



Innovation / Cooperation
/ Win-win

specification

RinTex-CEWB series
wireless channel
simulator

Rinfon Aerospace Technology (Beijing) Co., Ltd.

1. Product Overview

The RinTex-CEWB series wireless channel simulator is a high-performance wireless communication link simulation device. It simulates real-world space communication environments in laboratories and constructs high-precision, wide-bandwidth RF channel switching networks. The simulator dynamically simulates wireless channel characteristics in communication links, including transmission delay, Doppler frequency offset, amplitude attenuation, multipath, and fading models. It enables device-level and network-level wireless channel simulation, supporting R&D, verification, and testing tasks.







As a core component in modern electronic warfare and communication testing, the channel simulator is a high-fidelity simulation platform specifically designed to validate communication and countermeasure system performance in complex battlefield environments. This system accurately replicates the dynamic and multifactorial channel conditions of real combat scenarios, providing critical support for the development, testing, and training of various communication devices, countermeasure equipment, and electronic warfare systems.

The system simulates typical channel characteristics including multipath fading, Doppler effect, terrain effects, and weather influences, enabling the creation of comprehensive combat scenarios that integrate countermeasures, communication devices, background signals, and jamming equipment. Through flexible configuration, users can replicate high-intensity electromagnetic warfare scenarios such as communication link testing under severe interference, anti-jamming performance evaluation, complex signal recognition, and electromagnetic game theory.





The platform is widely used in equipment acceptance, protocol verification, tactical research and system integration testing, which solves the problems of high cost, limited conditions and difficulty in repetition of field combat testing, and enables researchers and trainees to effectively evaluate and improve the combat effectiveness of equipment in extreme battlefield environment in a

controllable laboratory environment.





2. Product Application

-  Wireless Communication Link Simulation and Test
-  semi-physical simulation test
-  Massive MIMO simulation test
-  Complex Electromagnetic Environment Simulation Test
-  Simulation and Test of Data Chain Communication
-  satellite network simulation test

3. product function

-  The system supports wireless channel model editing, including multipath configuration, delay, fading channel, Doppler shift, and SNR simulation. In full-network mode, all communication links' delay, frequency offset, fading, and multipath are independently configurable.
-  channel model :
 - ✧ Supports constant, Rayleigh, Rice, Nakagami, flat, circular arc, double Gaussian, Lognormal, Suzuki, pure Doppler, and Bartwiz;
 - ✧ Supports shortwave communication (ITS) and Watterson model.
 - ✧ Supports simulation of electromagnetic wave propagation modes such as skywave and ground wave.
 - ✧ Supports the impact of weather conditions such as atmosphere, rain, and snow on channel characteristics;
 - ✧ Supports user-defined channel model loading;
-  It can be interconnected with external storage devices via 10G network, receive baseband data, perform channel simulation, and output through the RF interface or return to the storage device; alternatively, it can store the collected RF input signals into the storage device.
-  Supports multi-channel editing of various wireless network topologies,

including linear, star, fully connected, and multi-subnet configurations.

-  Supports receiving software control from other platforms through Ethernet interface.
-  Supports dynamic simulation, including Doppler shift, time delay, and power.
-  It can receive external B (DC) code to synchronize the entire system.
-  It has narrowband jamming, broadband jamming, comb jamming, frequency hopping jamming, sweep jamming and pulse jamming;

4. qualification

| order number | Indicators | qualification | remarks |
|--------------|---|---------------------|---------|
| 1. | number of channels | 8 input, 8 output | |
| 2. | frequency range | 200MHz ~ 6GHz | |
| 3. | tape width | 500MHz | |
| 4. | input signal power range | -40dBm ~ 30dBm | |
| 5. | output signal power range | -120dBm ~ 0dBm | |
| 6. | output signal power resolution | 0.1dB | |
| 7. | output signal power accuracy | 1dB@ ≥ -90 dBm | |
| 8. | banding | Better than 40dBc | |
| 9. | dynamic range of multipath delay | 5us ~ 600ms | |
| 10. | standing-wave ratio | ≤ 1.6 | |
| 11. | interchannel isolation | Better than 120dB | |
| 12. | maximum Doppler frequency offset | ± 3 MHz | |
| 13. | maximum rate of change of Doppler shift | ≥ 80 KHz/s | |

| | | | |
|------------|-------------------------|--|--|
| 14. | ground noise | $\leq -160\text{dBm/Hz@Typical value}$ | |
| 15. | User-defined model | support | |
| 16. | Import STK files | support | |
| 17. | noise disturbance model | Supports AWGN, CW, and other formats interference simulation | |
| 18. | fading channel model | Supports free-space fading, shadow fading, multipath delay, Rayleigh, Rice, and Doppler characteristics (flat, arc, Gaussian, dual-Gaussian). Constant, Nakagami, Lognormal | |

5. solution architecture

5.1. Device configuration

The channel simulator hardware platform employs a standard VPX modular architecture, primarily consisting of a signal processing unit, an 8-channel signal transceiver unit, and a clock synchronization unit. It utilizes a professional main controller, high-speed backplane, and power unit as the operational platform. The entire hardware system is equipped with industrial-standard peripheral devices, housed in a standard 19-inch rack-mounted chassis, and supported by a fully functional software platform. Together, these components ensure the system's high performance and reliability.



Figure 51 Schematic diagram of device composition

The basic functions of each unit are as follows:

➤ 8-channel signal transceiver unit

Each 8-channel signal transceiver unit is composed of 8 RF signal receiving links and 8 RF signal transmitting links.

The RF signal receiving link performs signal reception, orthogonal down-conversion, and baseband sampling. The RF signal input through the receiving port undergoes signal conditioning, filtering, and analog-to-digital (AD) conversion before being converted to baseband signals for transmission to the signal processing unit. Each signal channel is equipped with a frequency synthesis module, allowing

independent frequency control. This configuration enables each receiving channel to operate at distinct frequencies.

The RF signal transmission chain performs digital-to-analog conversion, orthogonal up-conversion, and RF signal emission. The received signal processing unit processes the baseband signals transmitted from the source, executing DAC conversion, up-conversion, and gain control before output through the RF port. Each signal channel is equipped with an independent frequency synthesis module, enabling frequency customization. This configuration supports independent operation of transmission channels at distinct frequencies.

➤ signal processing unit

The system connects to the 8-channel signal transceiver unit via the VPX backplane connector. It receives digital signals from the RF receiver unit through the high-speed SERDES transmission bus, performing functions such as delay, Doppler simulation, attenuation, phase shift, and multipath simulation. The signals, after being processed through the superimposed channel model, undergo digital interpolation and filtering. Finally, the digital signals are transmitted to the RF transmitter unit via the VPX interface.

The system's synchronization processing is implemented through a signal processing card. Upon receiving external synchronization signals or synchronization commands from the host computer software, the card simultaneously distributes them to all RF receiving and transmitting units, enabling synchronized system control. The card can receive B-code signals from the Beidou timing unit, parse them, and synchronize the system clock with the Beidou system. When no external Beidou signal is available, the channel simulator uses the clock from the host control software's system as the system clock.

➤ clock synchronization unit

Responsible for the clock synchronization and time synchronization of all modules in the channel simulator mainframe.

➤ backplane unit

The backplane unit has the following functions:

High-speed signal exchange: to realize the multi-channel high-speed signal exchange;

Clock transmission: provides the operating clock for each signal processing card.

Synchronous trigger control: The trigger signal is introduced into each carrier plate.

Power distribution: supplies operating voltage to each independent module.

➤ power subsystem

The power unit converts external AC power into DC power through AC-DC conversion, supplying 220V mains voltage to all boards and modules.

➤ main control unit

The main control unit runs the device control software and analysis subsystem, which is responsible for the display, alarm, control and self-test of the wireless channel simulator, providing the external interactive interface, and accomplishing the control, monitoring and self-test of the system components. It provides the operating platform for the system control software and the human-machine interaction software.

The software platform is integrated into the main control unit, running underlying drivers, channel simulation software, and a human-machine interface. It provides the channel simulator's underlying drivers and software environment, executes channel simulator applications, and performs functions including configuration file management, test channel selection, system parameter configuration, system operation control, and user interface. Users configure system parameters and access help functions through the software interface, while the LCD screen displays system status and abnormal alarms for real-time monitoring.

5.2. mechanism of operation

The channel simulator operates on the principle of "software-defined damage, hardware-executed in real time." By converting complex electromagnetic wave propagation phenomena into computable digital models and processing signals in real time through pipeline operations on powerful hardware platforms, it successfully

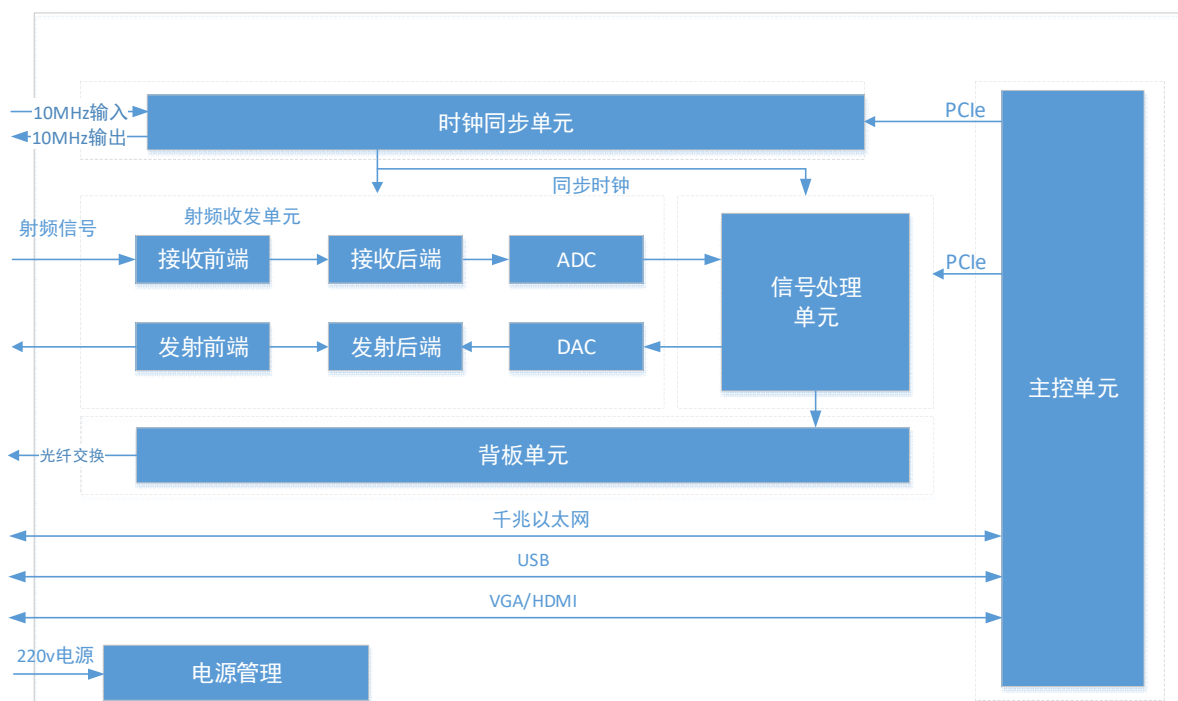
encapsulates the vast, uncontrollable real-world wireless environment within a compact laboratory chassis. This innovation provides an indispensable testing foundation for the rapid advancement of wireless communication technologies.

5.2.1. Core Principles and System Composition

The core mission of a channel simulator is to accurately replicate the various signal degradation effects of real-world wireless channels in a controlled laboratory environment. Its operation is based on a key concept: transforming an ideal digital baseband signal into one that has experienced real-channel fading, delay, and interference through a software-defined, hardware-implemented channel degradation model.

During channel simulation, channel characteristics must be analyzed based on test environments, terminal positions, and motion trajectories. The distance between terminals manifests as time delay and signal attenuation, while relative motion results in Doppler shift and Doppler spread. Changes in terminal positions cause signal routing variations. Different simulation environments correspond to distinct multipath quantities and fading types.

