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- [ ] Arc
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- [ ] Front End
- [ ] Injector
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ABSTRACT

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The TACL logic for the CEBAF fast shutdown system

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Introduction

The fast shutdown (FSD) system at CEBAF is a set of alarms and interlocks that is designed to shut off the electron gun in the event of a component failure that could result in serious damage by the beam to the accelerator. Major parts of the system are hardwired and thus independent of the control system, so they are immune to computer failure. At certain points, however, operator intervention is needed, so some coupling to the control system is called for. Used injudiciously, operator input could vitiate the entire system. The FSD logic must therefore be designed with care.

Closely tied to the FSD system is the set of beam loss monitors (BLMs). These are photomultiplier tubes and associated circuitry, placed around the accelerator and intended to detect the secondary radiation produced if the beam strikes a solid object such as its beampipe. Beam loss is not the only trigger for a fast shutdown, but it is the most important in the sense that it is the last line of defense. As such, the BLMs are often regarded as part of the FSD system, and they will be so treated here.

This note describes the TACL logic of the FSD/BLM system. It is meant as a guide for those who may wish to edit, augment, or troubleshoot it. As such, it is directed primarily to those persons who are empowered to program the logic controls at CEBAF. Those reading it should have some familiarity with TACL logic, and more particularly with the macro editing tool.

Logical signals in this note will often be referred to by their macro formulations, such as ISD$38L or IBL$281A. In these, the wild cards $28, $38 are to be regarded as expanded as necessary to correctly describe the node to which they are attached. For example, in the CAMAC crate in zone 04 of the North Linac is one FSD module. It has a signal ISD1L041L. In this case, the wild card $38 has been expanded into five characters, constructed as follows: a two-character label for the North Linac (1L), two digits for the zone (04), and a one-digit sequence number (1).

Operator intervention

The FSD system allows operator input at a restricted class of points. These include: (a) restoring operating conditions after a shutdown initiated by the system, (b) masking off unused or unwanted nodes during some low-power operations, (c) setting trip levels at which the BLMs respond, (d) resetting the BLMs, and (e) testing the FSD and BLM nodes to insure the integrity of the system.

Associated non-TACL software

This note describes only the TACL logic associated with the FSD system. Two non-TACL files are needed, however, for running. One of these is an archive-type file that contains a list of the default masks (unused nodes) for the entire accelerator. This file is maintained by the director of the control system archives, who is in this subject to the orders only of the director of operations. It is closely protected, and is not to be altered by operators. If changes are thought to be necessary, a review process must be invoked.

The other file is not so sensitive and therefore is not so secure. It is */users/controls/FSD/fsd.real*, an ASCII file that gives the FSD tree structure. It is used in the procedure of recovering from a fault that has caused a fast shutdown.

Displays

Most operator input is through the displays. Because it has so many nodes, the system is broken up into parts, so that a single display will show only a small part of the acccelerator. At present (January 1993), seven displays have been prepared: FSDIN, FSDNL, FSDEA, FSDTESTIN, FSDTESTNL, FSDTESTEA, and BLM. As additional sectors of the machine are brought on line, additional displays will be made up, with obvious nomenclature.

The careful student will note, however, that this procedure is unwieldy, particularly if fast response is wanted. Shorter reaction times are indeed possible if we can make use of the fact that, most of the time, most of the information on the displays comes from nodes that are working normally. These are uninteresting. A small group is therefore at this time working on a display that will cover the entire accelerator; it will zoom in on a region where a fault occurs, and will provide for operator inspection of arbitrary regions by allowing one to zoom in manually.

Gun control

The TACL logic for control of the Injector gun is tied to the FSD system at two points. The first is a request for high-power operation, and the second is a signal that permission to run at high power is either granted or denied. The initial request is seen as an input to the system, while the second is an output.

The input request for high power is the signal ISDXXXXCW, with default value 0 indicating that high power is desired. Because this default choice may seem anomalous, an explanation is in order. It may be more appropriate to refer to the input signal as a request to configure the FSD system for low-power operation, including masking, which is to be denied by default. ISDXXXXCW is in fact the signal that is used on the various FSD displays to enable operator definition of the masks after the correct password has been entered.

The output from the FSD logic to gun control is the signal ISDGO4IT, which must be equal to 1 if high-power operation is to be allowed. The logic is built so that ISDGO4IT is equal to 0 if any FSD module in the active system either is offline or has one or more non-default masks in place. Thus, permission to run at high power is granted only if all masks other than those of inactive nodes have been removed.

A significant portion of the FSD logic is concerned with the correct evaluation of ISDGO4IT. Beginning in the macro FSDMSK, the output signal ISDXXXXXE is non-zero only if ISDXXXXCW is equal to 1. Therefore, in default mode ISDXXXXXE is equal to 0. This means that the mask request in the macro FSDMOD is taken from the file of default masks (ISD$38C) rather than from operator definition (ISD$38L).

To be sure that all non-default masks have been removed, a test signal ISDXXXXXR is generated in FSDMSK. The value of the test signal is of no particular significance. Its only requirement is that it must be changed from time to time; to do this, it is defined so that it is incremented by 1 each time ISDXXXXCW is pulsed either on or off.

In each installed macro FSDMOD, the masks in force (ISD$38M) are compared with the 1's complement of the default masks, bit by bit. If any mask in force is non-default, the bit comparison will be non-zero. The result is added to the test pulse ISDXXXXXR, and is labeled ISD$38A. Thus, ISD$38A should be equal to ISDXXXXXR if the masks are set correctly.

