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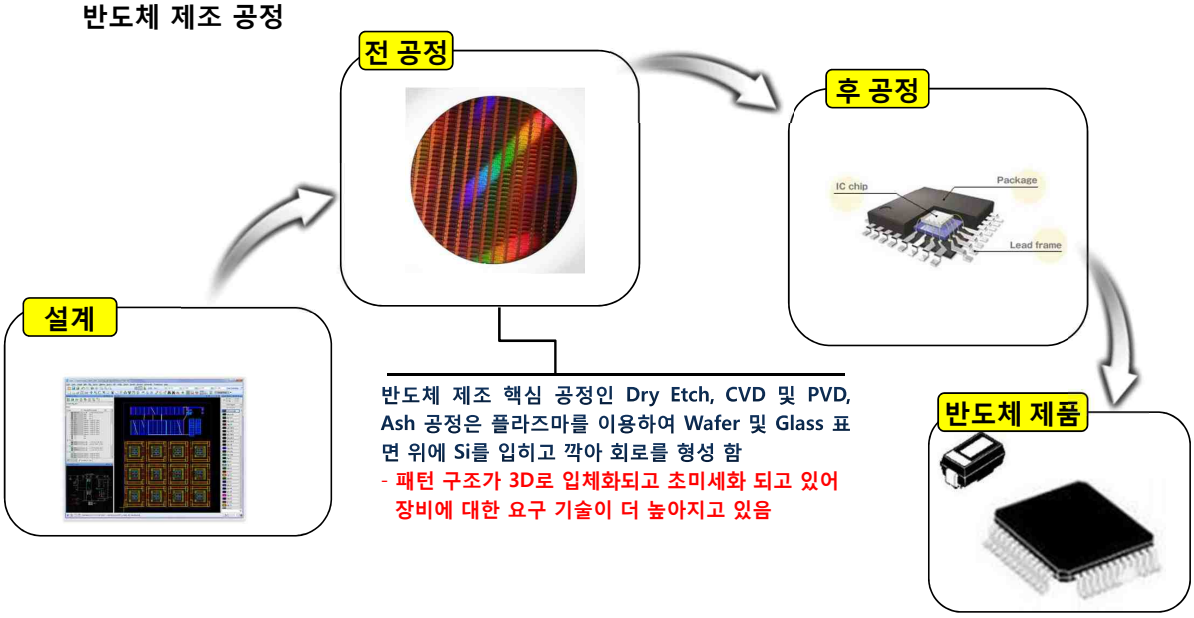
반도체 공정용 RF Generator 용도

반도체 전 공정 중, 핵심 공정인 화학기상증착(Chemical Vapor Deposition) 및 건식 식각(Dry Etch) 공정에서 플라즈마를 발생시키기 위한 핵심 장비임

