

# AC HYBRID SYSTEM

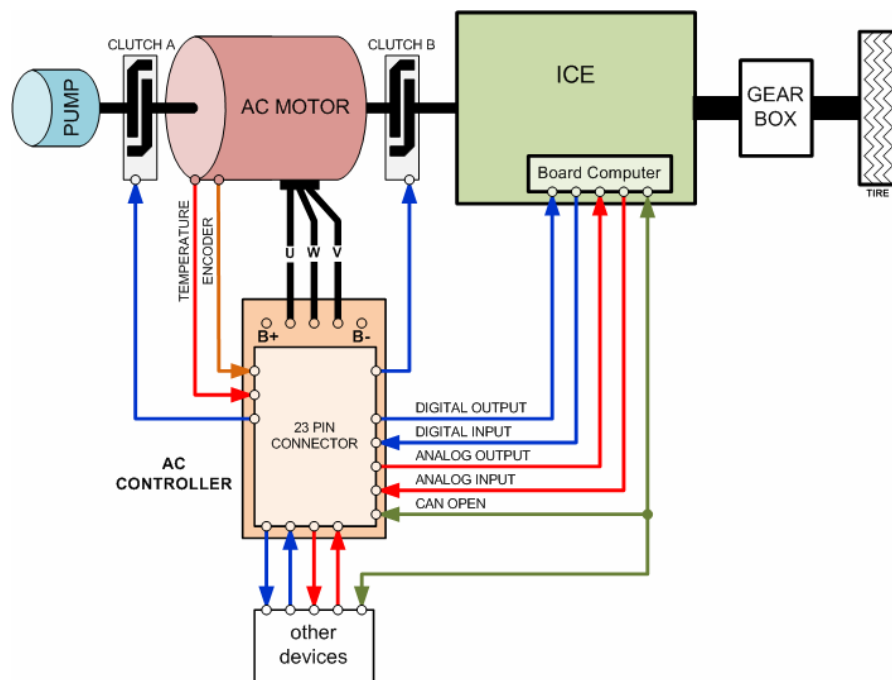
(48V/ 5 - 10kW)

## DESCRIPTION OF AC HYBRID SYSTEM

48V/ 5 - 10kW AC hybrid system is used for improving efficiency of systems where internal combustion engine (ICE) is used and downsizing of ICE itself. In principle this is a parallel hybrid where load can be driven by induction (AC) motor and ICE simultaneously. AC motor is located between ICE and hydraulic pump and is connected to them by two clutches. There are different operational modes that can be implemented by using this kind of configuration. We classify three different modes regarding to clutches position.

- PUMP MODE (A is engaged) – AC motor drives hydraulic pump
- ENGINE MODE (B is engaged) – AC motor can work as STARTER or GENERATOR or BOOSTER when used as a traction system (with gearbox).
- PUMP-ENGINE MODE (A and B are engaged) – AC motor can work as BOOSTER, GENERATOR or is not working at all.

All this operational modes are possible by using Iskra **AC MOTOR/GENERATOR** and **AC CONTROLLER** (Figure 1).



**Figure 1:** Hybrid system scheme

There are different advantages by using AC hybrid system:

- elimination of starter and alternator,
- ICE vibration and noise reduction when working booster mode,
- ICE dimension reduction,
- recuperation of energy (when lowering forks on forklifts or platform on aerial lifts),
- increased efficiency of the whole system (fuel consumption reduction),
- pollution reduction,
- automatic and smooth change between different operational modes.

## HYBRID SYSTEM COMPONENTS

Hybrid system is made of different components:

- AC MOTOR/GENERATOR (supplied by Iskra)
- AC CONTROLLER (supplied by Iskra)
- CLUTHES (up to customer, we recommend to use electromagnetic clutches)
- HYDRAULIC PUMP (up to customer)
- ICE (up to customer)

### 1. AC MOTOR/GENERATOR

AC motor axis is elongated on both side of flange so that clutches can be mounted easily. Axis is thicker on ICE side.

