 ISSN 0737-5921, ISBN 978-1-878068-44-6

TRUMPF Huettinger's Latest Innovative Power Products

Mark Seeman, Trumpf Huettinger, Inc., Santa Clara, CA

At TRUMPF Huettinger, Inc., we are excited to showcase our latest innovative product lineup at the SVC TechCon 2024. Our offerings encompass a wide range of cutting-edge solutions designed to meet the evolving needs of the vacuum coating industry. We strive to provide a comprehensive range of standard match boxes and generators for your sputtering applications. Last year's breakout products, the LHF to VHF generators enabled us to offer a variety of frequencies and power levels to aid our customers in their most challenging processes. Along with our continual enhancements in Highpulse power products with versatile versions that combine DC, Monopulse, and Bipolar Pulse all into a single product, provides our customers with unparalleled flexibility and performance. In addition, our complete RF+DC combination products enables lower sputtering voltages and reduced substrate temperatures that deliver exceptional results for our customers. This year, our topics of discussion will be centered on the following:

- Low Power DC and DC Pulsed generators
- RF Switch Topology (3D Coupler and 50 Ohm absorber)
- Innovative Matching Network Algorithm
- HPPMS with Superimposed DC
- 3rd Generation High Power 10kW RF Generators

We invite you to explore our innovative product lineup at the SVC TechCon 2024 and experience the TRUMPF Huettinger difference firsthand.

https://www.svc.org **DOI: https://doi.org/10.14332/svc24.proc.0058**

TRUMPF Hüttinger Welcomes you to 2024 SVC

Mark Seeman Regional / Sales Manager

TRUMPF

TRUMPF Huettinger Innovative Show Case Presentation

Summary of Slides

1. Introduction- Reliance on best practices
2. Line up new innovative products
3. Low Power DC and Pulsed DC
4. Gen 2 Match Networks
5. Smith Chart tutorial
6. Advanced model-based algorithm for match networks includes short movie
7. New Features of Highpulse
8. Gen 3 High Power RF
9. RF Amplifier Topology Breakthrough
10. Conclusion: We listen, we provide

TRUMPF

TRUMPF Huettinger Innovative Show Case Presentation

Extending features and benefits

Reliance on best practices

- Modularity and Commonality
- Correct frequency for process
- Same control PCB across all products
- Multi-line input power- above 10kW its 3-phase power
- Water cooling- built in heat exchanger – No real difference of heat removal cost
- Component selection- SiC transistors and diodes, microchannel cooling
- Automation – assembly and manufacture repeatable and reliable
- Synchronization of signals
- Culture – fun -open and inventive - flat management structure
- Customer experience – listening- direct feedback- not filtered by marketing

Cost efficiency **Better reliability** **Faster to market** **Shorter lead times** **Improved performance**

TRUMPF

TruPlasma Products Continuing Success

TruPlasma DC 3000/4000 G2.1 Low Power	TruPlasma Match 1000 G2	TruPlasma HighPulse 4000 G2	TruPlasma RF 3010 G3 10kW 13.56 MHz
Modern Design	**Modern Design**	**Modern Design**	**New to Portfolio**
SiC	Fast tune algorithms	SiC	SiC
Extended range	Extended range	Increased dep rates	Extended range
Robust	Robust design	Reverse Pulse	Robust
Cost savings	Customized solutions	Bipolar Capable	Cost savings
Modern feature sets	Built in smith charting	Superimposed DC	Modern feature sets

Generation 2.1 TruPlasma DC 3000/4000

Extended Capabilities

SiC
Cost Savings
More Reliable
Extended Range

Basic Features

- Solid state DC magnetron drive
- 1kW, 2kW, and 5kW
- 19” Rackmount form factor 5 ¼” (3U) height
- Front panel control
- Analog Digital I/O’s
- Air cooled
- HN or Lug Outputs
- Harting Han C Input
- Dual Unit