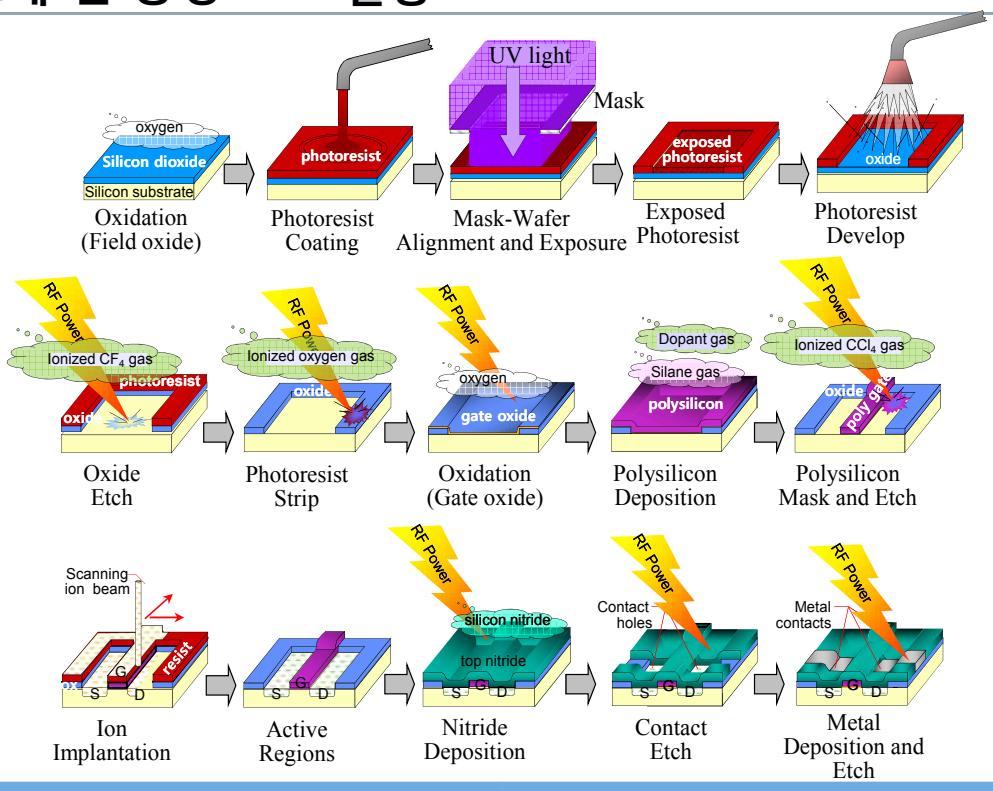
반도체 제조 공정



반도체 제조 핵심 공정인 Dry Etch, CVD 및 PVD, Ash 공정은 플라즈마를 이용하여 Wafer 및 Glass 표면 위에 Si를 입히고 깍아 회로를 형성 함

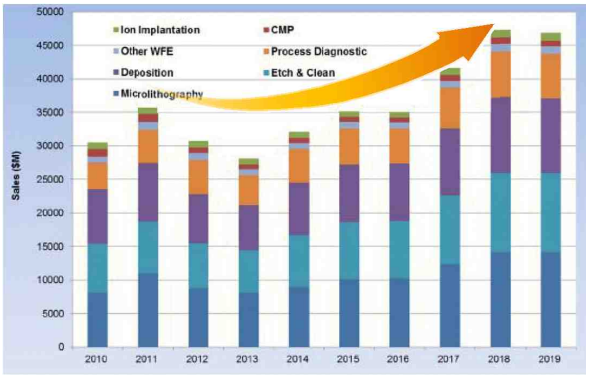
- 패턴 구조가 3D로 입체화되고 초미세화 되고 있어 장비에 대한 요구 기술이 더 높아지고 있음

