



AM 3200 PIV System – V2

Data Sheet v3.8



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AMCAD Engineering

Advanced Modeling for Computer-Aided Design

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1 Main Characteristic of the Pulse IV System

1.1 General Description

AM3200 is a useful instrument for Pulse IV and Load Pull applications. Pulse IV systems are used to bias transistors in quasi-isothermal conditions, enabling accurate compact modeling activities. The system operates in two independent power modes: **Pulsed** or **DC** (continuous mode). PIV 3200 supports LAN & USB connections and can be controlled with IVCAD software.

The PIV system is composed of a Control Unit and two Pulse Head Probes:

The AM3203 control unit is used to drive two pulsers. It contains:

- 200W AC/DC block which supplies all the internal components and gate pulser.
- Two 250V/5A DC/DC block which supply the drain pulser.
- Commercial μ PC board with USB hub & triggering interface.



Figure 1:1 AM3203 Control Unit

Pulsers heads feature measurement units and the protection systems. A Pulse head contains:

- Power switches, power drivers and overload protection devices.
- Analog to Digital Conversion system (ADC) for voltage and current measurements
- Pulse generator with delay capabilities.



(a) Gate Probe AM3211



(b) Drain Probe AM3221

Figure 1:2 Probes

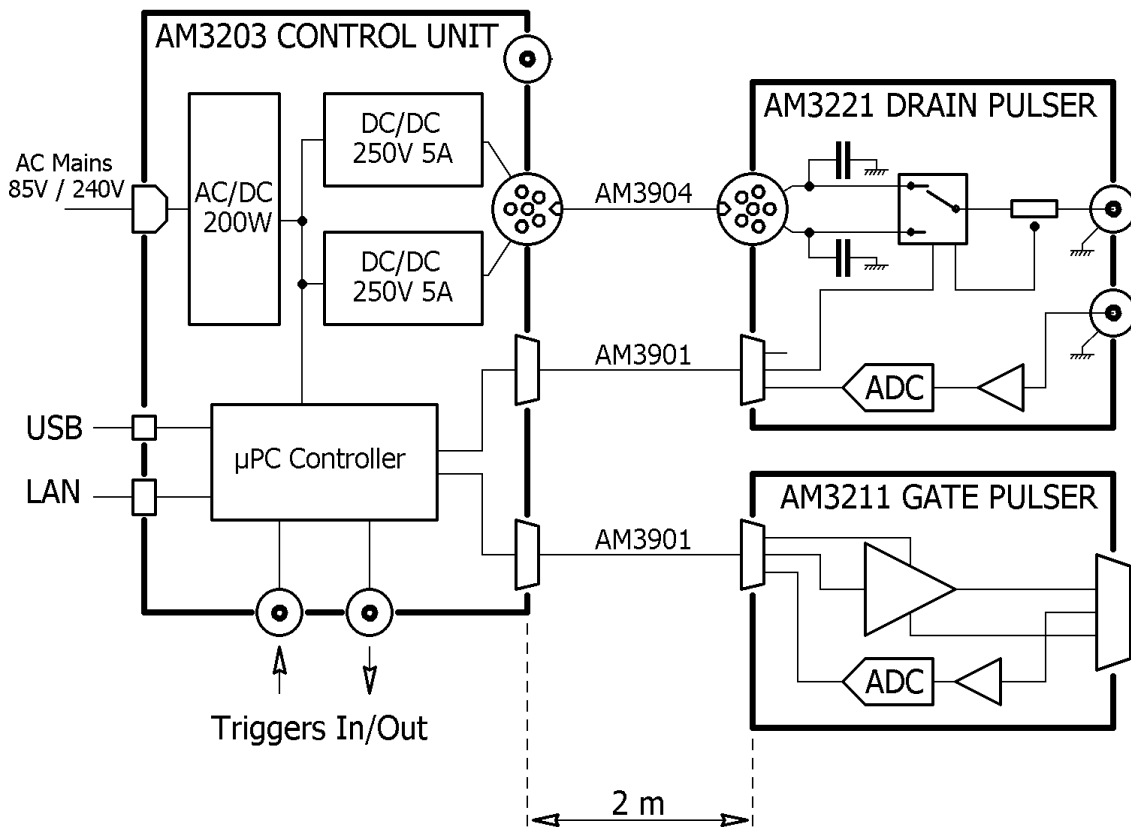


Figure 1:3 AM3200 system schematic



Figure 1:4 AM3200 system picture with Input and Output Probe Heads

For pulsed IV application, the objective is to provide small pulse widths in order to avoid self-heating, while for load pull application, measurements are made in “radar” like operating conditions with larger pulse width. In this latest case, the aim is to avoid voltage drop during the current consumption caused by the RF power level of the test signal.

1.2 Main features

The system's main features are:

- Reliable pulsers with long lasting performances (thermal, SOA and DUT breakdown protections)
- Pulsed or DC operation, pulse width down to 200ns from the generators
- Measurement pulse width capabilities down to 300ns (depends on the measurement range)
- Internal or external synchronization
- Extended stop conditions and built-in protection
- Modular system: Mix-and-match pulsers configuration
- **Long pulses up to hundreds of seconds for trapping and thermal characterization**
- Direct hardware programmability (SCPI commands)
- Embedded measurement units providing wide bandwidth & high accuracy for simultaneous current and voltage measurements:
 - Equivalent to 90Msamples/s & 10MHz bandwidth scope for pulse shape monitoring
 - Fast averaging function providing **16-bit multi-range resolution** and typical measurement accuracy **lower than 0,5%**
- Synchronized pulsed S parameter and IV measurements
- Embedded fast short-circuit current breaker, performing the protection of both pulser heads (drain and gate) as well as external component such as Bias Tees.
- Automatic pulser head calibration procedure
- Remote control through LAN or USB

1.3 Modularity

Standard configuration of the system consists of two pulse generators and one control box. Two combination of probe heads are possible:

- 1 Gate pulser (1xAM3211) and 1 Drain pulser (1xAM3221)



Figure 1:5 AM3200 configuration using 1 Gate pulser (AM3211) & 1 Drain pulser (AM3221)

- 2 Gate pulsers (2xAM3211)



Figure 1:6 AM3200 configuration using 2 Gate pulser (AM3211)

To improve the system flexibility, it’s possible to cascade several control units (AM3203) and pulser heads.

In this case, one of the control units must be identified as a Master, using the “Ptrig out” and/or “Mtrig out” to synchronize all other units. The “Strig” synchronization between the Slave and the Master is required to link the safety alarm, as shown in the following scheme:

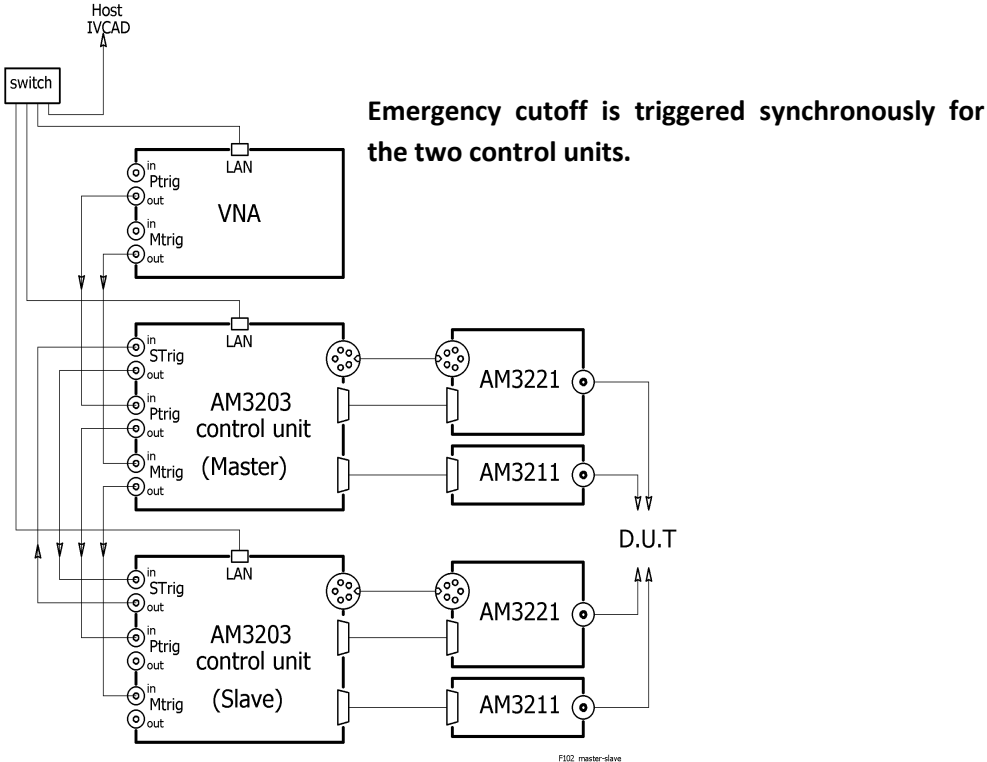


Figure 1:7 Scheme example of two cascaded control units (AM3203)

2 Control Unit (AM3203)

The AM3203 control unit can drive two configuration (one (1) gate and one (1) drain pulsers or two (2) gate pulsers) LAN & USB connections are supported for the remote control.

2.1 Connection and display

2.1.1 Front Panel

Pressing the ON/OFF button on the AM3200 will turn on the hardware. Blue LED blinks during the initialization (No communication is possible with the instrument while the operating system is starting). The system is ready when the LED light is steady.

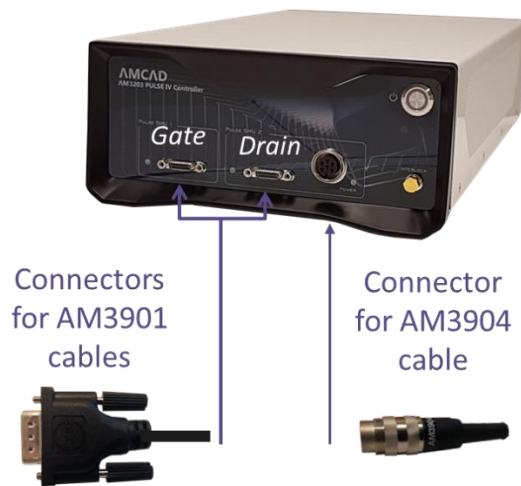


Figure 2:1 AM3200 front panel

2.1.2 Rear Panel

The AM3203 rear panel is composed of:

- LAN/RJ45 connection with 3 digits displaying the IP address.
- USB2 type A connection used for firmware update
- USB2 type B connection can be used for the connection with a PC
- AC 85V/240V 50 H 60 Hz source connection
- 7 coaxial SMB connectors



Figure 2:2 AM3200 rear panel

The Pulse IV system works with several programmable signals, which can give it the role of trigger box (like an Arbitrary Waveform Generator) in your setup.

The PIV system has 7 trigger connections (SMB connection) on the rear panel:

- **Pulse Trig in:** The input signal "**Ptrig-in**" is used to trigger the Pulse IV generator by an external device.
- **Pulse Trig out:** The output trigger signal "**Ptrig-out**" is generated by the Pulse IV with fixed duration (>2us), this one can be used to synchronize an external device such as an oscilloscope or a Digital Multi Meter.
- **Meas Trig in:** The input signal "**Mtrig-in**" (a periodic TTL signal) can be used to define the IV measurement windows location.
- **Meas Trig out:** The output signal "**Mtrig-out**" is an output periodic TTL signal that will correspond to the measurement windows defined for the IV measurements.
- **Synchronization Trig in:** The input signal "**Strig-in**" (a periodic TTL signal) can be used to synchronized & protected two control unit (AM3203) in cascaded mode.
- **Synchronization Trig out:** The output signal "**Strig-out**" is an output periodic TTL signal can be used to synchronized & protected two control unit (AM3203) in cascaded mode.
- **RF trig out:** The output signal "**RFtrig-out**" can be used to drive an external RF modulator that will require an output periodic TTL signal drive (application can be pulsed IV and pulsed Load Pull measurement for example)

2.2 Cable and connector

Two cables **AM3901** are provided with the system to connect the control unit to the Pulser I & II. See wiring configuration below:

- Three fast differential signals: USB, STRIG, PTRIG
- Two simple logic signals : MTRIG, ALARM
- Two supplies : +24V/GND, +5V/GND



Figure 2:3 AM3901 cable

The **AM3904** allows supplying pulser II. This cable is only used to supply the **AM3221** probe (250V, 30A).



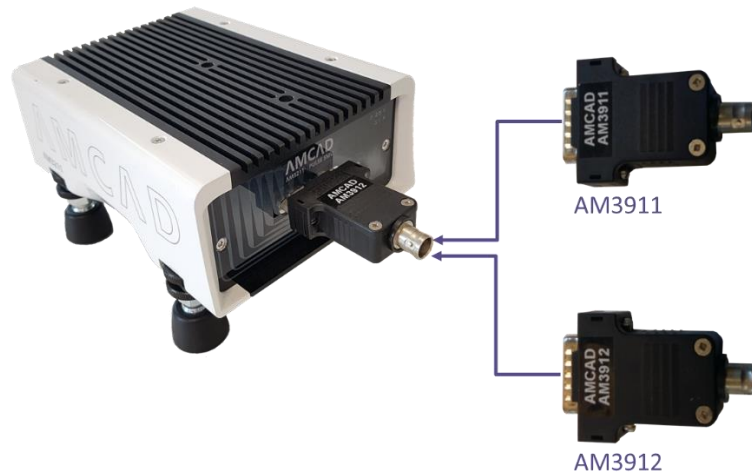
Figure 2:4 AM3904 cable

3 Gate Probe (AM3211)

3.1 Description

The AM3211 is a low noise pseudo isolated pulse generator dedicated to bias the transistor gate, optimized to quickly and safely drive the gate of any transistor without ringing or overshoot (RF Device, MOSFET, Bipolar transistors...).

On its front panel, the gate pulser has a D-SUB to BNC adapter. All accessories include a 10Ω series resistor for current sensing.



Two D-SUB to BNC adapters are available:

The AM3912 D-SUB to BNC adapter is basically used for RF transistors (HEMT, LDMOS, ...). The AM3912 block diagrams is shown on the following figure:

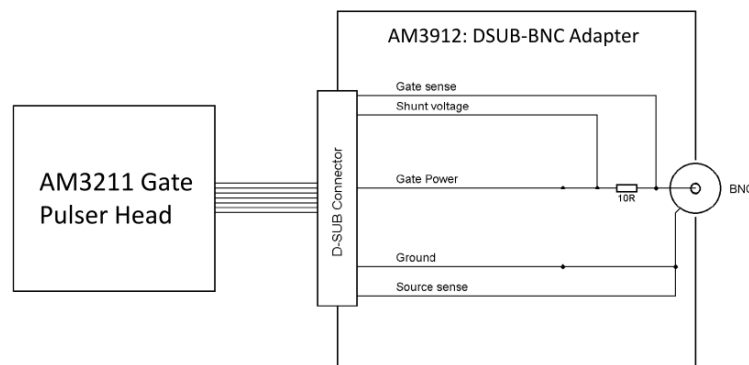


Figure 3:1 AM3912 Block diagrams

The AM3911 D-SUB to BNC adapter is basically used for switching mode transistors (MOSFET, ...). The AM3911 adapter embeds a 10 Ohms resistance and a capacitance of 2nF to mitigate the instability often met with high Gm components. The AM3911 block diagrams is shown on the following figure:

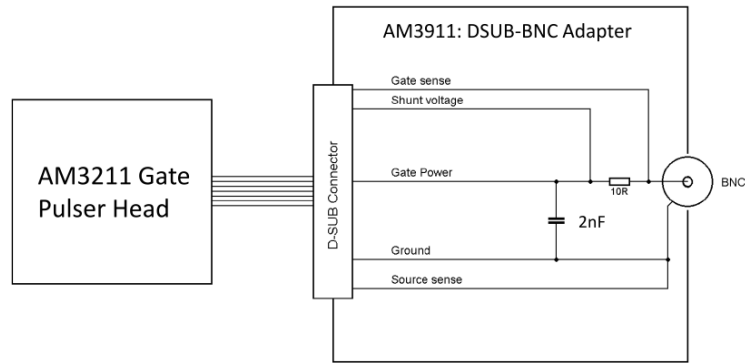


Figure 3:2 AM3911 Block diagrams

The connection to the rear panel of the AM3211 probe is shown on figure 3:3



S

Figure 3:3 Connection to the rear panel of AM3211 probe

Color coding is available for each pulser:

- **No light:** the pulser is stopped without error
- **Green:** the pulser is running
- **Red:** no connection available or error memorized

3.2 Operating area

Parameters	Conditions	Min	Max
Voltage programming range	Quiescent and pulse levels	-25V	+25V
Pulse amplitude	Difference between max. and min. programmed levels		30V
Pulsed current	source or sink, according to max RMS current	-1A	+1A
DC and RMS current		-300mA	300mA
Pulsed power	source or sink		10W
	source		3W
	sink		0,5W
Output DC impedance	1A & 10mA ranges	14,5Ω ± 2 %	
	100µA range	210Ω ± 0,2 %	
Output capacitance		20pF	
Probe impedance to the Earth	Max. 1W	100Ω	

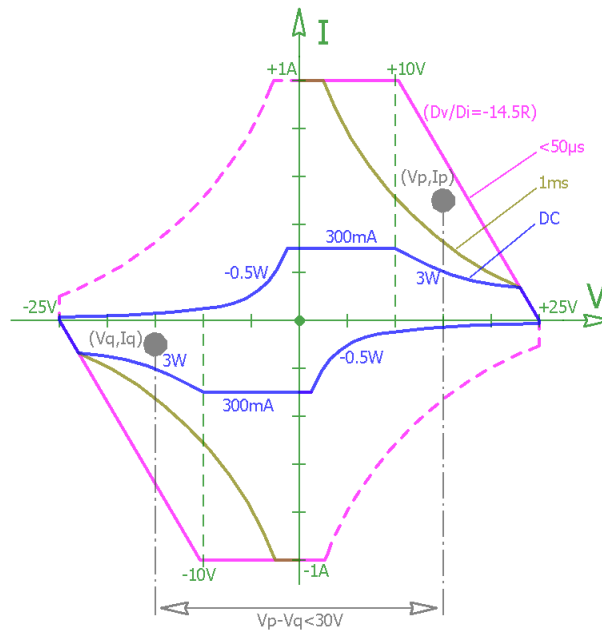


Figure 3: AM3211 Operating area

3.3 Pulse Specifications

The voltage switching speed can be set according to 3 predefined levels: **Fast, Medium and Slow**.

