Things to Review Before Your Next Rectifier Purchase

W. Boddison, American Plating Power, LLC, Fort Myers, FL

- Introduction

As we all know, every electro-chemical process uses a power-supply to deliver the electrical energy necessary for the process. To choose the right power-supply, a number of things need to be taken in account such as expected process voltage, current density in the bath (ASF) etc. During this session we will take a look at the various aspects that need to be considered before selecting a certain type of plating power-supply. With recent developments in power electronics comes the need to reconsider types of power-supplies that would have been no option 10 years ago. In this very traditional industry it may give you price and/or quality advantages to get/stay informed about new developments in power supply technologies.

For more Information, contact:
Waasy Boddison
American Plating Power, LLC
13300-56 S Cleveland Ave.
Fort Myers, FL 33907
Phone: (239) 275-5877
FAX: (239) 275-4959
E-mail: wboddison@usplating.com

- Overview
  - Introduction
  - Different electrochemical processes use different voltages and currents
  - Environmental conditions.
  - Output Ripple.
  - Pulse, Periodic Pulse Reverse operation
  - Other factors

- Different electrochemical processes use different voltages and currents

The first most important decision to be made in selecting a power-supply is the type of voltage (DC (direct current) or AC (Alternating Current)voltage) and the maximum voltage that the unit can deliver.
Select a power-supply that can output more than your process needs. Reason for this is to avoid problems like voltage drop in your electrical circuit due to long cabling and/ or contact resistance built-up over time.

Example common processes	Average process voltage
Copper plating Chrom plating Nickel plating	4 – 6 VDC
Example Special processes	E-coating
Aluminum anodizing Interference Coloring Anodic protection	

The second most important decision is the maximum current that the power-supply can deliver. Here it is important that you know the current that your maximum load will ever need (under-rating the power-supply will of course result in ASF (Amps per Square Foot) problems.) . Another factor to keep in mind is the output ripple which will be discussed later on.

- Environmental conditions

Most electrochemical processes use media that cause harmful fumes to power-supplies placed in their direct surrounding.
These fumes can cause damage to the electrical parts inside the power-supply resulting in down-time and the need for regular maintenance.
Every power-supply needs cooling in one form or another, to cool down internal parts that heat up during operation.
The majority uses air or forced-air cooling. As a result of this the acid fumes can get inside the power-supply and potentially harm components inside. Although smart internal airflow design

and formal coating of components reduce risks significantly, not all manufacturers design their power-supplies this way. Supplying fresh air to the air flow or placing the power-supply in a clean room will extent the lifetime of a power-supply.
In case no fresh air is available, there are alternatives:

- Water cooling

There are three forms of water-cooling:

- air-to-water heat exchanger
- open-circuit water-cooling (wherever a clean water supply is available)
- closed-circuit watercooling (water is recycled within the power-supply and by using a water-to-water heat exchanger heat is transferred outside. This is a solution if no clean water is available)

One thing to keep in mind is that the water-temperature can cause condensation inside the power-supply.
This can be avoided by using a temperature control.

- Oil cooling

Oil cooled power-supplies are optimal protected against the environment.
Possible drawbacks:

- bulky: space problems
- less service friendly.

- Output Ripple

When we speak about 'ripple' we basically are describing the quality of the DC output voltage of a DC-supply.
Ideally the DC output voltage looks like a straight line (see fig. 1):

FIG.1

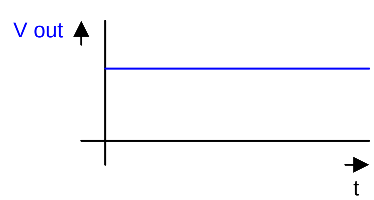
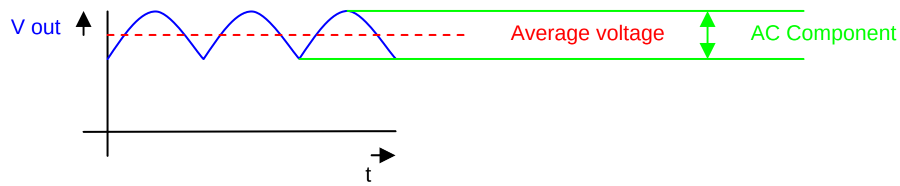


FIG. 2



Practically there will always be some sort of variation (or 'ripple) of the output voltage (see fig. 2). The amount of variation is expressed by taking the AC component of the output voltage, divide this by the average DC output voltage and multiply the result by 100. This gives us the ripple factor in percentages.
In a real life situation you can use a multi-meter, set it up to measure DC volts and connect it to the output of the power-supply. This gives you the average DC output voltage. Next you switch the multimeter to measure AC. This will give you the AC component of the output voltage. Divide the AC component by the DC component and multiply the result by 100 to optain the Ripple factor in percentages.

There are different power-supply technologies, with each their own characteristics as far as the output ripple is concerned.