반도체 전 공정 RFG 활용



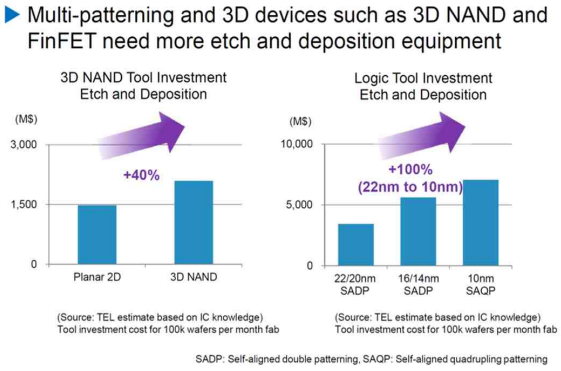
RFG 관련 반도체 장비시장 전망

전 공정 장비 시장 예측



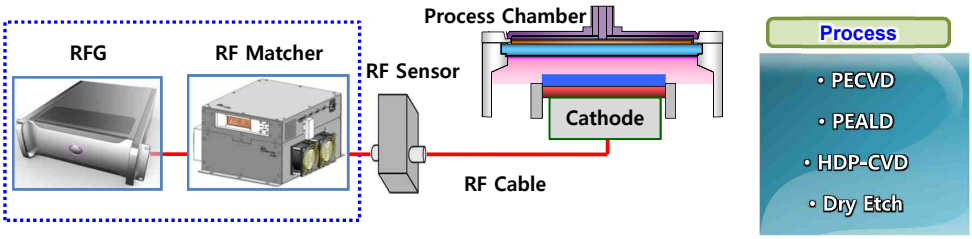
자료 : SEMI, 2015

공정 변화에 따른 증착, 식각 장비 수요 전망



반도체 공정용 RFG System 구성

장비 구성



RFG : 플라즈마 발생 용 RF Power 공급 및 제어

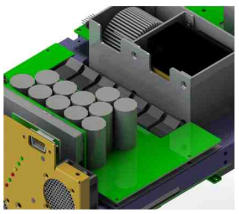
Matcher : Chamber 와 RFG의 임피던스 매칭

Process Chamber : 플라즈마 발생, 각 제조 공정 수행

Contents

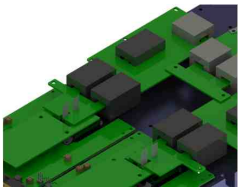
RFG 핵심 설계 기술

Power conversion



- S.M.P.S design
- Inductor ,transformer design
- Analog circuit design
- DSP firmware programming
- PID control design
- Interface system design
- Switching noise reduction

RF Power AMP

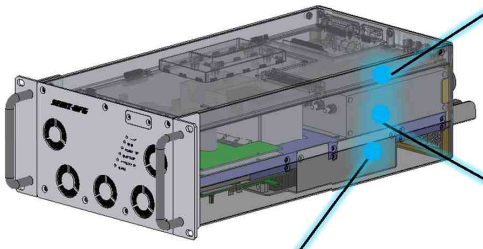


- RF circuit design
- RF sensor design
- High frequency transformer design
- High frequency inductor design
- High frequency inverter design
- RF noise reduction

Digital control

- Analog circuit design
- Logic circuit design
- RF Detector design
- Signal generation
- FPGA design
- DSP firmware programming
- PID control design
- U.I PC software programming

반도체 공정용 RFG 개발 사양



Digital control

- ▪Fast response PID control with dual DSP
- ▪High accuracy output PID control with dual DSP
- ▪System monitoring and abnormal protection
- ▪D.D.S and signal process with FPGA
- ▪Industrial standard interface
  (Profibus , EtherCAT, Devicenet,RS-232)

Power conversion

- ▪High power density and compact design
- ▪High efficiency , High power factor
- ▪Fast response for dynamic load
- ▪Compliance SAG-22 , CE ,UL

Topology

- • Buck ,Boost converter
- • Cascade Buck-boost converter
- • Resonant converter
- • Active or passive PFC

RF Power AMP

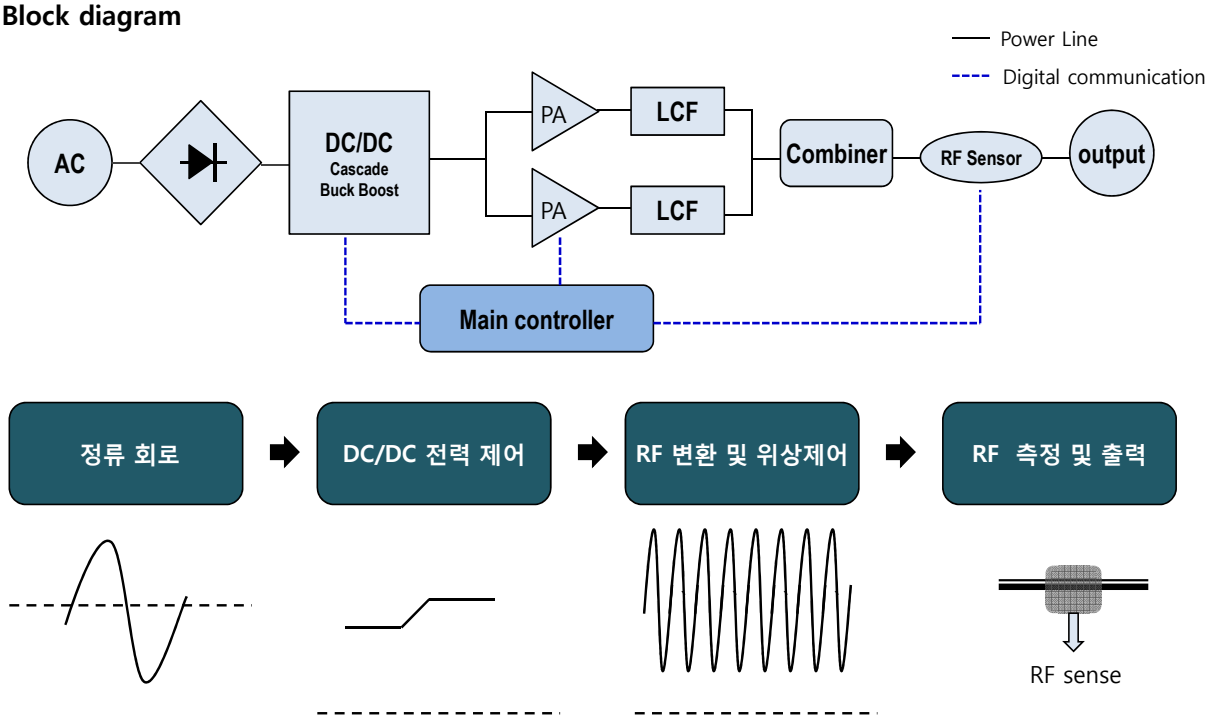
- ▪Low noise and distortion
- ▪Wide range power output control
- ▪High power density and high efficiency

