



**Time Electronics**  
**1010 DC Voltage Calibrator**

**Technical Manual**



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All Time Electronics' instruments are subject to continuous development and improvement and in consequence may incorporate minor detail changes from the information contained herein.

# 1. Introduction

## 1.1. General Description

The 1010 is an accurate battery/mains powered voltage calibrator sourcing up to 10 volts in 5 ranges with a resolution up to 0.01 $\mu$ V.

A precision zener reference diode is used as a basic reference source and low temperature coefficient resistors are used. Power is provided by a mains/rechargeable battery power unit. A front panel indicator monitors the battery condition. The completely solid state circuit design provides automatic standardisation against the internal reference and allows up to 30mA output current with less than 0.1 ohms output resistance. Short circuit overload protection and a normal-off-reverse switch are provided.

## 1.2. Specifications

**Ranges:** 0-9.9999V in 5 ranges

0-9.9999V in 100 $\mu$ V steps  
 0-999.99mV in 10 $\mu$ V steps  
 0-99.999mV in 1 $\mu$ V steps  
 0-9.9999mV in 0.1 $\mu$ V steps  
 0-999.99 $\mu$ V in 0.01 $\mu$ V steps

**Accuracy:** 10V & 1V ranges:  $\pm 0.02\%$  of setting +  $\pm 0.005\%$  of range  
 100mV range:  $\pm 0.05\%$  of setting +  $\pm 0.005\%$  of range,  $\pm 1\mu$ V  
 10mV & 1mV Ranges:  $\pm 0.05\%$  of setting +  $\pm 0.005\%$  of range,  $\pm 4\mu$ V

**Setting Resolution:** 5 digits

**Output Resistance:** Less than 0.1 ohm (type 0.05 ohm) on 10V, 1V and 0.1V ranges.  
 1 ohm on lower ranges.

**Maximum Output Current:** 25mA max. on 10V, 1V & 0.1V ranges (an internal short circuit current limit is set at approx 30mA). Lower ranges can be loaded up to the short circuit current value although it should be noted that loads less than 1000 ohms will give greater than 0.1% error.

**Maximum Overload:** The instrument can withstand a continuous short circuit on the output.

**Output Voltage Stability:** Less than 30 ppm/ $^{\circ}$ C to +50 $^{\circ}$ C)  
 Less than 20 ppm/V variation in supply voltage.  
 Less than 75 ppm/year not cumulative.  
 Less than 10 ppm/hr at constant temperature.

**Output Polarity:** Positive or negative switch selected. A centre 'off' position on this switch provides a short circuit on the output for 1010 voltage source.

**Output Noise Level:** 10, 1 & 0.1V ranges, less than 10 ppm of setting  $\pm$  2 $\mu$ V (0-10 Hz).  
 10mV & 1mV ranges, less than  $\pm$  0.05 $\mu$ V (0-10 Hz)

**Dimensions:** 20 x 160 x 190 mm.

**Weight:** Approximately 3.3kg.

### **1.3. Power Unit**

The 1010 is supplied with a mains/battery power unit. This can be configured when ordered for either 115V or 230V AC, 50/60Hz. See section 2.7.3.

### **1.4. Circuit Description**

The calibrator employs a temperature compensated zener diode as the basic reference source. This provides the input to a FET chopper amplifier system which operates in a feed-back stabilised mode, and has a gain value determined by a set of precision metal film resistors which are selected by a 5 decade thumbwheel switch. The output voltage is variable from 0 to 9.9999 volts in 5 ranges. An output resistance of typically 0.05 ohms is maintained on the top three ranges; the maximum output current that can be drawn on these ranges is automatically limited to 30mA. This is to prevent damage to the circuitry in the event of accidental short circuit etc.

The lower ranges have an output resistance of 1 ohm and will supply current up to the short circuit value. To ensure complete reliability the range switch employs two contacts in parallel for each position - even if a contact fails the 1010 still functions correctly.

### **1.5. Applications**

The uses of the instrument include the calibration applications of conventional voltage potentiometers. A 1010 in these applications has the advantage of requiring no standardisation and being able to supply much higher output currents without loss of accuracy. Long term stability is inherent since standardisation is not required.

