



EBV Table Football

Fieldbus Controlled Table Football Robot
Based on FPGA Technology



EBV Table Football

Fieldbus Controlled Table Football Robot
Based on FPGA Technology

INTRODUCTION

In order to demonstrate the performance capability of modern freely programmable circuits or FPGAs (Field Programmable Gate Arrays), the Laboratory for Motion Control and Digital Signal Processing at Cologne University of Applied Sciences, headed by Professor Jens Onno Krah, has developed a table football game that is automated on one side.

EBV Elektronik was a partner in the project. The mechanical structure of the football robot was produced by the Faculty of Information, Media and Electronic Technology, which was deliberately given an open design in order to ensure a high degree of transparency. The conception, wiring and programming were devised and implemented by three dissertation students.

HOW THE TABLE FOOTBALL ROBOT FUNCTIONS

The traditional pitch, a green-painted wooden board, was replaced by transparent, impact-proof 8 mm frosted security glass. Lighting was implemented below the football game using white ADJD-WD20 'JukGaRak' LED modules provided by Avago. This enables a camera to detect the yellow football from below using a tilted mirror. Once the ball has been detected, it is identified on the service monitor as a red dot. Image-processing algorithms calculate the co-ordinates and the speed of the football, which are then sent via UDP broadcast to four EBV Elektronik DBC2C20 Altera-Cyclone-II-FPGA development boards using a G-bit Ethernet switch. Each of these boards controls the two servo drives of one axis of the football game. One motor positions the players while the other is used to turn the players, i.e. to enable them to kick.

This is an innovative solution due to the freely programmable FPGAs that are used, instead of dedicated integrated circuits. The Ethernet Media Access Controller, a 5-in-1 Ethernet package from MaCo Engineering, the EtherCAT and CANopen field bus activation, as well as the processor are coded in VHDL (Very High Speed Integrated Circuit Hardware Description Language) and therefore form part of the FPGA configuration. A 32-bit, 50 MIPS NIOS[®]II processor with on-chip cache memory (2 kB data and 8 kB instructions) is configured. As part of the Segger EmbOS real-time operating system, this processes both the playing strategy and the activation of the servo drives using the field bus activation. The programs are translated with the NIOS-II-GNU-C cross



compiler from Altera, within the Eclipse IDE development environment. The goalkeeper is moved with an iron-free linear drive from Danaher Motion using an EtherCAT field bus connection. The two defenders are activated by two KEB servo drives using CANopen, the five mid-field players by Beckhoff servo drives using EtherCAT. CANopen and Lenze servo drives are used for the strikers.

The various servo drive systems were provided free-of-charge by the manufacturers. It is also impressive that the EtherCAT master was implemented for the first time on an embedded system with soft-core CPU rather than on a PC. A fifth FPGA development board counts the goals scored and displays them on the connected 8.4-inch TFT screen. Light barriers are installed in both goals for this purpose, for which the criterion 'behind the line' counts. The goal also counts if the ball rebounds onto to the pitch. The game lasts until one team has scored 10 goals.

The game strategy is simple and yet effective, as each football axis plays independently. The behaviour depends solely on the position of the ball. If the ball is directly in front of a player, it is kicked in the direction of the opposing team's goal. If it is not possible to reach the ball between the football axis and the opposing team's goal, the appropriate figure is positioned at ball level with the aim of blocking. If the game algorithm detects a ball position between the footballer's axis and the opposing team's goal, the player's feet are raised, thus making room for a goal to be scored.

In the first version of the table football robot, it was possible to win against the football robot thanks to the slow image processing of only 20 images per second.

The standard camera has now been replaced by a Pike high-speed camera produced by Allied Vision Technologies. Via a fire-wire interface, up to 70 colour images with 640x480 pixels can be processed per second. The fire-wire driver, a Windows proprietary driver which is all-purpose but too slow, was replaced by installing a fire package.

The table football game, which is unique in its technical implementation, can be seen regularly at EBV Elektronik trade fair stands.

