

Pulling Designs into an Enterprise Database

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Overview

We are going to look at a design data management system for electronic engineering in a startup company. Typically this system is used in the first three to five years of a new enterprise. After that it would be superseded by a real ERP system. The system is based on SQL so data migration is straight forward.

There are some differences between the needs of an MRP for manufacturing and such a system for engineering. This system is built to provide the appropriate flexibility for engineering, while presenting also clean and "rigid" output to manufacturing, but it is not designed for manufacturing inventory management, although its functions could be so extended.

History

Electronic design startups need to manage their design data in a way that presents unambiguous fabrication and assembly documents to manufacturing. The mission of the present system was/is to capture the engineers' intentions accurately and completely, and to reuse prior (known good) work as much as possible, keeping the count of part types low, and delivering usable information to the purchasing and manufacturing teams.

The first step was to create a part naming protocol. We adapted an existing protocol, with a long track record, to our present needs, mostly by shedding an

eight character limit for sixteen, and taking account of DX's reserved characters.

Once parts had reliable names, we created a new parts library that EEs never add to; they just draw from it. The library had no legacy parts, only parts created under the new rules. When new parts are needed, the EEs ask for them and pass us datasheets; we build the parts and decals. Their older libraries are available to them, but all finished designs draw exclusively from the new library.

The next step was to give all components unique part numbers for use in inventory and purchasing. This was done using a common seven digit system consisting of three digits of class code and four of base number.

Research demonstrated long ago that numbers longer than seven digits are subject to increased error rates. The three digit class code is meaningful and not unique. The four digit base number is unique but not meaningful; it is just pulled from a serial set of numbers.

In the four years since the introduction of this part numbering scheme, with about 50 electronic products, we have used about 870 base numbers, and the rate of new number creation has slowed to about ten per month. So 9999 distinct part types is plenty for the first decade of an electronics business.

Database structure

There are four basic tables in the system (fig. 1).

The top level is the "products" table (fig. 2 – next page). Every electronic product has a product ID number (the primary key) and a corresponding form known as the "product page". This is the fundamental index of design data for that product. Revision control is managed on this page. When an assembly package is generated, a PDF "snapshot" of this page is included in the package to show the state of all documents at the time of that release.

The "product page" shows the location, on a company server, of specifications, block diagrams, schematics, PCB designs, fabrication files (gerbers, PDFs, a CAM350 file, and an IPC netlist),

assembly files (drawings, BOMs, special instructions, stencils), and embedded and diagnostic software for the product.

The product page lists all relevant ECOs and provides hot links to them. The current revision levels of all documents are gathered in a block. The EE responsible for the design, and the PCB designer are listed. The various names and numbers for the product (in different departments) and the larger systems to which it belongs are all listed here.

This is the place where any work should start. Certainly an assembler or technician beginning work on a design should look here first to be sure he/she is starting with current documentation.