The comparison between ISD$38A and ISDXXXXXR is made in the gun control computer, in macro FSDCHECK. If they are equal, the output ISD$38B is equal to 1; if not equal, it is equal to 0.

The remainder of the check is merely a roll call in the sum macros, FSDSUM* (* = IN, NL, EA, SL, WA, or blank). The number of correctly set modules is compared with the number of modules in the system, a number that is edited into logic and is changed when the system is changed. If these last two numbers agree, ISDGO4IT is set equal to 1; otherwise, it is 0.

Macros

CEBAF control system policy encourages the use of macros to construct logic whenever possible, even when only single copies are to be installed. In keeping with this policy, all of the FSD and BLM logic has been written into a set of macros. At present, 15 macros define everything. This number includes two crate macros, FSDIO and Z0005, that are used for defining the CAMAC I/O. It also includes the six summing functions, which are separated only for convenience.

It is to be noted that the prescribed CEBAF nomenclature is not fully appropriate for the FSD/BLM system, which is tied to the CAMAC crates in the service buildings rather than to the accelerator. We have attempted to make the labels at least recognizable within the nomenclature; to that end, all signal names begin with the three letters ISD (for FSD variables) or IBL (for the BLMs). The prefix is followed by fillers that indicate the function and, where necessary, the location of the module to which the macro adheres. A typical signal will thus be represented in the macros as ISD$38M or IBL$28D.

As far as possible, the wild-card notation used in the macros is consistent throughout the set. Two wild cards, $38 and $28, appear frequently. The first, in many of the FSD macros, is to be expanded into three fields: two characters indicating the accelerator sector, two digits for the zone number, and one digit for the sequence number. The second, which is used in the BLM macros, is to be expanded into only two fields: two characters for the sector and two for the zone number. Because there is no provision for a sequence number, sometimes the two fields cannot be made unique within the usual naming conventions; such cases are handled ad hoc.

The logical connections of the FSD macros are indicated in Figure 1.

FSDMSK (Figure 2.)

This macro is installed in the gun control computer.

The gun control input signal ISDXXXXCW is received here and is used to set several switches that are distributed to the other macros. The password ISDXXXXME is tested here. The masks can be locked with the momentary input ISDSCRST.

The output for testing the network, ISDXXXXXR, is generated in this macro. The signal ISDXXXXXE is true (1) if operator-defined masking is enabled, which is allowed only if the correct password has been given and ISDXXXXCW is equal to 1. The latch network permits the operator to hide the password in the display by entering 0 for ISDXXXXME after masking is enabled. The output ISDXXXXXM is complementary to ISDXXXXCW; it is needed in the locking of masks, and also as a fail-safe in FSDSUM, preventing ISDGO4IT from assuming the value 1 when ISDXXXXCW is also 1 (calling for low-power operation).

FSDCOMP (Figure 3.)

This small macro is used only to transmit four inputs from the network to the FSD modules. The structure of TACL permits only single copies of some input signals on a computer, so if two or more modules are controlled by one local computer, these inputs would collide. To avoid this, FSDCOMP separates off the network inputs and distributes them as needed. One copy of this macro is to be installed in each local computer that controls one or more FSD modules.

FSDMOD (Figure 4.)

One copy of this macro, with expanded wild card, must be installed for each active FSD module. It is to be installed in the local computer that controls its CAMAC crate. The macro has 9 inputs and 3 outputs.

The global inputs that are received from FSDCOMP are ISDXXXXXB, ISDXXXXXE, ISDXXXXXM, and ISDXXXXXR. ISDXXXXXB is a startup signal that clears the non-default masks when the system is brought up. ISDXXXXXM will similarly clear the non-default masks, but is controlled by the operator; it is actuated (that is, made equal to 1) whenever high-power operation is requested. Thus, it is complementary to ISDXXXXCW. ISDXXXXXE is the mask enable signal; when it is non-zero, the operator can change the masks in force. ISDXXXXXR is the network test signal; its use will be described more fully later.

Masks are locked in place when ISDXXXXXB, ISDXXXXXE, and ISDXXXXXM are all equal to 0. Their values are controlled in macro FSDMSK or in the startup logic for the control system.

The operator-defined masks are given in the signal ISD$38L, which is read back in ISD$38U. Default masks are in ISD$38C. If ISDXXXXXE is zero, the masks are read from ISD$38C; otherwise, they are taken from ISD$38L. If, however, ISDXXXXXM and ISDXXXXXB are zero as well, the latch circuit will retain the last value of the masks in force.

ISD$38G is the input from CAMAC indicating which, if any, nodes are faulted. ISD$38N is another CAMAC input, showing the masks in force. It is the returned value of the output ISD$38M.

The one remaining input is ISD$38F, which is pushbutton controlled to reset the faulted crates. When it is actuated, it sends out the signal ISD$38Z, which will trigger the crate reset. ISD$38Z in general will require editing at the time the module is installed, as it must contain the correct address of the crate it refers to.

In the upper right corner of the macro is a network that tests to see if any masks other than default masks are requested, and then allows the system to find whether the network is operating. First, the 1's complement of ISD$38C is found by subtracting it from 65535. The result is bit added to ISD$38M, which means that a non-zero output is produced if any bit of ISD$38M that is not a default mask is set. This output is added to the network test signal ISD$38R; the sum is the final output, ISD$38A.

FSDCHECK (Figure 5.)

