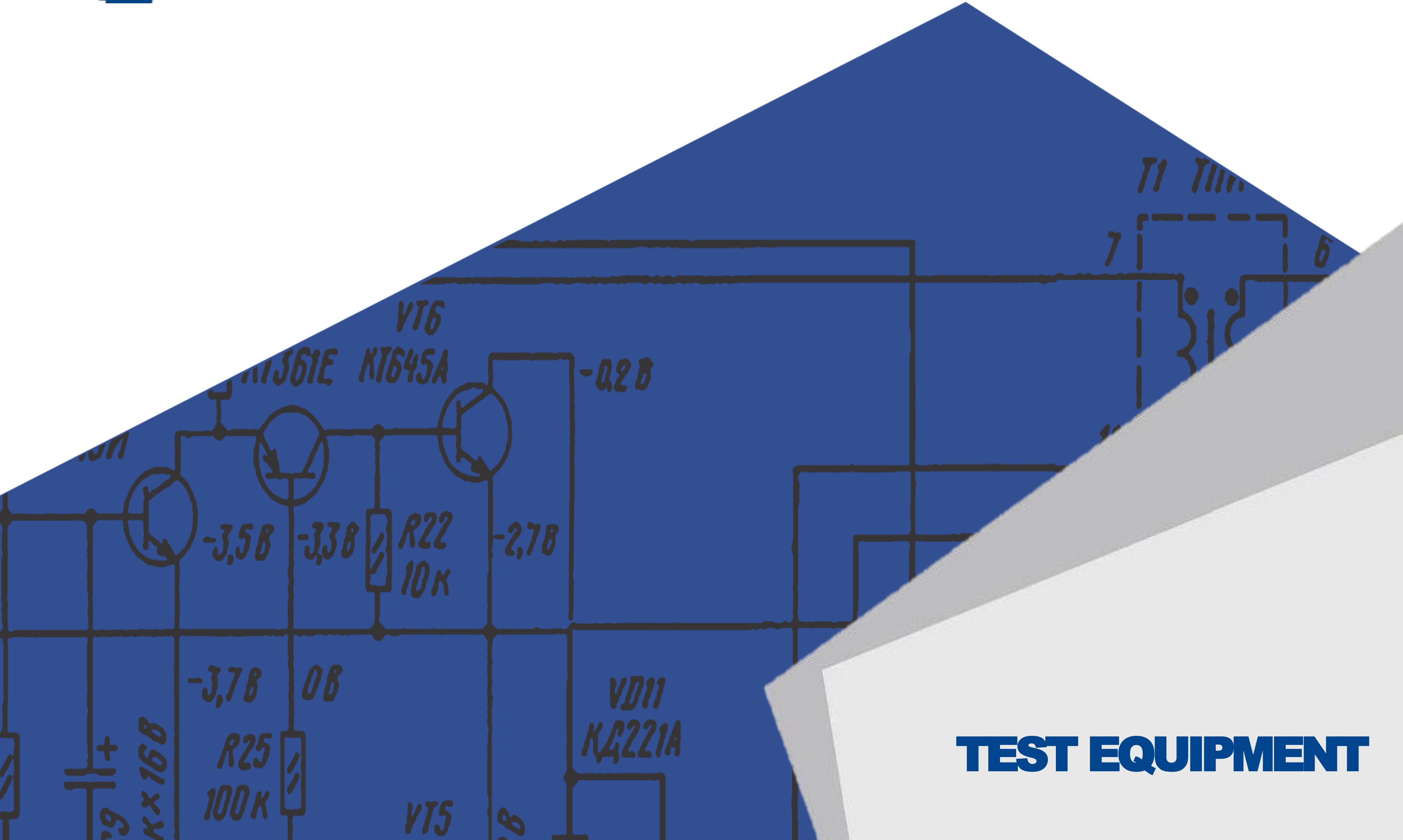
PROTON-ELECTROTEX



TEST EQUIPMENT

Quick facts

Automation laboratory

- Founded in 2011 to provide parent company with reliable Hi-End test equipment
- Located in Moscow
- From **Design** to **Production** to **Installation** to **Technical Support** and **Modernization**
- Multifunctional team of hi-qualified developers
- Main modern approaches to development are implemented: SCRUM, FMEA, TRIZ