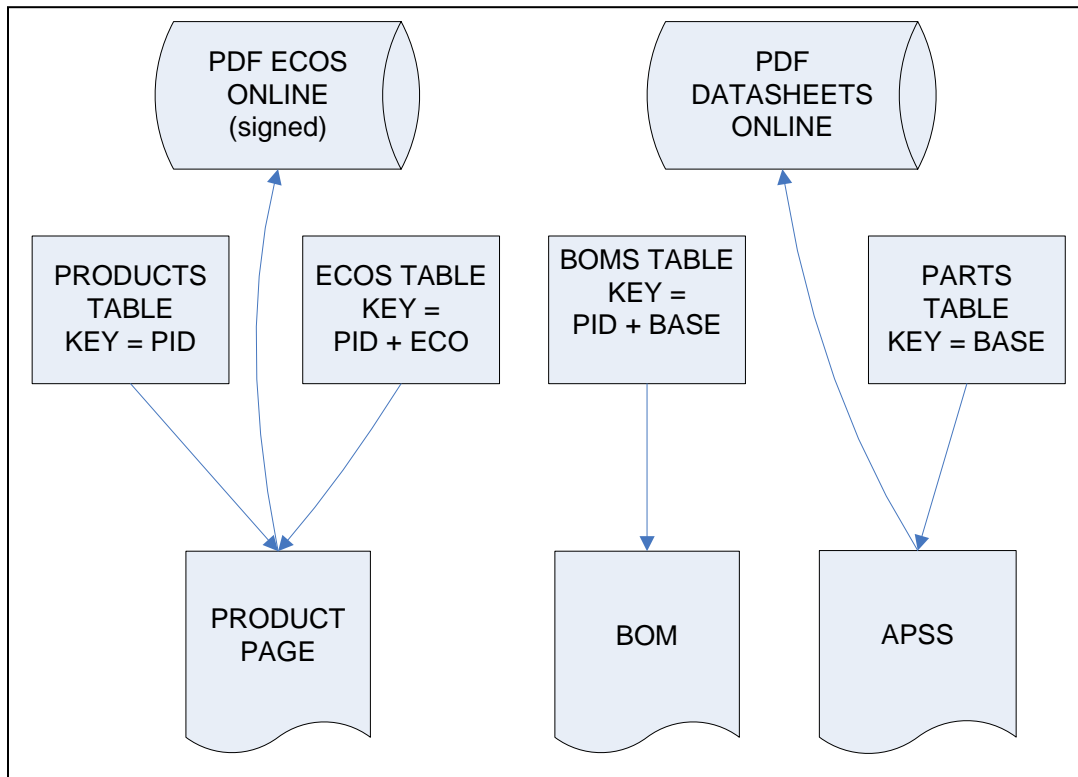


Figure 1 - Tables, PDF links, and report forms

BEMDATA_SQL

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BEM products

BEM Electrical Design Docs

Yellow Fields are for Purchasing Entry ONLY!

Product ID: **95**

Electrical Engineer: J Bond

PCB Design Engineer: R Hileman

Common Name: AQMOD6

Current Revisions:

PCB:	Fabrication:	Firmware:
BF	B	1.06
Schematic:	Assembly:	FW Checksum:
C	C	0x2FE7

BEM No. for PCB: 275-AQMOD6

BEM's "B" number for PCA: B903

Used in these products: D903P-M

Job Code: 100111

Next Build Quantity: 50

Good To Go? 1=yes; 0=no: 0

Pointers to current documentation for production of B.E.Meyers' printed circuit assemblies are found here. In most cases only the current revision is shown. In some cases, where the product is changing, the next revision is shown also. When development of a product is restarted, look for the next revision documentation in progress, and the \IBNI.txt file.

SPECS -- K:\Elec\designs\
AQMOD6\specs\AQMOD6 Product Description.doc

DESIGN-- K:\Elec\designs\
AQMOD6\BLOCK\AQMOD6.vsd

SCHEMATIC -- K:\Elec\designs\
903P-M(AQMOD6)\sch\AQMOD6C.1

PCB -- K:\Elec\designs\
903P-M (AQMOD6)\~Current PCB File\AQMOD6BF.pcb

FAB -- K:\fabdocs-elec\
903P-M (AQMOD6)\rev B\AQMOD6_revB_fab.zip

ASSEMBLY -- K:\assemblydocs-elec\
903P-M (AQMOD6)\Main Board\rev C
903P-M (AQMOD6)\

SOFTWARE: K:\Elec\designs\
903P-M (AQMOD6)\code\PC\AQMOD6_V1_06.EXE
903P-M (AQMOD6)\Laser\AQMOD6_V1_06.zip

REWORK -- K:\assemblydocs-elec\
NONE

ECOs

ECOnumber	ECOfilename	
601	ECO601.pdf	Show PDF
501	ECO501.pdf	Show PDF
*		Show PDF

ISSUES remaining before next PCB turn
AQMOD6 fab needs re-design for DFM.

Figure 2 - Product page

The bottom level of the system is the "parts" table where the APSS (Approved Parts Specification Sheet) resides for every component. The primary key for this table is the base number. This is the only table in our system that DxDesigner sees.

The APSS form (fig. 4 - next page) shows the name used for the part type in the schematic library, the name of the PCB decal, class code and base number, our description line, the description line used by the primary distributor, the manufacturer and their PN, the distributor and their PN, up to two alternate sources, and crosses, and various fields descriptive of the part.

