

IAR Embedded Workbench®

IAR Debugging probes User Guide

I-jet®, I-jet Trace, and I-scope™

for Advanced RISC Machines Ltd's

ARM® Cores



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I-jet

This chapter describes the I-jet in-circuit debugging probe. More specifically, this means:

- Introduction
- Working with I-jet
- Technical specifications

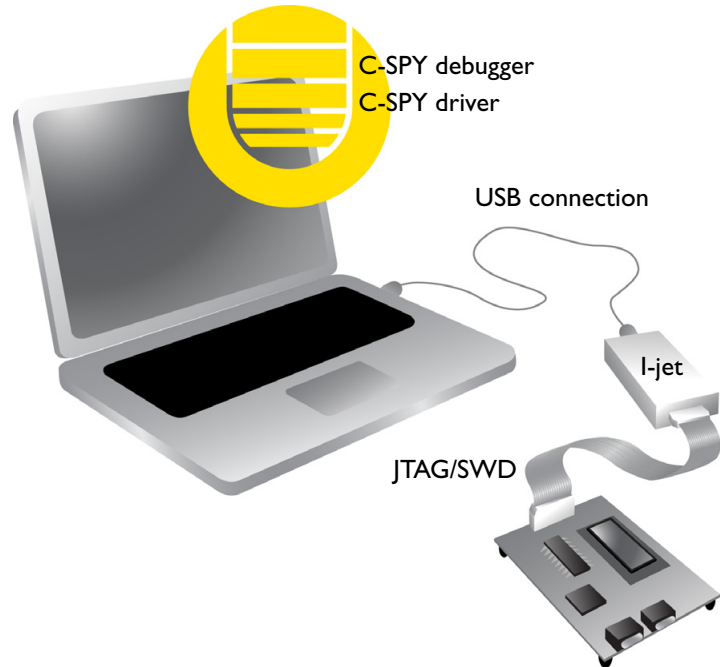
Introduction

This section gives a short overview of the I-jet in-circuit debugging probe. More specifically, this means:

- The I-jet in-circuit debugging probe
- Requirements
- Supported ARM core families
- Target connections.

THE I-JET IN-CIRCUIT DEBUGGING PROBE

I-jet is an in-circuit debugging probe, which connects to the target board via a JTAG or SWD connection, and to the host computer via the USB port.



I-jet communicates using USB 2.0. USB 1.0 is also supported but not advised. The I-jet in-circuit debugging probe is also referred to as a debug probe, debug adapter, or JTAG in-circuit emulator by different tool vendors.



I-jet streams the program counter, variables, and power measurement data to the host computer to provide a view into program execution in real time. Besides the typical JTAG debugging, I-jet is capable of providing power to the target board and measuring it with sufficient accuracy to provide a power profile during program execution in real time. This feature is referred to as *power debugging*.

For debugging Cortex devices, I-jet also supports the SWO (Serial Wire Output) feature, which can be used for tracing the program execution and tracking variables at predefined points in your code.

REQUIREMENTS

I-jet needs to be controlled by the IAR C-SPY® Debugger which comes with the IAR Embedded Workbench® IDE.

SUPPORTED ARM CORE FAMILIES

These cores are currently supported:

- ARM7
- ARM9
- ARM11
- Cortex-M
- Cortex-R
- Cortex-A.

TARGET CONNECTIONS

These interfaces are supported:

- JTAG
- SWD/SWO.

I-jet has a MIPI-20 connector on the front panel. I-jet comes with MIPI-20 and MIPI-10 cables, as well as a legacy ARM-20 adapter.

Working with I-jet

This section describes how to work with I-jet. More specifically, this means:

- Setup and installation
- Connecting the target system.

For information about debugging using I-jet, see the *C-SPY® Debugging Guide for ARM*.

SETUP AND INSTALLATION

Software

Before you can use I-jet, you need to install IAR Embedded Workbench for ARM.

Probe setup

I-jet does not require any special driver software installation. Normally, all drivers for I-jet are automatically installed as part of the installation of IAR Embedded Workbench.

If you need to install the USB driver manually, navigate to
`\Program Files\IAR Systems\Embedded Workbench x.x\arm\drivers\jet`
`\USB\32-bit or 64-bit` (depending on your system). Start the `dpinst.exe`
 application. This will install the USB driver.

For information about using multiple I-jet probes on the same host computer, see the *C-SPY® Debugging Guide for ARM*.

CONNECTING THE TARGET SYSTEM

Power-up your I-jet probe

- 1 Connect I-jet to the host computer using the USB micro cable.
- 2 Connect I-jet to the target board using the cable that matches the target board connector (MIPI-20 or MIPI-10). If a standard JTAG connector is used, you must first plug the JTAG-20 to MIPI-20 adapter into the JTAG connector.

Note: No harm is done if the above order is reversed.



To prevent damage, the target GND and the USB host GND must be at the same level. When *hot-plugging*, make sure that the PC and the target board power supply are connected to the same grounded wall outlet or a common grounded desktop power strip.

Note: It is possible to use multiple I-jet probes on the same host computer, provided that you run multiple instances of IAR Embedded Workbench® for ARM.

Power up your evaluation board

If you have an evaluation board that is prepared for it, you can power the board via I-jet through pin 19 on the standard JTAG-20 connector, or pin 11/13 on the small MIPI-20 connector. Target power of up to 420 mA can be supplied from I-jet with overload protection. Most of the IAR Systems KickStart Kits contain an evaluation board that can be powered this way. Make sure that the power jumper found on most of these boards matches your setup.

Note: The target board will get power via I-Jet once you choose the **Download and Debug** or **Debug without Downloading** command, but not before.

Note: The only way to use the power debugging feature is to power up your evaluation board via I-jet.

Technical specifications

This section provides technical specifications for the I-jet in-circuit debugging probe. More specifically, this means:

- The I-jet package
- Model specifications
- JTAG timing specification
- Hardware revision history
- Target interface
- The JTAG/SWD - MIPI-20 cable
- The JTAG/SWD - MIPI-10 cable
- Indicators
- Adapters.

THE I-JET PACKAGE

The I-jet package contains:

- The I-jet in-circuit debugging probe
- MIPI-20 JTAG cable
- MIPI-10 JTAG cable
- USB-micro cable
- MIPI-20 to ARM-20 adapter
- Welcome letter.

