

# Developing a Variable Frequency Inverter with C2000 Digital Signal Controllers

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# Agenda

- Inverter Theoretical Background
- Inverter's hardware design
- Algorithm implementation for inverter
- Inverter successful application cases

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# Some Concepts about Inverter

## ➤ Inverter: Frequency convertor

Inverter is one of the AC drive system, called VVVF ( Variable Voltage Variable Frequency ) in short.

## ➤ Control objectives of Inverter

Three-Phase AC asynchronous motor and three-phase DC synchronous motor, Appropriate Motor Pole Number is 2/4

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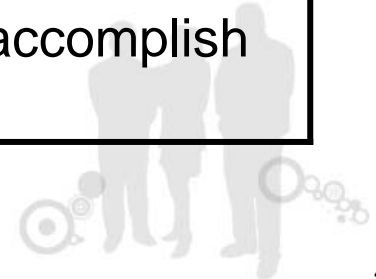
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# Some concepts about Inverter—Continued

## Advantages of variable speed Inverter

( Compared with other regulating speed methods to AC motor )

No.	Advantages
1	Let motor boot softly , assure motor's safe use
2	Can raise the motor speed via increasing output frequency conditionally
3	Continuous Variable Speed , improve the regulating accuracy greatly
4	Motor forward run or reverse run needn't switch Contactor
5	Convenient to access telecommunication networks to accomplish automatic manufacture



# Inverter Evolution History

	60s	70s	80s	90s	00s
Algorithm		V/F control	Vector control	Sensorless vector control	Algorithm optimization
Power&transistor	SCR	GTR	IGBT	IGBT large capacity	more capacity higher switching frequency
Computer technology			Single Chip Computer	High speed DSP Or ASIC	Higher speed and more capacity
PWM technology		PWM	DSP SPWM	Space voltage vector modulation technology	PWM optimization New generation switch technology
	Large volume, high price	Small volume	Super low noise Inverter began to be popular and be widely used in stead of DC equipment		The development trend in the future: Perfect Non-Harmonic Frquency Connverter For example: Matrix Inverter

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# Importance and Application

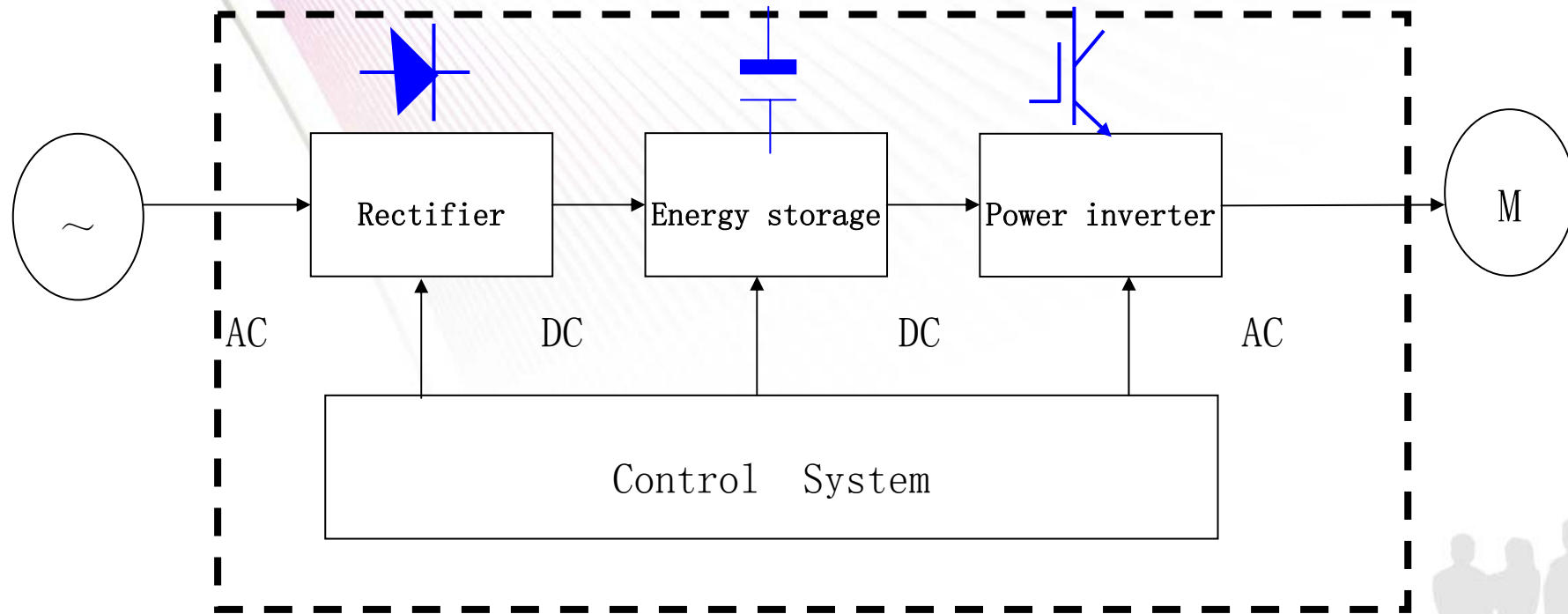
No.	Importance	Application
1	Energy saving	Electric Fan 、 water pump, Injection Moulding Machine
2	Improve product quality	Manufacture Line such as machine tool 、 printing press 、 packaging
3	Reform working environment	Elevator 、 Air-conditioner

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# Principle Block Diagram

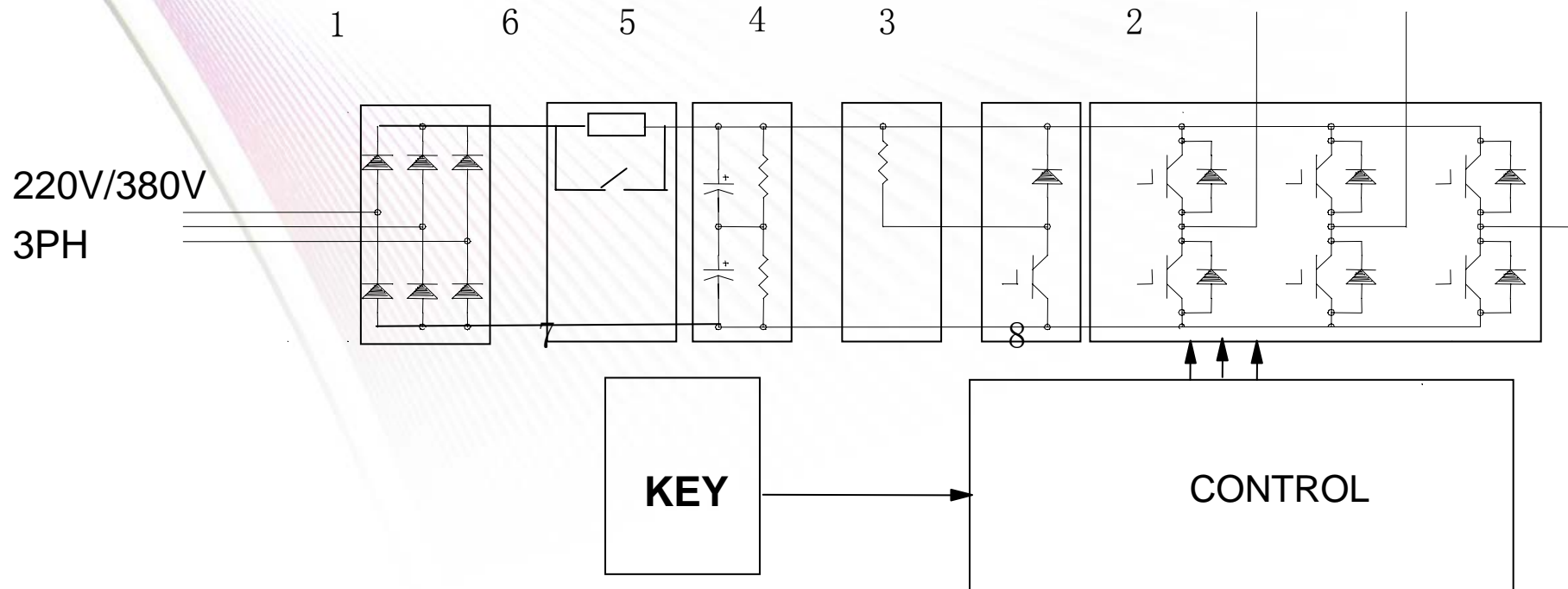
## General Inverter System Block Diagram