A pushbutton link to the PDF datasheet on our server is included, and the file name is shown. A where-used list is presented, with reference designators and PID numbers. Other fields show what quantity levels to buy, a judgment call usually based on the extent of the where-used list and the price of the component. Comments and special requirements have their own memo fields.

name	symbol	classcode_id	base	qu_in_stocd	part_value	tolerance	wattag	voltage	amperag	material_tech	decal	ht_mils	ht_mm
D-B340A	D-B340A	241	1	4414				40	3		SMA-KA	102	2.5
D-1N4148	D-1N4148	241	2	7111			0.225	100	0.15		SOD123-KA	53	1.4
AMP-04	AMP-04	281	3	31							SO8	63	1
Q-B55138ZX	Q-B55138ZX	254	4	7073		0.36	50	0.22			SOT23-123D5G	43	1
Q-B5584ZX	Q-B5584ZX	254	5	2937		0.36	-50	-0.13			SOT23-123D5G	43	1
C-678D107M040CG3	C-678D107M040CG3	226	6	216	100 uF	20		40		AlumElectr	CAPR-2-4	725	18
C00^1UF10%50VX7R	C00^1UF10%50VX7R	221	7	3560	0.1 uF	10		50		X7R	CC0805	28	0
C0022UF10%16VTAN	C0022UF10%16VTAN	222	8	1916	22 uF	10		16		TANT	CC6032-P	110	2
C0^01UF10%50VX7R	C0^01UF10%50VX7R	221	9	6925	0.01 uF	10		50		X7R	CC0805	43	1
C0033PF05%50VNP0	C0033PF05%50VNP0	221	10	4365	33 pF	5		50		NP0	CC0805	43	1
C-C1206C224K5RAC	C-C1206C224K5RAC	221	11	2148	0.22 uF	10		50		X7R	CC1206	53	1
C0^22UF10%25VX7R	C0^22UF10%25VX7R	221	12	4189	0.22 uF	10		25		X7R	CC0805	43	1
C0^068UF10%50VX7	C0^068UF10%50VX7	221	13	3620	0.068 uF	10		50		X7R	CC0805	43	1
R05-3^9K-CC0805	R05-3^9K-CC0805	231	14	9515	3.9K	5	0.1				CC0805	26	0
C1000PF10%50VX7R	C1000PF10%50VX7R	221	15	4818	1000 pF	10		50		X7R	CC0805	43	1
C0^22UF10%16VX7R	C0^22UF10%16VX7R	221	16	8330	0.22 uF	10		16		X7R	CC0805	43	1
Q-2TV705A	Q-2TV705A	252	17	550				140	0.5		TO-18	160	4

Figure 3 - DxDataBook view of the Parts table

BEMDATA_SQL - [partnumb]

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APSS Part Name: D-1N4148 PCB Decal: SOD123-KA DxDesigner Symbol: D-1N4148 Class: 241 Base: 0002

approved part specification sheet logic symbol on schematic

BEM Description: DIO 1N4148 switching SOD123

Distributor/Mfr Description: DIODE SWITCH 100V SOD123 K:\Elec\Parts\datasheets\MMSD4148T1-D.pdf

Value	Tolerance	Watts	Volts	Amps	Material Tech	Height (mils)	Height (mm)	Marks on device
		0.23	100	0.15		53	1.4	-

Store Temp Lo: -55 Store Temp HI: 150 Op Temp Lo: -55 Op Temp HI: 150 *All temps are in degrees C.*

Distributor #1 Part No.	Distributor #1	qu	reference	kit_has	id
MMSD4148T1GOSTR-ND	Digikey	20	D7 D8 D9 D10 D11 D12 D13 D14 D15 D16	0	12
MMSD4148T1G	ON Semiconduc	8	D1 D2 D3 D4 D5 D6 D7	0	18
		5	D1 D2 D3 D4 D6	0	8
		5	D1 D2 D3 D4 D6	0	13
1N4148WDICT-ND	Digikey	5	D1 D2 D3 D4 D6	0	22
		5	D1 D2 D3 D4 D6	0	23
1N4148W-7	Diodes Inc	5	D1 D2 D3 D4 D6	0	25
		5	D1 D2 D3 D4 D6	0	28
		5	D1 D2 D3 D4 D6	0	32
		5	D1 D2 D3 D4 D6	0	40
		3	D1 D2 D3	0	11
		3	D2 D3 D4	0	19
		3	D2 D3 D4	0	20
		2	D1 D2	0	33
		1	D5	0	1
		1	D3	0	7
		1	D1	0	27
		1	D2	795	10.1
		1	D5	0	46

special requirements: ULTRAFAST

comments: Was formerly a MINIMELF pkg. This part is a drop in replacement that we wish to use in the future. Please use the remainder of the MINIMELF pkgs & order this part from now on. G IN PART NUMBER =ROHS COMPLIANT