MODEL SPECIFICATIONS

These are the specifications of I-jet:

USB speed	480 Mbps (USB 2.0)
USB connection	Micro-B
Target connection	MIPI-20, MIPI-10

Adapters included	MIPI-20 to ARM-20
I-jet debug interface	JTAG and SWD
JTAG/SWD maximum clock	32 MHz
SWO protocols supported	Manchester and UART
SWO maximum speed	60 Mbps
Power supplied to target	420 mA max at 4.4 V-5 V
Over-current protection	~520 mA
Target power measurement resolution	~160 uA
Target power measurement speed	up to 200 ksps (kilo samples per second)
JTAG voltage range (auto-sensing)	1.8 V to 5 V ($\pm 10\%$)
JTAG VTref measurement resolution	~2 mV
Current draw from VTref	< 50 uA
JTAG clock rise/fall time (TCK)	≤ 2 ns*
Clock fall time	≤ 2 ns*

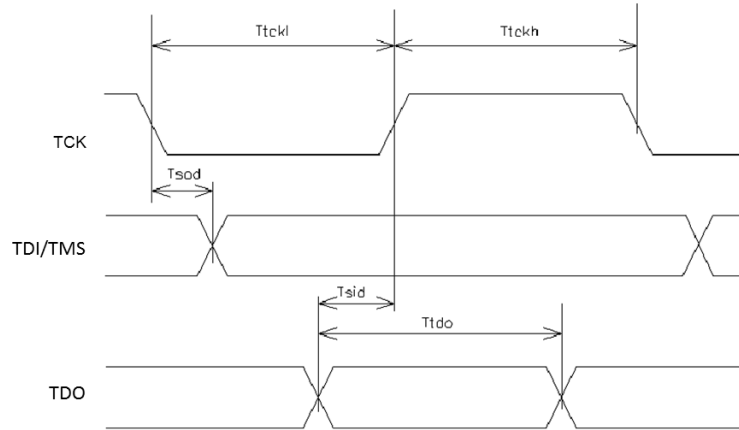
* ≤ 4 ns when the target board is connected

I-jet comes with a 20-pin MIPI connector (0.05 in \times 0.05 in pitch) on the front panel. It includes two cables:

- A 6-inch cable with 20-pin MIPI connectors on both ends for the Cortex-M targets with 20-pin MIPI headers. Pin 7 on each end is keyed with a white plug.
- A 6-inch cable with 20-pin MIPI connectors on one side (to connect to I-jet), and 10-pin MIPI connector on the other side for connection to Cortex-M targets with 10-pin headers. Pin 7 on each end is keyed with a white plug. A red stripe on the cable indicates pin 1 (VTref).

JTAG TIMING SPECIFICATION

This figure shows the JTAG timing and parameters:



In a JTAG device that fully complies to IEEE1149.1 standard, the TDI/TMS signals should be sampled on the rising edge of TCK, and TDO should be sent on the falling edge of TCK. I-jet takes advantage of these requirements and changes its TDI and TMS signals on the falling edge of TCK and samples the TDO on the rising edge of TCK. However, to accommodate target boards with long JTAG chains and fast JTAG clocks, I-jet allows TDO to be as late as 50 ns after the rising edge of TCK.

Note: In the adaptive mode of operation, I-jet samples the TDO on the rising edge of RTCK rather than TCK.

This table shows the timing specifications of the JTAG port measured at the end of its MIPI-20 cable without connection to target (V_{Tref} set to 3.3 V). The only load on the measured signals is the oscilloscope 3.9 pF probe.

Parameter	Min	Max	Description
T_{tckl}	15.6 ns	250 us	TCK LOW period
T_{tckh}	15.6 ns	250 us	TCK HIGH period
T_{sod}^1	--	2.0 ns	TDI and TMS outputs valid from TCK falling
T_{sid}^2	3 ns before TCK to 50 ns after TCK	--	TDO setup to TCK rising
T_{tdo}	T_{tckl}	--	TDO valid length

Table 1: Timing for the I-jet JTAG port

1 T_{sod} is the maximum delay from the falling edge of TCK and a valid level on the I-jet output signals TDI and TMS. The target MCU will sample these signals on the following rising edge of TCK and so the minimum setup time for the target, relative to the rising edge of TCK, is $T_{\text{bscl}} - T_{\text{bsod}}$.

2 T_{sid} is the minimum setup time for the TDO input signal, relative to the rising edge of TCK when I-jet samples this signal. Because the target MCU changes its TDO value on the previous falling edge of TCK, there might not be enough time at very-high JTAG speeds for the TDO to arrive before the positive edge of TCK. To compensate for any TDO delays, I-jet configures itself automatically to delays introduced to the TDO by the target board and will tolerate TDO delays of up to 50 ns after the positive edge of the TCK.

HARDWARE REVISION HISTORY

These are the versions of I-jet:

Version	Change specification	Date
Version A	The first version	April 2012

Table 2: I-jet versions

Version, production date, and serial number can be found on the backside of the probe.

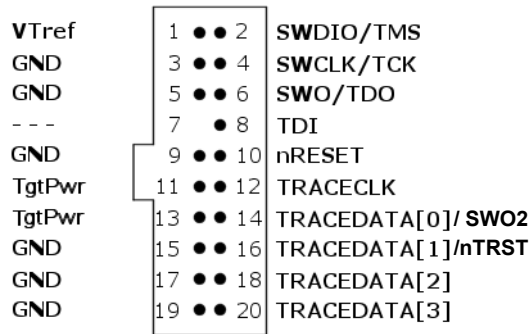
Note: In IAR Embedded Workbench, choose **I-jet/JTAGjet>EmuDiag** to open the **EmuDiag** dialog box where you can find both hardware and firmware versions of the plugged-in I-jet.

TARGET INTERFACE

This section contains descriptions of pinout, signals, and connectors.

The JTAG/SWD - MIPI-20 cable

I-jet comes with a 6-inch cable with 20-pin MIPI connectors on both ends for the Cortex-M devices with 20-pin MIPI headers. Pin 7 on each end is keyed with a white plug:



The mating connector for a target board has the part number FTSH-110-01-L-DV.