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# Practical Implementation Block Diagram



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# Technique Realization of the Inverter Controller

- **Hardware :**
  - Quicker processor, support multiple tasks control ( inverter control, motor dynamic control algorithm, man and computer interface, networking and communicating, etc.)
  - More accurate computation unit (16bit->32bit->on-chip floating point computation)
  - Quicker and more precise feedback :high speed interrupt response ability, event capture competence, high performance AD
  - More flexible upgrade capability :on-chip 128-Bit Security Key/Lock FLASH, be able to upgrade and program remotely
  - Chip upgrade ability : pin-compatible and code-compatible, manufacturer's long term product plan
  - Provide on-chip application specific peripherals :Such as PDPINT , PWM , HRPWM
  - More flexible peripherals expansion competence

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# Technique Realization of the Inverter Controller—Cont's

- **Software**
  - More excellent C/C++ Compiler/Assembler/Linker to enable C or C++ program to perform all the control function
  - Code portable and reusable simply take the advantage of large quantities of costs pc algorithms
  - Low level assembler manipulation capability to meet higher demands
  - Optimized floating-point algorithm library for fixed-point component

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# Inverter Requires Resources on Processor

- The increase of control points demands more outputs of PWM and more accurate output : Rectifier control(4-6),PFC control (1-2),DC-DC control,Brake control(1), Frequency convertor control(6)
- Complex control algorithm requires more powerful processing ability: Higher performance floating point computation,quicker cycle clock, Longer instruction Word, parallel processing, deep pipelines

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# TMS320F28XX Series DSP Resource

	F2812	F2810	LF2407A	LF2406A	LF2403A	LF2402A	LF2401A	LC2406A	LC2404A	LC2402A	LC2401A	F243	F241	F240	C242
<b>CPU</b>	<b>32-bit DSP</b>		<b>16-bit DSP</b>								<b>16-bit DSP</b>				
<b>MIPS</b>	<b>150 MIPS</b>		<b>40 MIPS</b>								<b>20 MIPS</b>				
<b>RAM (words)</b>	18K	18K	2.5K	2.5K	1.0K	1.0K	1.0K	2.5K	1.5K	544	1.0K	544	544	544	544
<b>ROM (words)</b>								32K	16K	6K	8K				4K
<b>Flash (words)</b>	128K	64K	32K	32K	16K	8K	8K					8K	8K	16K	
<b>BootROM (words)</b>	4K	4K	256	256	256	256	256								
<b>Event Manager CAP/QEP</b>	6/6	6/6	6/4	6/4	3/2	3/2	1/0	6/4	6/4	3/2	1/0	3/2	3/2	4/2	3/2
<b>PWM(CMP) TIMER</b>	16 7	16 7	16 4	16 4	8 2	8 2	7 2	16 4	16 4	8 2	7 2	8 2	8 2	12 3	8 2
<b>ADC Resolution # ofChan</b>	12-bit 16	12-bit 16	10-bit 16	10-bit 16	10-bit 8	10-bit 8	10-bit 5	10 bit 16	10-bit 16	10-bit 8	10-bit 5	10-bit 8	10-bit 8	10-bit 16	10-bit 8
<b>Conv time</b>	200ns	200ns	500ns	500ns	500ns	500ns	500ns	375ns	375ns	425ns	500ns	900ns	900ns	6.1us	900ns
<b>McBSP</b>	✓	✓													
<b>EXMIF</b>	✓		✓									✓		✓	
<b>Watch Dog</b>	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
<b>SPI</b>	✓	✓	✓	✓	✓			✓	✓			✓	✓	✓	
<b>SCI (UART)</b>	2	2	1	1	1	1	1	1	1	1	1	1	1	1	1
<b>CAN</b>	✓	✓	✓	✓	✓			✓				✓			
<b>Volts (V)</b>	1.8 core 3.3 I/O	1.8core 3.3 I/O	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	5.0	5.0	5.0	5.0
<b># I/O</b>	56	56	41	41	21	21	13	41	41	21	13	32	26	28	26
<b>Package</b>	176LQFP 179u*BGA	128LQFP	144LQPF	100LQPF	64LQFP	64PQFP	32LQFP	100LQFP	100LQFP	64PQFP	32LQFP	144LQFP	64PQFP 68PLCC	132PQFP	64PQFP 68PLCC

# TMS320F280X Series DSP Resource

All Devices are 100% Hardware, Software & Pin Compatible

TMS320™	Flash KB	RAM KB	ADC	PWM/ Hi-Res.	CAP/ QEP	Communication Ports
F28015	32	12	267ns	10/4	2/0	SPI, SCI, I <sup>2</sup> C
F28016	32	12	267ns	10/4	2/0	SPI, SCI, CAN, I <sup>2</sup> C
F2801-60	32	12	267ns	8/3	2/1	2x SPI, SCI, CAN, I <sup>2</sup> C
F2802-60	64	12	267ns	8/3	2/1	2x SPI, SCI, CAN, I <sup>2</sup> C
F2801	32	12	160ns	8/3	2/1	2x SPI, SCI, CAN, I <sup>2</sup> C
F2802	64	12	160ns	8/3	2/1	2x SPI, SCI, CAN, I <sup>2</sup> C
F2806	64	20	160ns	16/4	4/2	4x SPI, 2x SCI, CAN, I <sup>2</sup> C
F2808	128	36	160ns	16/4	4/2	4x SPI, 2x SCI, 2x CAN, I <sup>2</sup> C
F2809	256	36	80ns	16/6	4/2	4x SPI, 2x SCI, 2x CAN, I <sup>2</sup> C
F28044	128	20	80ns	16/16	0	SPI, SCI, I <sup>2</sup> C