Nominal power [kW]	5 - 10
Nominal phase voltage [Vrms]	30
Maximum speed [rpm]	6000
Maximum torque [Nm]	100
Protection against dust and water	IP 54
Diameter [mm]	312
Length [mm]	262
Encoder pulses	64
Temperature sensor	KTY 84-130

**Table 1:** AC motor specifications



**Figure 2:** AC motor

## 2. AC CONTROLLER

- **Specifications**

Nominal voltage [V]	48
Maximum voltage [V]	72
Minimum voltage [V]	32
Maximal phase voltage [V]	3 x 34
Maximum current 1 min [Arms]	350
Maximum current 60 min [Arms]	140
PWM frequency [kHz]	10
Minimum ambient temperature [°C]	-30
Maximum ambient temperature [°C]	60
Protection against dust and water	IP 64
Dimensions [mm x mm x mm]	200 x 155 x 76
Signal connector	AMPSEAL 23 pin

**Table 2:** AC controller specifications



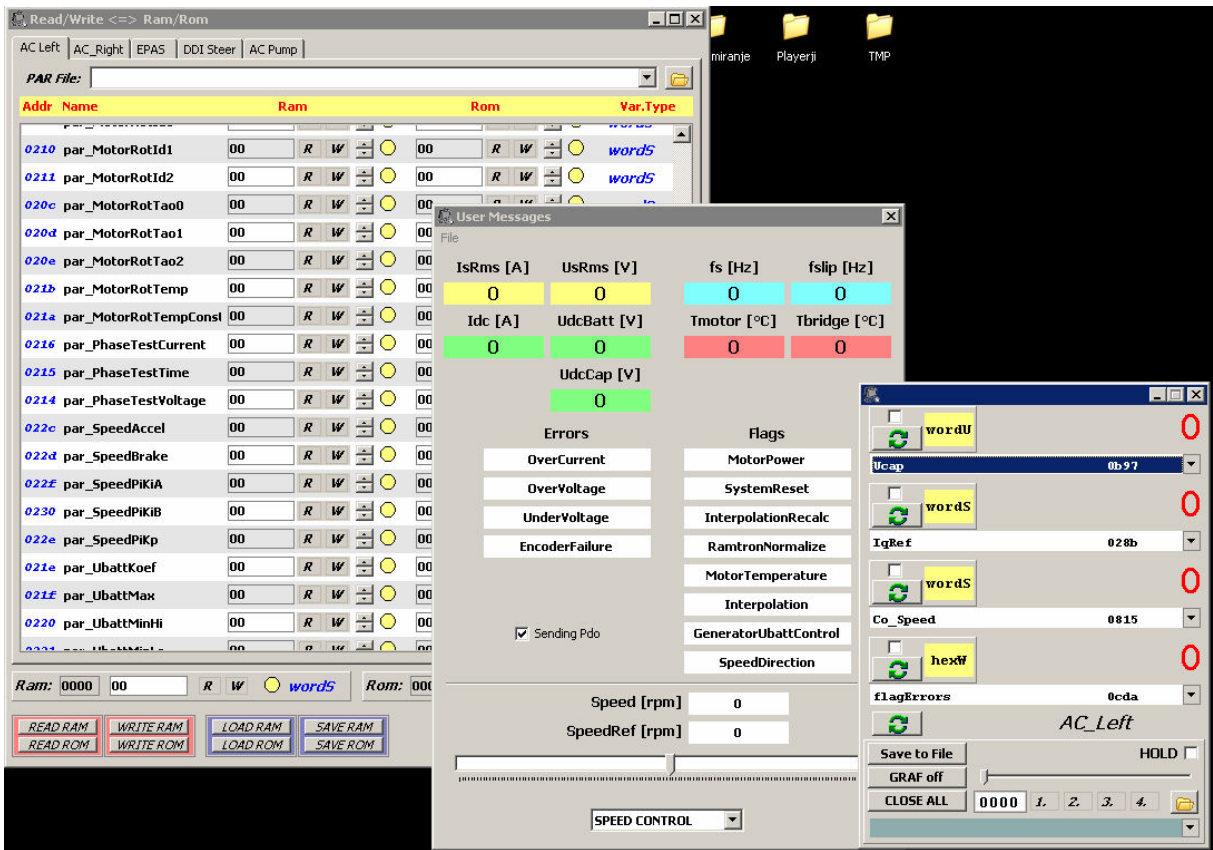
**Figure 3:** AC controller

- **Parameters and Can monitor and program download**