These are the MIPI-20 pin definitions:

Pin	Signal	Type	Description
1	VTref	Input	The target reference voltage. Used by I-jet to check whether the target has power, to create the logic-level reference for the input comparators, and to control the output logic levels to the target. It is normally fed from JTAG I/O voltage.
2	SWDIO/TMS	I/O, output	JTAG mode set input of target CPU. This pin should be pulled up on the target. Typically connected to TMS of the target CPU.
4	SWCLK/TCK	Output	JTAG clock signal to target CPU. It is recommended that this pin is pulled to a defined state of the target board. Typically connected to TCK of the target CPU.
6	SWO/TDO	Input	JTAG data output from target CPU. Typically connected to TDO of the target CPU. When using SWD, this pin is used as Serial Wire Output trace port. (Optional, but not required for SWD communication.)

Table 3: MIPI-20 pin definitions

Pin	Signal	Type	Description
--	--	--	This pin (normally pin 7) does not exist.
8	TDI	Output	JTAG data input of target CPU. It is recommended that this pin is pulled to a defined state on the target board. Typically connected to TDI of the target CPU. For CPUs which do not provide TDI (SWD-only devices), this pin is not used (tri-stated).
10	nRESET	I/O	Target CPU reset signal. Typically connected to the RESET pin of the target CPU, which is typically called nRST, nRESET, or RESET.
11	TgtPwr	Output	This pin can be used for supplying 5 V power to the target hardware from I-jet.
12*	TRACECLK	Input	Input trace clock.
13	TgtPwr	Output	This pin can be used for supplying 5 V power to the target hardware from I-jet.
14*	TRACEDATA[0] / SWO2	Input	Input Trace data pin 0. This pin can be used as secondary SWO.
16*	TRACEDATA[1] / nTRST	Input	Input Trace data pin 1. This pin can be used as nTRST.
18*	TRACEDATA[2]	Input	Input Trace data pin 2.
20*	TRACEDATA[3]	Input	Input Trace data pin 3.

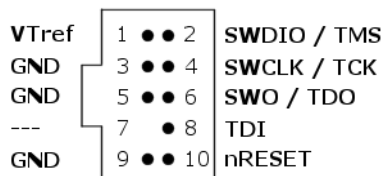
Table 3: MIPI-20 pin definitions

* Not used.

Pins 3, 5, 9, 15, 17, and 19 are GND pins connected to GND in I-jet. They should also be connected to GND in the target system.

The JTAG/SWD - MIPI-10 cable

I-jet also comes with a 6-inch cable with a 20-pin MIPI connector on one side (to connect to I-jet) and a 10-pin MIPI connector on the other side for connection to Cortex devices with 10-pin headers. Pin 7 on each end is keyed with a white plug:



The mating connector for a target board has the part number FTSH-105-01-L-DV.

These are the MIPI-10 pin definitions:

Pin	Signal	Type	Description
1	VTref	Input	The target reference voltage. Used by I-jet to check whether the target has power, to create the logic-level reference for the input comparators, and to control the output logic levels to the target. It is normally fed from JTAG I/O voltage.
2	SWDIO/TMS	I/O, output	JTAG mode set input of target CPU. This pin should be pulled up on the target. Typically connected to TMS of the target CPU. When using SWD, this pin is used as Serial Wire Output trace port. (Optional, not required for SWD communication)
3	GND	GND	Connected to logic GND on I-jet.
4	SWCLK/TCK	Output	JTAG clock signal to target CPU. It is recommended that this pin is pulled to a defined state of the target board. Typically connected to TCK of the target CPU.
5	GND	GND	Connected to logic GND on I-jet.
6	SWO/TDO	Input	JTAG data output from target CPU. Typically connected to TDO of the target CPU.
--	--	--	This pin (normally pin 7) does not exist.
8	TDI	Output	JTAG data input of target CPU. It is recommended that this pin is pulled to a defined state on the target board. Typically connected to TDI of the target CPU. For CPUs that do not provide TDI (SWD-only devices), this pin is not used (tri-stated).

Table 4: MIPI-10 pin definitions

INDICATORS

I-jet has three LED indicators on the top, marked TPWR, DBG, and USB. This section describes the indicators and their statuses.

The TPWR indicator (Target power)

Indicator status	Description
Off	Power to target is not provided by I-jet.
Green	Power to target is provided by I-jet.
Yellow	Warning. Power to target is above 420 mA.

Table 5: TPWR indicator statuses

Indicator status	Description
Red	Error. Overcurrent limit (520 mA) detected and power to target was switched off for protection.

Table 5: TPWR indicator statuses

The DBG indicator (JTAG/SWD)

Indicator status	Description
Off	vTRef on JTAG header is too low.
Green	vTRef is at or above 1.8 V.
Green blinking	Indicates JTAG/SWD communication activity.

Table 6: JTAG indicator statuses

The USB indicator

Indicator status	Description
Off	No USB power.
Green steady	Initial state or no transfer.
Green blinking	USB transfers to or from I-jet.
Red blinking	USB enumeration.
Red steady	USB did not enumerate or broken hardware.

Table 7: USB indicator statuses

ADAPTERS

There are a number of useful adapters available. All of them are automatically recognized by I-jet. The following adapters are described in detail:

- The MIPI-20 to ARM-20 adapter
- The MIPI-20 to TI-14 adapter
- The MIPI-20 to cTI-20 adapter.

Adapters not included in the I-jet package can be purchased from IAR Systems.

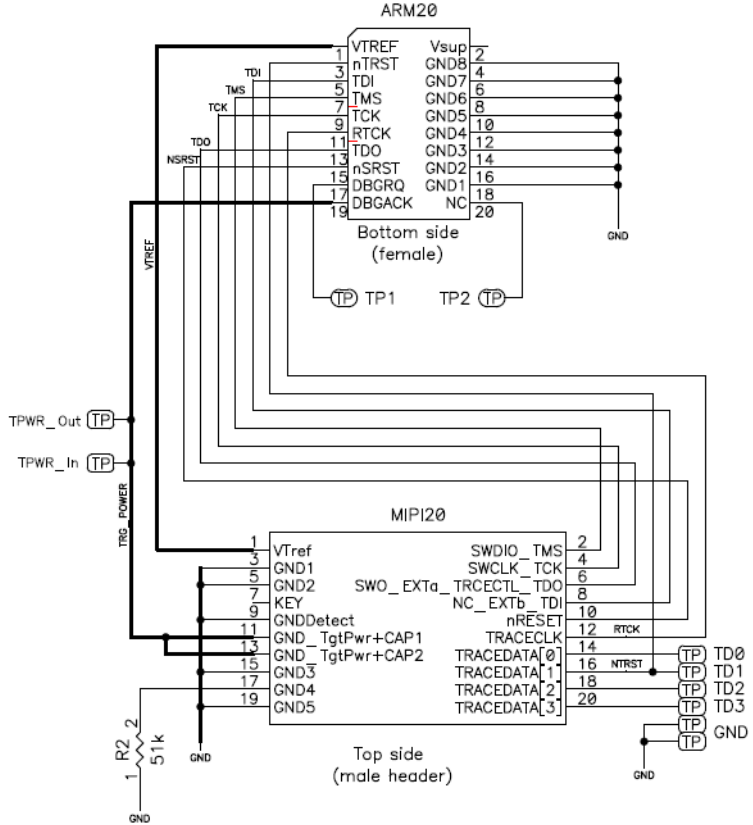
These are the mating target headers for the adapters

