GME1P34

1.3G 30kW Power Source

Technical Manual

1. Brief Introduction

1.1.Overview

GME1P34 1.3GHz 30KW solid-state power source with rated output power greater than or equal to 10KW.Adopting the ninth generation LDMOS all solid state technology, with a focus on performance indicators, stability, and practicality, while also considering standardization and serialization of appearance and structure.

1.2.System Characteristics

- Multiple special structural designs to ensure high-performance performance requirements
- The design of the single tube power amplifier module adopts the method of welding power amplifier tubes and printed boards on a pure copper base plate to improve the thermal conductivity and conductivity of the power amplifier module, and reduce the impact of temperature on the stability of the power amplifier.
- The RF matching circuit of the power amplifier module adopts high stability and reliability mica capacitors to reduce the impact of components on the performance indicators of the power amplifier tube matching circuit.
- Each power amplifier module output is equipped with a loop generator, which bears the total reflection power through the loop generator and corresponding load, and increases the loop generator power and the maximum load bearing power to improve stability under total reflection conditions.
- The conductor of the power amplifier output synthesizer is made of copper strip with a thickness of 2mm or more, which

reduces synthesis loss, increases thermal tolerance and throughput power capability.

- Distributed DC nearby DC power supply reduces the series resistance value from the power supply to the power amplifier module and improves pulse response performance. At the same time, the power module adopts a current sharing method to ensure redundant design of power supply.
- Highly reliable control method
- There are automatic and manual power on/off systems, and the automatic power on system has two methods: remote control and local touch screen control. The whole machine is equipped with multi-stage air switches to ensure reliable and sensitive control of the power source.
- Backup redundancy design, eliminating single fatal failure points, high reliability and stability
- The power amplifier module has a large power margin, redundant design, mutual backup, and can be replaced at will; When any module has a problem, it does not affect the overall operation of the power source.
- All power modules are powered by parallel current sharing.
- Modular design concept
- RF power amplification: It is mainly composed of 660W power amplifier modules, which are combined in a simple building block manner to form the main component of the whole machine, the power amplifier. Compact structure, clear boundaries between functional units, easy to maintain.

- DC power supply: Based on three 4KW power modules, combined into a 12KW output power component, multiple components are combined again to provide the required DC power for an amplifier cabinet.
- All kinds of protection functions are complete
- Switching power supply has high efficiency, wide voltage regulation range, and strong adaptability to changes in the power grid. It is equipped with protection measures such as over voltage, over current, under voltage, overheating, short circuit, and lightning protection.
- The power amplifier module is equipped with overheat, over excitation, and overload protection.
- The whole machine is equipped with measures such as high standing wave ratio, overheating, over excitation, phase loss and lightning protection, water circulation fault protection, as well as functions such as water pressure, water temperature, flow rate exceeding the preset range alarm

1.3. System composing

The 1.3GHz 30kW solid-state power source is structurally divided into three parts: pre amplifier and control cabinet, power amplifier cabinet, and high-power synthesis part. The overall structure is reasonable and the layout is beautiful. The control system and power amplifier are placed separately, and the RF related components are shielded in multiple layers to meet the design requirements of electromagnetic compatibility.

A single cabinet adopts a modular design, with four 660W level final power amplifier modules forming a 2KW power amplifier plugin, and six 2KW power amplifier plugins placed in one cabinet to form an 8KW

power amplifier cabinet.

Four power amplifier cabinets, along with a matching liquid cooling system, preamplifier and control cabinet, and waveguide synthesizer, are combined to produce a 30kW power source system.。

1.4. Structure

The GME1P34 solid-state power source has a total of 4 amplifier cabinets and 1 preamplifier and control cabinet.

In the preamplifier and control cabinet, there are distribution units, main control units and detection units, touch screen display units, preamplifier components, and power supply components.

The power amplifier cabinet contains electrical components such as power amplifier plugins, switch power supply components, single cabinet data acquisition and controller, and corresponding sensors.

