School of Electrical Engineering – University of Belgrade

PROJECT MANAGEMENT AND LEADERSHIP SKILLS IN POWER ELECTRONICS RESEARCH ENGINEERING

Candidate: Nikola Milivojevic
Advisor: Professor Dr. Slobodan Vukosavic

supervisors:
Professor Dr. Kurt Richter
Professor Dr. Mirko Vujošević
Professor Dr. Zoran Stojiljkovic

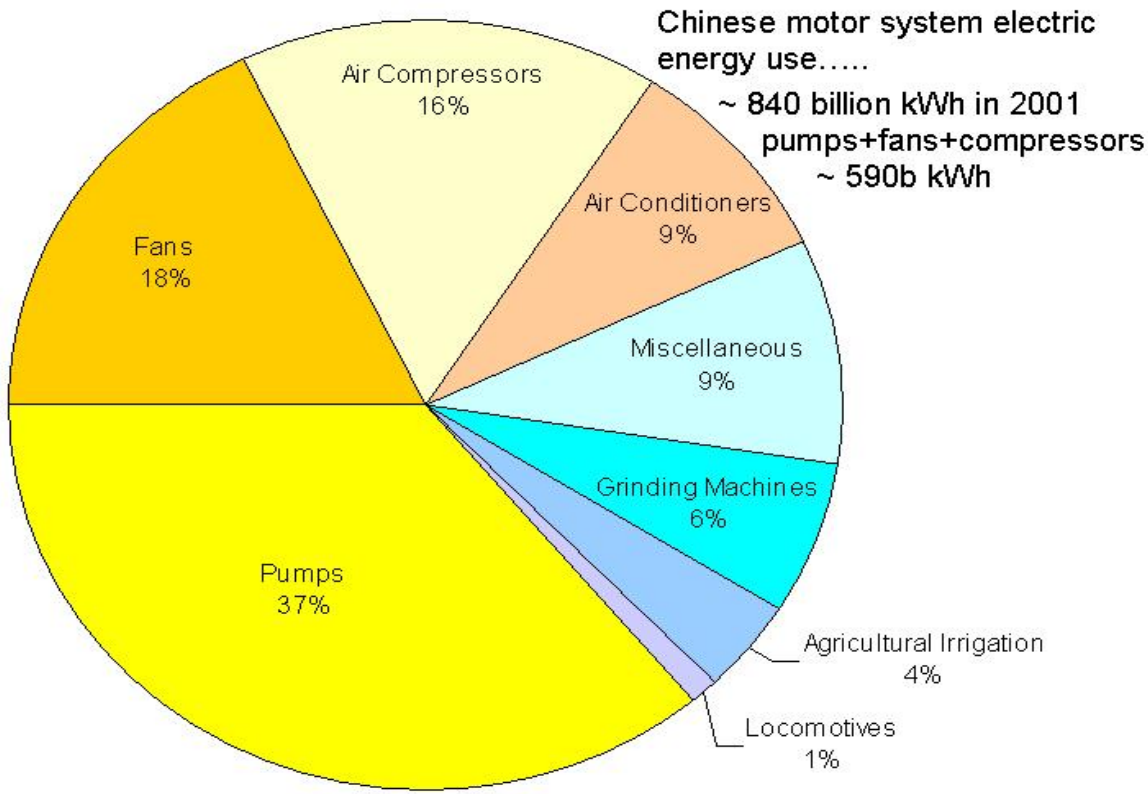
Belgrade, 24th of October 2007

Outline:

1. **Fundamentals of Electrical Drives**
2. **Typical Phases of the Projects in Power Electronics**
3. **The role of Project Managers and Team Leaders**
4. **Project methodology**
5. **Managing MiniDrive Power Electronics Project**

Fundamentals of Electrical Drives

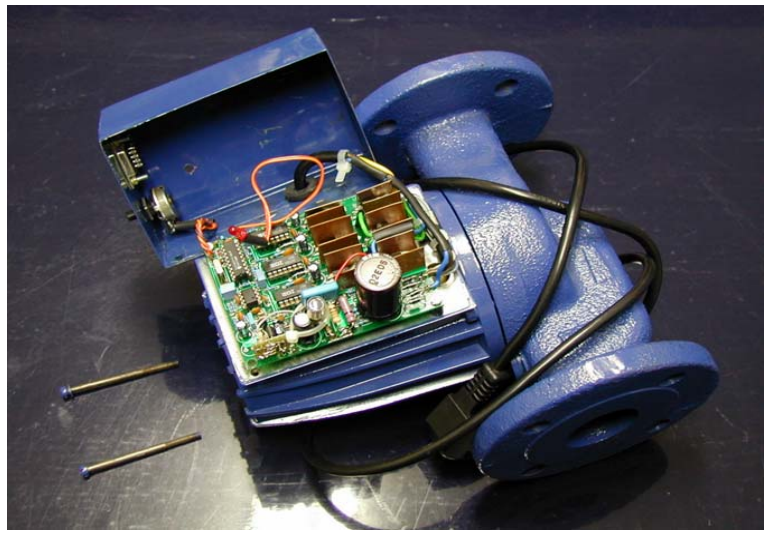
- 50% of total electrical energy produced in developed countries is converted into mechanical energy by electric motors
- Electric motors consume more than 75% of all electrical power in the US
- Adjustable-speed motors can improve the efficiency of these motors by about 50% in many applications.

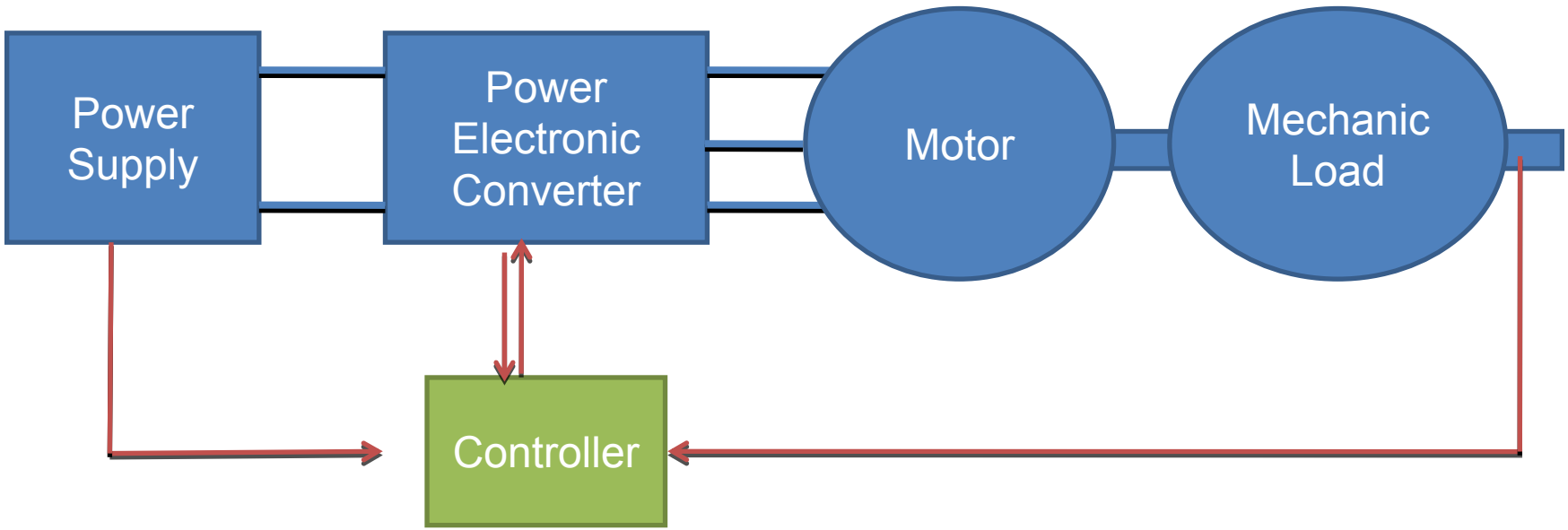


Fundamentals of Electrical Drives

A typical Adjustable-speed drive system consists of:

