KAD/MAT/101

Microcontroller-based module

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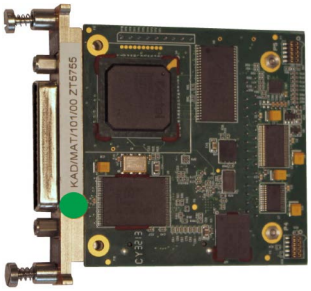

Key Features

- Computing module using industry standard C674x Digital Signal Processor (DSP)
- User-programmable microcontroller with embedded DSP
- 256K, 16-bit parameter input and result samples per acquisition cycle
- Object code can be downloaded directly via standard Curtiss-Wright tools
- Coherent data at two or three calculation cycles latency

Applications

- Creation of bespoke flight test applications

Overview

The KAD/MAT/101 allows you run your own programs based on a dual core C6000DSP+ARM9 microcontroller. It provides high performance DSP functions in a widely used architecture. You can develop C-based programs using a standard Integrated Development Environment (IDE).

The KAD/MAT/101 offers the functionality of a modern microcontroller and DSP and it facilitates access to the backplane so you can read parameters from and/or write results to other modules. These features allow you to perform a range of complex and computing intensive real-time operations (such as Fast Fourier Transforms [FFT]) to any of the parameters available on the backplane.

DSP programming is facilitated by the use of a C674x DSP library. This library includes C-callable, general-purpose signal-processing routines that are typically used in computationally intensive real-time applications. The Software Development Kit (SDK) comprises of a suite of tools used to develop and debug user applications and includes many other features such as a source code editor, compiler, debugger, and profiler.

When using the KAD/MAT/101, the user object code is developed using the Texas Instruments (TI) tool set on a Linux Virtual Machine (VM) running on a Windows operating system. The resulting binary file can be downloaded to the KAD/MAT/101 without the need for additional equipment or third party software.

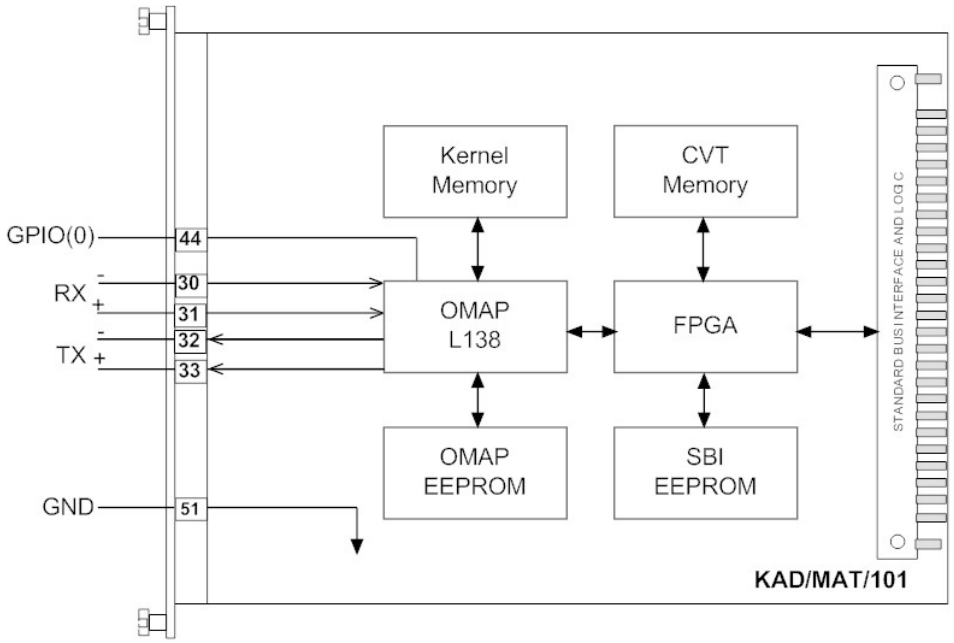

Figure 1: Microprocessor interface to serial debug output

Specifications

All values provided in the following specification tables are valid within the operating temperature range specified under "Environmental ratings" in the "General specifications" table.