Test equipment family

Bipolar Static Testers

up to 26kA, up 8500V

Bipolar Dynamic Testers

ATU, CROVU, Qrr tq, TOU

Surge Current Testers

up to 120kA

Power Cycling Testers

Clamping Systems

up to 150kN

Z_{th} testers

Under development

HTRB Testers

IGBT Static Testers

up to 13kA, up 8500V

Late stage development

IGBT Dynamic Testers

up to 15kA, up 3400V

Prototype

Full SiC MOSFET Testers

Static & Dynamic

Under development

Stray Inductance Testers

Under development

Main advantages

Modular design

- ✓ High maintainability
- ✓ Flexibility
- ✓ Easy update and modernization

All tests in one process

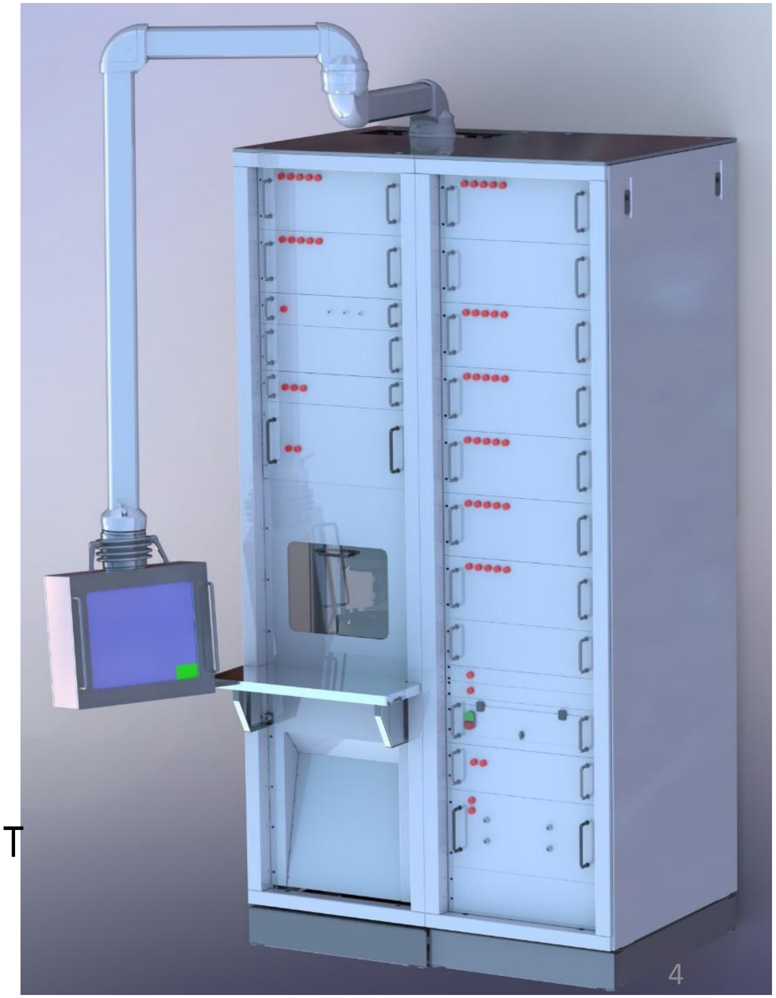
- ✓ “All tests in one clamping”
- ✓ High performance
- ✓ Minimization of human factor

High accuracy

- ✓ Automatic calibration
- ✓ High accuracy

Servo controlled pulse generation

- ✓ High test condition stability independent from DUT
- ✓ Wide measurement range
- ✓ Servo controlled signals