- Power Supply
- Power Electronic Converter
- Motor + Mechanical Load
- Controller

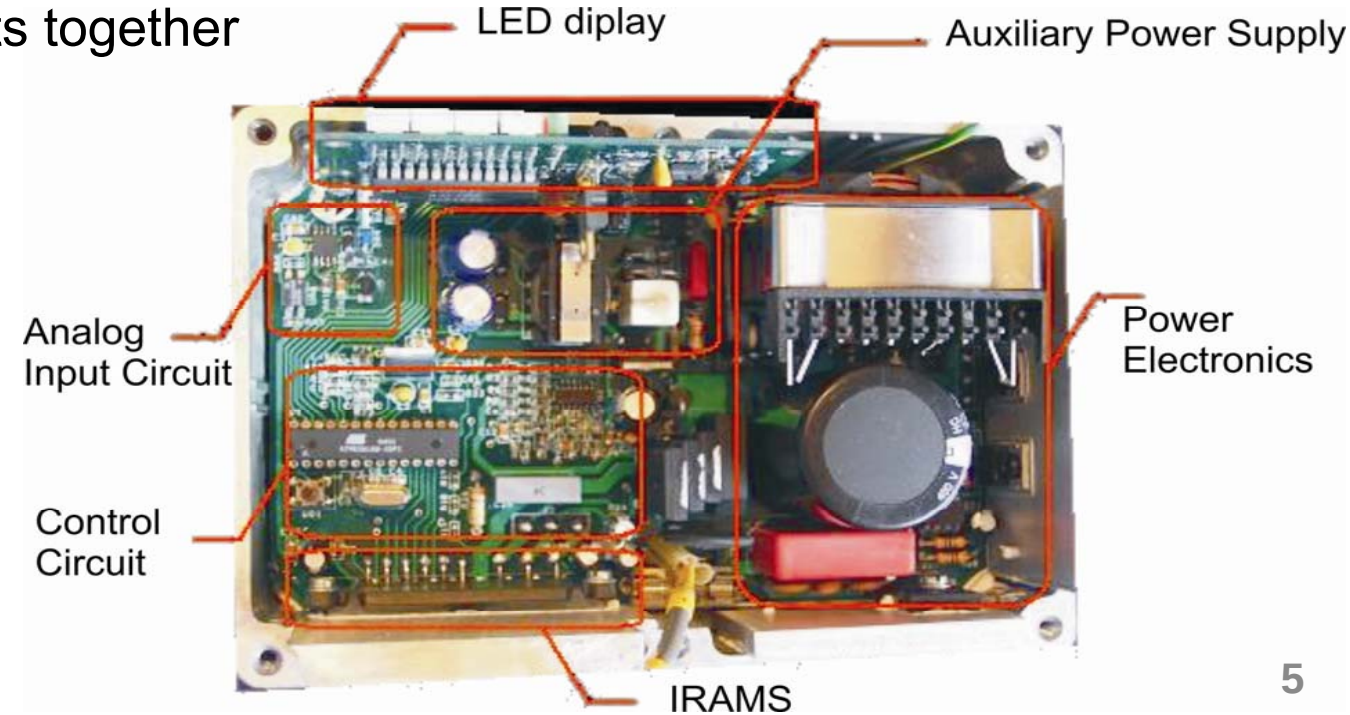




A typical adjustable-speed drive system

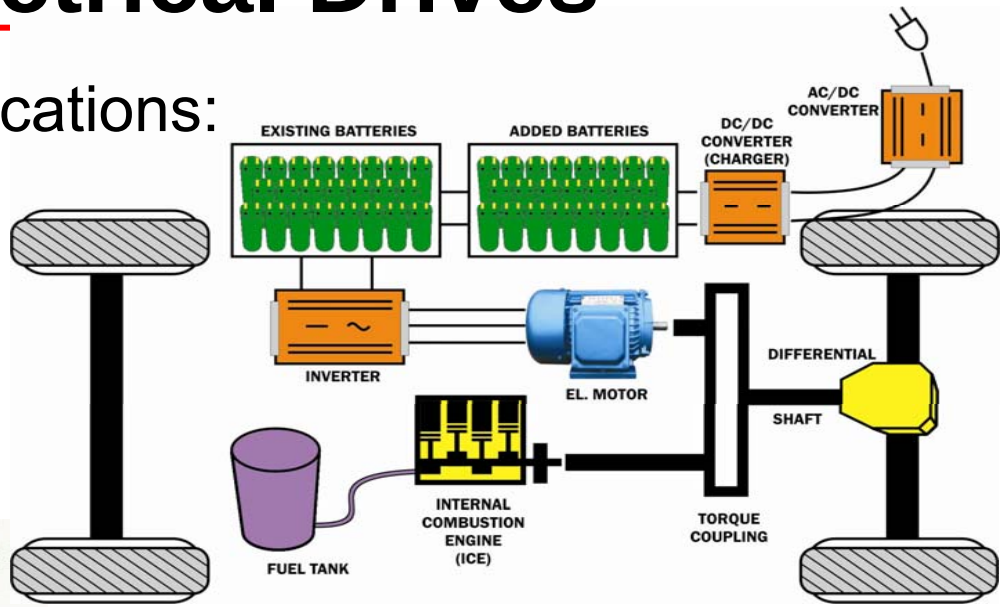
Fundamentals of Electrical Drives

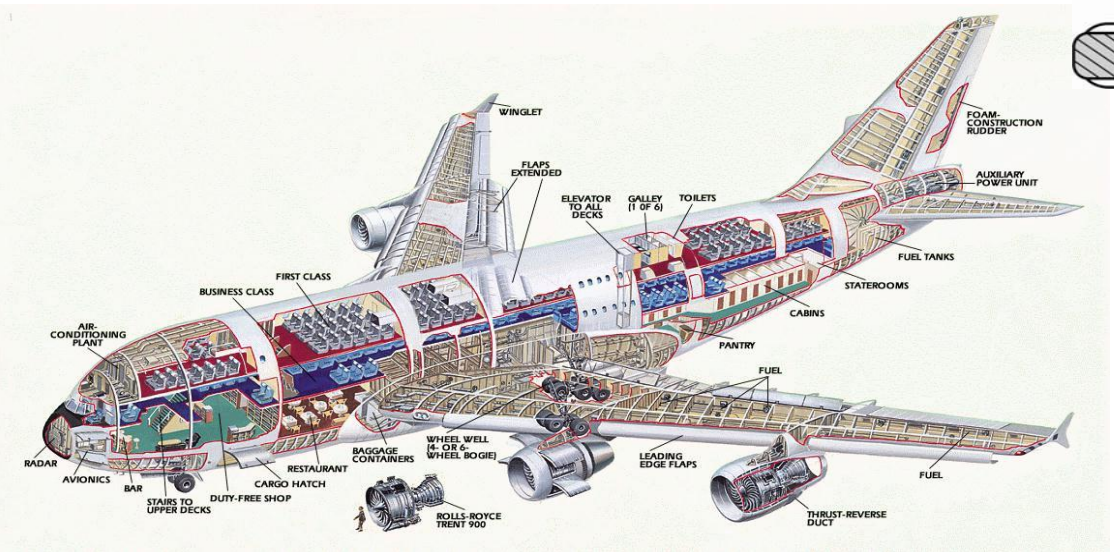
- Digital Control Applications:
  - Different Voltage levels
  - Communication among devices
  - Data converting (A/D & D/A conversions)
  - Programming
  - Thermal issues
  - Putting all parts together (soldering)
  - Testing...

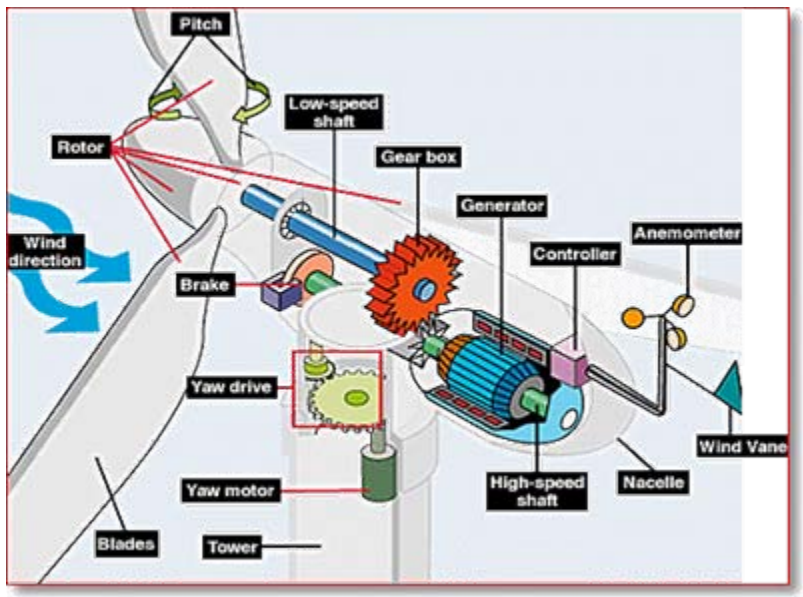


Fundamentals of Electrical Drives

- Complex Digital Control Applications:
  1. Hybrid Vehicles
  2. Marine applications
  3. Space vehicles
  4. Alternative Energy Sources…

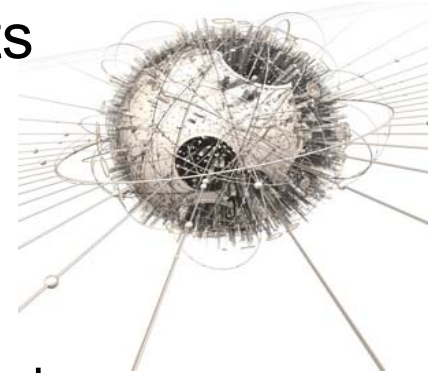






Complexity of Projects in Power Electronics

The requirements of the Power Electronics Projects are always the same:



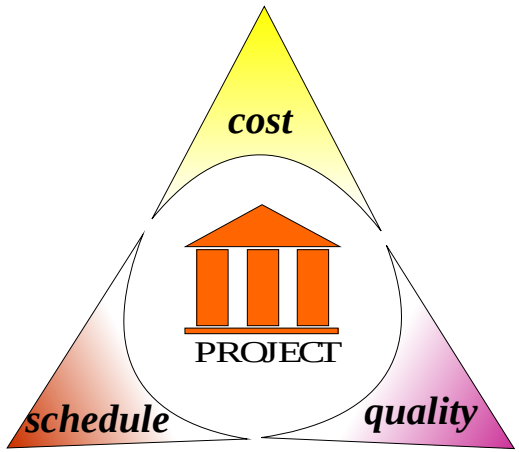
- More efficiency
- Less expanses and consumption
- Higher level of communication with other electrical devices
- Bigger working autonomy of devices etc.

Usually we need engineers from different field of expertise:

- Electronics
- Power
- Automation
- Software Design
- Communication
- Mechanical
- Material technology…

Need for a Project Management

- Projects in electrical engineering are complex with a multitude of variables
- New application must often interface with many other applications
- Thereby, there is a need for creating an integration challenge that is difficult to estimate in both time and resources



All three corners of the Bermuda Triangle can be achieved on ***every*** project

Project Leader's role

Leaders must have a wide range of skills, techniques and strategies. These include:

- Planning
- Communication skills
- Organization
- Awareness of the wider environment in which the team operates

- **Leaders' major role is to:**
  - **Set direction**
  - **Guide a vision**
    (have the strength of character to pursue their objectives in spite of failures)