Parameters	Conditions	Min	Max
Duty cycle	Any level, according to power limits	0%	100%
Frequency	Maximum switched voltage		500kHz
Pulse width	min. pulse width at Speed = FAST	200ns	
Rise time*	10% to 90%, Speed = FAST, no load	33ns (typ. value)	
Fall time *	10% to 90%, Speed = FAST, no load	32ns (typ. value)	

(*): 5V step, AM3912, open circuit

3.4 Voltage Specifications

Parameters	Conditions	Value
Programming resolution	16 bits	0,8mV
Absolute accuracy	1 year, no load	10mV+0,1%
Noise	0,1Hz-10kHz, peak-to-peak noise, no load	0,6mV
	0,1Hz-5MHz, peak-to-peak noise, no load	3mV
Glitch before pulse edge	Speed = FAST	70mV
	Speed = MEDIUM	30mV
	Speed = SLOW	15mV

3.5 Measurement Specifications

Parameters	Conditions	Voltage	Current		
		25V	1A	10mA	100µA
ADC Resolution	16 bits	880µV	35µA	0,35µA	4,8nA
Settling time ⁽¹⁾	To 99,9%	250ns	300ns	350ns	4µs ⁽⁶⁾ / 400µs ⁽⁷⁾
	to 99,99%	400ns	550ns	700ns	-
Recovery delay ⁽²⁾		-	-	0,6µs	1µs
Bandwidth ⁽³⁾	-3dB	14MHz	14MHz	6MHz	1,3MHz
Absolute accuracy ⁽⁴⁾	offset + gain	2,5mV + 0,07%	200µA + 0,08%	15µA + 0,08%	0,6µA + 0,1%
Noise ⁽⁵⁾	1 sample	±3,5mV	±140µA	±10µA	±1µA
	128 avg samples	±0,3mV	±14µA	±1µA	±0,1µA

(1) speed=fast, one quarter of the full-scale range step

(2) lower ranges can be continuously saturated without any damage. If a range has been saturated, allow a recovery delay for the measurement to be valid.

(3) simulation results

(4) 1 year, offset + % of reading, after 30-min warm-up, 256 averaged samples, DC

(5) measured with the outputs shorted (for voltage noise) or open circuit (for current noise).

(6) using AM3912 adapter, settling within 100nA of final value (99,6%)

(7) using AM3911 adapter, settling within 500nA of final value for a 20V step

3.6 Current range

The AM3211 embed three different current measurement range:

- **1A** and **10mA** current ranges may be switched automatically by the control box or manually by IVCAD (an internal 10Ω resistor is connected in serie with the output).
- **100µA** current range must be used very carefully because it may change the pulse waveform (an internal 100Ω resistor is connected in serie with the output). This range requires a minimum pulse width to provide good results:
 - 4us using AM3912 adapter
 - 400us using AM3912 adapter

3.7 Internal Protection Circuit

Parameters	Conditions	Typ. value
Pulse current	Threshold	±1.3A
	Response time	Time for the output to become Z 60ns
Average current	Threshold	±360mA
	Response time	Time for the system to stop 100ms
Average power	Threshold	±3,5W
	Response time	Time for the system to stop 100ms
Over voltage	Threshold	Max. progr. level + 4,5V
	response time	Time for the drain pulser to stop 150ns

4 Drain Probe (AM3221)

4.1 Description

The AM3221 probe is a power probe dedicated to bias the transistor drain (positive voltages). Optimized for high power pulsed measurements applications (250V, 30A), this probe head can be used either for Pulse IV or Load Pull applications.

On the front panel of the drain probe, two BNC connectors are available (Force & Sense), a switch lets the user select Sense or Force mode as presented below:



Figure 4:1 Selection of the mode: Sense or Force

Force mode (switch to the right) generates and measures the signal in the BNC reference plane:

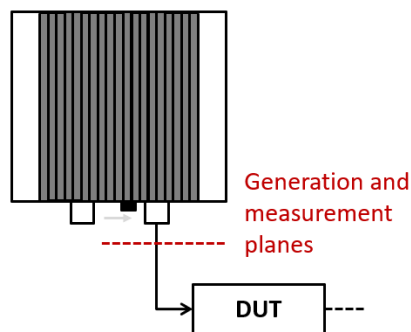


Figure 4:2 Top view of the Drain Probe (AM3221) in Force Mode

Sense mode (switch to the left) generates and measures in two different reference planes. The measurement done with the sense mode is only for the voltage measurement:

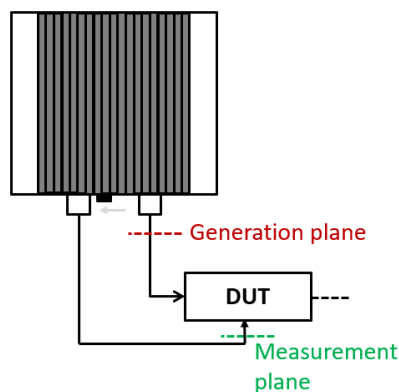


Figure 4:3 Top view of the Drain Probe (AM3221) in Sense Mode

The rear panel connection of the drain probe is depicted on the following picture:



Figure 4:4 Connection to the rear panel of AM3211 probe

Color coding is available for each pulser:

- **No light:** the pulser is stopped without error
- **Green:** the pulser is running
- **Red:** no connection available or error memorized

4.2 Operating area

Parameters	Conditions	Min	Max
Voltage programming range	Both quiescent and pulse levels	0V	+250V
Pulsed current	Probe stopped if exceeded		+33A
DC and RMS current	Probe stopped if exceeded		+5A
Pulsed power	Probe stopped if exceeded		3000W
DC power	Probe stopped if exceeded		100W
Output impedance	0.3A range selected & current < 0.7A	2Ω	
	30A, 3A, 0.3A and current > 0.7A	0.4Ω	
Probe impedance to the Earth	Max. 1W	100Ω	
Remote sense operating range	Max. DC drop in the power cable	-0.5V	+0.5V

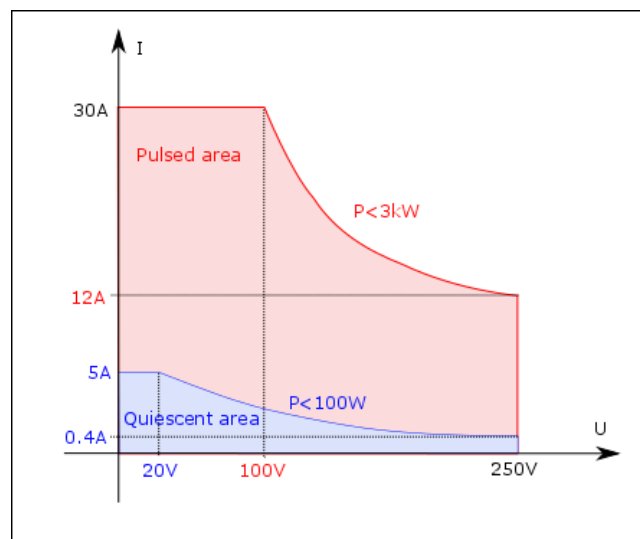


Figure 4:5 AM3221 Operating area

4.3 Pulse specifications

The voltage switching speed can be set according to 2 predefined values: Fast and Slow.

Parameters	Conditions	Min	Max
Duty cycle	Any level, according to power limits	0%	100%
Frequency	at 250V, speed = FAST		50kHz
	at 250V, speed = SLOW		10kHz
	absolute		500kHz
Pulse width	min. pulse width at Speed = FAST	200ns	
Rise time*	10% to 90%, Speed = FAST, no load	20ns (typ. value)	
Fall time *	10% to 90%, Speed = FAST, no load	22ns (typ. value)	

(*) 100V step, open circuit

4.4 Output Voltage specifications

Parameters	Conditions	Min	Max
Programming resolution	18 bits	1mV	
Absolute accuracy	1 year, no load		
Noise	Peak-to peak, DC-100kHz		
Small step settling time	10V positive step	3ms to 30ms	
	10V negative step (low drop circuit inhibited)	3ms to 20ms	
	10V negative step (low drop circuit activated)	50ms to 80ms	
Full range settling time	0 to 250V step	325ms	
	250V to 0V step (low drop circuit inhibited)	200ms	
	250V to 0V step (low drop circuit activated)	250ms	
Voltage drop during pulse	Low voltage drop circuit inhibited, 50µs pulse at 10A	-750mV	-700mV
	Low voltage drop circuit activated, 50µs pulse at 10A	-60mV	+10mV
Low voltage drop circuit response time		1µs	

4.5 Measurement specifications

Parameters	Conditions	Voltage		Current		
		250V	5V	30A	3A	300mA
ADC Resolution	16 bits	4,7mV	90µV	590µA	58µA	5,5µA
Settling time ⁽¹⁾	to 99,9%	200ns	300ns	250ns	350ns	250ns
	to 99,99%	300ns	500ns	500ns	600ns	700ns
Recovery delay ⁽²⁾		-	0,5µs	-	0,5µs	0,5µs
Bandwidth ⁽³⁾	-3dB	14MHz	7MHz/4MHz	10MHz	7MHz	10MHz
Absolute accuracy ⁽⁴⁾	offset + gain	20mV+0,1%	0,7mV+0,1%	5mA+0,3%	2,5mA+0,2%	0,1mA+0,1%
Noise ⁽⁵⁾	1 sample	± 14mV	± 1,2mV	±1,8mA	±1mA	±35µA
	128 avg samples	±1,4mV	±50µV	±130µA	±60µA	±2µA

(1) speed=fast, one quarter of the full-scale range step, non-inductive load

(2) lower ranges can be continuously saturated without any damage. If a range has been saturated, allow a recovery delay for the measurement to be valid.

(3) simulation results

(4) 1 year, offset + % of reading, after 30-min warm-up, 256 averaged samples, DC

(5) measured with the outputs shorted (for voltage noise) or open circuit (for current noise).

4.6 Internal Protection circuit

Parameters	Conditions	Value
Threshold setting range		1A / 33A
Threshold setting resolution		14 bits, 2.3mA
Threshold setting accuracy	Offset + % of current	100mA + 0.5%
Response time		50ns

5 System Operation

5.1 Start and stop process

START process:

1. When the first rising edge of “Strig” is detected, the output gate pulser is set to its associated quiescent level. After a programmable start delay, the output drain pulser is set to its associated quiescent level.
2. When the second valid rising edge of Ptrig is detected, the pulsed process between Vq (quiescent level) and Vp (pulsed level) starts according to “RFtrig”.

STOP process:

1. When the first falling edge of “Strig” is detected, the output drain pulser (0V) &” RFtrig” (Low level) are disabled. After a fixe stop delay (1µs), the output gate pulser is disabled (0V).

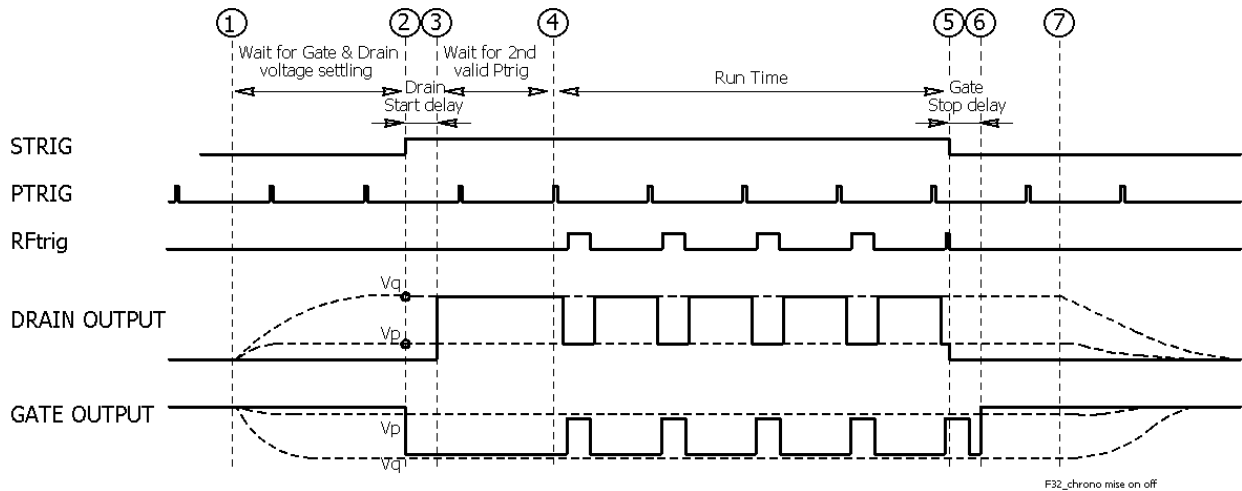


Figure 5:1 Start & Stop process chronogram

5.2 Shutdown conditions

5.2.1 Fast Pulser SOA (Safe Operating Area) global protection

AM3200 pulsers are fully protected against any attempt to overrun their safe operating area. Emergency cutoff is triggered synchronously for both pulsers.

Settings	Limits	Test conditions	delay	Usual Drain pulser value	Usual Gate pulser value	
Ip max, Iq max, Ir max	absolute output current	DUT	3 current thresholds: Ip, Iq and Ir	50ns	30A	not used
Pp max, Pq max	Pulsed output power, Quiescent output power	DUT	both Pp and Pq are checked	50ns	3kW	not used
parameter not programmable, defined by design only	RMS output current	Pulser	both Ip and Iq are checked, same limit	100ms	5A	not used
	average DC current	Pulser	limit on total current, pulsed & quiescent	100ms	5A	300mA
	DC input voltage		connection mismatch check	5ms		not used
	output transient voltage		protects Gate from Drain burn out	50ns	not used	Max(Vp,Vq)+4.5V, min 4,5V
	average output power	Pulser	limit on total power pulsed & quiescent	100ms	100W	3W
	average frequency		voltage dependent limit	1s	500kHz	N/A
	internal temperature			1s	60°C	60°C

The pulser provides a Safe Operating Area control system which combines:

- A multilevel fast comparator cutoff
- A I/V DC measurement at both power supply inputs
- An average frequency measurement
- A shared alarm signal between pulsers, which performs cutoff synchronization within 250ns.
- A temperature control

Standard pulsers (AM3200) offer programmable limits in order to protect the device under test with respect to its own safe operating area. (Max current and max instantaneous power for each level, Vp & Vq)

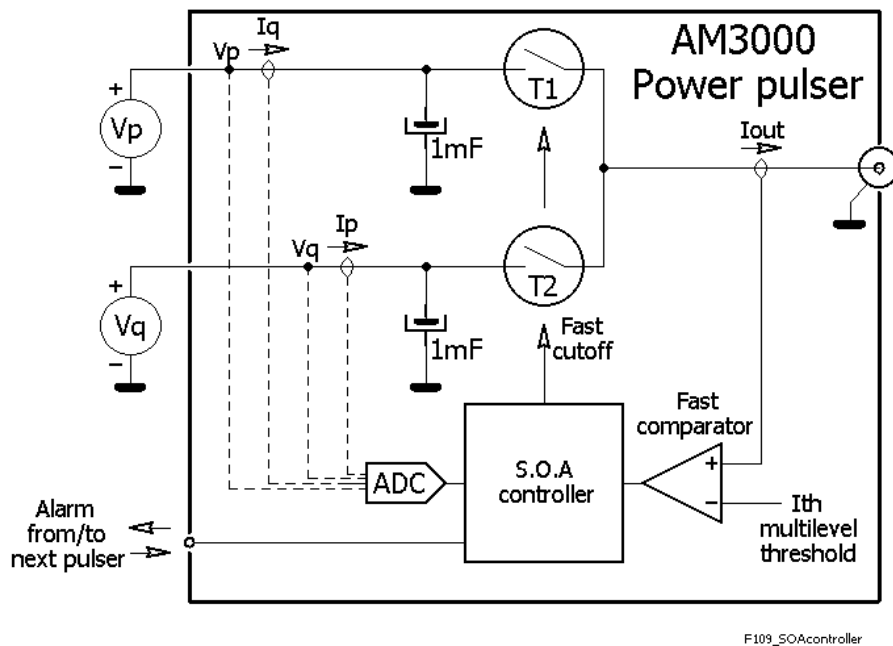


Figure 5:2 SOA controller schematic

5.2.2 Pulsed Current protection

Pulsed current protection is a DUT protection mechanism, it uses a fast current comparator to perform the cutoff of the power switch within 50ns.