BEM Part Number (bizwrks): 241-1N4148SM assy method: Machine qu_in_stock: 7111 price_q10: \$0.04 price_q100: \$0.04 price_q1000: \$0.04 lead time (weeks): Buy Level: 5

Buy levels: 1 - current need + a few, 2 - need + 20%, 3 - tape and reel, 4 - two reels, 5 - buy a heap o' reels

Modified: 11/9/2006 8:33:12 AM

Record: 2

Figure 4 - Approved Parts Specification Sheet

Next is the BOMs table. The primary key to this table is a "unique" combination of two keys: the PID number and the base number. Once you have selected a PID, a BOM can be printed for that product.

The BOM report from MS Access (fig. 5) will show in its header the revision levels for schematic, fab, assembly, the PID number, the product name, and other manufacturing numbers for it.

Besides a generous selection of fields from the "parts" table, some special columns show reference designators for parts that are to be stuffed, a "DNP" column for parts to be bought but not stuffed yet, and a "NoBuy" column for parts that exist in the design data that should or could not be purchased such as pad patterns for wires, or components not part of this configuration. The BOM, like the APSS, also shows whether the part is suited to machine placement or is to be stuffed by hand.

B.E. Meyers & Co., Inc. PC Assembly BOM		Assembly Rev: C		ECOs: 601 601		Product ID: 95								
		Fabrication Rev: B		Used On: D98P-M		BEM PCA 'B' # B903								
		Schematic Rev: C				BEM PCB P/N: 275-AQMOD6								
BEM P/N	QTY	Needs	Form	Short	Class	Base #	Name	Description	Manufacturer P/N	Mfr.	Marks	NoBuy	DNP	Reference Designators
241-BAY169NS-7	1	50	Machi	26	241	0166	D-BAY169NS	DiD BAY169NS-7 switching silicon 75V 200mW SOD323	BAY169NS-7	Diode Inc	T4 & 1			D17
221-0186	10	300	Machi	0	221	0186	0022UF10%50VX7R	CAP 0.22uF 10% 50V X7R 0805	C2012X7R1HZ24K	TDK	--			C2 C3 C4 C11 C13 C14 C16 C25 C26 C29
221-0200	1	50	Machi	26	221	0200	0022UF10%16VX7R	CAP 2.2uF 10% 16V X7R 0805	C2012X7R1C225K	TDK	--			C9
231-0218	1	50	Machi	26	231	0218	R05-012K-C0805	RES 12K 5% 1/10W C0805	260-12KRC	Xicon	123			R11
238-CAT5259DI	1	50	Machi	0	238	0235	CAT5259	IC CAT5259 Dig Quad Normal Pol 50K TSSOP24	CAT5259YF-50	Catalyst	CAT5259			U8
287-MAX3235	1	50	Machi	0	287	0283	MAX3235	IC MAX3235EENP UART DUAL W INT CAPS SMD16	MAX3235EENP	Maxim	MAX3235			U7
222-0335	2	100	Machi	0	222	0335	0047UF20%35VTAI	CAP 47uF 20% 35V TANT AVX TPS LO ESR 7543-P	TSEB76M03SR0200	AVX	476			C5 C33
243-LX3044UEB3	1	50	Hand	0	243	0353	LED-RND GRN	DiD LED GREEN HBright, Round, 3mm, T1	SSL-LX3044UEB3C	Lumileds	Oct --			D5
243-LX3044SYC	1	50	Hand	0	243	0354	LED-RND YEL	DiD LED YELLOW HBright, Round, 3mm, T1	SSL-LX3044SYC	Lumileds	Oct --			D6
290	0	0	Hand	0	290	0419	CON-5P-2MM	CON 1K5 VERT 2mm pitch PCB PAD PATTERN	--	--	--			J273
290	0	0	Hand	0	290	0420	CON-6P-2MM	CON 1K6 VERT 2mm pitch PCB PAD PATTERN	--	--	--			J5
290	0	0	Hand	0	290	0426	CON-14P-2MM	CON 1K14 VERT 2mm pitch PCB PAD PATTERN	--	--	--			J1
231-0427	1	50	Machi	26	231	0427	R05-130K-C0805	RES 130K 5% 1/10w 0805	260-130K	Xicon	134			R25
239-1006C	1	50	Hand	26	239	0435	THER-DC95F03W	THER 10K OHM NTC DC95 TYPE	DC95F03W	GE	--			R38
302-HFK10	1	50	Hand	26	302	0444	CON-10P-0.5MM-SMT	CON 10P Type Pad: 10P SMD 0.5MM lead top contact	FHL2A-10S-0.5SH	Hirose	--			SW2