  - **Establishes achievable goals**
  - **Support team members**
    (somebody might begin to lose confidence and therefore motivation)

Project Manager's role

- **Manager as a Planner.**

  A Manager has to take a long-term view; indeed, the higher you rise, the further you will have to look.

- **Manager as a Provider.**

  The Manager has access to information and materials which the team needs.

- **Manager as a Protector.**

  The manager should be there to guard against short-term excitements which can deflect the work-force from the important issues of the project, and to protect the team.

- **Managers' major role is to:**
  - **Do motivation**
  - **Define problems**
  - **Seek for solution**
  - **Delegate the job**

Project Definition

- **A Project is a *temporary* endeavor undertaken to create a *unique* product or service.**

Temporary:

Every project has a definite start and end that finishes with a final product

Unique:

Every project is different in some distinguishing way, unique final product

Each project in electrical engineering starts with:

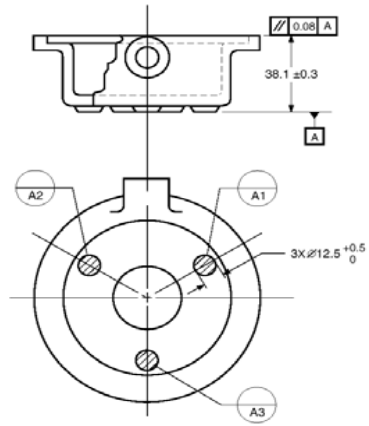
- **vision** – final result of the project (product)
- **mission** – process of making the final product
- **strategy** – outline of the project

MiniDrive Project Definition

- Future Energy Challenge Program Vision:
  - Encourage development of technologies to bring dramatic improvements to low-cost single-phase motor systems for home use
  - Incorporate practicality, manufacturability, and affordability into competition process
  - Improve education through development of innovative team-based solutions to complex problems

- Technical Goals:
  - Construct adjustable speed motor system costing less than US $40 for a 500 W unit
  - Achieve maximum efficiency and operating requirements
  - Maintain acceptable levels of performance, reliability, and safety

Starting with Project Specificatior



- A specification is a detailed definition of the project: a statement of the problem, not the solution.