TI-14	cTI-20
HTST-107-01-L-DV	TML-110-02-GD-SM-006 (shrouded) FTR-110-51-S-D-06 (unshrouded)

Table 8: Mating target headers, part numbers

The MIPI-20 to ARM-20 adapter

The MIPI-20 to ARM-20 adapter is included with I-jet. It converts the MIPI-20 I-jet cable to the legacy ARM-20 (0.1 in × 0.1 in pitch) JTAG headers. This is a diagram of the adapter:



These are the pin definitions of the ARM-20 adapter:

Pin	I-jet direction	Name	Description
nTRST	Output	Test Logic Reset	Test reset. Active LOW signal that resets the TAP controller's state machine.

Table 9: ARM-20 pin definitions

Pin	I-jet direction	Name	Description
TCK	Output	Test Clock	TCK synchronizes all JTAG transactions. TCK connects to all JTAG devices in the scan chain. TCK flows down the stack of modules and connects to each JTAG device. However, if there is a device in the scan chain that synchronizes TCK to some other clock, then all down-stream devices are connected to the RTCK signal on that processor.
TMS	Output	Test Mode Select	TMS controls transitions in the tap controller state machine. TMS connects to all JTAG devices in the scan chain as the signal flows down the module stack.
TDI	Output	Test Data Input	TDI is the test data input signal that is routed to the TDI input of the first device in the scan chain.
TDO	Input	Test Data Output	TDO is the return path of the test data input signal TDI. In a multi-device JTAG chain, the TDO of the first device connects to the TDI of the next device, etc. The last device's TDO is connected to the TDO on the JTAG header.
RTCK	Input	TCK Return	RTCK is a mechanism for returning the sampled clock to the JTAG equipment, so that the clock is not advanced until the synchronizing device captured the data. In adaptive clocking mode, I-jet is required to detect an edge on RTCK before changing TCK. In a multi-device JTAG chain, the RTCK output from a device connects to the TCK input of the down-stream device. If there are no synchronizing devices in the scan chain, it is unnecessary to use the RTCK signal and it is connected to ground on the target board.
VTref	Input	Voltage Target Reference	This is the target reference voltage. It indicates that the target has power. VTref is normally fed from Vdd on the target hardware and might have a series resistor (though this is not recommended). VTref is used by I-jet to detect if target power is active and to set JTAG signal voltage reference for level translators.

Table 9: ARM-20 pin definitions

Pin	I-jet direction	Name	Description
nSRST	I/O	System Reset	Active LOW open-collector signal that is driven by I-jet to reset the device and/or the target board. I-jet senses this line to determine when you have reset the device.
Vsupply	Output	--	This pin is not connected to I-jet.
DBGRQ	Output	--	This pin is not connected on I-jet.
DBGAC K/TRGP WR	Output	Target Power	This pin is used under SW control to supply 5 V power to the target board. It should be routed through a jumper shunt to the 5 V DC board input to eliminate the power adapter during debugging. The maximum current supplied by I-jet on this pin is about 420 mA. When the current supplied reaches ~500 mA, the power will be shut down for protection.

Table 9: ARM-20 pin definitions

The R2 pull-down on pin 17 of the I-jet MIPI20 connector is a signal to I-jet that a legacy ARM-20 adapter is being used. Other adapters will have different resistors so that I-jet can identify them if needed. A solid GND on this pin means that no adapter is being used and that the MIPI cable is connected directly between the I-jet and the target board.

TI14 header information (for target board)

The TI14 header is manufactured by Samtec USA. The model number is TSM-17-DV. For more information, see the manufacturer's web page

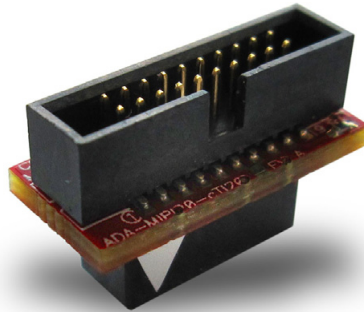
http://samtec.com/technical_specifications/overview.aspx?series=TSM.

The ADA-MIPI20-cTI20 adapter

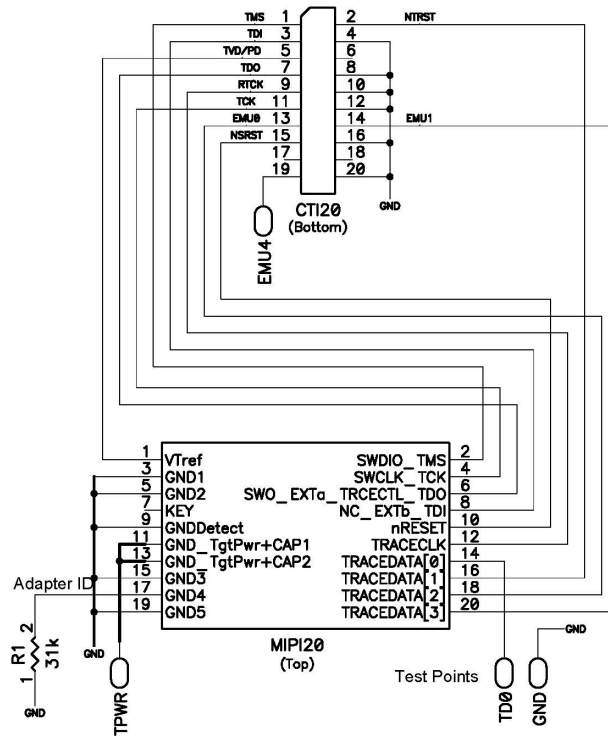
The ADA-MIPI20-cTI20 adapter adapts the I-jet standard MIPI-20 cable pinout to the Texas Instruments compact 20-pin JTAG interface used on some newer OMAP, DaVinci, and other TMS320, TMS470, and TMS570 target boards.