Topology

- • Half bridge inverter
- • Full bridge inverter
- • Push-pull inverter
- • High frequency ,high power LC filter

RFG 설계 구성

Block diagram



RFG H/W 설계

DC/DC

Input :AC ,3Φ 187V ~ 240V

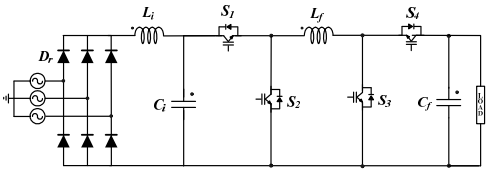
Output : DC 75~ 300V ,3.5kW

Topology : Cascade Buck-Boost
with synchronous rectification

Regulation : ≤ 1%

Turn on & rise time: ≤ 10ms

Efficiency : ≥ 95%



Power AMP

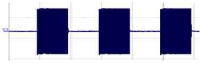
Output : 13.56MHz

Output range : 1W ~ 3kW

Output impedance : 50ohm

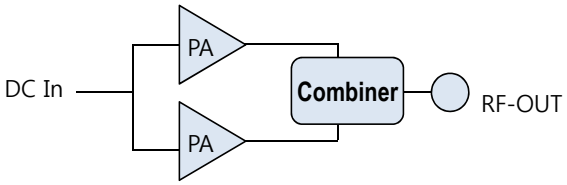
Output type:


C.W output


10Hz ~ 50kHz pulse output

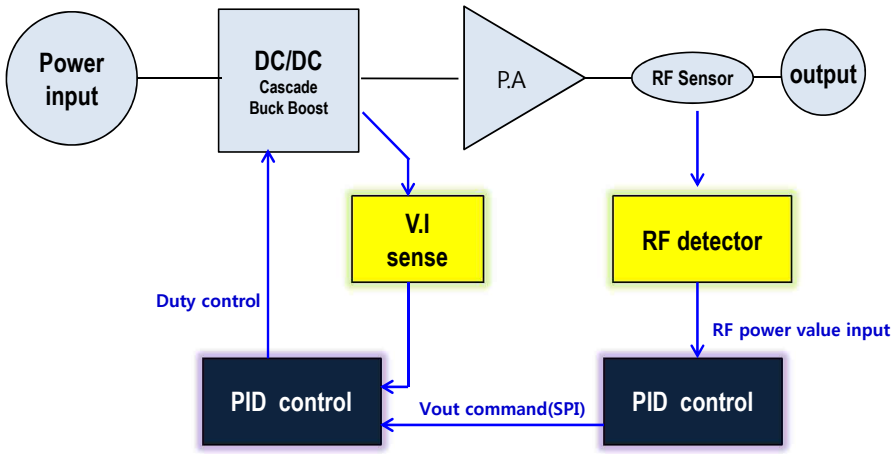
Topology : Full bridge inverter

Efficiency : ≥ 88%



RFG control system 설계

제어 개념도

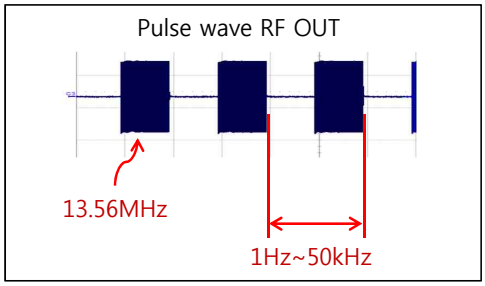


제어 최종 목표 : Pulse /Continuous RF output power

DDS 구성

DDS(Direct Digital Synthesizer) 란?