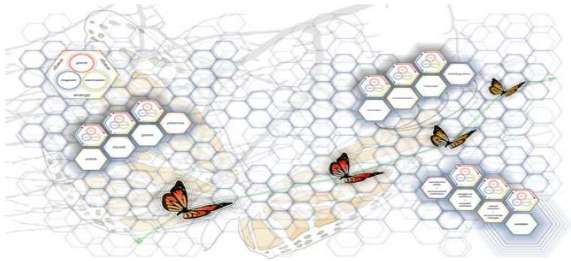
- The agreement upon a written specification has several benefits:
  - ***the clarity*** will reveal misunderstandings
  - ***the completeness*** will remove contradictory assumptions
  - ***the agreement*** forces all concerned to actually read and think about the details

MiniDrive Project Specification

Design Specifications

- Electrical noise – FCC Class A
- Acoustic noise – Less than 50 dBA sound level measured 0.5 m from the unit
- Self-protect against continuous stall, over temperature, or loss of input source
- Environment – Ambient -20C to +40C; suitable for indoor or outdoor domestic applications.
- 10 years maintenance free
- < 8 kg for complete system
- Metal casing must be connected to safety ground

Providing Structure



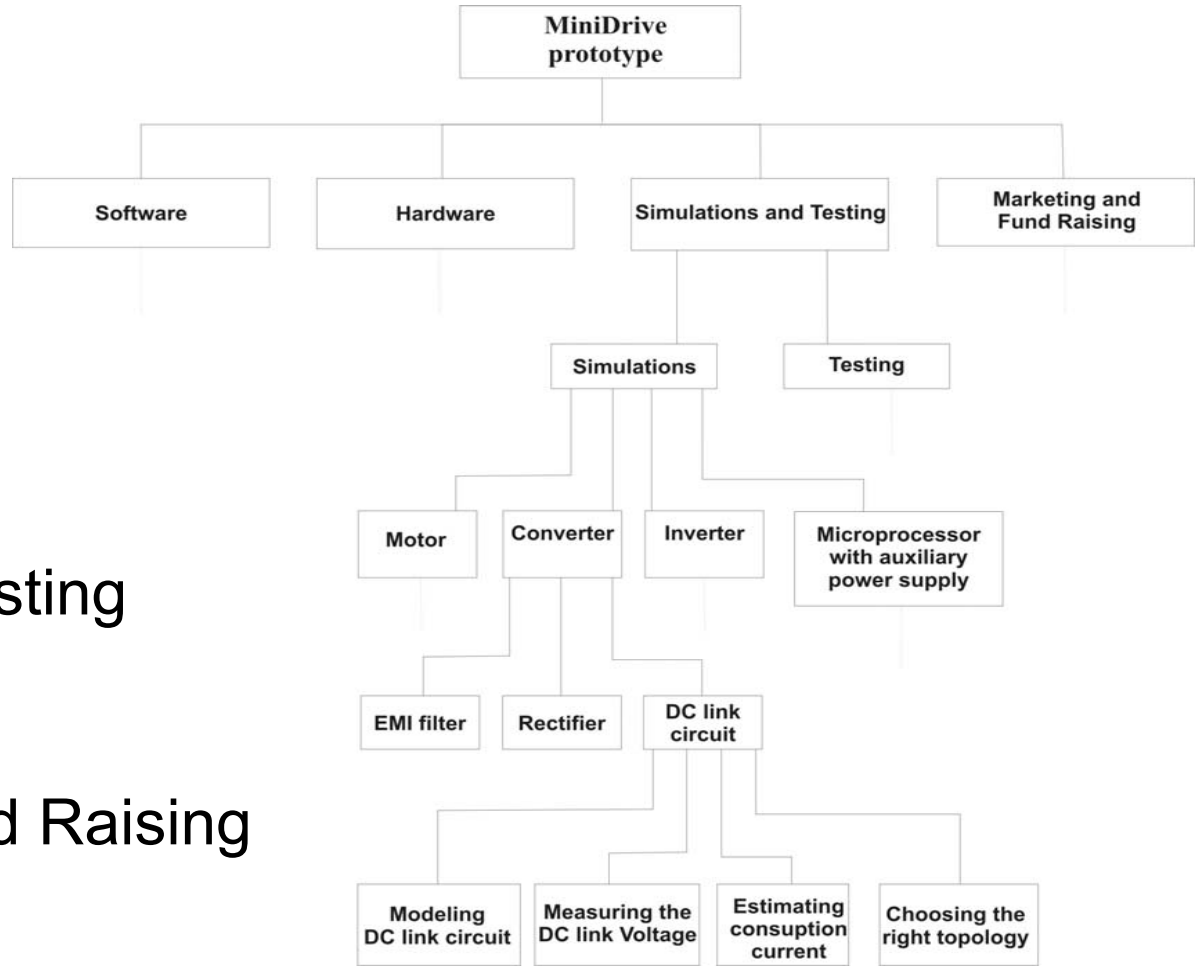
- After decided what is the specification, the next problem is to decide what the team actually needs to do, and how to do it.

- Providing some form of **framework**

- Once you have a clear understanding of the project, organize it as a set of simple tasks which together achieve the desired result

- In planning any project, it is needed to follow the same simple steps: if an item is too complicated to manage, it becomes a list of simpler items- ***work breakdown structure***

MiniDrive Structure



Divide the whole project into four big activities:

1. Simulations and Testing
2. Hardware research
3. Software research
4. Marketing with Fund Raising

Forming the right team of engineers

- Before much progress can be made, a core team needs to be formed
- Teams or sub-teams (groups) that are small enough to foster effective communication
- Cross-functional communication between groups
- To accomplish the project goals, it is necessary to choose right **Leader**
- One has to believe in the project and be ready to drive it forward

The job of the leader has three key components:

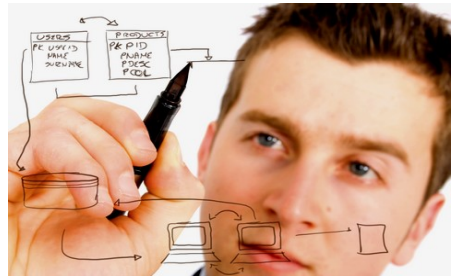
- ***Leading the overall effort*** ("Obsessed" Leader)
- ***Dealing with individuals*** - working with team members, understanding styles, communication and listening, motivating and rewarding, managing and resolving conflicts etc.
- ***Managing the work*** - planning, delegating, tracking…

MiniDrive team of engineers

Activities are carried out by individuals, but planning usually starts with classifications!