TECHNICAL DETAILS

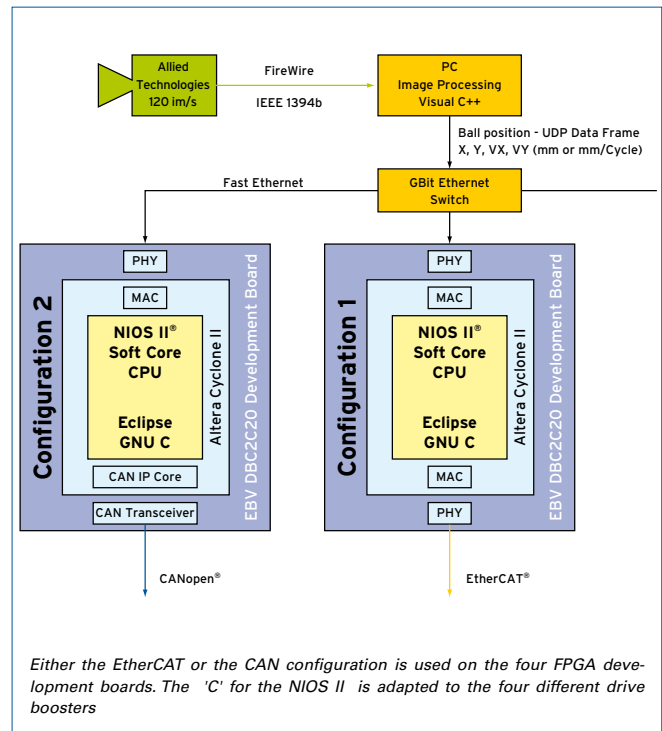
The central control unit is the DBC2C20 development board produced by EBV Elektronik:

Hardware

- Cyclone II FPGA from Altera® with 20,000 logic elements
- 16 Mbytes SDRAM
- 8 Mbytes flash
- 2* Ethernet PHY (fast Ethernet & EtherCAT)
- Fieldbus transceiver (CAN)
- 'Glue Logic' and I/O

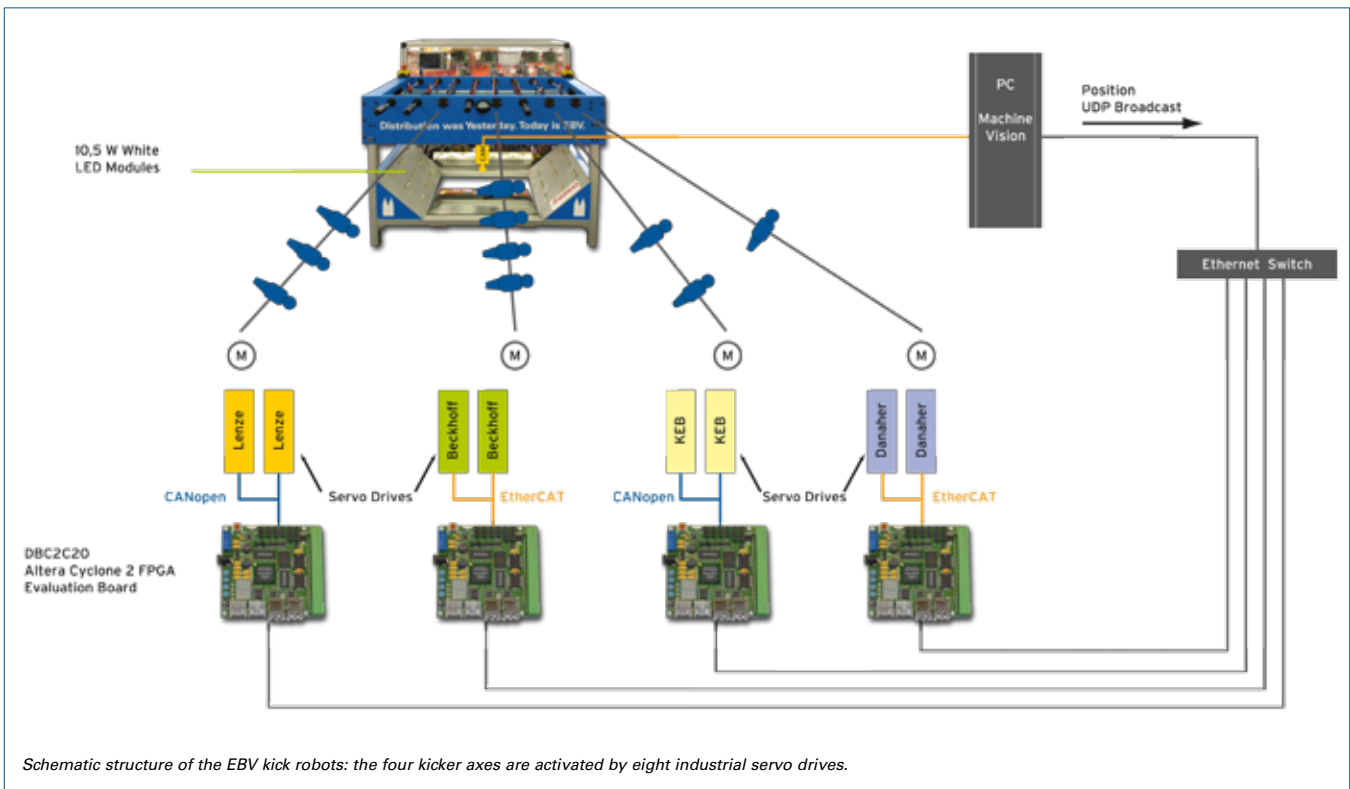
FPGA configuration with IP-Cores (intellectual property)