# Control Algorithm : VVVF and Vector Control

Core technique of AC regulating speed control:

To retain constant magnetic flux for the ideal variable speed effect

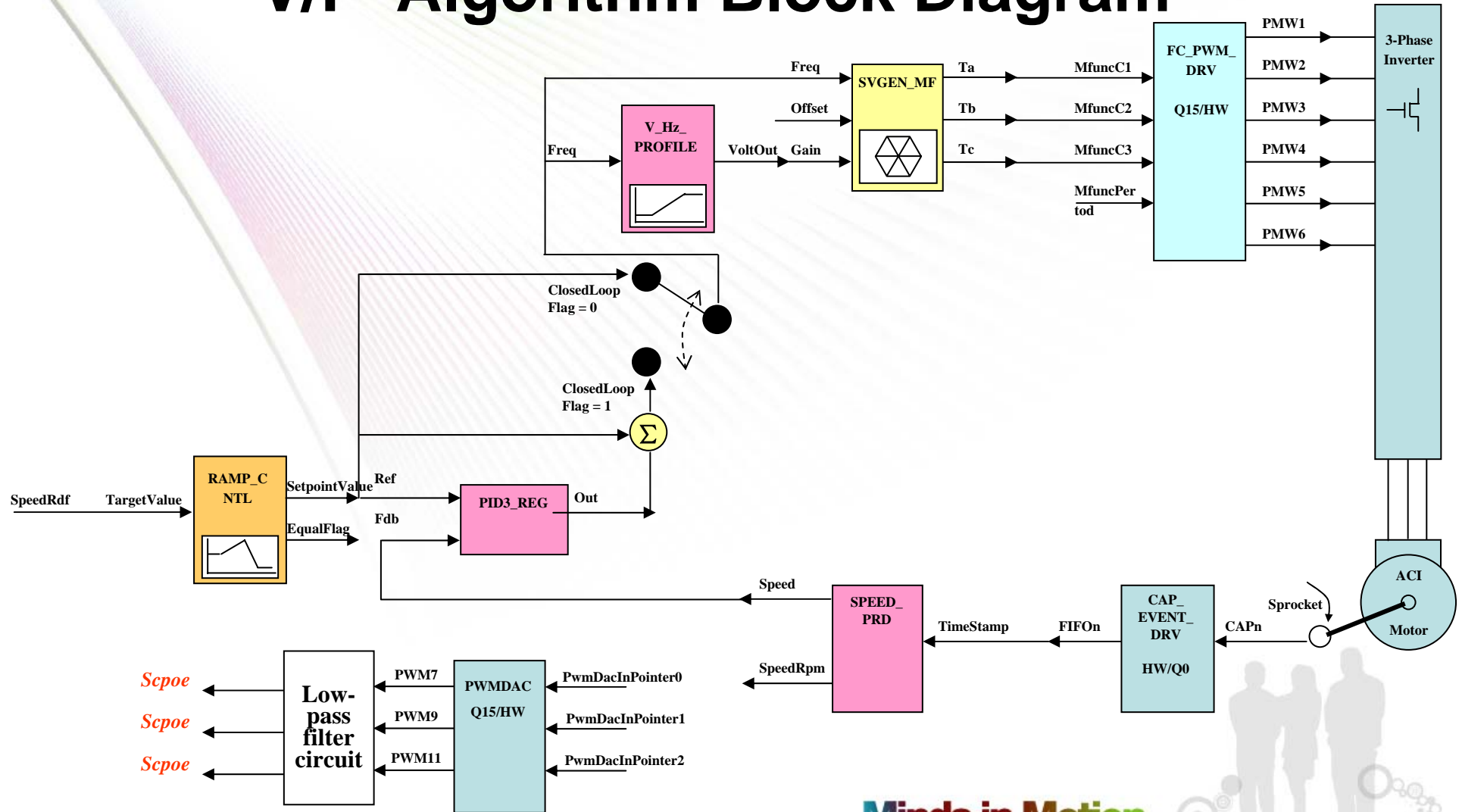
**V/F Control**—Simple, Practical, ordinary capability, widely used

**Vector Control**—High performance, mature technology, can compared with DC regulating speed

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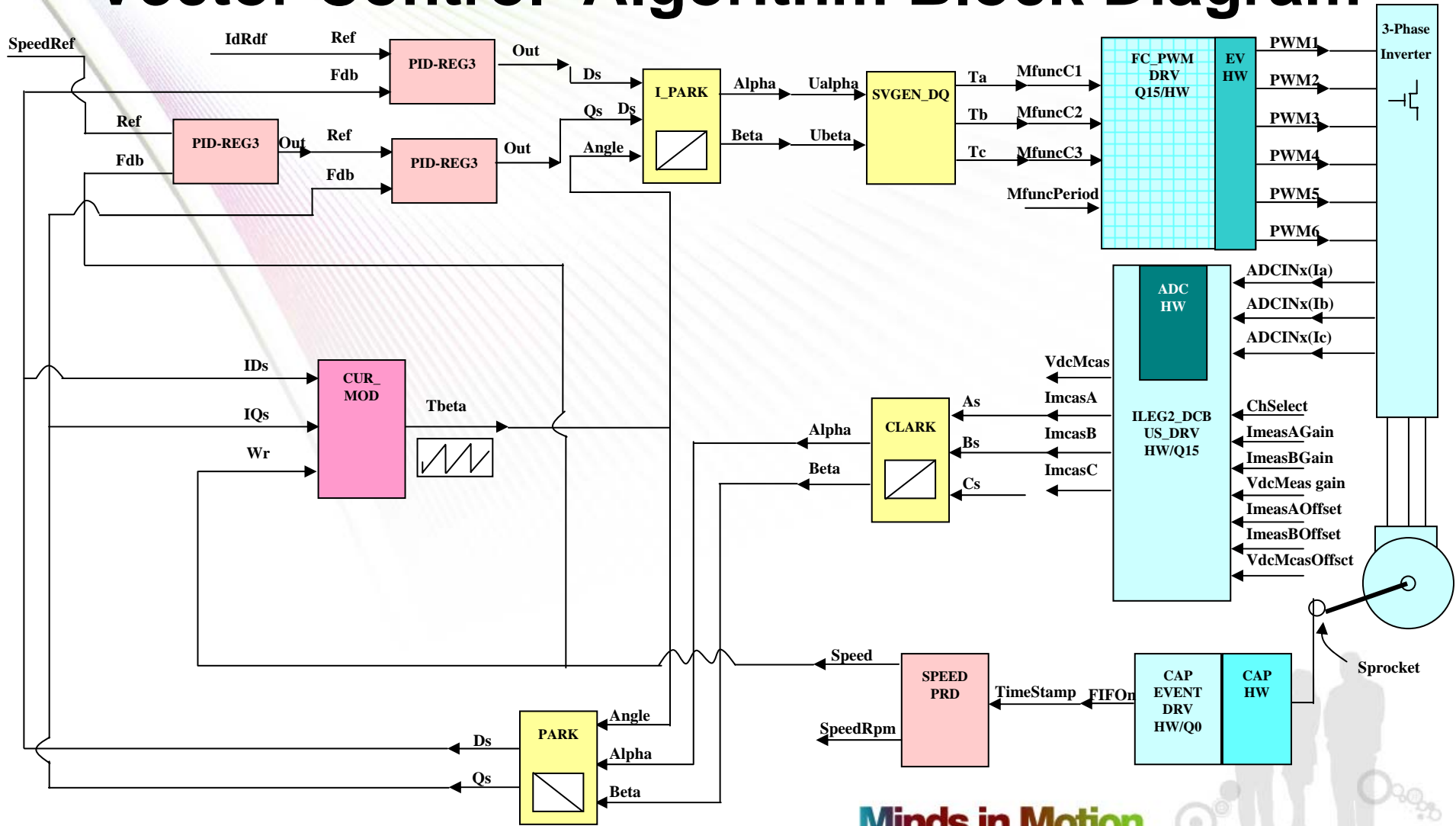
# V/F Algorithm Block Diagram