$I_{p\ max}$, $I_{q\ max}$ and $I_{r\ max}$ define the protection specification as illustrated below:

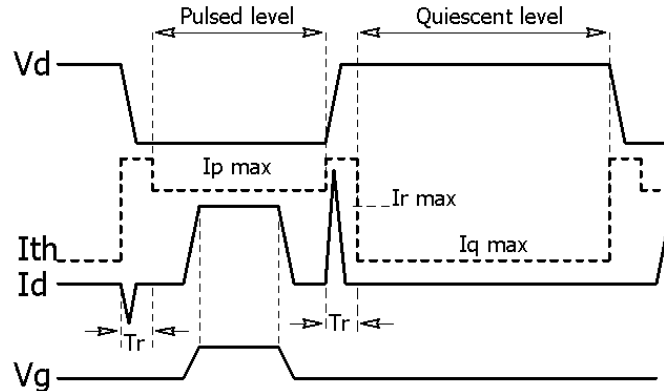


Figure 5:3 Pulsed current protection chronogram

Computing I_p and I_q current thresholds according to measured DC voltage, the SOA controller performs the limiting of the pulsed output power. The power switch cutoff will be performed within 50ns, as it does when an over-current occurs

5.2.3 RMS current protection (pulser)

The RMS current protection is a probe head (AM3211 & AM3221) protection system. The maximum stress sustained by the pulser is related to the RMS output current level, and not only the average DC current level.

Combining I_{dc} and I_{pulsed} control, the SOA controller checks the actual RMS current, whatever the voltage duty cycle of both Drain and Gate. As average I_{dc} measurement is integrated on 200ms, the max. RMS current cutoff cannot be processed faster, but this is compliant with transient thermal stress capability.

5.2.4 Maximum Switching frequency protection (pulser)

The maximum switching frequency protection is also a probe head (AM3211 & AM3221) protection system. As the switching losses are directly proportional to the switching frequency, each pulser calculates the appropriate frequency in order to limit dissipated power and regulate the probe temperature:

- The difference between Pulsed and Quiescent levels (ΔV)
- The maximum frequency: $F_{max} = f(\Delta V)$ specific to each pulser
- The duty cycle: $D = F \times T_{on}$

5.3 Pulse definition

The pulse timing is computed inside each pulser, using a 50MHz clock which is synchronized by the P_{trig} pulse. The internal time reference of each pulser exhibits a calibrated minimum delay of 200ns, and a maximum time jitter of $\pm 2,5$ ns.

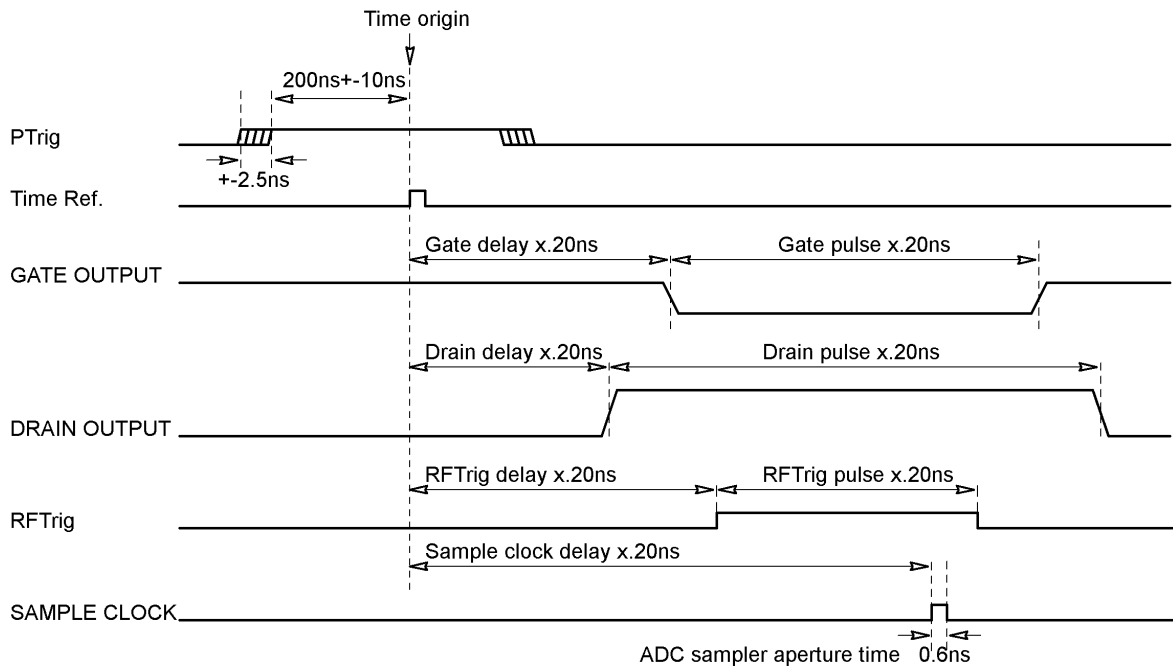


Figure 5:4 AM3200 pulse timing definition

Parameters	Conditions	spec.	min	max
Time jitter	Ptrig to any output			$\pm 2,5\text{ns}$
Minimum time delay from Ptrig	Fixed delay from Ptrig to any output	200ns	190ns	210ns
Time delay calibration error	parameter inside each pulser	$\pm 10\text{ns}$		
Time resolution	delay and duration counting	20ns		
Pulses duration setting range	31 bit counting		200ns	40s
Pulses delay setting range	31 bit counting		200ns	40s
Sample clock delay setting range	31 bit counting		200ns	40s
Internal Pptrig range	Period (timer resolution $1.1\mu\text{s}$)		$1.1\mu\text{s}$	200s
	Frequency		$9.09\text{e}5\text{Hz}$	0.005Hz

5.4 Measurements Definition

5.4.1 High bandwidth embedded sampling measurement

The complete measurement and Analog to Digital conversion system is located into the pulser and operates fully isolated from ground, performing fast sampling and high analog bandwidth

ADC sampler aperture time	0,6ns
programmable measurement delay resolution	20ns
measurement settling time	300ns
ADC resolution	16 bit
ADC maximum full range non linearity	$\pm 1,5$ bit
ADC conversion & read time = minimum sampling period	$1,1\mu\text{s}$
memory buffer size (voltage + current) x (gate + drain)	4×1024
memory buffer read time to PC computer (typical, depends on software performances)	250ms

5.4.2 Automatic range

The automatic range allows to automatically switch to the appropriate range during the measurement, in order to keep the maximum measurement accuracy.

5.4.3 Synchronous measurement by Ptrig

Application: *Pulse IV / LP / Pulse shape recording*

In this mode, a single point measurement is performed at each Ptrig period. The minimum sampling period is $2\mu\text{s}$ (= the minimum period Ptrig).

A measurement can contain between 1 to 1024 successive points. It is triggered asynchronously by the software. The delay between Ptrig and the measurement is adjustable by steps of 20ns.

The initial delay is adjustable from 200ns to 40s (usual value <10ms).

The offset delay at each period is adjustable from 0 to 40s, (usual value <1ms)

For pulsed mode applications between 500KHz and approximately 100Hz, the delay offset simulates a sampling frequency up to 50MHz, and can build the shape of the pulses within the bandwidth of the measuring system.

To improve the S/N ratio with periodic signal, the same measurement can be averaged from 1 to 100 times.

The following chart shows: 1 burst of 4 measurements with offset.

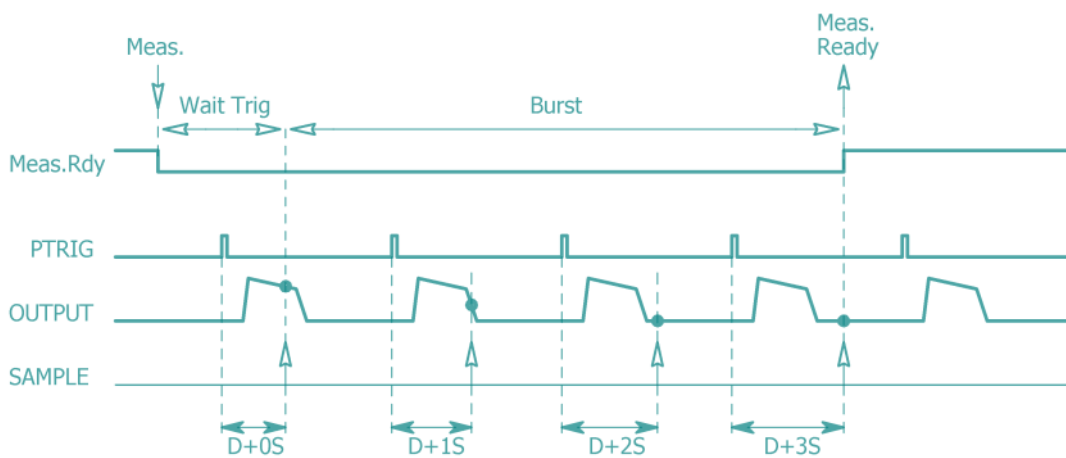


Figure 5:5 Chronogram of Synchronous measurement mode

In this case, the time measurement depends on the signal period and on the number of points chosen.

1.1.1 Asynchronous measurement

Application: *Pulse shape recording / Long Period / Traps Observation*

In this mode, a single pulse Ptrig allows to do a complete acquisition.

The sampling period is stable and adjustable from 1.1µs to 200s, in steps $\geq 1.1\mu s$

One measurement can contain between 1 to 1024 successive points. The delay between Ptrig and the first measurement is equal to this sampling period.

Measurement acquisition starts from the second pulse Ptrig detected.

The following chart shows:

- $N \times \text{sampling period} > \text{Ptrig}$

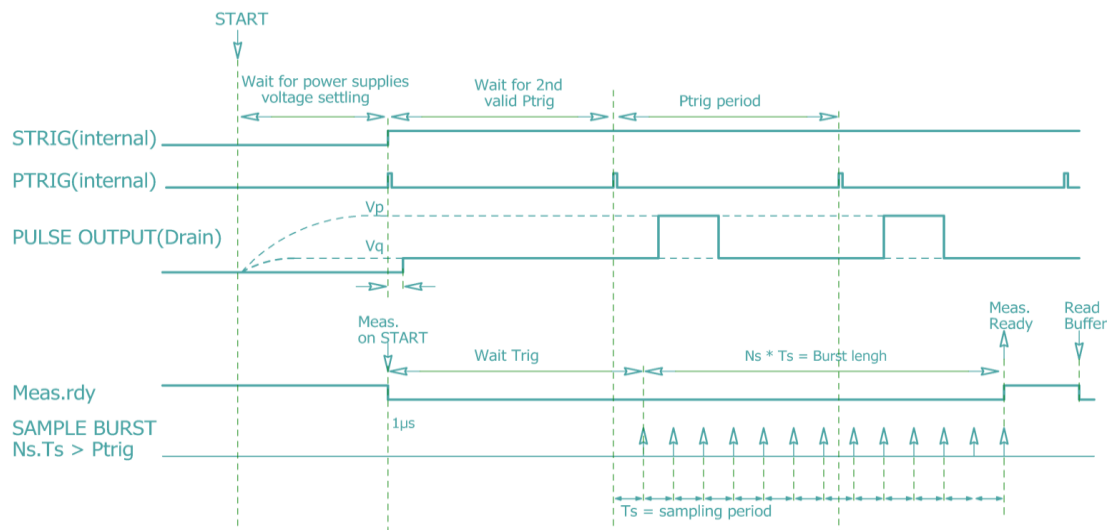
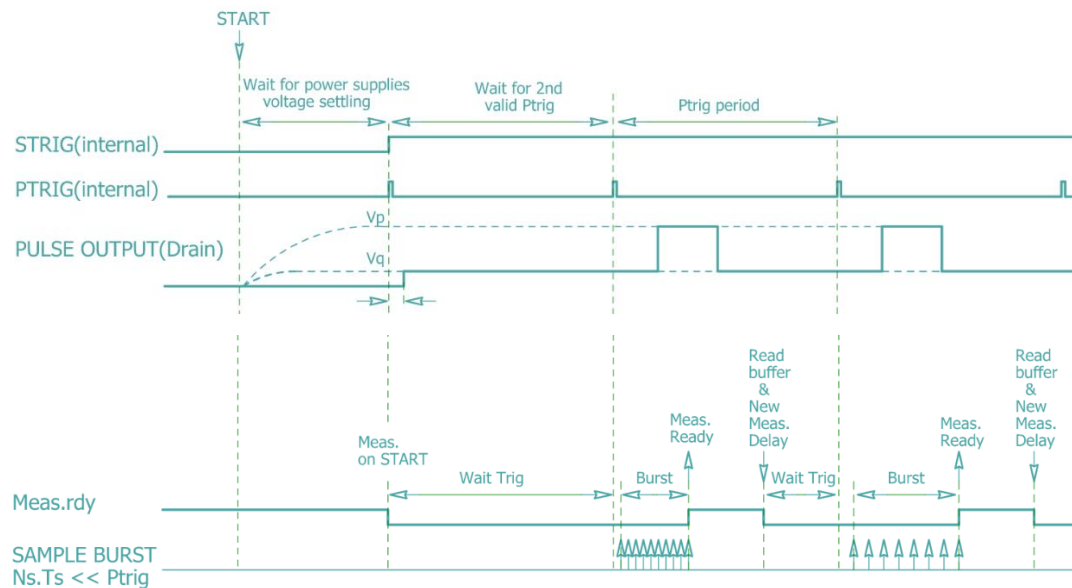


Figure 5:6 Chronogram of Asynchronous measurement mode ($N \times \text{SamplingPeriod} > \text{Ptrig}$)

- $N \times \text{sampling period} < \text{Ptrig}$



systeme_chrono_acq_TrigBurst_F33

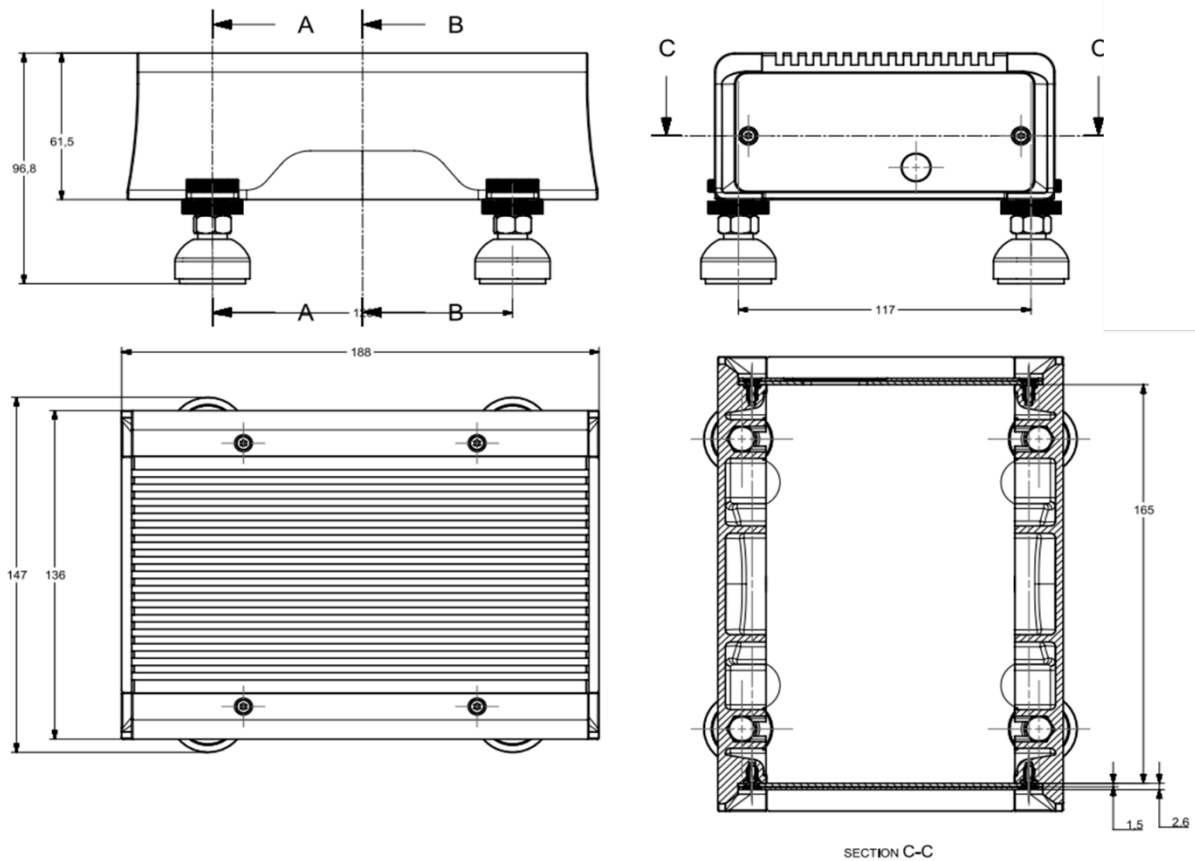
Figure 5:7 Chronogram of Asynchronous measurement mode ($N \times \text{SamplingPeriod} < \text{Ptrig}$)

6 Mechanical Characteristics

AM3211 & AM3221 (Gate and Dain Probes)

- Weight: 3.2lbs
- Length: 7.5"
- Width: 5.5"
- Height: 3" (without legs)

Probe dimensions (mm)



AM3203 (Control Box)

- Weight: 11lbs
- Length: 15"
- Width: 8.5"
- Height: 4.25"

7 Accessories

7.1 Components list

Ref.	Function	Description
AM 3203	control unit	control and power supply for one gate and one drain two levels pulser
AM 3901	control cable	2 m length, required for any gate pulser or drain pulser
AM 3904	power cable	2 m length, required for any drain / power pulser
AM 3211	Gate pulser	+25V 1A, DSUB15 output connector
AM 3911	BNC adapter	standard output adapter required for MOSFETs devices
AM 3912	BNC adapter	standard output adapter required for HEMTs devices
AM 3221	Drain pulser	+250V 30A low drop, two BNC output connectors
AM 32xx	output resistor	2 BNC / 1BNC adapter including 50 Ohm serial resistance
AM 32xx	output resistor	2 BNC / 1BNC adapter including 1/10 KOhm serial resistance
AM 3202	power supply	additional power supply unit for a two drain set-up

7.2 Standard output connector for general purpose pulser

- The AM3211 pulser is fitted with a DSUB 15 connector, required for remote capacitor, remote current sense & remote voltage sense. A DSUB/BNC adapter is supplied with the pulser for simple & straight connection.
- The AM3221 pulser is fitted with two parallel BNC connectors: Force output and Remote sense input connections. The remote sense input can be disabled or enabled using a slide switch on the front panel.

