Gas Turbine Data Acquisition and Monitoring System for Combined Cycle Power Plant

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Abstract—This paper presents a data acquisition and monitoring system for a gas turbine. The proposed system entitled C-Tune DAS plays an important role to make an analysis of the real-time operation of the gas turbine under maintenance. The designed LabVIEW based software is divided into three parts according to their original functions, i.e., data acquisition, data analysis with display, and data storage. The data acquisition part receives data from a PMS (Plant Management System) server and two cFPs (Compact-Field Point). To verify the validity of the developed system, it is applied to gas turbines in the combined cycle power plant in Korea.

Index Terms—Compact-Field Point (cFP), LabVIEW, Plant Management System (PMS).

I. INTRODUCTION

Compared to conventional steam power plants, gas turbines tend to be natural-gas-fired smaller units, which adjust quickly and easily to changing loads. Generally, gas turbines have low capital costs and relatively high fuel costs, which mean they are most cost-effective as peaking power plants that run only intermittently [1].

A basic gas turbine usually drives a generator to produce electric power. Fresh air is drawn into a compressor where spinning rotor blades compress the air, rising its temperature and pressure. Then compressed air is mixed with fuel. The mixed fuel is subsequently burned in the combustion chamber. The hot exhaust gases are expanded in a turbine and released to the atmosphere. The compressor and turbine share a connecting shaft, so that a portion, typically more than half, of the rotational energy created by the spinning turbine is used to power the compressor [1]-[4]. The overall process mentioned above including gas turbine maintenance should be controlled and monitored by administrators. Generally a basic server system like PMS (Plant Management System) is supplied for a stable operation of gas turbine when a gas turbine is installed. On the other hand, a client system like ProDAS is designed for additional purpose. It is used to collect gas turbine data when gas turbine is under maintenance. The ProDAS receives a large number of data from PMS and collects important data from several sensors inserted in gas turbine directly. All data are used to check the operation of the gas turbine. There are no troubles when it receives data from PMS; it only depends on the network status. To acquire sensor data from the gas turbine, ProDAS employs three Data Scan boxes, which are linked to gateway via RS232 cables. This configuration is somewhat complex and because all channels are fixed, it is difficult to modify the sensor position. To solve these problems, we present a gas turbine data acquisition and monitoring system using LabVIEW [5]. It was entitled C-Tune DAS; it plays an important role to make an analysis of the real-time operation of the gas turbine under maintenance. Its software operation is basically equal to that of ProDAS. It was designed for user friendly and flexibly. It was programmed by LabVIEW instead of BridgeVIEW. The hardware configuration was modified for simplicity and high stability. The LabVIEW based software is divided into three parts according to their original functions; data acquisition, data analysis with display, and data storage. The data acquisition part receives data from a PMS (Plant Management System) server and two cFPs (Compact-Field Point). From the PMS server, it takes real-time data from other gas turbines in operation. In order to access the PMS server, it requires a special driver containing protocol. 30 sensors installed in the gas turbine under maintenance detect important information such as temperature, pressure, flow, and so on. These data are transferred to the C-Tune DAS via two cFPs. In the data analysis and display, raw data received from the PMS and cFPs are collected in a lookup table. It analyzes and tunes significant parameters of the mended gas turbine. It also displays significant status of the gas turbine. It includes Main Display, Display Flow, TAT1, TAT 2, and other display windows related to system setting. Finally, data storage part saves all important data required to additional analysis like efficiency, data losses, and performance analysis. To verify the validity of the developed system, it is applied to gas turbines in a combined cycle power plant in Korea. Consequently, we found that C-Tune DAS shows high performance and reliability in data accuracy compared with a conventional data acquisition system (ProDAS).

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II. PRODAS AND C-TUNE DAS

Commercial ProDAS is a standard instrument for a test run of a gas turbine. It gives important data to engineer for an efficient test working and safety of the gas turbine. The main purposes of the ProDAS are measurement and calculation of cooling air, display of important operation parameters, verification of stable condition, computation of efficiency, averaging of the measured data, and so on.

