Piezo · Nano · Positioning

news

Issue 37

Technology that gets under your skin

Ultrasonic piezo linear drives—new application in non-invasive medical technology

In medical engineering, modern PILine® ultrasonic piezo linear drives are opening up applications which were impossible using classic electric motor leadscrew systems. Due to the piezoelectric effect and the direct creation of linear motion, PILine® drives are not only faster, lighter and more compact than conventional motorized drives, but they can also be made non-magnetic. They achieve resolutions of 20 nm (0.02 µm) and velocities of up to 1 m/s. Their travel range is basically unlimited, and they are available in a number of different integration levels to match the desired (OEM) application. Medical engineering provides an up-to-date example.

Piezo technology enables fast, compact, high-resolution OCT scanner

In addition to the classic, invasive, punch biopsy technique, there are a number of only partially satisfactory non-invasive procedures in clinical and cosmetic research for properly categorizing skin changes. Those based on ultrasound do not provide good resolution, and confocal microscopy cannot penetrate sufficiently below the epidermis. Now, however, there is a practical alternative: the new SkinDex scanner – developed by ISIS Optronics in Mannheim, Germany – combines the advantages of ultrasound and confocal microscopy.

Continued on page 2

Contents: Page

Continued from page 1

The SkinDex scanner is based on the technology of optical coherence tomography (OCT) and examines the tissue on and under the skin surface non-invasively. The results obtained are extraordinary. The information contained in the 2-D and 3-D sectional images is comparable to that of a histological examination.

OCT uses the basic transparency of skin together with the interference fringes obtainable with white light. The optical paths are made up of optical fibers.

Exact positioning for precise results

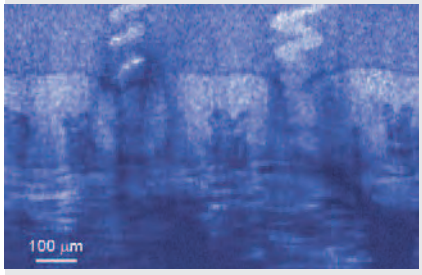
To enable creation of 2- and 3-dimensional images from interference patterns, the optical fibers must be moved both axially and laterally during the scan. This task requires positioners capable of the highest precision. Ultimately, it is the performance of the drives which determine the system resolution and hence the quality of the images.

A PILine® P-661 OEM motor is used to position the reference-arm mirror (depth parameter). This motor was chosen primarily because of its compact design and, considering its size, its high force capacity of 2 newtons (0.5 lbf). Total travel is 2 mm, the position resolution in this application 30 nm (0.03 µm, 1.18 micro-inch).

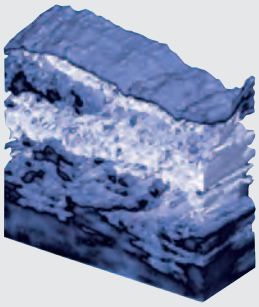
As the images are recorded sequentially, the high speed and excellent dynamic response of the drive is a great advantage. As a result, the SkinDex needs only a few seconds to generate its highly informative images. The lateral motions of the optical fibers in the sensing arm executing the surface scan are also performed by a PI drive.

In this case it is a PIHera® P-622.2CD, a flexure-guided, 2-axis, piezo nanopositioning system, which provides a resolution of 1 nm (0.001 µm, 0.04 µ-inch) and covers an area of 250 x 250 µm. Piezo-based drives have thus again contributed to an innovation from which many people will benefit in the future.

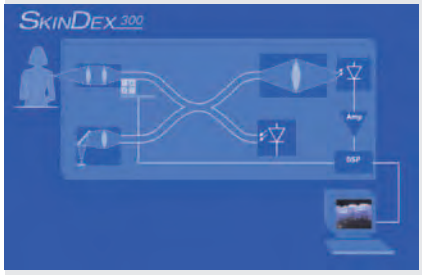
The SkinDex scanner based on OCT technology for non-invasive but reliable examination of the tissue on and under the skin surface (photo ISIS Optronics).



A look under the skin of the ball of the thumb. Even the untrained eye can recognize the spiral-shaped sweat-gland ducts.