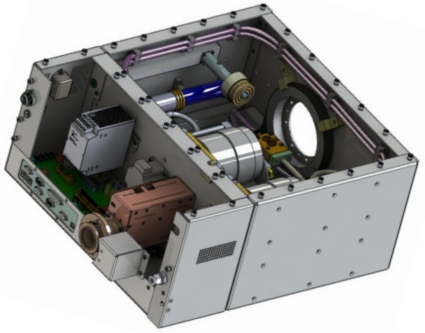
Extended Features

- Flexible input voltage 200-240VAC Single Phase
- 1500 ignition voltage
- Extended current and voltage range
- Extended frequency range
- Dual output models available
- Advanced functions capable
- Better accuracy and stability at low powers

TRUMPF

Generation 2 TruPlasma Match 1000

Extended Capabilities



Basic Features

- Frequency bands: 2, 4, 13.56, 27, 40, and 60 MHz
- Power ranges 1, 3, 6, 12, 24, and 27 kW
- Aluminum metal box
- Auto tuning
- 110 – 240VAC single phase input power
- Analog, digital I/O
- Air Cooled and water cooled depending on size
- Rugged BLN 20 Output and 7/16 Inputs
- Strap or water-cooled strap or EIA 5/8 for higher powers

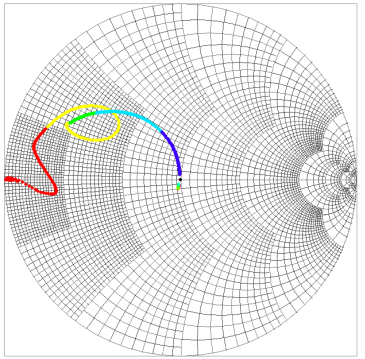
Extended Features

- FPGA and Sitara based logic
- Fast signals digitalization, filtering, processing, and response
- Model-based Tune Algorithm
- Purely all digitally controlled
- Profibus, EtherCat, RS, analog, DeviceNet
- Built-in smith charts
- Built-in Voltage and Current Probes
- Complex multi-step actions possible
- Built in life-time monitor for mechanical parts
- ALD optimized solution

Generation 2 TruPlasma Match 1000

Model-based Tuning Algorithm

Previously	Now
-- Manual adjust to tune point for changing conditions	++ Improves tuning speed and robustness
-- Wrong tune point when impedance changes a lot	++ Correct averaging to optimize tune point
-- Impedance display updated with > 1ms resolution	++ Live Display 1us resolution
-- No Dual Frequency, Auto Frequency Tuning	++ Support for DF, AFT and pulse without the need of reconfiguration
-- Manual filter configuration for changing frequency	++ Automatic lock-in to operating frequency (Frequency Tuning
-- Manual configuration of regulation speed to pulse frequency and duty cycle.	++ Automatic lock-in to pulse frequency
-- Very simple V/I measurement at the output	++ Harmonic measurements possible for V and I at Match output (First 3 harmonics)
-- Calibration of V/I sensors did not include cross-coupling between voltage and current channels	++ Improved accuracy of V/I sensors compensation similar to vector network analyzer

