



# PORTABLE DIALYZER-A SAFETY ENGINEERING ON THE DESIGN OF HEMODIALYSIS SYSTEM

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**Abstract:** Renal failure is a term to describe a situation when the kidneys fail to work. This may be a permanent or temporary failure. When the kidneys fail, Wastes begin to accumulate in the blood (uremia)As homeostasis is upset within the body, other organs can also begin to shut down – heart, liver, etc. The end result of renal failure is usually death unless the blood is filtered by some other means. The ideal intervention is to replace the failed kidneys with a donor kidney (STSE).While a person waits for a donor kidney, they usually have to undergo dialysis, a method where their blood is filtered and cleaned on a regular basis using machines. This paper gives a brief review about home dialysis machines.

**Keywords:** uremia, homeostasis, dialysate, British Pharmacopoeia.

## INTRODUCTION

The main stages that blood passes through during the dialysis process includes [1] Blood enters machine from body (under pressure from radial artery) then it is sent to the Pump (some diagrams show a roller pump) controls pressure and flow rate. The Anticoagulant is added to prevent clotting. The Blood then passes through dialysis membrane (equivalent to kidney nephrons).The Bubble Trap then removes any gas bubbles from blood. Blood is filtered then returned to the patient's radial vein.

### Hemodialysis

The principle of hemodialysis[3,6] is the same as other methods of dialysis; it involves diffusion of solutes across a semi permeable membrane.

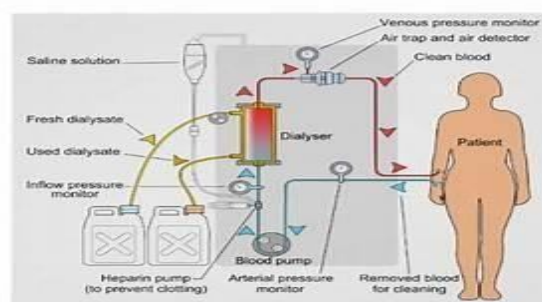


Fig. Haemodialysis Machine process

Hemodialysis utilizes counter current flow, where the dialysate is flowing in the opposite direction to blood flow in the extracorporeal circuit. Counter-current flow maintains the concentration gradient. Fluid removal (ultrafiltration) is achieved by altering the hydrostatic pressure of the dialysate compartment, causing free water and some dissolved solutes to move across the membrane along a created pressure gradient. The dialysis solution that is used may be a sterilized solution of mineral ions or comply with British Pharmacopoeia. Urea and other waste products, potassium, and phosphate diffuse into the dialysis solution. However, concentrations of sodium and chloride are similar to those of normal plasma to prevent loss. Sodium bicarbonate is added in a higher concentration than plasma to correct blood acidity. A small amount of glucose is also commonly used.

### DIALYSIS MACHINES OVERVIEW

Dialysis machines are artificial kidneys that perform most, but not all, kidney functions for patients who have permanent or temporary renal failure. The machines use hemodialysis to clean the blood and balance its constituents. With this process, the patient's blood is circulated through the machine where it is filtered and balanced for electrolytes, pH, and fluid concentration before being returned to the patient. One common problem with renal failure is water retention, so it is common for the process to remove several pints of fluid from the patient's blood. There are two basic classes of dialysis machines: clinical units, which are commonly cabinet-size machines operated by trained technicians; and home-use dialysis machines, which are smaller and sometimes portable. Normally, patients with complete loss of kidney function would need to visit the clinic at least three times per week and spend about four hours connected to the machine. With home-use machines, patients have more flexibility in scheduling dialysis, and they can dialyze for longer periods and more frequently. Thus, home-use machines are growing in popularity because they offer greater convenience and better clinical outcomes.

### GENERAL OPERATION OF DIALYSIS MACHINE

The patient's blood is continuously pumped from an artery, a large vein, or a surgically modified vein to allow high blood flow rates. Its pressure is both upstream and downstream from the peristaltic blood pump. Before the blood enters the dialyzer, heparin is added to prevent clotting. A syringe pump is used to deliver the heparin at a precisely controlled rate. The blood then enters the dialyzer where it passes across a large surface-area, semi permeable membrane with a dialysate solution on the other side. A pressure gradient is maintained across the membrane to ensure the proper flow of compounds out of and into the blood. After cleansing and balancing within the dialyzer, the blood is passed through an air trap to remove air bubbles before it is returned to the patient. An air bubble sensor ensures that no air bubbles remain. Blood-pressure, oxygen-saturation, and sometimes hematocrit levels (blood cell concentration) are monitored for proper operation of the machine and to ensure patient safety.

