International Power and Standards Conversion

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Chapter 1) About the Author & Copyright

International Power and Standards Conversion

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Chapter 2) Introduction

2.1) Scope of this document

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The following types of questions arise quite often:

* Question: Will my U.S. made TV and VCR work in Europe?

  Answer: A simple step down transformer to convert from 220 to 110 V will
  probably permit them to work together (i.e., to play previously recorded
  tapes) but you will not be able to receive any cable or broadcasts.

* Question: I have a microwave oven but will be moving to France.  Would I be
  better off selling it or getting a power adapter?

  Answer: Due to the high wattage of a microwave oven, converting the power
  will be costly.  Sell it and buy a new one at your destination.

* Question: Should I bring by European appliances back to the U.S.?
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Answer: This depends on the specific appliances. See the remainder of this document!

* Question: Will my Onkyo receiver work in Japan?

  Answer: Not without some modifications - which may not be worth it.

We cannot generally provide an answer based on your exact model equipment and the specific standards in use. There are too many variations to deal with in this sort of document. However, the information contained herein in conjuntion with the type and specifications of the equipment you own and the power and standards in use at your destination should enable you to make an informed decision.

A great deal of specific country information is available at:

* http://www.cris.com/~kropla/electric.htm

  including power, plug configurations, telephones, and TV standards.

This should help you issues involved before you reach your destination!

In addition, we deal with general issues related to adapting entertainment equipment and appliances to different power and the implications of reduced or increased voltage and frequency.

Note: this initial release will concentrate mostly on power issues. Later, we will deal with video, communications, and phones systems. For those, the documents: "Notes on Video Conversion", "Troubleshooting and Repair of Computer and Video Monitors", "Troubleshooting and Repair of Television Sets", and "Troubleshooting and Repair of Video Cassette Recorders", and others at this site may contain some of the information you seek on these other topics.

Chapter 3) Types of Conversion

3.1) You mean it is more than just the type of plug?

It would be nice if all you had to do was match up a plug and socket to make anything in the universe work together. Unfortunately, while this does work for some things - garden hoses, for example :-) - it rarely is as simple as this for electrical power, video, or communications.

3.2) Power

This relates to what comes out of the wall socket. Nearly every country in the world uses an AC voltage between 90 and 240 V at 50 or 60 Hz. There may be some exceptions (like 600 V at 25 Hz powering portions of the New York City subway system or 28 V at 400 Hz on board an F-18 - but this is not something you are likely to need to deal with!) - if you encounter such unusual situations, we will be happy to add them to this document!

The three important considerations are:

* Voltage - the RMS (Root Mean Square - you really don't need to worry about the term) value of the nominal power line voltage. (OK, if you really care, the RMS value of an AC waveform will be equal to that of a DC voltage which will have the same heating effect. It is the squareroot of the mean (average) of the waveform squared. Got that? :-).

* Frequency - the number of cycles per second now expressed in Hz (pronounced like the Hertz car rental company). Almost all power around the world is AC. There are some exceptions but you will be unlikely to encounter them.

* Plugs and sockets - there are several dozen variations (at least) with and without a safety ground depending on your location. If you purchase *the* adapter that they recommend at the travel store, there is good chance it will not fit when you actually get to your destination! However, there are universal plug and socket adapter sets which may have a better track record.

3.3) Video standards

This relates to the scan rates, color encoding, and audio transmission of the baseband video signals in use in your country.

* Scan rate - how many total scanning lines are used and how many times per second a complete picture is 'painted' on the picture tube screen. (Note that exsiting TV standards use interlaced scanning - a picture is made up of an even field (all the even numbered lines) and an odd field (all the odd numbered lines) and a picture consists of both of these. The most common (pre-HTDV) are 525 lines at 30 Hz (e.g., U.S. NTSC) and 625 lines at 25 Hz (e.g., U.K. PAL). However, there are others.

* Color Encoding - the way the color information is combined with the basic monochrome (black and white) picture signal. These differ between NTSC and PAL and there are several variations for PAL as well. The effect of a TV with the wrong decoding circuitry will be either a black and white picture or possibly color interference effects.

* Audio - the location of the subcarrier frequency for the sound information among other things may differ as well.

3.4) Broadcast (and cable) standards

* Radio - AM and FM channel locations and spacing.

* Video - VHF and UHF channel assignments, color encoding, audio carrier, etc.

* Telephone - ???

Chapter 4) Common types of Voltage Converters

4.1) How to get power for equipment A to work with equipment B

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There are a variety of approaches to adapting equipment designed for one
power system to another.

* Transformers will always work but may be too heavy or expensive to justify
  their use.

* Electromechanical approaches go back quite far, are quite efficient, but
  are heavy, bulky, noisy, not very flexible.

* Solid state converters vary widely in complexity, capabilities, and cost.
  Some may destroy motors or electronic equipment and this may not be obvious
  from the product description.

Note that in cases, the proper (or close enough) power may be available
already.

* Where 110 VAC is standard, 220 VAC is usually present in the residence since
  the power originates from a 220-0-220 VAC utility (pole) transformer.  In
  some cases, a suitable outlet will even be present though usually one will
  have to be added.  Whether this is worth the effort and expense for a $30
  coffeemaker you picked up in your travels is another matter. :-)

  In industrial or office buildings, 208 VAC will be available (since they use
  three-phase power but that is another story) and this may be close enough
  for most applications (though heating appliances won't be quite as zippy  as
  if they were running on the proper 220 VAC and therefore your eggs may take
  a little longer to cook).