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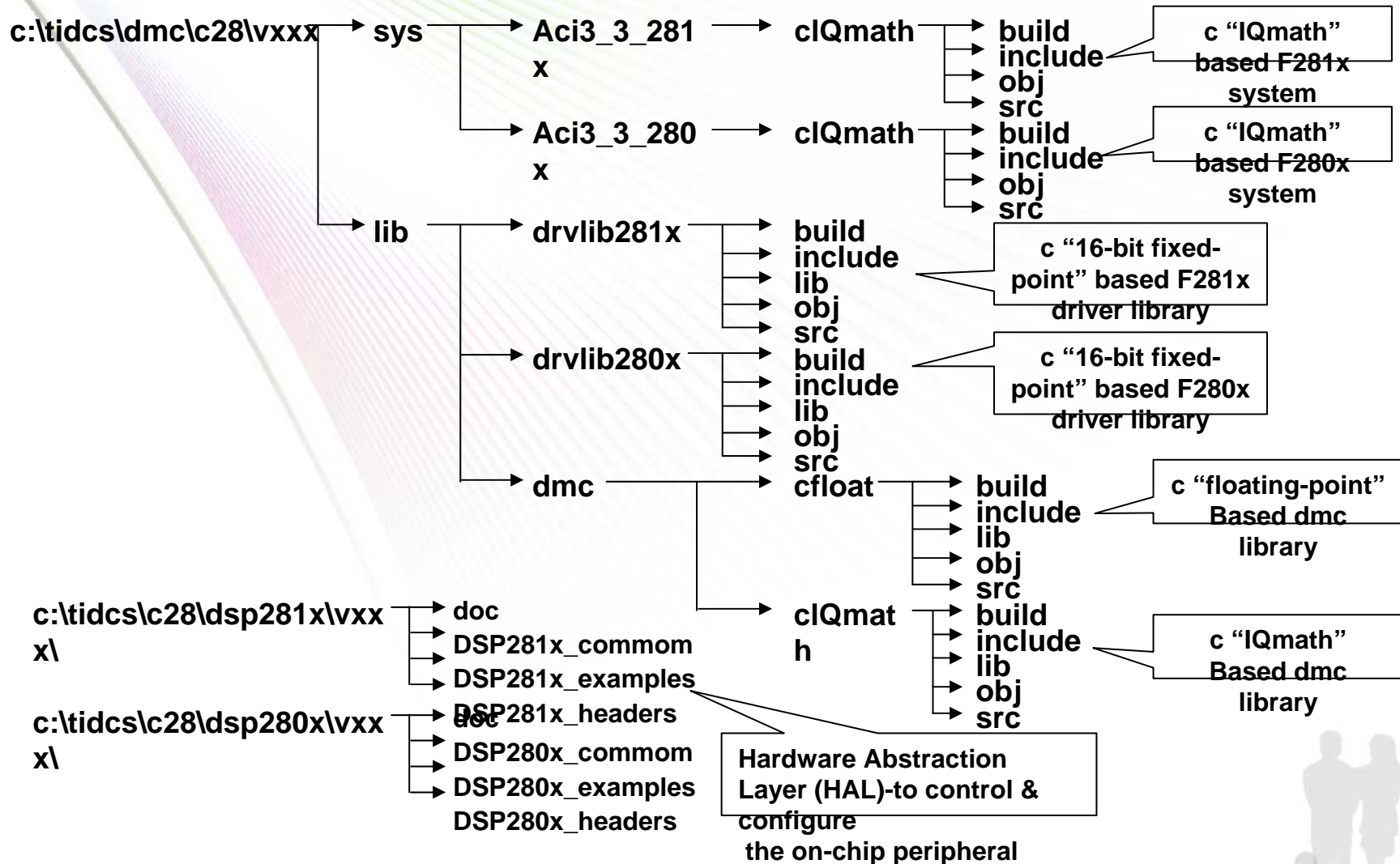


# Vector Control Algorithm Block Diagram



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# DSP Program Algorithm Library

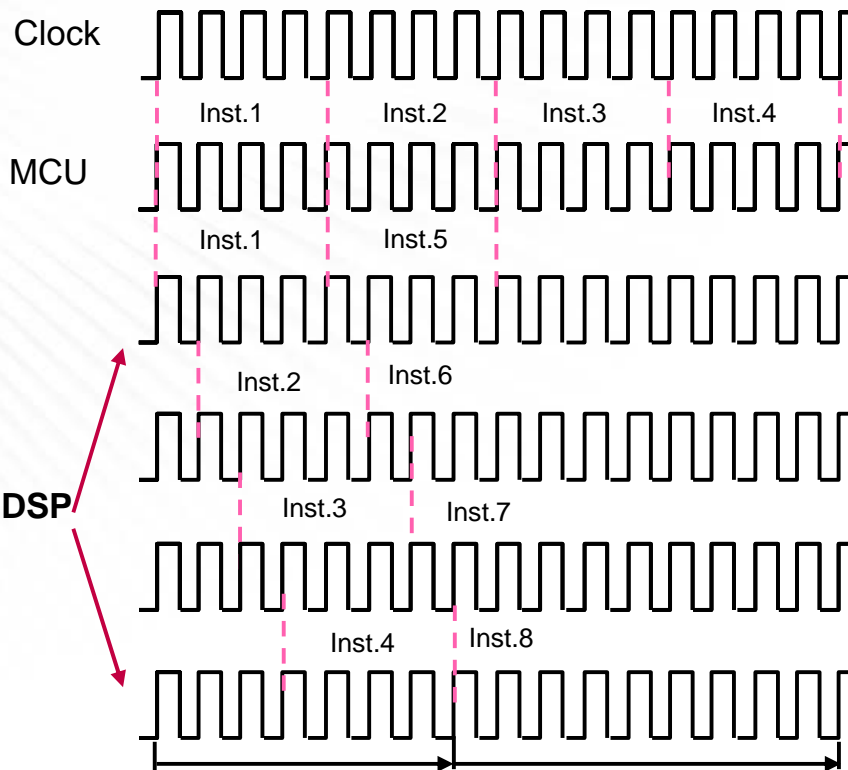


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# DSP Advantages over other choices