7.3 Resistive networks

The resistive networks are made of serial resistances. They are compatible only with the AM3221 drain power heads in order to outsource the voltage measurements.

At the DUT side, a BNC connector allows a direct connection with the bias Tees. They are equipped of heat sinker and connection pads for oscilloscope voltage and current probes. The resistive networks are fitted with two parallel BNC female connectors. The output is a single BNC connector.



AM3221 probe side



DUT side

Figure 7:1 resistive network

Two resistor values are available:

- AM3991-R50P20: 50Ω 100W serial resistor
- AM3991-R1000P20: 1KΩ 50W serial resistor

There is an interest to use such resistive networks for the characterization of semiconductors with the pulse IV system. Indeed, the addition of resistive networks changes the equivalent impedance of the power heads. Consequently, these impedances can change the device behavior, especially at low frequency where some oscillations can onset.

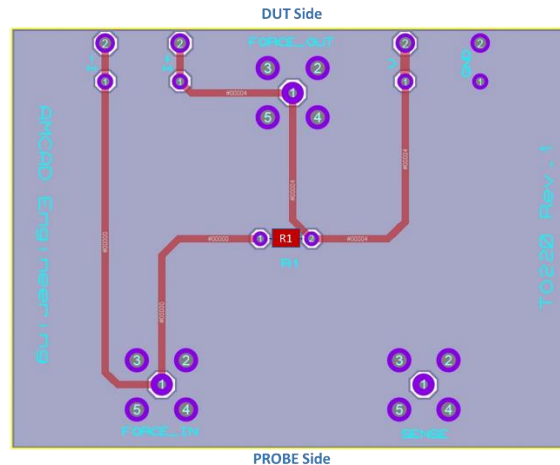


Figure 7:2 resistive network layout

The sense BNC connector of the resistive network is not connected, as a consequence, the serial resistance value is connected downstream of the measurement reference plane of the probe head. The user has to select the **FORCE mode** thanks to the switch on the drain probe's front panel. **(Never use the SENSE mode of the probe when a serial resistance is connected, the ADC of the probe may be damaged during the measurements).**

In addition, the lagging effect that can be observed on the current pulse shape is linked to this resistance value. The higher this resistance value, the lower the rise and fall time of the current waveform, especially in the ohmic area. Increasing this resistance value enables to reduce the pulse width for accurate Ron parameter determination.

- 50 Ohm 100W serial resistor
→ *Ohmic area*

For example, if a 50Ω serial resistance is added to the drain probe head's internal resistance, it will decrease the current rise and fall time as illustrated on the Figure 7:3.

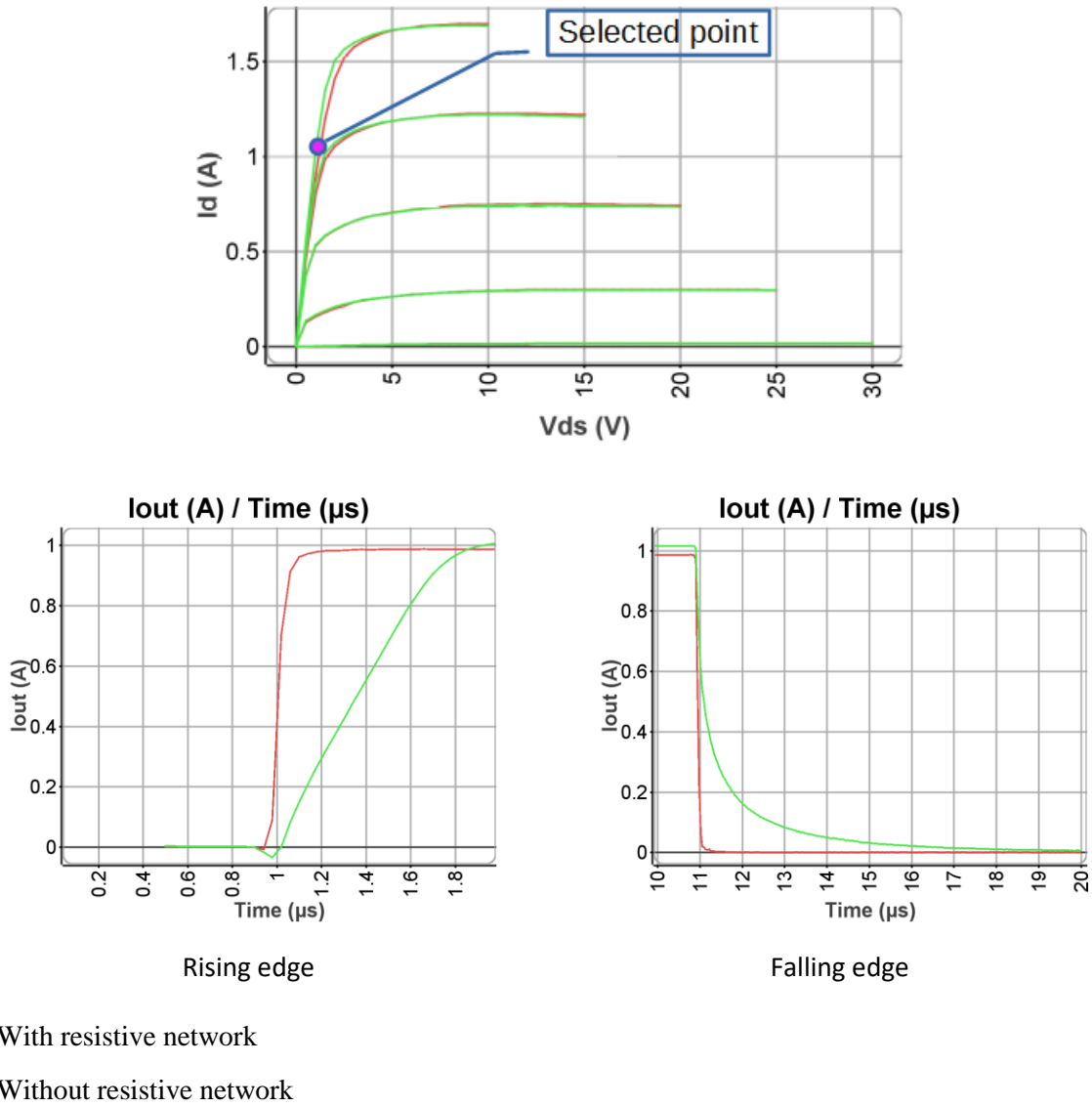
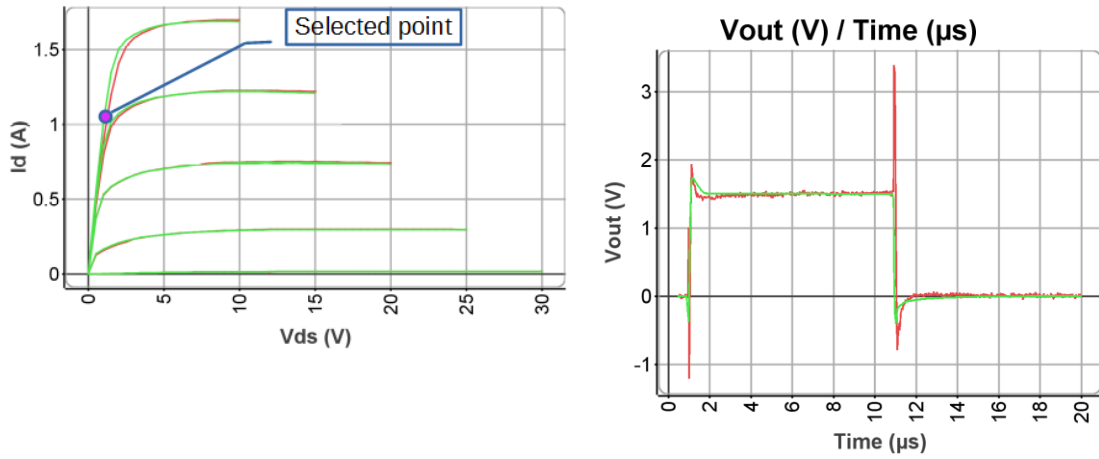


Figure 7:3 Serial Resistance added to the Generator internal impedance: Ohmic area - Current characteristic

The lower the rise/fall time of the current pulse, the faster the voltage drop across the serial resistance, obviously, this will increase the voltage spikes seen by the device under test. This phenomenon is depicted Figure 7:4.

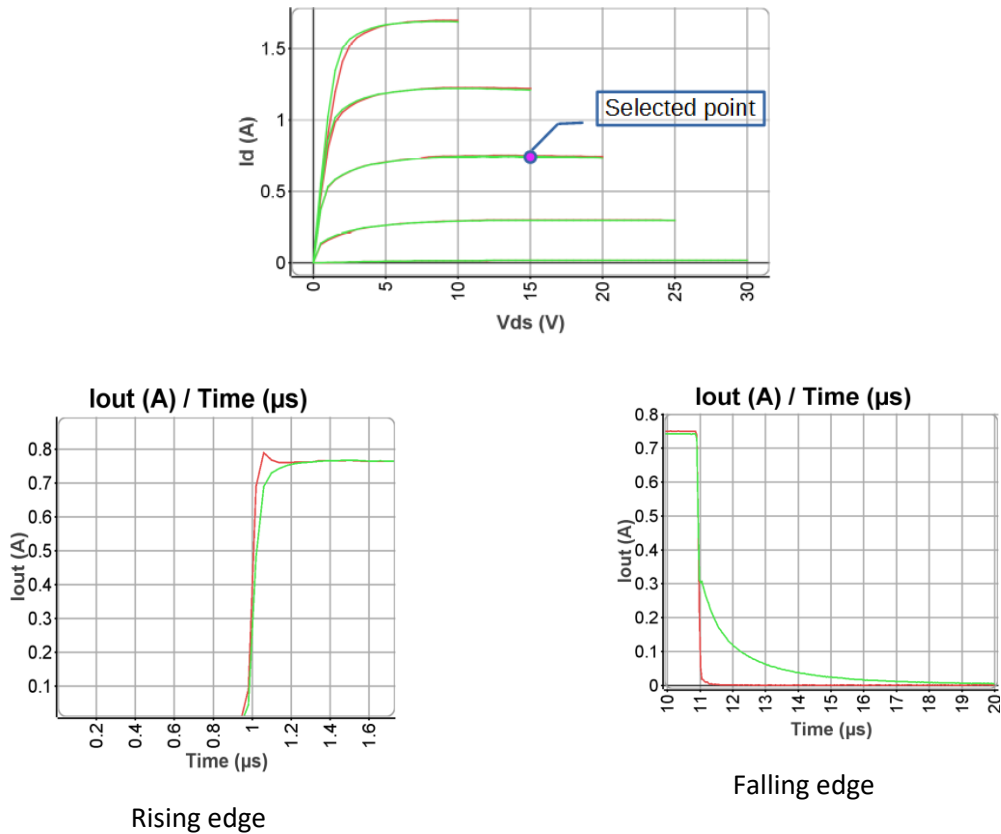


- With resistive network
- Without resistive network

Figure 7:4 Serial Resistance added to the Generator internal impedance: Ohmic area - Voltage characteristic

→ *Saturation area*

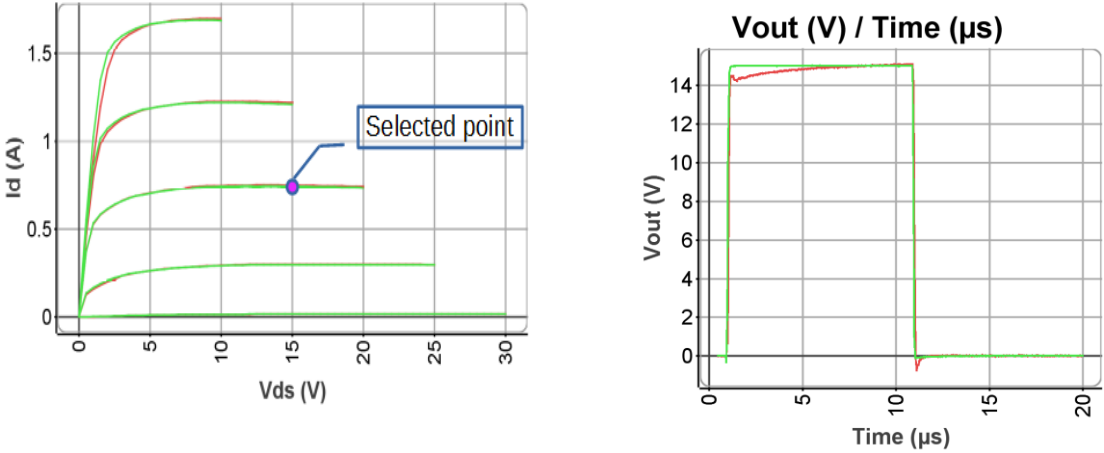
In the saturation area, the current rise time is similar with or without resistive network. However, the resistive network reduces the current fall time, Figure 7:5.



- With resistive network
- Without resistive network

Figure 7:5 Serial Resistance added to the Generator internal impedance: Saturation area - Current characteristic

In the saturation area, the voltage settling time is faster without resistive network, Figure 7:6.



- With resistive network
- Without resistive network

Figure 7:6 Serial Resistance added to the Generator internal impedance: Saturation area - Voltage characteristic

- 1kΩ 50W serial resistor

The resistive network role is to limit the excursion of the maximum output current available. When the equivalent resistance is adjusted to 1kΩ, the maximum excursion of the current is limited to 250mA, even if the PIV can provide an intrinsic current of 30A (Figure 7:7).