- Few students (core team) that were ***committed***
- Form the whole team (17 members) and divide it into 4 groups
- Communication between the groups **- *Team Meetings***
- Team building - helps develop a true, committed team spirit
- Sharing results
- Present Progress and remind on Milestone

Planning phase

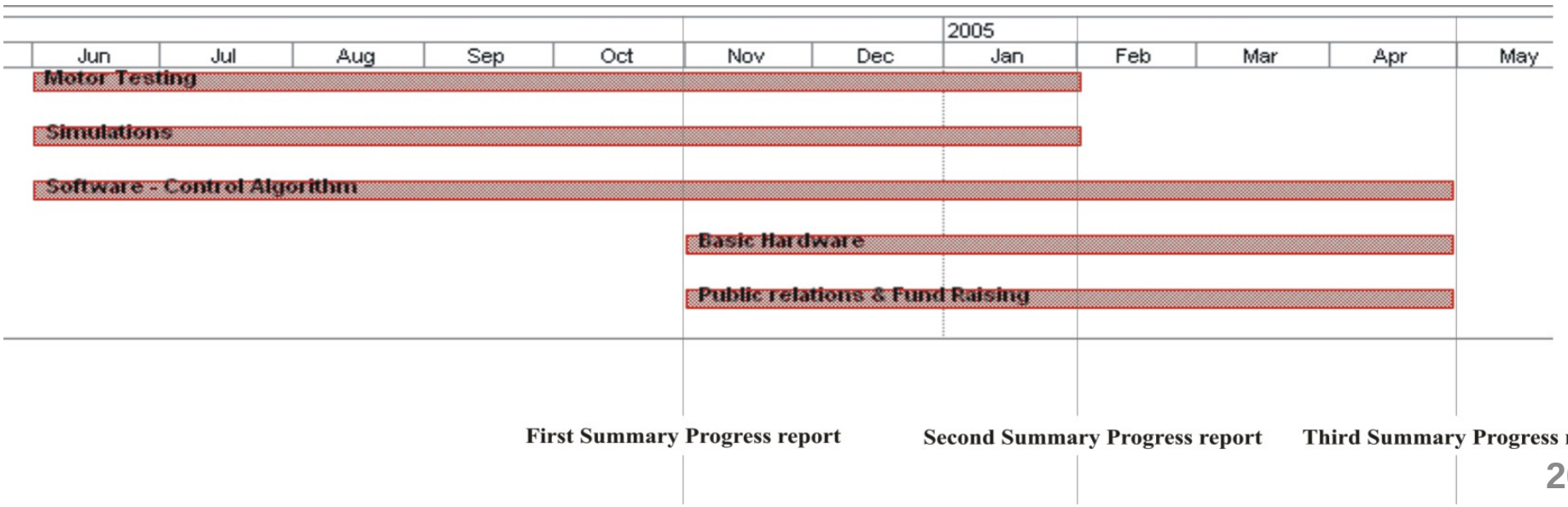


- The team must be involved in the planning of projects
- Not only they will provide information and ideas,
  but also they will feel ownership in the final plan
- Projects should be planned by leader and managers,
  based upon all the available experience and creative ideas
- With planning, projects can run on time and interact
  effectively with both customers and suppliers

MiniDrive Planning

- Setting the Milestones -

- Take the main components and lay them out
- Assign critical dates and any key relationships (dependencies)
- Milestones are needed in order to control the progress of a project
  - **External:** Progress Reports (deadlines given by organizers)
  - **Internal:** Set with Advisor and Consultants



MiniDrive Gantt Chart

ID	Task Name	Duration	Start	Finish	Predecessors	Resource Names
1	**1. DRIVE**	**305 days**	**Tue 6/1/04**	**Mon 8/1/05**		
2	**SIMULATION RESEARCH**	**78 days**	**Tue 6/1/04**	**Thu 9/16/04**		A2,A1
3	Motor Simulation	34 days	Mon 8/2/04	Thu 9/16/04	7	A1
4	converter simulation	33 days	Tue 6/1/04	Thu 7/15/04		A2
5	simulation of microprocessor with auxiliary power supply	23 days	Mon 8/2/04	Wed 9/1/04		A1
6	inverter simulation	30 days	Mon 6/21/04	Fri 7/30/04		A1
7	**MOTOR TESTING**	44 days	Tue 6/1/04	Fri 7/30/04		A3
8	**SIMULATION RESULTS**	22 days	Fri 9/17/04	Mon 10/18/04	3,4,5,6	A4
9	**DRIVE TESTING**	33 days	Thu 6/16/05	Mon 8/1/05	10,29	A3,A1
10	**2. HARDWARE**	**272 days**	**Tue 6/1/04**	**Wed 6/15/05**		
11	**AUXILIARY POWER SUPPLY (APS)**	**154 days**	**Thu 7/1/04**	**Tue 2/1/05**		**B1,B2**
12	Flyback converter analyzis	55 days	Thu 7/1/04	Wed 9/15/04		B1
13	Buck converter analyzis	55 days	Thu 7/1/04	Wed 9/15/04		B2
14	Generating the final Schematic for APS	88 days	Fri 10/1/04	Tue 2/1/05	13,12	B1,B2
15	**INVERTER**	60 days	Wed 9/15/04	Tue 12/7/04	19	B3,B4
16	**PFC**	**110 days**	**Wed 9/1/04**	**Tue 2/1/05**		**B5**
17	Examine the Standards	28 days	Wed 9/1/04	Fri 10/8/04		B5
18	Generating PFC	78 days	Fri 10/15/04	Tue 2/1/05	17	B5
19	**DC LINK CIRCUIT**	35 days	Thu 7/15/04	Wed 9/1/04		B6
20	**RECTIFIER & EMI FILTER**	**206 days**	**Tue 6/1/04**	**Tue 3/15/05**		**B5,B4**
21	rectifier	44 days	Tue 6/1/04	Fri 7/30/04		B5
22	EMI filter	42 days	Mon 1/17/05	Tue 3/15/05		B4
23	**CONTROL CIRCUIT & PROTECTION**	54 days	Mon 1/17/05	Thu 3/31/05		B5
24	**TERMIC DESIGN**	15 days	Mon 5/2/05	Fri 5/20/05	16,19,15,11	B4
25	**CHOOSING THE COMPONENTS**	43 days	Fri 4/1/05	Tue 5/31/05		B4
26	**PRINTING BOARD**	11 days	Wed 6/1/05	Wed 6/15/05		B4
27	**ASSEMBLING THE ELEMENTS ONTO THE PRINTING BOARD**	11 days	Wed 6/16/04	Wed 6/30/04		B6
28	**3. SOFTWARE**	**259 days**	**Tue 6/15/04**	**Fri 6/10/05**		
29	**PROGRAMMING**	**259 days**	**Tue 6/15/04**	**Fri 6/10/05**		
30	control algorithm	259 days	Tue 6/15/04	Fri 6/10/05		C1,C2,C3
31	A/D conversion and protection	56 days	Mon 8/16/04	Mon 11/1/04		C1,C2
32	PWM signali	45 days	Thu 7/1/04	Wed 9/1/04		C3
33	LED Display	24 days	Tue 3/15/05	Fri 4/15/05		C1,C2
34	Digital Communication	54 days	Tue 2/15/05	Fri 4/29/05		C1
35	Protections	64 days	Tue 2/1/05	Fri 4/29/05		C2
36	**REALIZATION OF OBJECT ORIENTED INTERFACE**	54 days	Tue 3/1/05	Fri 5/13/05		C2
37	**4. MARKETING**	**344 days**	**Tue 6/1/04**	**Sun 9/25/05**		
38	**MAKING THE PROJECT**	23 days	Tue 6/1/04	Thu 7/1/04		D1
39	**WEB SITE**	**120 days**	**Tue 6/1/04**	**Mon 11/15/04**		**D2**
40	internal	11 days	Tue 6/1/04	Tue 6/15/04		D2
41	external	34 days	Wed 9/29/04	Mon 11/15/04	38	D2
42	**PUBLIC RELATIONS**	190 days	Mon 1/3/05	Sun 9/25/05		D3
43	**FUND RAISING**	67 days	Mon 5/2/05	Tue 8/2/05	38,41	D4