Bipolar Static Test Equipment

Characteristic	Designator	Range		Accuracy	Conditions
Peak on-state voltage , V	$V_{TM(FM)}$	0.3	5	±0.5% of reading ±5mV	$I_{TM(FM)}$ = 400..25200A; Signal shape: trapezoidal, sinus, s-curve Duration up to 10ms
Repetitive peak off-state voltage, Repetitive peak reverse voltage, V	V_{DRM}, V_{RRM}	100	8000	±1% of reading ±10V	$I_{DRM/RRM}$ = 0.1..300mA; Signal shape: sinus, DC Duration 8.3..10ms Frequency 5 / 50Hz
Repetitive peak off-state current, Repetitive peak reverse current, mA	I_{DRM}, I_{RRM}	0.1	10	±1% of reading ±10uA	$V_{DRM/RRM}$ = 100..8000V; Signal shape: sinus, DC Duration 8.3..10ms Frequency 5 / 50Hz
		10	100	±1% of reading ±0.1mA	
		100	300	±1% of reading ±1mA	
Gate trigger direct voltage, V	V_{GT}	0.1	4.5	±2% of reading ±10mV	V_D = 12V;
Gate trigger direct current, mA	I_{GT}	50	1000	±2% of reading ±1mA	V_D = 12V;
Holding current, mA	I_H	30	1000	±2% of reading ±1mA	I_G = 1A;
Isolation test voltage, V	$V_{ISOL\ AC\ (RMS)}$	100	10000	±1% of reading ±10V	I_{ISOL}=0.1..5mA;
	$V_{ISOL\ DC}$	100	12000	±1% of reading ±10V	
Isolation resistance, MOhm	R_{isol}	5	1000	±1% of reading±1MOhm	V_{ISOL} = 1000..2500V;

Bipolar Dynamic Test Equipment

Characteristic	Designator	Range		Accuracy	Conditions
Critical rate of rise of off-state voltage, V/us	dV_D/dt	50	2500	±10%	V_{DM} = 300..4500V t = 50..200us
Reverse recovery charge, uQ	Q_{RR}	1	10000	According to the oscilloscope accuracy and resolution*	$I_{TM(FM)}$ = 100..500 (2000)A dI/dt = 1..100A/us V_R = 100V
Reverse recovery time, us	t_{RR}	1	100	According to the oscilloscope accuracy and resolution*	$I_{TM(FM)}$ = 100..500 (2000)A dI/dt = 1..100A/us V_R = 100V
Reverse recovery current, A	I_{RRM}	10	500 (2000)	±1.25% ±0.1A	$I_{TM(FM)}$ = 100..500 (2000)A dI/dt = 1..100A/us V_R = 100V
Turn-off time, us	t_Q	1	2000	According to the oscilloscope accuracy and resolution*	$I_{TM(FM)}$ = 100..500 (2000)A dI/dt = 1..100A/us V_R = 100V V_D = 100..2000V dV/dt = 20..200V/us
Peak reverse power, kW	P_{RSM}	1	70	±5% ±0.1kW	I_{PRSM} = 0.2..60 A;
Avalanche voltage, V	V_{BR}	100	9000	±4% ±10V	-
Gate controlled turn-on time, us	t_{gt}	0.5	30	±3% ±100ns	-
Gate controlled delay time, us	t_d	0.5	30	±3% ±100ns	-

* Scope device specification:
14 bit (0.006 %) resolution (16 bit enhanced resolution)
500 MS/s sampling
250 MHz bandwidth
32 MSamples memory per channel
0.25 % DC vertical accuracy, 0.1 % typical
25 ppm time base accuracy