- The SCR (Silicon Controlled Rectifier) type power-supply

  These power-supplies have a ripple of +/- 5% at full output capacity. When decreasing the output of these power-supplies, the ripple factor will go up i.e. get worse. The most common way of improving the ripple factor here is to add an output filter an/or capacitors. This will somewhat smoothen the output waveform but is only effective above +/- 60% of the full capacity of the power-supply. (diagram)

- Tap switch power-supply

The tap switch gives a constant output ripple of +/- 5%. The adjustment however is manual and in a limited amount of steps, so there is no accurate remote control of the output possible. In some cases however it is an economical solution

- VARIAC or Variable Auto transformer Power-supply

Again here the output ripple is +/- 5% with the advantage of stepless output control over the whole range (meaning that the ripple stays at +/- 5% from 0 – 100 % output voltage.

- The Switched Mode Power Supply

Due to the evolution of power electronics this technology offers power-supplies with an contant output ripple of < 3%! For applications where you want the ripple to be as small as possible, these power-supplies offer the best solution in addition to other factors like more compact designs etc.

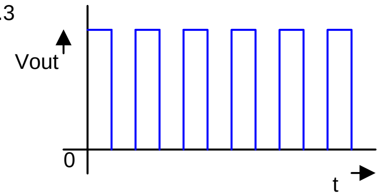
- Pulse, Periodic Pulse Reverse operation

Pulse plating offers in certain processes improved throwing power, shorter production cycles (higher throughput).

- PULSE:

For some electrochemical processes it is necessary, or it gives advantages to periodically interrupt the output voltage. This creates a pulse-like waveform (see fig.3).

Fig.3

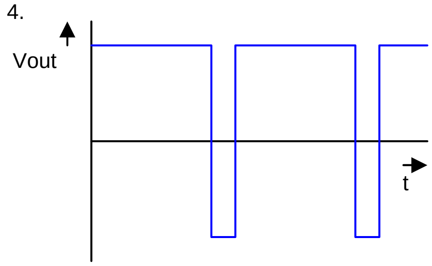


This interruption can be achieved with a mechanical switch (wear, long switching times) or electronically (with an external solid state switch or internally in the power-supply itself.

- PULSE REVERSE:

Another more frequent used output waveform is created by a Pulse Reverse Power-supply. In this case there is output polarity switching involved (see Fig.4).
Although it has been around for decades, pulse reverse became popular, especially in the Printed Circuit Board industry about 7 years ago. Again due to new developments in electronics made it possible to manufacture power-supplies specialized for pulse operation. Before it was done with switch-boxes, but these turned out not to work for more demanding applications.

Fig 4.



More advanced waveforms include Pulse on Pulse (Fig.5) and the use of Dead Time (Fig.6).

Fig.5

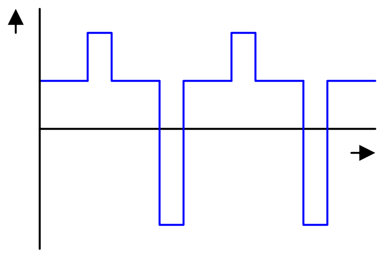
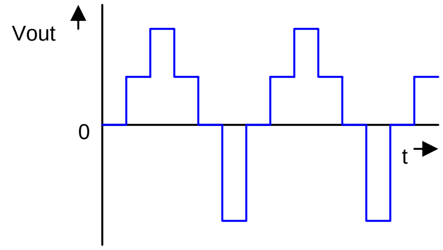
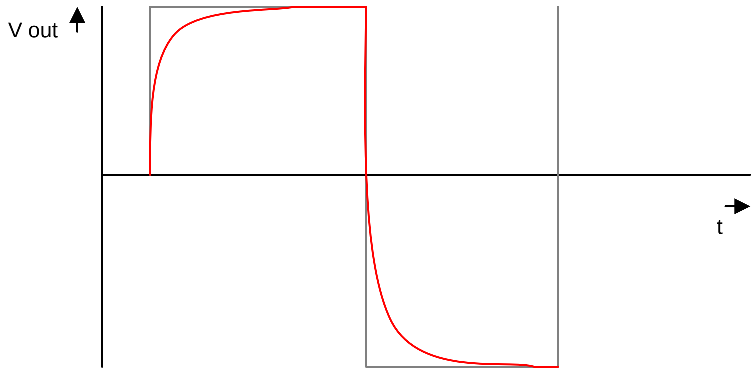


Fig.6



One aspect, using pulse waveforms, that is sometimes overlooked is cable induction. Cable induction has a negative effect on rise and fall times of pulse signals. The higher the induction of the cable, the less 'rectangular the output waveform of the rectifier will be.(see Fig. 7). To get the best possible waveforms you therefore want to use a low inductance cable like for example a coax cable.



- Other factors

- Investment, budget
- Space restrictions (SMPS versus SCR) (SMPS Cabinets etc.)
- Easy to service (modular systems)

Additional

Control methods

- Local control (pot's on rectifier, digital user interface)

- Remote
    - Analog (0-20mA,0-10V) distant restricted
        - PLC isolation amplifiers
    - Digital
        - Modbus
        - Fieldbus control
            - Interbus-S
            - Profibus DP

Data logging

Automation of complete plating process

Amp/hour meters, timers rampers