MiniDrive Cost

2005 FUTURE ENERGY CHALLENGE

Inverter and Motor Costing Spreadsheet

UNIVERSITY: University of Belgrade

NAME OF MAIN CONTACT: Igor Stamenkovic

PROJECT NAME: Min Drive

DATE: 5-Aug-05

DEVICE	QTY	DESIG	UNIT	MEASURE	VOLT (Vpk)	VOLT (Vrms)	CUR (Avg)	CUR (Arms)	UNIT COST	EXTENDED COST
DIODE	3	D7, D8, D9			600		1		2.12	6.35
DIODE	1	D26			600		8		2.50	2.50
DIODE	1	D24			600		4		2.28	2.28
DIODE	2	D4, D5			1000		1		2.15	4.30
DIODE	2	D21, D22			100		1		2.07	4.14
MOSFET	2	M1, M2			500		9		6.22	12.45
SCR	1	VDR			275		4		0.62	0.62
CAP (ALUM)	1	C30	10	uF	25				0.10	0.10
CAP (ALUM)	3	C32, C35, C38	100	uF	63				0.16	0.47
CAP (ALUM)	3	C20, C22, C24	22	uF	63				0.11	0.34
CAP (ALUM)	3	C28, C71, CD6	100	uF	25				0.11	0.33
CAP (ALUM)	1	C70	560	uF	450				15.80	15.80
CAP (FILM)	1	C72	1	uF	630				2.45	2.45
CAP (FILM)	2	C73, C74	0.000001	uF	1000				0.63	1.26
CAP (FILM)	1	C29	0.01	uF	630				0.65	0.65
POWER RESISTOR	1	R27	5	W					1.20	1.20

Mass Scaled Electromagnetic Devices	QTY	DESIG			note	Mass (kg)		Mass (kg)	UNIT COST	EXTENDED COST
MAG (HF Ferrite)					kg of Ferrite		kg copper			
MAG (HF Powdered Iron)					kg of Powdered Iron		kg copper			
MAG (HF Cool Mu)					kg of Cool Mu		kg copper			
MAG (Laminations)					kg of Si-steel		kg copper			
MAG (Soft Mag Material)					kg of SMC		kg copper			
Aluminum Die Castings					kg of Al					
MAGNETS (Ferrite)					kg of Ferrite					

Running the Project

- When the planning phase is over, the "doing" phase begins
- There are two key elements to the control of a project
  - ***milestones*** (clear, unambiguous targets of what, by when)
  - established ***means of communication***
- Description of the activities as a communication tool:

Activity Description	
Project:	**Project name** **Page 1 of 1**
Activity:	**5.5.20.5 Evaluate Written Proposals**
Description:	**Evaluate written proposals received from vendors in response to the RFP.**
Inputs:	▪ **Requirements definition (5.5.5)** ▪ **Request for proposal (5.5.15)** ▪ **Written proposals from vendors**
Effort:	▪ **Review vendor proposals** ▪ **Reject proposals that do not meet mandatory requirements** ▪ **Weight proposals for degree of compliance to optional requirements** ▪ **Prepare recommendations for short list**
Resources:	▪ **Project manager (20%)** ▪ **Hardware analyst (80%)**
Outputs:	▪ **Evaluation results consisting of:** ▪ **Short list of qualified vendors or** ▪ **Rejection of all proposals** ▪ **Letters to vendors informing them of evaluation results**

Running MiniDrive Project

- **Being formal.**
  When we wanted to find out how people were doing, we never asked casually and never relied on an oral response

- **Being specific.**
  We made sure all team members understood that when they say an activity is complete, it is complete

- **Form appropriate documentation.**
  Documenting the activities is important because later, anybody can do the same activity just using the existing documentation