IGBT Static Test Equipment

Characteristic	Designator	Range		Accuracy	Conditions
Gate-to-Emitter Leakage Current, uA	I_{GES}	1	1 000	±1% of reading ±1uA	V_{GE} = 15V..40V; V_{CE} =0V
Gate Threshold Voltage, V	$V_{GE(on)}$	4	10	±1% of reading ±10mV	I_C = 10..1000mA; V_{CE} = V_{GE} ;
Collector-to-Emitter Leakage Current, uA	I_{CES}	0.1 1 000	1 000 300 000	±1% of reading ±10uA ±1% of reading ±1mA	V_{GE} = 0V; V_{CE} = 100..8500V; Signal shape: half-sine, DC
Collector-to-Emitter Breakdown Voltage, V	$V_{(BR)CES}$	100	8000	±1% of reading ±10V	V_{GE} = 0V; I_C = 100nA..300mA; Signal shape: half-sine, DC
Collector-to-Emitter Saturation Voltage, V	$V_{CE(on)}$	0.2	10	±1% of reading ±10mV	I_C = 200..12600A; V_{GE} = 10..20V; Signal shape: trapezoidal, sinus, s-curve
Max Reverse Leakage Current, uA	I_R	10 1 000	1 000 300 000	±1% of reading ±10uA ±1% of reading ±1mA	V_{BR} = 100..8000V; Signal shape: half-sine, DC
Cathode Anode Breakdown Voltage, V	V_{BR}	100	8000	±1% of reading ±10V	I_C = 0..10mA; Signal shape: half-sine, DC
Forward Voltage, V	V_F	0.2	10	±1% of reading ±10mV	I_C = 200..5000A; Signal shape: trapezoidal, sinus, s-curve
Isolation test voltage, V	$V_{ISOL\ AC\ (RMS)}$ $V_{ISOL\ DC}$	100 100	10000 12000	±1% of reading ±10V ±1% of reading ±10V	I_{ISOL}=0.1..5mA;

IGBT Dynamic Test Equipment

Characteristic	Designator	Range		Accuracy	Conditions
Collector-emitter voltage after switching off, V	V_{CE}	20	2 800	According to the oscilloscope accuracy and resolution***	V_{CC} = 20V..3400V; V_{GEON} = 5..20V; t_P = 5..1000us;
Peak collector-emitter voltage, V	$V_{CE(peak)}$	20	3 400		
Peak collector current, A	I_{CM}	500	2 500		
Turn-off energy, mJ	E_{off}	1	1 000		
Turn-on energy, mJ	E_{on}	1	1 000		
Turn-on delay time, ns	$t_{D(on)}$	10	10 000		
Rise time, ns	t_R				
Turn-off delay time, ns	$t_{D(off)}$				
Fall time, ns	t_F				
Tail time, ns	t_Z				
Reverse recovery time, ns	t_{RR}				
Decay current rate , A/us	di/dt	10	8 000		
Non-repetitive peak collector current, A	I_{CSM}	500	15 000		
Reverse recovery current , A	I_{RR}	500	4 000		
Reverse recovery charge , uC	Q_{RR}	1	3 000		
Reverse recovery energy, mJ	E_{REC}	1	1 000		
Decay recovery current rate , A/us	di_{REC}/dt	10	8 000		

Test types:

- Single pulse RBSOA
- Double (multiple) pulse RBSOA
- Short Circuit
- Avalanche Test

*** Scope device specification:
14 bit (0.006 %) resolution (16 bit enhanced resolution)
500 MS/s sampling
250 MHz bandwidth
32 MSamples memory per channel
0.25 % DC vertical accuracy, 0.1 % typical
25 ppm time base accuracy