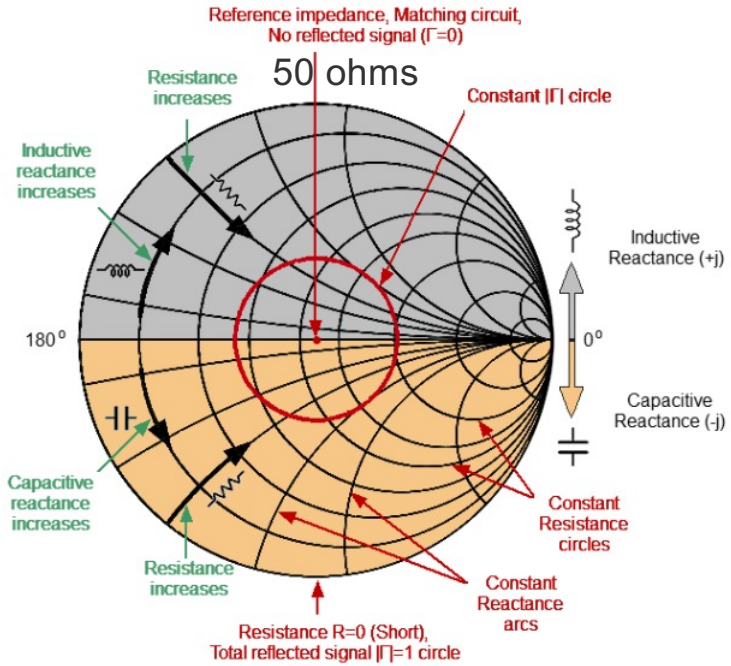


TRUMPF

Generation 2 TruPlasma Match 1000

Smith Chart Diagram

$$X_L = 2\pi fL$$



Smith chart properties

$$X_C = \frac{1}{2\pi fC}$$

Used with permission from Copper Mountain Technology, LLC
Please visit their website at Smith Chart Format (coppermountaintech.com)

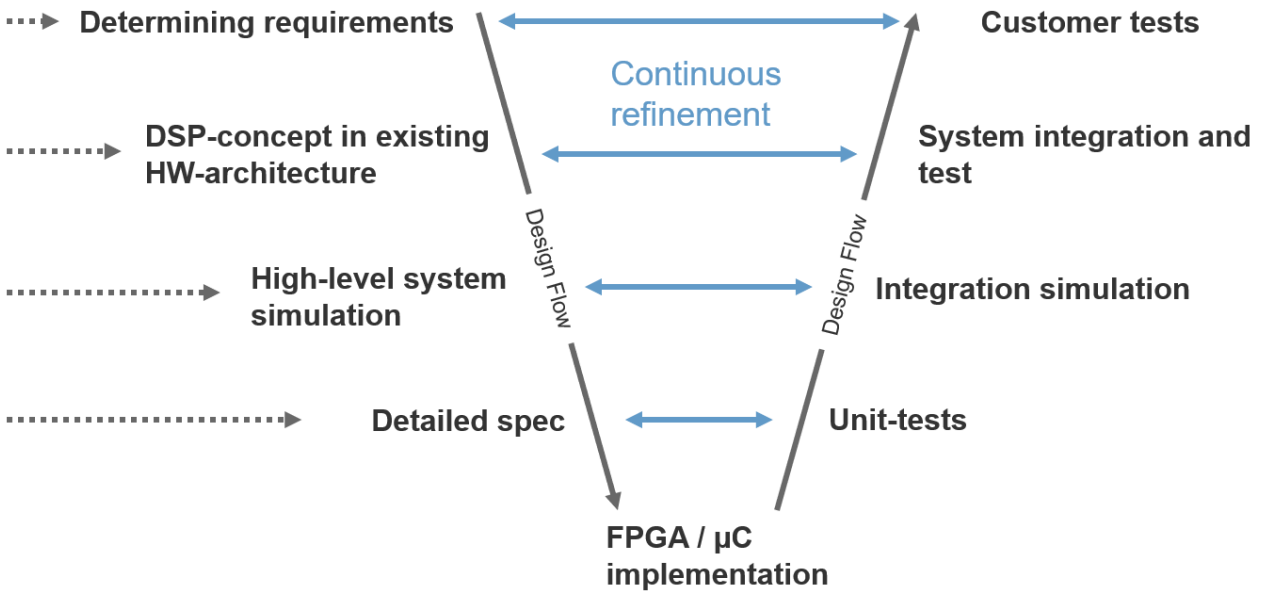
TRUMPF

Generation 2 TruPlasma Match 1000

Simulation Driven Approach

Input

- Customer application Feedback
- Expert DSP know-how in-house and external
- Real data recorded from customer processes
- Simulated data with exactly known components
- High-level simulation results and HDL system know-how.