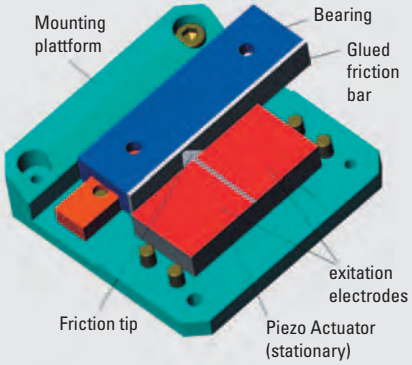


3-D OCT image: Individual laminar and cylindrical structures such as larger blood vessels are visible under the rough skin surface.



White-light interferometry is the basis of OCT. Using optical fibers, light is divided into a sensing and a reference beam. After being reflected by the target (i.e., a cutaneous structure) and the reference mirror respectively, the beams are recombined and enter the detector. An interference signal pattern results (photo: ISIS Optronics).

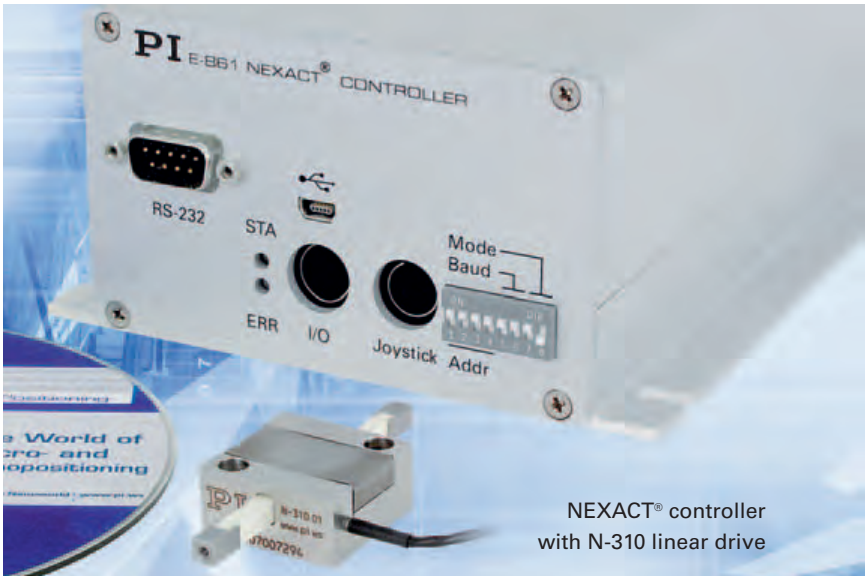
Integration levels in PILine® ultrasonic motor technology: from 8-millimeter drives, through the successful Rod-Drive linear drive, to integrated multi-axis systems.



Working principle of an ultrasonic piezo drive.

NEXACT® Linear Drive Controller

Operate piezo stepping linear motors with proven Mercury™ flexibility



NEXACT® controller with N-310 linear drive

NEXACT® PiezoWalk®

The patented NEXACT® PiezoWalk® stepping drives are distinguished by high speed, long travel ranges, and high force generation of more than 10 N combined with compact size. These stepping drives feature a highly stable autolock mode with a holding force actually higher than the drive force. This means that once a target position is reached, the servo-loop is quiescent, eliminating holding currents and servo dither which could contribute to heat generation and drift. Additional features include:

- Position Resolution in the Sub-Nanometer Range.
- Analog mode providing up to 7 µm of smooth, high-dynamics motion at any position, e.g. for fast scanning or active vibration compensation.

The new E-861 controller was designed for the simple setup and automation of NEXACT® piezo stepping linear motors. The E-861 is based on the successful Mercury™ controller series (see box) which stands out for its high performance, simple operation and low price.

Running piezo stepping drives is somewhat more complex than driving classical DC motors. The stepping motions of the multiple piezo actuators integrated in the NEXACT® modules are coordinated by a DSP (digital signal processor) and, using a special algorithm, output through a sophisticated amplifier front-end.

The E-861 can be run in open- and closed-loop. For closed-loop operation, a high-resolution linear encoder input is provided, backed up by the required DSP processing power. For open-loop-operation, step size, count and frequency can be set by software. Velocity of 10 mm/s and more with nanometer resolution are obtained.

Mercury™ Class Controllers

With the new generation of Mercury™ controllers, PI offers economical system components for various mechanical drives. Over the last decade Mercury™ class controllers have found many fans around the world. The 3rd generation now provides an even wider range of features with added operating convenience for both stepper motors (C-663) and DC motors (C-863).