* Where 220 VAC is standard, hotels and other public buildings may provide
  110 VAC convenience outlets for foreign visitors.  While the frequency will
  probably still be the standard 50 Hz for these countries, many appliances
  don't care.  See the chapter: "Frequency Issues".

* Many appliances have a voltage selector switch usually near the power cord
  entrance though some may require changing internal jumpers.  See your user
  manual!  This is particularly true of appliances that are typically used
  overseas like shavers.
```

4.2) True transformers

This refers to devices that consist solely of a pair (at least) of windings on an iron core. There are no other devices in a transformer beyond possibly a switch, indicator light, thermal protector, and/or a fuse or circuit breaker, and a plug or terminal block for input and socket or terminal block for output.

In the following, we assume that the two voltages are 110 VAC and 220 VAC. Similar comments apply if the ration is not 2:1.

There are several types including:

* Isolated step-up for converting from 110 VAC to 220 VAC.
* Isolated step-down for converting from 220 VAC to 110 VAC.
* autotransformer step-up for converting from 110 VAC to 220 VAC.
* autotransformer step-down for converting from 220 VAC to 110 VAC.

Autotransformers are cheaper but do not provide line isolation which may be desirable. In general, a step-up or step-down transformer can be used backwards to effect the opposite conversion - whether this is possible is a construction detail. In addition, a 1:1 isolation transformer can be used as a 1:2 (stepup) or 2:1 (stepdown) autotransformer with a VA rating twice of what it would be when used normally.

The relevant parameters characterizing a tansformer consist of:

* Voltage - The ratio of the number of turns of wire on the output winding(s) and input winding determines the output:input voltage ratio. Electrically, input and output can be interchanged to obtain the opposite conversion. Whether this is supported by the packaging is another story.

* Power/VA capacity: The size of the core and the wire determine the power handling capability. VA is simply the voltage (V) multiplied by the current (A) for the input or output. For a resistive load like a space heater or light bulb, this is the same as true power in watts (W). Due to unavoidable losses in the transformer, the input and output ratings are not quite the same. The transformer must be capable of supplying the required VA of the desired maximum load without exceeding the current rating of the input line.

Transformers of adequate capacity can be used with all types of equipment.

However, they are heavy and costly and do not convert frequency. Thus, they may be unsuitable in some situations and there may be cheaper more appropriate alternatives. A *suitable* transformer large enough to power a space heater would weigh about 50 pounds and cost perhaps $200 - much more than the the space heater is worth.

4.3) Thyristor based converters

These are the low cost devices available at Radio Shack or a travel accessories store that weigh almost nothing and have huge power ratings. They operate by switching the power on to the load at the appropriate time during each cycle of the AC voltage (120 or 100 times a second) resulting in approximately the proper power being delivered to the load.

Thyristor based converters are for converting from 220 VAC to 110 VAC without changing frequency with major restrictions:

* WARNING: These are suitable ONLY for resistive loads like light bulbs, space heaters, and frying pans WITHOUT induction motors, transformers, or electronic controls.

* They are designed to provide approximately the correct *power* conversion factor for resistive loads (and possibly universal motors). The maximum voltage may still be close to that of the input - 220 V. This will instantly destroy electronics and may destroy induction motors only slightly more slowly.

* The output is very spike-y unlike the smooth sinusoid of the normal power line AC. This in itself may result in addition problems including radio frequency interference (RFI) and equipment buzz or hum.

4.4) Motor alternators

Before the development of solid state power devices, these represented an efficient, if bulky way of converting both voltage and frequency. A synchronous induction motor is coupled to an alternator (AC generator) on the same shaft. By designing with the appropriate number of poles for each, this could easily, if noisily, perform both voltage and frequency conversion.

4.5) Solid state (AC->DC->AC) converters

These provide efficient conversion of both voltage and frequency in a light weight compact package. The best of these generate an output nearly identical to the power obtained from the wall socket and operate as follows:

* Rectify and filter AC input to provide direct current (DC).

* Chop the DC at a high frequency controlling both polarity and amplitude to synthesize a replica of the desired power (sinusoidal) waveform.

* Use a transformer to step this up to the required voltage

* Provide a filter to remove the high frequencies from the output.

The waveform before smoothing would look similar to the following:

```
                     ||                  ||
                   ||||||              ||||||
                  ||||||||            ||||||||
                 ||||||||||          ||||||||||
                 ||||||||||          ||||||||||
                           ||||||||||          ||||||||||
                           ||||||||||          ||||||||||
                            ||||||||            ||||||||
                             ||||||              ||||||
                               ||                  ||
```

After smoothing, the result would be very similar to a sinusoid.

This more costly approach enables arbitrary voltage *and* frequency conversion but as we will se later, this is rarely needed.

Cheaper models simply generate a square wave or modified sinewave at the appropriate frequency:

```
Squarewave:
                  _________           _________
                 |         |         |         |
                 |         |         |         |
                 |         |         |         |
                 |         |         |         |
                           |         |         |         |
                           |         |         |         |
                           |         |         |         |
                           |_________|         |_________|

Modified sinewave:
                     _____               _____
                    |     |             |     |
                    |     |             |     |
                    |     |             |     |
                 ___|     |____     ____|     |____
                               |     |             |    |
                               |     |             |    |
                               |     |             |    |
                               |_____|             |____|
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The nice thing about the modified sinewave is that its RMS and peak values match that of the true sinusoid (as well as other advantages in terms of harmonic content). If you don't know what this means, don't worry, Your life doesn't depend on it. One implication, however, is that heating loads and electronic devices which rectify and filter the input power will see the same effective voltage.

