

Soluzioni di I/O e Controllo Discreto in ambito Wireless

La Specifica Discrete I/O HART

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La Specifica “Discrete I/O” HART



- ✱ Up to now, HART supported only Process Automation devices.
- ✱ Continuous measurements or control actions, analogue floating-point values.
- ✱ However, even process intensive applications need many discrete I/O.
- ✱ Intelligent (Wireless) Discrete Devices are a new class of HART field devices.
- ✱ Discrete Devices complement existing HART Process Automation devices.
- ✱ Discrete Devices are described within the – draft – “Discrete Applications” specification.



Dispositivi HART “Discreti”. Perché?



- ✱ Up to now, HART supported only Process Automation devices.
- ✱ Extend the HART protocol beyond continuous measurement
- ✱ In most PA plants Discrete Applications are important!
- ✱ In some industry segments, over 80% of the total I/O may be Discrete.
- ✱ Traditionally I/O cards within DCS or PLC were used.
- ✱ Discrete I/O integration within HART networks looks desirable.
- ✱ Local intelligence for reduced latency, also in a Wireless context.



Applicazioni HART “Discrete”. Come?



- ✱ Define a set of new, dedicated HART commands
- ✱ Define three new types of HART devices:
 - ✱ (Wireless) Discrete field devices
 - ✱ (Wireless) Hybrid field devices
 - ✱ (Wireless) Discrete adapters
- ✱ Specify a set of standardized Discrete Functions Block
- ✱ Include a Discrete Logic Execution Engine (optional)
- ✱ Include support for diagnostic information (optional)



Nuovi tipi di dispositivi HART



✱ HART Device Profile Codes

Code	Device Description
1	HART Process Automation Device
2	HART Discrete Device
3	Hybrid: Process Automation + Discrete
129	WirelessHART Process Automation Device
130	WirelessHART Discrete Device
131	WirelessHART Hybrid: Process Automation + Discrete
141	WirelessHART Process Adapter
142	WirelessHART Discrete Adapter



Esempi di Prodotti “Discreti” supportati



- ✱ Limit switches
- ✱ Proximity sensors
- ✱ Flame detection
- ✱ Vibrating level switches
- ✱ Pressure, level, or temperature switches
- ✱ Photo sensors
- ✱ Field powered electric actuators
- ✱ On-off motor starters
- ✱ Solenoid valves
- ✱ Contact closures



II Wireless “Discrete Field Device”



- ✱ Support field-level, discrete (on/off) input and output connections.
- ✱ Can directly perform simple logic, control or plant automation functions.
- ✱ Support only discrete I/O (no Process Variables support).
- ✱ Provide diagnostic information.
- ✱ Smart, predictive diagnostics often included.



II Wireless “Hybrid Field Device”



- ✱ Combine the capabilities of “Traditional” and “Discrete” HART devices
- ✱ Include both Continuous and Discrete capabilities.
- ✱ Support both Process Variables (i.e. Device Variables) and Discrete Variables.
- ✱ Hybrid Devices Examples:

Level transmitter with backup level switches

Positioner with limit switches providing full-open or full-closed valve position.



II Wireless “Adapter Field Device”



- ✱ Adapters are communication bridges, not native I/O devices.
- ✱ Connects a (mini/micro) PLC to a HART communication channel.
- ✱ Give access to Read/Write registers inside the PLC.
- ✱ Presents PLC registers as Discrete Variables.
- ✱ May allow the PLC programs being transferred via the HART BT service.
- ✱ PLC data accessible within the HART Network as any other HART data.
- ✱ Local control to be integrated within a HART Network by remote mounted PLC.