Figure 5 - Bill of Materials report

The last of the basic four tables in this system is the "ECOs" table. Again a "unique" key is made from two fields, the PID number and the ECO number. Some ECOs refer to more than one product. This table (in Access) automatically generates the name of the ECO PDF file. The ECO list in the product page provides a link to those PDFs.

Another trick from the "parts" table is "bag labels" (fig. 6). This is a report form that prints on Avery address label sheets. It prints a basic set of fields for each component by drawing from the "parts" table. The list of components can be selected for a particular BOM by filtering for a PID. This makes a handy tool for pulling a kit, or an entire label set, maybe for bin boxes, could be printed.

Inventory and purchasing use another report from the BOMs table, the "open items report" (fig. 7 - next page), to easily assess the components still needed by a kit. This requires that the next build quantity is entered into the product page, to drive demand, and that the "kit has" column is filled in as the kit is pulled. This serves some limited MRP functionality.

There are several other tables in the system which are not demonstrated here: buycards, purchase orders, vendors, manufacturers, representatives, Corrective Action Preventive Action (CAPA), non-conforming product (NCP), test data, product models, and a serial numbers table with UID label and RFID label printing capabilities.

Part Number	Description	Quantity	Part Number	Description	Quantity	Part Number	Description	Quantity
D-B340A	B340 A-13	241 0001	Q-BSS138ZX	BSS138TA	254 0004	Q-BSS84ZX	BSS84TA	254 0005
	DIO B340A-13 schottky 3A 40V SMD			TRN BSS138ZX N-Ch FET SOT23			TRN BSS84ZX P-Ch FET SOT23	
B340	241-B340ADI	SS	254-BSS138ZX	SP	254-BSS84ZX			
C00*1UF10%50VX7R	C0805C104K5RACTU	221 0007	CO*01UF10%50VX7R	CC501B103K	221 0009	C1000PF10%50VX7R	CC501B102K	221 0015
	CAP 0.1 uF 10% 50VX7R 0805	221-0007		CAP 0.01 uF 10% 50VX7R 0805	221-0009		CAP 1000 pF 10% 50VX7R 0805	221-0015
D-SMCJ33CA	SMCJ33CA-13-F	242 0032	D-S5DC-13	S5DC-13-F	241 0034	X-EC3951-04M	ECS-3951M-040-BN-TR	332 0041
	DIO SMCJ33CA-13 TVS bi-dir 33V 1500W SMC			DIO S5DC-13 5A 200v SILICON SMC			XTL 4 MHz OSC ECS-3951 S04	
BFM	242-SMCJ33		S5DC	241-S5DCDI		3951-1M-40BN	332-XC294	
F-SR-33V1*5A	MFSM150B3-2	327 0042	F-SR-60V0*14A	MINISMD014-2	327 0044	IND-140UH2 BEADS	EXCELDR35V	335 0045
	FUS 1.5A 33V Resetting SMD	327-SM150/33		FUS 0.14A 60V Resetting MINISMD014 ("D.14A") FUSESM			IND 140 uH RF DUAL BEAD EXC-ELDR35C BEAD CORE	
150				327-MINISMD014				335-140UH
LM317-223	LM317AEMP	282 0048	LT1782	LT1782IS#TR	281 0050	MAX814	MAX814TESA	285 0051
	IC LM317AEMP 1.0A ADJ VOLTAGE REG SOT223			IC LT1782IS5 LINEAR TECH SMT OPAMP SOT23-5			IC MAX814TESA Power Monitor S08	
N07A	282-LM317LT		LTLE	281-LT1782IS5			285-MAX814S	

Figure 6 - Bag Labels for a Kit.