For many devices including all resistive loads, either of these approaches is adequate. However, devices with motors and/or transformers will be much happier with smoothed sinusoidal power. Switching power supplies (except universal types) will be underpowered with the simple squarewave inverter and may overheat running near full load.

4.6) Is frequency conversion needed

The question of 50 Hz vs. 60 Hz always comes up in conjunction with international power. However, except for equipment with induction motors (e.g., fans, compressors), or where the line frequency is used for timing (electric or line powered electronic clocks), the line frequency may be irrelevant. See the chapter: "Frequency Issues".

4.7) Effects of improper voltage on resistive loads

* Incandescent light bulbs. Light output will increase or decrease by a

greater relative percentage than the voltage change. Life will be impacted dramatically. The life function for an incandescent light bulb is roughly (V/Vo)^^14. This is the actual voltage divided by the nominal voltage raised to the 14th power! A 5 percent increase in voltage will decrease life by about 50%.

With greatly excessive voltage (i.e., running a 110 V light bulb on 220 V), burnout will be nearly instantaneous - the bulb may even explode.

With reduced voltage, the light output will be reduced and life will be extended dramatically as well. However, efficiency decreases faster than voltage so it doesn't make sense to use bulbs on lower voltage unless they are in a hard-to-reach spot as the energy cost dominates. Extending the life of a 25 cent bulb just doesn't save money in the end especially if a higher wattage or additional bulbs must be used to make up the light reduction.

* Space heaters (excluding fans) and heating appliances like rice cookers, deep fryers, toaster, etc. Power is proportional to the square of the voltage. Reduced voltage will result in less heat or longer cycles (if thermostatically controlled). Excessive voltage will result in more heat or shorter cycles. However, there could be fire risk if the appliance is not designed with adequate insulation and safeguards to handle the extra power.

  With greatly excessive voltage, heating devices will blow a fuse or internal thermal protector, the AC fuse or circuit breaker, or burn out.

4.8) Effects of improper voltage on constant power loads

* Induction motors. These are found in refrigeration equipment (fridges, freezers, air conditioners, dehumidifiers), air compressors, washing machines, dryers, some stationary shop tools, pumps, and many other domestic and industrial applications.

  An induction motor is a nearly constant speed drive. Reduce the voltage and it will still try to maintain almost the same speed. Where the load is constant, this means that it will draw greater current to compensate for the reduced voltage (remember: P = constant = V*I). This will result in excessive heating and stress. The equipment may fail to start properly at all or cycle on its thermal/overcurrent protector. Its life may be shortened or it may burn out quickly.

  Excess voltage isn't good either since the construction may result in magnetic core saturation which will also result in overheating, added noise (hum), and lower efficiency.

* Regulated switchmode power supplies

  These share many of the characteristics of induction motors in that they will attempt to maintain the same power to the load. Thus, at low line voltage, they will draw additional current and internal parts may be stressed to the point of (possibly catastrophic) failure. Unlike induction motors, this is much more difficult to predict as it is highly design dependent.

  Usually a slight reduction or increase in voltage will not affect the performance or longevity. However, unless specified as a universal input (90 to 240 VAC) or where specific recommendations are available, remaining within a 10 percent window is best. This is especially critical on the low side when running near full load.

Running a non-universal switching power supply from a squarewave inverter result in overheating and subsequent failure near full load. The reason is that the peak value of the input waveform is about 7/10ths of that from the normal AC line and the current must increase to compensate.

4.9) Effects of improper voltage on transformer loads

While the ideal transformer (the one they may have taught you about in EE101) doesn't care about its actual input voltage, real transformers do. If the voltage increases significantly above what it was designed for, the core may saturate. This means that the magnetic field in the core cannot increase any further and the result is to effectively short circuit the input (above a certain voltage on the waveform). At the very least, this will result in excessive heating and hum or buzz. The transformer may burn out if a fuse doesn't blow first.

How much excess voltage is acceptable is not something that can be determined without testing. Some transformers are designed very conservatively (bigger cores, more copper, etc.) while others just barely get away with running on the nominal line voltage.

Certainly, 2:1 will be too much for almost any transformer. You may get away with a 25% increase without too many problems.

It is possible to test for this by slowing increasing the input voltage while monitoring input current. Up until saturation, it will increase linearly with voltage. As saturationg sets in, a small increase in voltage will result in a large increase in current and increased buzz or hum as well.

Reducing voltage to a transformer is not a problem unless the load will then demand more current - which may result in excessive heating and failure.

4.10) Effects of improper voltage on motor loads

* As noted above, induction motors are constant speed devices so that the current will tend to decrease as voltage is increased and increase as voltage is decreased. There can also be core saturation effects just as with transformers.