The core components and data flow are shown in the figure below:



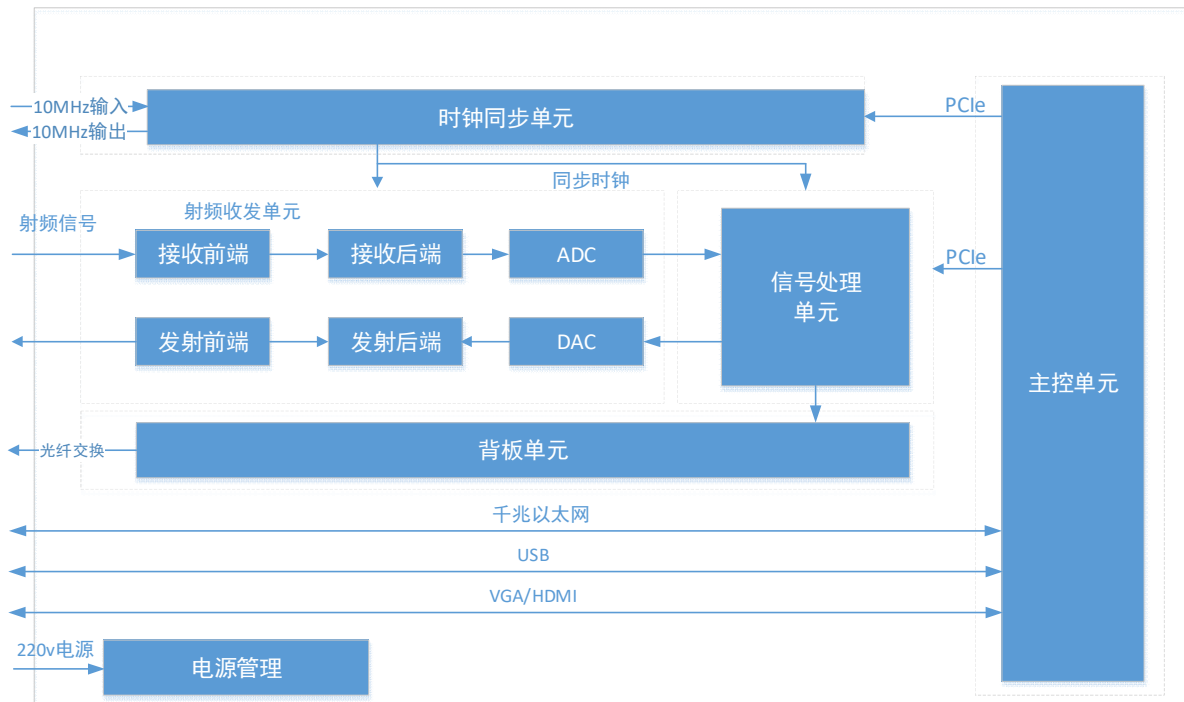


Figure 52 Schematic diagram of device working principle

The RF module group handles up-conversion from baseband to RF signals and down-conversion from RF to baseband signals, with 32 up/down physical channels. Each channel operates at an independently configured frequency.

The signal processing board enables channel simulation. A single board integrates four FPGA chips to simulate 1 input signal and multiple output channels, while two boards work together to simulate 16 input signals and multiple output channels. The boards are interconnected via fiber optic interfaces for seamless data exchange.

The clock synchronization module provides the synchronization clock for the whole system, ensuring the phase consistency of each channel.

The backplane unit supplies power to each hardware board and provides high-speed interconnection between boards.

The master control module runs the host computer software and controls the whole system through PCIe.

5.2.2. Detailed Operating Mechanism and Signal Processing Flow

The channel simulator features 16 RF channels and supports both multi-link and networking modes. In multi-link mode, all signal input/output ports are numbered

sequentially (e.g., IN1->OUT1, IN2->OUT2,..., INX->OUTX). Networking mode allows all input signals to be output through any interface, with various channel characteristics layered between them.

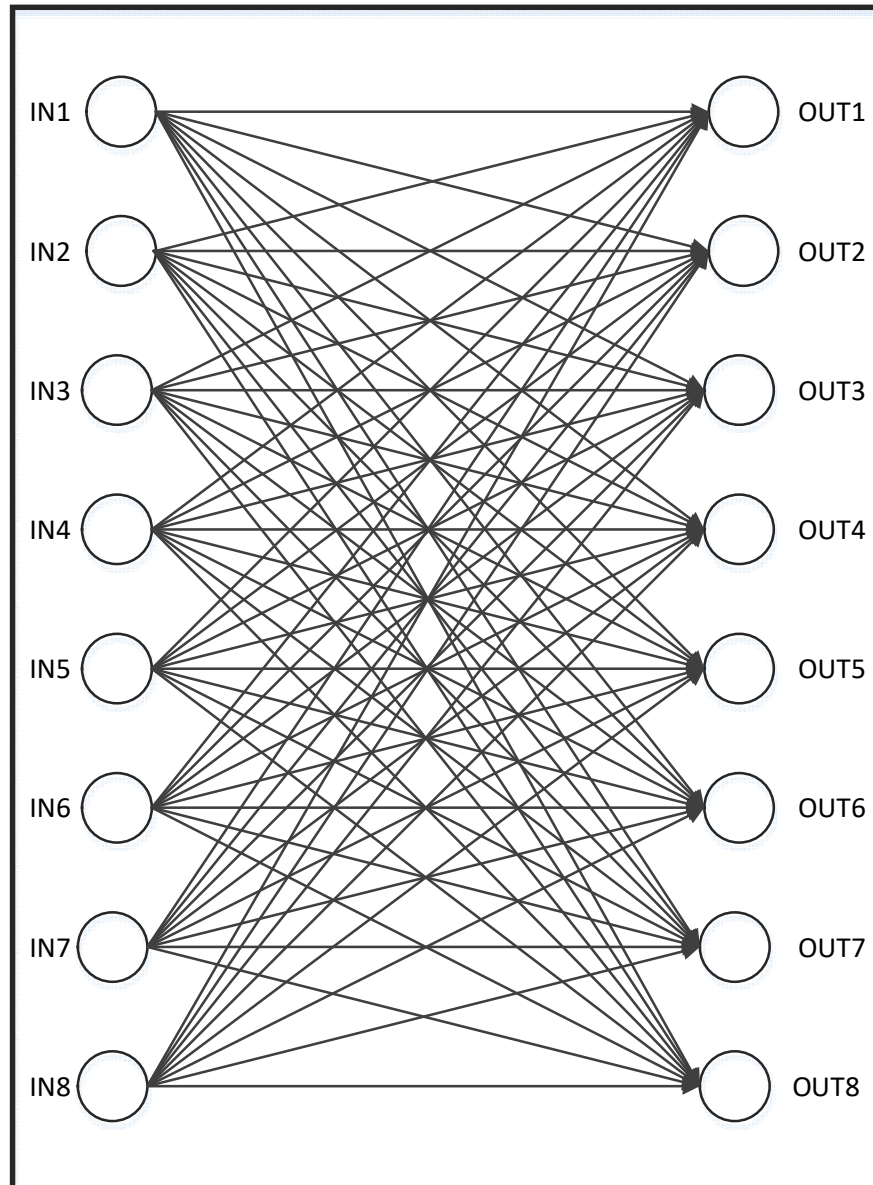


Figure 53 8-channel signal networking

The signal processing workflow for each link is illustrated in the figure below.

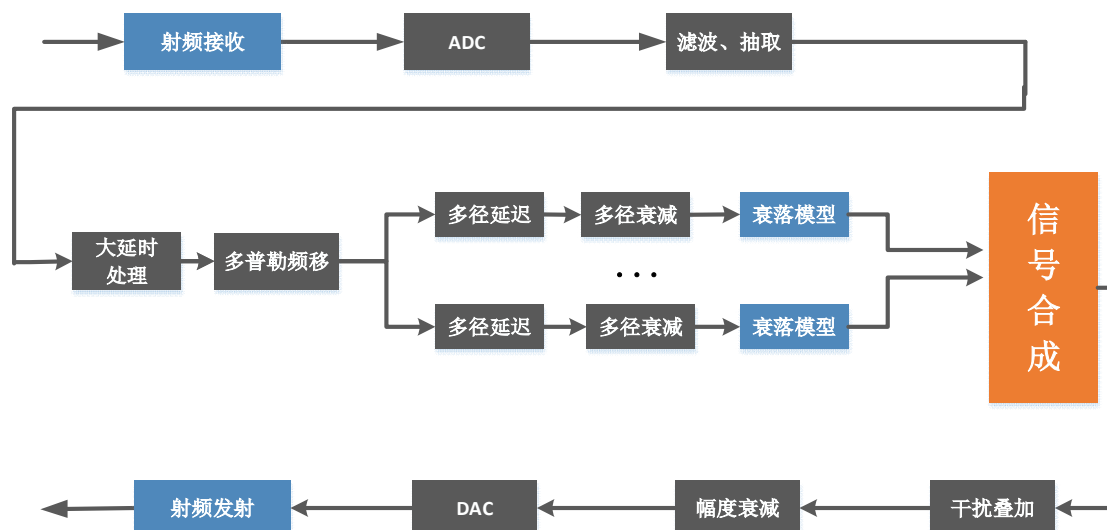


Figure 54 Single-link Signal Processing Flowchart

The signal processing flow is as follows:

The external RF signal input is configured according to the user's preset frequency and bandwidth parameters of the input signal, which completes the orthogonal transformation, filtering and signal amplitude conditioning of the RF signal to meet the sampling requirements of the ADC in the digital signal processing unit.

Each channel performs channel simulation processing on the received signals, such as: large delay, small delay, multipath simulation (relative delay, attenuation, fading), Doppler simulation, interference simulation, amplitude attenuation, etc.

The signal synthesis is carried out to achieve the superposition of multiple signals. Then the analog IQ signal is output through the DAC.

The RF transmitter module performs up-conversion and amplitude modulation of analog signals and outputs them.

6. equipment structure design

6.1. Product form

The channel simulator platform is designed with a standard 6U chassis, featuring a custom backplane to enable high-bandwidth signal transmission between boards. All modules are integrated into a single standard rack-mounted chassis. The modular design facilitates easy assembly and disassembly, enabling rapid fault diagnosis and

resolution.

The device features a clean and understated design with high-quality materials. Its exterior is spray-painted for aesthetic appeal and wear resistance, while the overall color scheme harmonizes beautifully with the surrounding environment. See the schematic diagram of the narrowband wireless channel simulator's design below:



Figure 61: Exterior view of the chassis

6.2. external interface

The device's external interfaces primarily include RF channel interface, reference clock interface, trigger signal interface, remote control communication interface, time synchronization signal interface, and power supply interface, as shown in the figure below.