The adapter has the MIPI-20 male header on top for connecting the I-jet MIPI-20 cable, and a cTI-20 style female header (socket) on the bottom. The cTI-20 JTAG header is a 20-pin, double-row, high-density 0.05 in × 0.1 in (1.27 mm × 2.56 mm) pitch connector

with a key (plug) in position 6 to prevent misconnections. In case the plug is missing, a white arrow on pin 1 of the cTI-20 connector helps you ensure proper orientation.



This is a diagram of the adapter:

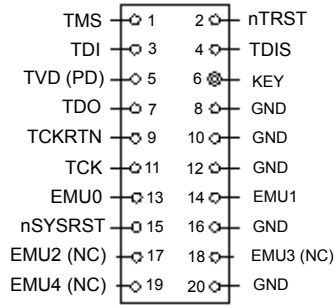


These are the pin definitions for cTI20:

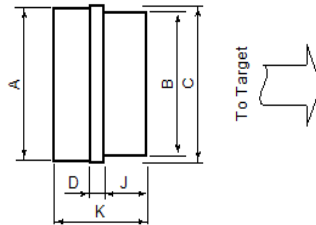
Pin	I-jet direction	Name	Description
nTRST	Output	Test Logic Reset	Active LOW signal that causes all test and debug logic in the device to be reset along with the IEEE 1149.1 TAP.
TCK	Output	Test Clock	This is the test clock used to drive the IEEE 1149.1 TAP state machine and logic.
TMS	Output	Test Mode Select	Directs the next state of the IEEE 1149.1 TAP state machine.
TDI	Output	Test Data Input	IEEE 1149.1 scan data input to the device.
TDO	Input	Test Data Output	IEEE 1149.1 scan data output from the device.
RTCK	Input	TCK Return	Used only in Adaptive Clocking mode. I-jet monitors RTCK to determine when to send the next TCK.
PD	Input	Power Detect	Should be tied to the I/O voltage of the target device. Used by I-jet to detect if target power is active and to set the JTAG signal voltage reference for level translators.
EMU0	I/O	Emulation 0	Depending on the device, EMU pins support boot modes and other features. I-jet does not use this pin but it is routed to the TRACEDATA[2] pin on the MIPI20 connector. For proper booting, this pin should be pulled-up on the target.
EMUI	I/O	Emulation 1	Depending on the device, EMU pins support boot modes and other features. I-jet does not use this pin but it is routed to the TRACEDATA[3] pin on the MIPI20 connector. For proper booting, this pin should be pulled-up on the target.
nRESET	I/O	System Reset	Active LOW open-collector signal that can be driven by I-jet to reset the device and/or the target board. I-jet senses this line to determine when a board has been reset by the user or by watchdog timer.

Table 10: cTI20 pin definitions

This is the pinout of the target cTI20 JTAG header. Pin 6 should be missing to indicate the proper orientation.

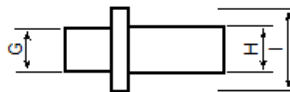


These are the top view dimensions of the ADA-MIPI20-cTI20 adapter:



A	18.9 mm (0.74 in)
B	17.7 mm (0.7 in)
C	19.4 mm (0.76 in)
D	1.8 mm (0.07 in)
J	6.0 mm (0.24 in)
K	12.8 mm (0.50 in)

These are the side view dimensions of the ADA-MIPI20-cTI20 adapter:



G	0.5 mm (0.19 in)
H	5.1 mm (0.2 in)

I 9.1 mm (0.36 in)

cTI20 header information (for target board)

The cTI20 header is manufactured by Samtec USA. The model number is FTR-110-51-S-D-06. For more information, see the manufacturer's web page http://www.samtec.com/technical_specifications/overview.aspx?series=FTR.

I-jet Trace

This chapter describes the I-jet Trace for Cortex-M in-circuit debugging probe. More specifically, this means:

- Introduction
- Working with I-jet Trace
- Technical specifications

Introduction

This section gives a short overview of the I-jet Trace in-circuit debugging probe. More specifically, this means:

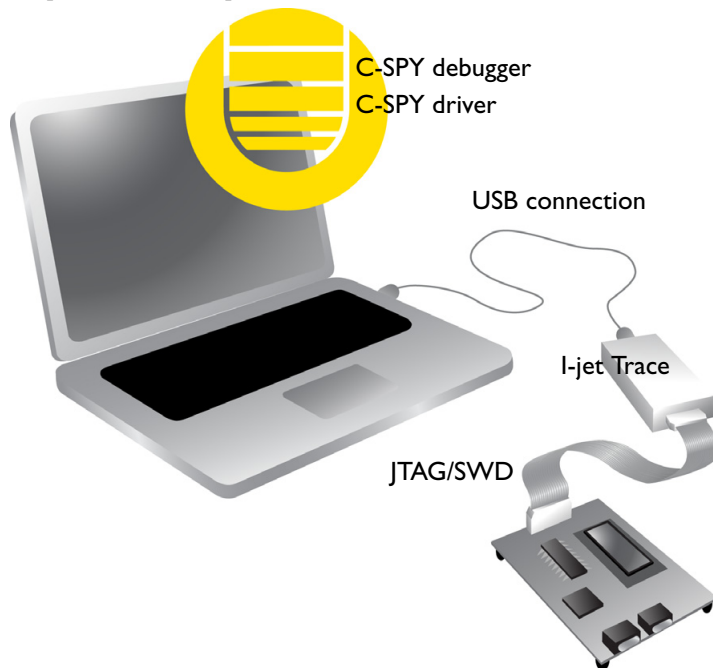
- The I-jet Trace in-circuit debugging probe
- Requirements
- Target connections.

THE I-JET TRACE IN-CIRCUIT DEBUGGING PROBE

I-jet Trace is an in-circuit debugging probe, designed to take full advantage of the speed and current delivery of the USB3 communication ports. USB 2.0 is also supported, but not recommended due to slower speed and smaller power delivery.

I-jet Trace has all the features of I-jet, but with enhanced performance and ETM (Embedded Trace Macrocell) support, which allows for real-time tracing of the application and data over a 1-, 2- or 4-bit trace bus on Cortex-M devices.