Progress Report

Project: _____ For Week Ending: _____

Name: _____

Activity	Scheduled Completion	Projected Completion

Problems Encountered

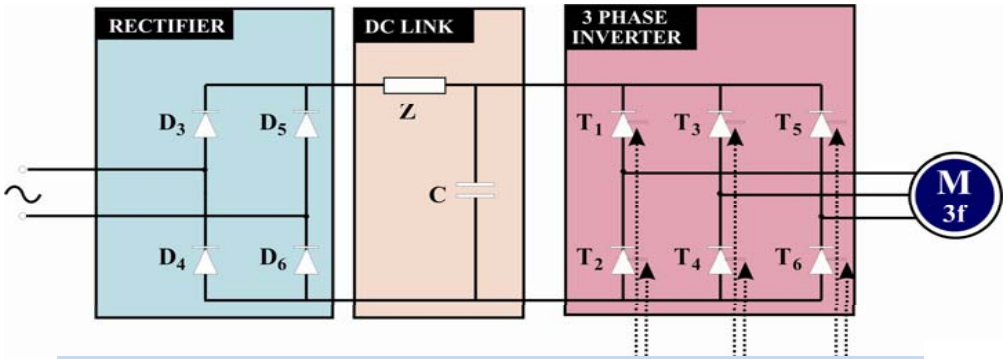
Progress Made

Progress Expected

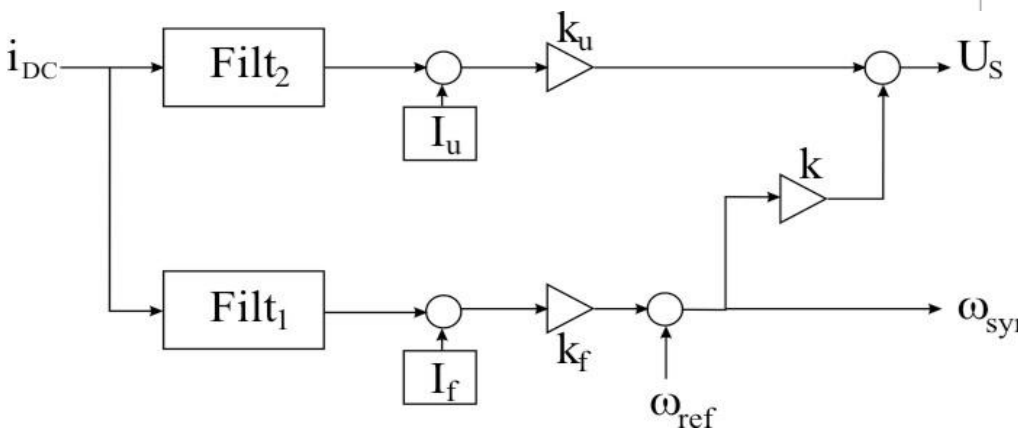
Example of weekly progress report

MiniDrive Progress

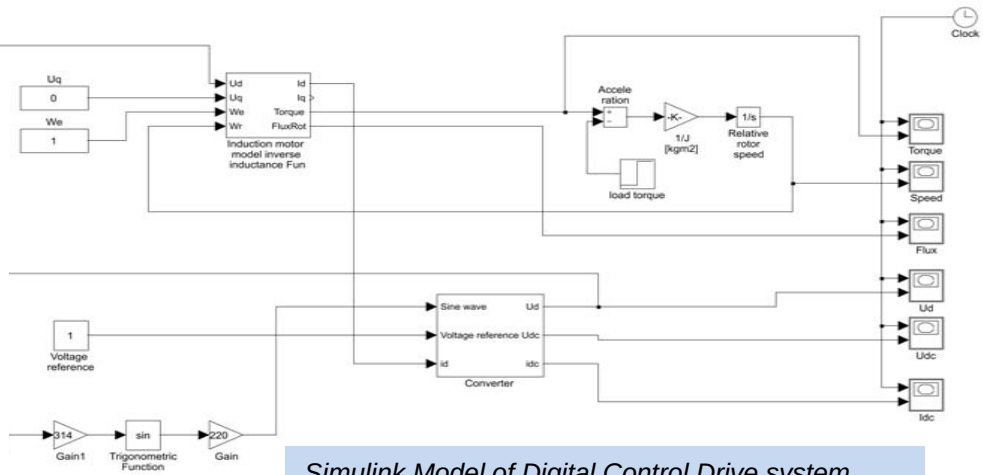
- **Progress in simulating and testing the drive**



Chosen topology of Digital Control Drive system



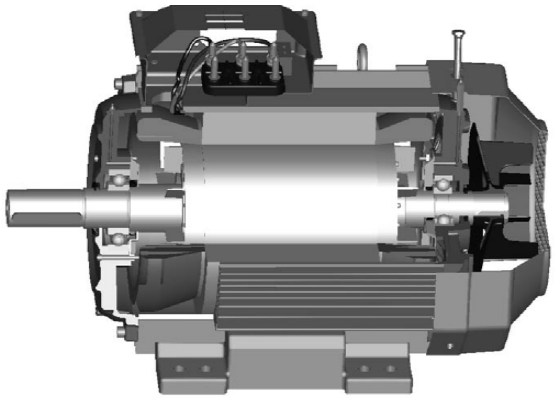
Structure of control algorithm



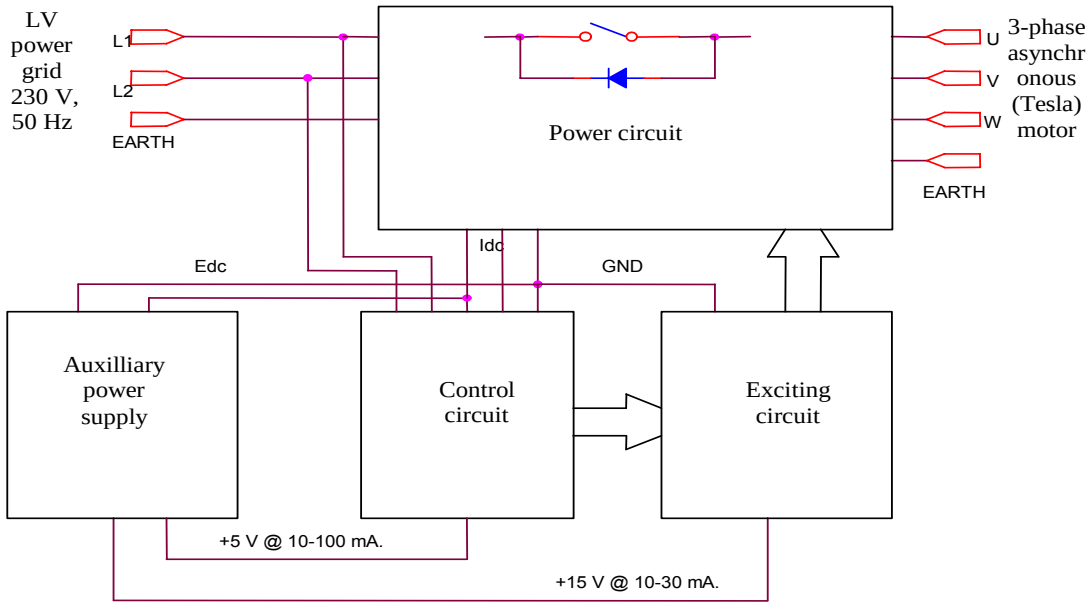
Simulink Model of Digital Control Drive system

MiniDrive Progress

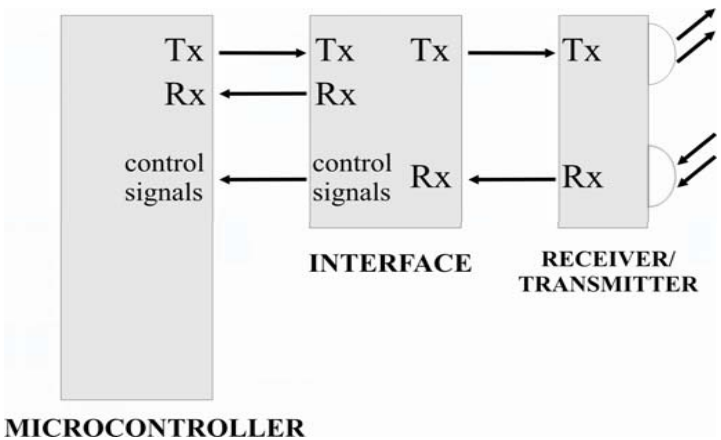
- **Progress with hardware**



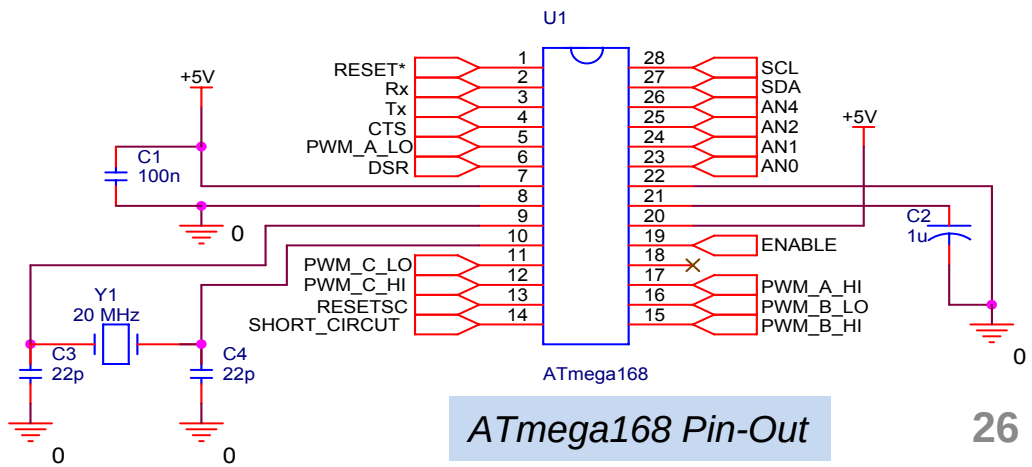
One of the options - ABB induction motor