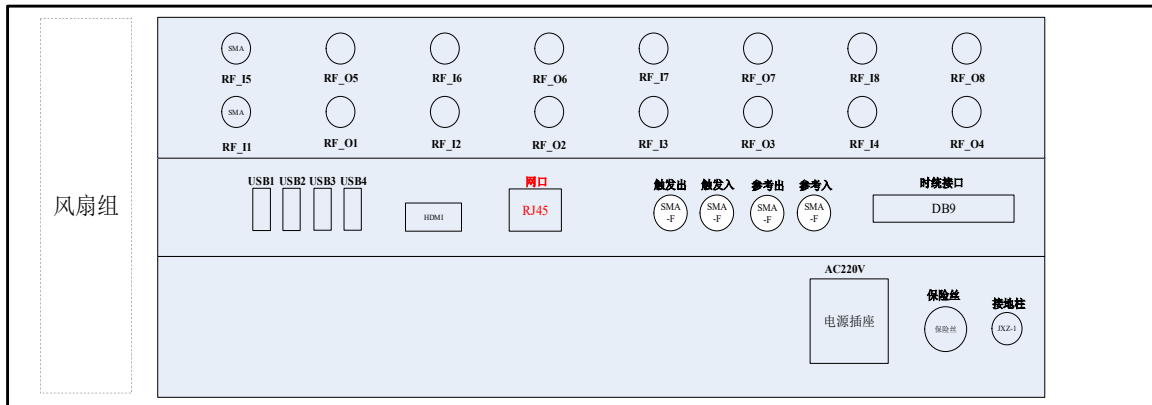


Figure 62 Schematic diagram of the device's external interfaces

Table 61 External Interface Table

| order number | Interface name | interface type | explain |
|--------------|-----------------------|-------------------------------------|--|
| 1 | RFI1~RFI8 | SMA | 8 input interfaces: The 1.5MHz~6GHz channel utilizes an SMA interface. |
| 2 | RFout1~RFout8 | SMA | 8-channel RF output interface: The 1.5MHz~6GHz channel utilizes an SMA interface. |
| 3 | gigabit Ethernet | RJ45 | 1 Gigabit Ethernet Control Interface |
| 4 | CLK IN | SMA | External 10MHz/100MHz reference clock input |
| 5 | CLK OUT | SMA | Internal 10MHz reference clock output |
| 6 | HDMI | HDMI | HD video interface |
| 7 | USB | USB | 4 USB 3.0 ports |
| 8 | source | National Standard Three-Pole Socket | 220V power input interface for the entire machine |
| 9 | TRIGIN | SMA | Trigger input, 1.8V or 3.3V TTL available |
| 10 | TRIGOUT | SMA | Trigger output, 3.3V TTL |
| 11 | time system interface | DB9 | RS422 level, used for receiving time synchronization signals |

7. Software interface display

7.1. Create Simulation

7.1.1. essential parameter

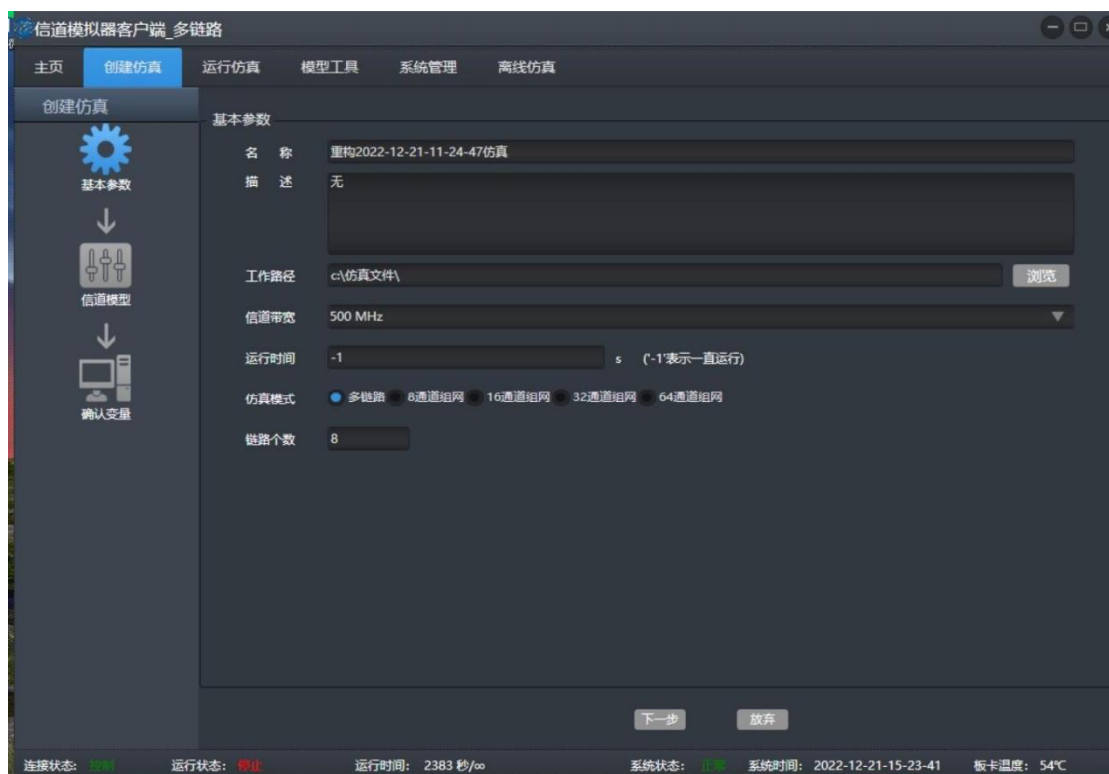


Figure 71 Basic Parameters

The basic parameter page sets the simulation parameters, with the following specific meanings.

| | | |
|----------------------|---|--|
| Interface parameters | parameter declaration | |
| name | Create a simulation file name to display during simulation run or editing. | |
| description | Brief description of the simulation file. | |
| Work path | Simulation file storage path. | |
| channel bandwidth | The simulation channel bandwidth selection supports 40 MHz, 120 MHz, 250 MHz, and 500 MHz. | |
| performance period | Simulation runtime duration. Set '-1' to run continuously until the user stops the simulation manually. | |
| simulation mode | networking | It realizes the network communication between multiple terminals. |
| | multilink | Multiple links are implemented with each link's channel characteristics individually defined, ensuring independence between links. |

1.1.1. channel model

The interface of channel model mainly sets the parameters of the simulation link such as delay, Doppler and other trajectory parameters, and the model parameters of the channel model and shadow model.

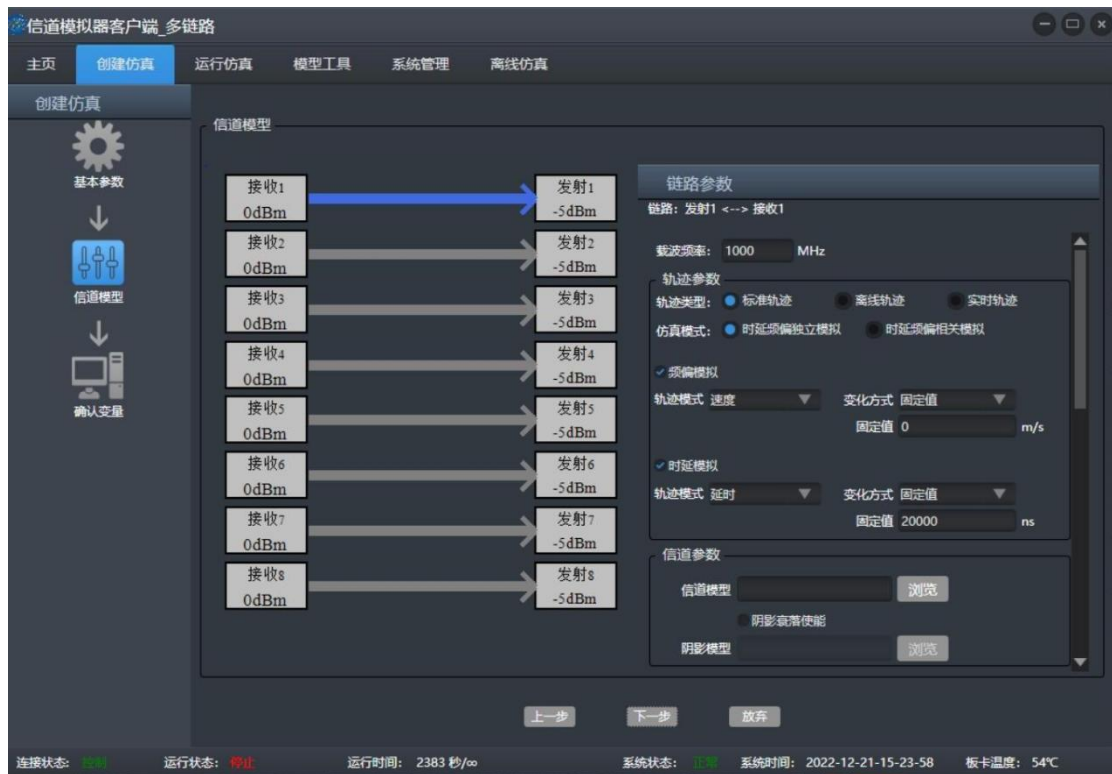


Figure 72: Channel Model Interface

The parameter descriptions are shown in the table below.

| Interface parameters | parameter declaration | |
|----------------------|-----------------------|--|
| trajectory parameter | standard track | <p>The trajectory mode supports delay, Doppler, Doppler 率 one change, Doppler 率 two change, distance, velocity, acceleration, and acceleration acceleration mode for trajectory design.</p> <p>Change modes include fixed, linear, sine, and custom.</p> |

| | | |
|-----------------------|---|--|
| | Offline trajectory | Import STK and WI software to save trajectory files. |
| channel parameter | channel model | Select a channel model or create a standard channel model. |
| | shadow model | Enable shadow fading, whether the channel model considers the shadow effect to switch; Select a shadow model or create one. |
| atmospheric parameter | The atmospheric parameters enable the channel model to consider the influence of atmospheric effects on the switch. Rain fade, set the rain fade energy; | |

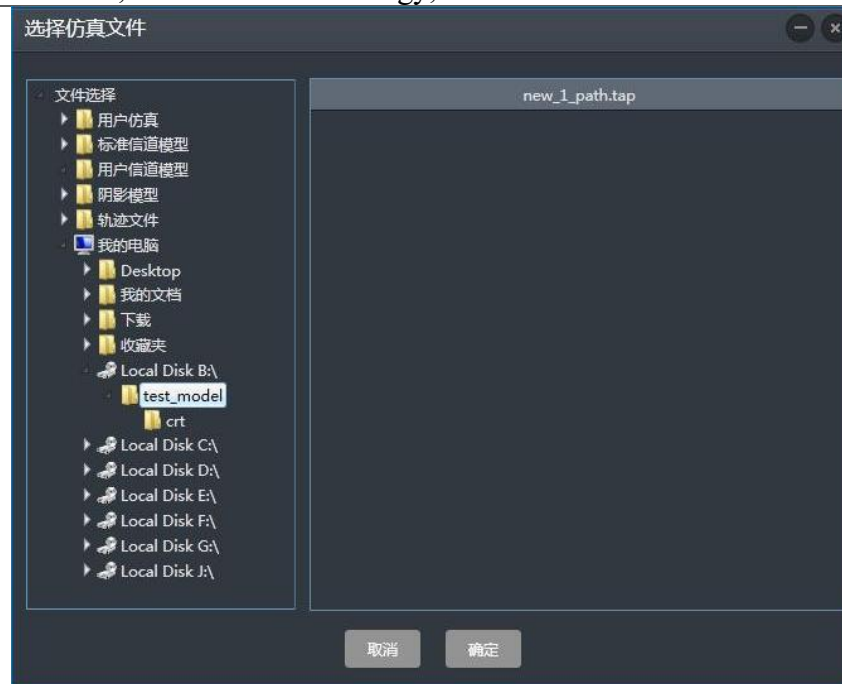


Figure 73 User-defined channel model selection

Output port, where you can set the output power, group delay, and interference parameters of this link



Figure 74 Output Port Settings

The input port power and frequency can be set in the same input port.