AC controller drives AC motor by using space vector field oriented control developed by Iskra. Beside driving AC motor/generator and controlling both clutches AC controller software has also other functions like temperature protection (motor and controller), encoder fault detection, short and open circuit detection, check sum control, digital output fault detection, checking battery status, checking capacitor status, speed control, torque control, battery current control, etc. Software can be modified to fits customer specific demands.

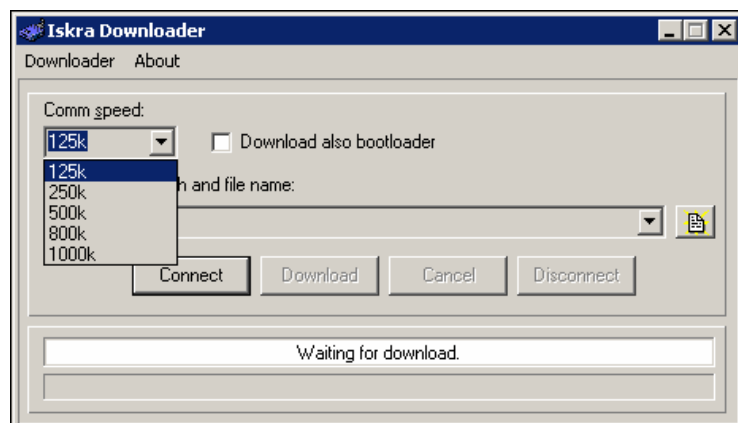
- **Parameters and Can monitor and program download**

Software behaviour is controlled by a set of parameters. Setting and reading parameters is possible using CAN adapter and suitable PC software. PC software can be provided by Iskra Avtoelektrika. Customer should buy CAN adapter by himself and it must be **isCAN USB** can adapter that is produced by **Ifak system GmbH**.



**Figure 4:** PC software for monitoring parameters and variables

Downloading program into controller is possible using the same CAN adapter and suitable PC software. PC software can be provided by Iskra Avtoelektrika.