One copy of this small macro is installed on the gun control computer for each active FSD module in the system. Each has two inputs: ISD$38A from FSDMOD for the module, and ISDXXXXXR from FSDMSK. According to the definition of ISD$38A, the two inputs should be equal if no non-default masks are in place and different otherwise. Therefore, they are compared here, with the result of the comparison being delivered as the logical signal ISD$38B. If they are equal, ISD$38B is equal to 1; if not equal, it is 0.

FSDSUM, FSDSUMIN, etc. (Figures 6–11.)

The number of correctly-masked modules is calculated in the summing macros. Each signal ISD$38B is equal to either 1 or 0, depending upon whether the masks applied to the module are correct. The macros are separated as they are only for convenience, as all the sums could have been performed in a single, rather large macro. Almost at the end of the macro FSDSUM, which does the final computation, the signal ISDXXXXXM is tied to a normally-open switch. This is a fail-safe that insures that the output ISDGO4IT is never equal to 1 unless ISDXXXXCW is equal to 0. That is, the operator must request high-power operation in order that ISDGO4IT can be 1. If the switch is closed (ISDXXXXXM is equal to 1, or ISDXXXXCW is equal to 0), the value of ISDGO4IT depends upon the outcome of the comparison between the sum of the roll-call signals ISD$38B and the number of online FSD modules, which is programmed into the logic. If these numbers agree, ISDGO4IT is set equal to 1, and the logic returns this value to gun control.

BLMMASK (Figure 12.)

One copy of the macro BLMMASK is installed in the gun control computer. Somewhat similar to FSDMSK in function and operation, this macro is not intended to be used in normal beam operations. It is primarily for the people who test the hardware, in this case the beam loss monitors.

BLMMASK has two inputs, IBLSCRST and IBLXXXMER. The first is a toggle switch. In the 'ON' position, it allows the operator to enter a password and put the beam loss monitors into their test mode. The test mode can be latched while hiding the password, but it cannot be locked in the same way as the FSD masks. When the toggle IBLSCRST is 'OFF,' all masks and test signals for the BLMs are disabled.

The output signal from BLMMASK is IBLXXXXME.

BLM1, BLM2 (Figure 13.)

A copy of either BLM1 or BLM2 is installed for each BLM module in the accelerator. The macros are quite similar, differing only in that the remote input and tie IBLXXXXME in the lower left corner of BLM1 is eliminated in BLM2. The reason for this is that only one such input is necessary for all modules attached to a single local computer. Therefore, if more than one BLM module is on a computer, the first one should be described by BLM1, while all subsequent modules on the computer are to be described by BLM2.

The body of either macro, excepting IBLXXXXME, can be separated into four equivalent parts, one for each BLM controlled by the module. They are distinguished by their sequence numbers, 1, 2, 3, 4, which follow the wild card $28.

Four signals are tied to the CAMAC module for each BLM: IBL$28nA, IBL$28nB, IBL$28nD, and IBL$28nE. All but the third are elementary. IBL$28nA is the trip point for the BLM; it is a positive number between 0 and 255, entered by the operator. IBL$28nB is the readback value of the signal level, also between 0 and 255. IBL$28nE is the readback of the masks and faults for each BLM. Only the lowest-order two bits of its word are significant; the first (bit 0) indicates whether the BLM is masked, while the second (bit 1) indicates the fault status.

The remaining signal, IBL$28nD, is only slightly more complicated. It is the operator input that allows masks to be set or cleared, and faults to be cleared. It is in a network of comparitors and converters that insure that masks are allowed only when in test mode, and that test signals are transmitted also only when in test mode.

The test pulse (IBL$28nD=3) is controlled by the operator input IBL$28nT, which is tied to the display ouput IBL$28nR.

user2:[kloeppel.tex]taclfsd.tex

Appendix 1. FSD and BLM macros.

macro	where installed, comments
1. CAMAC I/O	
FSDIO	on local computer; 1 for each FSD module
Z0005	on local computer; 1 for each BLM module
2. FSD controls	
FSDMSK	on gun control computer; 1 copy
FSDCOMP	on local computer; 1 for each computer with FSD module
FSDMOD	on local computer; 1 for each FSD module
FSDCHECK	on gun control computer; 1 for each FSD module
FSDSUMIN	
FSDSUMNL	
FSDSUMEA	
FSDSUMSL	
FSDSUMWA	
FSDSUM	
3. BLM controls	
BLMMASK	on gun control computer; 1 copy
BLM1	on local computer; for 1st BLM module on computer
BLM2	on local computer; each subsequent BLM module

Appendix 2. Input, output, and tie-point signals of the FSD/BLM system.