### PORTABLE DIALYSIS MACHINE (PORTABLE KIDNEY MACHINE)

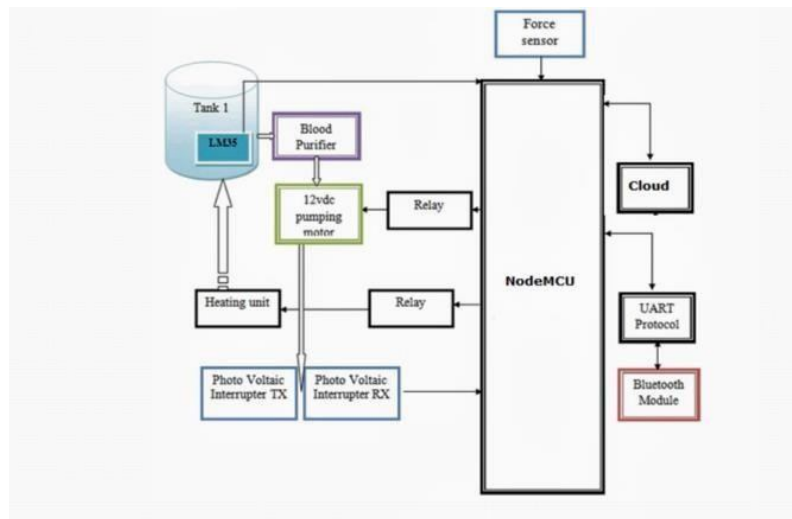


Fig. Portable Dialysis Machine (Maxim Model)

### SPECIAL REQUIREMENTS OF HOME UNITS:

For general convenience, home systems are smaller and sometimes portable. Since they require the additional function of dialysate preparation, the need for small, compact design is increased over clinical machines. The disinfection cycle at the end of therapy is also a power-hungry process. To accomplish the heating required in a reasonable amount of time, batteries or ultra-capacitors are included to provide short-term high-power capability to supplement line power as needed. When line-power usage drops below the 15A limit, the batteries or ultra-capacitors are recharged.

### BLOCK DIAGRAM



### Power Supply

Due to the long duration of the dialysis process, all dialysis equipment is AC-line powered. Standard AC-DC converters meeting medical safety standards are employed. Due to the variety of components requiring power, a variety of voltage rails are needed at different power levels. A power system with multiple-output switching regulators is needed with a significant amount of linear regulation at the load for noise-sensitive precision circuits. Safety regulations require power-supply self-monitoring for voltage, temperature, and current flow. Overvoltage and under voltage detectors are common. Due to the higher power levels, active cooling is required using fans and temperature sensors in a variety of locations. Home-use machines include water sterilization capabilities, which can require more power than is available from a standard wall outlet at 15A. Therefore, the power supply must be capable of limiting the current drawn from the AC line and adding in parallel power from a battery (or ultra-capacitor).

### PHOTO VOLTAIC INTERRUPTER

As the core of photovoltaic power station, inverter plays a main role in converting the irregular direct current of photovoltaic module into sine wave alternating current, and has the functions of over voltage, over current protection, insulation resistance protection, leakage current protection, grid voltage and frequency abnormal protection.

**Node MCU** is a low-cost open source IoT platform. It initially included firmware which runs on the [ESP8266 Wi-Fi SoC](#) from Espressif Systems, and hardware which was based on the ESP-12 module.<sup>[6][7]</sup> Later, support for the [ESP32](#) 32-bit MCU was added.

### SPI Protocol

SPI communication is always initiated by the master since the master configures and generates the clock signal. Any communication protocol where devices share a clock signal is known as synchronous. SPI is a synchronous communication protocol. There are also asynchronous methods that don't use a clock signal. For example, in UART communication, both sides are set to a pre-configured baud rate that dictates the speed and timing of data transmission.

### Blood purifier

Blood purification is one treatment for kidney failure. It is to use certain equipments to remove pathogenic materials so as to purify the blood and treat diseases. It is wider than dialysis and includes hemodialysis, peritoneal dialysis, plasma exchange, immune adsorption, blood perfusion and hemofiltration. Then software equipments are used in the portable dialyzer.

The **LM35** series are precision integrated-circuit temperature devices with an output voltage linearly-proportional to the Centigrade temperature. The LM35 device has an advantage over linear temperature sensors calibrated in Kelvin, as the user is not required to subtract a large constant voltage from the output to obtain convenient Centigrade scaling. It is a small and cheap IC which can be used to measure temperature anywhere between -55°C to 150°C. It can easily be interfaced with any Microcontroller that has ADC **function** or any development platform like Arduino.

## ADVANTAGES

1. Patients with complete loss of kidney function would need to visit the clinic at least three times per week and spend about four hours connected to the machine. With home-use machines, patients have more flexibility in scheduling dialysis, and they can dialyze for longer periods and more frequently.
2. Low-power design.
3. Wireless interfaces (such as Wi-Fi®) may also be included for direct connection to hospital wireless networks.
4. Data card slots are also available on some designs. This allows patients to carry an ID card with personal medical information stored on it to enable automatic setup of many of the machine parameters.

## CONCLUSION

The Maxim Model is better when compared to the other models because of the following reasons. This Model has a very good sensitivity. The Frequency range of operation about 8 MHz. The Temperature operation range of about -40 to 85 deg. centigrade and Sensor and the price of the instrument is also affordable. Wi-Fi Connectivity is also being implemented in this device.

## ACKNOWLEDGEMENT

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