Proposed structure of miniature drive converter



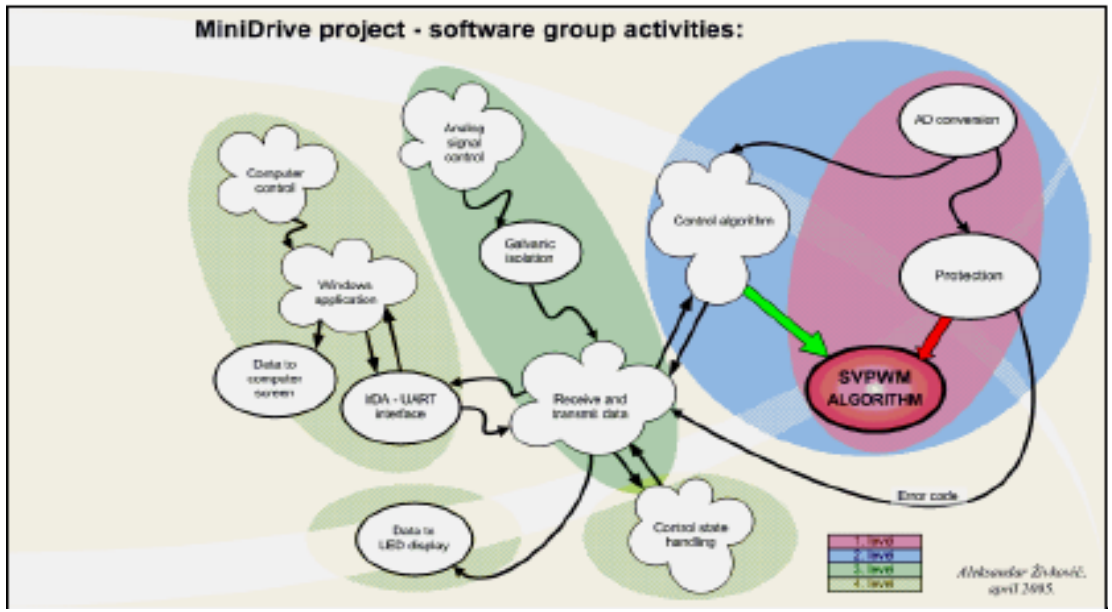
IC circuits for realization of IR communication



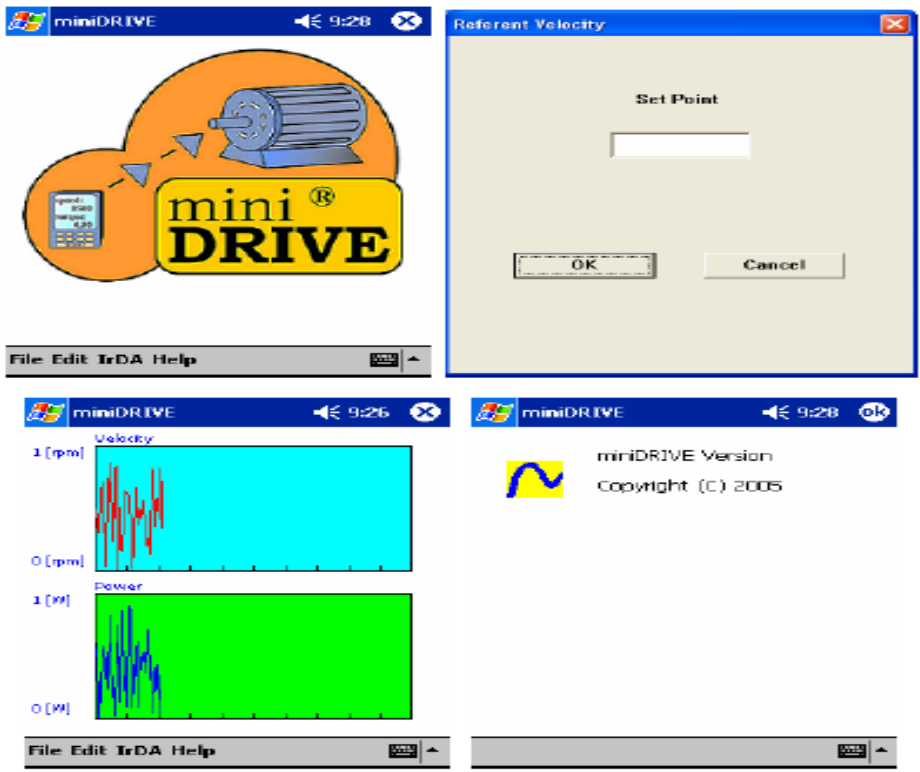
ATmega168 Pin-Out

MiniDrive Progress

- **Progress with software**



The software group activities



Graphical User Interface for Pocket PC

MiniDrive Progress

- **Progress of the marketing group**

Belgrade University, Serbia & Montenegro:

Belgrade reaches final stage in the Future Energy Challenge

University of Belgrade Student Branch Mini Drive Team.

EVERY OTHER year, four IEEE societies (Power Electronics, Industry Applications, Power Engineering and Industrial Electronics) run a worldwide Future Energy Challenge competition. All graduate and post-graduate students from all over the world are encouraged to take part.

The Laboratory for Digital Control of Electrical Drives in the Faculty of Electrical Engineering at Belgrade University applied on June 2004. 20 students led by two post-graduates presented the first results at an IEEE conference in Seattle on 6-9 October 2004. Our team was the only non-American team to reach the final stage of the contest which will be held in Chicago, USA, on 15-19 August 2005.

This year, the goal of the contest is to make a single-phase adjustable speed motor drive with characteristics that comply with strict standards. The most important criteria is the production price that should be under US$40.

The competition allows students to get creative while at the same time improving their knowledge on the particular subject. This project is also useful for students in gaining experience in delivering conference papers and writing technical documentation. Not least, it is highly motivating to realize that something they developed will have some practical value.

If you would like to find out more about our work on this project, please get in touch at the contacts below.

Miloš Rakic
Nikola Milivojevic
Belgrade-MiniDriveTeam
ddc@etf.bg.ac.yu
www.md.etf.bg.ac.yu

Istanbul Technical University, Turkey:

MiniDrive Prototype

MiniDrive Success

Conclusions

- Project Management – necessity of Engineering Project
- Start on time
- Delegate
- Expect failures, overcome problems
- Invest time instead of money
- Keep groups cross-functional and allow cross communication
- Allow panel discussions, bring all possible solutions on table
- Manage different mentality of team members
- Bad experience is still an experience, which may turn into success!