**DSP—Digital Signal Processor**



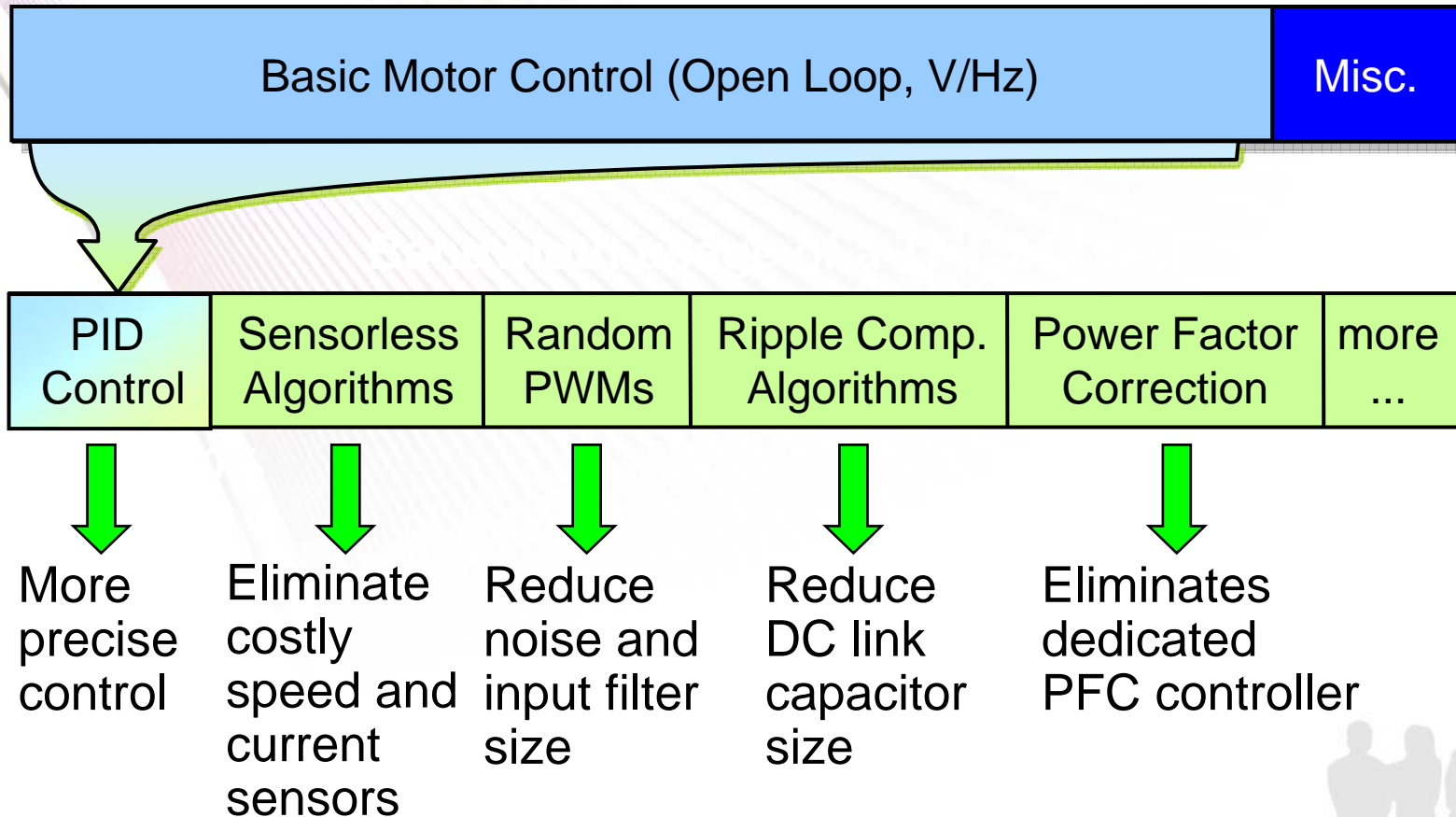
**CPLD/FPGA—Large Scale Programmable Array**

**MCU—Single Chip Microcomputer**

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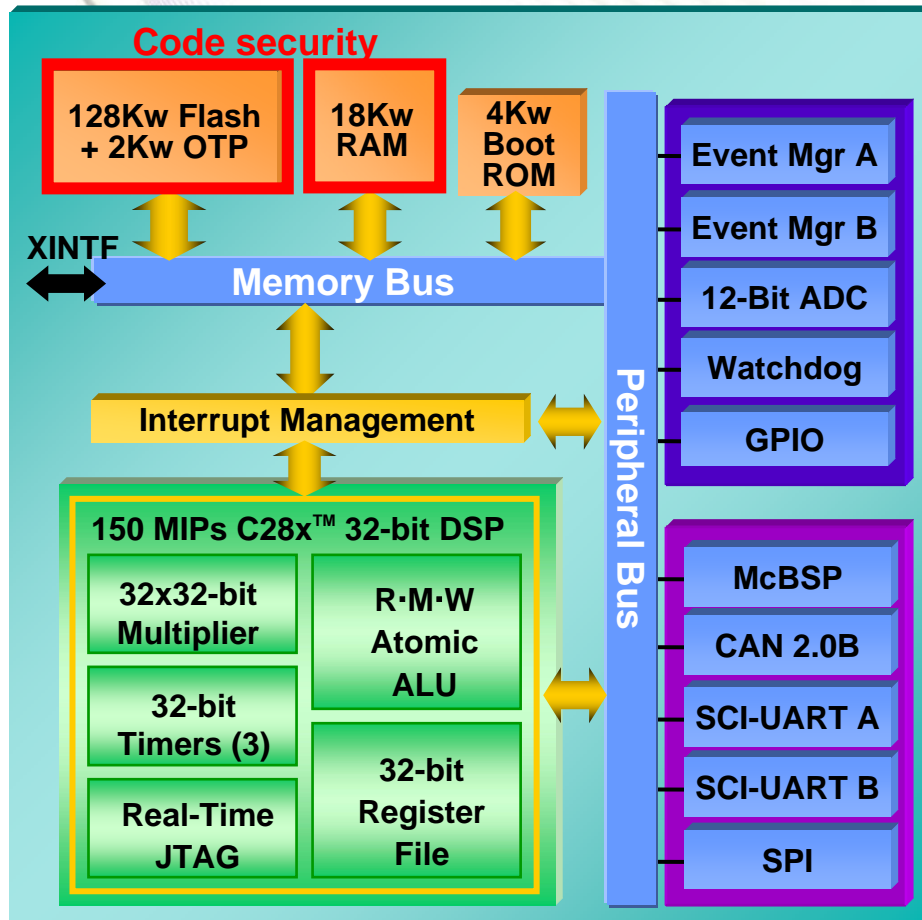
# DSP Powerful Computation Performance



