8. STOP AND START COMMANDS

This chapter deals with the following topics:

- Cycle start and stop commands in automatic mode: main principles
- Selecting the operating mode
- The signals definition
- Start and stop in local automatic modality (AUTO): Teach Pendant
- Start and stop in remote automatic mode (REMOTE): signals and system variables
- Control Unit activation procedure in remote automatic mode
- Examples of use and timing of system signals dedicated to interfacing with the line.

8.1 Cycle start and stop commands in automatic mode: main principles

Under “automatic mode” we understand the involvement of the Robot System in the production process through independent and automatic execution of the programs in PDL2 and related movements.

The automatic mode requires the integrator to perform the robot system correct integration in the working area, as provided for by the reference standardised directives and norms currently in force (refer also to Chap.7. - Safety on page 197).

The Control Unit can be started and stopped in automatic modality through controls:

– given on the Teach Pendant

– or, given by **I/O**.

The two modalities (commands from Terminal or I/O) are to be selected through the modal selector switch of the Control Unit , i.e. AUTO and REMOTE mode respectively.

The cycle start command is not allowed in programming modality (T1),while the stop command (Drive Off and Hold) are active in any modality (T1, AUTO and REMOTE).

The **commands in T1 and AUTO** mode are given by the Teach Pendant.

The **commands in REMOTE mode are possible only through I/O after configuring** the system creating **profiles** to match the “System variables” -> “System events” -> “I/O“ (default profiles are available) or through user’s specific customization.

Generically, the **cycle start procedure** is summarized as follows:

– selection of the operating mode on selector switch (AUTO or REMOTE according to the requirements)

– the start of motors (procedure called **Drive On**)

– the cycle start (procedure called **Start**).

Generically, the **cycle stop procedure** is summarized as follows:

– the cycle stop (procedure called **Hold**)

– the start of motors (procedure called **Drive Off**).

In the following paragraphs the commands hardware aspects will be described detailed. Please refer to the manual "Control Unit Use" and "PDL2 Programming Language Manual" for further configuration and programs details.

8.2 Selecting the operating mode

The operating modality selection depends on the user's needs:

- **Local automatic** mode (abbreviated **AUTO**), if the commands are to be given through the Teach Pendant. This mode may not be available for some Teach Pendant (see par. 3.3 on page 48)models.
- **Remote automatic** mode (abbreviated **REMOTE**), if the commands are to be given through remote system (e.g. with PLC systems).
- **Programming** mode (abbreviated **T1**), if the Robot has to be moved in programming modality. This modality does not allow the **cycle start commands** will not be mentioned in the following paragraphs.

The mode can be selected only through the Control Unit modal selector switch, according to the features listed in Tab. 8.1.

Each modal selector position is unique and it is not possible to set two or more modes contemporaneously.

The **modal selector switch is installed** on the C5G-TP5 Teach Pendant: cable connection, 3 positions key selector for T1, AUTO and REMOTE mode (see par. 3.3.4 on page 53).
If Terminal remote options are available, the modal selector switch could be installed on the remote option.

Tab. 8.1 - Operating mode features

Operating mode	Selector switch selection	Functionality
C5G-TP5 **Automatic local (AUTO)**		– The cycle start / stop controls are given through the **Teach Pendant**, acting on the push-buttons dedicated to the specific function – This mode may not be available for some models. – Details in par. 8.4 Start and stop in local automatic modality (AUTO): Teach Pendant on page 291.
C5G-TP5 **Automatic remote (REMOTE)**		– The cycle start / stop controls are given through **physical** or **logical I/O**. – Details in par. 8.5 Start and stop in remote automatic mode (REMOTE): signals and system variables on page 292

Tab. 8.1 - Operating mode features (Continued)

Operating mode	Selector switch selection	Functionality
C5G-TP5 **Programming (T1)**		– The cycle start / stop controls cannot be given in this modality. – Nevertheless, if the $\overline{\text{Drive Off}}$ / $\overline{\text{Hold}}$ controls have been configured from remote device, the motion functions in programming are inhibited until the signal is closed or temporarily cut off (see par. 8.3.2 Temporary cut-off of the Drive Off and Hold signals in programming mode on page 290).