name	macro	output	input	description
BLMCODE	BLMMASK	display	operator	password; for debugging only
IBL$28nA	BLM1,BLM2	CAMAC	operator	trip level set point
IBL$28nB	”	display	CAMAC	BLM signal level
IBL$28nD	”	CAMAC	operator	mask set, fault clear, test input
IBL$28nE	”	display	CAMAC	mask in place, fault
IBL$28nT	”	—	operator	test signal toggle
IBL$28nR	”	display	—	display of IBL$28nT
IBLSCRST	BLMMASK	—	operator	toggle request for test mode
IBLSCRSTR	”	display	—	display of IBLSCRST
IBLXXXMER	”	—	operator	password
IBLXXXME	”	display	BLM1,BLM2	test mode permission toggle
IBLXXXME	BLM1	—	BLMMASK	remote in; test mode permission
ISDMRST	FSDMSK	—	—	mask request; complement of ISDXXXXCW
ISDSCRST	”	—	operator	mask lock; momentary switch
ISDSCRSTR	”	display	—	display of ISDSCRST
ISDXXXXCW	”	—	operator	request for masks; high/low power toggle
ISDXXXXCWR	”	display	—	display of ISDXXXXCW
ISDXXXXME	”	—	operator	password
ISDXXXXXE	”	FSDCOMP	—	mask enable toggle
ISDXXXXXM	”	”	—	mask request; same as ISDMRST
ISDXXXXXR	”	”	—	network test signal
ISDXXXXXB	FSDCOMP	FSDMOD	startup	startup signal; initialization
ISDXXXXXE	”	”	FSDMSK	see FSDMSK
ISDXXXXXM	”	”	”	see FSDMSK
ISDXXXXXR	”	”	”	see FSDMSK
ISDXXXXXB	FSDMOD	—	FSDCOMP	see FSDMSK
ISDXXXXXE	”	”	”	see FSDMSK
ISDXXXXXM	”	”	”	see FSDMSK
ISDXXXXXR	”	”	”	see FSDMSK
ISD$38A	”	FSDCHECK	—	comparison of masks with defaults
ISD$38C	”	—	remote	default masks
ISD$38F	”	—	operator	crate reset pushbutton
ISD$38G	”	display	CAMAC	FSD faults
ISD$38L	”	—	operator	masks requested
ISD$38M	”	CAMAC	—	masks in force
ISD$38N	”	display	CAMAC	CAMAC response to ISD$38M
ISD$38R	”	—	display	timing signal
ISD$38T	”	—	—	timing signal
ISD$38Z	”	CAMAC	—	crate reset signal
ISD$38A	FSDCHECK	—	FSDMOD	see FSDMOD
ISD$38B	”	FSDSUM()	—	mask status (1=default only; 0=non-default masks)
ISDXXXXXR	”	—	FSDMSK	see FSDMSK
ISD$nnB	FSDSUMIN	FSDCHECK	—	mask status; sent to appropriate block
	FSDSUMNL	”		
	FSDSUMEA	”		
	FSDSUMSL	”		
	FSDSUMWA	”		
ISDINSUM	FSDSUMIN	FSDSUM	—	check sum for Injector
NLSUM1	FSDSUMNL	—	—	intermediate check sum for North Linac
NLSUM2	”	—	—	”

NLSUM3	”	—	—	”
NLSUM4	”	—	—	”
ISDNLSUM	”	FSDSUM	—	check sum for North Linac
EASUM1	FSDSUMEA	—	—	intermediate check sum for East Arc
EASUM2	”	—	—	”
EASUM3	”	—	—	”
ISDEASUM	”	FSDSUM	—	check sum for East Arc
SLSUM1	FSDSUMSL	—	—	intermediate check sum for South Linac
SLSUM3	”	—	—	”
SLSUM4	”	—	—	”
ISDSLSUM	”	FSDSUM	—	check sum for South Linac
WASUM1	FSDSUMWA	—	—	intermediate check sum for West Arc
WASUM2	”	—	—	”
WASUM3	”	—	—	”
ISDWASUM	”	FSDSUM	—	check sum for West Arc
ISDINSUM	FSDSUM	FSDSUMIN		see FSDSUMIN
ISDNLSUM	”	FSDSUMNL		see FSDSUMNL
ISDEASUM	”	FSDSUMEA		see FSDSUMEA

(The last three are the present-day active inputs. Others will be added for the South Linac and West Arc when they come on line.)

ISDMRST	FSDSUM	—	FSDMSK	see FSDMSK
ISDGO4IT	FSDSUM	display	—	high-power beam permission (1=granted, 0=denied)