Features including:

- Stand-Alone Operation (no PC required)
- Joystick Interface
- Networking for multi-axis applications
- USB + Classical RS-232 interface
- Digital I/O Lines
- Macro Functionality

The E-861 NEXACT® controller incorporates the same core as the Mercury™ series, as will the forthcoming C-867 PILine® ultrasonic piezomotor controller.

Of course, all Mercury™ based controllers can be internetworked and controlled with the same command structure.

The fastest microscope objective nanopositioner

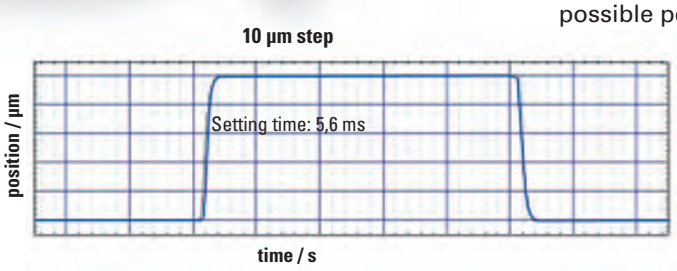
P-726 high-power PIFOC®

PI has extended its successful PIFOC® line of objective nanopositioners with a new, high-power unit. The P-726 PIFOC® can move heavy, high-NA objectives (>200 g, 7 oz) faster than any other system currently available, with accuracies of 1 nm over a travel range of 100 µm.

Here, the convincing performance specifications – achieved with a load of 300 g (11 oz): The E-726 can be operated with a variety of controllers ranging from the economical E-621 card, the E-625 controller to a number of digital controllers for the highest possible performance.

- Resonant frequency: 430 Hz (with 300 g), 1100 Hz without objective
- Closed-loop position noise: <0.4 nm
- Position stability over 100 s: 4 nm
- Maximum operating frequency (amplitude <10 µm): 150 Hz*
- Maximum operating frequency with full travel (100 µm): 60 Hz*
- Settling time (10 µm steps): 6 ms**
- Settling time (full travel): 15 ms**

* Amplifier power limited. Higher performance with E-505, 200 W power module
** Faster settling with smaller load



Settling behavior of the P-726 for a 10 µm step.

Mercury™ DC motor controllers

The third generation

Micropositioning systems driven with Mercury™ controllers make an especially cost-effective automation solution.

The well-proven, single-channel Mercury™ for micropositioning stages with DC motors has undergone a facelift and been improved in a number of areas. The new model, the C-863 is fully compatible with the previous generation devices, and can thus be operated in mixed multi-axis systems.

The C-863 and stages of the M-403, M-414 and related series can be combined to provide particularly economical positioning solutions.

Features:

- USB- and RS-232 interfaces, more flexibility
- Encoder counting rate raised to 20 MHz, making highly precise positioning possible even at higher speeds.
- Stand-alone operation without run-time PC connection using easily created and edited macros, stored in the controller.
- Supports PI GCS Code as well as the classical Mercury™ command set
- Multi-axis operation: Up to 16 Mercury™ Class controllers can be networked, including any combination of new C-863s, C-862s (predecessor) and C-663s (stepper motor version).
- Flexible automation using digital I/O lines, for example for intrasystem communication in stand-alone mode.
- Manual control via directly connected joystick.
- Up to 30 V output voltage for high-power motors (power supply dependent)

Vacuum compatible high-load Hexapod moves loads up to 1 ton with micron accuracy

Heavy-duty motion in 6 axes

The M-850K high-load Hexapod is proof of the fact that the parallel kinematics design can also provide extraordinary position-accuracy performance with very high loads.

Equipped with six brushless motors, this Hexapod can move masses of up to one metric ton with never-before-attained accuracy. It has a minimum incremental motion of down to 1 µm in all motion directions over the entire travel of 24 mm; angular moves of up to 8° can be executed in minimum increments as small as 5 µrad (1 arcsecond). Designed for vacuum operation, it is equipped with brakes, allowing any position to be held indefinitely with no current flow to cause heat.

Hexapod Applications

PI Hexapods are being used for positioning tasks requiring extreme accuracy in research and industry. Applications range from the unfathomable to the microscopic: from astronomy to medicine or basic research, like experiments on centrifuges.