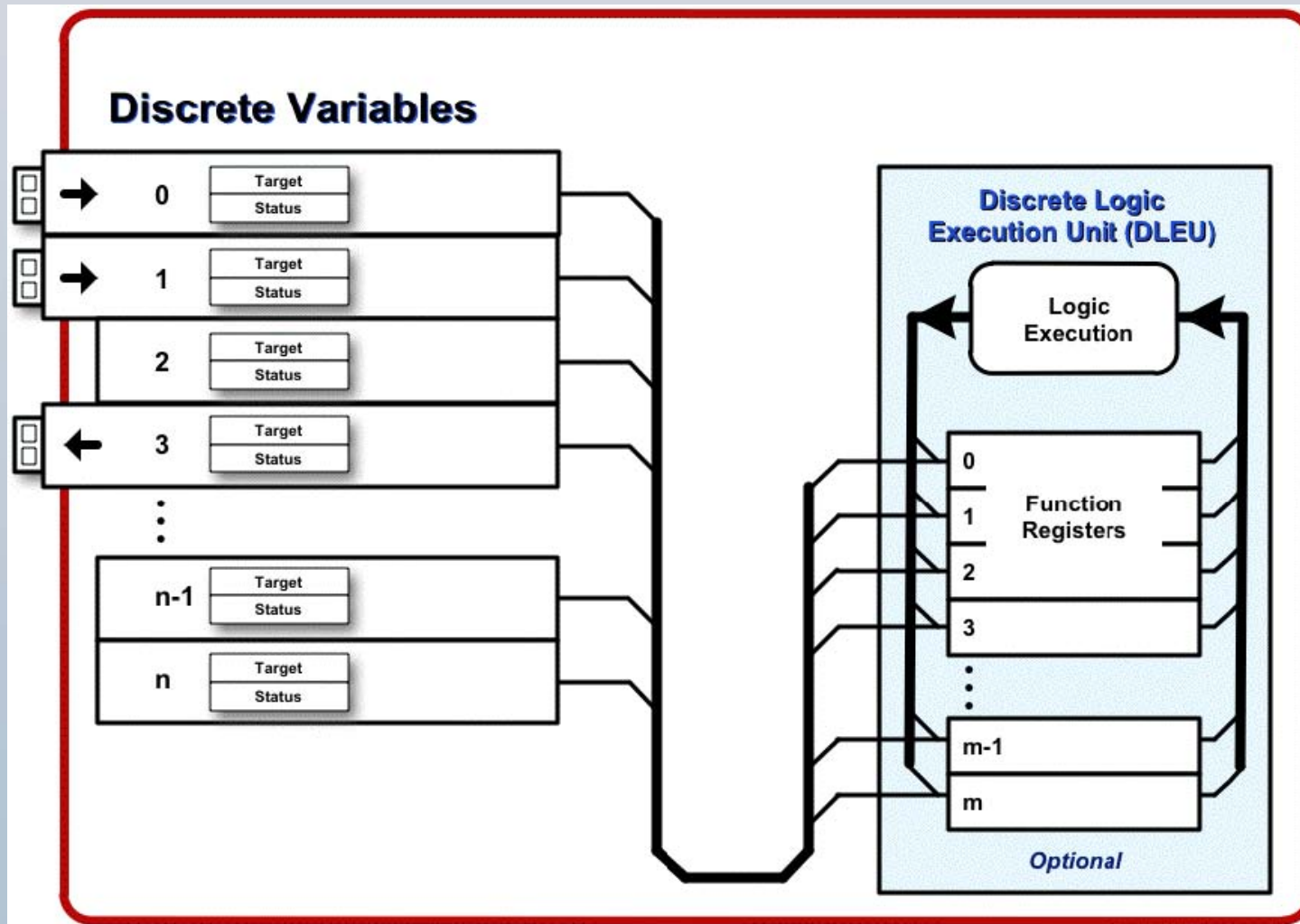


Variabili Discrete e DLEU



- ✱ A Discrete Device must support Discrete Variables.
- ✱ A Discrete Device can support a Discrete Logic Execution Unit (DLEU).
- ✱ Discrete Variables are on/off or state-related values and may be inputs from or outputs to the plant.
- ✱ Discrete Variables are may be inputs from or outputs to the Plant.
- ✱ Discrete Variables are always 16 bits (i.e. one Word)

Variabili Discrete e DLEU





Variabili Discrete di Ingresso



- ✱ Inputs receive a plant signal and status and convert those signals into a digital value.
- ✱ The input information may be coded either as:
 - a simple Boolean value (single bit):
- ✱ Or as:
 - a binary coded data (BCD) (full Word, 16 bits)



Variabili Discrete di Uscita



- ✱ Output transmit single bit or state signals to activate various devices, e.g.:
 - Actuators, Solenoids, Blocking valves, on-off valves, Motor starters
- ✱ The device can report an Actual value – in addition to the stored Target value.
- ✱ The device can report also the output status (i.e. output is functioning correctly).
- ✱ A host application:
 - modifies discrete outputs by writing the *target value*
 - monitors the transitions to intermediate and/or final states by reading the *actual value*

Allocazione dei Registri HART Discreti



0x0000-0x3FFF	16-bit Words	Discrete Variables	
0xE000-0xEFFF	16-bit Words	Function Registers	(non-volatile)
0xF000-0xF1FF	32-bit Double Word Pairs	Timers-Target/Setpoint	(non-volatile)
0xF200-0xF3FF	32-bit Double Word Pairs	Timers-Actual	
0xF400-0xF5FF	16-bit Words	Counters-Target/Setpoint	(non-volatile)
0xF600-0xF7FF	16-bit Words	Counters-Actual	
0xF800-0xFFFE	16-bit Words	Drum Registers	(non-volatile)