Other applications as a precision voltage source include calibration, linearity and gain stability measurements, etc., on D.C. amplifiers, digital and electronic voltmeters, transducers and as a variable low current power supply or backing-off voltage. The 10 ppm/HR stability and low noise levels are of particular interest when an extremely stable voltage is required rather than a high accuracy calibration source.

## 2. Operation

### 2.1. Operating Procedure

Operation of the 1010 is self explanatory from the front panel controls and specification. Normal precautions concerning overload and incorrect range etc., should be observed. Battery condition should be checked on the front panel display before and during use.

For quick zeroing of output set the Polarity switch to 'OFF'. This applies a short on the output terminals

#### 2.1.1. Operating Position

Unlike many potentiometers and devices incorporating Standard Cells, the 1010 DOES NOT require operation or transportation in a particular position.

#### 2.1.2. Output terminals

The selected output voltage is connected to the front panel safety terminal binding posts which are suitable for normal wire compression connection or by 4mm plug insertion.

#### 2.1.3. Case terminal

The case terminal is connected only to the instrument case and is isolated from the circuitry. The case provides an overall electrostatic screen for the 1010 and can be earthed as required to improve rejection of noise pick-up.

## 2.2. Front Panel Controls

### 2.2.1. Supply on/off

A miniature toggle switch interrupts the supply line to the circuit module. Indication of supply on/off is provided by the battery level indicator.

### 2.2.2. Output polarity

A change-over toggle switch enables the output polarity to be reversed. A centre position provides a short circuit on the 1010 output terminals.

### 2.2.3. Battery level

The battery level is continuously monitored on a front panel indicator which also serves as a supply on-off indication. A minimum mark indicates when the batteries need replacing or recharging.

### 2.2.4. Output voltage range

Selected by a 5 position rotary switch.

### 2.2.5. Output level:

Selected on a 5 digit thumbwheel switch. The resolution of setting is 0.01% of full scale.

### **2.3. Output noise**

The electrical noise on the output voltage consists of chopper intermodulation, thermal noise and random variations. Thermal noise becomes more significant on the lower ranges (see Thermal EMFS). In general the total noise level is less than 20ppm of setting  $\pm 2 \mu\text{V}$  for the 10v, 1v and 100mV ranges over the frequency range 0 - 10 Hz and less than  $\pm 0.2\mu\text{V}$  (0-10 Hz) for the lower ranges. Lower noise levels can be obtained by connecting a low pass filter on the output terminals.

### **2.4. Common mode noise**

Additional noise and variation of the output voltage can be caused by large common mode voltages. These occur when the 1010 is used to calibrate (or measure) any input which is above ground potential or has an a.c. component with respect to ground. When battery powered, the 1010 has inherently a very high d.c. common mode rejection, but it is not recommended that 100V d.c. common mode be exceeded. The a.c. common mode rejection is determined by the capacitive unbalance to ground of the output terminals and associated connections. The 1010 is checked before despatch with 30 Vp-p 50 Hz common mode voltage on the output terminals.

### **2.5. Thermal emfs**

When the 1010 is used to provide precision voltages of less than about 1 mV, care must be exercised to avoid errors due to thermal emfs. These occur where temperature differences are present at the junctions of dissimilar metals, e.g. a normal solder to copper junctions has a thermal emf of approximately  $3 \mu\text{V}/^\circ\text{C}$ . Errors inside the 1010 under temperature stable conditions are typically less than  $\pm 0.2\mu\text{V}$ .

### **2.6. Fuses**

The power supply and output fuses are mounted on the **INSIDE** of the front panel printed circuit board. Access is by removing the instrument front panel as described in Section 3. Both are 20mm 250mA types. Spare fuses can be obtained directly from Time Electronics Ltd, from your local supplier, or an authorised distributor.

## 2.7. Mains Power Unit

### 2.7.1. Type PU2

The PU2 incorporates a rechargeable Nickel-Cadmium battery and electronics charge control circuitry. The circuitry is arranged to enable the PU2 to provide power directly from the mains if the mains input is connected or alternatively from the rechargeable battery if mains is not connected.

When the mains is connected the charging circuitry provides the correct charge current (40-45mA) for the battery and automatically reduces this to a trickle rate (3 - 4mA) when the battery is fully charged. This means that it is impossible to overcharge the battery.