TRUMPF

Generation 2 Highpulse 4000

New Features to Improve Processes

SiC
Cost Savings
More Reliable
Extended Range

Basic Features

- Solid state HiPMS Magnetron Power Supply
- Power ranges 10, 20, 40 kW
- Multi-line voltages 400 – 480VAC
- 19” rackmount
- Full front panel
- Analog Digital I/Os
- Water cooled – Built heat exchanger
- Input and output lug connectors

Extended Features

- SiC Transistors
- Up to 2kV and 4kA
- Reverse pulse available
- Bipolar versions available
- Bipulse, Monopulse, DC in one
- Extended frequency and pulse durations
- Current wave form shaping
- Advanced average power control
- Soon arriving DC superposition

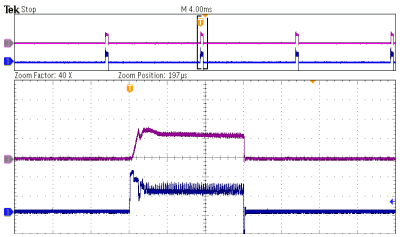
TRUMPF

Generation 2 Highpulse 4000

New Features to Improve Processes

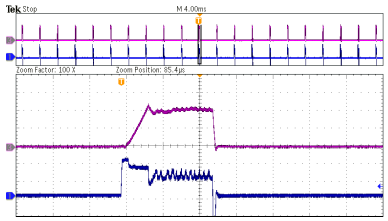
Wave shape control

Active regulation of pulse current shape



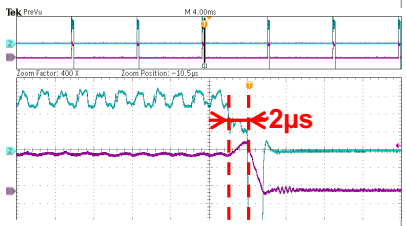
- Easy adjustment to obtain required coating color.
- High repeatability even under changing conditions.
- High ionization during whole pulse time.

Unique method of average power control



- High repeatability even under changing conditions.
- High plasma stability.
- Extremely high film hardness.