I-jet Trace connects to the target board via a JTAG or SWD connection, and to the host computer via the USB port.



I-jet Trace streams the program counter, variables, and power measurement data to the host computer to provide a view into program execution in real time. Besides the typical JTAG debugging, I-jet Trace is capable of providing power to the target board and measuring it with sufficient accuracy to provide a power profile during program execution in real time. This feature is referred to as *power debugging*.

For debugging Cortex devices, I-jet Trace also supports the SWO (Serial Wire Output) feature, which can be used for tracing the program execution and tracking variables at predefined points in your code.

The I-jet Trace in-circuit debugging probe is also referred to as a debug probe, debug adapter, or JTAG in-circuit emulator by different tool vendors.

REQUIREMENTS

I-jet Trace needs to be controlled by the IAR C-SPY® Debugger which comes with the IAR Embedded Workbench® IDE.

TARGET CONNECTIONS

These interfaces are supported:

- MIPI-20 (part number FTSH-110-01-L-DV): JTAG, SWD, SWO, ETM
- MIPI-10(part number FTSH-105-01-L-DV): JTAG, SWD, SWO
- ARM-20(part number HTST-110-01-L-DV): JTAG, SWD, SWO

I-jet Trace comes with a MIPI-20 connector on the front panel and with MIPI-20 and MIPI-10 cables, as well as a legacy ARM-20 adapter.

Note: Only the MIPI-20 cable supports the ETM trace functionality. All other connections (MIPI-10 and ARM-20) are only for plain JTAG/SWD/SWO debugging.

All other available I-jet adapters are also compatible with I-jet Trace.

Working with I-jet Trace

This section describes how to work with I-jet Trace. More specifically, this means:

- Setup and installation
- Connecting the target system
- Using trace

For information about debugging using I-jet Trace, see the *C-SPY® Debugging Guide for ARM*.

SETUP AND INSTALLATION

Software

Before you can use I-jet Trace, you need to install IAR Embedded Workbench for ARM. For more information, see the *Quick Reference Installation and Licensing* guide.

Probe setup

I-jet Trace does not require any special driver software installation. Normally, all drivers for I-jet Trace are automatically installed as part of the installation of IAR Embedded Workbench.

If you need to install the USB driver manually, navigate to
\\Program Files\\IAR Systems\\Embedded Workbench x.x\\arm\\drivers\\jet
\\USB3\\32-bit or 64-bit (depending on your system). Start the `dpinst.exe`
application. This will install the USB driver.

The USB LED will flash twice after enumerating on the USB2 ports, and three times on USB3 ports.

For information about using multiple I-jet probes on the same host computer, see the *C-SPY® Debugging Guide for ARM*.

CONNECTING THE TARGET SYSTEM

Power-up your I-jet Trace probe

- 1 Connect I-jet Trace to the host computer using the USB micro cable.
- 2 Connect I-jet Trace to the target board using the cable that matches the target board connector (MIPI-20 or MIPI-10). If a standard JTAG connector is used, you must first plug the JTAG-20 to MIPI-20 adapter into the JTAG connector.

Note: No harm is done if the above order is reversed.



To prevent damage, the target GND and the USB host GND must be at the same level. When *hot-plugging*, make sure that the PC and the target board power supply are connected to the same grounded wall outlet or a common grounded desktop power strip.

Note: It is possible to use multiple I-jet probes on the same host computer, provided that you run multiple instances of IAR Embedded Workbench® for ARM.

Power up your evaluation board

If you have an evaluation board that is prepared for it, you can power the board via I-jet Trace through pin 19 on the standard JTAG-20 connector, or pin 11/13 on the small MIPI-20 connector. Target power of up to 420 mA can be supplied from I-jet Trace with overload protection. Most of the IAR Systems KickStart Kits contain an evaluation board that can be powered this way. Make sure that the power jumper found on most of these boards matches your setup.

Note: The target board will get power via I-Jet Trace once you choose the **Download and Debug** or **Debug without Downloading** command in C-SPY, but not before.

Note: The only way to use the power debugging feature is to power up your evaluation board via I-jet Trace.

USING TRACE

To use ETM trace, the target board must have a Cortex-M device with the ETM trace pins (usually named TraceCLK and TraceD0-D3), and these pins must be connected to the MIPI-20 debug header. Because on some devices, the trace pins are multiplexed, take care not to connect these pins to other logic devices on the PCB to minimize the loading and improve signal integrity.

C-SPY will initialize and enable all necessary registers on the MCU to allow the ETM port to function properly so that no special user code instrumentation is necessary. However, take care so that the running application code does not interfere (read, write, etc.) with the GPIO pins used for the ETM trace.

The TRACE LED on the I-jet Trace debug probe will turn green when the trace data collection is ready for ETM data. This usually happens after trace is enabled in C-SPY and the Run command is issued.

For more information about trace, see the *C-SPY Debugging Guide*.

Technical specifications

This section provides technical specifications for the I-jet Trace in-circuit debugging probe. More specifically, this means:

- The I-jet Trace package
- Model specifications
- Connectors

THE I-JET TRACE PACKAGE

The I-jet Trace package contains:

- The I-jet Trace in-circuit debugging probe
- MIPI-20 JTAG cable
- MIPI-10 JTAG cable
- USB3 A to micro-B cable
- MIPI-20 to ARM-20 adapter
- Welcome letter.

MODEL SPECIFICATIONS

These are the specifications of I-jet Trace:

USB speed	4.8 Gbps (USB 3 SuperSpeed) 480 Mbps (USB 2.0 Hi-Speed)
USB connection	USB 3 Micro-B (USB 2.0 Micro-B-compatible)

Target connection	MIPI-20 (ETM, JTAG, and SWD) MIPI-10 (JTAG and SWD) ARM-20 (JTAG and SWD)
External DC power input	Optional 5 V DC, 1 A minimum, 1.3 × 3.5 mm
Adapters included	MIPI-20 to ARM-20
Debug interface	ETM, JTAG, and SWD
JTAG/SWD maximum clock	100 MHz
JTAG/SWD clock rise & fall time	≤ 2 ns
ETM maximum trace clock	150 MHz (trace clock is usually ½ of the MCU clock)
SWO protocols supported	Manchester and UART
SWO maximum speed	200 Mbps
ETM trace memory	up to 256 Mbytes depending on model
Power supplied to target (4.1 V-4.6 V)	400 mA max with USB 3 ports 200 mA with USB 2 ports 400 mA with ExternalDC power
Over-current protection	~420 mA with USB 3 ~220 mA with USB2 ~420 mA with ExternalDC power
Target power measurement resolution	~160 µA
Target power measurement speed	up to 200 ksps (kilo samples per second)
JTAG/SWD/ETM voltage range	1.65 V to 3.3 V (5 V tolerant)
Current draw from target VTref	< 50 µA
Power requirement	3000 mW maximum (from USB or external DC, without target)
Operating temperature	0-30 C
Storage temperature	0-80 C

CONNECTORS

External power

I-jet Trace has a small (1.35 mm × 3.5 mm) external power connector right next to the USB connector. It can be used whenever the host computer is unable to deliver the necessary power to I-jet Trace and to the target board. The external power supply must deliver 5 V DC at 1 A minimum.