13.56MHz 의 RF를 발생 시키기 위한 기준 신호
2개의 AMP 의 위상차를 이용해 출력제어에 사용



RFG에서 DDS 구성

DDS 설계 사양

Frequency : 13.56MHz ± 0.005%

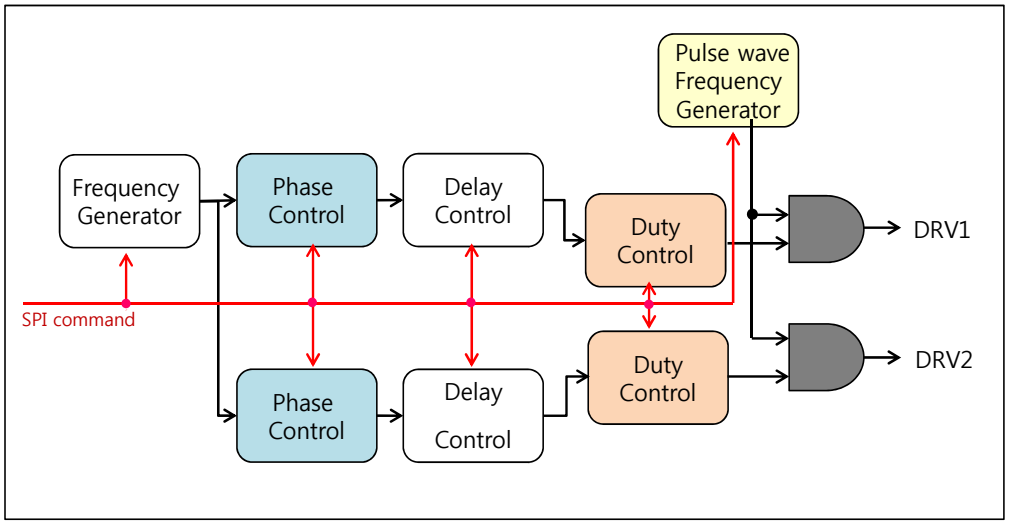
Main freq. Duty : 1 ~ 50%

Phase : 0deg ~ 180deg

Pulse freq :1Hz ~ 50kHz

Pulse duty:1~99% & CW

Timing resolution : 4ns



구조 및 배치

Main controller

DSP Dual core x 2

DDS with FPGA

Interface

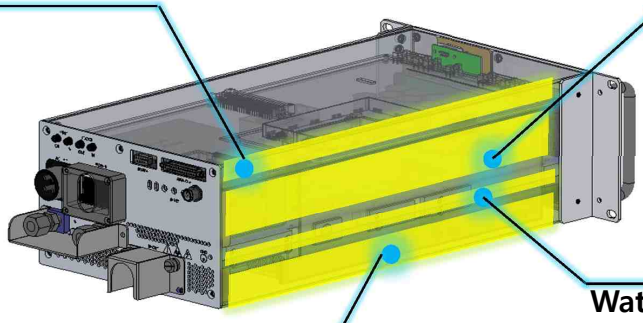