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# TMS320F28XX Structure Diagram



Find Datasheet at: <http://www-s.ti.com/sc/ds/tms320f2812.pdf>

## High Performance CPU (C28x™ Core)

- 150MIPS performance
- Single cycle 32 x32-bit MAC (or dual 16 x16 MAC)
- Very Fast Interrupt Response
- Single cycle read-modified-write
- F24x/LF240x Source Code Compatible

## Memory Sub-System

**Fast program execution out of both RAM and Flash memory**

- 100-120 MIPS with Flash Acceleration Technology
- 150 MIPS out of RAM for time-critical code

## Control Ports

**Event Managers**

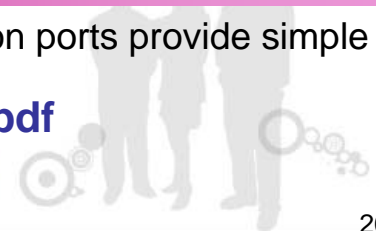
**Ultra-Fast 12-bit ADC**

- 12.5 MSPS throughput
- Dual sample&holds enable simultaneous sampling
- Auto Sequencer, up to 16 conversions w/o CPU

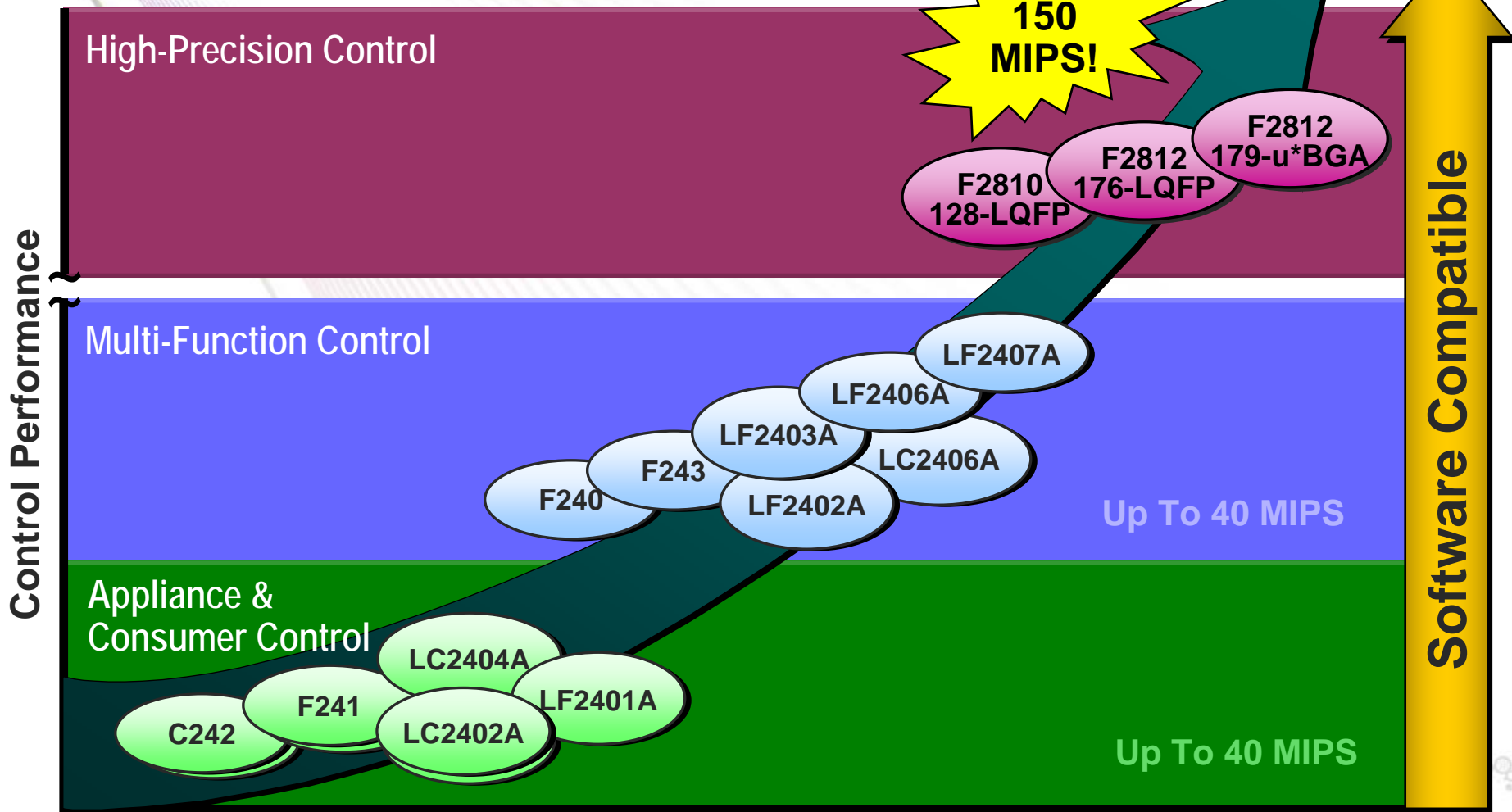
## Communications Ports

Multiple standard communication ports provide simple interfaces to other components