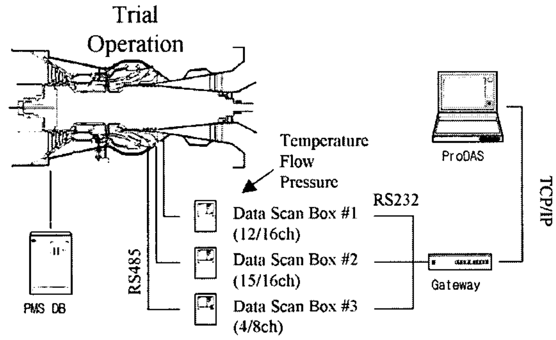


Fig. 1 Hardware configuration of ProDAS.

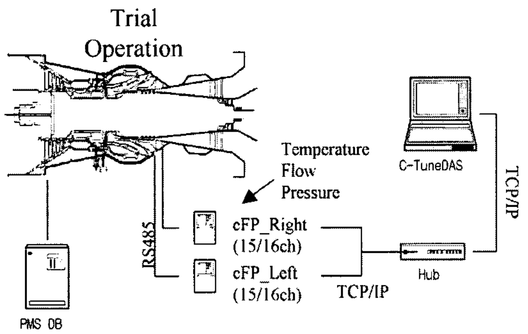


Fig. 2 Hardware configuration of C-TuneDAS.

Fig. 1 shows the configuration of ProDAS with a gas turbine being tested. During the test working, ProDAS receives operation data of the gas turbine from PMS server via TCP/IP communication. It also collects raw sensor data from three Data-scan boxes. These scan boxes play important role to acquire real-time data, which are measured from several installed sensors such as temperature, pressure, flow, etc. Each sensor adapts a HART protocol so the variation of the sensor current is in the range of 4 to 20 [mA]. These measured values are transferred to ProDAS via RS-232 communication. Then ProDAS converts these detected current into real values using weight factors. Based on these collected data, ProDAS internally calculates proper parameter values for tuning the gas turbine. ProDAS programmed by Bridge View are working on Window 95 operating system. It is well-designed program, which is suitable for tuning a gas turbine. However, it has several drawbacks such as a complex hardware configuration, losing in operation speed by means of internal software complication, most of all it is difficult to change the program setting when the user wants to change the target gas turbine.

To improve these problems, we developed a modified data acquisition and monitoring system for gas turbine entitled C-Tune DAS. It means a Combustion Tuning and Data Acquisition System.

Fig. 2 shows the hardware configuration of the proposed C-Tune DAS with a gas turbine being tested. It employs two cFPs (Compact-Field Point) instead of three Data-scan Boxes. It uses TCP/IP protocol so it shows high reliability in long distance transmission. To access the PMS server, C-Tune DAS uses a new special driver, which is designed by Visual C++; it helps to gain in operation speed. C-Tune DAS performs a basic operation of ProDAS. It improved the program setting method. It supports web-based monitoring service, and has useful function for operators.

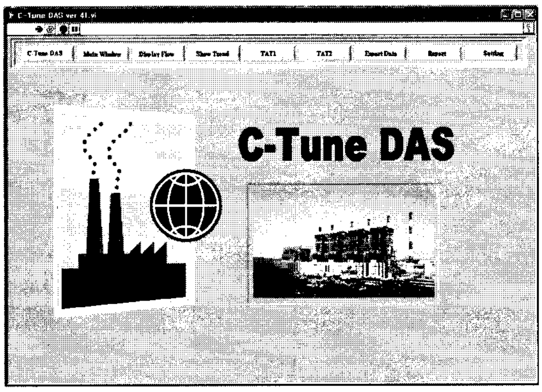
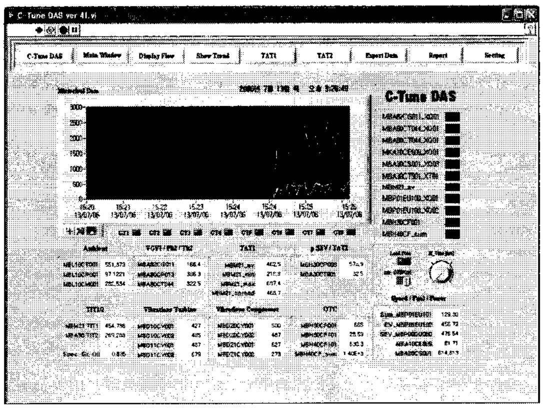
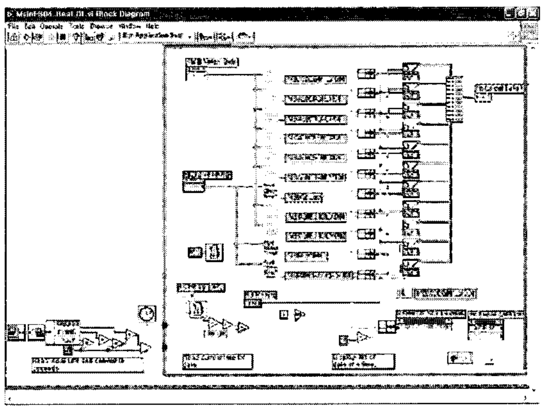


Fig. 3 Initial display window of C-Tune DAS.