The DC performance is as follows:

With mains connected: DC output 15.5 - 7V (0 - 100mA load).

With mains disconnected (and battery fully charged): DC 14.5 - 15.5V (0 - 100mA load)

Mains input range: 110 - 250V AC 40 - 60 Hz. IEC mains input fuse is 20mm F1A.

The capacity of the rechargeable battery is approximately 450mA Hrs. This allows about 40 - 50 hrs continuous use of the 1010. To fully recharge the battery requires 14-16 hours with mains connected.

### 2.7.2. Constructional details PU2

The P.C.B. is located on the rear panel by 4 screws and is spaced off approx. 10mm. A metal cover protects and screens the P.C.B. and components. The output connectors and output fuse are located outside the cover. The cover is fixed to the rear panel by a 4 screws. Later versions of PU2 have a 20mm F500mA fuse located inside cover.

**Important Note: Take care when checking and dismantling a PU2. Even though disconnected from the mains, there is still sufficient power stored in the rechargeable battery to cause catastrophic damage to the electronic circuitry if inadvertent short circuits occur. These can easily occur when the metal cover is being removed.**

### 2.7.3. 240V to 110V conversion

The PU2 mains transformer has tapings for 240V or 110V AC mains. The following procedure should be adopted to convert from 240V to 110V.

- 1) Remove mains power unit from 1010.
- 2) Remove P.C.B. metal screening cover.

**Note:** Take care not to short any part of the circuitry when converting a PU2.

- 3) Connect mains transformer windings in parallel by rewiring the mains input to the transformer (As shown on the side of the transformer).
- 4) Replace the screening cover.

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## 3. Constructional Layout Details

The complete instrument assembly (except the Power Unit) is mounted on the front panel. A printed circuit board which carries the components and range switch is located immediately behind the front panel. The panel and p.c.b. can be removed as follows:

- 1) Remove Power Unit - located in instrument rear by 4 screws.
- 2) Disconnect supply - connected to power unit by 2 press stud connectors.
- 3) Remove front panel locating screws.
- 4) Withdraw front panel and p.c.b. - the power supply lead can also be withdrawn through a hole in the plastic power supply cover.

For recalibration the power supply can be connected without rehousing in the case.

### 3.1. Chopper amplifier module

#### 3.1.1. Description

The module contains the F.E.T. Chopper amplifier, precision zener and associated circuitry. It is a fully encapsulated module and connections are via a 16 pin connector moulded into it. The modular form of the 1010's basic circuitry protects it from damage due to adverse conditions and thermal gradients which could give rise to thermal emf errors. A replacement procedure should be adopted in the case of failure or malfunctioning of the module - see Section 3.1.2.

#### 3.1.2. Module replacement

- 1) Remove and disconnect power unit located in instrument rear by 4 screws.
  - 2) Remove front locating screws.
  - 3) Carefully withdraw the front panel and associated printed circuit board (p.c.b.). The power supply lead can also be withdrawn through a hole in the plastic supply cover.
  - 4) Remove 4 nuts which locate the module on the p.c.b.
  - 5) Withdraw the module from the p.c.b.
  - 6) Remove 4 nuts remaining on module mounting studs. Put these nuts on the new module. Replace new module in reverse order ensuring the connector pins align correctly - it may be necessary to bend slightly the mounting studs in order to obtain smooth alignment of the 16 pin plug and socket.
- Note:** It is important not to overstress the plug and socket, since poor connection will result.
- 7) Adjust the position of the module above the p.c.b. with 6 nuts on the module side of the p.c.b. When the module is parallel the plug and socket just closed, the nuts on the opposite side of the p.c.b. can be tightened. It is important to ensure that no strain is put on the connector when the nuts are finally tightened.

- 8) Set Module zero and recalibrate as described on the following page.



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## 4. Recalibration

This is performed with the panel and p.c.b. outside the case. Please see Fig. 1 for trimmer layouts.

### 4.1. Zero

The F.E.T. chopper amplifier zero must be set before calibration can be done. The zero is set when the instrument is manufactured and under normal operation will not require readjustment. If a new circuit module is fitted or readjustment is found necessary, the following procedure should be adopted.