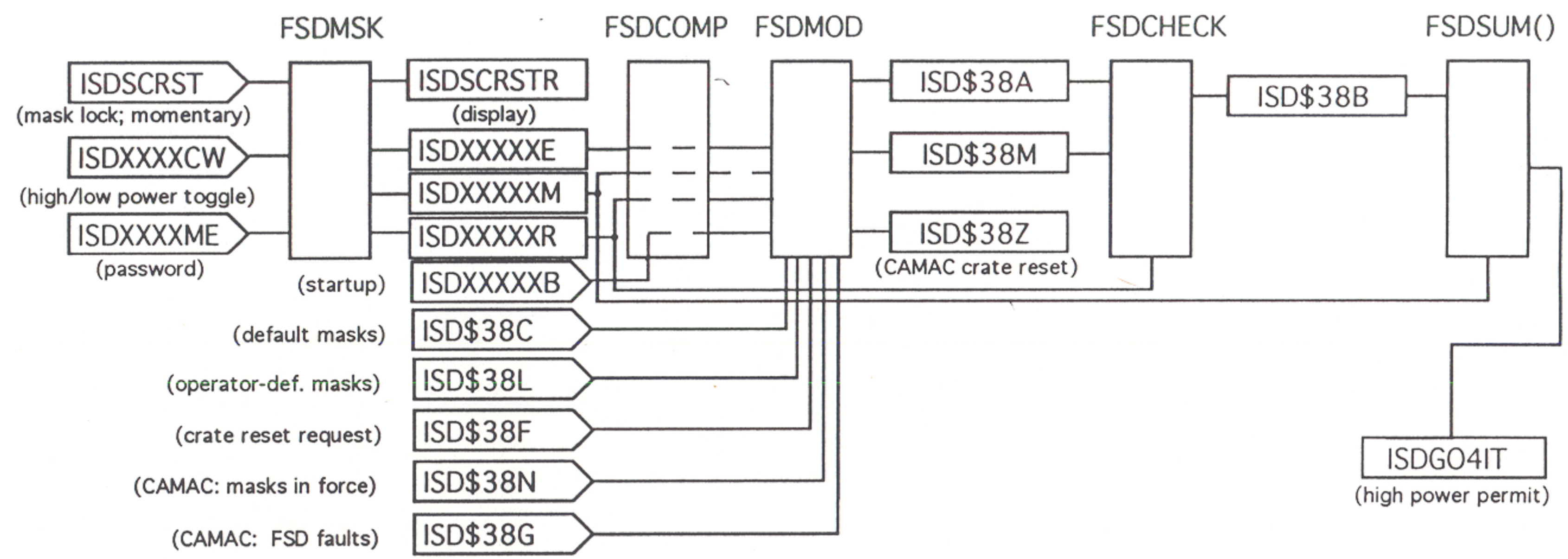

Figure 1. Connections among the FSD macros.

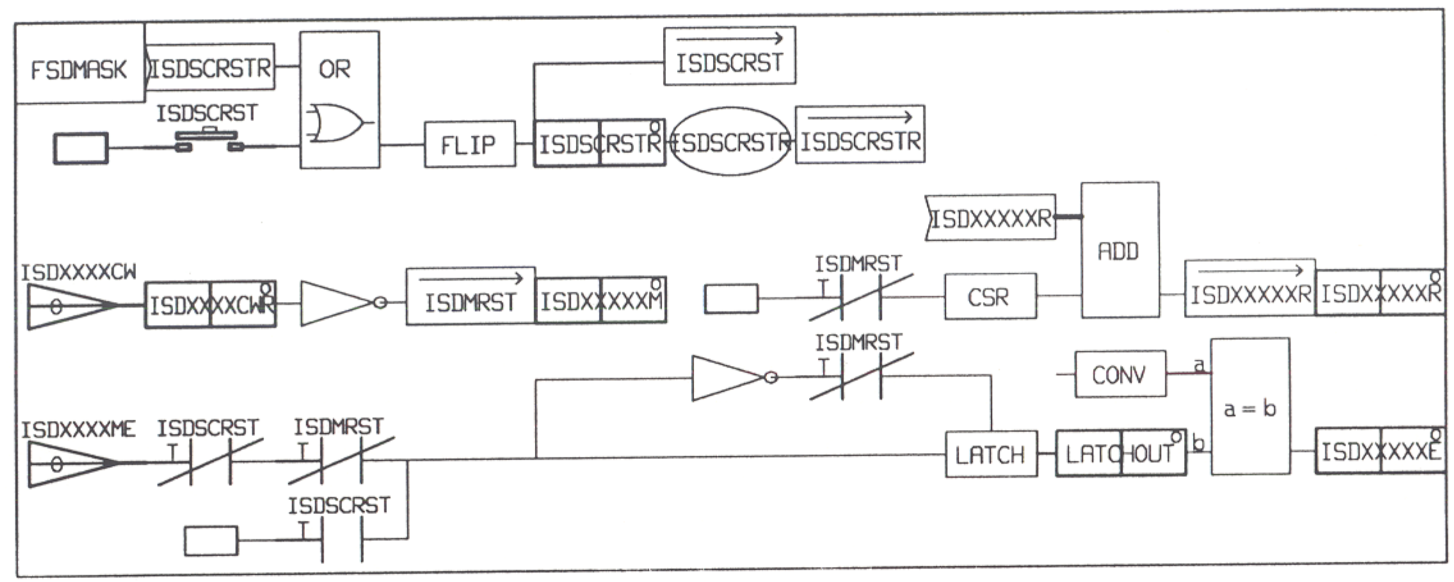

Figure 2. Macro FSDMSK, as installed on in01.

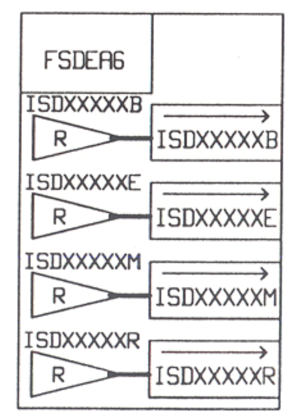

Figure 3. Macro FSDCOMP, as installed (typical).