Stati di I/O Discreto Permessi



	Description
0	Off
1	On
2	Stop
3	Run
4	Close
5	Open
6	Closed
7	Fast
8	Slow
9	Forward
10	Reverse
11	Top

	Description
12	Bottom
13	Full
14	Empty
15	Hot
16	Cold
17	Opening
18	Closing
19	Raising
20	Lowering
21	Filling
22	Draining
23	Heating

	Description
24	Cooling
25	Stopped
26	Running
27	Stopping
28	Starting
29	To Fast
30	To Slow
31	Reversing
32	Dry
33	Wet
34	Turning Off
35	Turning On

	Description
36	Turn Off
37	Turn On
38	Up
39	Down
40	Fill
41	Drain
42	Heat
43	Cool
44	Present
45	Absent
46	Opened
47	Start

- ✱ Each Function Block specifies the Discrete Variable states it supports.

- ✱ Each Discrete Variable is associated with a specific Discrete Function Block
- ✱ For each Function Block a a Control Sequence (i.e. state machine) is defined.

	Function Block	Passive State	Description
1	On/Off Switch	User def.	General Purpose On/Off Switch (can hold last value when power fails)
2	Limit Switch	N/A	Limit or Proximity Switch (unpowered).
3	Motor	Stop	Motor
4	Valve, NO	Open	Normally Open Valve (resets to default position when power fails).
5	Valve, NC	Closed	Normally Closed Valve ((resets to default position when power fails).
6	Motor Valve	Stop	Motor Operated Valve.
7	2 Spd Motor	Stop	2 Speed Motor.
8	2 Dir Motor	Stop	2 Direction Motor.
9	Elevator	Stop	Elevator.
10	Tank	Stop	Tank Filling / Emptying Operations.
11	Heat / Cool	Off	Heat / Cool.
12	Wet / Dry	N/A	This is a switch indicating the presence or absence of a liquid.
13	Pres. / Absen.	N/A	This is a switch indicating the presence or absence of a medium.



Formato di un £Function Block” discreto”



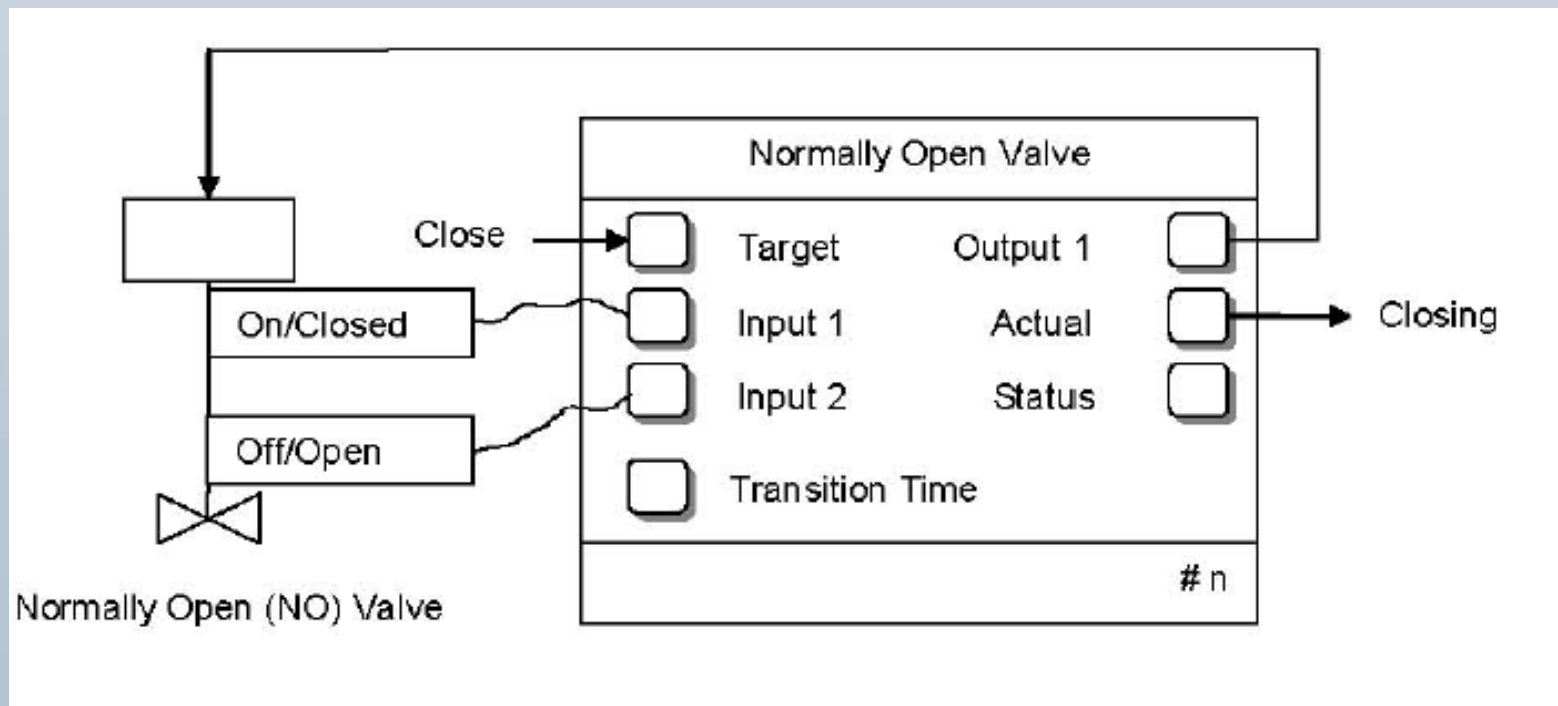
Discrete Function Block	
☐ Target	Output 1 ☐
☐ Input 1	Output n ☐
☐ Input 2	Actual Value ☐
☐ Input n	Status ☐
☐ Transition Time	
☐ Simulate Enable	
☐ Simulate Value	
☐ Simulate Status	
# n	