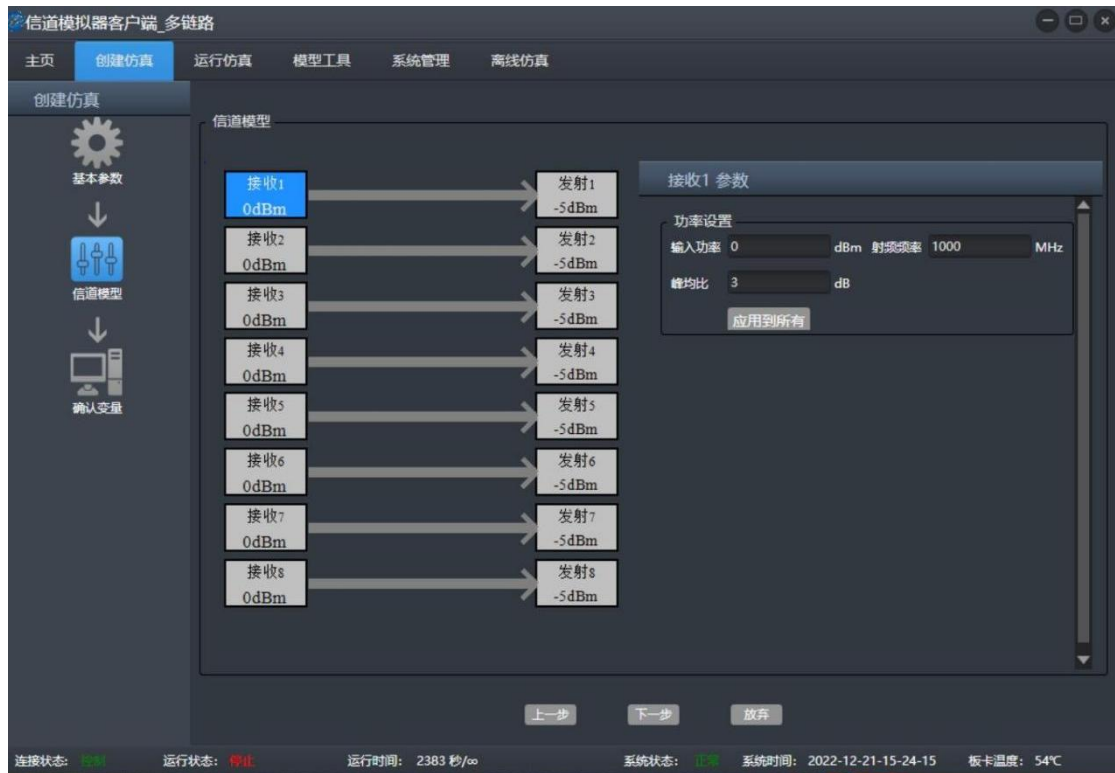


Figure 75 Input Port Settings

7.1.2. Confirm variables

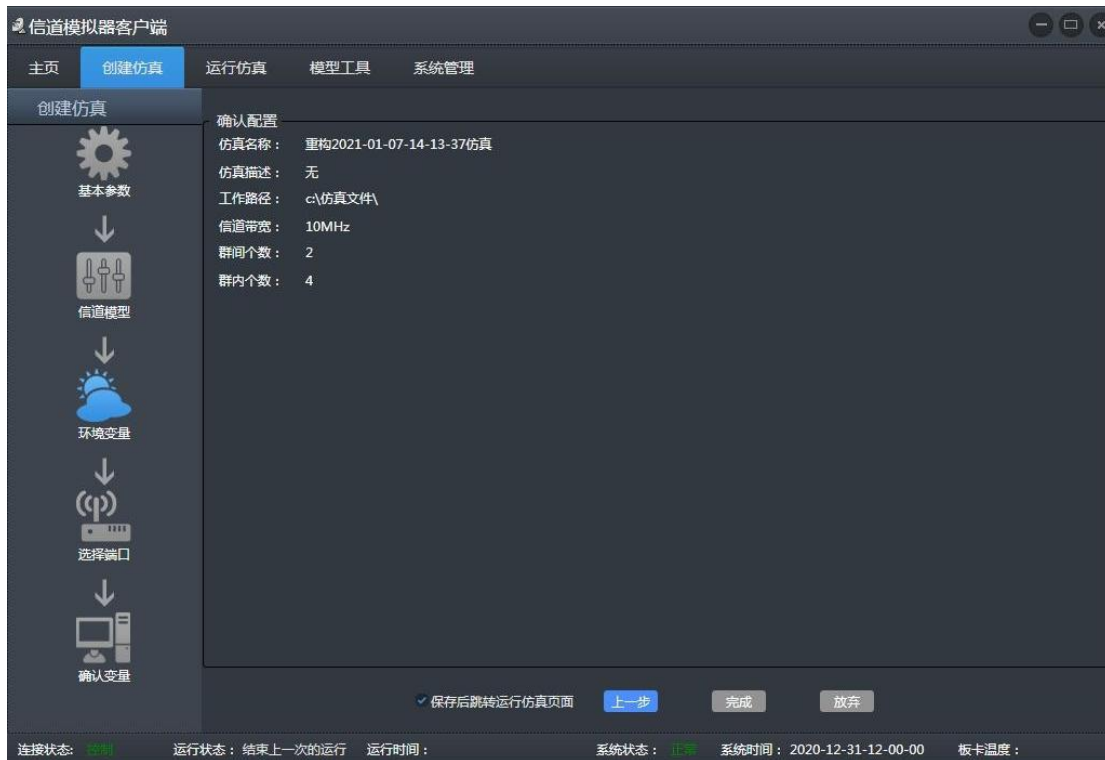


Figure 75: Confirmed variables

The confirmation variable interface is actually a summary interface where you can view most of the channel information you set up earlier. After confirmation, you can switch to the simulation interface.

7.2. run simulation

There are three ways to enter the operation simulation interface:

- ① Home, Run Simulation;
- ② Run Simulation in the menu bar;
- ③ To start the simulation, confirm the variables, and click Complete to open the simulation interface.

The simulation interface menu bar consists of functional modules: File, Operation, Simulation Settings, Window, and Log. The File module manages simulation files, including opening and closing operations. The Operation module controls the start and stop of simulation chains. The Window displays simulation settings and waveform, with the settings module allowing modification of parameters during simulation. The Window serves as the waveform display area for simulation

curves, while the Log module shows system abnormal states.

7.2.1. document






-  Open: Select the simulation file;
-  Close: Close the current open simulation file.
-  Save: Click Save to save the modified configuration for future reference.
-  Save as: Supports saving rsim files.
-  Recent files: Files you've accessed recently for quick access.







Figure 76 File Operation Icon Bar

7.2.2. operate



Figure 77: Operation Icon Bar

-  Run: Run simulation;
-  Pause: Simulates the current state without updating CIR, while hardware maintains the parameters as at the pause moment.
-  Stop: End this simulation;
-  Trigger settings: Choose from multiple trigger modes (default, network, external, or scheduled) based on user requirements.

7.2.3. Simulation Settings

The link can modify the 率 signal center frequency, trajectory parameters, channel model and atmospheric parameters.

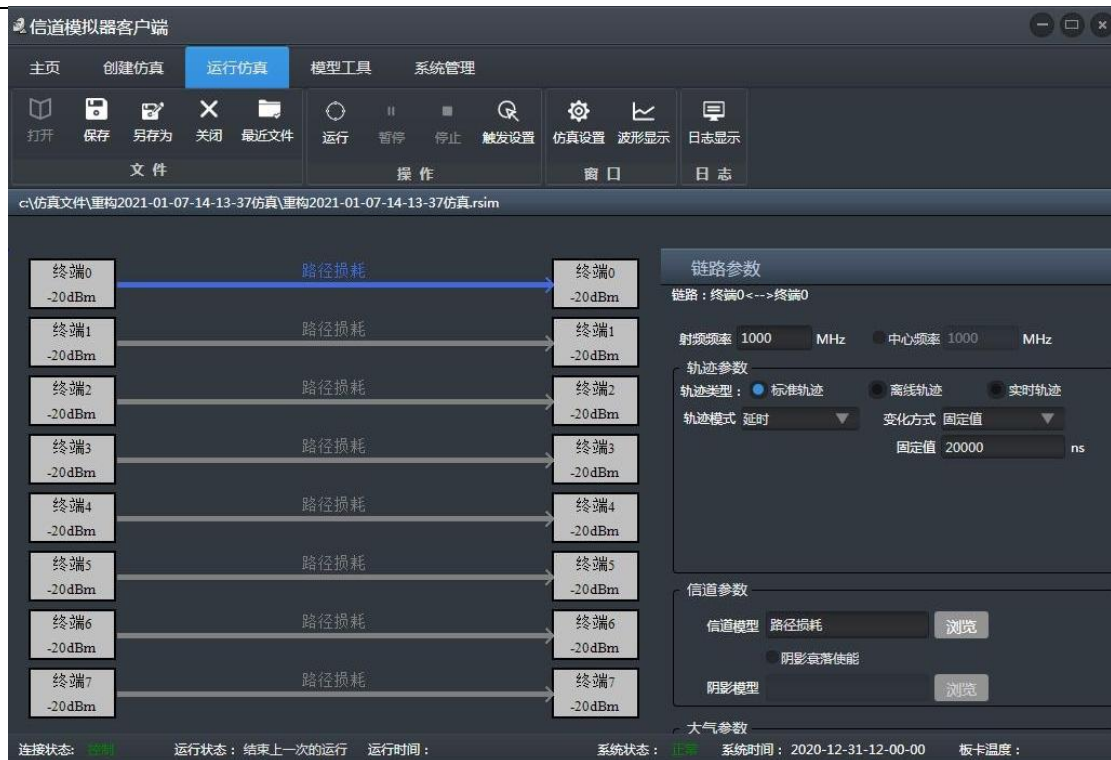


Figure 78: Operation Simulation Parameter Link Configuration Interface

The input port can set the power of the channel simulator input port.



Figure 79: Input settings boundary for operational simulation parameters

The output port can set the power of the input port of the channel simulator.



Figure 710: Output settings interface for operational simulation parameters

7.2.4. waveform display








Figure 711 Waveform display

The shortcut icon "Waveform Display" switches to the Run Simulation> Waveform Display interface. In the View menu bar, click "Chart Layout"> "Add Chart" to customize the display page layout.

7.3. Model Tools

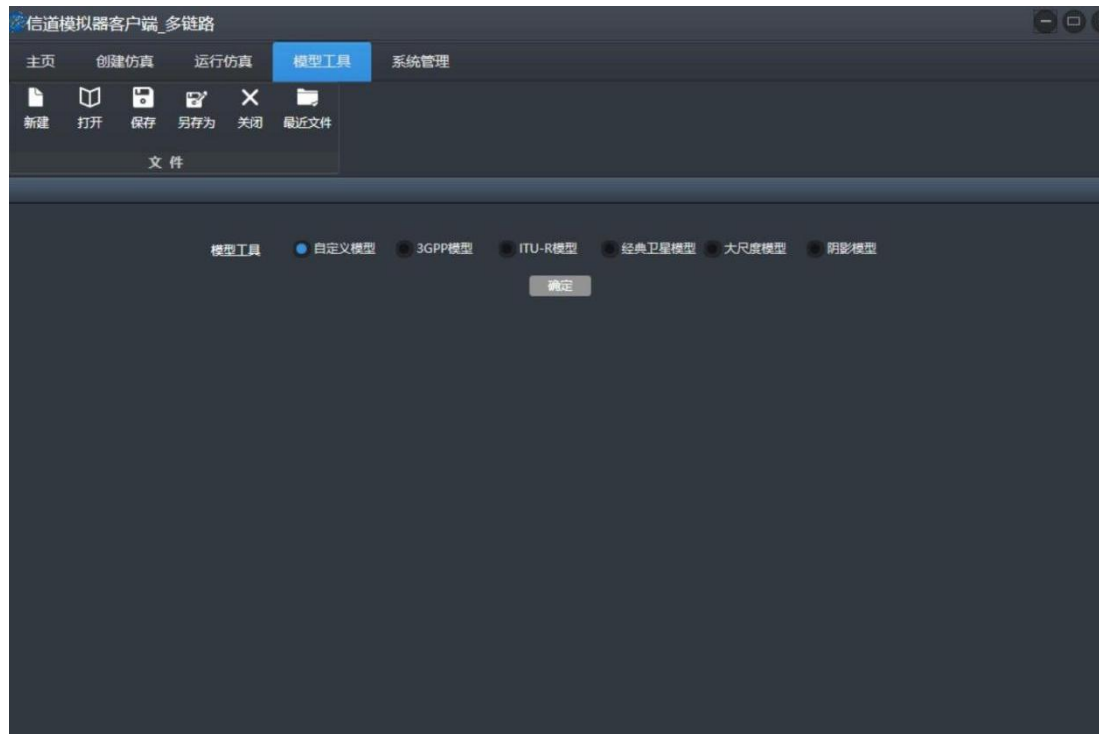
Model tools create or edit channel models and shadow models.