1.5. System functions

- The overall system is mainly divided into four parts based on functions: RF amplification system, control system, cooling system, power system, etc
- RF amplification system: including pre power amplification unit, final power amplifier, power divider and synthesizer, directional coupler, etc;
- Control system: The control system is a "hierarchical" monitoring system based on ARM, consisting of touch screen, main control unit, power control module, power amplifier data acquisition and control module and other units and modules;
- Cooling system: using liquid cooling method, the system consists of a water separator, a water collector, a pipeline control ball valve, a quick connect joint, and flow and

temperature detection sensors, etc;

- Power system: The power system consists of AC power supply and a switch stabilized DC power supply component. The switch stabilized DC power supply supplies DC power to the power amplification unit. Control the power supply to provide power (+12V) for the touch screen display unit and the detection board. The power distribution unit of the control cabinet is responsible for controlling and distributing the power source AC power. The DC power supply is first combined into a power component, and the output of each power component is connected to the busbar for parallel current sharing before supplying power to the amplifier plug-in.

1.5.1. RF system

The RF amplification system includes main components such as preamplifier plug-in, final amplifier plug-in, power distribution and synthesizer, directional coupler, etc. The preamplifier plugin is mainly used to amplify the input signal to provide sufficient driving power for the final amplifier, while limiting the amplitude function before amplification to prevent excessive input power from causing system failure of the entire machine. The power divider divides the driving power into a corresponding number of ports to provide driving power to the final amplifier. After being amplified by the final power amplifier and synthesized by the synthesizer, the output power is delivered to the load. The directional coupler couples the output RF sampling signal from the main path for RF detection and power monitoring.

1.5.2. The functions of control system

- The GME1P34 control system consists of four subsystems:
- First level subsystem: Whole machine control unit (CCU);

Receive data from the "second level subsystem" and send "control instructions" to each subsystem.

- Second level subsystem: refers to the main control unit distributed in various power amplifier cabinets and distribution cabinets; Receive data sent by the "whole machine control system" and reply to the data; Forward "control instructions" and read the status of each subordinate system.
- Third level subsystem: data acquisition and control modules within each unit. Mainly includes power amplifier data acquisition module, power supply data acquisition module, power control board, etc; Collect the status and data of subordinate systems and report them to the main control unit.
- Fourth level subsystem: water temperature/pressure, water leakage monitoring (inside the liquid cooling unit cabinet), etc.
- The GME1P34 control system is the "command" center for power source operation, and its functions include:
- Power source logic control: including on/off operations, controlling a module's RF switch, etc.
- Equipment fault protection and alarm: such as VSWR, temperature, pressure, etc.
- Operation status indication: It can be displayed in separate menus through the touch screen of the control cabinet.
- Main parameter measurement indicators: such as device output power, module voltage and current, inlet and outlet temperature, etc.
- Equipment operating parameter settings.
- Communication with remote control device (PC): Receive remote control PC commands, report device working status and

parameters.

1.5.3. The functions of power distributor

The GME1P34 has a high overall power output, and the system power supply is divided into multiple sub distribution systems. Each sub distribution system has AC power monitoring and AC power distribution and control functions. AC power monitoring is mainly used to determine whether the input power status meets the system's operating requirements, in order to ensure the power supply of the switching power source. There are a large number of power source switch power modules, which are independently controlled to ensure that one of them can be disconnected at will during the system operation.