Esempio di “Function Block” discreto



- Normally Open Valve
- Blocking valves are used to block movement in one or more directions.





Esempio di “Function Block” discreto



- The transition logic summary

Initial State	Target Value		Actual Value		Inputs		Outputs
	Open	Close	Intermediate State	Final State	Input 1 (Closed)	Input 2 (Open)	Output 1 (On/Close)
<i>Opened</i>	✓			<i>Opened</i>	0	1	0
		✓	<i>Closing</i>		0	0	1
		✓	<i>Fail</i>		0	0	1
		✓		<i>Closed</i>	1	0	1
<i>Closed</i>		✓		<i>Closed</i>	1	0	1
	✓		<i>Opening</i>		0	0	0
	✓		<i>Fail</i>		0	0	0
	✓			<i>Opened</i>	0	1	0

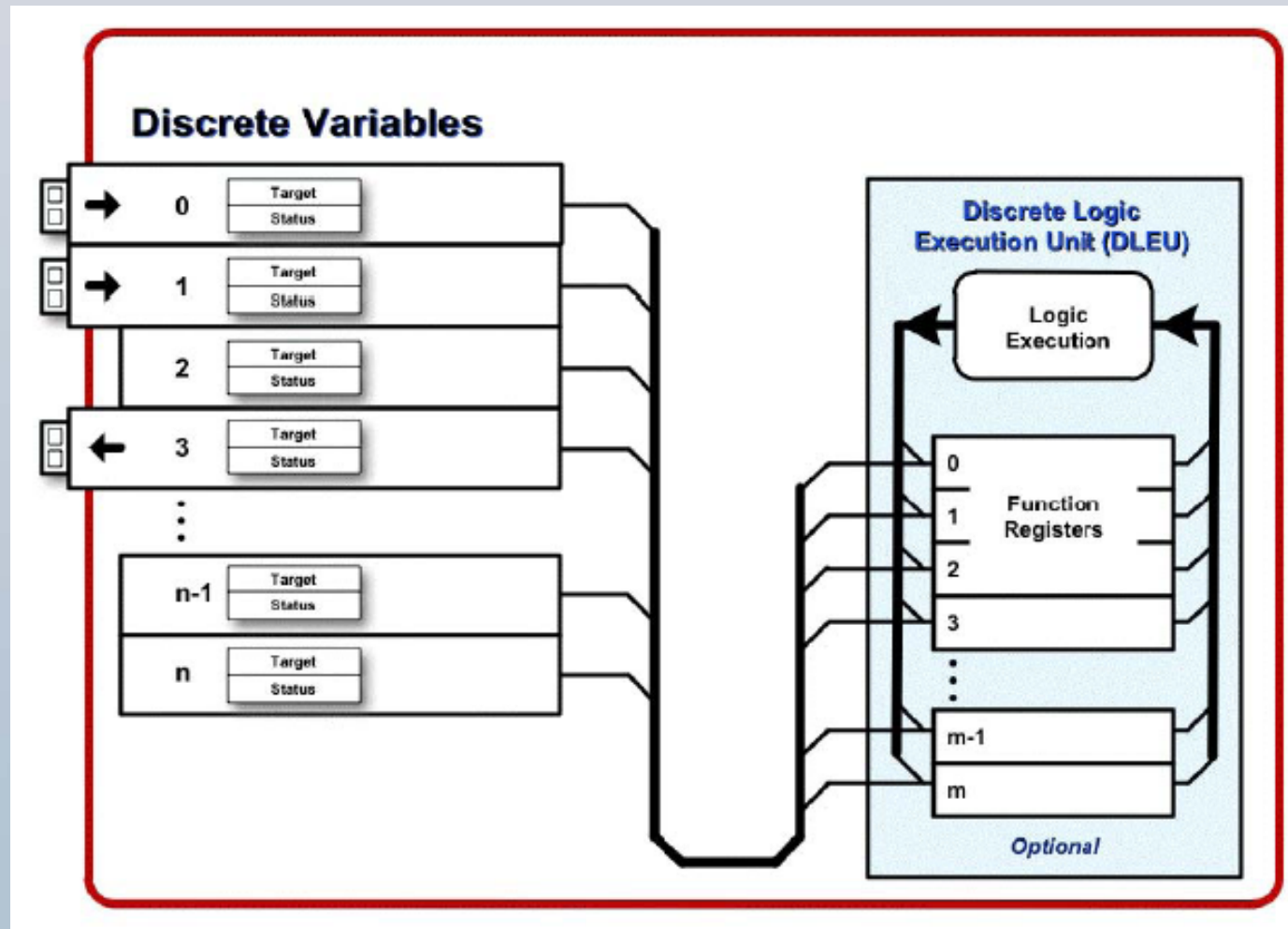


La Discrete Logic Execution Unit (DLEU)



- The DLEU allows the local execution of medium-complexity discrete control functions.
- Logic sequences can be executed within a Discrete or Hybrid Field Device.
- Local control action possible without HART network latency.
- Fast reaction to local events possible via HART Burst messaging.

La “Discrete Logic Execution Unit” (DLEU)