- 1) Connect power supply.
- 2) Select 99.999mV range.
- 3) Set all digits to zero.
- 4) Set output polarity to normal.
- 5) Connect a null meter to output terminals. The meter sensitivity should be  $\pm 100\mu\text{V}$  f.s.d. with a resolution of better than  $10\mu\text{V}$ . It is possible to use the Time Electronics 1007 for this purpose, although any micro-volt null meter or sensitive D.V.M. may be used.
- 6) Adjust the zero trimming pot on the module for less than  $\pm 10\mu\text{V}$  reading on the meter. The zero trimmer is marked on the module label.
- 7) Check the zero reading for the other 4 ranges. The readings should be as follows:
  - 999.99 $\mu\text{V}$  range less than  $\pm 0.25\mu\text{V}$
  - 9.9999mV ranges less than  $\pm 0.75\mu\text{V}$
  - 999.99mV ranges less than  $\pm 40\mu\text{V}$
  - 9.9999V ranges less than  $\pm 100\mu\text{V}$

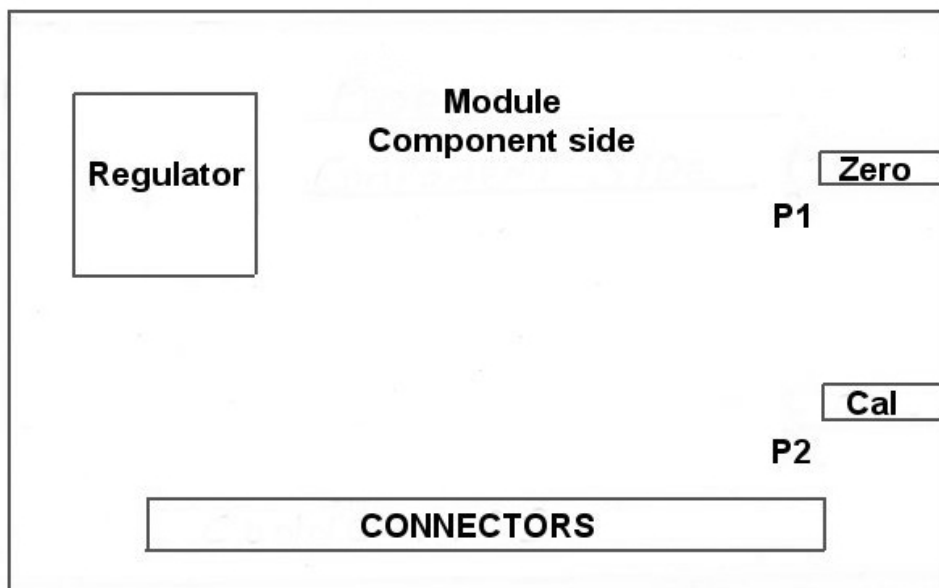
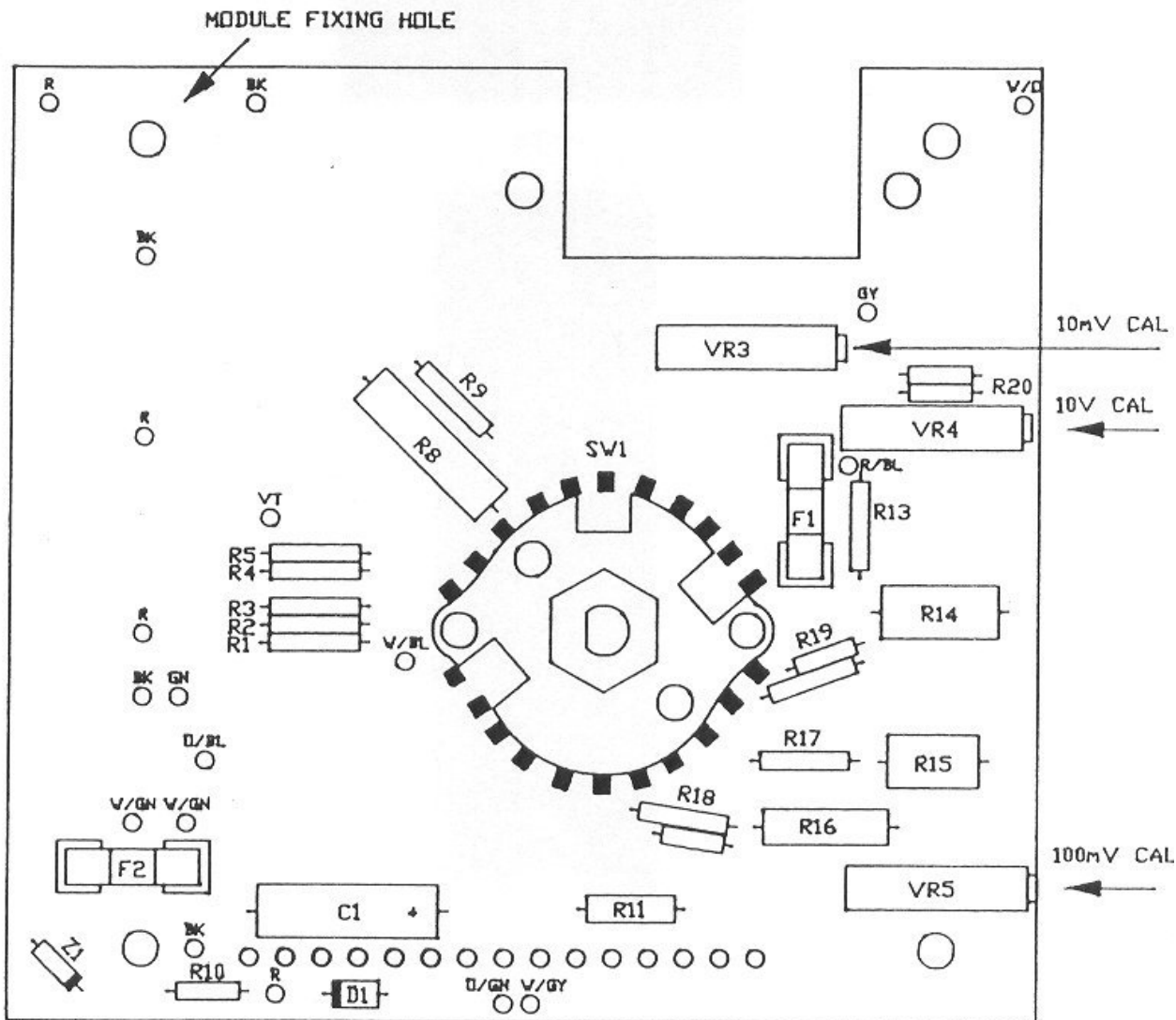
### 4.2. Full Scale