Whether in coarse or fine adjustment, the freely definable pivot point remains fixed, independent of the positions of the linear axes. All positions are programmed directly in Cartesian coordinates and processed by a high-performance digital controller. The controller and software are fully compatible with most other PI positioning systems.

Wide Performance Spectrum

Since PI built the first Hexapods for precision optics applications in the early 1990s, the performance spectrum of these devices has been continuously expanded.
The lower end, in terms of load capacity, is represented by the recently introduced M-810 mini-Hexapod, while currently a system for loads of up to 3 tons is being developed.

Further Advantages of PKM

The parallel kinematics design of the Hexapods, in addition to providing very high accuracy, also has other advantages like the large central aperture, low inertia and better, axis-independent dynamics.

New Multi-Axis Piezo Controller Provides Higher Precision, Flexibility

Digitally Controlling the Nano-World – in up to 6 Axes

The new, E-712 multi-axis piezo-controller picks up where the successful E-710 left off. It features a faster processor, a real-time operating system and significantly higher servo update and sensor sampling rates to provide extremely precise coordinated motion in up to 6 degrees of freedom with nanometer precision.

The E-712 controller is available in 3- and 6-channel configurations.

Additional advantages:

- Versatile interfaces: TCP/IP for remote control through the internet; additional USB 2.0 and the classic RS-232. Available high-resolution analog inputs for direct control with high-bandwidth analog signals.
- 20-bit D/A converters make possible sub-nanometer position resolution, even over long travel ranges of >1000 µm, like those of the new P-629 PIHera® piezo nanopositioning stages.
- Available high-power amplifier modules, to supplement the integrated amplifiers for high-frequency scanning / tracking applications.
- Software – tunable, proportional-integral, digital servo-control with 2 notch filters allows operation of the piezomechanics closer to its resonant frequency.
- 600 MHz processor and sensor and servo update rates of up to 50 kHz assure faster updating of the position and control data – especially important for high-dynamics periodic motion. In addition, optional Digital Dynamic Linearization, ensures that tracking errors are reduced to the nanometer level even in high-dynamics scanning applications.
- Internal coordinate transformation for parallel-kinematics systems with user-friendly position commands in Cartesian coordinates.

Mature operating software with intuitive interfaces make operating the system almost child's play. No programming knowledge is needed, whether commissioning, optimizing system parameters, creating new user-defined motion profiles for the integrated wave generator, or recording data generated during the motion. The comprehensive package of supporting software, including LabVIEW drivers and DLLs, ensures easy integration in a variety of system environments.

Increased presence in local markets

PI UK

PI France

Reorganization of PI subsidiaries in Europe

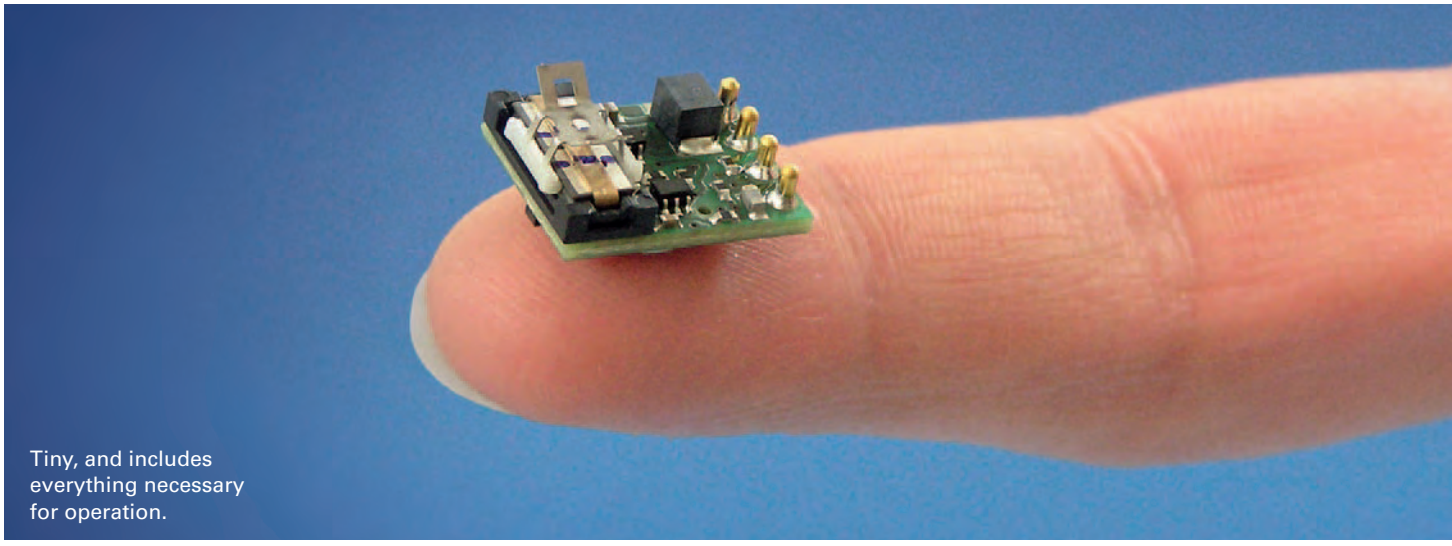
PI had already founded sales-office partnerships in France and Great Britain in the early 90s.