TABLE 1	General specifications				
PARAMETER	MIN.	TYP.	MAX.	UNITS	CONDITION/DETAILS
Slots	–	–	1	–	Can be placed in any user-slot in any combination.
Mass					
	–	90	–	g	
	–	3.17	–	oz	Design metric is grams.
Height above chassis					For recommended clearance requirements see the *CON/KAD/002/CP* data sheet.
bare connector	–	–	11	mm	
bare connector	–	–	0.43	in.	Design metric is millimeters.
Access rate	–	–	2	Msps	Maximum combined access rate for read and write.
Power consumption					
+5V	87	–	321	mA	
+12V	79	–	99	mA	
total power	1.86	–	2.793	W	Running a 512 x 32-bit fixed point FFT every 100ms. Particular combinations of chassis and Acra KAM-500 modules may have power or current limitations. For details, see *TEC/NOT/016 - Power dissipation, TEC/NOT/049 - Power estimation*, and the relevant chassis data sheet.
Environmental ratings					See *Environmental Qualification Handbook*.
operating temperature	-40	–	70	°C	Chassis base/side plate temperature.
storage temperature	-55	–	105	°C	

TABLE 2	RS-232 inputs				
PARAMETER	MIN.	TYP.	MAX.	UNITS	CONDITION/DETAILS
Inputs	–	–	2	–	
Signaling rate					
	300	–	115200	bps	
Input voltage					
operating range	-25	–	25	V	Do not exceed operating range.
logic 0	–	–	0.6	V	
logic 1	2.4	–	–	V	
overvoltage protection	-25	–	25	V	Voltages outside of this range can damage input.
ESD protection	15	–	–	kV	Human Body Model.
Input resistance					
each input to GND	3	5	–	kΩ	Module powered on.
each input to GND	–	4.4	–	kΩ	Module powered off.

TABLE 3	RS-232 outputs				
PARAMETER	MIN.	TYP.	MAX.	UNITS	CONDITION/DETAILS
Outputs	–	–	2	–	
Signalling rate					
DATA	300	–	115200	bps	
Output voltage					
absolute operating range	-13.2	–	13.2	V	Absolute voltage of the operating signal must stay within this range.
logic 0	–	–	0.6	V	V_{0+} - V_{0-} ; R_{LOAD} = 100Ω.
logic 1	2.4	–	–	V	V_{0+} - V_{0-} ; R_{LOAD} = 100Ω.
short circuit current	-60	–	60	mA	
short circuit duration	–	–	∞	s	Only one output may be shorted at a time.
ESD protection	15	–	–	kV	Human Body Model.
Output resistance	–	10	–	MΩ	

TABLE 4	BTTL inputs				
PARAMETER	MIN.	TYP.	MAX.	UNITS	CONDITION/DETAILS
Inputs	0	4	8	–	
Signaling rate					
	0.001	–	10,000	kHz	
Input voltage					
operating range	0	–	5.5	V	
logic 0	–	–	0.8	V	
logic 1	2	–	–	V	
overvoltage protection	0	–	5.5	V	Voltages outside of this range can damage input.
Input resistance					
each input to GND	–	31	–	MΩ	Module powered on.
each input to GND	–	44	–	kΩ	Module powered off.

TABLE 5	BTTL outputs				
PARAMETER	MIN.	TYP.	MAX.	UNITS	CONDITION/DETAILS
Outputs	0	4	8	–	
Signaling rate					
	0.001	–	10,000	kHz	
Output voltage					
logic 0	–	–	0.8	V	Sinking 50mA.
logic 1	2	–	5	V	Sourcing 50mA.
short circuit current	–	–	50	mA	
short circuit duration	∞	–	–	s	To GND.
Output resistance	50	–	–	Ω	100Ω in series with standard TTL.

TABLE 6	Ethernet interface				
PARAMETER	MIN.	TYP.	MAX.	UNITS	CONDITION/DETAILS
Inputs/outputs	–	–	1	–	IEEE 802.3 compatible; 10BaseT/100BaseTX full-duplex only. Can be used with both cross-over and straight-through cables.

Setting up the KAD/MAT/101

All module setup can be defined in XML using XidML® schemas (see http://www.xidml.org).

