Control PC

NI PCI-6723
32-Channel Analog Output
P/N 778701-01

NI PCI-6229
32-Channel Analog Input
P/N 779068-01

NI PCI-6723
32-Channel Analog Output
P/N 778701-01

NI PCI-6723
32-Channel Analog Output
P/N 778701-01

NI GPIB-USB-HS
NI-488.2
P/N 778927-01

SHC68-C68-S
P/N 186380-02
X2

SHC68-C68-S
P/N 186380-02
X2

SHC68-C68-S
P/N 186380-02
X2

SHC68-C68-S
P/N 186380-02
X2

BNC-2115
P/N 777808-01
X2

BNC-2115
P/N 777808-01
X2

BNC-2115
P/N 777808-01
X2

BNC-2115
P/N 777808-01
X2

Agilent E3634A DC 250W Power Supply (X8)
Source/Drain Power

HEMT Gates (x32)

RF In Diode Detector Output (x32)

Drain Current Output (x32)

RF Out Diode Detector Output (x32)
RF Power Supply (x4)

- Tuning: 2 GHz = 8 VDC
- Power Supply: 15.0 V, 45.0 mA
- DC Power
- Voltage Controlled Oscillator (VCO) (Spectrum Microwave)
- Variable Attenuator (JFW Industries)
- 40 dB Amplifier (Empower)
- Power Splitter 1:2
- 5 W Output
RF Splitter Board Detail (x8)

- SMA (RF Input)
- 4-Way Splitter (Mini-Circuits)
- CPL Reverse
- 68 Ω
- 56 pF x2
- 4.7 kΩ
- CPL Forward
- 68 Ω
- 56 pF x2
- 4.7 kΩ
- Coupler (Mini-Circuits)
- Diode Detector (Agilent)
- BNC (V out)
- Isolator (Ferrocom)
- BNC (V out)
- SMA (RF Output)
Detector Board Characterization

Synthesized Sweeper \( (P_{\text{in}}, \text{dBm}) \)

Diode Detector

Digital Multimeter \( (V_{\text{out}}, V) \)

At 2 GHz:
\[
P = a[\ln(bV)]^3 + c[\ln(bV)] + d
\]
Device Board Photos
Device Board Layout

Pin Layout
1 – Source
2 – Gate Monitor
3 – Gate Bias
4 – Source
5 – Drain Bias
6 – Drain Monitor
7 – Source

Input Matching Components

Output Matching Components

GaN HEMT

DC Components

1 7

o   p

m   n

k   l

i   j

g   h

a   b
c   d
e   f
Device Board Characterization

- **Synthesized Sweeper**
- **DC Power Supply (10 V, 2.85 A)**
- **Amplifier (1 W)**
- **Attenuator (30 dBm)**
- **Power Sensor (Output)**
- **Power Sensor (Reverse)**
- **Power Sensor (Forward)**
- **Directional Couplers**
- **Device Board**

- **DC Power Supply (Drain Bias = 20 V)**
- **DC Power Supply (Gate Bias ~ -2 V, I = 30% Isat)**
1.2 mm GaN HEMT Power Characterization

![Graph showing input power in dBm, output power in dBm, and gain in dB. The graph includes a legend indicating the different power levels and gains.]
Master System Monitor
Single Device Monitor
Single Device Monitor
RF Source and Temperature Controller
System Images
System Photo

Device Boards (8)

Detector Diodes (12)

Splitter Boards (4)
Heater Setup and Tuning

### Notes on tuning a PID controller

- Start with default values (P=20, I=0, D=0), turn on output at desired setpoint (100 or 125 C would be good)
- If controller reaches set point in a reasonable time and does not oscillate, do nothing – most tuning is required either to compensate for droop or oscillation, or to alter the approach to the set point (try to make it sharper, or eliminate overshoot)
- To tune controller, decrease P until temperature begins to oscillate, note period of oscillation – this is purely proportional control, and you have pushed the system to an instability
- Now increase I, an ideal value should be half the period of oscillation – this integrates the error signal over time to compensate for droop
- Now increase D, an ideal value should be I/10 – this takes the rate of change of the temperature into account, and is typically used to eliminate overshoot or on very fast or slow systems

---

**Diagram:**

- **Thermistor slot**
- **TEC 2**
- **TEC 1**
- **Device Board**
- **Thermistor: McShane TS104-170**
- **TECs: Melcor HOT2.0-65-F2A**
- **Use thermal grease for improved conductivity between layers**

**Notes:**

- Use thermal grease for improved conductivity between layers
Note: By shorting JP1.1 to JP1.4, the controller address will become 99 – this can be used to set the addresses of controllers in a loop.
Controller Box I/O Diagram

TEC/Thermistor – 6 pin DIN connector

- Inside Box: Red, Blue, Green, Brown
- Outside Plug: Blue, Brown, Red, Green

RS485 – 6 pin mini-DIN connector

- Inside Box: Red, Green, Black
- Outside Plug: Red, Black, Green

Status: Incomplete (parts are in the boxes under the table the controller boxes are on)

Note: current RS485 connection is hard wired to the controllers through holes in the boxes – the scenario shown on the left would be an ideal case, but I have not gotten it to work (either poor soldering job or the connectors alter the characteristic impedance of the loop so that it no longer matches the terminating resistor (120 ohm))
Controller Software (single)

Set point (input temperature, click “Send Box Values” to change)

Proportional = temp range around which directly proportional control is applied (set where system just begins to oscillate)

Integral = \( \frac{1}{2} \) (period of oscillation)

Derivative = Integral/10

Temperature band where controller is activated by temperature change

Compensates for differences between Thermistor(s) and actual temperature

Multiplier compensates for asymmetric response of TEC between heat and cool

RS232 Port (set to COM1)

Address=1-32, 0=all, 98=default for new

Box must be checked when addressing nonzero controller

Click to begin communications with controllers

Measured Temperature

Set point (from tuning box)

Percentage of max output power

Output pulse width

Set point input

Control type must be PID without reference temp

Direction of current flow in TEC for heating

Fixed value alarm is preferred to rate of change

Output power is disabled at alarm condition

Enables output power

Alarm must be manually cleared before resuming output

Actual controller address

Alarm sensor (irrelevant without second thermistor)

Temperature units

Check box to enable logging in log box (logs temp readings, can be copied to excel)

Click to start/stop sampling (button flashes when sampling)