SiC Dynamic Test Equipment

Characteristic	Designator	Range		Accuracy	Conditions
Collector-emitter voltage after switching off, V	V_{CE}	100	1 700	According to the oscilloscope accuracy and resolution***	V_{CC} = 20V..3400V; V_{GEON} = 5..20V; t_P = 5..1000us;
Peak collector-emitter voltage, V	$V_{CE(max)}$	100	2 000		
Peak collector current, A	I_{CPK}	50	6 50		
Turn-off energy, mJ	E_{off}	1	1 000		
Turn-on energy, mJ	E_{on}	1	1 000		
Turn-on delay time, ns	$t_{D(on)}$	20	10 000		
Rise time, ns	t_R				
Turn-off delay time, ns	$t_{D(off)}$				
Fall time, ns	t_F				
Tail time, ns	t_Z				
Reverse recovery time, ns	t_{RR}				
Decay current rate , A/us	di/dt	10	8 000		
Non-repetitive peak collector current, A	I_{CSM}	10	650		
Reverse recovery current , A	I_{RR}	20	650		
Reverse recovery charge , uC	Q_{RR}	0.1	3 000		
Reverse recovery energy, mJ	E_{REC}	1	1 000		
Decay recovery current rate , A/us	di_{REC}/dt	10	8 000		

*** Scope device specification:
14 bit (0.006 %) resolution (16 bit enhanced resolution)
500 MS/s sampling
250 MHz bandwidth
32 MSamples memory per channel
0.25 % DC vertical accuracy, 0.1 % typical
25 ppm time base accuracy

Clamping systems

Characteristic	Value				
Package type	Module	Stud	Disk	Semiconductor element (bipolar)	Surge Current
Type	Manual; Electromechanical	Manual; Electromechanical	Electromechanical	Electromechanical	Electromechanical
Force	2kN	2kN	100kN	100kN	150kN
Heating	150˚C	150˚C	200˚C	200˚C	200˚C
Maximum current	6kA	6kA	30kA	30kA	120kA
Isolation	8kV	8kV	15kV	15kV	15kV
Form factor	Table housing	Table housing	19” Rack	19” Rack	19” Rack

Surge Current

Characteristic	Designator	Range		Accuracy	Conditions
Peak on-state voltage , V	$V_{TM(FM)}$	0.3	5	±1% of reading ±5mV	$I_{TM(FM)}$ = 400..15000A; Signal shape: trapezoidal, sinus, s-curve Duration up to 10ms
Surge Current, kA	I_{SC}	0.5	40/80/120	±5% of reading	$V_{TM(FM)}$ up to 60V
Dimensions 40 kA type, mm	H x W x D	2200 x 800 x 1200			19” Rack
Dimensions 80 kA type, mm*	H x W x D	2200 x 1600 x 1200			19” Rack x 2
Dimensions 120 kA type, mm*	H x W x D	2200 x 2400 x 1200			19” Rack x 3

Power Cycling

Power supply: 1500A

Capacity: 5 modules (10 IGBTs)

19” Rack

HTRB

Power supply: 3000V, 1A

Temperature: up to 200˚C

Capacity: 10 modules (20 IGBTs)