Instrument settings

SETUP DATA	CHOICE	DEFAULT	NOTES
Manufacturer	-	-	-
Name	ACRA CONTROL	ACRA CONTROL	Name of manufacturer.
PartReference	KAD/MAT/101	KAD/MAT/101	The instrument part reference.
SerialNumber	AAA/1234	AAA/1234	Unique name for each module.
Settings	-	-	-
Latency	Fast Standard Custom	Fast	Choice of Fast (2 data acquisition cycles), Standard(3 data acquisition cycles) or Custom (user-defined) result latencies through the system.
ZIP File Path	UTF-8 String		The ZIP file path for the user code (which is down-loaded to the KAD/MAT/101).
Header File Path	UTF-8 String		The file path for the generated header file (which is used in the compilation of the user code).
Settings Advanced	-	-	-
Heart Beat Enable	Enabled Disabled	Enabled	Controls watch dog functionality. Do not disable unless debugging.
Processes	-	-	-
Calculation-Input(2047:0)	-	-	-
Settings	-	-	-
Algorithm Description	UTF-8 String Min size in bytes: 1 Max size in bytes: 1024	My FFT algorithm accord-ing to ref. 123	Description/notes of algorithm used.
Data Conversion	Native 2's Complement Q15 Q31 C15 C31 Native_Byte_Swap	Native	Data format expected on the OMAP-L138 for this calculation channel (see the KAD/MAT/101 User Guide for more information).
Sample Rate	0 to 1e6	1	-
Calculation-Output(2047:0)	-	-	-
Settings	-	-	-
Output Rate	0 to 1e6	1	Number of instances of the Result parameter (set by wizard).
Channels	-	-	-
Event(3:0) PacketiserEvent Input	-	-	If data occurs intermittently it can be sent as one of four packetizer streams
Settings	-	-	-
Packet Size	9 to 719	719	Size of packet buffer in words (including 7-word header).
Packetization Enabled	True False	False	-
Stream Id	0 to FFFFFFFF	FFFFFFFF	Stream ID of packets on this channel.
Packet Rate	0 to 1e6	10	Sets the number of packets per second expected from the KAD/MAT/101.

Parameter definitions

NAME/DESCRIPTION	BASE UNIT	DATA FORMAT	BITS	REGISTER DEFINITION
Global Parameters				
ErrorCount Number of errors detected sofar	BitVector	BitVector	16	R[15:0]
IrigTime48 48-bit wide IRIG time word. The time when this bank was written on the chassis.	BitVector	BitVector	48	R[47:0]
MessageTimeHi Hours and minutes time of bank switch.	BitVector	BitVector	16	R[47:32] R[15:13] Reserved - Reserved for future use. R[12:7] Hours - BCD Hours 0 to 23. R[6:0] Minutes - BCD Minutes 0 to 59.
MessageTimeLo Seconds and centiseconds time of bank switch.	BitVector	BitVector	16	R[31:16] R(15) Reserved - Reserved for future use. R[14:8] Seconds - BCD Seconds 0 to 59. R[7:0] Centiseconds - BCD Centiseconds 0 to 99.
MessageTimeMicro Microsecond time of the first bit of bank switch.	Second	BCD	16	R[15:0] R[15:0] Microseconds - BCD Microseconds 0 to 9999.
Report Reports the status of the module.	BitVector	BitVector	16	R[15:0] R(15) Fresh Event - Indicates new event or error. R[14:6] Reserved - Reserved for future use. R(5) OMAP-L138 user event - OMAP-L128 toggled Event line - application event marker (not a Panic). R(4) OMAP-L138 Panic - OMAP-L128 asserted Panic line - serious application error on OMAP-L138 R(3) DMA Write Truncation - EDMA Write Truncated R(2) DMA Read Truncation - EDMA Read Truncated R(1) Read Fifo Underflow - EDMA READ FIFO underflow - x"dead" will be inserted R(0) Watch Dog Error - Watch dog fired - OMAP-L138 was reset.
Calculation-Input(2047:0) Parameters				
Input(127:0) 16-bit input parameter	BitVector	BitVector	16	R[15:0]
Calculation-Output(2047:0) Parameters				
Result(127:0) 16bit result parameter	BitVector	BitVector	16	R[15:0]

NOTE: It is recommended that names are less than 20 characters, have no white space or contain any of the following five characters "/><\.

Getting the most from the KAD/MAT/101

The processor used in the KAD/MAT/101 is a TI OMAP-L138 dual core processor. Refer to the Texas Instruments website at http://www.ti.com under the OMAP section for full technical details and documentation.