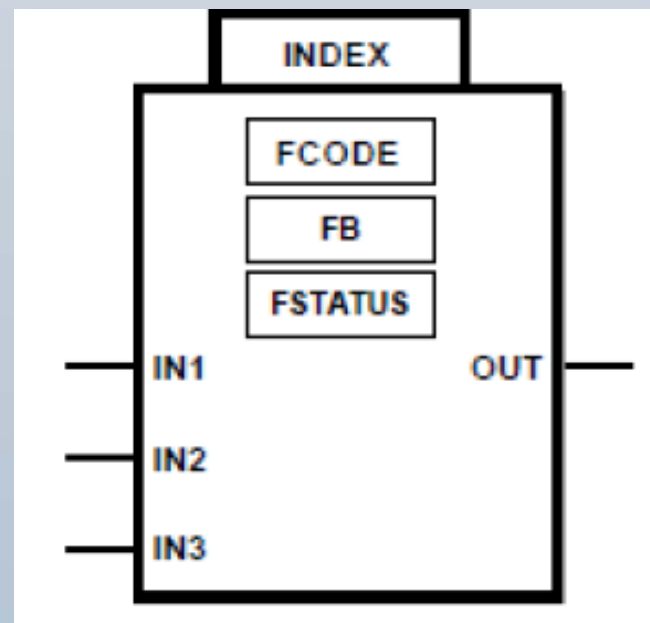
Funzionamento della DLEU



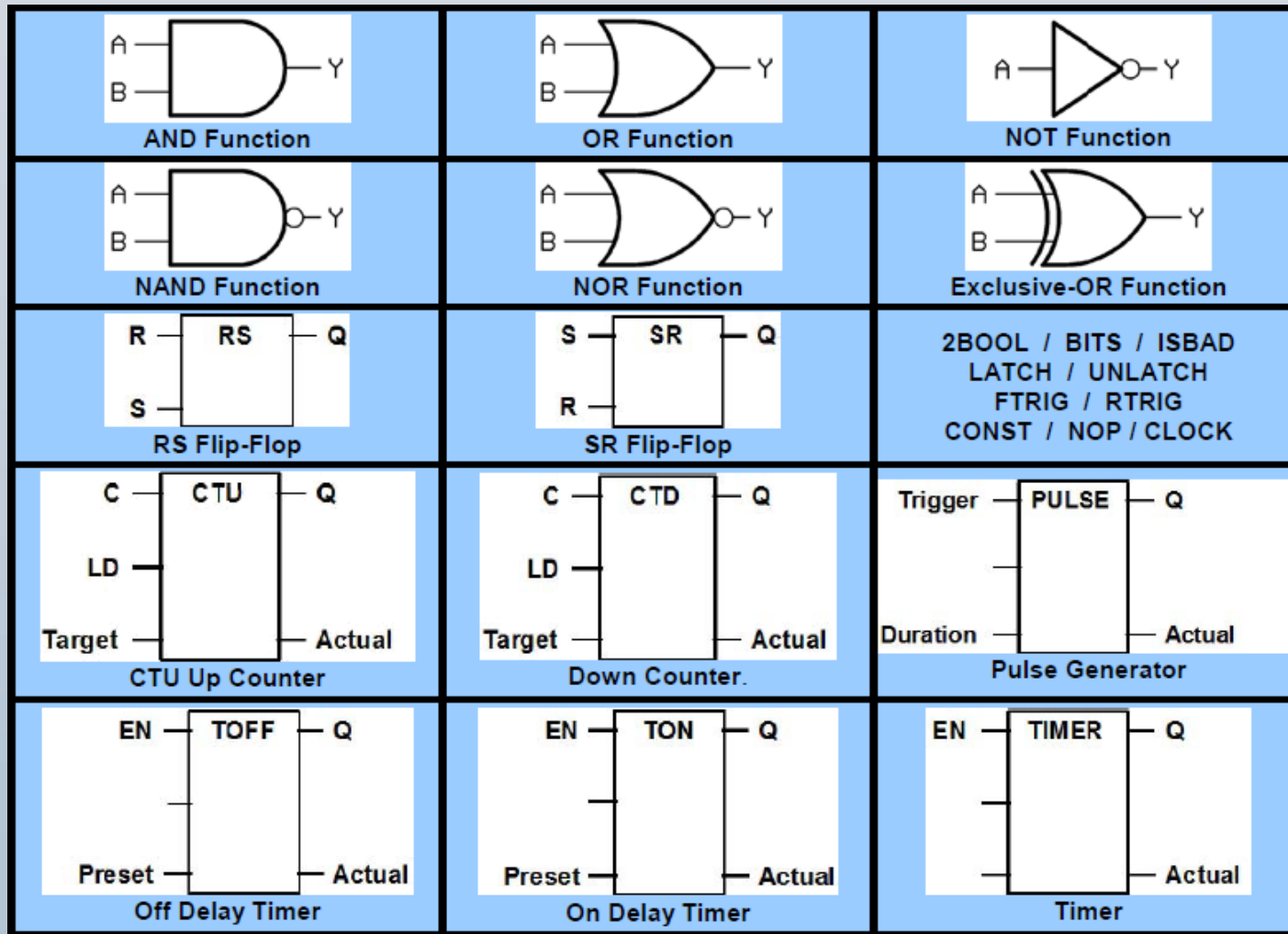
- ✱ The DLEU contains Function Registers used to control the logic execution (viz to specify the logic program).
- ✱ The DLEU is simplified logic solver:
- ✱ Each Register specifies a Logic Function
- ✱ The Logic Execution Unit sequences through the registers and execute the function associated with each register.
- ✱ Minimum DLEU capabilities:
 - 8 Function Registers; All Logic Functions;
- ✱ Optional DLEU capabilities
 - at least 4 Timer and Counter Registers;
 - at least 4 Drum/MUXs with at least 16 values each



Formato Function Register



Funzioni Logiche Standard





Funzioni “Timer & Counter”



- ✱ Counters allow events to be counted/totalized.
- ✱ Timers support a variety of timing functions
- ✱ Pulse timing, on/off timer, delay functions, ...



Funzioni “Drum”



- Drum/MUX functions allow complex sequences to be generated/controlled.
- Drum registers contain constants organized into 16-bit words.
- Each drum registers set A set of configurable
- Discrete values store constants in a device for later retrieval.
- Drums are typically used for driving predetermined sequence logic.
- Complex sequences can therefore to be stepped through.



Funzioni Mux”



- ✱ Drum/MUX functions allow complex sequences to be generated/controlled.
- ✱ Mux registers are similar to Drum registers.
- ✱ The MUX function is used to select from pre-stored values.
- ✱ The OUT reflects the selected MUX value.