(a)

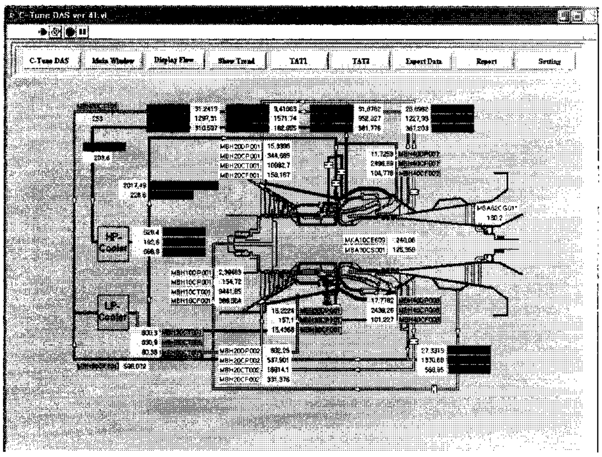


(b)

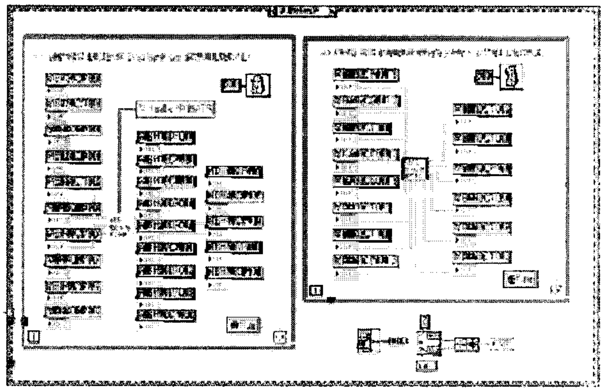
Fig. 4 Main window display of C-Tune DAS. (a) Front panel. (b) Block diagram.

Fig. 3 shows an intro-display of C-Tune DAS. It was programmed by LabVIEW 8.0 and LabVIEW Real-Time 8.0 under Windows XP operating system. The upper side buttons shift C-Tune DAS display and function.

Fig. 4(a) and 4(b) show front panel and block diagram of main window display in C-Tune DAS, respectively. Fig. 4(a) contains the information for the present time and date, status connected gas turbine, control knob for axis setting, and so on. 11 historical data are managed in this display to monitor the variation of important data. As shown in Fig. 4(b), most data are read from PMS server which controls gas turbine operation. Three data are internally calculated by using specific equations. They were designed by XY chart to control the buffer size.



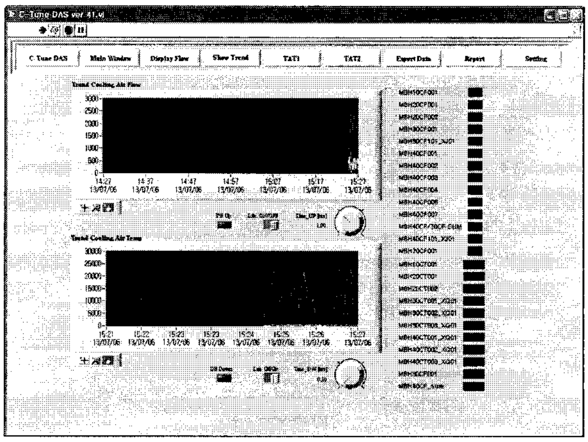
(a)