- NIOS II soft core CPU 50 MHz cycle frequency from Altera fast configuration with 2 Kbytes data cache and 8 Kbytes instruction cache
- 5-in-1 Ethernet Media Access Controller from MaCo Engineering, Karlsbrunn
- CAN (IP core) from IFI, Wertheim
- EtherCAT (IP core) from Beckhoff, Verl



NIOS II Software

- emBetter TCP/IP protocol suite, Steinbeis Transfer Centre, Lorrach
- EtherCAT master with 2 ms cycle time, Cologne University of Applied Sciences
- CANopen activation, event-controlled, Cologne University of Applied Sciences



EBV European Headquarters

D-85586 Poing | Im Technologiepark 2-8 | Tel. +49 (0)8121 774-0 | www.ebv.com

EBV REGIONAL OFFICES

AUSTRIA

A-1150 Wien
Diefenbachgasse 35/1
Tel. +43 (0)18 91 52-0
Fax +43 (0)18 91 52-30

BELGIUM

B-1831 Diegem
Kouterveldstraat 20
Tel. +32 (0)27 16 00 10
Fax +32 (0)27 20 81 52

CZECH REPUBLIC

CZ-170 00 Praha 7
Argentinská 38/286
Tel. +420-234 091 011
Fax +420-234 091 010

DENMARK

DK-8230 Åbyhøj
Ved Lunden 9
Tel. +45 86 25 04 66
Fax +45 86 25 06 60

DK-2860 Søborg

Rosenkærret 11 C
Tel. +45 39 69 05 11
Fax +45 39 69 05 04

ESTONIA

EE-10621 Tallinn
Laki 12
Tel. +372 683 38 66
Fax +372 683 38 70
Cell. +372 513 22 32

FINLAND

FIN-02240 Espoo
Pihatörmä 1 a
Tel. +358 (0)927 05 27 90
Fax +358 (0)9 27 09 54 98

FIN-90100 Oulu

Nahkatehtaankatu 2
Tel. +358 (0)85 62 49 10
Fax +358 (0)85 62 49 15

FRANCE

F-13854 Aix-en-Provence
115, Rue Nicolas Ledoux
Immeuble Hemiris, Bâtiment A,
Tel. +33 (0)442 39 65 40
Fax +33 (0)442 39 65 50

F-92184 Antony Cedex (Paris)

3, rue de la Renaissance
Tél. +33 (0)140 96 30 00
Fax +33 (0)140 96 30 30

F-35510 Cesson Sévigné (Rennes)

29, av. des Peupliers
Tél. +33 (0)299 83 00 50
Fax +33 (0)299 83 00 60

F-67400 Illkirch Graffenstaden

Rue Gruninger
Parc d'innovation d. Illkirch
Tél. +33 (0)3 90 40 59 69
Fax +33 (0)3 88 65 11 25