7.3.1. document

-  Open: Select the simulation file;
-  Close: Close the current open simulation file.
-  Save: Click Save to save the modified configuration.
-  Save as: Supports saving rsim files.
-  Recent files: Files you've accessed recently for quick access.

7.3.2. Custom Model (.tap)

Go to File> New, as shown below



Create a new 712 model tool

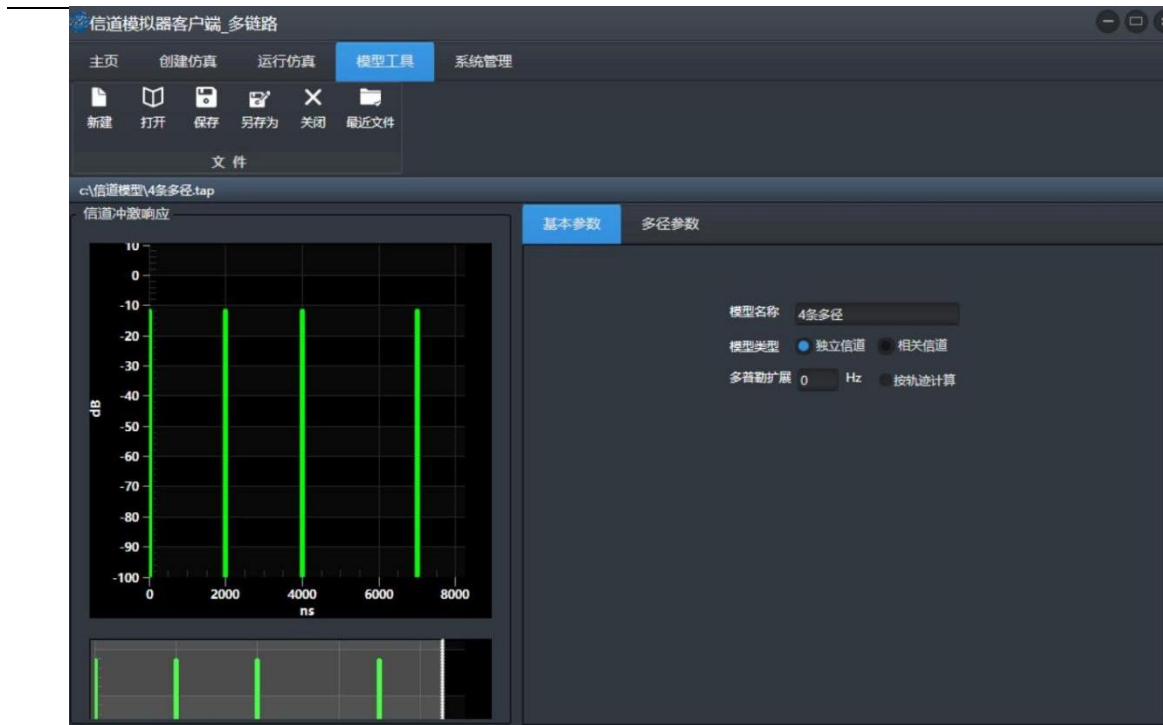


Figure 713: Model Tool-New Channel Model Basic Parameters Interface

The interface of the new channel model created by the model tool is divided into three parts: the model file path display area, the channel impulse response schematic display area, and the interface parameter display area. The interface parameters are introduced as follows.

| Interface parameters | | parameter declaration |
|----------------------------------|-------------------|--|
| es | Model name | Create channel model name |
| se nti al pa ra m | types of models | An independent channel refers to a channel without correlation; this function is selected when the simulated channels exhibit correlation, and can be adjusted based on the degree of correlation. Edit the corresponding channel correlation matrix in the radius parameters (this feature is retained in the current version) |
| et | Doppler expansion | The maximum Doppler spread is 500KHz. If you select trajectory calculation, set this parameter. The set value is invalid. The extended value is calculated based on |

| | | |
|----|--|-----------------------------------|
| er | | the actual trajectory parameters. |
|----|--|-----------------------------------|

maximum of 24 routes supported. Select a route and click "Edit" to modify its parameters.

After editing, click OK to save. The relevant parameters in the multipath parameter editing interface are as follows:

| Interface parameters | | parameter declaration |
|----------------------|---|---|
| multipath parameter | path delay | Supports three multipath relative delay methods: fixed, linear, and sine, with multipath relative. Maximum delay: 20us |
| | average amplitude attenuation | Supports three multipath amplitude attenuation modes: fixed, linear, and sine, with an attenuation range. 0—60dB |
| | decline model | It provides four fading modes: direct, Rayleigh fading, Rice fading, and pure Doppler. |
| | angle of arrival | The angle between the direction of the incoming wave and the receiver's movement direction ranges from -180° to 180° . 180° |
| | direct and scattered work 率compare | The ratio of the direct-view diameter 率 to the average power of other diameters, where a smaller value indicates stronger direct-view diameter. |
| | phase deviation | Phase difference between multipaths, range -180° to 180° |
| | | |

| | | |
|--|----------------------------|---|
| | correlation characteristic | <p>You can browse or edit the photo only after selecting the relevant channel in the basic parameters.</p> <p>Guan matrix</p> |
|--|----------------------------|---|

7.3.3. Shadow Model (.shd)

Go to the New menu, as shown below.

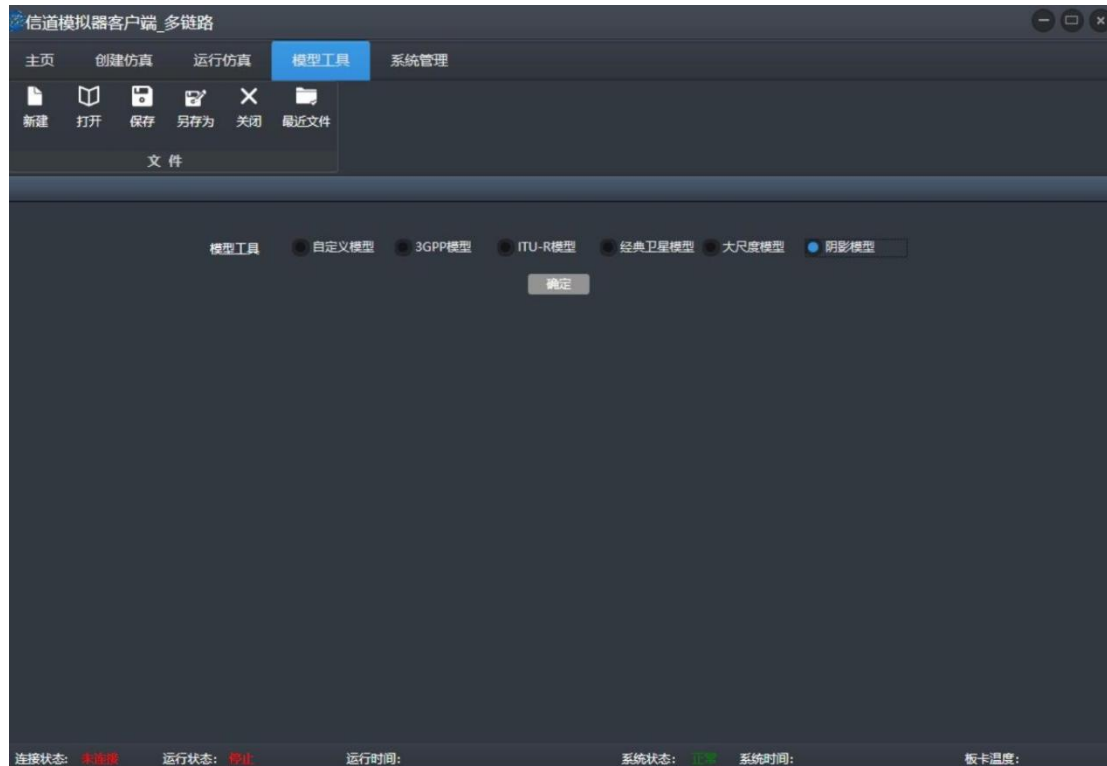


Figure 716: Multipath Parameter Editing Interface for Channel Model

Select a model type, click OK, and the new model interface will appear as shown below

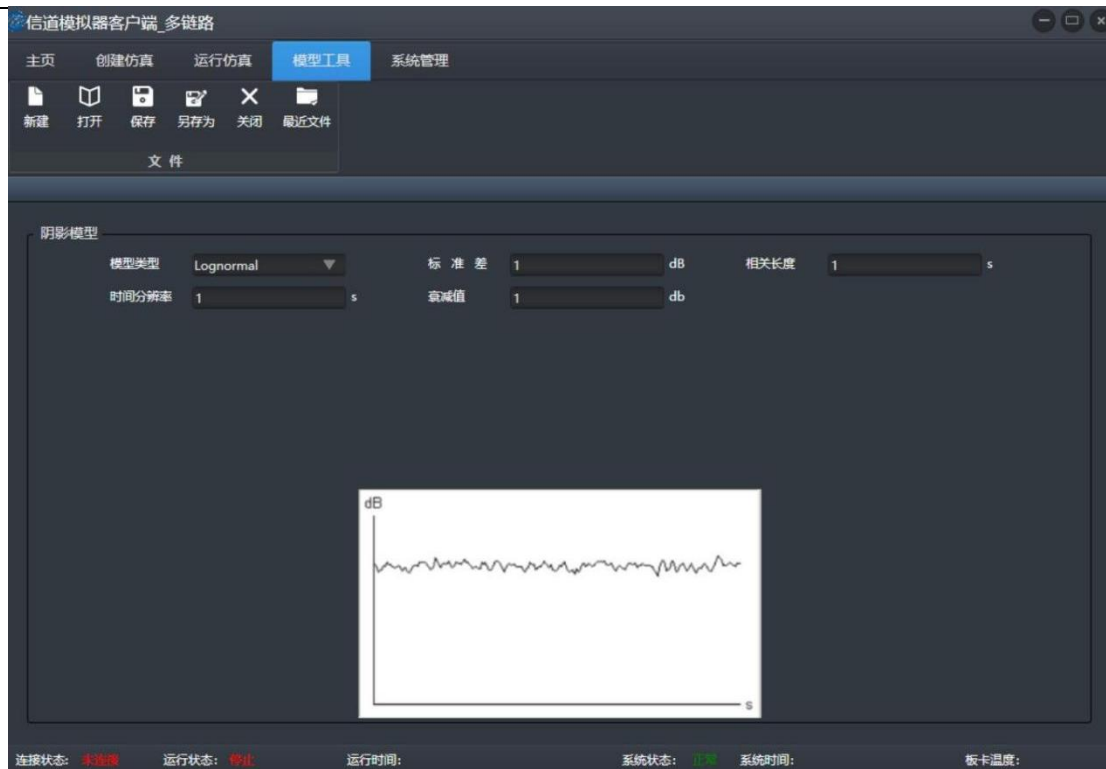


Figure 717 Shadow Model Editing Interface

After editing the shadow model, click Save to save it, or click Save As to choose a path.