Continuing growth and expansion into new fields has prompted PI to develop these partnerships into separate subsidiaries. PI France S.A.S. was thus founded last year, and now in England we have PI (Physik Instrumente) Ltd.

This move allows us to provide improved service with optimal customer proximity, and to focus more directly on our main offerings. We wish the teams in both countries the greatest of success under the new banner.

News Brief: P-653 piezo linear motor drive – 8 mm (5/16 inch) small, 120 mm/s (4.7 ips) fast

Tiny ultrasonic linear motor drive opens new applications



Tiny, and includes everything necessary for operation.

A further development of the P-652, the new P-653 ultrasonic linear drive is even smaller, and exhibits stunning performance:

- Speeds to 120 mm/s (4.7 ips)
- 2 mm Travel Range
- 0.15 N Load Capacity
- Lifetime 5,000,000 Cycles
- Minimal Power Consumption

This makes the drive unit ideally suited for moving/positioning small objects like lenses, or for mechanical handling tasks.

Integration is facilitated by the fact that, in the P-653.01, the drive comes mounted on a circuit board which also carries the drive electronics necessary for operation. The unit is then controlled by 5 V signals.

Because of the low power requirement, the drive can even be run off a USB interface. The result is the P-653.01D, which consists of a drive and drive electronics all mounted on a USB stick. It is designed for rapid setup and demonstration purposes. Just install a small program, plug in the unit, and go!

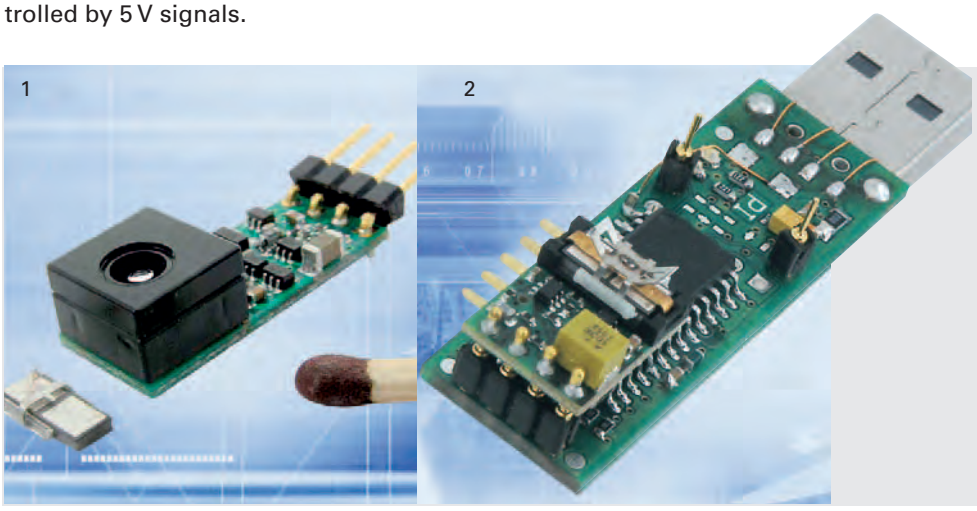


Figure 1
P-653 moving a lens in an optics module integration.

Figure 2
Easy to set up for testing and demonstration purposes. The P-653.00K has the drive mounted on a USB stick.
It is controlled over the interface using software also on a stick.