1.5.4. The functions of liquid system

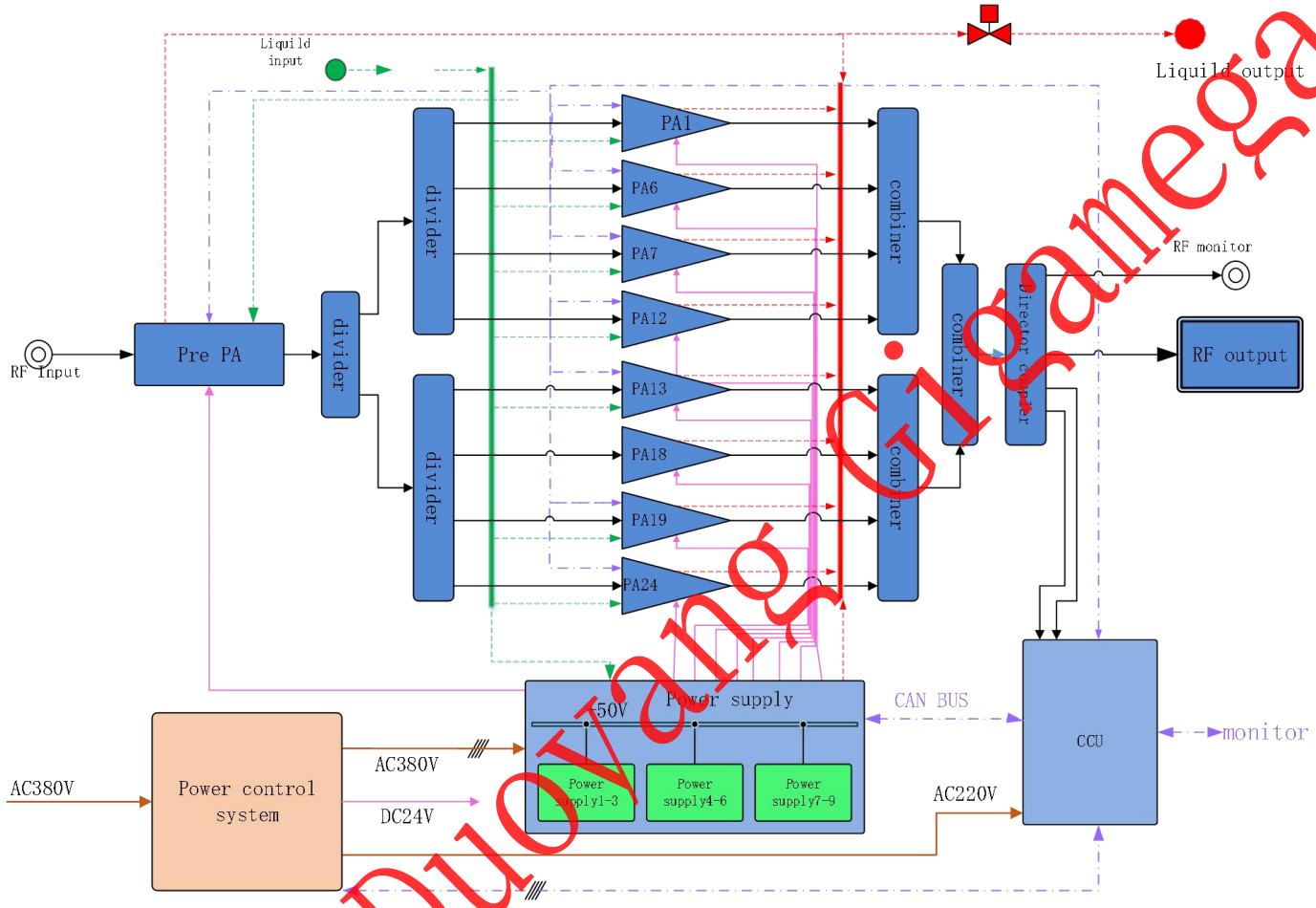
The cooling method of GME1P34 is liquid cooling, and the liquid cooling system mainly includes a heat dissipation part, liquid cooling pipeline distribution and control. External cold water enters the power source. Firstly, the cold water is sent to each power amplifier plug through an electromagnetic valve and a water separator. Heat exchange is carried out through a heat exchange pipe buried inside the power amplifier plug to ensure that the working temperature of the power amplifier tube is maintained within a certain range, The hot water left by the amplifier plug-in is returned to the chiller for cooling and then turned into cold water, and this cycle takes away the heat generated by the amplifier.