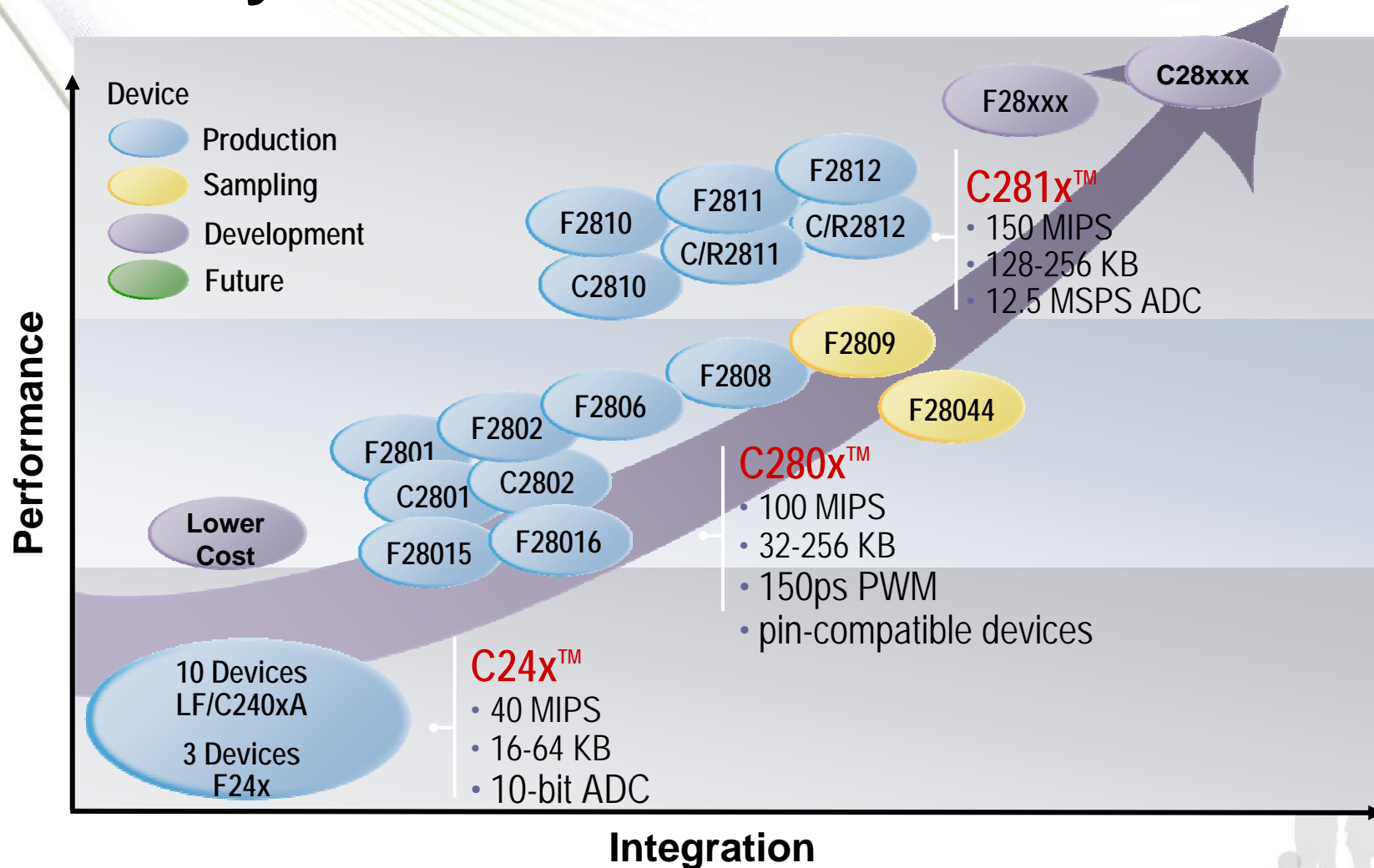
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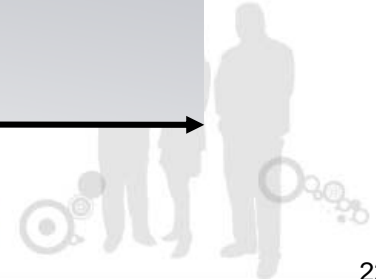
# Widely Adopted TMS320C2000 DSP in Inverter Industry



# Newly released C2000 DSP ROADMAP



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# Advantages of TI DSP for Inverter Design

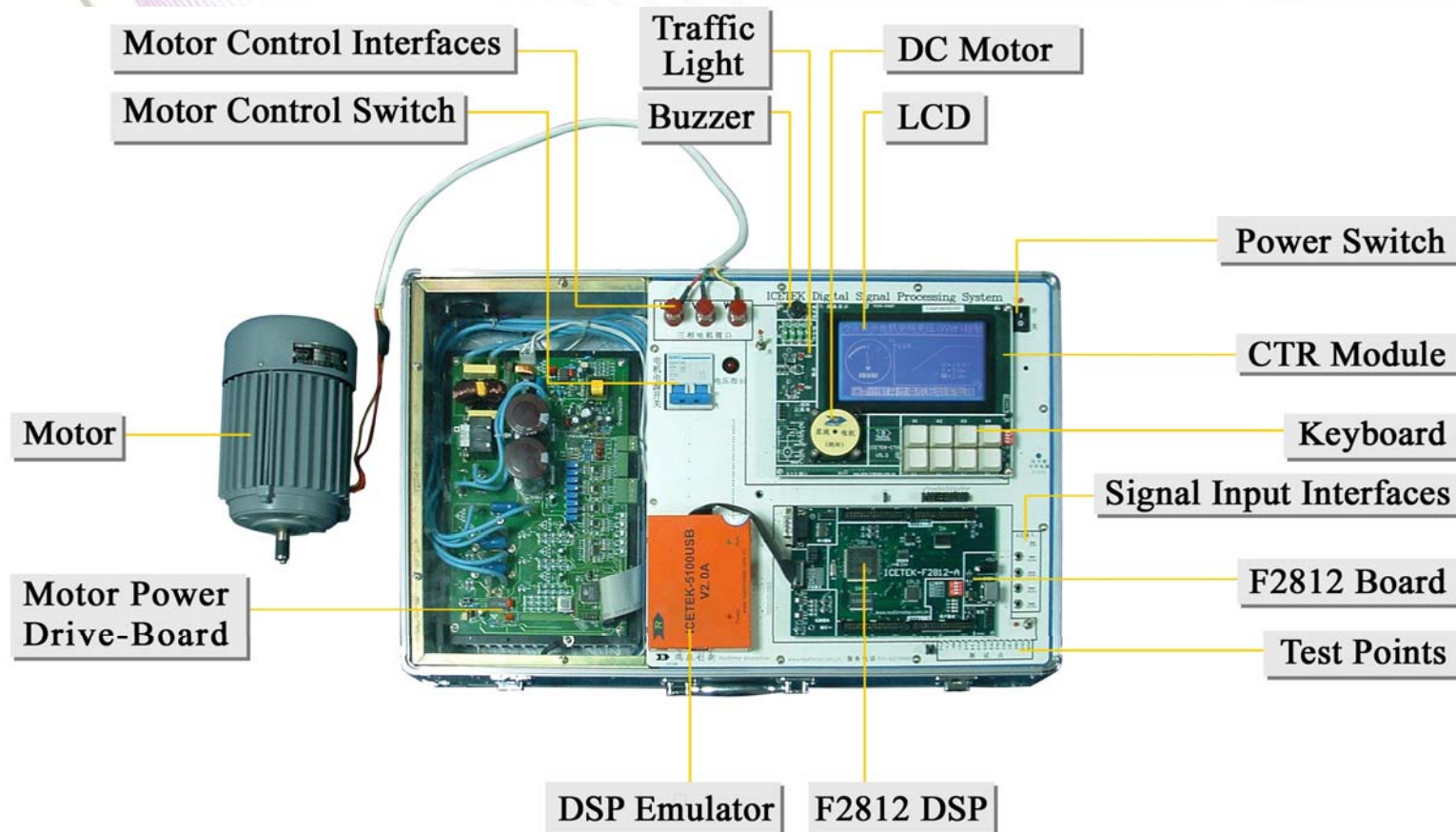
- Hardware design optimized for Computation, especially suitable for Q15 format programming
- Abundant software resources
- Low price, various selection
- The best choice to replace C196
- Mature reference design

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# TI DSP + Large Power Drive + Motor Control Solution