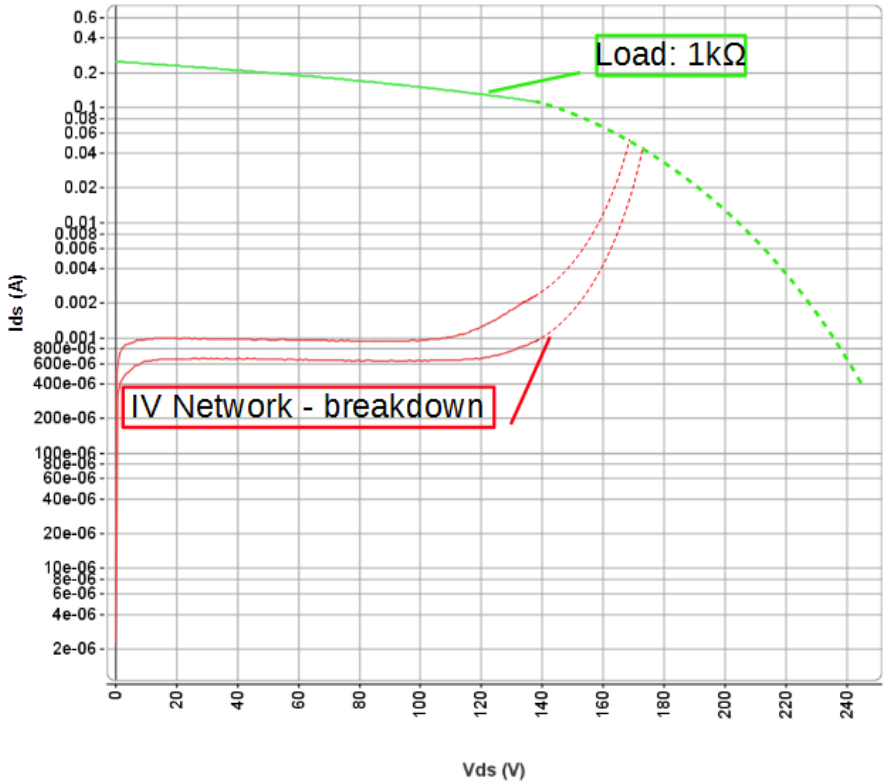


Figure 7:7 Maximum power area

7.4 Resistive networks into IVCAD

When the drain probe head is connected to a resistive network (1kΩ for example), the parasitic R_{s1} resistance needs to be filled into the IVCAD interface (Figure 7:8) in order to de-embed the IV measurement into the DUT reference plane. **For this kind of measurement, the user has to select the FORCE mode thanks to the switch on the drain probe’s front panel.**



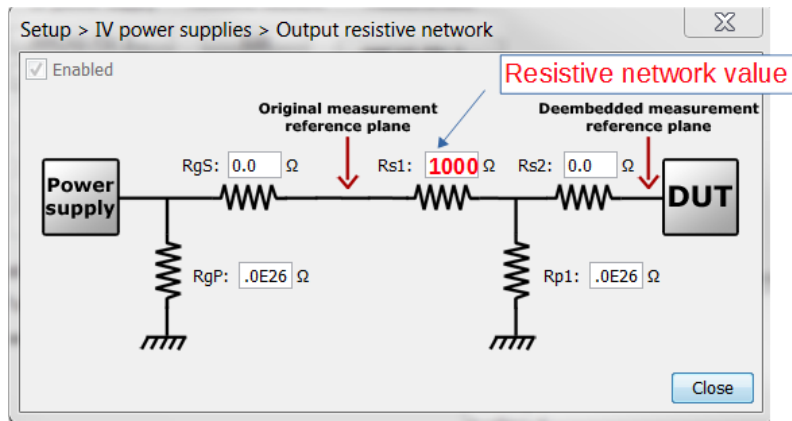


Figure 7:8 AM3221 Probe + Resistive network

Moreover, if the assembly also includes the bias network, the parasitic Rs2 resistance of the bias Tee still needs to be filled into the IVCAD interface (Figure 7:9) in order to de-embed the IV measurements into the DUT reference plane. For this kind of measurement, the user has to select the FORCE mode thanks to the switch on the drain probe’s front panel.

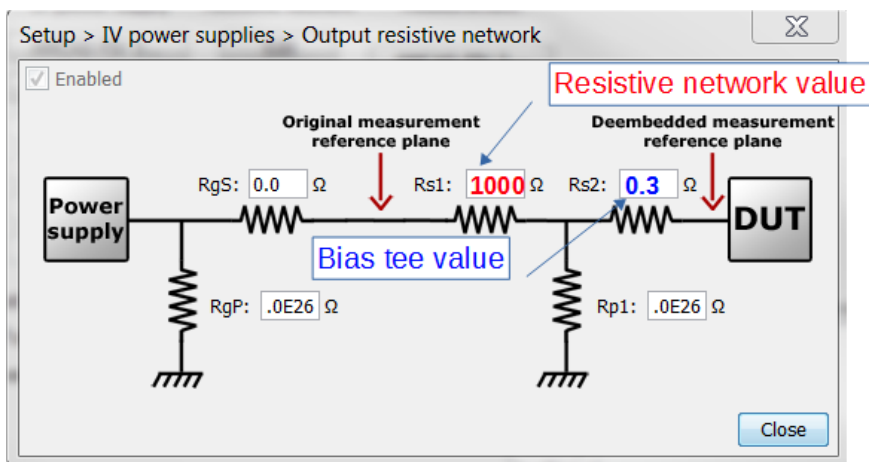


Figure 7:9 AM3221 Probe + Resistive network + bias tee

7.5 Kelvin (4-wire) Resistance Measurement

When no resistive networks are plugged to the DUT, it may be necessary to improve the voltage measurement accuracy through a Kelvin connection. Indeed, if an accurate voltage measurement of the device under test has to be measured (such as in the ‘Ron’ area), it could be problematic if the component is located at a significant distance away from our probe. Such a scenario would be

problematic because the probe will measure all the resistances in the circuit loop, which includes the resistance of the wires. In that case, a Kelvin connection permitted, the switch of the probe can be switched to the SENSE mode. The parasitic R-generator-Serial (RgS) resistance needs to be filled into the IVCAD interface (Figure 7:10) in order to de-embed the IV measurement into the DUT reference plane. For this kind of measurement, the user has to select the SENSE mode thanks to the switch on the drain probe’s front panel.

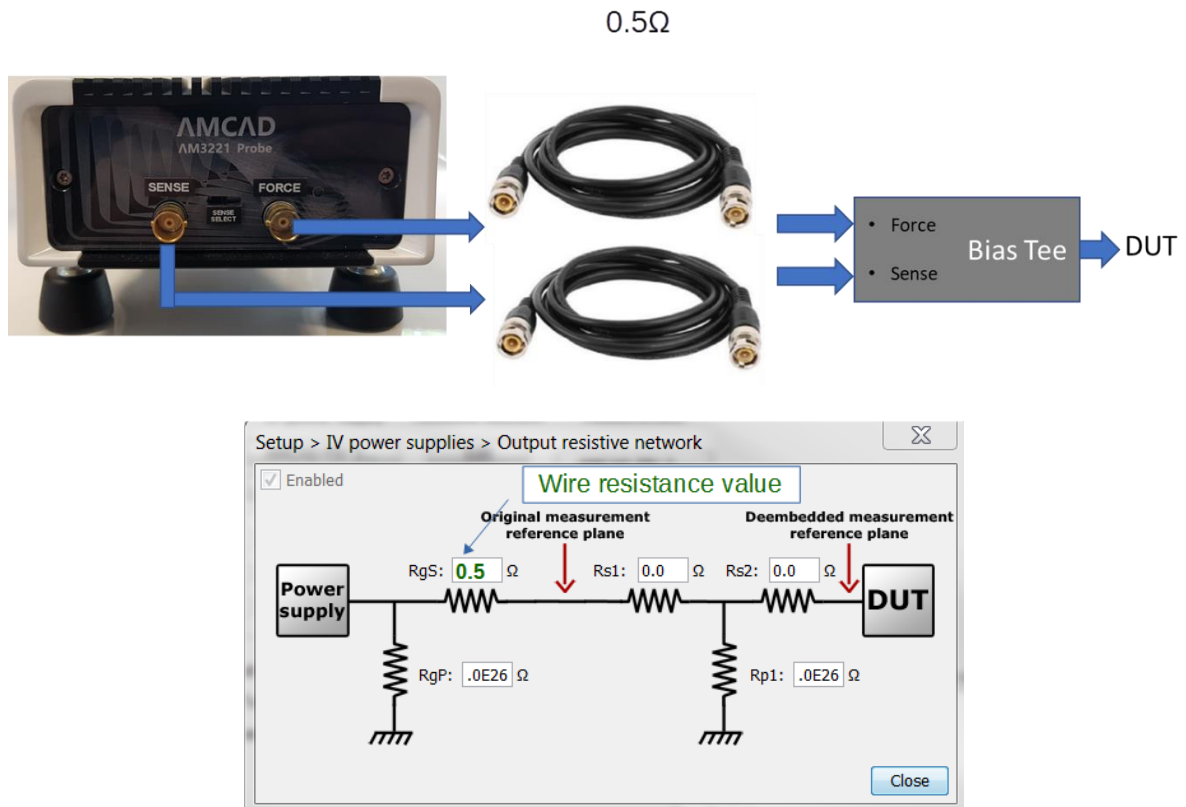


Figure 7:10 AM3221 Probe + Resistive network + Wire or cable

It is important to note that the voltage correction due to a cable or a wire is possible if its voltage drop is less than 500mV. If the voltage drop is higher, switch back to the Force mode; and fill the field Rs1 instead.

8 How to configure the AM3200 in IVCAD

Before starting IVCAD, the AM3200 need to be added in the VISA layer. As shown below in example, through "Keysight Connection Expert" or "National Instruments NI Max" free software, add the AM3200 as a LAN device.

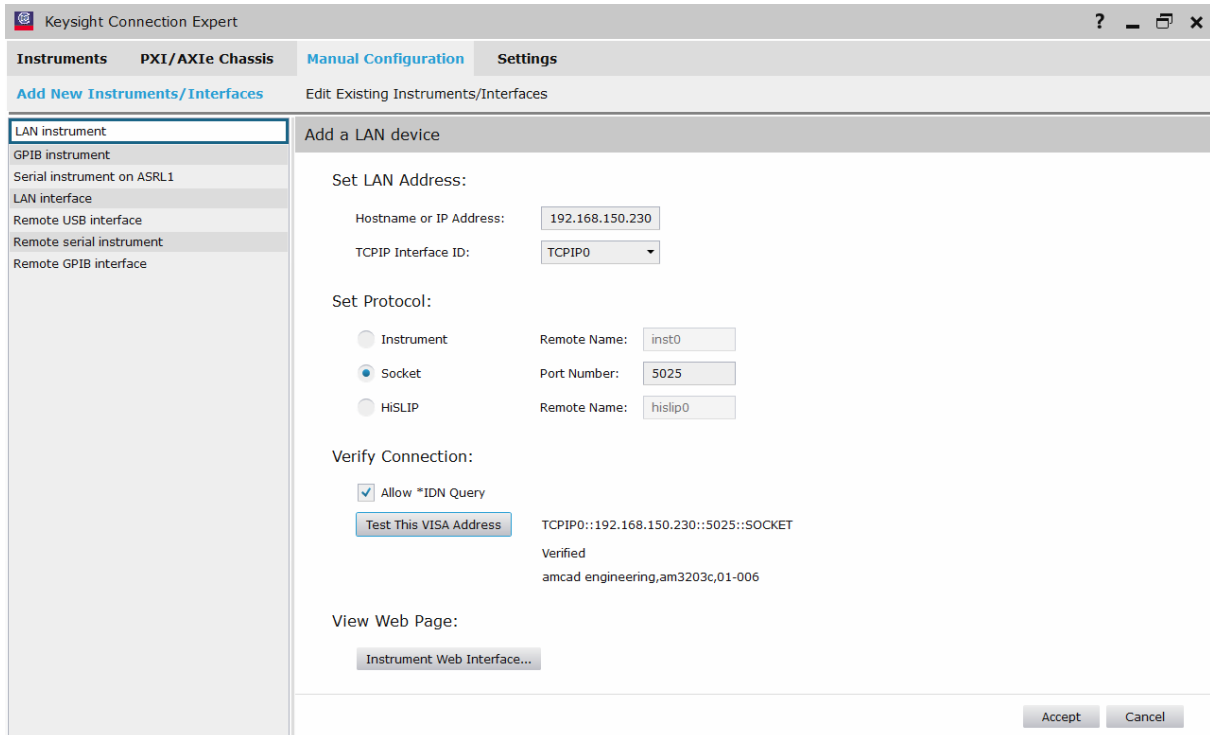


Figure 8:1 AM3200 add as instrument using Keysight Connection Expert software

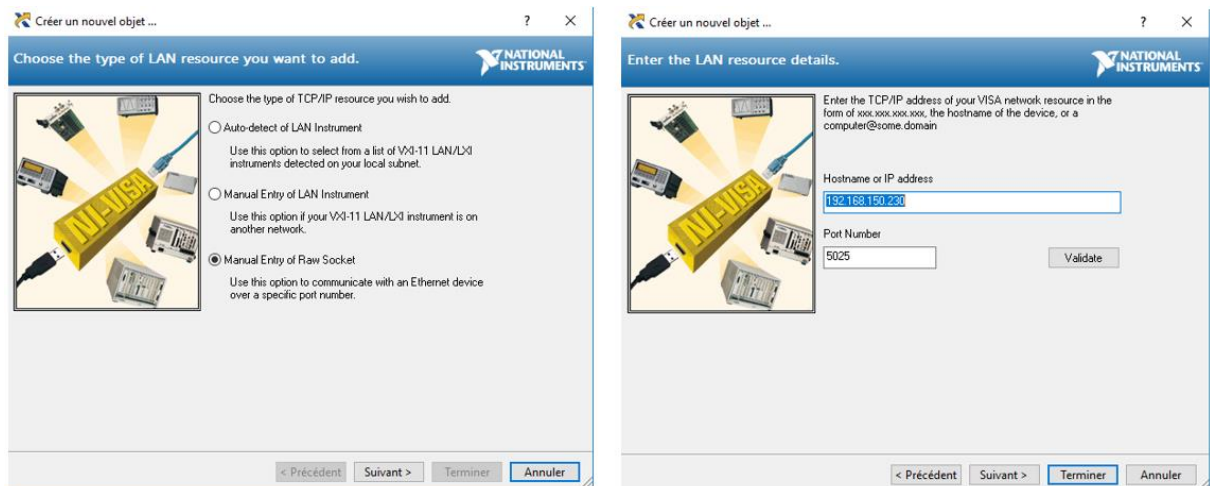


Figure 8:2 AM3200 add as instrument using Nlmax software

After launching IVCAD, the first step is to choose the measurement setup by clicking on "New" in "Measurement system-> Measurement->Setup & Measurement". Then, three measurement setups are proposed as depicted below:

- IV measurement
- Load Pull measurement
- Traditional Load Pull measurement

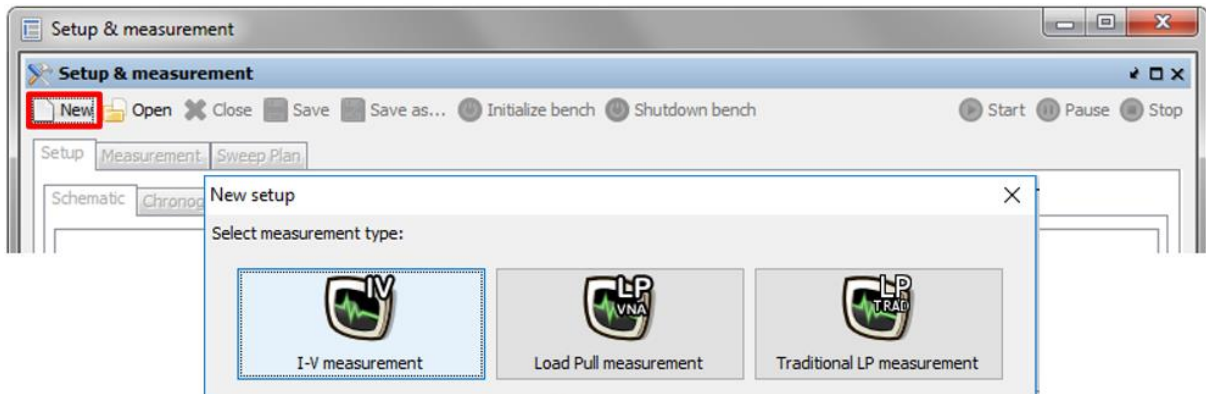


Figure 8:3 New setup in IVCAD

In this section, two configuration methods are presented to drive the PIV 3200 using IVCAD software.

8.1 AMCAD PIV Easy Configuration (IVCAD 3.8)

In order to help users set AMCAD PIV system (AM200 series & AM3000 series), IVCAD embed an easy configurator feature (since IVCAD 3.7). This feature allows to configure easily your IVCAD I-V and VNA based Load-Pull setups.

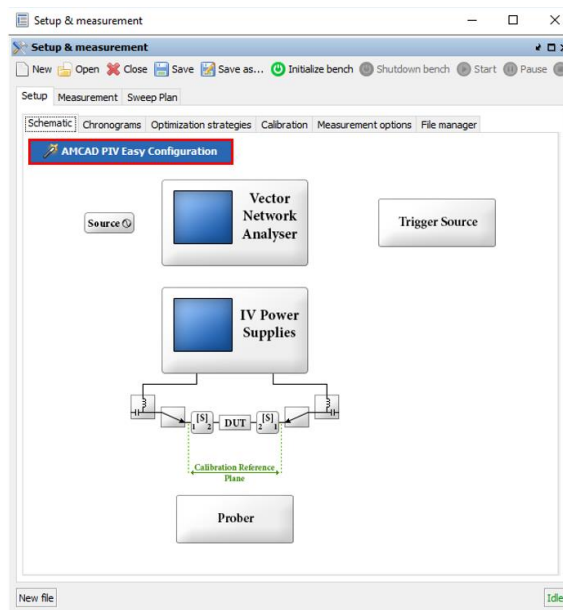


Figure 8:4 AMCAD PIV easy configuration access

Note that the AM3200 system needs to be upgraded to 1.6 or later firmware version to be compatible with this feature.

8.1.1 I-V setup

This part proposes to set an I-V measurement setup using “AMCAD PIV Easy Configuration”.