Shadow Model Parameter Description

| | |
|----------------------|---|
| Interface parameters | parameter declaration |
| Model name | Edit the shadow model name |
| types of models | The shadow model supports five types: Lognormal, Sawtooth, Sine, Triangle, and Custom. Shadow types and corresponding simple diagrams are available in the workspace during setup. |
| time resolution | Keep. The configuration will be 率 updated and unified when needed. |

Lognormal parameter configuration

| | |
|--------------------|--|
| standard deviation | Describe the distribution of decay values. A larger value indicates a greater deviation from the average. |
| Relevant length | Describe the time correlation of the Lognormal model. The average decay of Lognormal depends on Standard deviation (retained) |

Parameter configuration of sawtooth wave and triangular wave

| | |
|----------------|--|
| origin | Describe the initial value of shadow model attenuation |
| terminal point | Describe the maximum attenuation value for this shadow model setting |
| period | The complete cycle time of a sawtooth wave or triangular wave |

Sinusoidal wave parameter configuration

| | |
|--------|--|
| mean | Mean value of sine shadow attenuation amplitude |
| range | The magnitude of variation above and below the mean |
| period | The time it takes for a sine wave to complete one full cycle |
| epoch | Initial phase of the sine wave variation |

Custom shadow models can be set directly on the interface as shown in the figure below, or imported from external data.

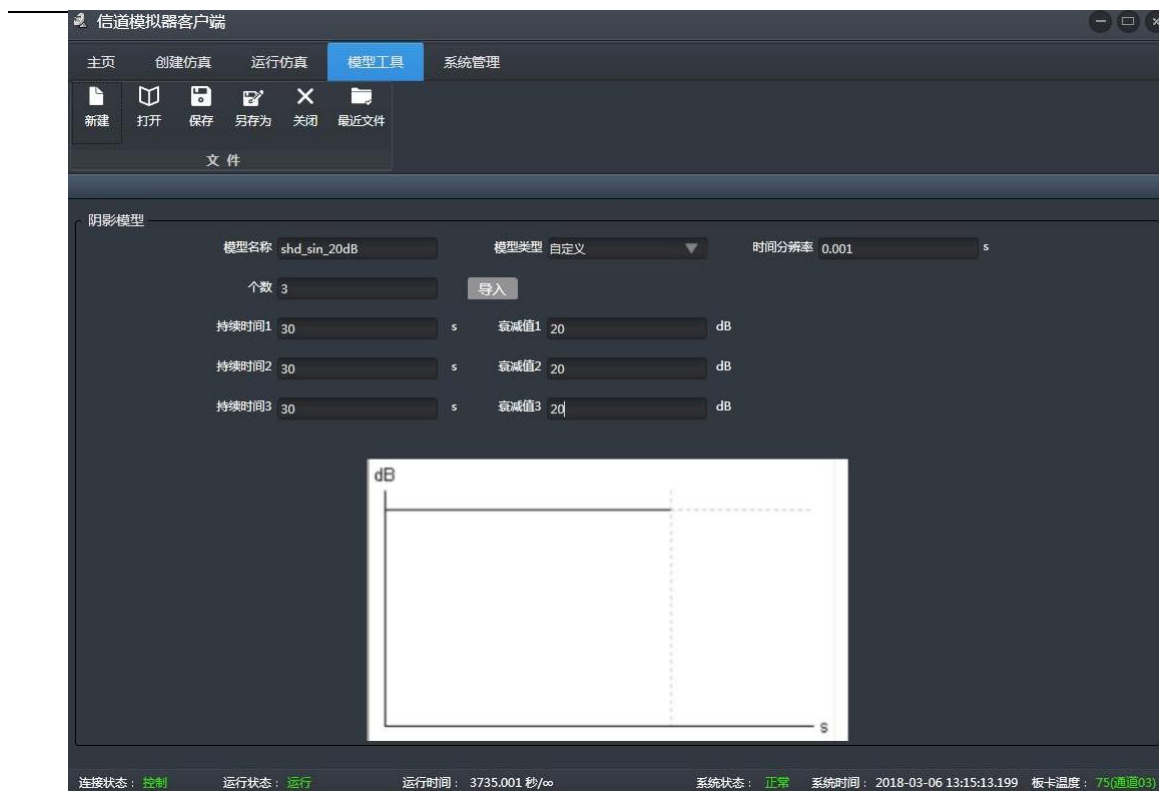


Figure 718 Custom Shadow Model Editing Interface

7.3.4. 3GPP model (.gpp)

Click the New menu, as shown below.

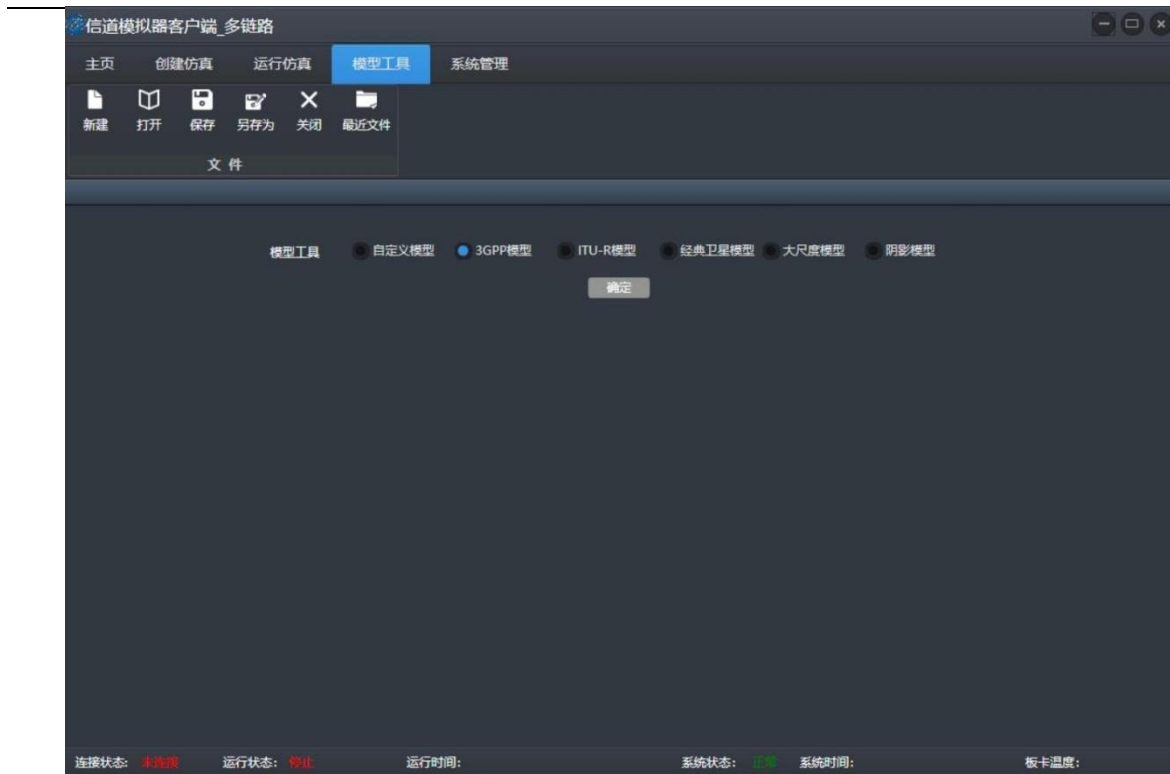


Figure 719 3GPP New Interface

The 3GPP model comprises two types: 3GPP-CDL and 3GPP-TDL.

The 3GPP-CDL is categorized into: CDL_A, CDL_B, CDL_C, and CDL_D.

3GPP-TDL is categorized into four types: TDL_A, TDL_B, TDL_C, and TDL_D.

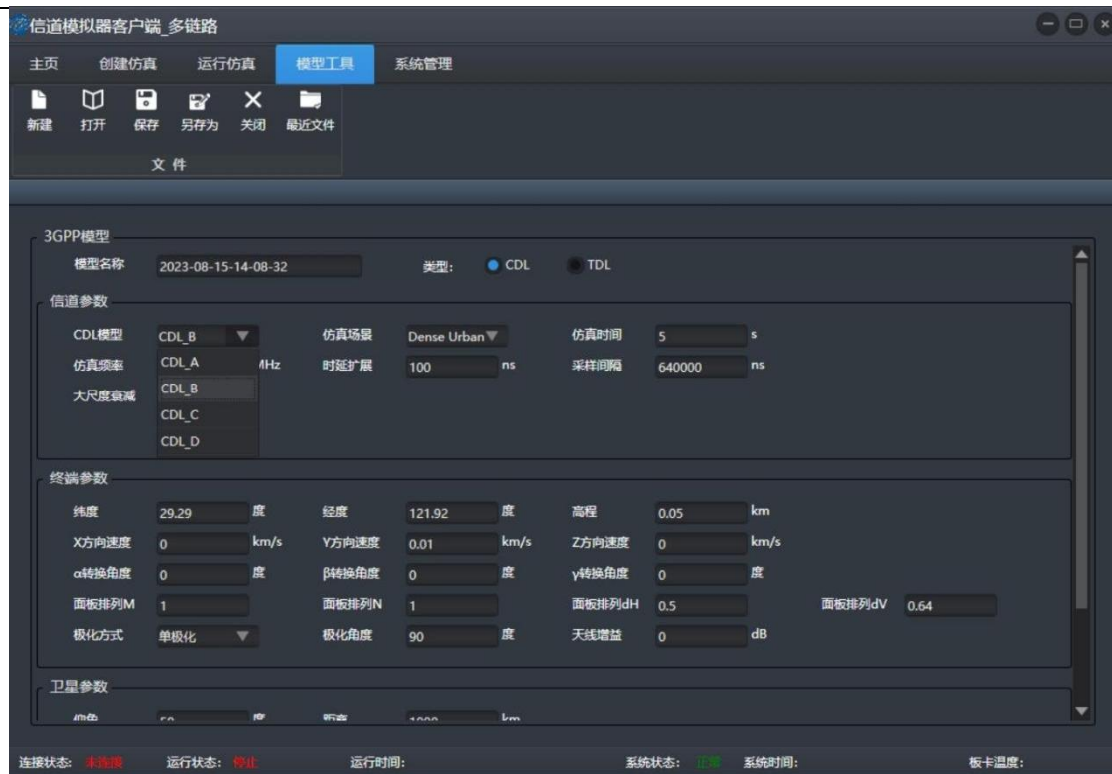


Figure 720 CDL type

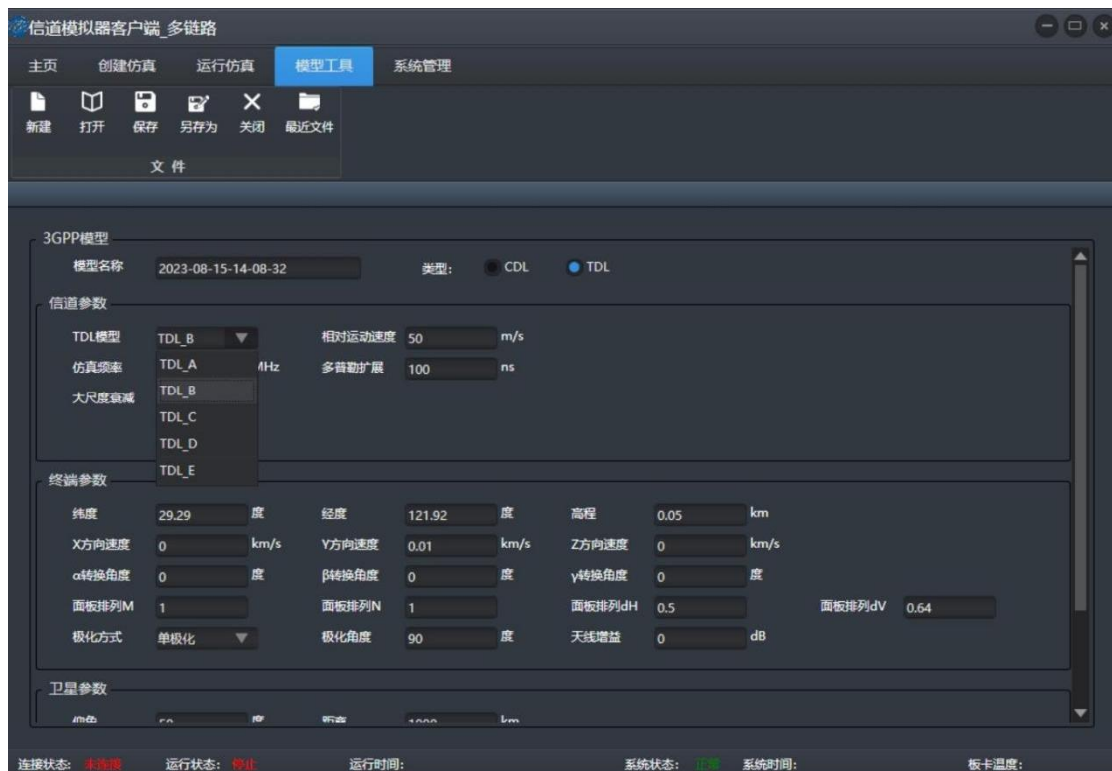


Figure 721 TDL type

The parameters include channel parameters, terminal parameters and satellite parameters.