19” Rack

Zth

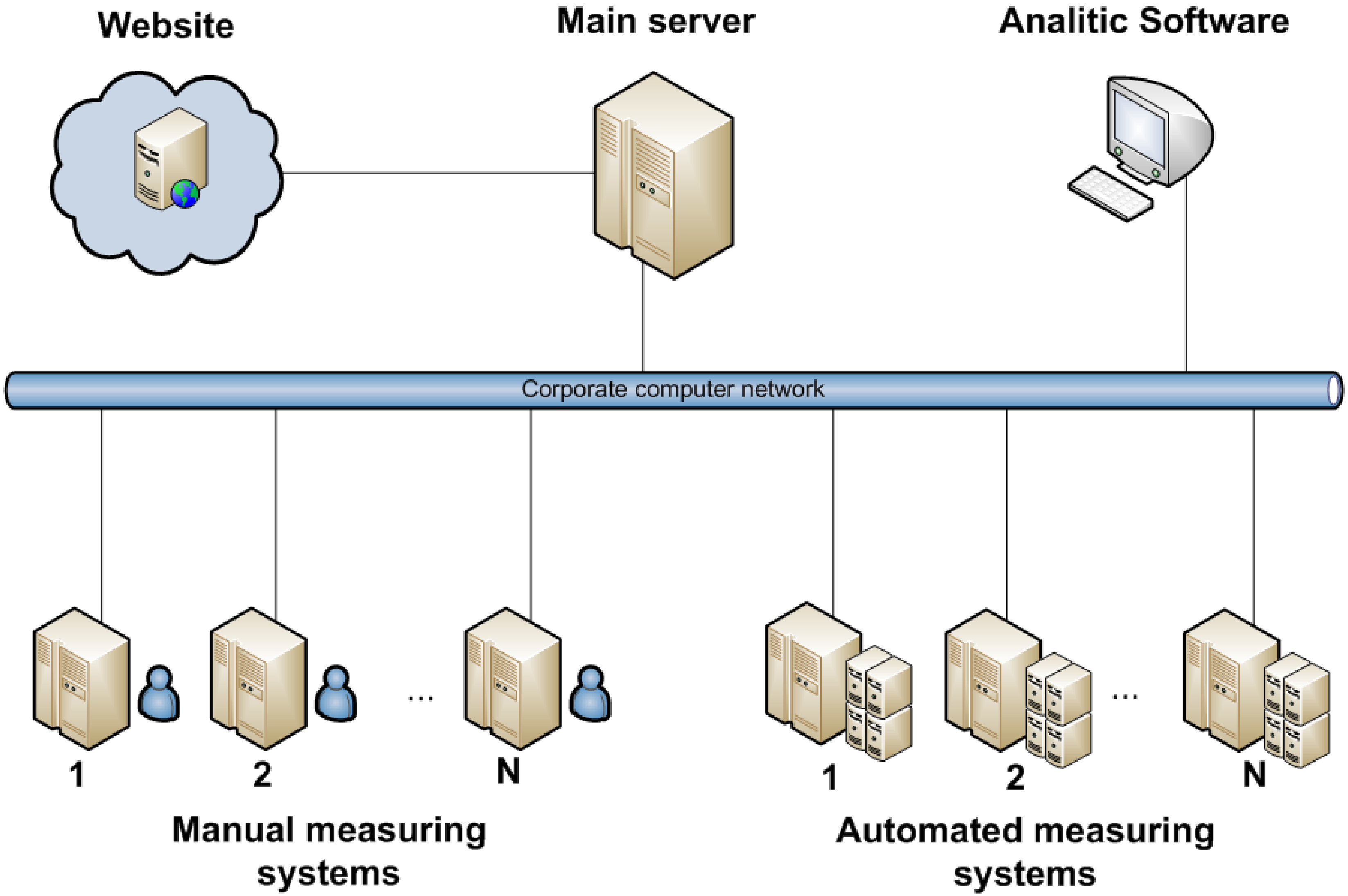
Main power supply: 1000A, 10ms-1000s

Pulse power supply: 2500A, 100us-10ms

Measuring current: 0.5A-5A 0.1%

Equipment in production

Turn-key IT solution



Testing process

Recognition
- Barcode scanning

Adjustment
- Test conditions request to main server and selection of proper Test Profile

Test
- Sequential Tests with only one clamping (connection)

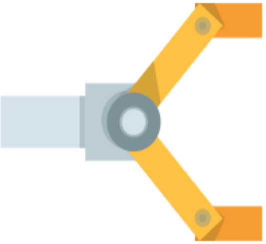
Save
- Saving results to the main server

Turn-key IT solution advantages

- ✓ Centralized test profiles control
- ✓ Automatic equipment adjustment
- ✓ Centralized results storage

ATSM

ATSM – **A**utomated **T**est **S**ystem for power semiconductor **M**odules



- ✓ Fully automated test process
- ✓ All types of tests in one system (RT and Tjmax)
- ✓ Automatic DUT labelling (pass / reject)

PROTON-ELECTROTEX

Thank you!