When external power is connected, almost the entire power will be taken from the external power supply, allowing more power-consuming targets (up to 400 mA) to be powered by I-jet Trace.

I-scope connector

The I-scope connector is provided for connecting the I-scope analog probe to the I-jet Trace CM. Unlike I-jet, I-scope cannot be connected to the same MIPI-20 connector that is used for target boards. When I-scope is connected to I-jet Trace, the Target connector on I-scope cannot be used.

Expansion connector

This connector is reserved for future use to add more functionality and features to I-jet Trace.

I-scope

This chapter describes the I-scope power probe for I-jet. More specifically, this means:

- Introduction
- Working with I-scope
- Technical specifications

Introduction

This section gives a short overview of the I-scope power probe for I-jet. More specifically, this means:

- Reasons for using I-scope
- The I-scope probe
- Current and voltage measurement using I-scope.

REASONS FOR USING I-SCOPE

The main benefit of using I-scope is to provide you with power data of the running application in real time so you can view the power profile and optimize your code for better power efficiency. The C-SPY Timeline window displays power data in correlation with the application source code to enable power analysis of the program flow.

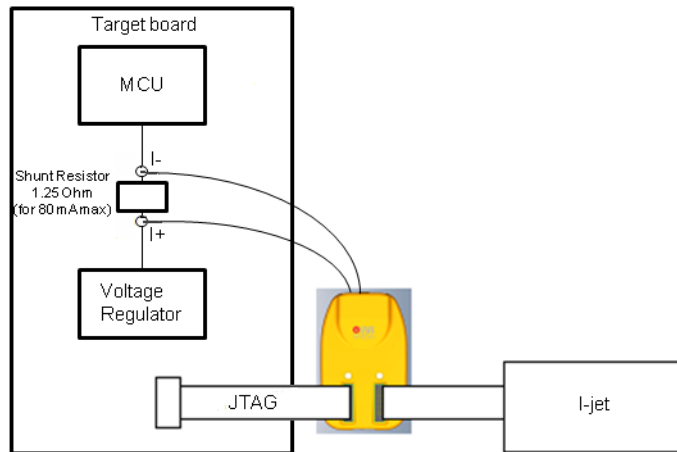
The analysis will reveal which functions and peripheral units consume more power, which I/O activity causes current spikes, how much power the MCU consumes in various sleep modes or in the main idle loop, etc. The captured data can be used to help you make your design less power-consuming, as well as help you initialize the GPIOs and peripheral units to achieve the best power efficiency without compromising the target's performance.

THE I-SCOPE PROBE

IAR I-scope for I-jet plugs in between the I-jet in-circuit debugging probe and the target board. I-scope adds detailed current and voltage measurement capability to I-jet. These measurements can be done at any designated points on the target board and displayed in real time by the IAR C-SPY debugger.

CURRENT AND VOLTAGE MEASUREMENT USING I-SCOPE

I-scope contains a 12-bit A/D converter for current and voltage measurements. The current input is implemented using a sensitive differential amplifier. The current measurement is done by connecting the two differential current measurement leads (marked I+ and I-) across a shunt resistor on the target board.

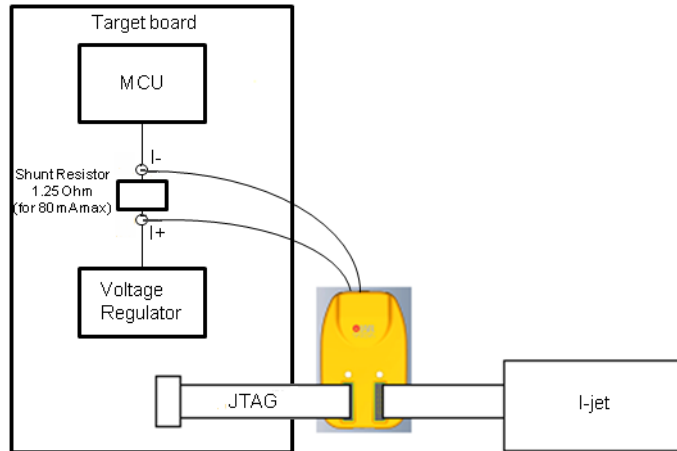


Many hardware engineers add small shunt resistors to the board to measure (using a digital voltmeter) the currents taken by specific logic blocks or devices. This method is mainly used in early stages of development. The shunt resistors are placed in series with the power rail to be measured and they need to be small enough not to drop too much voltage to make the logic block or MCU operate outside of its minimum voltage requirements. For most MCUs, the power rails are specified within 100 mV of their normal V_{dd} values and that is why I-scope is designed to work with shunt resistors that will provide up to 100 mV voltage drop.

The calculation of the shunt resistor value is very simple. Assuming that the MCU's maximum operating current at the selected clock speed and all peripherals enabled is 80 mA, Ohm's law will give the value for the shunt resistor as follows:

$$R = V/I = 0.1 \text{ V} / 0.08 \text{ A} = 1.25 \text{ Ohm}$$

Based on this example, the dynamic range of the power probe would be from about 20 μA ($80 \text{ mA}/4096$) to 80 mA.



It is recommended to use 1% (or better) resistors to get good accuracy in the measurements. If the calculated value does not match the standard resistor value, select the next smaller value. In our example, the next smaller standard resistor value is 1.24 Ohm.

Larger resistor values can be used, but I-scope will hit its maximum allowed value at 110 mV and anything over this will be cut off. So if you want to measure some low-level currents, you can use much bigger shunt resistors to get better resolution. Make sure that the MCU Vdd line does not drop below the minimum allowed by the manufacturer when the MCU goes into the high-current mode. For information about the minimum value for your specific processor, see its data sheet.