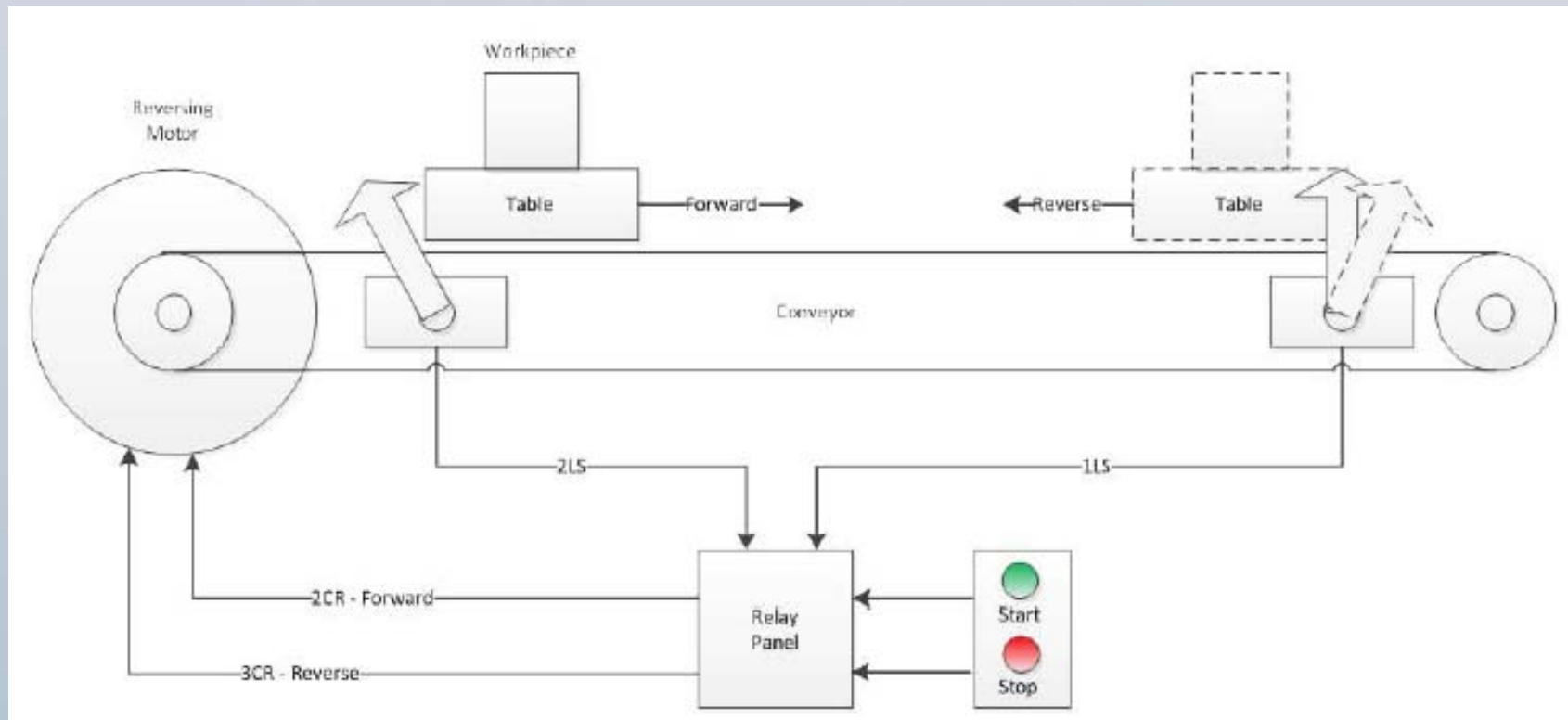


Un Esempio di utilizzo di DLEU



- ✱ A workpiece must travel back and forth on a conveyor.
- ✱ The location of the workpiece is determined by two limit switches.
- ✱ When the location is detected control signals are sent to a reversing motor contactor.
- ✱ The machine is started and stopped from a local set of push button switches.

Un Esempio di utilizzo di DLEU





Un Esempio di utilizzo di DLEU



• States and I/O Definition

<u>SYSTEM STATES</u>	
State	Description
S0	Off
S1	On-Forward
S2	On-Reverse
S3	Off-Forward
S4	Off-Reverse