1.6. Technical parameters

No.	Content	Parameters
1	Frequency	1.3GHz ±1MHz
2	Rated output power	10KW(CW),1kW-10KW
3	1dB compression point output power	≥10KW
4	operation mode	Continuous wave; Pulse modulation
5	Duty cycle	1%～100%， 100μs
6	Pulse repetition frequency	1～100Hz， step 1Hz
7	Open loop amplitude stability of the whole machine output	≤1%
8	Whole machine output open-loop phase stability	≤1°
9	efficiency	≥40%
10	redundancy	3%When the power amplifier module is damaged, the entire machine can be pushed to full power
11	harmonic suppression	≤-30dBc
12	Clutter suppression	≤-60dBc
13	Input signal level	10dBm
14	Output interface	WR650
15	Amplifier plug-in	Each amplifier plugin contains independent circulators and loads
16	Cooling method	The power amplifier plug-in and power module are both water-cooled, with deionized water as the water quality
17	Device consistency	After randomly replacing the power amplifier plug-in, the gain change of the solid-state power source is ≤ 0.1dB

1.7. The system principle diagram

1.7.1. Principle diagram



1.7.2. RF System

The whole machine has one preamplifier cabinet and four power amplifier cabinets with a designed output power of 8.5KW. After power distribution, the output power of the preamplifier provides excitation power to each final amplifier. The final power amplifier (cabinet) outputs a rated output of 30kW after two rounds of secondary synthesis. Each power amplifier cabinet has 6 final power amplifier plugs, each with 4 final power amplifier module boards (PAP) designed to output 660W power. The preamplifier excitation output inside the power amplifier is composed of a 2kW power amplifier plug

PAU through a microstrip distributor, final power amplifier, circulators, synthesizers, and directional couplers (please refer to the power amplifier plug schematic and instructions). Directional couplers are installed at the output terminals of each amplifier cabinet to provide FWD and REF detection and monitoring interfaces for the equipment.

2. Main plugins and components

2.1 Pre amplification plugin

The preamplifier plugin is a unit component that integrates RF limiting, amplification, and control. Mainly including limiter, power amplifier, RF switch, monitoring module, and switching power supply. The power amplifier module in this plugin also generates heat during operation, so this plugin also adopts liquid cooling heat dissipation method, and the heat dissipation bottom plate is made of aluminum plate buried with copper tube.

After the RF signal is input into the preamplifier plug-in, it sequentially passes through the input sampling, RF switching switch, RF limiter, two-stage RF amplifier, circulator, and directional coupler for output. The RF switch works in a normally closed state by default. When there is a control signal, it disconnects and connects the input signal to the load to improve signal isolation. The input sampling signal is sent to the control board and the upper limit power value is set. The pre control amplification plug-in monitoring system can be equipped with an external LCD display and buttons. Users can view the working status of the control amplification plug-in and set various working parameters. In addition, the monitoring system also provides fault detection, alarm, and automatic protection functions such as overload, overheating, and loss of lock, ensuring the safety of the control amplifier plug-in and power amplifier. The

interconnection between the control amplifier plug-in and the power source monitoring system is achieved through the CAN bus communication port.

2.2 Final amplifier plug-in

The power amplifier plugin consists of one front-end power amplifier module and four final stage power amplifier modules. After entering the power amplifier, a portion of the RF signal is taken for detection, and another portion is detected and sent to the power amplifier control board for data acquisition indication. The RF signal is amplified and synthesized before being output. A directional coupler is added to the output section, and a portion of the signal is taken to the panel for monitoring. In addition, both forward and reverse RF signals are taken out and sent to the detection board. After detection, they are converted into DC voltage and sent to the control board for analog-to-digital conversion and acquisition. After the DC power supply enters the amplifier plug-in, it is first divided into five channels for current distribution and sampling. The power output is controlled by solid-state relays, and the working status of the solid-state relays is controlled by the control board, which can control the power supply of any module. The sampled output analog DC signal is sent to the control board for digital to analog conversion processing. The amplifier plugin has an IIC interface temperature sensor inside, and the sensor signal is collected by the control board. All collected signals are processed according to a certain processing method.