* Universal motors - those found in vacuum cleaners, portable shop tools, and so forth - will run with a speed that it related to input voltage (unless feedback regulated). On low voltage, the speed will be lower and your vacuum cleaner won't suck as well. Since it uses bypass air to cool the motor, it may overheat also. On higher than normal voltage, it will run faster adding wear and tear to the bearings. Blowers and flywheels may disintegrate if not designed for the added centrifugal loads.

* Fan motors - these are shaded pole induction type usually and so lossy to begin with that speed will vary with voltage. Again, bad things may happen at too low or too high voltage but they will probably survive modest changes.

Chapter 5) Frequency Issues

5.1) Effects of improper frequency

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* Clocks/timers run slow or fast.  Devices that depend on synchronous motors
  or count the cycle of the line voltage directly like desk or alarm clocks,
  clocks in clock radios, appliance timers, anti-burglery timers, and so forth,
  will run fast or slow by the precise ratio of the correct to actual line
  frequency.  In nearly all cases, this will be either 5/6 or 6/5 based on
  the ratio of 50 to 60 Hz and vice-versa.

  In the case of synchronous motors, there is nothing you can do - the speed
  is determined by construction and the gear ratios.

  Those that are entirely electronic may have a switch or jumper (probably
  inside) to select the AC frequency - 50 or 60 Hz.

  Many devices use an internal quartz crystal for the clock or timer and will
  not be affected at all.  Devices like VCRs may or may not use the power line
  for timing.  Of course, battery operated equipment will always use an
  internal quartz crystal as there is no connection to the power line.

* Transformer core saturation - excessive heating.  Reducing the frequency of
  the input to a transformer also increases the likelihood of core saturation.
  Therefore, going from 60 Hz to 50 Hz may be a problem for your stereo (which
  likely uses a power transformer) if its design is marginal.  As with voltage,
  there is no way to know except by testing unless the nameplate specifically
  states a frequency spec - 50/60 Hz.

* Induction motor speed and torque.  As noted, these are nearly constant speed
  devices dependent on power line frequency:

   - Going from 50 Hz to 60 Hz: motor will run fast with reduced torque.

   - Going from 60 Hz to 50 Hz: motor will run slow with reduced torque.

* Note that most modern electronic equipment (with the possible exceptions
  listed above) does not depend on the power line frequency for anything.
  This includes CD players, cassette decks, servo-drive turntables, TVs
  (unless there is an on-screen line timed clock), VCRs (ditto), computers,
  monitors, printers, fax machines, etc.
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Chapter 6) Recommendations for specific devices

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Television sets and video cassette recorders.
--------------------------------------------

A voltage converter - preferably a true transformer or modified or true
sinewave inverter will be needed to adapt the voltage unless the unit has
a universal power supply.

Modern TVs do not care about power line frequency at all as they do not
have any power transformer.  Really old sets may run into core saturation
problems but these are mostly dead by now.

Note: the video frame rate is not tied to the power line in any way.
Therefore, a U.S. TV with a 60 Hz (actually 59.94 Hz) frame rate will work
just fine in a country with 50 Hz power assuming the voltage is correct.
However, it will not be compatible with broadcast or cable or likely a VCR
purchased in that country - see below.

VCRs may use a small power transformer in the power supply so changing from
60 Hz to 50 Hz may result in overheating though probably not likely.