To convert the current measurements to the actual power consumed by the MCU, I-scope automatically measures voltage at the I- terminal of the shunt resistor.

I-scope measures current and voltages at a sampling rate of up to 200 kHz and sends it to I-jet which synchronizes it with the running MCU's program counter (if available), so it can be displayed in real time and analyzed using C-SPY.

For more information about power debugging using C-SPY, see the *C-SPY Debugging Guide*.

Working with I-scope

This section describes how to work with I-scope.

INSTALLATION

- 1 Connect I-scope to I-jet using the supplied MIPI-20 cable.
- 2 Connect the target to I-scope using the MIPI-20 cable that came with I-jet.
- 3 Start IAR Embedded Workbench and select your project.
- 4 To measure current, connect the I+ and I- leads across the shunt resistor on your board. The I+ lead should be connected on the higher voltage side, which is the one coming from the voltage regulator or power supply. If the leads are reversed, the Power graph in the Timeline window will show current and power equal to 0.

To measure voltage, connect one or more of the I+, V1, V2, and V3 scope channels to any voltage test points that you want to monitor.

- 5 From the C-SPY driver menu in IAR Embedded Workbench, choose **Power Log Setup** and enter the shunt resistor value in the Power Log Setup window.
- 6 Start the application. To enable power logging, choose **Enable** from the context menu in the Power Log window or from the context menu in the Power Log Graph in the Timeline window. The power and voltage data shown in the Power graph in the Timeline window will be displayed in real time while the MCU program is running.

Technical specifications

This section provides technical specifications for the I-jet in-circuit debugging probe. More specifically, this means:

- The I-scope package
- External characteristics
- I-scope probe specification.

THE I-SCOPE PACKAGE

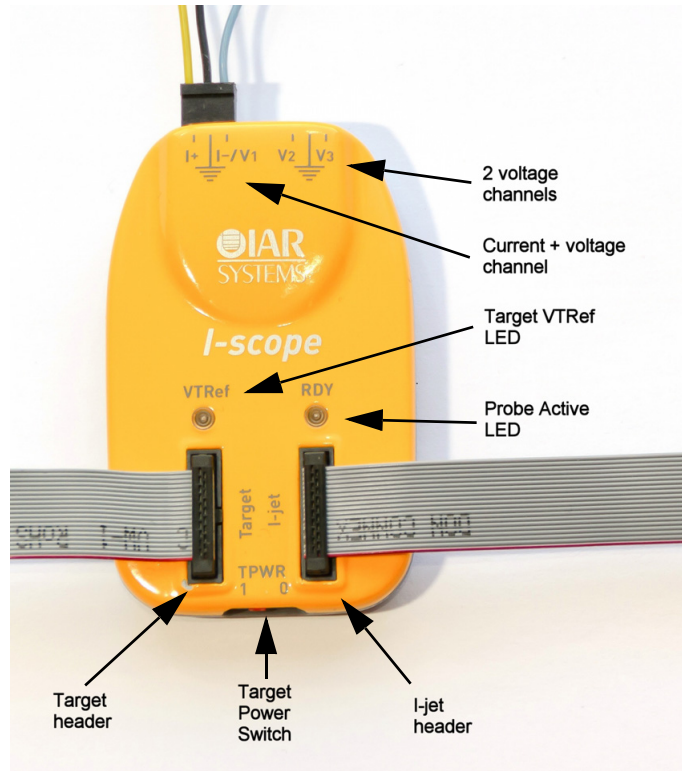
The I-scope package contains:

- I-scope probe
- Short MIPI-20 flat cable for attaching to I-jet
- Two probes consisting of three flying test leads each
- Six grabbers

- Welcome letter.

EXTERNAL CHARACTERISTICS

This figure shows the I-scope probe and its connections and switches:



These are descriptions of the I-scope connections and switches:

I+ Current probe positive (higher voltage) side of the shunt resistor. On MCU power rails, this lead goes to the power supply side of the shunt resistor (Vdd or Vcc).



Analogue ground connection to target. This connection is optional if the probe is connected to the target's JTAG header, but should be used when more precise measurements are needed.

I- V1	Current probe negative (lower voltage) side of the shunt resistor. On MCU power rails, this lead should be on the MCU side of the shunt resistor (load side). The shunt resistor should be calculated to allow a voltage drop of around 100 mV when the MCU is operating at its maximum current consumption. The voltage relative to ground can be measured separately on this input. This allows measurement of both current and voltage at the selected measurement point.
V2	Voltage probe channel for measuring voltages from 0 V to 6 V.
V3	Voltage probe channel for measuring voltages from 0 V to 6 V.
VTRef	Target reference voltage LED will turn green when the target voltage is > 1.65 V. This is the minimum target voltage at which the I-jet will operate.
RDY	Ready LED will turn yellow as soon as the power probe is enabled. After I-jet calibrates the probe, the RDY LED will turn green to indicate that I-scope is ready to be used.
Target	Connector for a cable that goes to the target's board JTAG header.
I-jet	Connector for a cable that goes to I-jet.
TPWR	Target power switch. When in position 0 (off), it will disconnect the I-jet target power rail (TPWR) from going to the target. The default position is 1 (on), which allows I-jet to supply 5 V power to target boards. However, target board power measurements will not be accurate and should not be used when I-scope is connected.

I-SCOPE PROBE SPECIFICATION

Size (W * L * H)	700 mm * 44 mm * 14 mm
ADC resolution	12 bits
Maximum sampling rate	200 ksp/s
V1, V2, V3 voltage channels range	0 to 6 V
V1, V2, V3 voltage channels resolution	1.49 mV (1 LSB)
V1, V2, V3 voltage channels accuracy	2.98 mV (2 LSB)

Maximum differential voltage between I+ and I- probes 110 mV

These are the I-scope specifications per shunt:

	1 Ohm shunt	10 Ohm shunt	100 Ohm shunt
Current channel resolution	26.8 μ A	2.68 μ A	0.268 μ A
Current channel accuracy	53.7 μ A	5.37 μ A	0.537 μ A
Current channel measurement range	0-110 mA	0-11 mA	0-1.1 mA
Applications	General purpose MCU current and power measurements	Low-power MCU current and power measurements	Measuring power-down and sleep modes current consumption

Table 1: I-scope specifications per shunt



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