- Main features:
- The final power amplifier tube of the power amplification plug-in adopts the 9th generation LDMOS transistor with relatively high

power level and excellent performance. Through optimized design, it has achieved relatively high efficiency and electrical performance;

- The internal design of the amplifier plug-in has strong and complete protection functions, and the monitoring circuit adopts digital circuit design, resulting in high data acquisition accuracy;
- The connection connector used for the cooling system is a quick plug connector, which can automatically cut off the circulation path when the power amplifier plug is removed from the cabinet, preventing liquid from flowing out.
- The power tube of the amplifier plug-in adopts liquid cooling method, which has high cooling efficiency.

3. Passive components

The single cabinet adopts a six channel in-phase synthesis scheme, which not only ensures low insertion loss and meets the requirements of high power, but also achieves a simple and clear structure, perfectly combining with the overall layout of the power source.

In the complete system, due to the designed output power of a single cabinet exceeding 8KW, the high-power synthesis between cabinets is composed of cascaded waveguide synthesizers, requiring a total of secondary synthesis.

3.1 Combiner

- Frequency: 1.3GHz ±10MHz
- Input: 1-5/8″
- Output: 3-1/8″

- Input/output reflection coefficient: ≤-26dB
- Insertion loss: ≤0.1dB
- Uneven amplitude: ≤0.1dB
- phase difference : ≤3°

3.2 Waveguide synthesizer

- Frequency: 1.3GHz ±10MHz
- Input: WR650
- Output: WR650, FDP14
- Input/output reflection coefficient: ≤-26dB
- Insertion loss: ≤0.1dB
- Uneven amplitude: ≤0.1dB
- phase difference: ≤3°

3.3 Divider

- Frequency: 1.3GHz±10MHz
- Input/output: SMA-K/50Ω
- Input power: ≤10W
- VSWR: <1.1@1.3GHz
- Insert loss: ≤0.3dB
- Isolation: ≥28dB@1.3GHz
- Amplitude unevenness: ±0.3dB
- phase difference: ≤±3°

4. Control system

The main control unit of the 30KW power source monitoring system is the center of the entire power source control system, responsible for external communication and data collection and control of other sub

units within the power source. The main control unit consists of three parts: the ARM chip control motherboard, the switching power supply, and the detection circuit.

- The main control board adopts NXP's I The MAX6UL processor is a highly integrated single-chip embedded processor with ARM CORTEX A7 as the core and rich peripheral interfaces. The mechanical structure adopts the method of adding a main board and a core board to reduce processing difficulty, improve yield, and facilitate system maintenance. The completed functions include:
- Data collection, storage, statistics, and analysis of the entire machine;
- Whole machine control and parameter setting;
- Provide the external control interface LAN for the entire machine;
- Fault protection and alarm.

4 Power distribution

The power supply for the complete system is AC380V50Hz, three-phase five wire (TN-S) system, and each cabinet has an independent grounding point. Due to the high DC power required for the entire machine, the cabinets that need power supply are scattered, so distributed power supply is adopted. The AC power output from the distribution unit inside the amplification control cabinet is divided into four paths and supplied to each of the four amplifier cabinets. AC power is supplied to each cabinet, providing power to the switch power conversion modules distributed in each amplifier cabinet.

5 Power supply

Factory set value of output voltage: DC50V (adjustable, current device setting is 42V, voltage needs to be confirmed before replacing power supply).