Power block

Single core DSP

Line noise filter

3.5kW DC/DC

400W sub DC/DC



Water cooling Heat sink

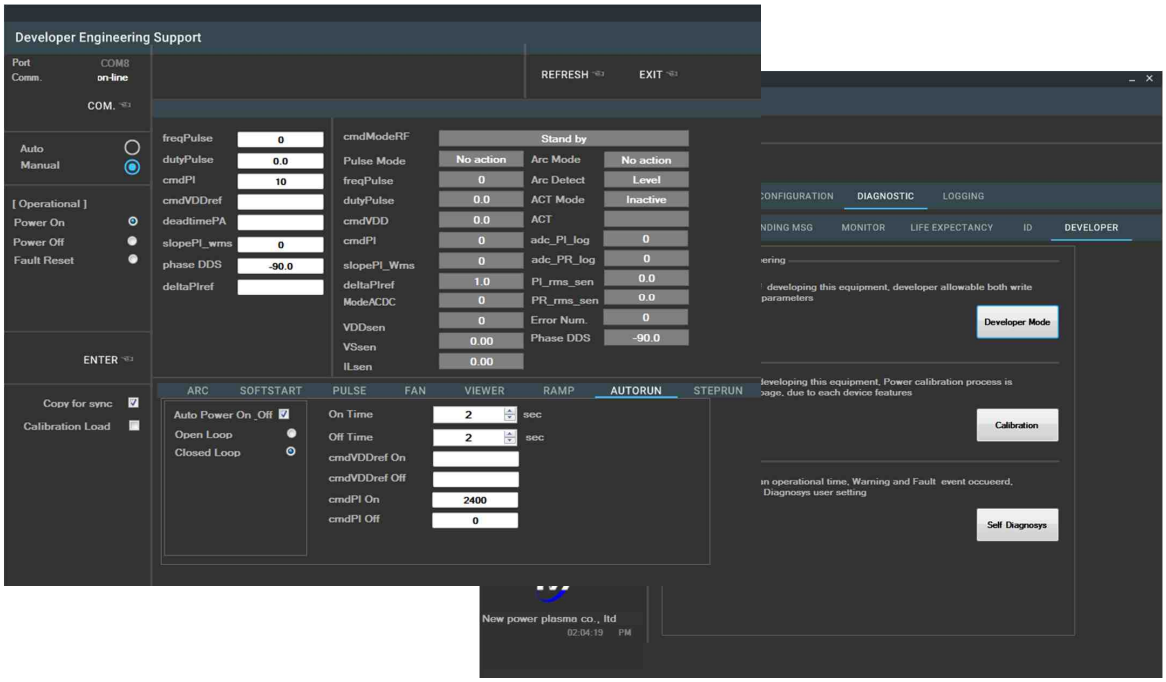
R.F block

Dual Power AMP

RF gate Driver

RF sensor

U.I PC software



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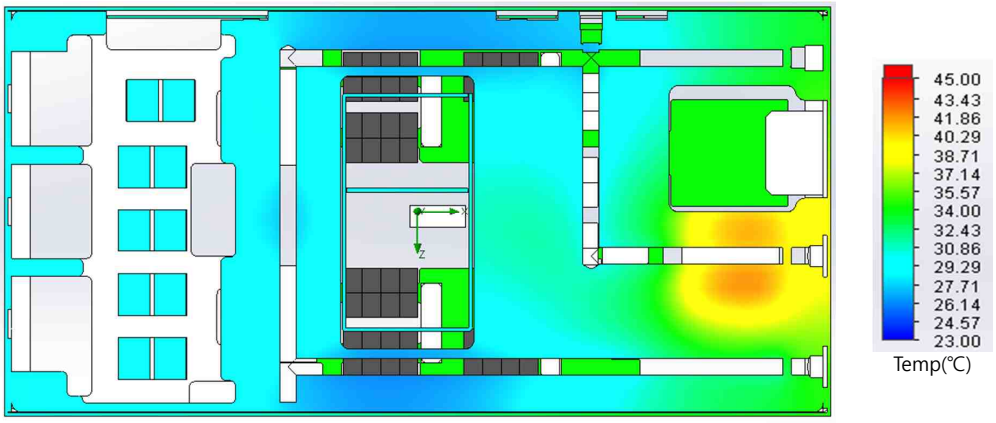
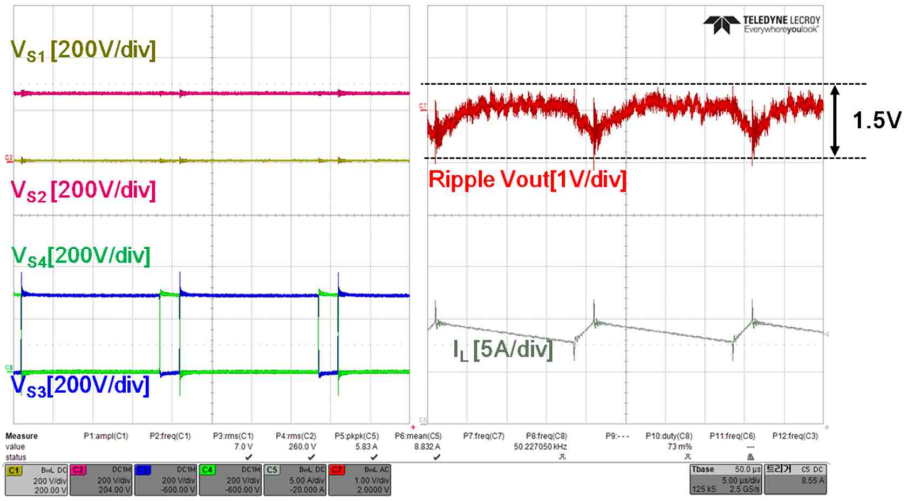
열 해석

