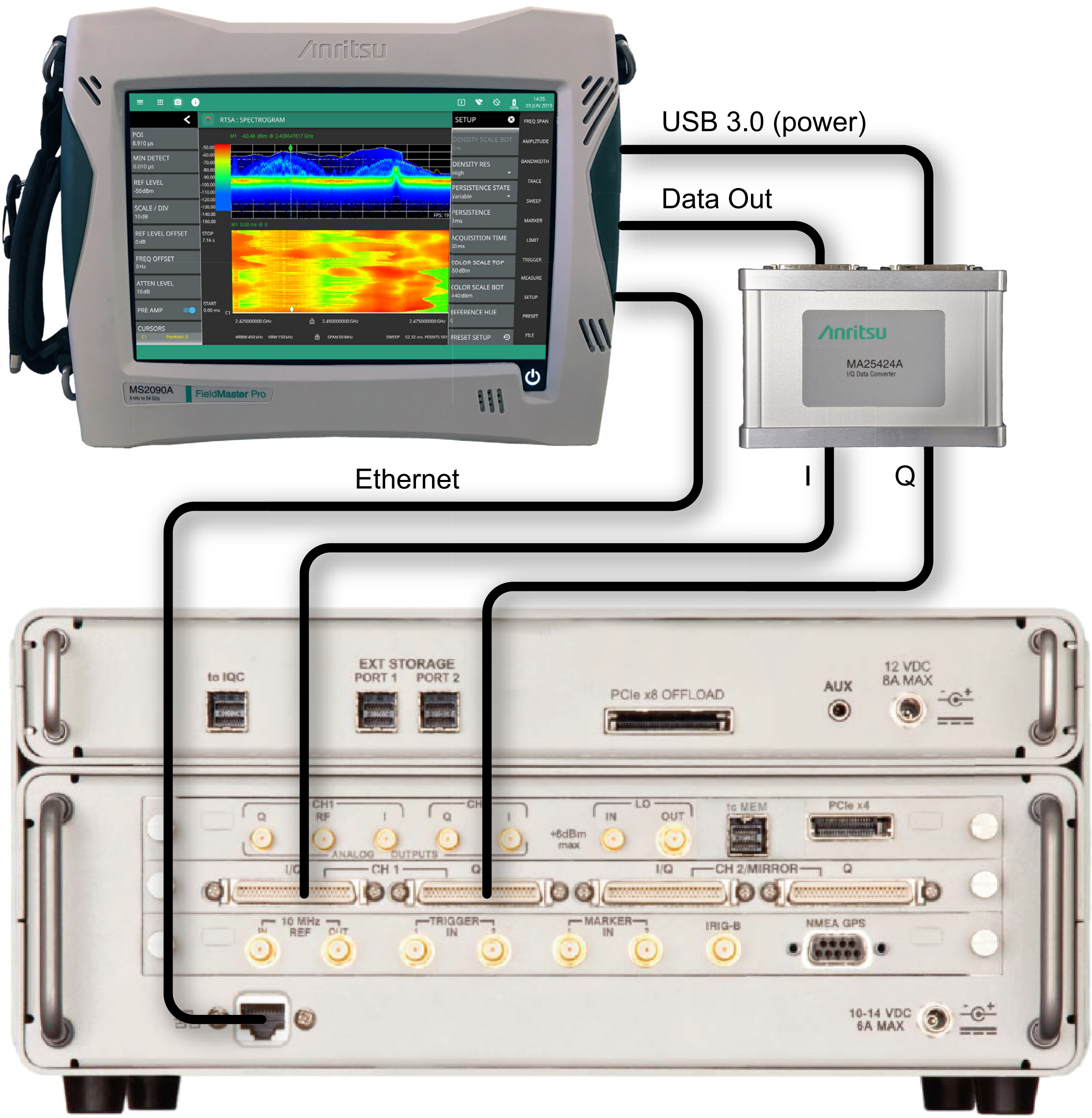


Figure 2-1. MA25424A and IQC5000B Setup

The IQC5000B controls the IQ streaming operation via the Ethernet connection to the instrument. The instrument Data Out and USB ports connect to the MA25424A Data In and USB ports (note that the USB port is used for power and this could come from any external USB 3.0 power supply capable of supplying ~4 W). The MA25424A splits the I and Q signal components to the two respective I and Q output ports (IEEE 1284-C) and streams the data to the IQC5000B I and Q input ports.

Refer to the IQC5000B documentation for a description of its controls.

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