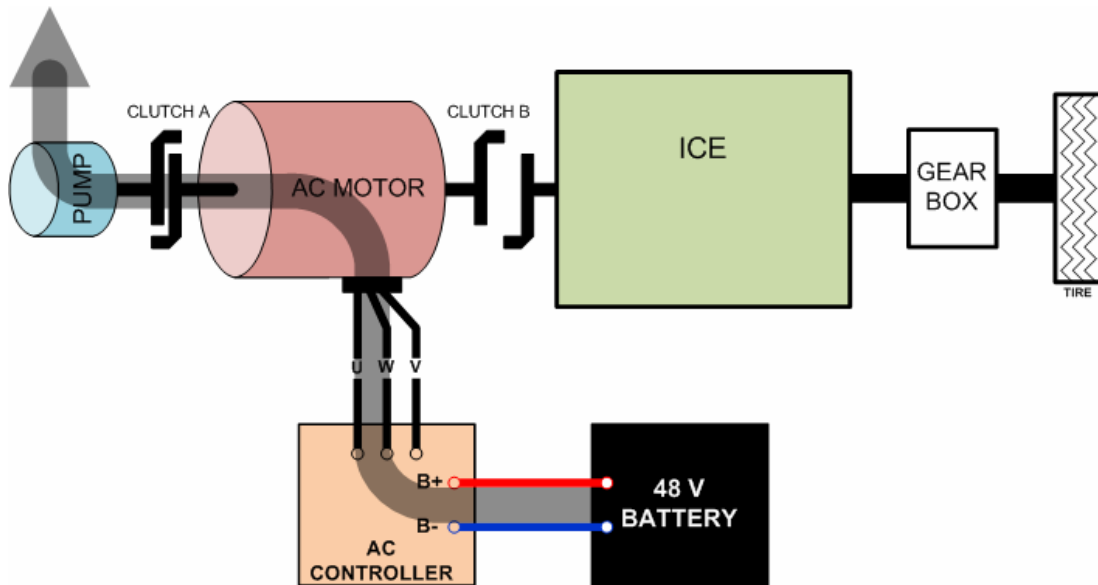


**Figure 5:** Download program

## OPERATIONAL MODES

### 1. PUMP (MOTOR) MODE

Clutch A is engaged and clutch B is disengaged. Hydraulic pump is driven by AC motor and the whole energy is taken from the battery (Figure 6). By changing parameters is possible to obtain different kinds of torque speed characteristics.



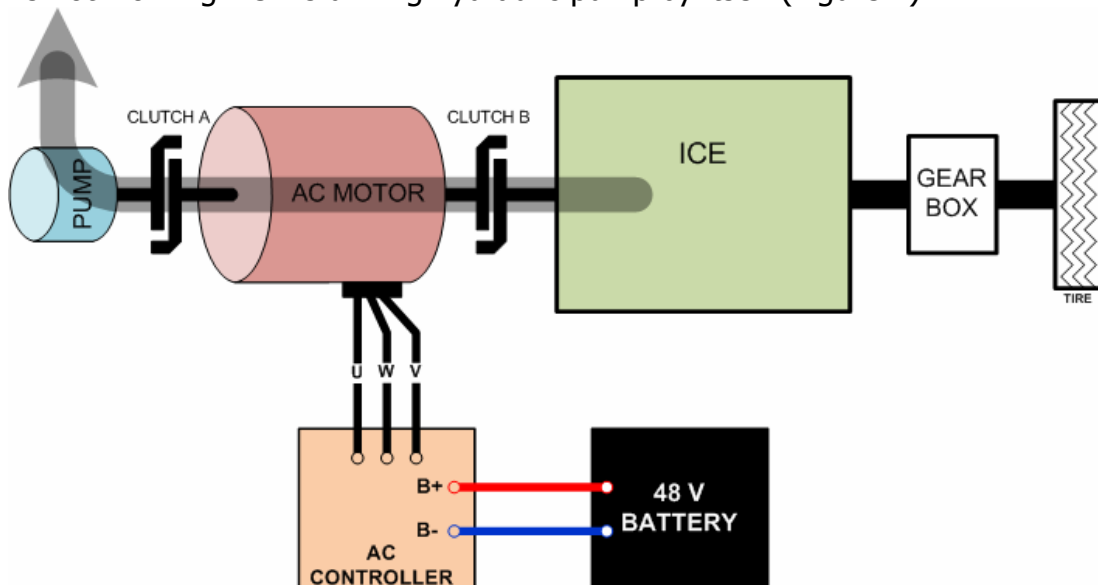
**Figure 6:** Pump (motor) mode – energy flow

### 2. PUMP-ENGINE MODE

Clutch A and B are engaged. There are three sub modes that are possible in this regime.