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TI | Developer Conference

# TI DSP + Medium - Power drive + Motor control solution



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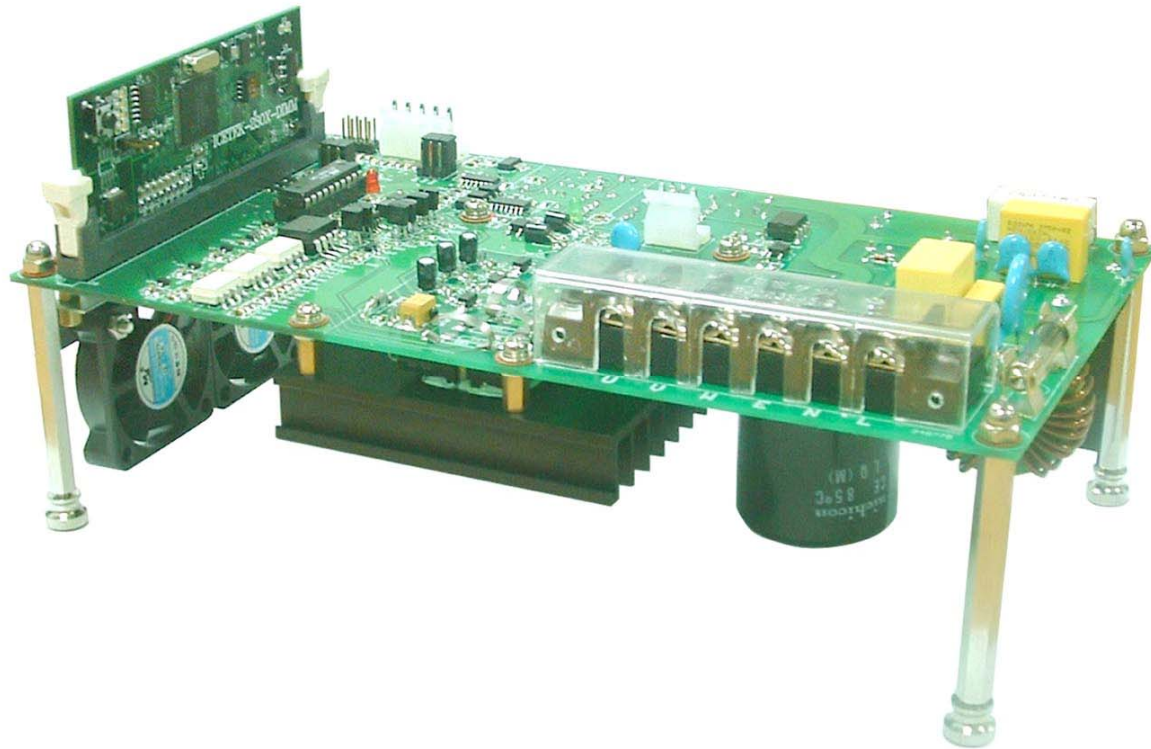


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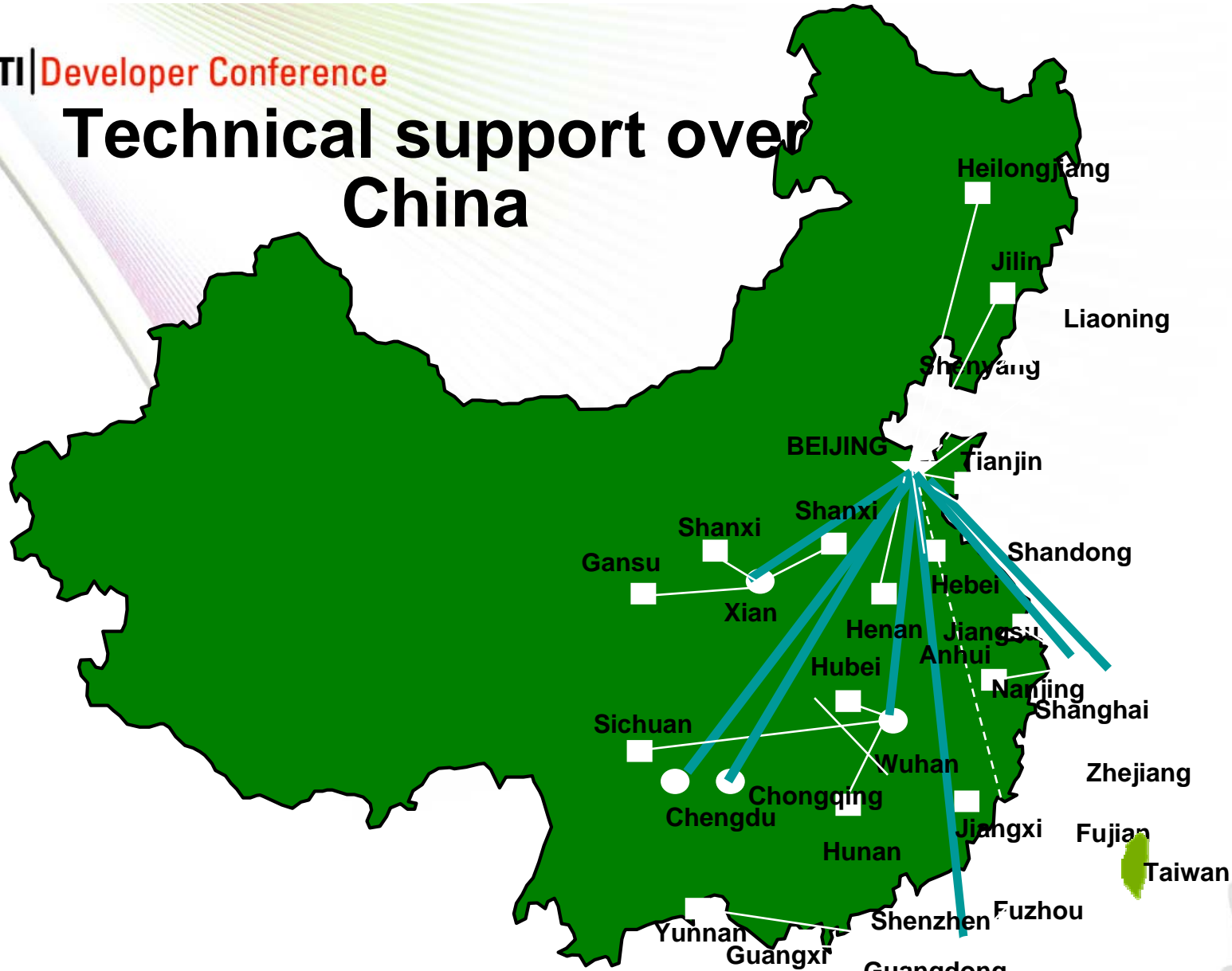
# Inverter Reference Design



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# Technical support over China



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# Technical Support Structure

- Headquarter and development center :
  - Beijing , Shanghai
- Training center:
  - Beijing , Shanghai , Shenzhen
- Branch offices :
  - Beijing , Shanghai , Nanjing , Wuhan , Chengdu , Shenzhen , Xian , Haerbin
- Technical service center and agencies :
  - Capital City

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# Beijing/Shanghai Development Center



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# TI Developer Conference

19 - 26 June 2007 • Beijing • Shanghai • Shenzhen • Taipei

# Thanks!

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