However, taking a VCR and TV from the U.S. to a European country, for
example, may not be worth it.  They will work fine with each-other (as
long as the voltage is proper) but the video standards in foreign countries
are not compatible with those in the U.S.  Therefore, it may be better to
buy new equipment overseas unless you are taking your prized collection of
videos and will obtain other equpiment to deal with broadcast and cable.
There are also services for copying video cassettes from one standard to
another and these may represent an alternative to lugging the equipment
with you.
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6.1) Audio equipment

```
These include tuners, amplifiers, receivers, tape decks, CD players, etc.

Except for the tuner or tuner portion of the receiver, the only issue is power.
Audio equipment almost always uses a transformer type power supply so the
comments in the previous chapters should apply.  A voltage converter will be
need to go from 110 VAC to 220 VAC or vice-versa.  In this case, it really
should be a true transformer.  Anything else is quite likely to introduce
unaccceptibel interference in the form of a hum or buzz even if it doesn't
result in any damage to the equipment.  As noted, going from 60 Hz to 50 Hz
could intruduce problems of transformer core saturation in marginally designed
equipemnt as well.
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6.2) Small appliances

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Specific recommendations will depend on the actual devices inside the
appliance - motors, heating elements, timers, and so forth.

* For appliances containing ony heating elements - no fans or other motors -
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any type of voltage converter will be suitable. For example, the very inexpensive and light weight thryistor type of 220 VAC to 110 VAC type should work fine with a waffle iron.

* Where motors are involved, a true transformer will be best but may be excessively heavy or expensive.

* With timers, the line frequency will also be important.

* If the appliance is powered by a wall adapter outputting DC, a substitute wall adapter may be the best option.

6.3) Microwave ovens

If the voltage is different, sell where you are located and buy a new one at your destination. The power involved would require a large, heavy, expensive voltage converter - preferably a true transformer. It doesn't make sense for a $150 microwave.

Line frequency doesn't affect the performance of a microwave that much (perhaps a 5 percent increase in cooking power from 50 Hz to 60 Hz) but the timer and clock will likely be affected and may not be easily adjusted - not at all in the case of a mechanical timer though there may be a jumper for an electronic timer. However, the turntable and cooling fan motors will also be affected and attempting to account for all the variations is probably just not worth it!

6.4) Clocks

Electric clocks using a synchronous motor would require a motor or gear transplant - not worth it. Of course, you could just live with shorter or longer days :-).

Clocks using the power line to drive an electronic display may have a jumper to select 50 or 60 Hz. Even this may not be worth the effort to locate as it is likely not going to be labeled.

6.5) Radioas, tuners, receivers

In addition to the power issues (see the section: "Audio equipment", station frequencies and channel spacing differ from country to country.

6.6) PCs and laptop/notebook computers

Check your equipment. Most PC power supplies have a switch to select between 110 VAC and 220 VAC. Some have universal power supplies that will work within a range of voltage between 90 and 240 V AC (up to 400 Hz) or DC. The latter is generally true of laptop/notebook power packs.

Similary, monitors may use a switch or jumper to select voltage or have a universal power supply.

PCs and monitors do not use the line frequency for anything - not even the real time clock.

6.7) Laser printers

These may use a switching or transformer based power supply. This is not the real problem. What is, is the power for the fuser - several hundred watts. Therefore, if using a true transformer for voltage conversion, a large one will be required.

Some may have universal power supplies - check your instruction manual!

6.8) Non-laser printers

There will usually use a power transformer type power supply so a voltage converter will be needed. The frequency will only matter with respect to transformer core saturation. Nothing in a printer depends on line frequency.

Chapter 7) Items of Interest

7.1) TV, shortwave, power worldwide

(From: Mark Zenier (mzenier@netcom.com)).

A book, "The World Radio TV Handbook" published by Billboard that covers TV, along with where all the world's shortwave radio transmitters are, and what sort of power comes out of the wall plug all around the world. It has a new edition each year and costs around $25 to $30.

7.2) How big a difference in voltage before a converter is needed

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"I would like to bring a variety of small to medium-sized Japanese
 electrical products (100V 50/60 Hz) with me when I move back to the U.S.
 (e.g., lights, rice-cooker, cassette player, VCR...) Individual
 transformers like those sold in travel shops are quite expensive.  Is it
 possible buy a large number of small stepdown transformers -- or to make
 them as kits?  Any advice would be greatly appreciated."

First, for some of these like the VCR, the 15% difference between 115 VAC
and 100 VAC may not matter.  The only way to be sure is to check with the
manufacturer.

For others like the rice cooker, it too may be ok if it uses a thermostat
to control its heating element.

However, the simplest way to reduce 115 to 100 VAC is to buy or construct
an autotransformer.

To construct one, you need a stepdown transformer with an output of about
15 V (for this example) and a secondary current rating at least equal to
your total current needs.  Then, the primary is connected to the line and
the secondary is wired anti-phase in series with the loads and the line.

For devices using AC adapters, I would just replace the AC adapters with
a US version.
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7.3) Equipment that will probably not care about the frequency of the line

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The following are generally insensitive to frequency (50/60 Hz):

* Appiances with only heating elements (e.g., toaster, radient space heater)
  and incandescent light bulbs.

* Devices with universal motors (e.g., vacuum cleaner, electric drill).

* Fluorescent lamps using electronic ballasts (including many compact
  fluorescents).

* TVs, VCRs, computers, monitors, universal AC adapters, other devices
  using switching power supplies.  (The a clock may run at an incorrect
  rate if it depends on the power line frequency.)

However, note different TV standards will likely result in your TV and VCR
working together but not able to receive or record broadcasts or cable.

Some equipment explicitly states the acceptable voltage and frequency range.
In the case of a universal power adapter, this may range from 90 to 260 V
DC or AC up to 400 Hz - or more.
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7.4) Equipment that may work with a different line frequency

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The following will probably work when going from 50 Hz power to 60 Hz power and
may work going the other way.  However, transformer cores designed for 60 Hz
may saturate on 50 Hz and run hotter and/or blow internal fuses and cooling
fans will run slower - this should be checked to make sure there is no hazard:

* Audio equipment (e.g., receivers, CD players, tape decks, servo locked
  turntables).  However, since the broadcast channel spacing may differ,
  tuning may not operate correctly.)

* Devices using wall wart AC adapters with actual transformers (these are
  massive as opposed to universal AC adapters which weigh almost nothing)
  (e.g., calculators, boomboxes, telephones and answering machiens, external
  modems and CDROM drives, dust busters hand vacs).  However, the phone system
  may not be compatible.)

* Printers, fax machines, and other computer peripherals which use a power
  transformer in their power supply.

* Microwave ovens (power is related somewhat to frequency, cooling fans and
  turntables will run slow on 50 Hz).

* Fans and blowers (will run slower on 50 Hz).

* Convection space heaters (shaded pole fan motor will run faster on 60 Hz).
  If designed for 60 Hz and run off 50 Hz, it will run slower possibly
  resulting in overheating.
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7.5) What appliances will be damaged by reduced voltage?

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Here is a summary of various appliance types and how they are affected
by the severely reduced voltages possible during a brownout:

* Resistance heating elements/incandescent bulbs/ and similar will not be
  damaged and will actually last longer.  Of course, light and/or heat will
  be reduced.

* Constant horsepower loads like refrigeration compressors will be severely
  stressed and may burn out.

* Shaded pole motors will run slow but will probably not be damaged.  Many
  of these are designed to survive a stalled condition as well.

  Examples: fans and some blowers, can openers, pencil sharpeners.

* Capacitor run and other larger induction motors without a starting switch
  will run slow with reduced torque.  However, if they stall, overheating
  and burnout is possible.
```

Examples: some blowers, dishwashers.