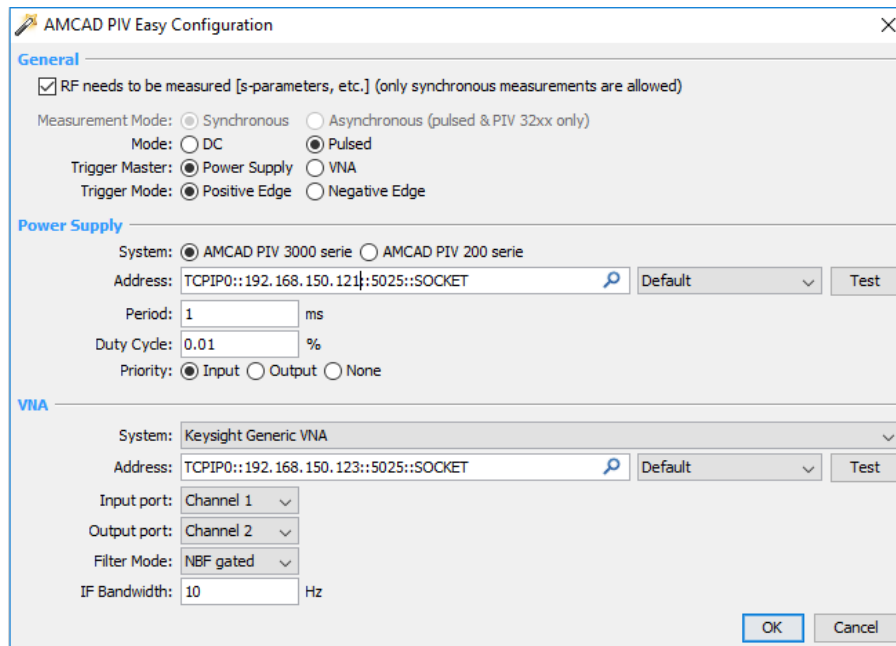


Figure 8:5 Example of AMCAD PIV easy configuration for an IV setup

The configuration begins by selecting some general parameters:

- Activate or not the RF measurement (S-parameters...)
- Choose the "Measurement Mode": Synchronous or Asynchronous (only in pulsed mode for Pulse shape recording)
- Choose the "Mode": DC or Pulsed.

Then, the PIV system (power supply) must be set:

- Choose the system "AMCAD PIV 3000 serie".
- Enter the VISA address, clicking on the magnifying glass and choosing the PIV system.
- If the PIV system is in Pulsed mode the "Period" and the "Duty Cycle" must be set.
- The bias can be applied firstly on the "Input" or the "Output" thanks to the "Priority" field. If the user selects "None" both biases ("Input" and "output") are applied at the same time.

Then the last part is dedicated to the VNA configuration if the "RF need to be measured" box is selected.

- Choose your VNA in the "System" list.
- Enter the VISA address, clicking on the magnifying glass.
- Select the Input and the output ports
- Select the IF bandwidth and the Filter mode

Then clicking on OK, IVCAD will fill automatically all the parameters needed to “Initialize” the bench directly.

The length of the measurement window and the number of points in the pulse are defined by IVCAD to ensure a good trade-off between speed and accuracy. The proposed pulse timing can be modified directly in the Chronogram tab (refer to ‘IVCAD MT930JK OM PIV’ documentation).



Figure 8:6 Example of Chronogram defined with the AMCAD PIV easy configurator

8.1.2 VNA based Load Pull setup

This part proposes to set a Load Pull measurement setup using “AMCAD PIV Easy Configuration”. For the VNA based Load-Pull, the AMCAD PIV Easy Configuration window is similar to the "AMCAD PIV Easy Configuration" of the IV setup, adding the power meter setting. Clicking on OK, all the parameters and chronogram are automatically set, only the source and load tuning station remains unset. When your source and load tuning setting has been manually configured, the calibration can be directly performed.

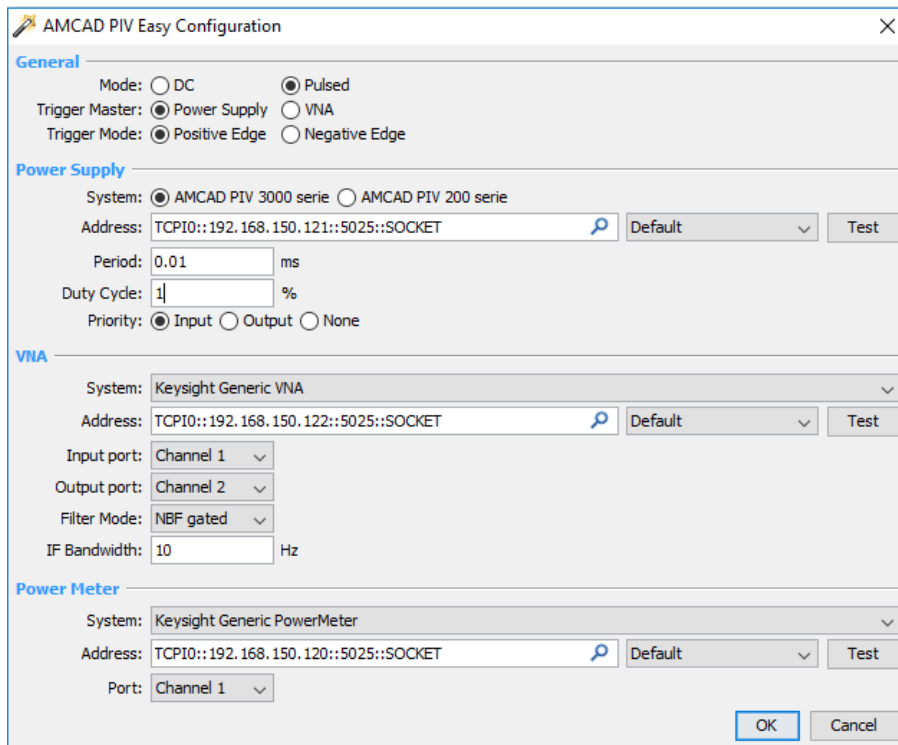


Figure 8:7 Example of AMCAD PIV easy configuration for an LP setup

8.2 Manual configuration

The AM3200 system has to be set and defined in the ‘DC Power supplies’ block of the IVCAD schematic.



Figure 8:8 IVCAD IV Power Supplies block

The ‘DC or Power Supplies’ setup window is common with the ‘I-V Measurement units’. It is divided into four configuration settings:

- Power supply** used to define the power supplies
- Resistive network** used to define the resistive networks
- Voltage measurement** used to define the instruments for the voltage measurement
- Current measurement** used to define the instruments for the current measurement

When clicking on ‘DC or Pulse Power Supplies’, the following window appears:

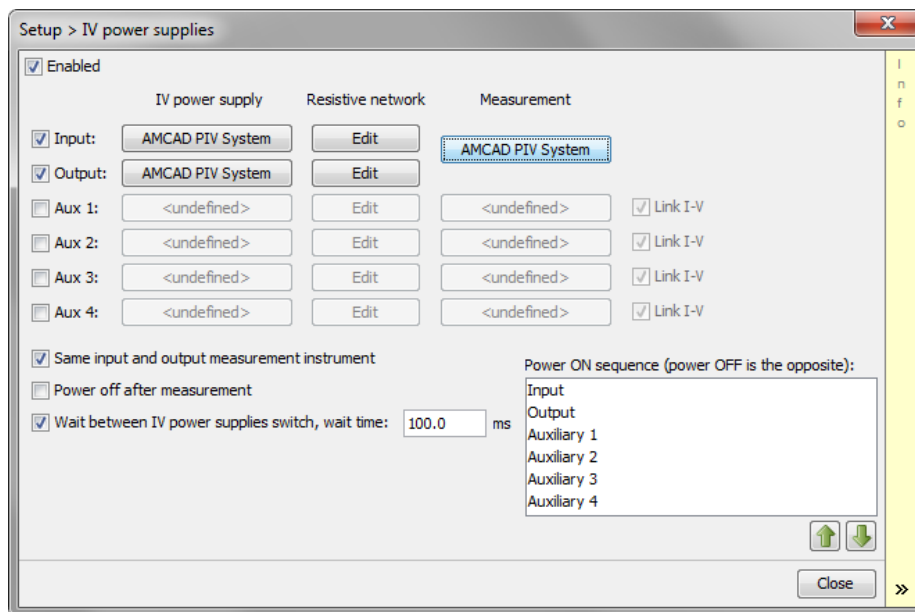


Figure 8:9 IVCAD IV power supplies & IV measurement window

8.2.1 Input DC supplies (AM3211) configuration

The input power supply is generally used to bias the gate access of a transistor. For AM3200 systems, the input DC supply corresponds to the AM3211 gate probe head.

By clicking on a 'Input Power supply', the following window is displayed:

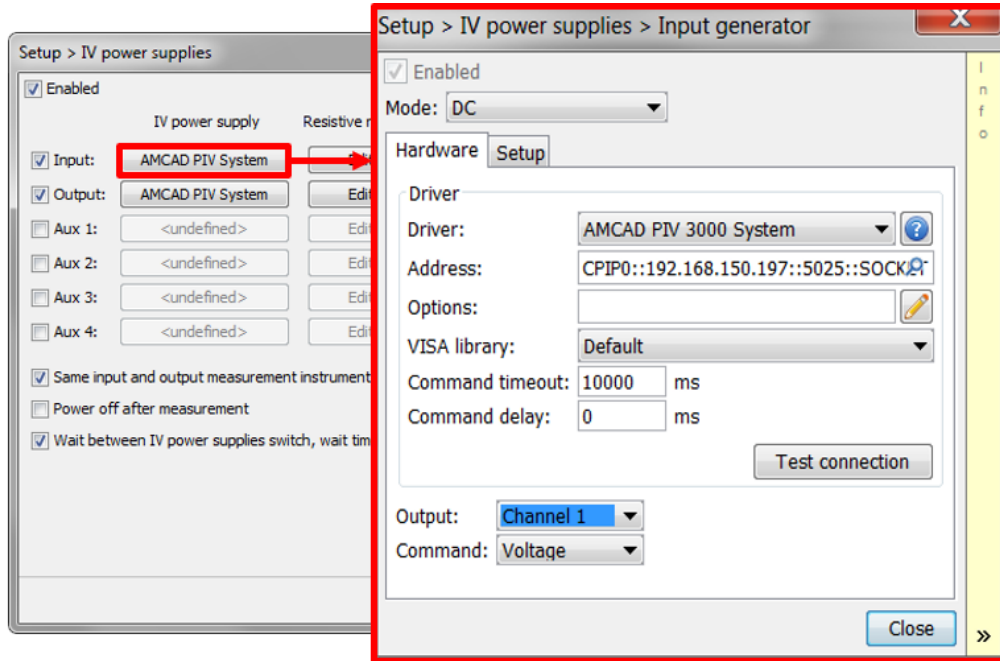


Fig 8:10 Input IV Power Supplies configuration

The fields to fill are:

Mode	choose the measurement mode (CW or Pulsed)
Driver	select AMCAD PIV 3000 System
URL	set the TCP/IP Address
Options	additional driver options (depends of selected driver)
VISA implementation	set the VISA DLL which will be used to communicate with this instrument
Command timeout	elapsed time before returning an error message if no response
Command delay	delay before sending a command
Test connection	send a command to the GPIB bus to test the instrument connection
Output	select the Channel 1
Command	select Voltage or Current

The fields to fill in the 'Setup' tab depend on the selected mode:

- DC mode

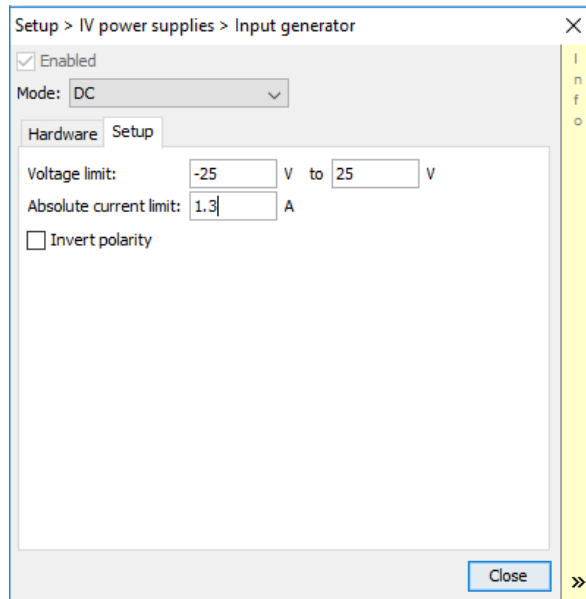


Figure 8:11 Input IV Power Supplies in DC mode configuration

Bias Voltage limit set the minimum and the maximum voltage limits of the probe (-25V to +25V for the AM3211)

Bias Absolute current set the maximum transient current limit achievable by the AM3211 (1.3A)

- Pulsed mode

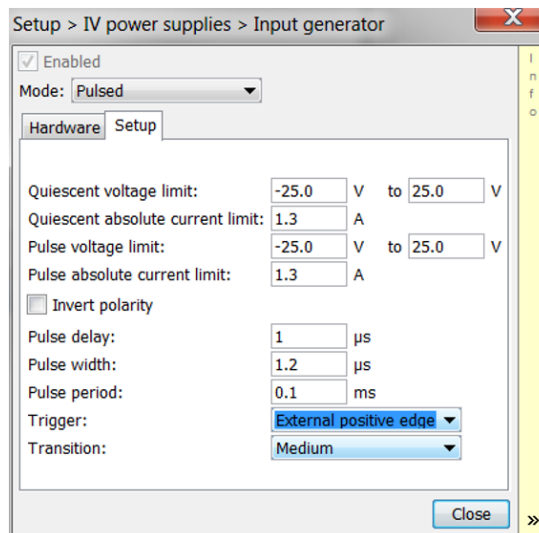


Figure 8:12 Input IV Power Supplies in Pulsed mode configuration

The fields to fill are:

Bias Voltage limit set the minimum and the maximum voltage limits of the probe (-25V to +25V for the AM3211)

Bias Absolute current set the maximum transient current limit achievable by the AM3211 (1.3A)

Pulse Voltage limit	set the minimum and maximum voltage limits of the probe (-25V to +25V for the AM3211)
Pulse absolute current limit	set the maximum transient current limit achievable by the AM3211 (1.3A)
Pulse delay	set the pulse delay ¹
Pulse width	set the pulse width
Pulse period	set the pulse period
Trigger	select internal or external trigger. The internal trigger signal comes from the PIV system, whereas an external trigger signal comes from another instrument.
Transition	select the transition mode. The transition mode will modify the rise time of the pulsed signal, which depends on the characteristics of the PIV system as well as the operating conditions (DUT characteristics, bias tees...). For the AM3211 gate probe only the transition: ‘Smooth’, ‘Medium’ and ‘Hard’ are available (refer to the section 3.3)

8.2.2 Output DC supplies (AM3211 or AM3221) configuration

The output power supply is generally used to bias the drain access of a transistor. For AM3200 systems, the output DC supplies corresponds to the AM3211 gate probe head or AM3221 drain probe head, depending on your configuration.

In any case, select **Channel 2** as Output, as illustrated below:

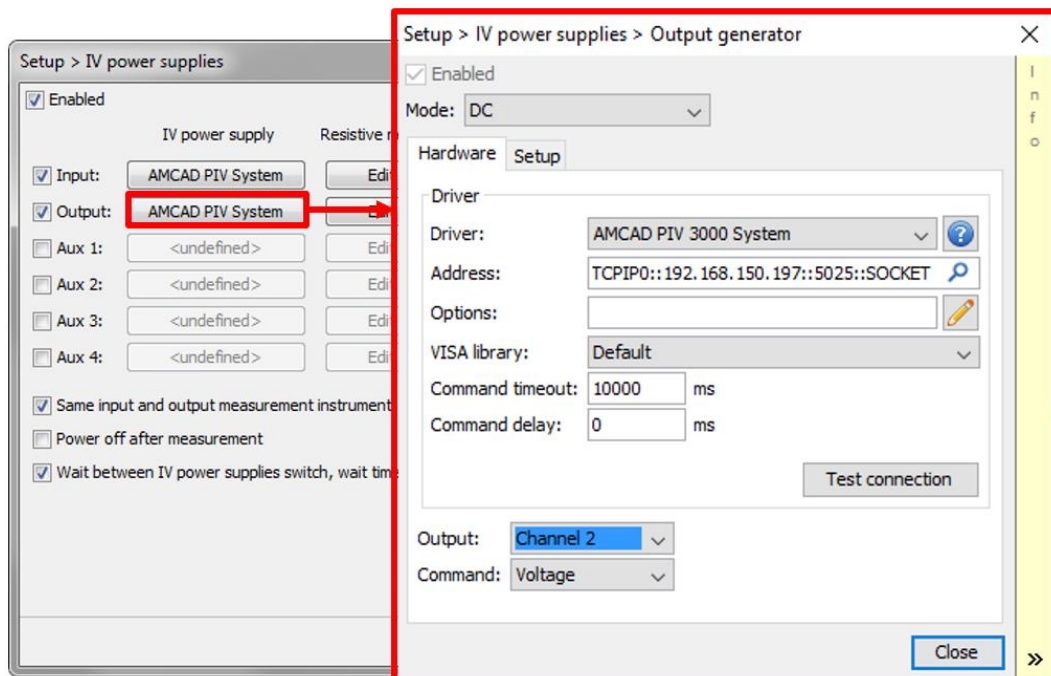


Figure 8:13 Output IV Power Supplies configuration

¹ These timings can be re-adjusted in the ‘Chronograms’ tab.