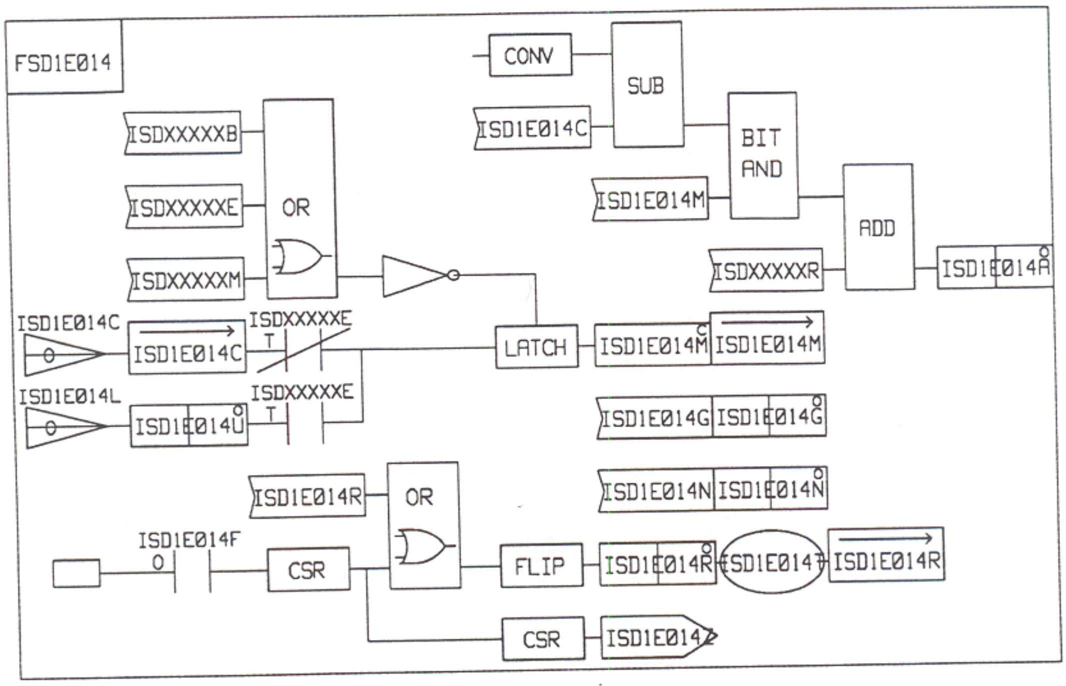

Figure 4. Macro FSDMOD, as installed (typical).

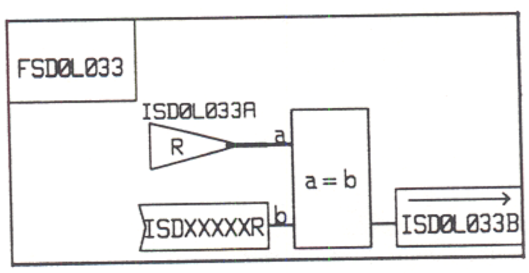

Figure 5. Macro FSDCHECK, as installed on in01 (typical).

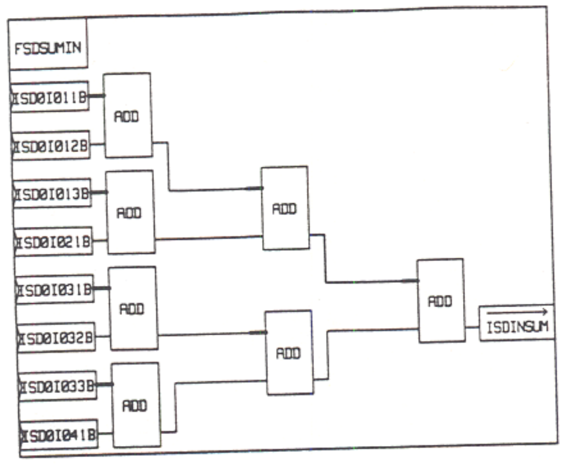

Figure 6. Macro FSDSUMIN, as installed on in01.

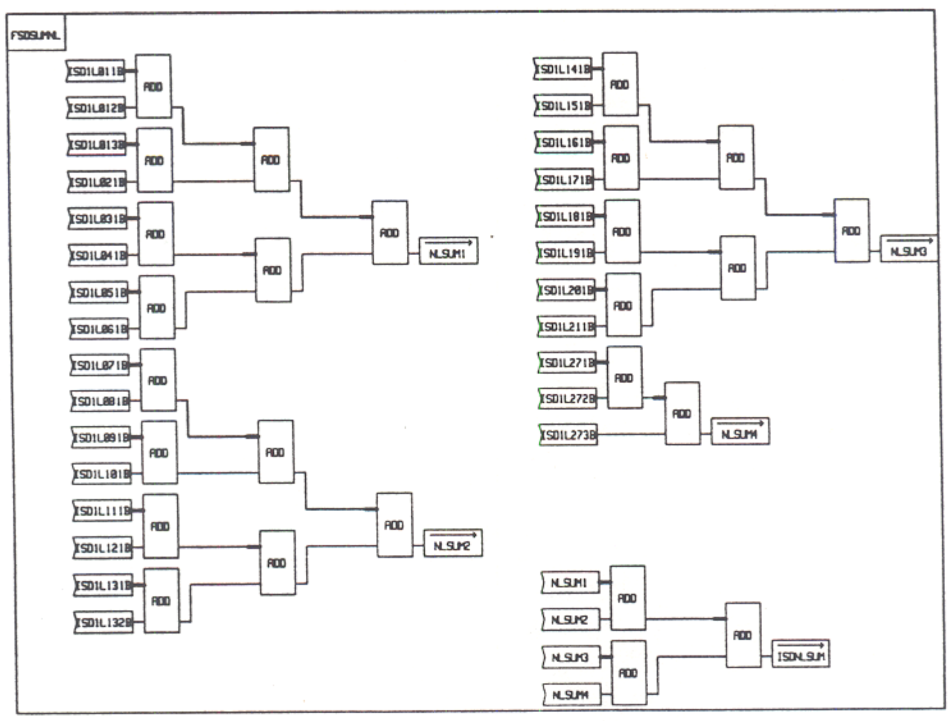

Figure 7. Macro FSDSUMNL, as installed on in01.