* Motors with a starting switch may not reach starting winding cutout speed and result in motor damage - burnt out starting winding.

  Examples: washing machines, cloths dryers, circulator and other larger pumps, large furnace blowers, stationary shop tools.

* Universal motors will run slow with decreased torque and reduced cooling. There may be a range of speeds over which they will overheat.

  Examples: vacuum cleaners, electric leaf blowers, many other portable line powered tools

* Switching power supplies will run hot and may fail.

  Examples: TVs, some VCRs, computers (PCs and laptops), monitors, and some peripherals,

* Linear power supplies will probably just not regulate well resulting in hum in audio or hum bars in video.

  Examples: Stereo receivers, CD players, cassette decks, phones, some fax machines, some printers.

* Anything with relays may have problems with the relays not operating reliably or cycling.

  Examples: heating and cooling systems, garage door openers, etc. but most of these will have other components more severely affected.

For appliances with more than one type of device like a microwave oven, all factors must be considered. For this example, the oven will heat at a reduced power level (which is safe) but the cooling fan(s) will also run more slowly resulting in possible overheating and failure of the magnetron. A convection space heater may overheat for similar reasons.

7.6) Equipment that may have problems on different line frequency

The following may have problems:

* Audio equipment using AC motors like some turntables and reel-to-reel tape decks. Speed will be incorrect. Mechancial adapters may be available.

* Clocks and devices with built in clocks or timers. Many of these depend on the power line frequency for timekeeping. They will therefore run at a 5/6 or 6/5 rate when the frequency changes. (This may be desirable - your day could last 20% longer! :-)).

* Electric shavers depending on a resonant linear motor (vibrator). The frequency difference may be enough to kill the resosnance and result in weak or no blade motion. (Remingtons used to use this technique; I do not know what manufacturers still do.)

* Large fixed power devices like refrigeration compressors.

* Equipment with a combination of resistive heating elements and/or induction motors and/or electronics. One or more subsystems may have performance or overheating problems.

7.7) About the vertical scan rate

TVs never ever used the line frequency for vertical rate. The vertical rate is not even equal to line frequency, actually 59.94 Hz (NTSC). It was set originally to 60 Hz to minimize the visibility of interference between the deflection and power transformer. When NTSC added color, it changed to 59.94 Hz. And, TVs no longer have power transformers.

7.8) Taking a microwave oven oversees (or vice versa)

Microwave ovens are high power appliances. Low cost transformers or international voltage adapters will not work. You will need a heavy and expensive step down or step up transformer which will likely cost as much as a new microwave oven. Sell the oven before you leave and buy a new one at your destination.

Furthermore, for microwave ovens in particular, line frequency may make a difference. Due to the way the high voltage power supply works in a microwave oven, the HV capacitor is in series with the magnetron and thus its impedance - which depends on line frequency - affects output power.

High voltage transformer core saturation may also be a problem. Even with no load, these may run hot even at the correct line frequency of 60 Hz. So going to 50 Hz would make it worse - perhaps terminally - though this is not likely.

* Going from 50 Hz to 60 Hz at the same line voltage may slightly increase output cooking power (and heating of the magnetron). The line voltage could be reduced by a small amount to compensate.

* Going from 60 Hz to 50 Hz may slightly decrease output power and possibly increase heating of the HV transformer due to core losses. Using a slightly lower line voltage will reduce the heating but will further decrease the cooking power.

The digital clock and timer will likely run slow or fast if the line frequency changes as they usually use the power line for reference. Of course, this may partially make up for your change in output power! :-)

7.9) Determining unknown connection on international power transformers

Most likely, you can figure this out if you can identify the input connections.

There will be two primary windings. Each of these may also have additional taps to accommodate various slight variations in input voltage.

For the U.S. (110 VAC), the two primary windings will be wired in parallel. For overseas (220 VAC) operation, they will be wired in series. When switching from one to the other make sure you get the phases of the two windings correct - otherwise you will have a short circuit! It is best to test with a Variac so you can bring up the voltage gradually and catch your mistakes before anything smokes.

An multimeter on the lowest resistance scale should permit you to determine the internal arrangement of any taps.

With any luck, the transformer wiring will even be labeled on the case!

7.10) Taking equipment overseas (or vice-versa)

When does it make sense to take an appliance or piece of electronic equipment to a country where the electric power and possibly other standards differ?

For anything other than a simple heating appliance (see below) that uses a lot of power, my advise would be to sell them and buy new when you get there. For example, to power a microwave oven would require a 2KVA step down (U.S. to Europe) transformer. This would weigh about 50 pounds and likely cost almost as much as a new oven.

Note that some places like Japan may even have varying power specifications in different parts of the country. Isolated areas such as islands may have their own power generators with very erratic and voltage and frequency. The following discussion assumes power from a large (national) grid.

There are several considerations:

1. AC voltage - in the U.S. this is nominally 115 VAC but in actuality may vary from around 110 to 125 VAC depending on where you are located. Many European countries use 220 VAC while voltages as low as 90 or 100 VAC or as high as 240 VAC (or higher?) are found elsewhere.