If the AM3200 is configured with two AM3211 probes, please set the ‘Output power supply’ in IVCAD as the ‘Input power supply’ (refer to the section [8.2.1](#))

If the AM3200 is configured with an AM3221 probe (classical configuration), the fields to fill in the ‘Setup’ tab depend on the selected mode:

- DC mode

Bias Voltage limit set the minimum and the maximum voltage limits of the probe (**0 to +250V** for the AM3221)

Bias Absolute current set the maximum transient current limit achievable by the AM3221 (**30A**)

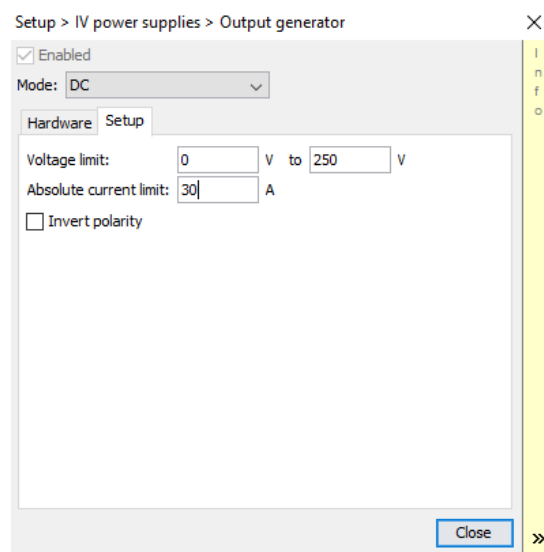


Figure 8:14 Output IV Power Supplies in DC mode configuration (AM3221)

- Pulsed mode

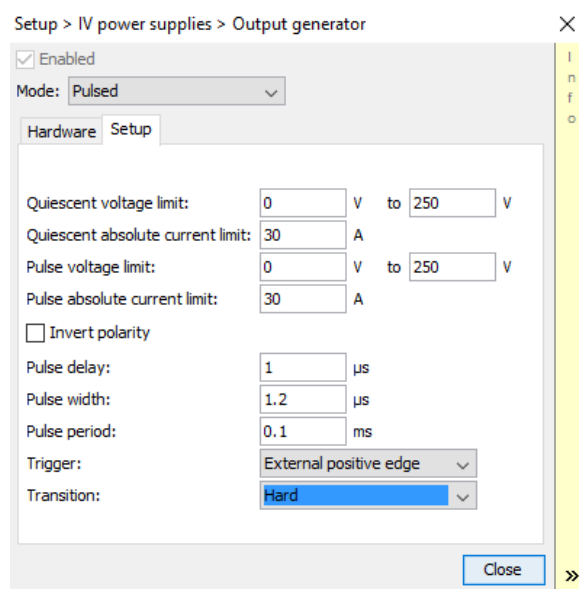


Figure 8:15 Output IV Power Supplies in Pulsed mode configuration (AM3221)

The fields to fill are:

Bias Voltage limit	set the minimum and the maximum voltage limits of the probe (0V to +250V for the AM3221)
Bias Absolute current	set the maximum transient current limit achievable by the AM3211 (30A)
Pulse Voltage limit	set the minimum and maximum voltage limits of the probe (0V to +250V for the AM3211)
Pulse absolute current limit	set the maximum transient current limit achievable by the AM3211 (30A)
Pulse delay	set the pulse delay ²
Pulse width	set the pulse width
Pulse period	set the pulse period
Trigger	select internal or external trigger. The internal trigger signal comes from the PIV system, whereas an external trigger signal comes from another instrument.
Transition	select the transition mode. The transition mode will modify the rise time of the pulsed signal, which depends on the characteristics of the PIV system as well as the operating conditions (DUT characteristics, bias tees...). For the AM3211 gate probe only the transition: ‘Medium’ and ‘Hard’ are available (refer to the section 4.3)

8.2.3 IV Measurement units

AM3200 system uses a single instrument to measure both input and output (gate and drain) voltages and currents, therefore the ‘Same input and output measurement units’ check box must be activated.

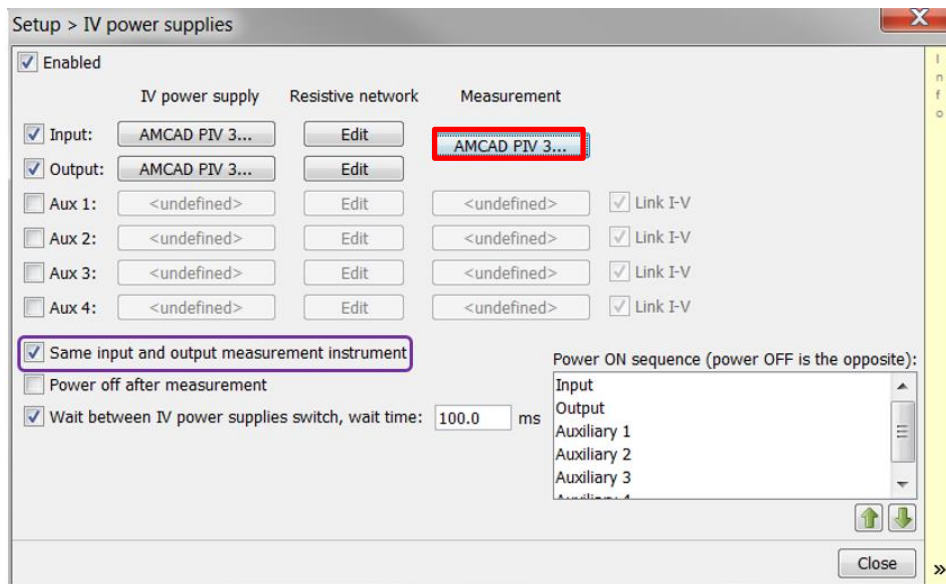


Figure 8:16 IV measurement configuration for AM3200 system

Clicking on ‘Input/Output Measurement’, the following window is displayed:

² These timings can be re-adjusted in the ‘Chronograms’ tab.

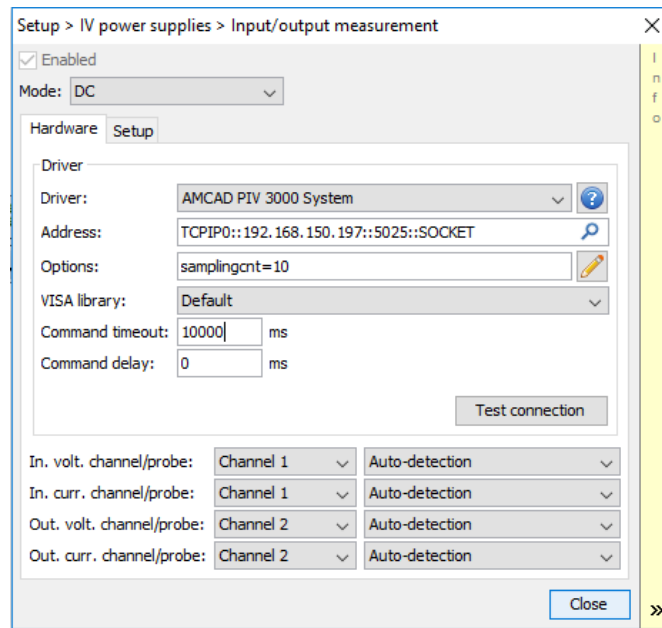


Figure 8:17 Input/Output Measurement configuration

Mode	choose the measurement mode (CW or Pulsed)
Driver	select AMCAD PIV 3000 System
URL	set the TCP/IP Address
Options	additional driver options (depends of selected driver)
VISA implementation	set the VISA DLL what will be used to communicate with this instrument
Command timeout	elapsed time before returning an error message if no response
Command delay	delay before sending a command
Test connection	send a command to the GPIB bus to test the instrument connection
In. volt. Channel/probe	select the Channel 1 => Autodetection
In. curr. Channel/probe	select the Channel 1 => Autodetection
Out. volt. Channel/probe	select the Channel 2 => Autodetection
Out. curr. Channel/probe	select the Channel 2 => Autodetection

The fields to fill in the ‘Setup’ tab depend on the selected mode:

- DC mode

Averaging	set averaging (for AM3200 system averaging need to be set at 1, refer to section 8.3 to know how change the AM3200 measurement averaging)
Correction factor	set correction factor, which multiplies the value of the measurement
Correction offset	set correction offset, which adds (or subtracts) a constant value

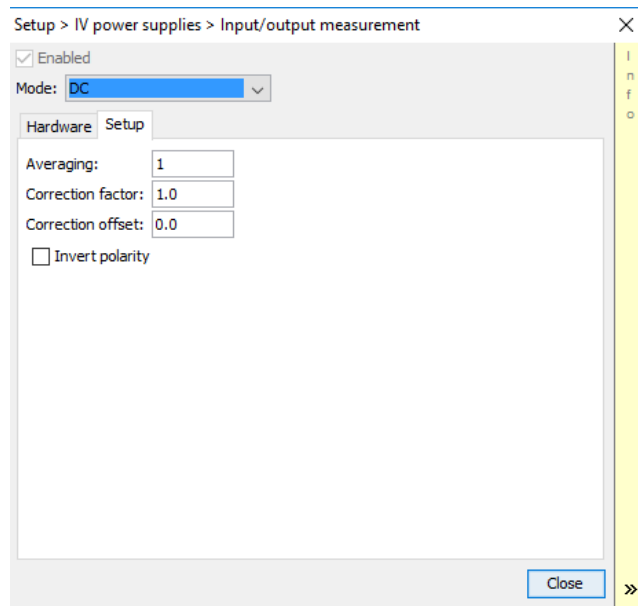


Figure 8:18 Input/Output measurement in DC mode configuration

- Pulsed mode

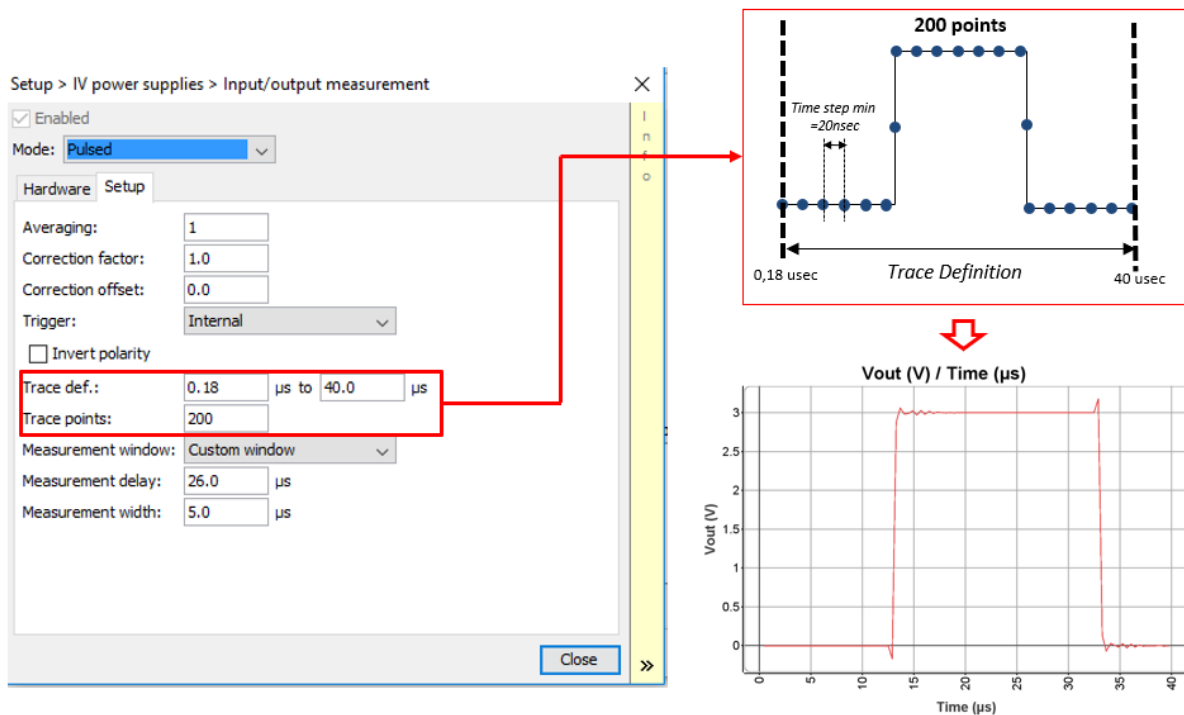


Figure 8:19 Input/Output measurement in Pulsed mode configuration

Averaging

set averaging (for AM3200 system averaging need to be set at 1, refer to section 8.3 to know how to change the AM3200 measurement averaging)

Correction factor

set correction factor, which multiplies the value of the measurement

Correction offset

set correction offset, which adds (or subtracts) a constant value

Trigger

select internal or external trigger. For AM3200 measurement units, it is recommended to always set the trigger as an internal trigger even if the AM3200 generator is defined with an external trigger.

- Trace def** Defines the window which contains the full pulse shape. When using the AM3200 system, minimum delay is 200ns, maximum recording stop time is 1.3ms (**for a higher recording length refer to section 8.3**).
- Trace point** Defines the number of points which contain the full pulse shape. When using the AM3200 system, the maximum time resolution is **20nsec**.
- Meas. window** Defines the window where the measurements are averaged to plot the IV network. Select measurement window, either synchronized with RF signal, synchronized with VNA measurement, or user customized

8.3 Advanced options

Some additional options concerning the AM3200 system can be set clicking on the ‘Input/output measurement’ => Click on the ‘Pen’, as illustrated below:

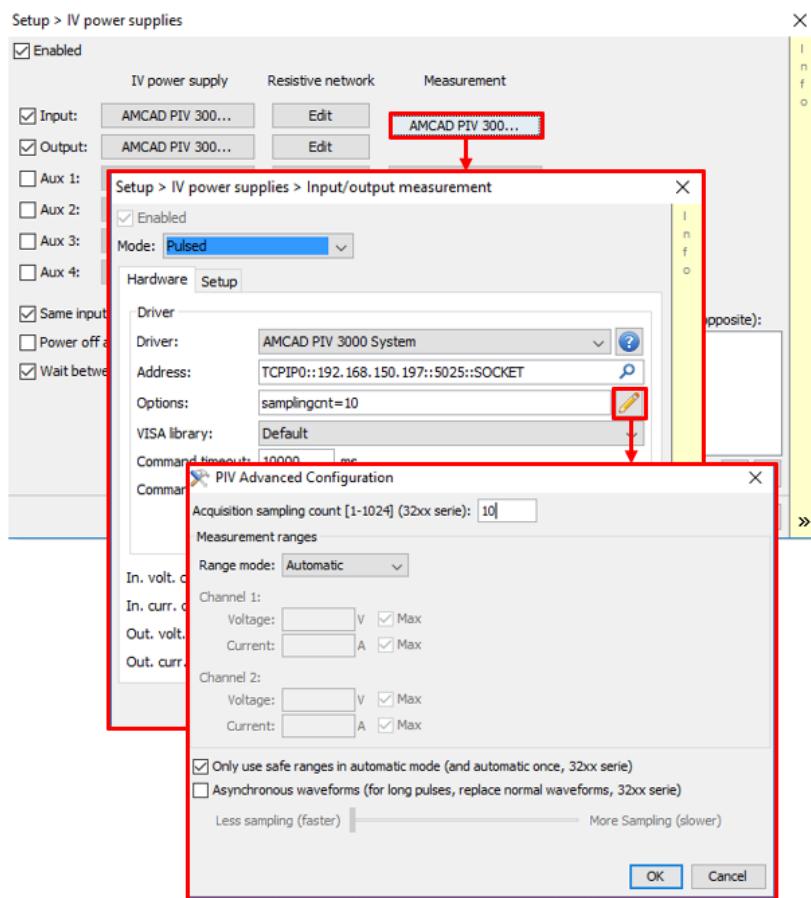


Figure 8:20 AM3200 Advanced options access

8.3.1 Acquisition sampling count

When using the PIV system as a measurement unit, different time step resolutions can be applied. For example: the IV measurement window can contain 10 points while the pulse shape recording window can contain 200 points.

The measurement window defines where the pulsed voltage and current are measured for IV curves. In this window it’s possible to measure several points, in order to get an average value of the pulsed current and voltage (important to improve numerically the measurement accuracy). This number of point can be set using the ‘Acquisition sampling count’.

It is possible to apply different horizontal resolutions between the measurement window and the window which contains the full pulse shape. The acquisition sampling count setting allows to provide a lower horizontal resolution for the pulse shape definition than for the measurement window.