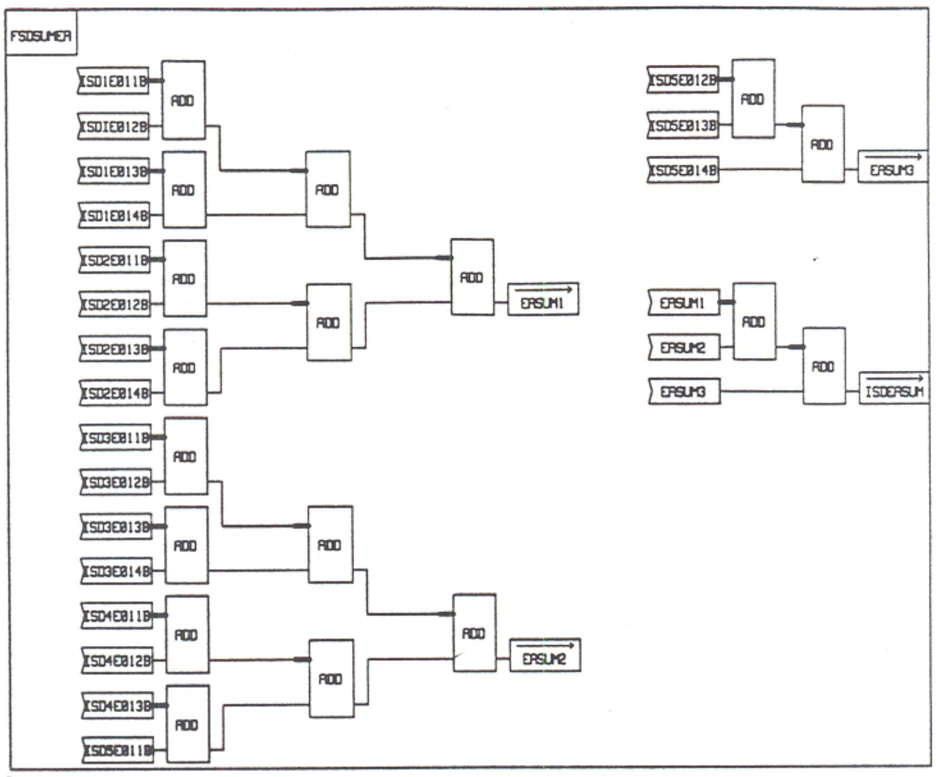

Figure 8. Macro FSDSUMEA, as installed on in01.

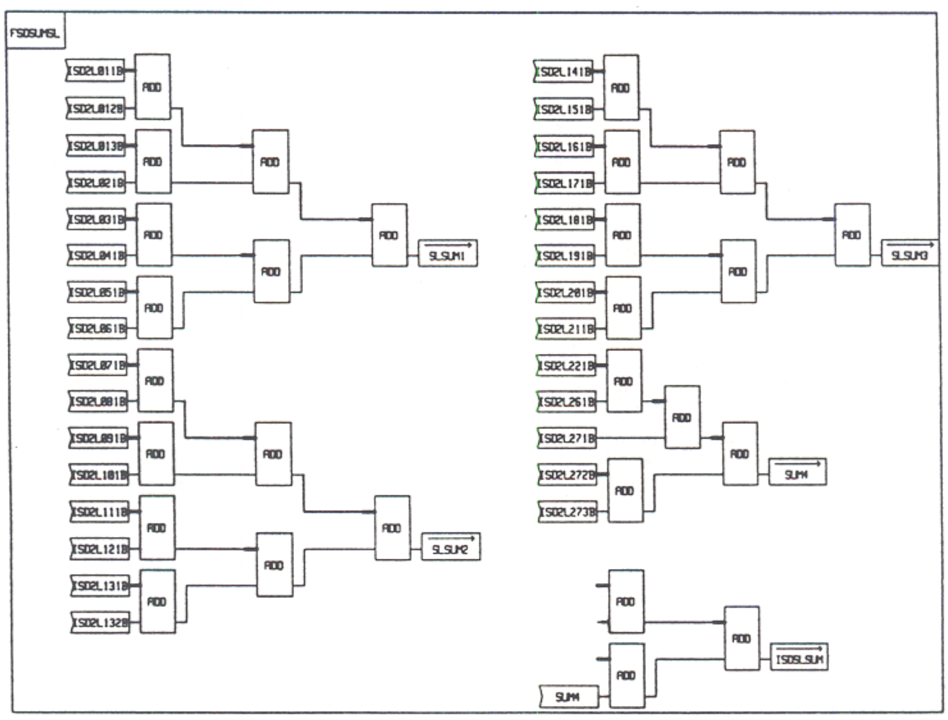

Figure 9. Macro FSDSUMSL, as installed on in01.