2. Power line frequency - in the U.S. this is 60 Hz. The accuracy, particularly over the long term, is excellent (actually, for all intents and purposes, perfect) - better than most quartz clocks. In many foreign countries, 50 Hz power is used. However, the stability of foreign power is a lot less assured.

3. TV standards - The NTSC 525L/60F system is used in the U.S. but other countries use various versions of PAL, SECAM, and even NTSC. PAL with 625L/50F is common in many European countries.

4. FM (and other) radio station channel frequencies and other broadcast parameters differ.

5. Phone line connectors and other aspects of telephone equipment may differ (not to mention reliability in general but that is another issue).

6. Of course, all the plugs are different and every country seems to think

that their design is best.

For example, going to a country with 220 VAC 50 Hz power from the U.S.:

For electronic equipment like CD players and such, you will need a small step down transformer and then the only consideration power-wise is the frequency. In most cases the equipment should be fine - the power transformers will be running a little closer to saturation but it is likely they are designed with enough margin to handle this. Not too much electronic equipment uses the line frequency as a reference for anything anymore (i.e., cassette deck motors are DC).

Of course, your line operated clock will run slow, the radio stations are tuned to different frequencies, TV is incompatible, phone equipment may have problems, etc.

Some equipment like PCs and monitors may have jumpers or have universal autoselecting power supplies - you would have to check your equipment or with the manufacturer(s). Laptop computer, portable printer, and camcorder AC adapter/chargers are often of this type. They are switching power supplies that will automatically run on anywhere from 90-240 VAC, 50-400 Hz (and probably DC as well).

Warning: those inexpensive power convertors sold for international travel that weigh almost nothing and claim to handle over a kilowatt are not intended and will not work with (meaning they will damage or destroy) many electronic devices. They use diodes and/or thyristors and do not cut the voltage in half, only the heating effect. The peak voltage may still approach that for 220 VAC resulting in way too much voltage on the input and nasty problems with transformer core saturation. For a waffle iron they may be ok but not a microwave oven or stereo system. I also have serious doubts about their overall long term reliability and fire safety aspects of these inexpensive devices..

For small low power appliances, a compact 50 W transformer will work fine but would be rather inconvenient to move from appliance to appliance or outlet to outlet. Where an AC adapter is used, 220 V versions are probably available to power the appliance directly.

As noted, the transformer required for a high power heating appliance is likely to cost more than the appliance so unless one of the inexpensive convertors (see above) is used, this may not pay.

7.11) Taking a CD player overseas (or vice-versa)

Fortunately, the standard for the CDs themselves is the same everywhere in the explored universe Yes, even Australia :-). Thus, there should be no issues of incompatibility. The differences will relate only to the power supply.

First, check your user's manual (which you of course have saved in a known location). It may provide specific instructions and/or restrictions.

Most component type CD players use a simple power supply - a power transformer followed by rectification, filter capacitors, and linear regulators. These will usually only require a small step up or step down transformer to operate on a different voltage. Since power requirements are minimal, even a 50 VA transformers should be fine. WARNING: never attempt to use one of those cheap lightweight power adapters that are not true transformers to go from 220 V to 110 V as they are designed only for heating appliances. They will smoke your CD player (or other equipment not designed to handle 220 V to 240 V input).

Some CD players may have dual voltage power transformers which can be easily rewired for the required voltage change or may even have a selector switch on the rear panel or internally.

The frequency difference - 50 or 60 Hz should not be a problem as nothing in a CD player uses this as a timing reference. The only slight concern would be using a CD player specified for 60 Hz on 50 Hz power - the transformer core may saturate and overheat - possibly blowing the internal fuse. However, I don't really think problems are likely.

For portable CD players, if your wall adapter does not have a voltage selector switch, obtain one that is rated for your local line voltage or use a suitable transformer with the one you have. As with power transformers, a frequency difference may cause a problem but this is not likely.

7.12) Buying a TV in Europe

"I have the following question for you specialists:

Can I buy a TV in any west-european country and use it in any other west European country? For example, buying a TV in the Netherlands and use it in Greece or buying in France and using in England.

Any help would be appreciated as I do not really trust the sale people at the store."

Neither would I.

Along with the multiple audio/video formats, there may be differences in channel frequency assignments between the various countries.

Channel 5 in country X may not be on the same actual frequency as Channel 5 in country Y or Z. The channel spacings or modulation may also be different.

From: Phil Nichols

Plus, in different countries the audio signal can be transmitted at a different frequency relative to the vision signal. Great! Perfect picture, no sound!

I believe most continental European countries use PAL B (narrow vision bandwidth; sound carrier 5.5MHz higher than vision carrier), whereas the UK and Ireland use PAL I (wider vision bandwidth; sound carrier 6MHz higher than vision carrier).

The wisest thing is to decide which countries you are most likely to want to visit with your TV, find out what transmission system they use, then go looking for a TV which can use that/those system(s).

Almost all TVs in west Europe are compatible (PAL-B/G),
>except Britain (PAL-I) and France (SECAM-L).
>Greece is also using SECAM, but on very few channels and not all the
>time.