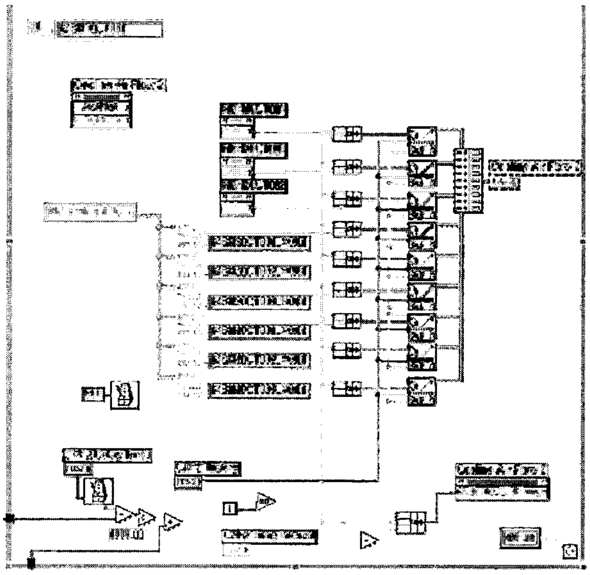
(b)

Fig. 5 Display flow display of C-Tune DAS. (a) Front panel. (b) Block diagram.

Fig. 5(a) shows a front panel of Display Flow. It shows real-time data, which are collected from PMS and cFPs. As shown in Fig. 5(b), all data are managed by KKS number (index). We designed that C-Tune DAS automatically searches corresponding tag and KKS number in a look-up table. Fig. 6(a) shows two graphs for cooling air flow and temperature. 14 points for displaying cooling air flow and 11 points for displaying cooling air temperature are displayed by XY charts. They are suitable for displaying historical data management. To synchronize display and storage timing, it uses internal time stamp. By using property node, all data are shared with other display windows.



(a)



(b)

Fig. 6 Cooling air flow of C-Tune DAS. (a) Front panel. (b) Block diagram.

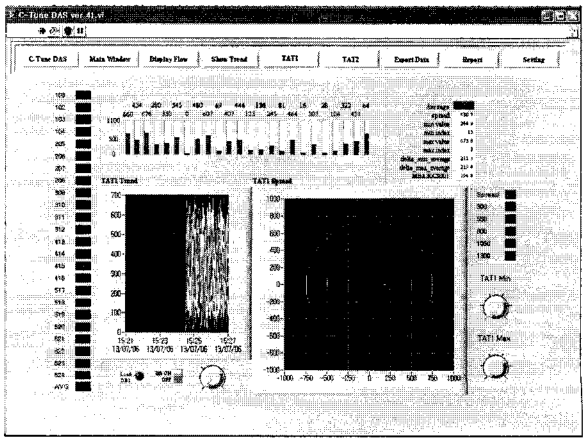
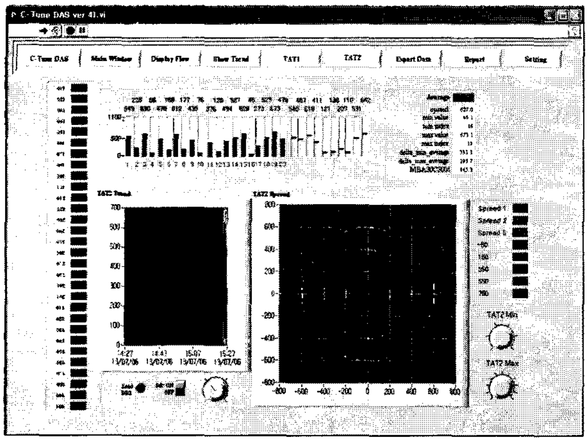
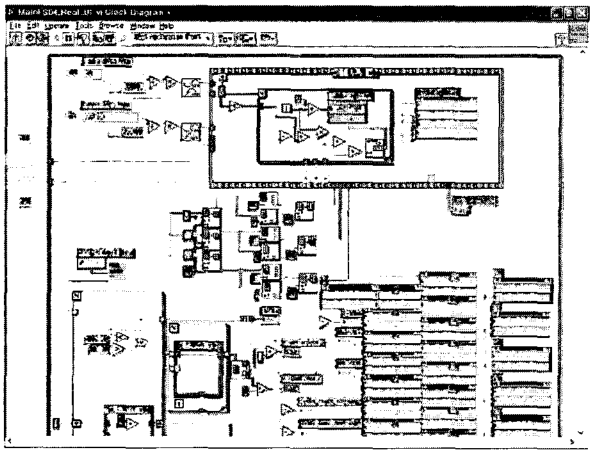


Fig. 7 TAT 1 front panel of C-Tune DAS.