- **Normal sub-mode**

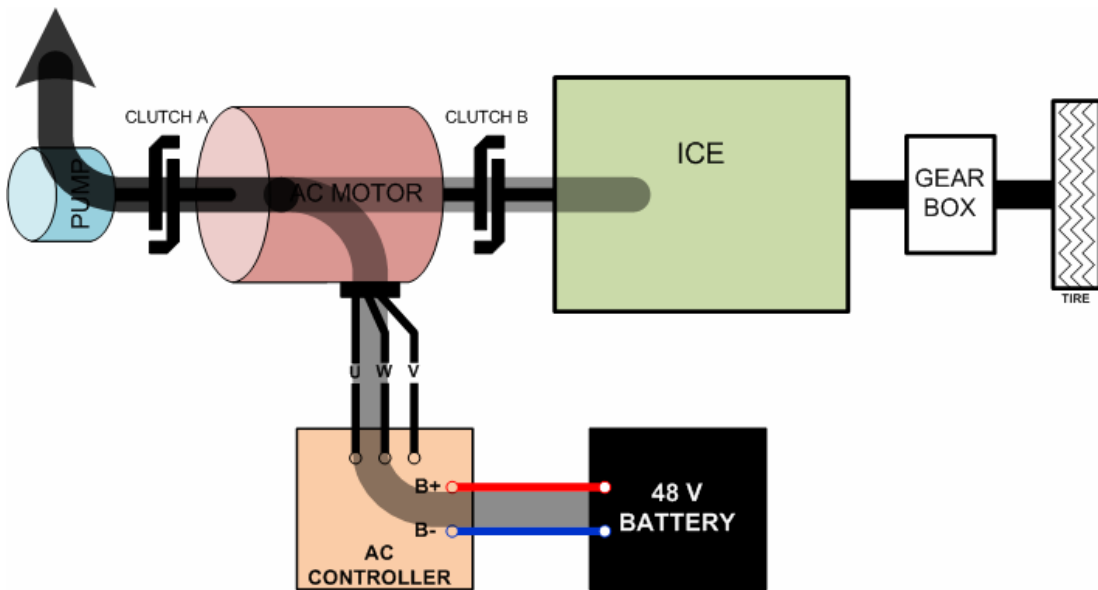
AC motor is not working. ICE is driving hydraulic pump by itself (Figure 7).