The fastest arc management system

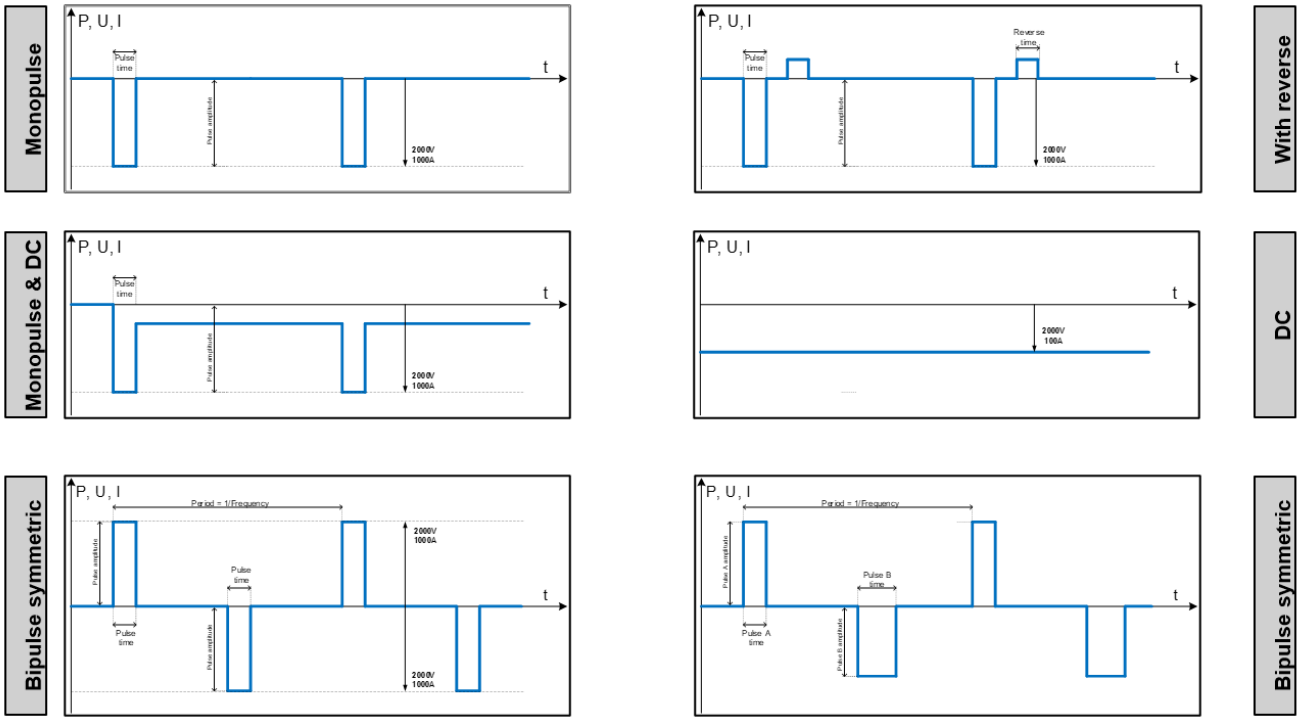


- Droplet-free layers.
- Extremely low arc energy.
- Excellent film quality without defects.

Generation 2 Highpulse 4000

New Features to Improve Processes

Wave shapes



TRUMPF

TruPlasma RF 3005/3010 10kW RF Gen 3

SiC
Cost Savings
More Reliable
Extended Range

Cost Reducing Design

Basic Features

- 5kW and 10kW 13.56 MHz Solid State Generator
- 19” Rackmount form factor 5 ¼” (3U) height
- LED Lights in Front Passive Panel
- Analog Digital I/O’s
- Water Cooled
- 7/16 and LC Output
- Harting Han C Input

Improvements

- Cost improvements – reduced by manufacturing costs
- High efficiency – reduced energy costs
- More robust design SiC transistors - low down time
- 3d Coupler and 50 ohm Absorber - Reliability and Stability
- Configurable – flexibility - order just what is needed
- No cable length matching required btw Gen and Match
- High Reflected Power 1000 and 2000 Watts
- 400kHz Pulsing
- Integrated Web based Gui
- Ethernet IP

TRUMPF

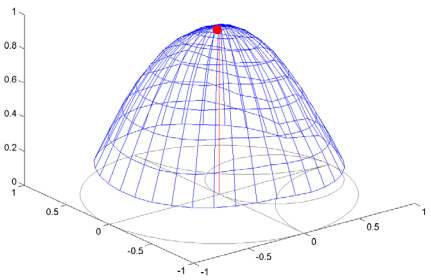
Robust Design

Technology for improved plasma stability and performance

Cable Length Independency

- The load trajectory of any amplifier is highly un-symmetrical
- The output power strongly depends on reflection coefficient and phase

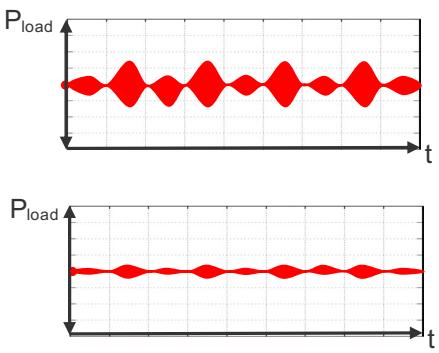
- The TRUMPF combine line technology symmetrizes the output power dependency on the complex impedance
- Independence of cable length



Plasma Stability

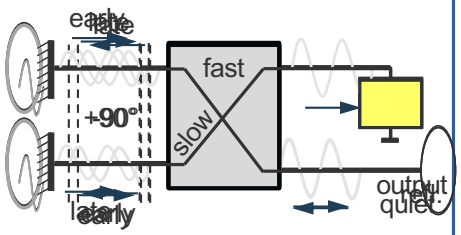
- P_{load} implicitly (even without regulation) decreases into every mismatch direction
- High amplitude of load power inaccuracies