Fine adjustment of the 1010 output voltage is provided by 4 trimmers. One is located on the module is marked 'CAL' and provides equal adjustment of the output voltage for ranges. The other 3 trimmers are located on the front panel p.c.b. and provide individual adjustment for the 10V, 100mV and 10mV ranges. Since a common attenuator is used for the 10mV and 1mV ranges, the 1mV range is automatically calibrated when the 10mV range is calibrated. All the trimmers are set up when the instrument is manufactured and normally will not need readjustment. If a new circuit module is fitted or readjustment found to be necessary the procedure below should be adopted.

It is important to note that the maximum range of adjustment provides about  $\pm 0.2\%$  variation in the output voltage. If errors of greater than this magnitude are occurring there is no point in attempting to recalibrate using the trimmers and a fault condition will be occurring somewhere in the unit.

Fig. 1

1010 Trimmer Layouts



### 4.3. Calibration Procedure

- 1) Ensure zero has been set as in 3.2.1.
- 2) Connect power supply.
- 3) Select 999.99mV range, normal output polarity, and output digits to 99999.
- 4) Connect a suitable accuracy voltage standard with microvolt null meter to the output terminals. The voltage standard should have 0.005% accuracy or better and ranges from 10mV to 10V f.s. The null meter should have a resolution of better than 1uV and preferably have calibrated ranges. A high performance D.V.M. can be used for calibrating.

**Note:** It is possible to calibrate against another 1010 but the inaccuracies in that unit (if known) need to be taken into account.