Operation

Using the manufacturer's datasheet, we enter the parts in the database first, where all the particulars are coordinated on one page, the APSS. Then we build the library items. Once all the new parts are created, we open up, or create, the schematic and drag and drop the components from DX Databook (fig. 3 - page 4) onto the schematic page in DX Designer. As soon as we can create a parts list and PCB net list without errors, the schematic is printed and reviewed by the EE, and the process iterates. When we freeze the schematic, we import its parts list to the BOMs table using a PID number (product ID) assigned previously.

At this point a preliminary BOM report can be printed, the buyers can get to work on the long lead parts, and PCB design in PADS starts too. We need to discover if the BOM has some hope of fitting in the mechanical envelope provided. Both tasks are important feedback to the EE: 1) his design is buyable and 2) it fits. Or not. In either case it's good to find out early. From this point forward all changes are done by ECOs.

A set of cards are fabricated and a few assemblies are built up by hand in-house. These cards are programmed and tested and the flow of ECOs begins. When the EE and the test tech are happy, we freeze the design and send a larger kit out for the assembly of somewhere between one and ten panels of fabs.

For the assembly data package ("assembly.zip"), the schematic is printed to PDF, as are the BOM, assembly drawing, PID page, rework notes, and relevant ECOs.

These files are on our servers with read/write access limited to two database administrators, and read/only access for technicians, assemblers, and buyers. Engineers still have read/write to their schematics. All design documents -- schematics, PADS PCB job files, gerbers, and the assembly zip package, -- reside within a standardized structure online. They are all controlled by limited directory access to establish accountability.

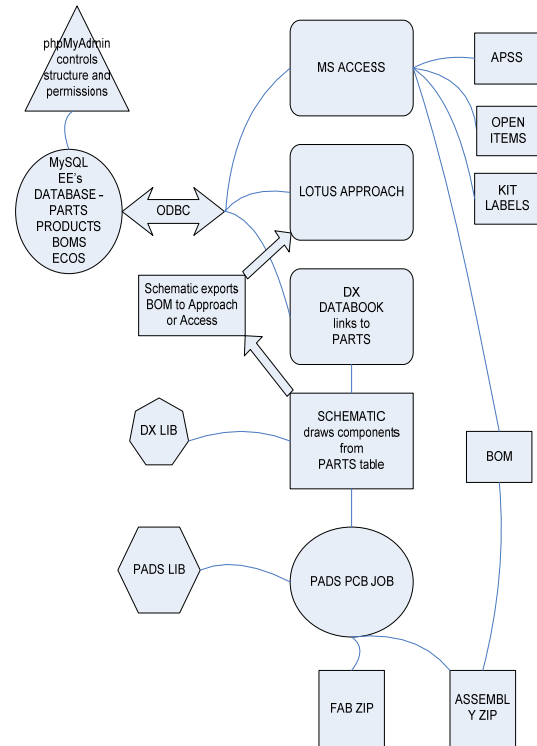


Figure 8 - System structure

Administration

The MySQL database we use is administered using phpMyAdmin. We use MySQL version 4.0.20a-nt and phpMyAdmin version 2.8.1. We are using Windows IIS web server and running php on a mostly dedicated Win server which also houses the MS Access file and the Lotus Approach file. We all have shortcuts to these same two front end files though we limit editing them to the database administrators. Everyone has either Access or Approach, or both, on their local machines.

phpMyAdmin is a great tool (fig. 9). It provides for MySQL database administration through a web browser, using php running on a web server. It is password protected. Administrators can create and configure new tables, new users and permissions, new databases here. Exporting and importing the entire database, or just the structure, or just the data, is easily and quickly done from this tool. The resulting export file is a readable text file and surprisingly small.