**Figure 7:** Pump-Engine mode – normal

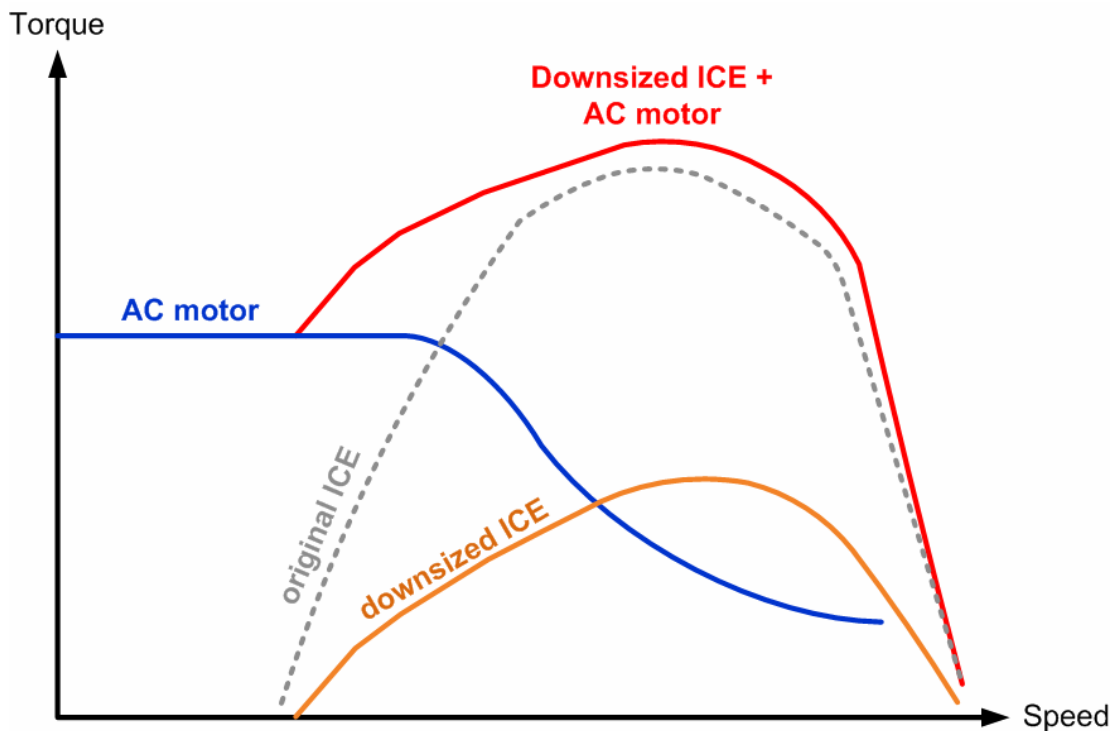
- Booster sub-mode**

AC motor assists ICE (Figure 8). Hydraulic pump is driven by torque which is a sum of torque from AC motor and ICE. In this mode ICE vibration and noise is reduced.



**Figure 8:** Pump-Engine mode – booster

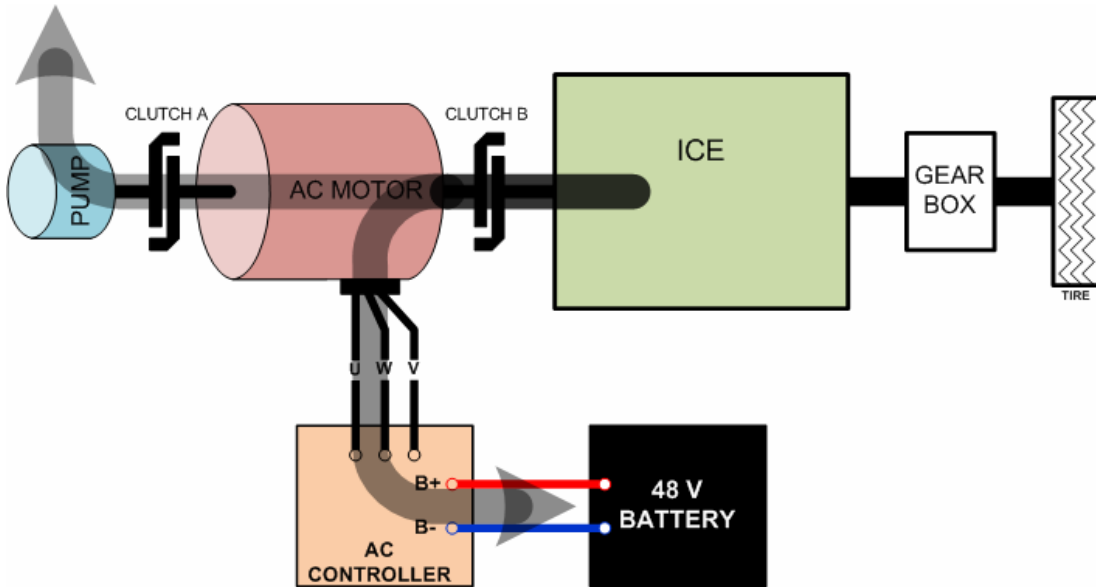
Combining ICE and AC motor together can lead to a reduction of ICE motor (Figure 9).



**Figure 9:** Pump-Engine mode – Booster (ICE motor dimensions reduction)

- **Recharge sub-mode**

AC motor takes of some of ICE's torque and save this energy back in the battery (Figure ). ICE is still capable to drive hydraulic pump.