- 6) Adjust the CAL trimmer on the module for better than 50uV null balance against an output of 999.99mV from the standard. Note that the maximum range of adjustment of this trimmer is 0.3%.
- 7) Select 9.9999V range and adjust the 10V range trimmer (VR4), for less than 500uV null balance against an output of 9.9999V from the standard. Maximum range of adjustment of this trimmer is 0.08%.
- 8) Select 99.999mV range and adjust the 100mV range trimmer (VR5) for less than 5uV null balance against an output of 99.999mV from the standard.
- 9) The specification allowances for these 3 ranges are as follows:
  - 9.9999V range, +/- 2.5mV.
  - 999.99mV range, +/- 250 uV.
  - 99.999mV range, +/- 55uV.

### 4.4. 10mV and 1mV Range Calibration

The two ranges are obtained by resistive attenuation of the 10V and 1V ranges. The attenuation factor is 1000:1. The calibration of the attenuator is via the 10mV range trimmer (VR3). Maximum range of adjustment is 0.16%.

The Attenuator is set up when the 1010 is manufactured and normally requires no further adjustment. If, however, any of R2-R5 have been damaged by overload they will require replacing with equivalent types.

After replacing the resistors recalibration may be necessary beyond the range of the 10mV trimmer. The 1010 output should be checked against a 9.9999mV output from the standard and adjusting resistors (either R6 or R7) selected to bring the calibration within range of adjustment of the trimmer, which can then be adjusted for the final calibration as described above.

The calibration should be done on the 9.9999mV range and due account taken of any thermal emf's generated in soldering the adjustment resistor in position.

**Note:** It is important to ensure that the zero and calibration have been set before commencing 3.2.1.

The specification allowances for these ranges are as follows:-  
 9.9999mV range: +/- 5.75uV. 999.99uV range: +/- 0.75uV.

## 5. Guarantee & Servicing

### Guarantee Period

This unit is guaranteed against defects in materials and workmanship for a period of **one year** from its delivery to the customer.

We maintain comprehensive after sales facilities and the unit can, if necessary be returned to us for servicing. During this period, Time Electronics Ltd will, at its discretion, repair or replace the defective items. For servicing under guarantee, the instrument type and serial number must always be quoted, together with details of any fault and the service required. The purchaser of the instrument must prepay all shipping charges. Time Electronics Ltd will pay return shipping charges.

This guarantee is void if servicing has been attempted by an unauthorised person or agent. If, during the guarantee period, failure is due to misuse or abuse of the unit, the repair will be put in hand without delay and charged unless other instructions are received.

Please note that if you require a new UKAS Certificate during the warranty period, this will be charged at the current rate on our price list.

### Service After Guarantee Period

Even after the guarantee period has expired, Time Electronics Ltd., can still service your instrument. As the manufacturer, we have the specialised knowledge needed to keep your instrument in peak condition and we also maintain a comprehensive spare parts service.

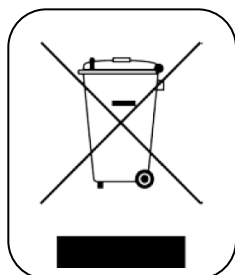
Please enclose details of the service required and your full company details including a contact name when returning for servicing.

### Returning Instruments

When returning instruments, please ensure that they have been adequately packed, preferably in the original packing supplied. **Time Electronics Ltd will not accept responsibility for units returned damaged.** Please ensure that all units have details of the service required and all relevant paperwork.

Send the instrument, shipping charges paid to:-

**Time Electronics Ltd**  
 Botany Industrial Estate, Tonbridge, Kent, TN9 1RH  
 Tel: +44(0)1732 355993 Fax: +44(0)1732 770312  
 Email: mail@TimeElectronics.co.uk  
 Web Site: www.TimeElectronics.com



#### **Disposal of your old equipment**

1. When this crossed-out wheeled bin symbol is attached to a product it means the product is covered by the European Directive 2002/96/EC.
2. All electrical and electronic products should be disposed of separately from the municipal waste stream via designated collection facilities appointed by the government or the local authorities.
3. The correct disposal of your old appliance will help prevent potential negative consequences for the environment and human health.
4. For more detailed information about disposal of your old appliance, please contact your city office, waste disposal service or return to Time Electronics.