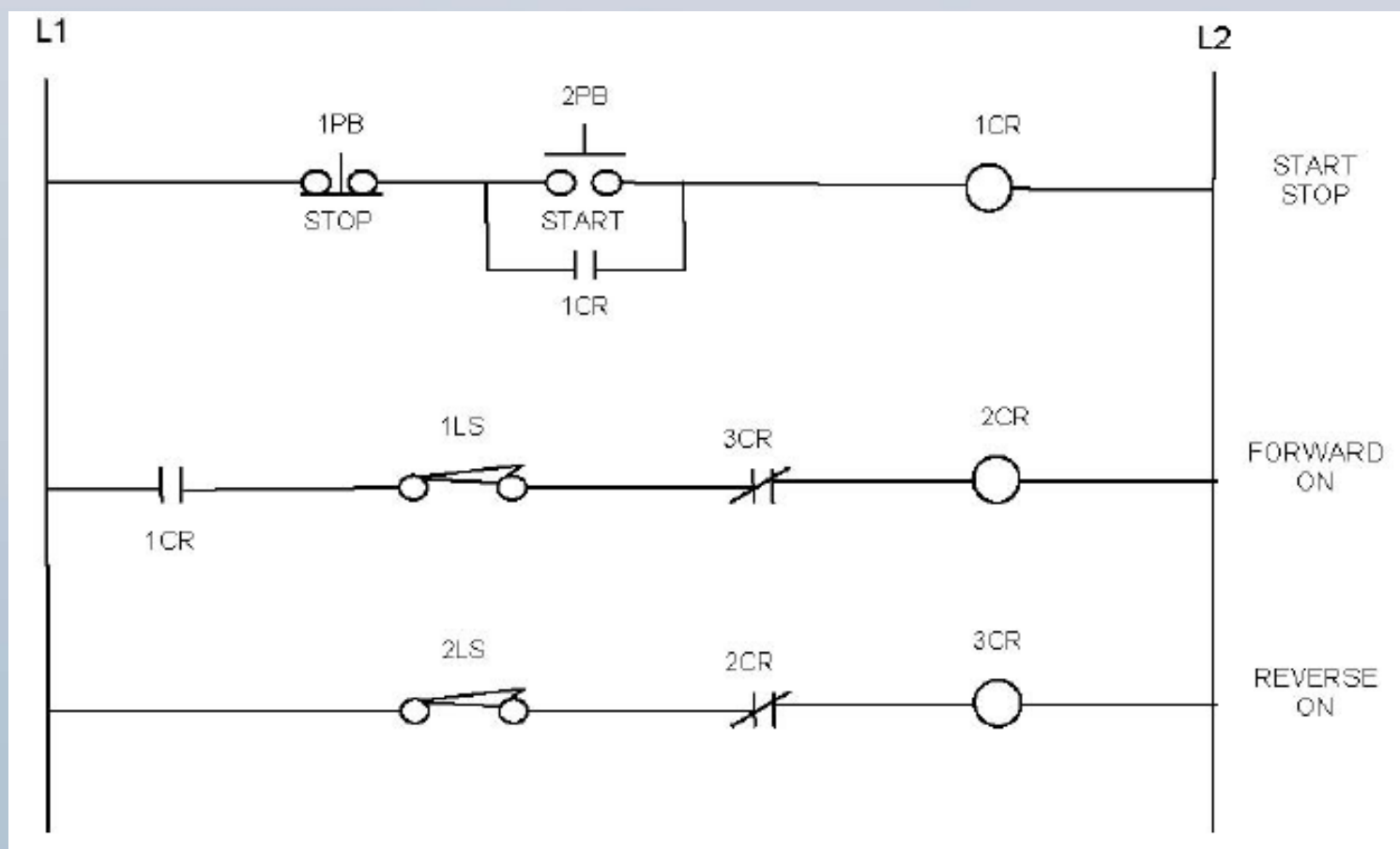
<u>I/O DEFINITION</u>	
DLEU	Signal
I0	Start PB
I1	Stop PB
I2	Limit Switch 1 (1LS)
I3	Limit Switch 2 (2LS)
I4	Forward drive cut-off
I5	Reverse drive cut-off
O0	Start motor forward (2CR)
O1	Start motor reverse (3CR)



Un Esempio di utilizzo di DLEU



• Ladder Logic Representation



Un Esempio di utilizzo di DLEU



✱ Discrete Variables Summary

DLEU	Signal	Type	Connection Code	Fault State	Classification Code
I0	Start PB	Packed	Input from plant	None	Not Classified
I1	Stop PB	Packed	Input from plant	None	Not Classified
I2	Limit Switch 1 (1LS)	Packed	Input from plant	None	Not Classified
I3	Limit Switch 2 (2LS)	Packed	Input from plant	None	Not Classified
I4	Forward drive cut-off	Packed	Input from plant	None	Not Classified
I5	Reverse drive cut-off	Packed	Input from plant	None	Not Classified
O0	Start motor forward (2CR)	Packed	Output to Plant	None	Not Classified
O1	Start motor reverse (3CR)	Packed	Output to Plant	None	Not Classified
R0	Internal Register (1CR)	Packed	No connection	None	Not Classified
R1	Internal Register (2CR)	Packed	No connection	None	Not Classified
R2	Internal Register (3CR)	Packed	No connection	None	Not Classified
R3	Internal Register	Packed	No connection	None	Not Classified
R4	Internal Register	Packed	No connection	None	Not Classified
Target	Target from DCS	State	No connection	Fail to value	Motor
Actual	Actual Value returned to DCS	State	No connection		Motor

✱ Resulting DLEU Block Configuration (Function Registers interconnection diagram)