**Figure 10:** Pump-Engine mode – recharge

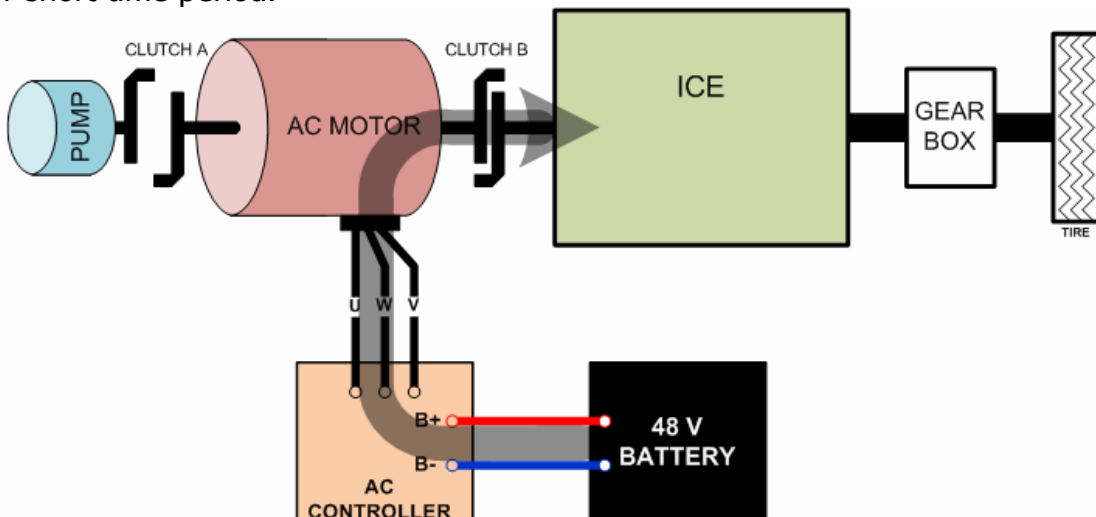
Recharge mode is active only in a specified speed range, when ICE has maximum efficiency and higher torque, so that the influence of AC motor is neglected in compare with ICE's available torque.

### 3. ENGINE MODE

Clutch A is disengaged and clutch B is engaged. There are three sub modes that are possible in this regime:

- **Starter sub-mode**

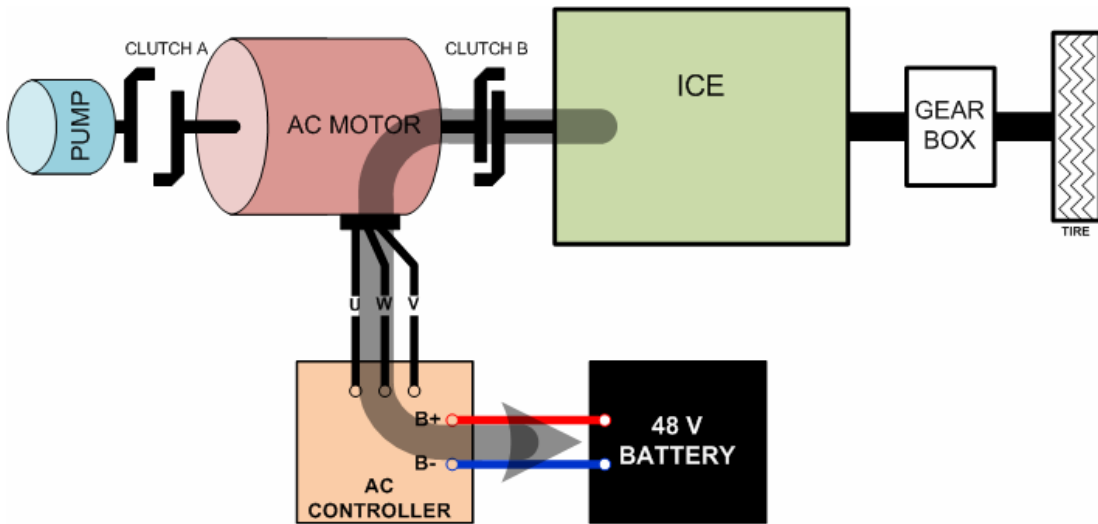
AC motor can be used to start engine instead of starter motor. AC motor can produce 100 Nm torque for short time period.