The software running on the OMAP-L138 processor can be written using the TI SDK which runs on Linux (Ubuntu 10.04). This Linux development environment can be run as a VM on a Windows operating system containing the SDK and extensions.

For ease of development, the object code can be transferred to the KAD/MAT/101 using DAS Studio 3. A serial link is available on the top connector for console messages. When updating the user application while the module is at an elevated temperature, a power cycle may be required to ensure correct loading of the user application.

NOTE: After power-up, the KAD/MAT/101 generates undefined result content and undefined BTTL outputs until the user process is running.

A training course can be given to aid development of user programs on the KAD/MAT/101. Attendees are expected to be familiar with embedded programming in C. The course focuses on backplane data transfer to and from the KAD/MAT/101 and on how to integrate with DAS Studio 3.

Due to the user-definable nature of KAD/MAT/101 modules, Curtiss-Wright cannot provide support for debugging customer-generated code. Instead, example code with instructions for use is provided (see the KAD/MAT/101 User Guide for details).

Support is provided in the form of confirming hardware functionality and to supporting the example_loopback , ug_led and ug_serial examples provided in the MAT user documentation.

Power consumption

The power consumption varies depending on the amount of processing performed by the card and may exceed the allowed 260mA (on the 5V rail) and 96mA (on the 12V rail) for a single slot.

Suggested applications

The KAD/MAT/101 allows you to develop bespoke applications for flight test applications in the following domains:

- Frequency analysis of analog signals
- Digital filtering of analog parameters
- Data transformation and concentration
- Engineering unit conversion
- Custom Built-In Test (BIT) reports
- Exceedance reporting
- NMEA message parsing
- Fuel level tracking
- SNMP monitoring

The Fast Fourier Transform (FFT) program

The KAD/MAT/101 module ships with example code for an FFT program. The following steps are required to create a turnkey application:

1. Decide on an input parameter set.
2. Decide on a return parameter set.
3. Produce a configuration file with these settings.

The resulting configuration file is then used in DAS Studio 3 to produce a C-language header file, which defines the indices of the input and return parameter instances in the kernel memory. The program is then written using the Texas Instruments DVSDK on Ubuntu 10.04 and a cross compiled image is produced as an .ELF file. This executable is cross-compiled using the GNU tool chain specifically for the ARM processor and only runs on the KAD/MAT/101 processor. The ELF executable and all related files (if any) are then compressed into a ZIP archive on Ubuntu and copied to the PC, where it is then referenced in the task configuration file. During subsequent programming, the .ELF file is transferred to the KAD/MAT/101 module and is run during data acquisition. Results produced by the program are written to memory, which is then accessible over the backplane for further use.

How buffering works

The KAD/MAT/101 module retrieves and stores data in banks of parameters. These banks are timestamped and all parameters in the banks are coherent. The module can receive up to 256K words (16 bits) of input instances during a calculation cycle. Available kernel memory on the microprocessor can be used to increase the amount of data which is buffered. This buffered data can then be used to increase the resolution of an FFT calculation, for example by using overlapped buffers.

Typically, the module is used for data reduction and it processes far more inputs than it produces results; however by selecting the result page, the entire 256K of result space can be accessed if required. The result data is coherent; however it lags by two or three calculation cycles depending on the latency setting.

File system storage

The standard file system is read-only. There is provision made for 512KB of read/write file system if required for the turnkey application.

RAM and EEPROM space available for user code

The following space is available for user code:

- 80MB of RAM
- 5.5MB of EEPROM (maximum zip is 1MB)

Additional I/Os

There are additional I/Os available on the top-block for end-user use.

- Dedicated console and user-application RS-232 links
- Eight BTTL I/O (subject to available current on BTTL)
- One full-duplex Ethernet I/O

The eight general purpose I/Os can be configured in two banks of four to be either inputs or outputs:

Bank A contains pins GPIO(0) to GPIO(3); and Bank B contains pins GPIO(4) to GPIO(7).

The banks can be independently configured as input only or output only.

NOTE: The direction of the GPIOs can be configured as a bank only. For instance, if GPIO(0) is selected to be an input, then all GPIOs in bank A will be inputs; they cannot be individually configured within the bank.

The Ethernet, RS-232, and eight TTL I/Os are not used during standard operation and require additional software development. We recommend that only advanced users (preferably with experience in the development of firmware for embedded systems) program these I/Os when used for acquisition purposes.