Water cooling heat sink simulation



실험 결과

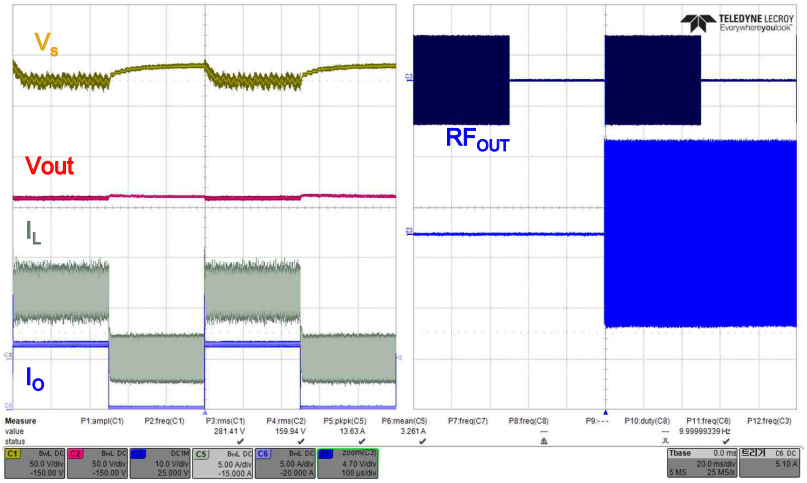
DC/DC output ripple voltage



***V-ripple : 1.5V @300V(3.5kW) output**

실험 결과

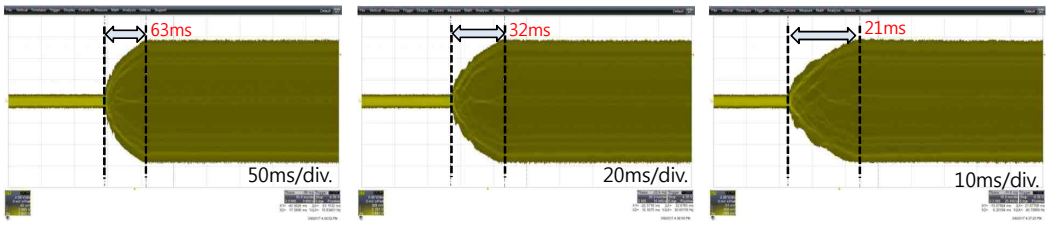
DC/DC output @ pulse mode



***Fast response 동작 ,pulse output 대응**

실험 결과

Ramp up output



< 50w/ms >

ΔPower	3000	W
Slope	50	W/ms
Set	60	ms
Result	63	ms

< 100w/ms >

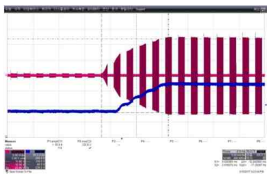
ΔPower	3000	W
Slope	100	W/ms
Set	30	ms
Result	32	ms

< 150w/ms >

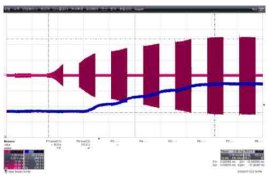
ΔPower	3000	W
Slope	150	W/ms
Set	20	ms
Result	21	ms