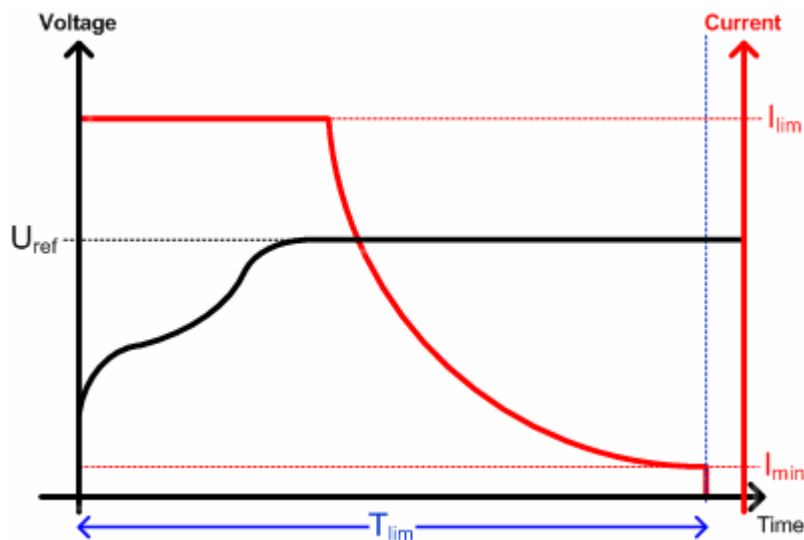
**Figure 11:** Engine mode – starter

- **Generator sub-mode**

AC motor can be used to recharge batteries of alternator (Figure 12). In this mode a battery voltage regulation with current limit is applied. If actual battery voltage is lower than  $U_{ref}$  then battery current is limited to  $I_{lim}$ . Battery current is regulated so that battery voltage does not exceed  $U_{ref}$ . After a predefined time  $T_{lim}$  or if the battery current is lower than  $I_{min}$ , the process is stopped (Figure 13).



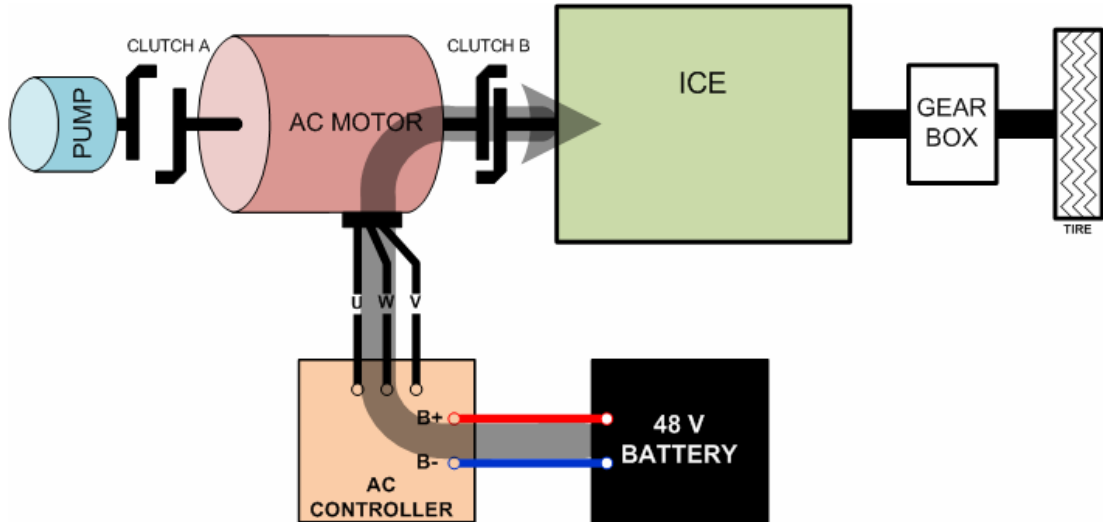
**Figure 12:** Engine mode – generator



**Figure 13:** Engine mode – recharging process

- **Traction (booster) mode**

AC motor can be used to add torque to ICE motor when it is in driving/traction mode (Figure 14). In this mode the gearbox is used connected to ICE motor.



**Figure 14:** Traction (booster) mode

## APPLICATIONS

- Material handling (forklifts),
- Construction machines,
- Aerial platforms,
- Agriculture machinery,
- Hybrid drive system (traction only)