Fig. 7 and Fig. 8 are TAT 1 and TAT 2, respectively. They show important temperature characteristics of gas turbine. They display average, maximum, minimum, and deviations of each point related to turbine temperature. All data should be located in a safe range when the gas turbine is stable. The block diagram given in Fig. 8(b) is almost equivalent to that of Fig. 7.



(a)



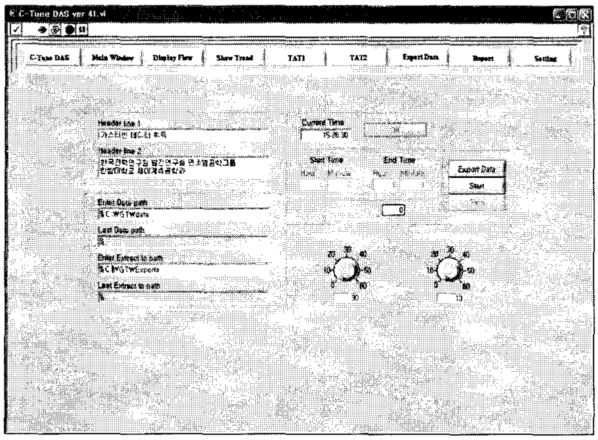
(b)

Fig. 8 TAT 2 of C-Tune DAS. (a) Front panel. (b) Block diagram.

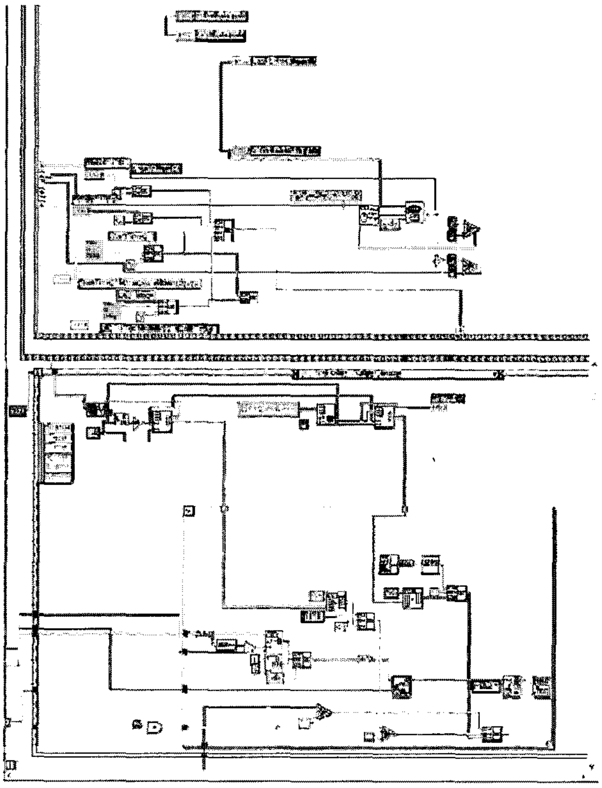
Fig. 9(a) shows the composition of Export Data front panel. It saves 306 raw data collected from PMS and two cFPs to three Excel files in sequence. It uses the ASCII code. 325 data including internally calculated 19 data are saved by time stamped method. It can reserve the storage interval and average time easily.

Fig. 9(b) shows the block diagram of Export data part. It contains setting of file storage path, header file definition window, start/end time setting function, storage file format, and other timing set related programming. It also plays a role to extract data from virtual data arrays which contain data obtained from PMS and acquired from two cFPs. All data changed to have the same format. Here we use Excel format. Definition for Row and column data position is set in this block diagram.

Fig. 10 shows the configuration of C-Tune DAS setting. It sets up the initial condition for data acquisition of PMS and two cFPs. It is very simple and easy to change the target gas turbine. From this window, we can notice the connection status of gas turbine and cFPs. It also shows the IP address and service port of the PMS server automatically.



(a)



(b)

Fig. 9 Export Data of C-Tune DAS. (a) Front panel. (b) Block.

Fig. 11 shows a storage result by ASCII code saved in a excel file. Generally, a gas turbine has somewhat large time-constant so we set up the storage interval to 30 seconds. Each excel file has an automatic index 0, 1, and 2 in sequence. The name of the file becomes the present time and date. Fig. 12 shows the average values of the raw data saved in three excel files. It can control the time interval by turning the knob in Fig. 9.