F-31673 Labège Cedex (Toulouse)

Immeuble Actys B2, voie 3,
BP17316
Tél. +33 (0)561 00 84 61
Fax +33 (0)561 00 84 74

F-69693 Venissieux (Lyon)

Parc Club du Moulin à Vent
33, Av. du Dr. Georges Lévy
Tél. +33 (0)472 78 02 78
Fax +33 (0)478 00 80 81

GERMANY

D-12277 Berlin-Mariendorf
Kitzingstr. 15 - 19
Tel. +49 (0)30 74 70 05-0
Fax +49 (0)30 74 70 05-55

D-30938 Burgwedel
In der Meineworth 21
Tel. +49 (0)5139 80 87-0
Fax +49 (0)5139 80 87-70

D-41564 Kaarst
An der Gumpgesbrücke 7
Tel. +49 (0)2131 96 77-0
Fax +49 (0)2131 96 77-30

D-71229 Leonberg
Neue Ramtelstraße 4
Tel. +49 (0)7152 30 09-0
Fax +49 (0)7152 759 58

D-07806 Neustadt/Oria
Zum Mühlenberg 9
Tel. +49 (0)36481 2 44-0
Fax +49 (0)36481 2 44-99

D-85586 Poing
Im Technologiepark 2-8
Tel. +49 (0)8121 774-0
Fax +49 (0)8121 774-422

D-78050 VS-Villingen
Kaiserring 12
Tel. +49 (0)7721 998 57-0
Tel. +49 (0)7721 998 57-70

D-65205 Wiesbaden
Borsigstraße 36
Tel. +49 (0)6122 80 88-0
Fax +49 (0)6122 80 88-99

GREECE

GR-17778 Tavros
Anaxagora Str. 1
Tel. +30 210 34 14 300
Fax +30 210 34 14 304

HUNGARY

H-1037 Budapest
Montevideo u. 2/B
Tel. +36 1 436 72 29
Fax +36 1 436 72 20

IRELAND

IRL-Dublin 12
Ballymount Trading Estate
Ballymount Road
Walkinstown
Tel. +353 (0)14 56 40 34
Fax +353 (0)14 56 40 35

ISRAEL

IL-40600 Tel Mond
Drorrim South Commercial Center
P.O. Box 149
Tel. +972 (0)9 778 02 60
Fax +972 (0)9 796 68 80

ITALY

I-20092 Cinisello, Balsamo (MI)
Via C. Frova, 34
Tel. +39 02 66 09 62 90
Fax +39 02 66 01 70 20

I-41100 Modena (MO)

Via Carlo Cattaneo, 54
Tel. +39 059 29 24 211
Fax +39 059 29 29 486

I-50127 Firenze
Via Panciatichi, 40
Palazzo 11
Tel. +39 05 54 36 93 07
Fax +39 05 54 26 52 40

I-80128 Napoli (NA)

Via G. Capaldo, 10
Tel. +39 081 579 97 70
Fax +39 081 579 97 70
Cell. +39 335 8 39 05 31

I-00155 Roma
Viale Palmiro Togliatti 1639
Tel. +39 064 06 36 65/789
Fax +39 064 06 37 77

I-35030 Sarmeola di Rubano (PD)
Piazza Adelaide Lonigo, 8/11
Tel. +39 049 89 74 701
Fax +39 049 89 74 726

I-10156 Torino
Corso Vercelli, 348
Tel. +39 011 262 56 90
Fax +39 011 262 56 91

NETHERLANDS

NL-3606 AK Maarssenbroek
Planetenbaan 116
Tel. +31 (0)346 58 30 10
Fax +31 (0)346 58 30 25

NORWAY

Postboks 101, Manglerud
Ryensvingen 3B
N-0681 Oslo
Tel. +47 22 67 17 80
Fax +47 22 67 17 89

POLAND

PL-02-672 Warszawa
ul. Woloska 18
Tel. +48 (0)22 640 23 55
Fax +48 (0)22 640 23 56

PL-50-062 Wrocław
Pl. Solny 16
Tel. +48 (0)71 34-2 29-44
Fax +48 (0)71 34-2 29-10