7.3.5. ITU-R Space Terrestrial Link Transport Model (ITU-R)

Click the New menu, as shown below.

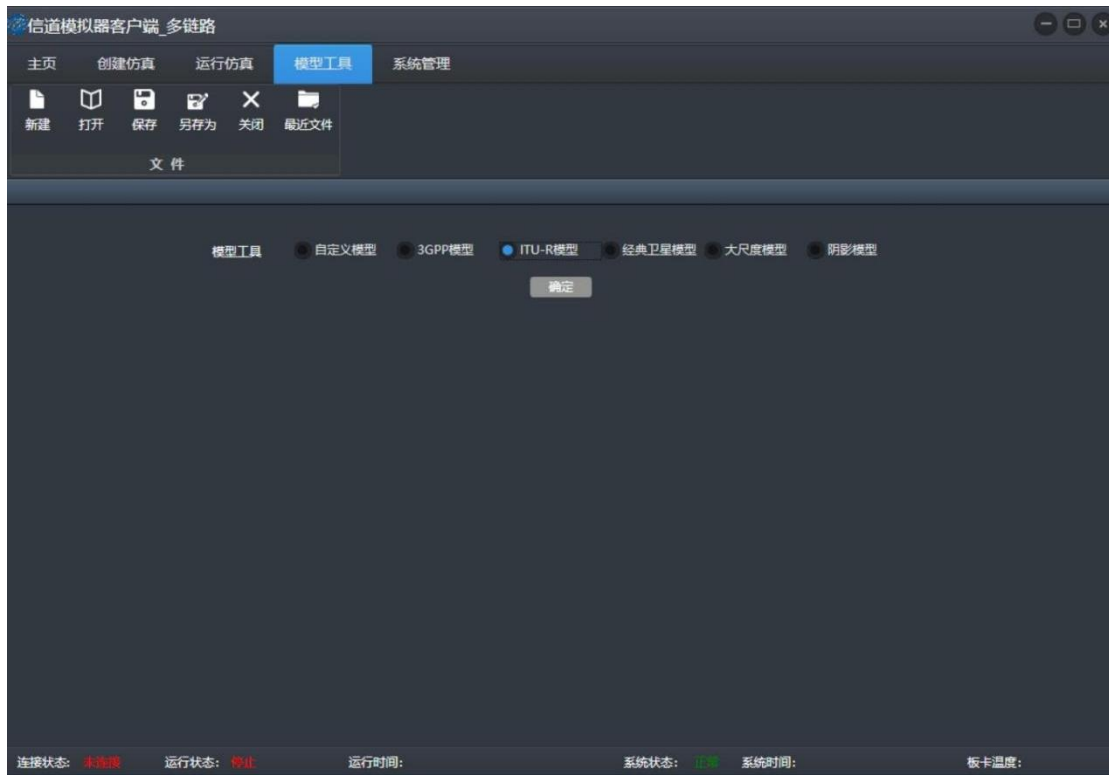


Figure 722 RTU-R Space-to-Earth Link Model New Interface

The RTU-R space-ground link model is classified into: P.618, P.619, P.676, P.681

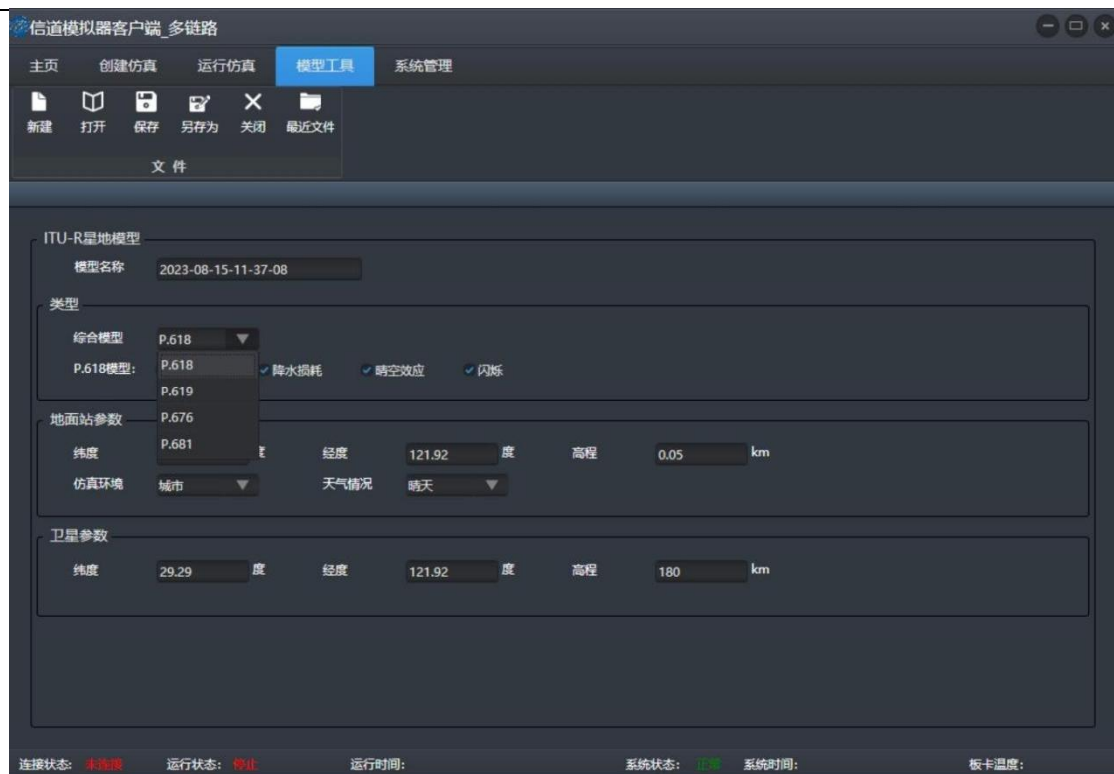


Figure 723 Classification of RTU-R Space-to-Earth Link Models

The parameters include: type, ground station parameters and satellite parameters.

7.3.6. Classic Satellite Model (.cla)

Go to the New menu, as shown below.

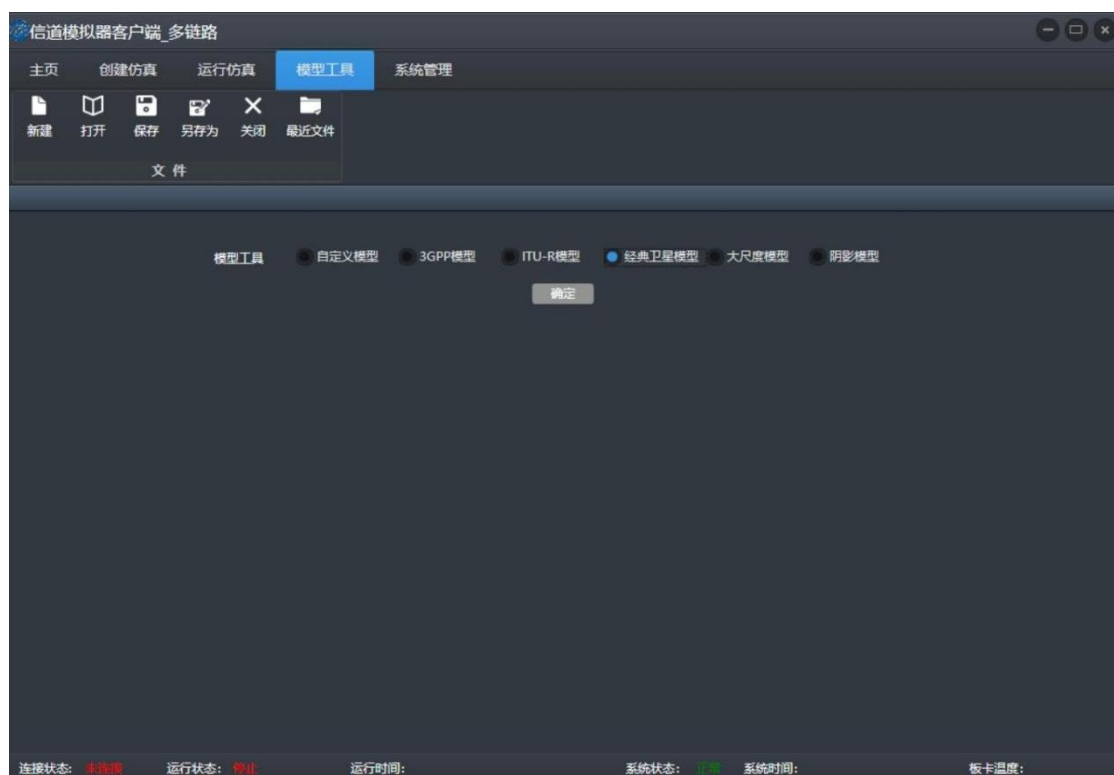


Figure 724 Classic Satellite Model

The classic satellite models include: Loo, Corazza, Abdi, Lutz, and LRR.

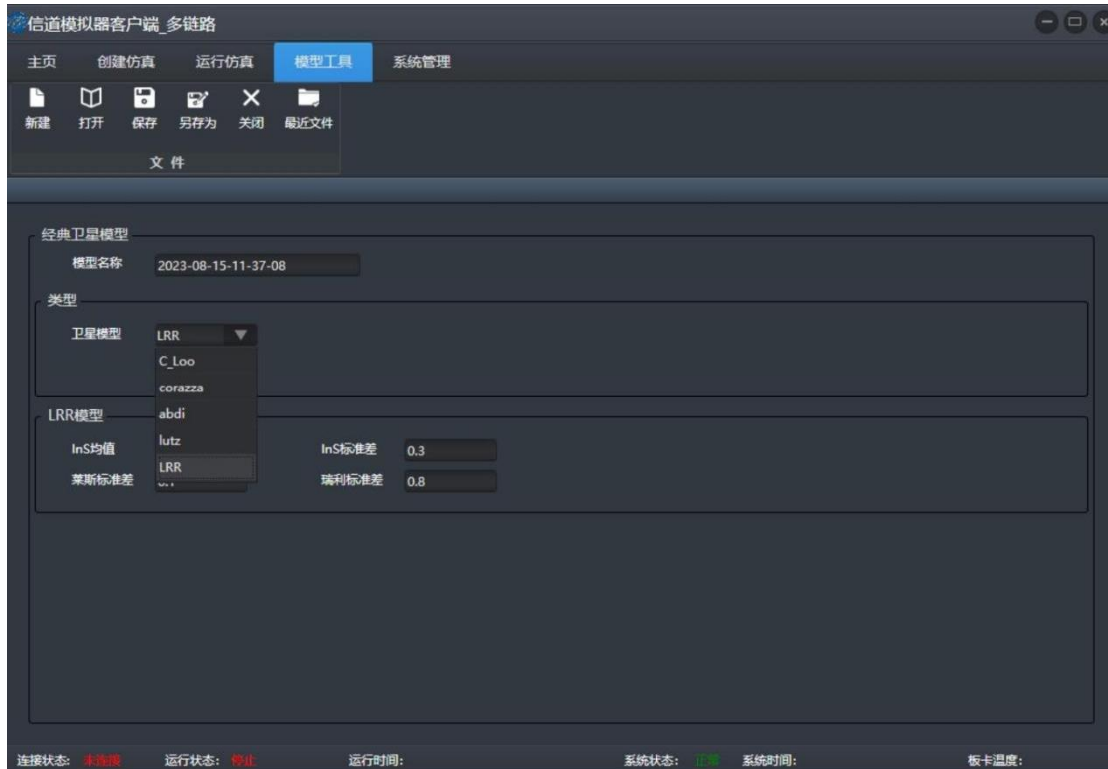


Figure 725 Classification of Classic Satellite Models
 Parameter settings include type and LRR model.