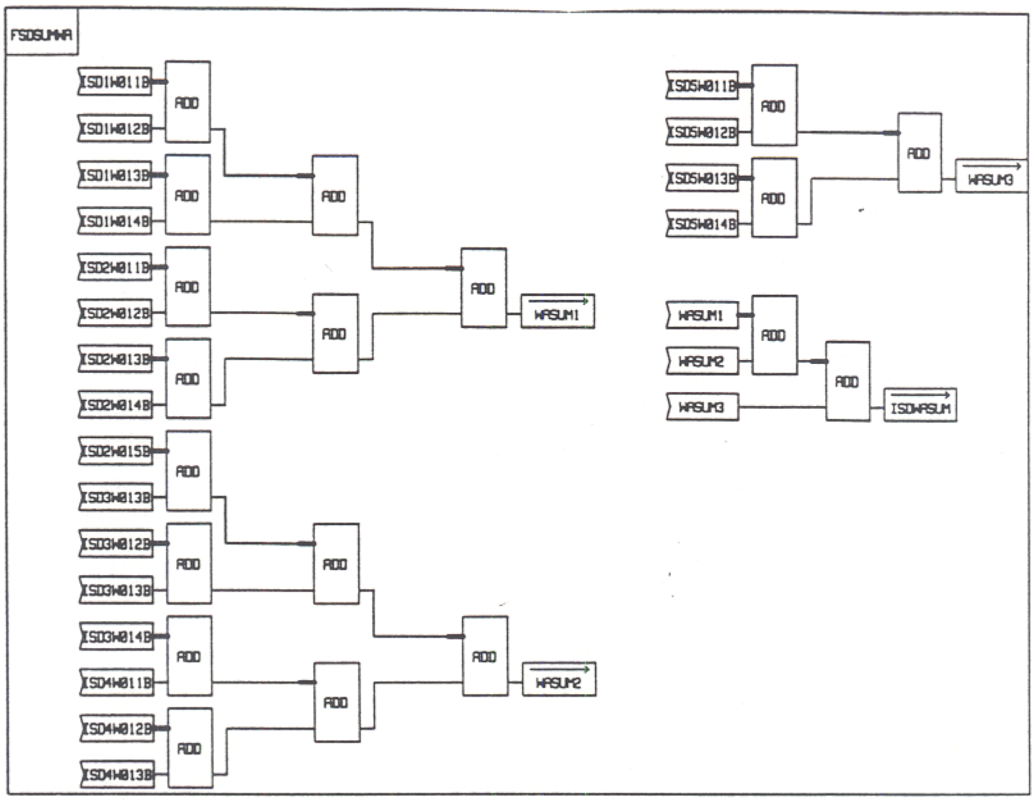

Figure 10. Macro FSDSUMWA, as installed on in01.

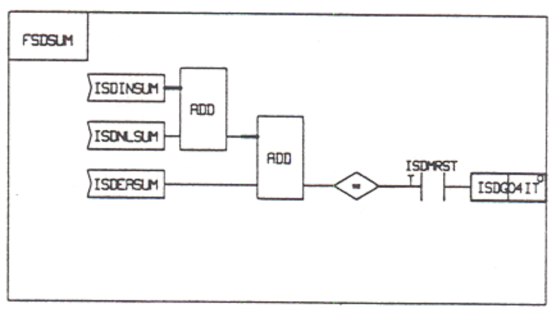

Figure 11. Macro FSDSUM, as installed on in01.

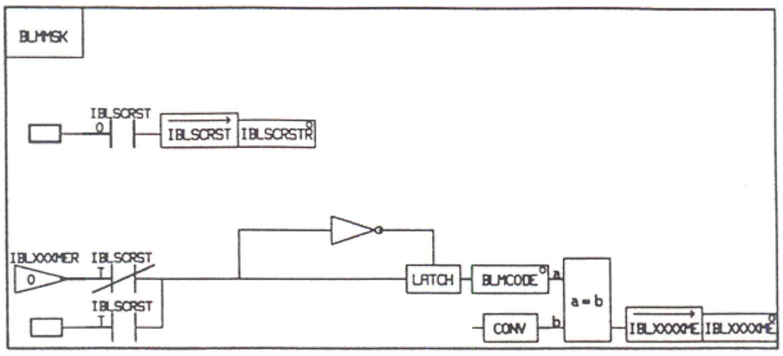

Figure 12. Macro BLMMASK, as installed on in01.

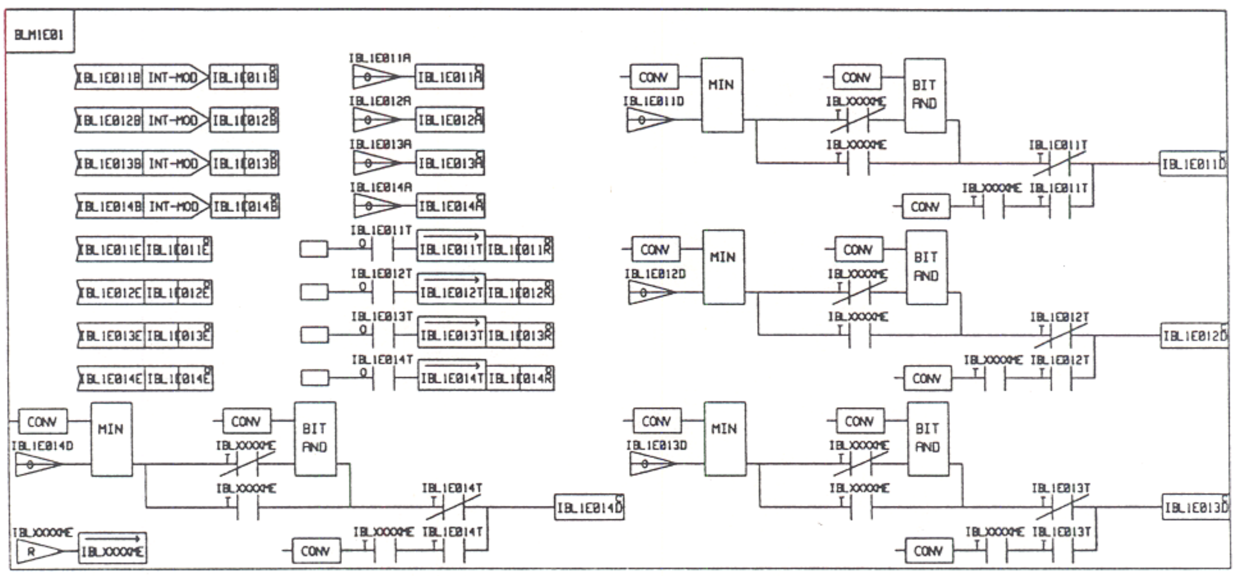

Figure 13. Macro BLM1, as installed (typical).