Fig. 13 shows a photograph of developed data acquisition system. It was designed by cFP (Compact-field point). Most data pre-calculation and sensor calibration are performed by embedded software of cFP.

Table I shows the hardware comparison between ProDAS and C-Tune DAS. We can notice that C-Tune DAS has a simple and sufficient configuration compared with conventional ProDAS.

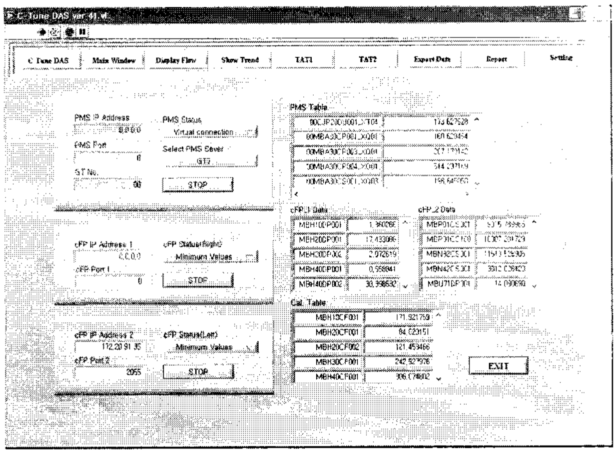


Fig. 10 The composition of C-Tune DAS (Setting).

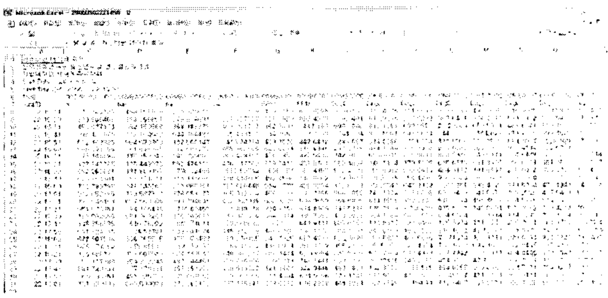


Fig. 11 Storage result (raw data in ASCII code).

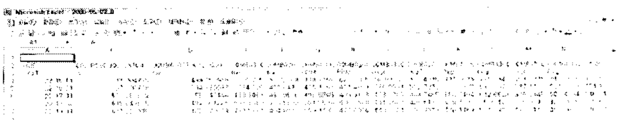


Fig. 12 Storage result (average data in ASCII code).

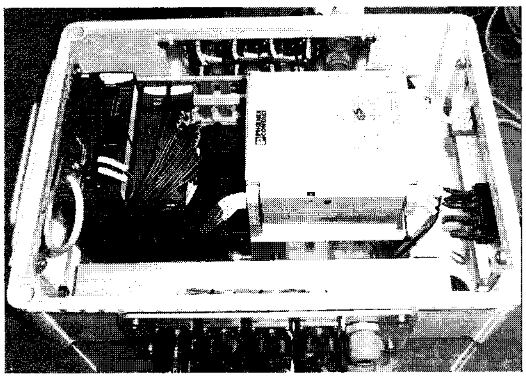


Fig. 13 Photograph of designed cFP (Compact-field point) data acquisition system.

III. CONCLUSION

This paper proposed a gas turbine data acquisition and monitoring system based on a LabVIEW. The developed real-time monitoring system entitled a C-Tune DAS plays an important role to make an analysis of the real-time operation of the gas turbine under maintenance. Its operational characteristics are similar to that of ProDAS. The LabVIEW based software is divided into three parts according to their original functions; Data acquisition, Data analysis and display, and Data storage. Each part was well-designed to be satisfied the original function.

To verify the validity of the developed system, it was applied to gas turbines in the combined cycle power plant in Korea. Consequently, we found that C-Tune DAS shows high performance and reliability in data accuracy compared with a conventional data acquisition system.

Table 1. Comparison Between Prodas and C-Tune das

	ProDAS		C-Tune DAS
	Data Scan DA7327	Data Scan DA7221	Compact FieldPoint (cFP*2)
No. of Channel	16	8	each 16 ch (Max 64 ch)
Physical measurement	Flow Temp	Temp	Flow/Temp/Pressure
Signal	Analog Input	Analog Input	Analog Input
Unit	V	V	V or mV
Sensor Type	RTD Flow meter	RTD	Flow meter/RTD
Interface	RS485	RS485	TCP/IP

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