We can still zip the entire database onto a single floppy. Permissions can be controlled down to the field level, but we only do it down to tables. We have found that we can trust users to stay out of the fields they have no business changing. If that policy fails we can resort to field level control, but it is overhead we'd like to avoid.

In calling Acrobat Reader from MS Access for launching PDFs listed in the database, we ran into a problem with an interesting and amusing solution. Not everyone in the company has the same version of Acrobat, and the versions incorporate the version level into the directory name wherein resides the executable, so we could not call Acrobat directly from within a script in Access. Our solution was to create a batch file in a fixed server location that passed the call for the file directly to the client Windows, which uses its registry to figure out where its Acrobat is for opening the PDF file type. It is a single line batch file, to wit "Call %1". We named the file "acro.bat".

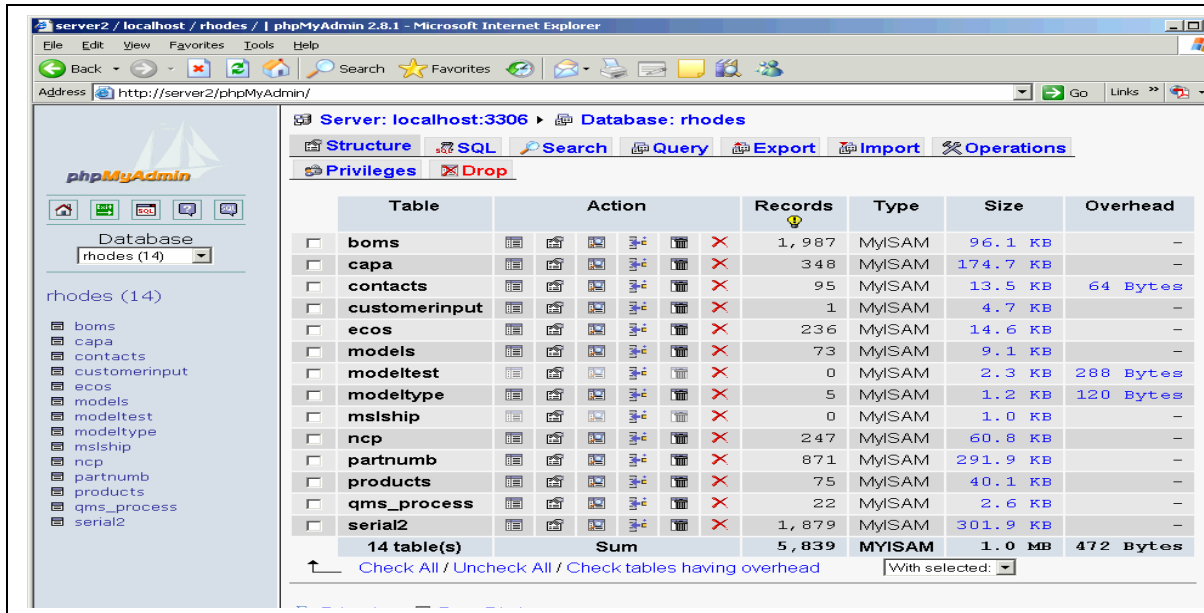


Figure 9 - phpMyAdmin tool for administering a My SQL database.

Summary

We have shown you a robust system for managing electronics design data that can be made by a database analyst in collusion with an electronics technician. Although experience with the design process is required, the creation of the system is neither costly nor terribly difficult, and you can build as you go. The system can easily migrate to the next level of enterprise software that will be implemented after a few years of company growth.

The system encourages the use of completely attributed parts in DX schematics and PADS PCB jobs, by making them easy to drag and drop from DxDatabook to DxDesigner. This tends to generate more complete design documentation.

It provides for easy reuse of parts existing in the system, and thus in inventory. This tends to limit part type count.

It reduces errors by keeping parts information in a central location that can be used by anyone in the company with appropriate SQL permissions.

It produces complete BOM reports for use by purchasing and assemblers.

It enables inventory to pull electronic kits easily, and publish shortage lists to purchasing on a “pushbutton” basis.

Most significantly, it has provided a reference system to control the revisions of all design documents.

This system enabled B E Meyers, in four years, to triple in size smoothly, and its implementation provided a foundation for the company to achieve ISO 9001 certification in 2006.