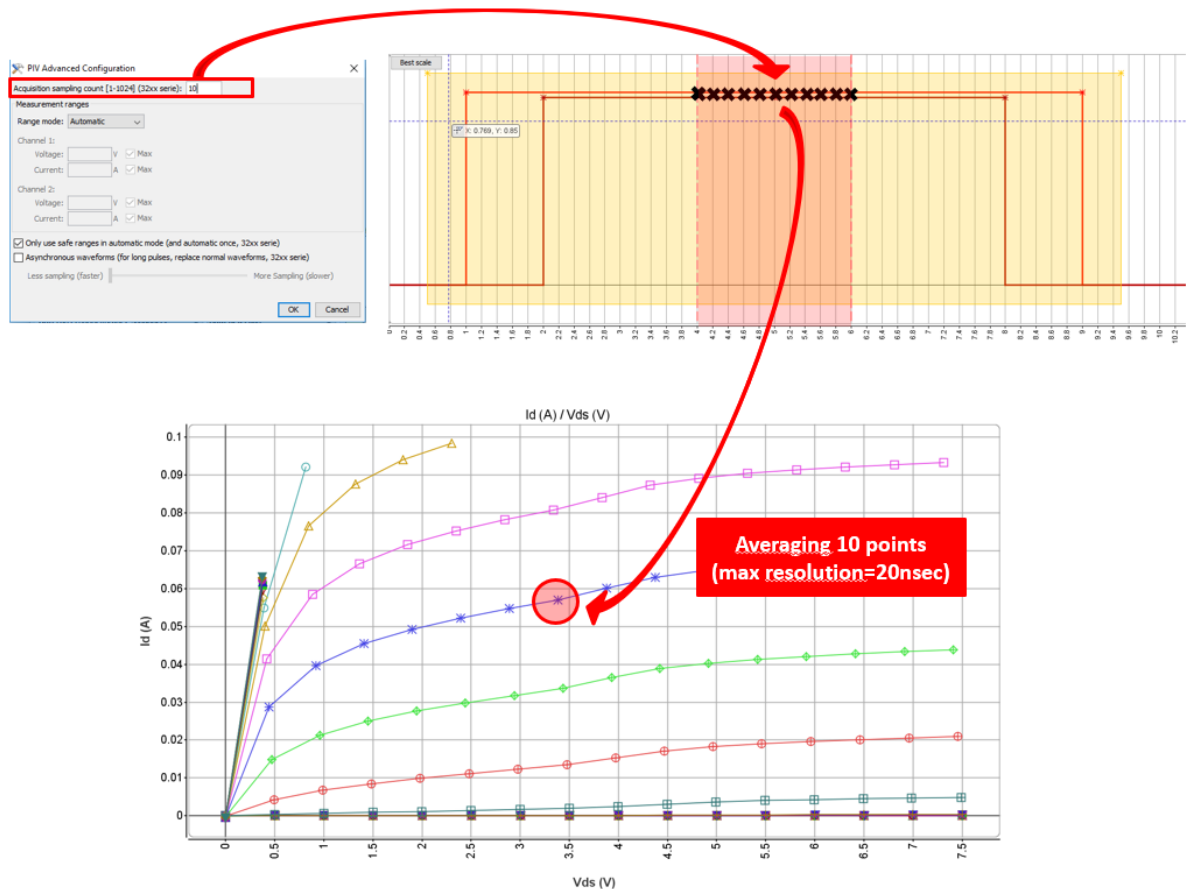


Figure 8:21 Acquisition sampling count scheme

In this mode (**Synchronous mode**) the AM3200 operation is similar to the stroboscopic effect (one measurement per period).

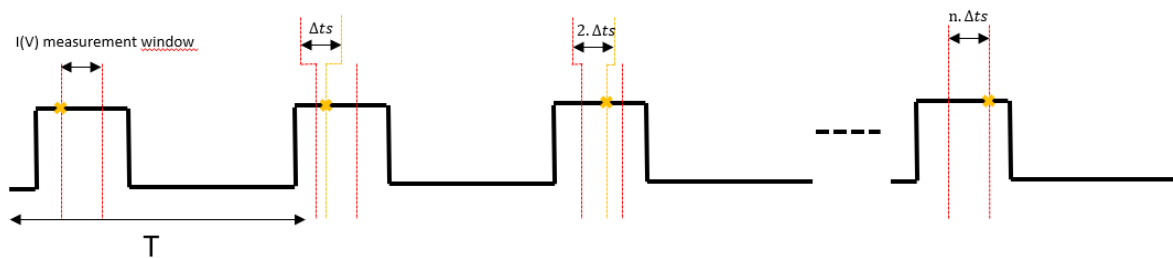


Figure 8:22 AM3200 operation in synchronous mode

Example : 10 points in 2usec => $\Delta ts=200nsec$ (Note that the min Δts achievable by PIV3200 is 20ns), the final value of $V1p$, $V2p$, $I2p$, $I1p$ & $V1q$, $V2q$, $I2q$, $I1q$ will be the average of this 10 points.

Considering the signal period (T), the acquisition sampling count can be a sensitive parameter to set in order to find a good trade-off between speed measurement and accuracy.

8.3.2 Measurement ranges

This option “Measurement range” allows to user to define different measurement range mode

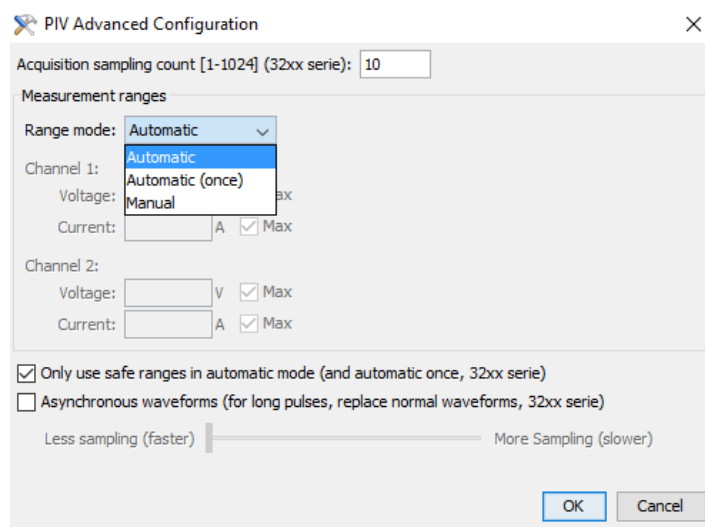


Figure 8:23 AM3200 measurement range options

There are three different range modes:

- Automatic** set the appropriate range on each probes head. The range verification is done for each point of measurement.
- Automatic (once)** set the appropriate range on each probes head. The range verification isn't systematically done for each point of measurement, it depends on the parameters change (e.g. change of voltage or timing). Can improve the measurement speed.
- Manual** this mode allows to set manually the range of each probe head. As shown in the example below, user set the maximum current and voltage achievable with the DUT, in order to set the higher measurement range needed.

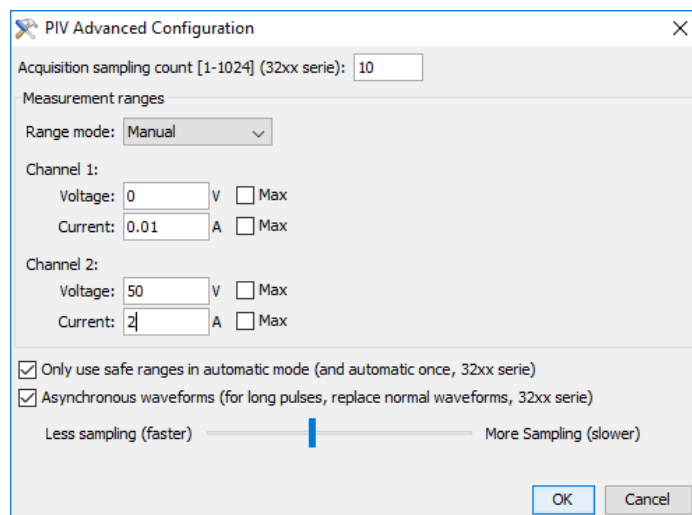


Figure 8:24 AM3200 manual measurement range

8.3.3 Asynchronous Mode (Long pulse shape recording >1.3msec)

The III-V transistor technology is difficult to model, due to the long time constant (>1.3 msec) of its memory effect (Thermal effects & Trapping effects). In order to characterize, this time constant, the AM3200 system embeds an asynchronous waveform recording feature. This feature allows to record a long pulse shape (>>1sec).

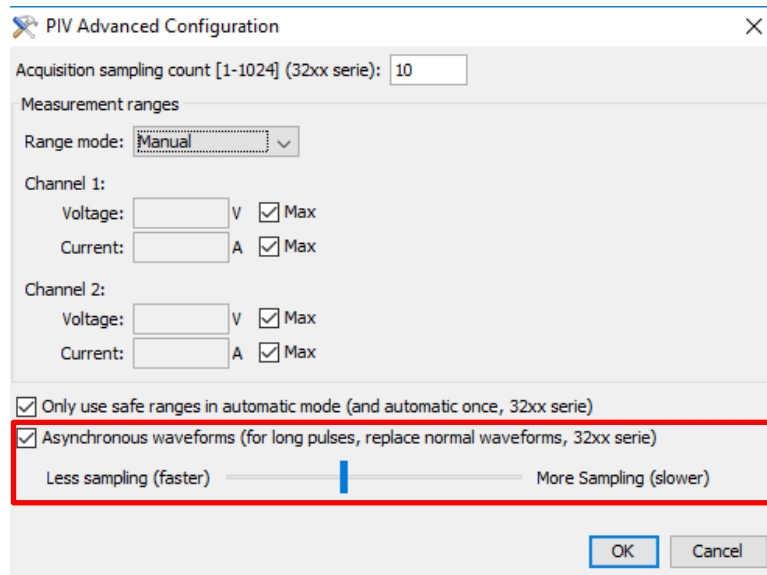


Figure 8:25 Asynchronous mode enable

The measurement windows in asynchronous mode starts from 0 sec to the end of the I-V trace windows (orange windows). In this mode, the number of « Trace points » defined in « Chronograms » isn't taken into account, the number of point is automatically set with the slider, as shown in figure 8.25.

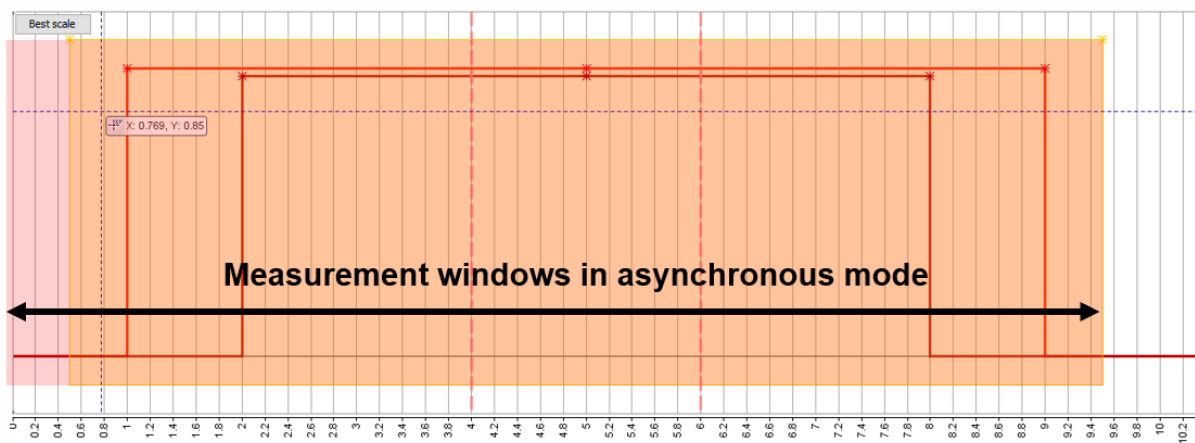


Figure 8:26 Asynchronous measurement window

The slider setting defines the time step and so the number of points for the acquisition. Note that in this mode, the AM3200 has a minimum step of 1.1usec between each measurement and is limited to 1024 points for one acquisition (hardware limitations).

The AM3200 asynchronous mode feature works as a semi-logarithmic time scale, as described below:

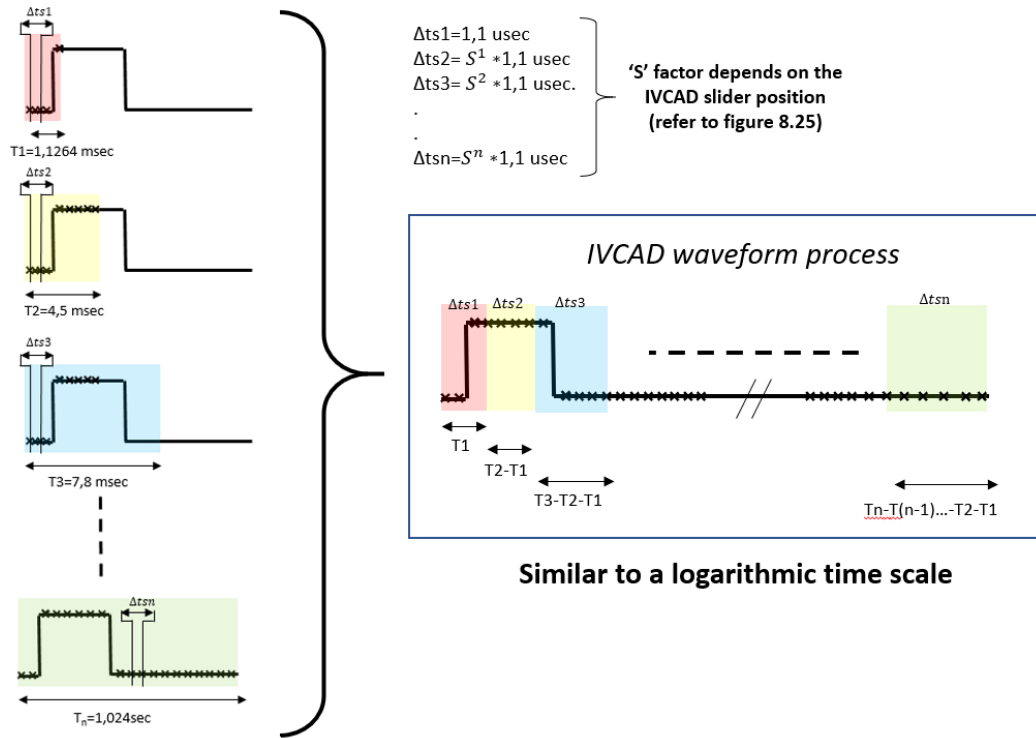


Figure 8:27 Asynchronous time step process

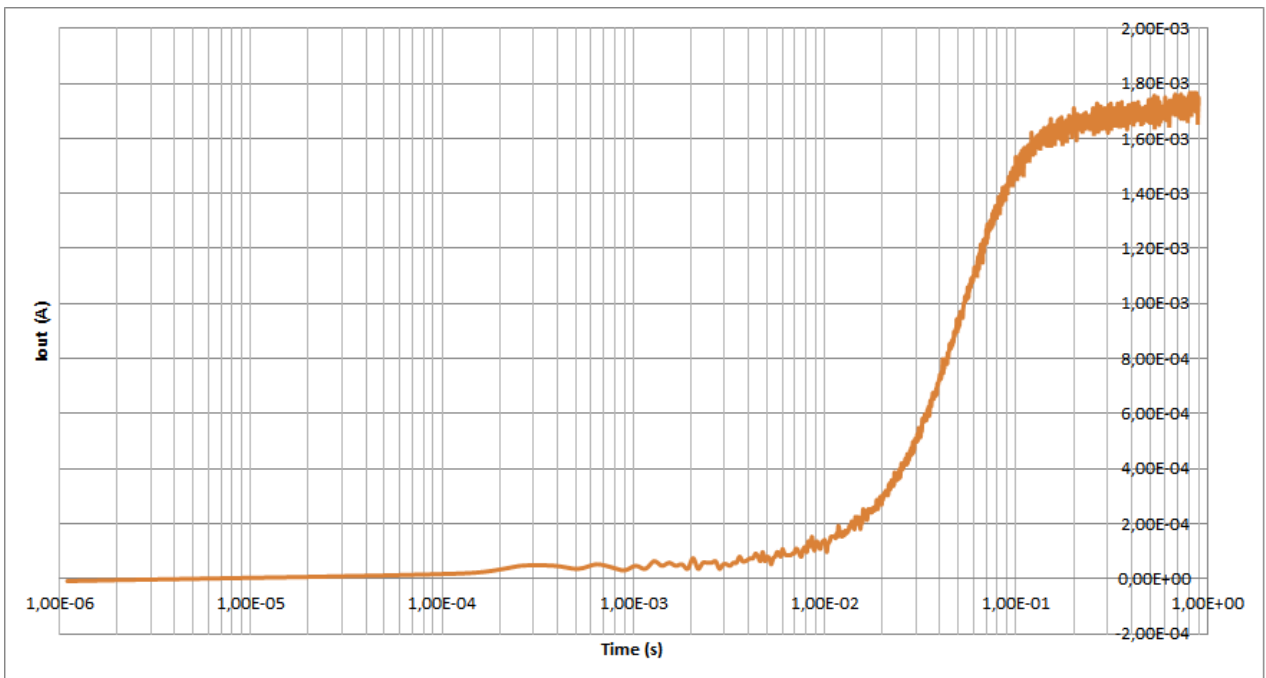


Figure 8:28 Example of long pulse shape recording

Contact Information

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