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From: wolfi@berlin.snafu.de (Wolfgang Schwanke)

This is correct, but maybe not the whole story.
There are differences in the broadcast bands used.
At least Italy uses different channel allocations than the rest
of the PAL-B/G crowd. Germany uses frequencies on cable that are
unused elsewhere, which only special tuners can get.
Also, there are different methods for transmitting stereo sound
(NICAM vs. analogue).
New TVs nowadays (sold in Europe anyway) are often all-world-standard
all-frequency-bands, because it's easier for the manufacturer to
make a "one for all" set instead of having so many different designs
for every country. But don't rely on it.

(From Jeroen.Stessen@ehv.ce.philips.com)

Oh boy, here goes another long story:

PAL-plus is an attempt to extend the life-cycle of terrestrial
PAL transmissions by including compatible wide-screen (16:9)
transmissions. It is an advanced variant of the letterbox format,
this means that when you receive a PAL-plus widescreen program
on an older 4:3 receiver you will see black bars top and bottom.
It was originally developed in Germany (university of Dortmund
in cooperation with German terrestrial broadcasters and some
setmakers). Later a large consortium of European and Japanese
setmakers took over and finished the job. Strangely, the German
broadcasters seem to use PAL-plus only very rarely.

The PAL-plus standard comprises three extensions to the PAL-standard:
1. Vertical helper. In order to compensate for the fact that 1/4 of
   the video lines are not used, which would deteriorate vertical
   resolution for the widescreen viewer, the missing vertical
   information has been coded into the black lines in a manner as
   to be nearly invisible on a 4:3 receiver (you see some dark blue).
   The 16:9 PAL-plus receiver combines 432 visible lines plus 144
   helper lines into 576 new visible lines.
2. Colour-plus. The PAL colour carrier is modulated in a slightly
   different way (making use of correlation between 2 fields) in
   order to give a cleaner Y/C separation in the PAL-plus receiver.
3. Signalling bits from which the receiver can conclude whether
   the transmission is 4:3/16:9/PAL-plus and adapt the display
   format accordingly. The bandwidth of these bits is low enough
   to survive recording on a VHS recorder.

In order to enable a poor-man's PAL-plus receiver, the standard
permits using the mark "PAL-plus" if at least the vertical helper
reconstruction is included. Colour-plus is optional, so you will
find sets on the market with only half of the PAL-plus extension.

PAL-plus may also be combined with teletext, ghost cancellation
reference, digital Nicam stereo, VPS, PDC and what-you-have more.
Theoretically it can be broadcast over a satellite channel too,
but it was not designed for that and some aspects of a satellite
channel do indeed give interesting technical problems.

There are also sets marketed as "PAL-plus compatible". These are
mostly widescreen sets without any PAL-plus processing at all,
but they allow switching of the display format between 4:3 and
16:9. They may well do that automatically, based on the
signalling bits.

There are 2 methods for displaying a 4:3 letterboxed signal
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on a 16:9 display, without using the PAL-plus helper lines:
1. Increase of the vertical deflection amplitude to display only
   the centre 432 lines
2. Vertical interpolation without using the helper, to convert
   432 lines into 576 lines and display on a 576 lines display.
Both modes may be called "movie expand".
Only when you really convert to full-resolution widescreen will
it be called "widescreen".

And there are 4 methods for displaying a regular 4:3 signal on
a 16:9 display (regular PAL, has nothing to do with PAL-plus):
1. Decrease of the horizontal deflection amplitude, this
   gives black bars left and right
2. Horizontal interpolation, to convert N pixels to 3/4*N pixels.
Both modes may be called "4:3" or "normal"
3. Non-linear horizontal deflection waveform, called "Panorama
   mode" by JVC, works by increasing the S-capacitor value.
4. Non-linear horizontal interpolation, called "Superwide"
   by Philips, works with an advanced sample-rate convertor.
With both modes, the left and right edges of the picture will
be stretched to fill the left and right bars, but the aspect
ratio of the centre part of the picture will hardly be affected.

Interesting, ain't it ?

(From: Allan Mounteney (allan@amounten.demon.co.uk)).

RE: Is there a TV set that covers international standards?

The answer is YES.

Reason I know is that I was with a company that made computers
with TV-OUT for world wide use and wanted something that could
show that the TV Out worked for various countries.

This ONE and ONLY one we could find Three years ago came from
Germany and covered PAL, SECAM and the American NTSC systems and
came with a note that said from the time of making/selling that
set it would not work in just one small country in South America.
All features (including audio) were adjustable from the front
panel Menu and it was a Grundig 17" job. I am advised that there
is a load of others on the market now.

The company who seemed to know all about these international sets
and gave us good service at that time was Andrew McCulloch Ltd in
Cambridge UK. Phone #44(0)1223-351825
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7.13) Running three phase motors on single phase power

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This may be an issue if you picked up a South Bend lathe with a 10 foot bed
at a garage sale for $1 or more realistically with professional shop equipment
like large saws or planars.

A three phase motor will run on single phase power once started - but at
somewhat reduced output power (horsepower).  The very simple approach (compared
to complete conversion) is to just provide a means for starting.  The motor
will then run at the correct speed (assuming the line frequency is the same)
but will not be able to develop full torque before stalling.  Actually
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converting single phase to three phase will likely be more expensive than
replacing the motor.

There is some info at:

http://www.loganact.com/mwn/howto/ph-conv/ph-conv.html
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