7.3.7. COST207-large scale model (.lar)

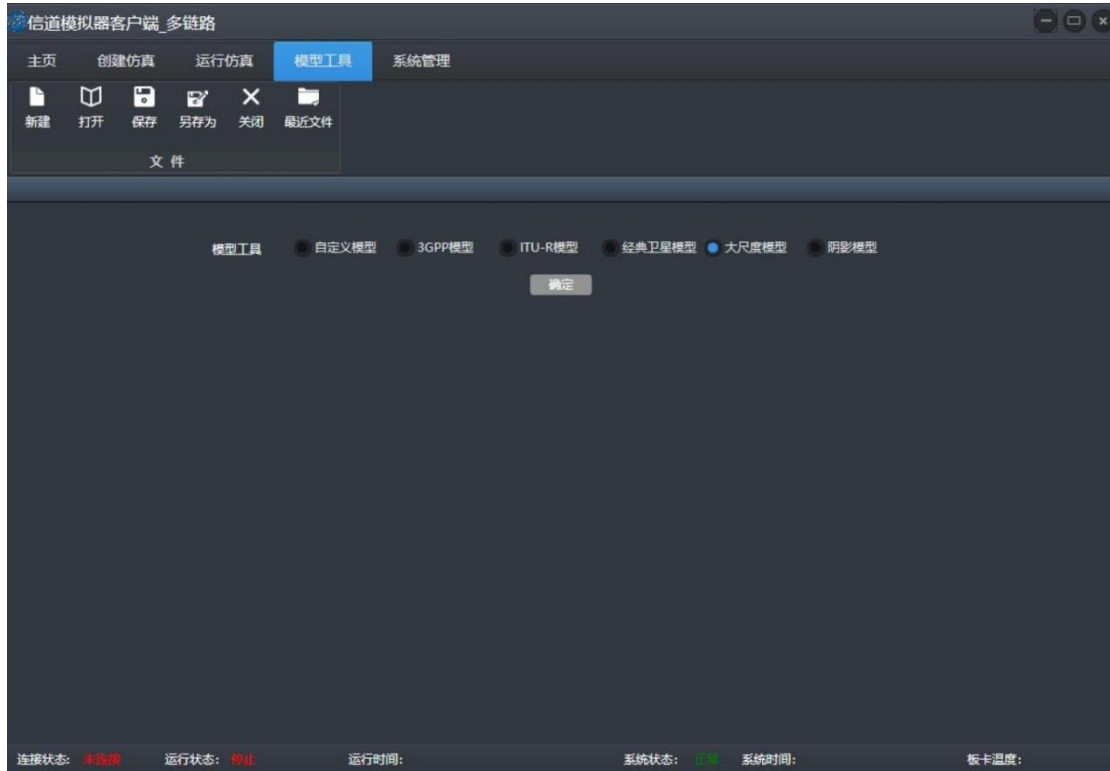


Figure 726 COST-207 Large-scale fading model

COST-207 Large-scale fading model classification parameter setting

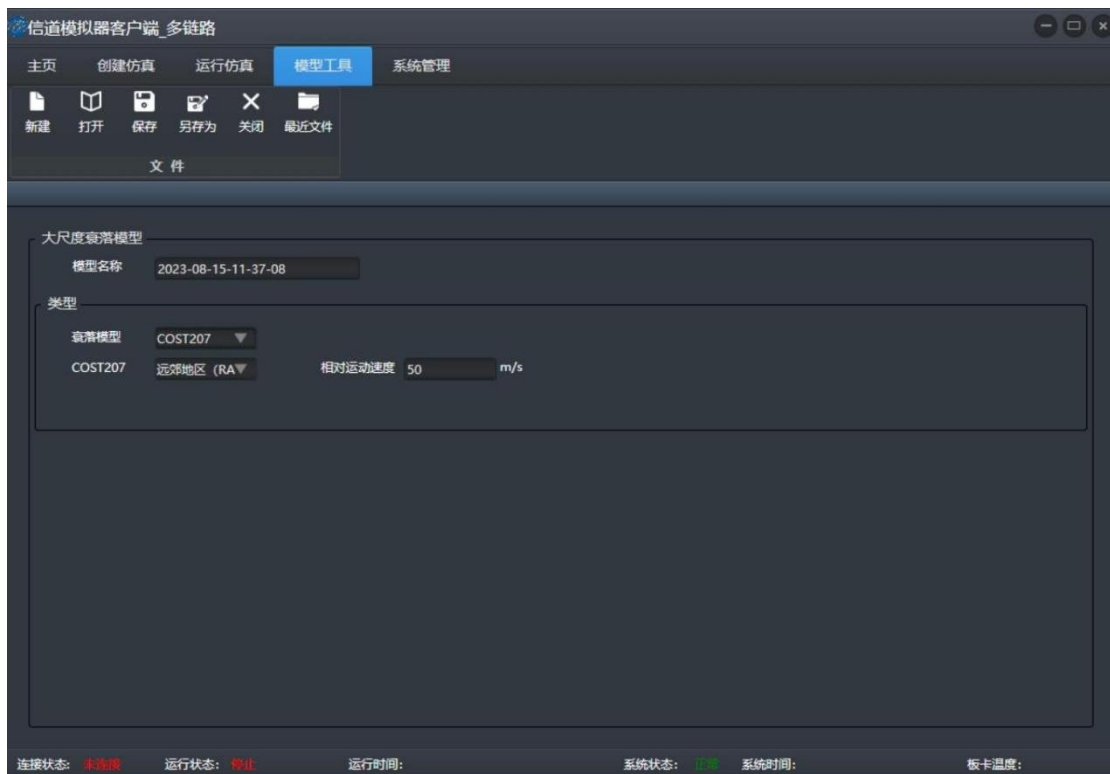


Figure 727 COST-207 Large-scale fading model

7.4. real-time trajectory

The system can process real-time data from third-party software and transmit satellite-to-ground link data, simulating the actual radio frequency link between satellites and ground stations.

7.4.1. channel software settings

Select 'Real-time Trace' in the link parameter field to configure input/output port frequency and power.

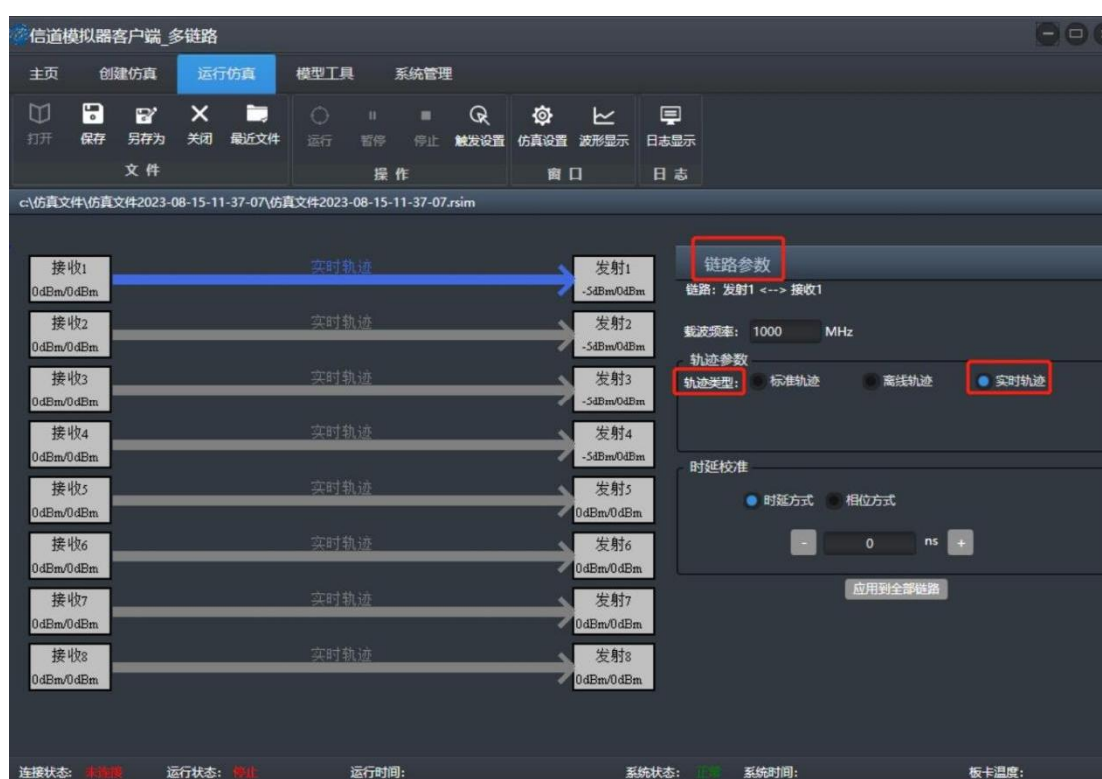


Figure 728 Real-time Trajectory Settings Page

7.4.2. Third-party software settings

Create a scene and add satellites, ground stations, user terminals, antennas, and links. The number of added links and center frequency must match the settings in the channel simulator software.

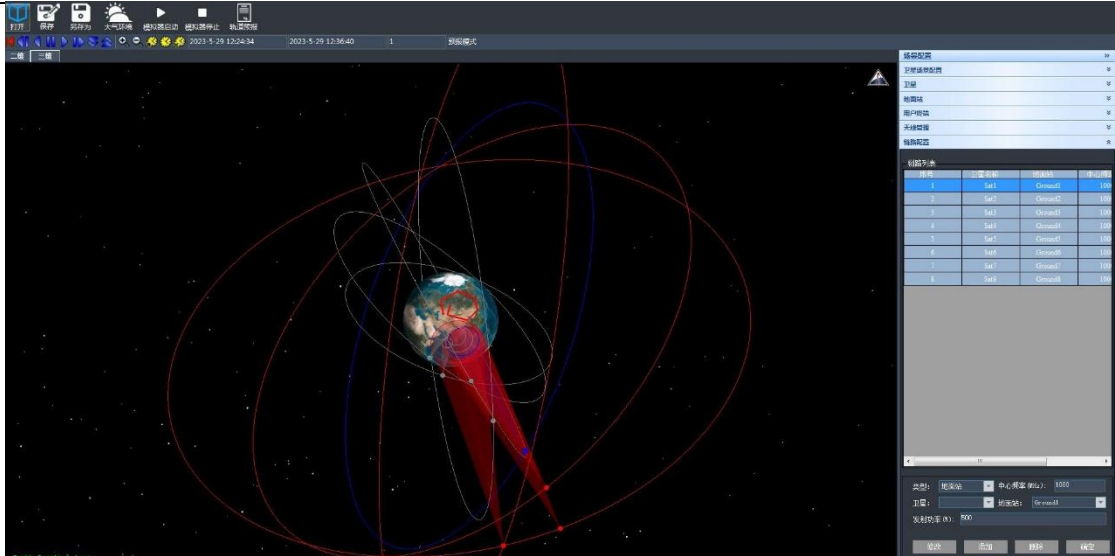


Figure 729 Third-party software settings page



RuiXinFeng Aerospace Technology (Beijing) Co., Ltd.
Rinfon Aerospace Technology (Beijing) Co., Ltd.

Address: Room 502,5th Floor, Building 41, No.8, Dongbeiwang West Road, Haidian
District, Beijing, China