Instead of using inputs via the top-block, we recommend using backplane data as the input for standard operation. Following this recommendation, dedicated KAD modules can be used to parse other buses (such as Ethernet and RS-232) and pass the data to the KAD/MAT/101 over the backplane.

NOTE: There is no internal pull-up or pull-down resistors on the BTLL I/O. If required, these can be placed externally.

Connector pinout of the KAD/MAT/101

PIN	NAME	SEE SPECIFICATIONS TABLE	COMMENT
1	DNC		Do not connect
2	DNC		Do not connect
3	DNC		Do not connect
4	DNC		Do not connect
5	RS_IN(1)	RS-232 inputs	Serial line; available for end-user
6	RS_IN(0)	RS-232 inputs	Serial line (console)
7	RS_OUT(1)	RS-232 outputs	Serial line; available for end-user
8	DNC		Do not connect
9	CHASSIS	Chassis	
10	DNC		Do not connect
11	DNC		Do not connect
12	DNC		Do not connect
13	DNC		Do not connect
14	DNC		Do not connect
15	DNC		Do not connect
16	DNC		Do not connect
17	GPIO(7)	BTTL inputs/BTTL outputs	General end-user I/O (Bank B)
18	GND		For use with I/O
19	GND		For use with I/O
20	GND		For use with I/O
21	GND		For use with I/O
22	GND		For use with I/O
23	GND		For use with I/O
24	GND		For use with I/O
25	GND		For use with I/O
26	RS_OUT(0)	RS-232 outputs	Serial line (console)
27	CHASSIS	Chassis	
28	DNC		Do not connect
29	DNC		Do not connect
30	RX(-)	Ethernet interface	Ethernet interface
31	RX(+)	Ethernet interface	Ethernet interface
32	TX(-)	Ethernet interface	Ethernet interface
33	TX(+)	Ethernet interface	Ethernet interface
34	DNC		Do not connect
35	GPIO(6)	BTTL inputs/BTTL outputs	General end-user I/O (Bank B)
36	CHASSIS	Chassis	
37	DNC		Do not connect
38	DNC		Do not connect
39	DNC		Do not connect
40	DNC		Do not connect
41	DNC		Do not connect
42	DNC		Do not connect
43	DNC		Do not connect
44	GPIO(0)	BTTL inputs/BTTL outputs	General end-user I/O (Bank A)
45	GPIO(1)	BTTL inputs/BTTL outputs	General end-user I/O (Bank A)
46	GPIO(2)	BTTL inputs/BTTL outputs	General end-user I/O (Bank A)
47	GPIO(3)	BTTL inputs/BTTL outputs	General end-user I/O (Bank A)
48	DNC		Do not connect
49	GPIO(4)	BTTL inputs/BTTL outputs	General end-user I/O (Bank B)
50	GPIO(5)	BTTL inputs/BTTL outputs	General end-user I/O (Bank B)
51	GND	Internal ground	
52	CHASSIS	Chassis	

Ordering information

PART NUMBER	DESCRIPTION
KAD/MAT/101	Microcontroller-based module

By default, one DEV/KIT/001 or DEV/KIT/001/CHN is included with each order, while a standard mating connector, CON/KAD/002/CP, is included with each module in the order. Their part numbers will be added to the Confirmation of Order unless an alternative option is specified (see the *Cables* data sheet).

Revision history

REVISION	DIFFERENCES	STATUS
KAD/MAT/101	First release	Recommended for new programs

Supporting software

SOFTWARE	DETAILS
DAS Studio 3	User interface for setup and management of data acquisition, network switches, recorders and ground stations in an integrated environment
Ubuntu 10.04 + TI DVSDK	A Linux cross-compilation environment is required to generate the user configurations (in C++ using the C6Accel framework from TI)
DEV/KIT/001	Development kit for KAD/MAT/101

Related documentation

DOCUMENT	DETAILS
DOC/DBK/001	Acra KAM-500 Databook
DOC/HBK/002	Environmental Qualification Handbook
DOC/MAN/030	DAS Studio 3 User Manual
DOC/USG/017	KAD/MAT/101 User Manual
TEC/NOT/016	Power dissipation
TEC/NOT/049	Power estimation