ROMANIA

Construdava Business Center
Șos. Pipera-Tunari 4c
Voluntari, Ilfov (Bucharest)
RO - 077190 Romania
Tel. +40 21 529 6911
Fax +40 21 529 6901

RUSSIA

RUS-127486 Moscow
Korovinskoye Shosse 10,
Build 2, Off.28
Tel. +7 495 937 87 07
Fax +7 495 937 87 06

RUS-195197 St. Petersburg

Polustrovsky Prospect 43,
Office 421
Tel. +7 812 635 70 63
Fax +7 812 635 70 64

SLOVAK REPUBLIC

SK-85101 Bratislava
Digital Park, Einsteinova 21
Tel. +421 2 321 111 41
Fax +421 2 321 111 40

SLOVENIA

SI-1000 Ljubljana
Dunajska c. 159
Tel. +386 (0)1 56 09 778
Fax +386 (0)1 56 09 877

SOUTH AFRICA

ZA-8001 Foreshore, Cape Town
1 Mediterranean Street
5th Floor MSC House
Tel. +27 (0)21 402 19 40
Fax +27 (0)21 419 62 56

ZA-3629 Westville
Forest Square, 11 Derby Place
Suite 4, Bauhinia Building
Tel. +27 (0)31 205 12 05
Fax +27 (0)31 205 22 65

ZA-2157 Woodmead,
Johannesburg
Woodlands Office Park
141 Western Service Road
Building 14-2nd Floor
Tel. +27 (0)11 236 19 00
Fax +27 (0)11 236 19 13

SPAIN

E-08950 Esplugues de Llobregat
(Barcelona)
Antón Fortuny 14-16 Esc.C 3º 2a
Tel. +34 93 473 32 00
Fax +34 93 473 63 89

E-28760 Tres Cantos (Madrid)
Centro Empresarial Euronova
C/Ronda de Poniente, 4
Tel. +34 91 804 32 56
Fax +34 91 804 41 03

SWEDEN

S-21 235 Malmö
Derbyvägen 20
Tel. +46 (0)40 59 21 00
Fax +46 (0)40 59 21 01

S-19 272 Sollentuna
Sjöängsvägen 7
Tel. +46 (0)859 47 02 30
Fax +46 (0)859 47 02 31

SWITZERLAND

CH-8953 Dietikon
Bernstrasse 394
Tel. +41 (0)44 745 61 61
Fax +41 (0)44 745 61 00

CH-1010 Lausanne
Av. des Boveresses 52
Tel. +41 (0)216 54 01 01
Fax +41 (0)216 54 01 00

TURKEY

TR-34742 Istanbul
Perdemsac Plaza
Bayar Cad. Gülbahar
Sok. No: 17 D: 134 Kozyatagi
Tel. +90 (0)21 64 63 13 52
Fax +90 (0)21 64 63 13 55

UKRAINE

UA-03040 Kiev
Vasilovskaya str. 14
off. 422-423
Tel. +380 44 496 22 26
Fax +380 44 496 22 27

UNITED ARAB EMIRATES

Post Box No: 18657
Warehouse No: FZS1AL06
JAFZA South Zone, Jebel Ali
Dubai, United Arab Emirates
Tel. +971 (4) 886 09 50
Fax +971 (4) 886 09 52

UNITED KINGDOM

South East
Thames House
17 Marlow Road
Maidenhead
Berkshire, SL6 7AA
Tel. +44 (0)16 28 77 07 07
Fax +44 (0)16 28 78 38 11

South West & Wales

12 Interface Business Park
Bincknoll Lane
Wootton Bassett
Wiltshire, SN4 8SY
Tel. +44 (0)17 93 84 99 33
Fax +44 (0)17 93 85 95 55

North
Manchester International
Office Centre, Suite 3E (MIOC)
Styal Road
Manchester, M22 5WB
Tel. +44 (0)16 14 99 34 34
Fax +44 (0)16 14 99 34 74

Scotland
144 West George Street
Glasgow, G2 2HG
Tel. +44 (0)14 13 52 20 50
Fax +44 (0)14 13 52 20 59