Publisher:

Physik Instrumente (PI)
GmbH & Co. KG
Auf der Römerstrasse 1
D-76228 Karlsruhe
Tel. +49 721 4846-0
Fax +49 721 4846-100
info@pi.ws

Editor:
Dr. Karl Spanner

Editorial Staff:
Steffen Arnold,
Stefan Vorndran,
Sandra Ebler

Creation & Design:
Regelmann Kommunikation,
Pforzheim

Production:
Systemedia, Pforzheim

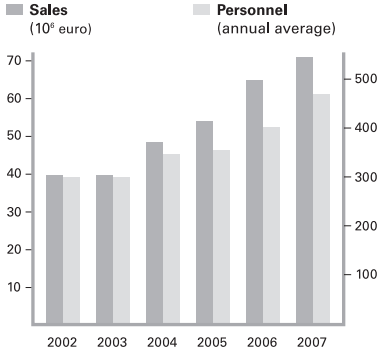
PI turns 500!

Working at PI means setting ambitious goals:

- Market and technological leadership in nano-positioning, high level of vertical integration in R&D and manufacturing.
- Innovative applications in semi-conductor technology, biomedical sciences and metrology
- Unrivalled piezo technology, both customized for niche markets and as alternative drives in automation and handling
- Double-digit growth rates in recent years and outstanding prospects for the future

Visit us, as customer, partner or as 500th employee.

Sales and personnel development of the PI Group in recent years.



Tradeshows 2008

May 6 – 8	**CLEO**	San Jose, CA, USA	San Jose Convention Center	OSA	**Booth #1538**
June 3 – 5	**Nanotech**	Boston, MA, USA	Hynes Convention Center	NSTI	**Booth #910**
June 24 – 26	**Astronomical Instrumentation**	Marseille, France	Palais des Congres Parc Chanot Conf. Ctr	SPIE	**Booth #131**
July 15 – 17	**Semicon West**	San Francisco, CA, USA	Moscone-North Hall	Semi	**Booth #6346**
Aug 12 – 14	**Optics & Photonics**	San Diego, CA, USA	San Diego Convention Center	SPIE	**Booth #443**
Sept 17 – 18	**Diskcon**	Santa Clara, CA, USA	Hyatt Regency/ Santa Clara Conv. Ctr	IDEMA	**Booth #101**

USA

PI (Physik Instrumente) L.P.
16 Albert St.
Auburn, MA 01501
Tel. +1 (508) 832 3456
Fax +1 (508) 832 0506

5420 Trabuco Rd., Suite 100
Irvine, CA 92620
Tel. +1 (949) 679 9191
Fax +1 (949) 679 9292
info@pi-usa.us
www.pi-usa.us

JAPAN

PI Japan Co., Ltd.
Akebono-cho 2-38-5
Tachikawa-shi
J-Tokyo 190
Tel. +81 (42) 526 7300
Fax +81 (42) 526 7301

Hanahara Dai-ni Building, #703
4-11-27 Nishinakajima,
Yodogawa-ku, Osaka-shi
J-Osaka 532
Tel. +81 (6) 6304 5605
Fax +81 (6) 6304 5606
info@pi-japan.jp
www.pi-japan.jp

GREAT BRITAIN

PI (Physik Instrumente) Ltd.
Lambda House, Batford Mill
GB-Harpenden, Hertfordshire
AL5 5BZ
Tel. +44 (1582) 764 334
Fax +44 (1582) 712 084
pi@lambdaphoto.co.uk
www.lambdaphoto.co.uk

ITALY

Physik Instrumente (PI) S. r. l.
Via G. Marconi, 28
I-20091 Bresso (MI)
Tel. +39 (02) 665 011 01
Fax +39 (02) 665 014 56
info@pionline.it
www.pionline.it

FRANCE

PI France S.A.S.
32 rue Delizy
F-93694 Pantin Cedex
Tel. +33 (1) 48 10 39 38
Fax +33 (1) 48 10 09 66
info@pi-france.fr
www.pi-france.fr

CHINA

Physik Instrumente
(PI Shanghai) Co., Ltd.
Building No. 7-301
Longdong Avenue 3000
201203 Shanghai, China
Tel. +86 (21) 687 900 08
Fax +86 (21) 687 900 98
info@pi-china.cn
www.pi-china.cn