- No peaking in case of varying plasma conditions or matchbox malfunction
- High accuracy in power delivery



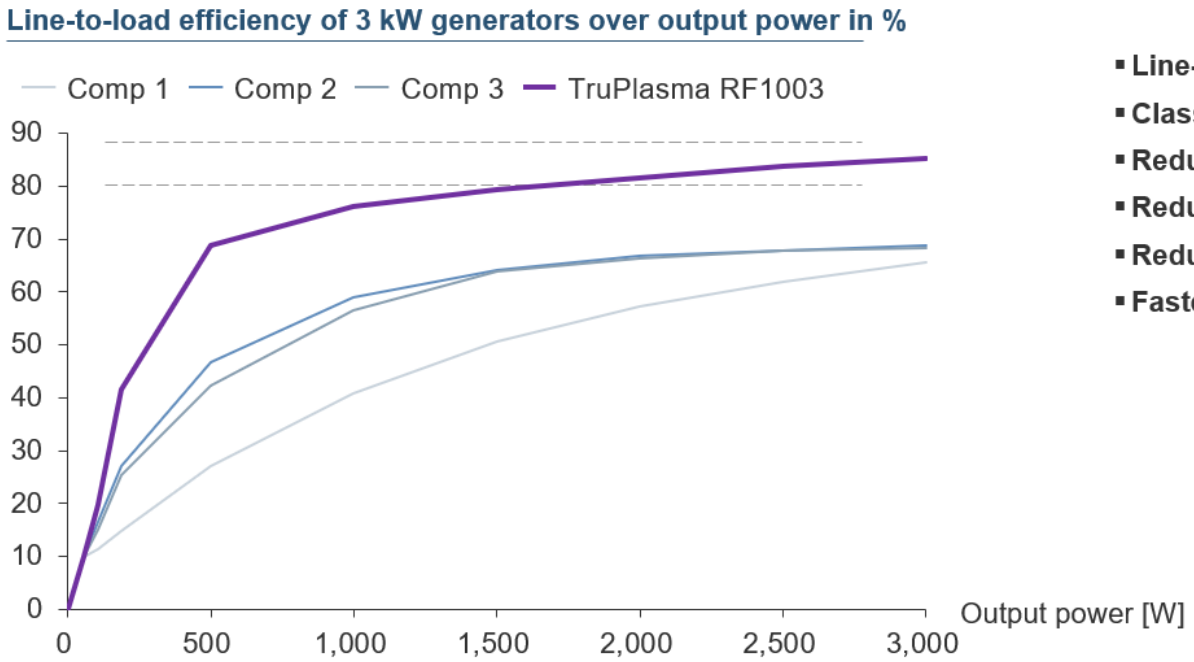
Power Dissipation

1. **Standard operating**
   - Power from 2 sources is led to the output (constructive interference)
2. **Reflection inwards**
   - Reflected power is split and fed back to sources
   - Sources are not good dissipaters and re-reflect the power
3. **Dissipation of reflected power**
   - Phase of re-reflected power is reversed and does not appear at the output
   - The re-reflected power is lead to the internal absorber and dissipated



Patented 3d Coupler and 50 ohm Absorber

20% More Efficient



- Line-to-load efficiency of > 80 %
- Class D Amplifier
- Reduces cooling effort
- Reduced power consumption
- Reduced effort for thermal management
- Faster ROI

TRUMPF

SVC Vendor Innovative Showcase

Conclusion

- Best in class components
- Commonality and modular design technique
- Innovative approaches coming from all stakeholders
- Next generation products
- Constant improving features and benefits
- We listen, we provide

Booth 104

Mark Seeman/ mark.seeman@trumpf.com

TRUMPF