1) Rated output current: 80A

2) Output voltage adjustment rate: ≤ ±0.5%

3) Output current adjustment rate: ≤ ±0.5%

4) Peak to peak ripple voltage: ≤ 300mV (20MHz oscilloscope)

5) Range of AC input voltage: 380V±20% (47HZ-53HZ)

6) Communication input undervoltage protection point: AC300V±5V

7) Output overvoltage protection: Yes

8) Output overcurrent protection: Yes

9) Short circuit protection: Yes

10) Conversion efficiency: ≥ 92%

11) Operating frequency: ≥ 30KHZ

12) Current uniformity accuracy; ≤ ±5%

13) Over temperature protection: 80℃±3℃

14) Working temperature: -5 ℃~+45 ℃, industrial grade- 20℃~+55℃

15) Storage temperature- 30 ℃~+60 ℃, industrial grade- 40℃~+70℃

16) Relative humidity; ≤ 90%

17) Working conditions: water-cooled heat dissipation

18) Altitude; ≤ 2000m industrial grade; ≤ 5000m

19) Insulation strength: Input to chassis ≥ 200M Ω, input to output

≥ 100 M Ω;

20) Output to chassis: ≥ 100M Ω.

6 Liquid cooling system

6.1 The parameters of liquid system

（1）Water cooling

(2) Stainless steel water pipes for entering and exiting the cabinet;

(3) The inlet and outlet water levels of the cabinet are located behind the bottom of the cabinet, and flow meters and solenoid valves are installed at the outlet of the cabinet;

(4) Both the inlet and outlet pipes are equipped with temperature probes for monitoring the inlet and outlet temperatures.

(5) The maximum pressure resistance of the waterway pipeline system design is 1MPa.

(6) Minimum water flow requirement:> 8m3/H inlet water temperature 25 ° C.

6.2 Cooling medium

The main component of the cooling medium designed for this liquid cooling circulation system is deionized water. Water has a much higher specific heat capacity than air, resulting in lower temperatures of the cooled power tubes compared to air-cooled cooling. Therefore, it can achieve better cooling effects, lower relative failure rates, longer mean time between failures, and strong environmental adaptability. In areas where the indoor temperature is below 0 degrees Celsius in winter, a certain proportion of antifreeze can be added to the coolant to effectively lower the freezing point and reduce corrosion of metals. The coolant shall be prepared and filled after calculation according to the local natural environment

conditions and the proportion parameters of the frozen liquid, otherwise the pipeline may freeze and crack in winter.

6.3 Principle of Liquid Cooling System

The heat dissipation of this machine adopts liquid cooling method. The main heat dissipation equipment of one 10KW power source includes 8 liquid cooled power amplifier plugs, 3 switch power supply plugs, and 1 preamplifier plug. Cold water input will pass through solenoid valves and then enter the water distribution system, and then enter various plugins; The water heated by various plugins is then collected by the water collection system and sent out for heat dissipation. The liquid cooling circulation system first flows from the cooled cold water through the bottom inlet of the cabinet into the water separator, which distributes the cooling water to 8 output channels. The water divider is connected to the water-cooled input quick connector of 6 power amplifier plugs, responsible for providing cooling water for the 6 power amplifier plugs; Provide cooling water inflow to the front end through route 1; The remaining path needs to be divided into 4 paths again (currently only 3 paths have been used). The 4 paths are connected to the water cooling quick connector input of the switch power plug, providing cooling water input for the switch power plug. One of the paths is reserved and does not connect to the water pipe. After passing through the liquid circulation pipeline of the required heat dissipation components, the circulating water with heat will flow out from the outlet of each component and enter the water collector for convergence. The power amplifier plug-in and the pre outlet water will directly enter the lower part of the water collector; The water from the switch power supply enters the upper water collector and is finally connected to the lower water collector. All hot water is collected in the water collector and

flows out of the water collection system through the rear outlet at the bottom of the cabinet to dissipate heat.

Valves are installed at the top of each water separator and collector, which can be used for exhaust when the cooling effect is affected by the air inside the pipeline, thus improving the overall cooling efficiency.