실험 결과

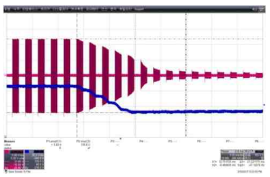
Pulse output



< 400Hz 50% duty Rising >



< 400Hz 50% duty Rising >



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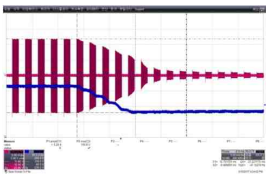
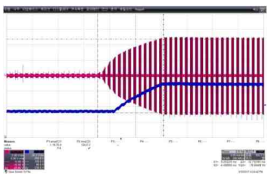
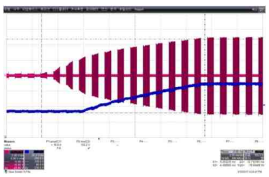


< 400Hz 50% duty Falling >



< 1kHz 50% duty Rising >



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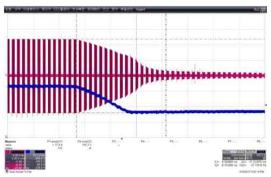
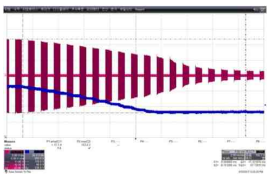


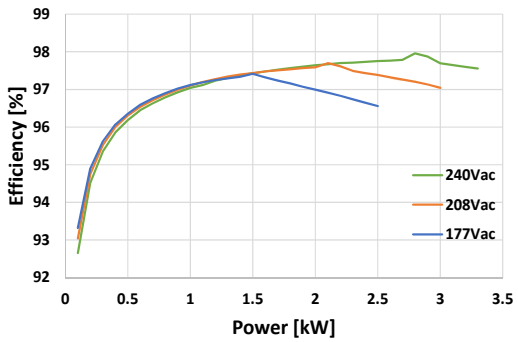
< 1kHz 50% duty Falling >



< 1kHz 50% duty Falling >

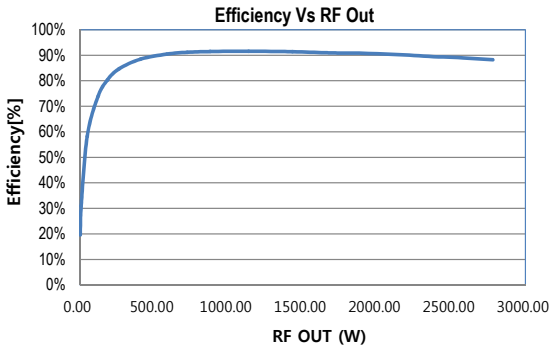
실험 결과

DC/DC



효율 : 95% 이상 달성

Power AMP



효율 : 88% 이상 달성

Contents

RFG 기술의 발전 방향

차세대 RFG의 방향

- ◆High power density
- ◆Compact size
- ◆Variable frequency output
- ◆Automatic impedance matching
- ◆mW Power control resolution
- ◆Smart control

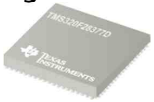
Power

- ●New topology 적용
- ●전력 부품 소형화 기술
- ●고 정밀 출력제어

RF

- ● 정밀 RF 출력 제어 기술
- ● 정밀 RF 출력 센싱 기술
- ● 자동 매칭 회로 개발

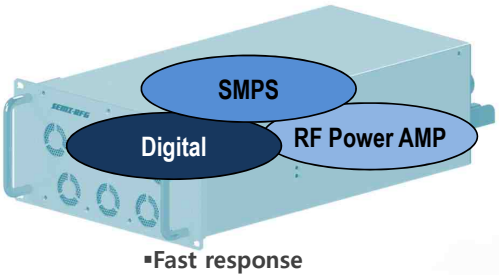
Digital control



- ● 고 정밀 출력 제어
- ● 수명 및 고장 예측
- ● 온도 및 부품 편차 자동 보상
- ● Plasma 공정 Monitoring

RFG 적용 기술 응용 산업

RF Generator



- Fast response
- High accuracy
- Wide range output
- High power density
- High reliability
- Low noise

응용분야

산업용 유도 가열기
초음파 발생기

방산 장비
레이더
방송통신기기

의료기기
X-선 진단기
자기 공명 진단 기

신 재생 에너지
에너지 저장 장치
전기 자동차

감사합니다.