8.3 The signals definition

- Signals provided for start and stop procedures: Drive On, Drive Off, Start e Hold
- Temporary cut-off of the Drive Off and Hold signals in programming mode

8.3.1 Signals provided for start and stop procedures: Drive On, Drive Off, Start e Hold

Drive On

- To allow the Drive On procedure start (in any modality) all safety signals have to be properly connected. On this issue consult the par. 7.1 Safety signals features and definitions on page 197.
- In the automatic cycle running program it is necessary to consider that the DRIVE ON procedure shall be started at least 1 second after the last $\overline{\text{Drive Off}}$.

$\overline{\text{Drive Off}}$

- The $\overline{\text{Drive Off}}$ command on the Teach Pendant is always active, in any modality (AUTO / REMOTE / T1).
- The $\overline{\text{Drive Off}}$, signal is always active in any modality (AUTO / REMOTE / T1), only after being configured as remote command.
- If the $\overline{\text{Drive Off}}$ (or $\overline{\text{Hold}}$) signals are missing in programming modality (T1), the motors cannot be started. Is possible in T1 modality onlyTemporary cut-off of the Drive Off and Hold signals in programming mode (see par. 8.3.2 on page 290).

Start

- The Start command has no priority on other stop commands.
- Only after being configured as remote command, the Start signal is active in Automatic modality only and provided that no system errors are occurring

$\overline{\text{Hold}}$

- The $\overline{\text{Hold}}$ command on the Teach Pendant is always active, in any modality (T1, AUTO, REMOTE).
- The $\overline{\text{Hold}}$ signal is always active in any modality (T1, AUTO, REMOTE), only after being configured as remote command.
- If the $\overline{\text{Hold}}$ (or $\overline{\text{Drive Off}}$) signals are missing in programming modality (T1), prevents the Start command. Is possible in T1 modality onlyTemporary cut-off of the Drive Off and Hold signals in programming mode (see par. 8.3.2 on page 290).

8.3.2 Temporary cut-off of the Drive Off and Hold signals in programming mode

If the **Drive Off** and **Hold** are missing in programming modality (T1) (open signal) the motors cannot be started. If necessary, the signals can be temporarily cut-off.

The Drive Off or Hold cut-off may reduce the functional precautions adopted by the external command system / interfacing with the production line.

The temporarily procedure to cut-off the signals is the following:

– Enter to the Control Unit from WinC5G or from the TPInt function on the Teach Pendant

– Control: SET INPUT REMOTE, select **DISABLE**

– The monitor displays the message “cut-off done”. If the command is given in programming modality with Motors on, the motor are immediately stopped.

– The deactivation is not possible in one of the automatic states (AUTO or REMOTE).

The procedure to start again the signals is the following:

– Enter to the Control Unit from WinC5G or from the TPInt function on the Teach Pendant

– Control: SET INPUT REMOTE, select **ENABLE**

– In any case, the cut-off is automatically deactivated, when the mode is selected again in one of the automatic states (AUTO or REMOTE).

For more details about WinC5G and Teach Pendant program usage, refer to the “Control Unit Use” manual.

8.4 Start and stop in local automatic modality (AUTO): Teach Pendant

The commands in automatic **local** mode are issued only from the **Teach Pendant**.

To **start** the Control Unit in **local** automatic modality, act as follows:

– select the local Automatic modality (AUTO) on the modal selector switch placed on the Teach Pendant / docking station.

– press the push-button DRIVE ON / OFF to start the motors

– press the push-button START to start the program

To **stop** the Control Unit in **local** automatic modality, act as follows:

– press the push-button HOLD to stop the program. The program can be restarted from the point where it is stopped, by pressing again the push-button START.

– press the push-button DRIVE ON / OFF to stop the motors.

Fig. 8.1 - Keys on C5G-TP5 to start and stop in AUTO mode

C5G-TP5

A - Modal selector switch
B - Push-button START
C - Push-button HOLD
D - Push-button DRIVE ON / OFF (Push-button R5 on the right menu)
E - Green LED signalling the DRIVE ON status (steady on if the motors are switched on)

The Teach Pendant usage is deeply dealt in the “Control Unit Use” manual.

8.5 Start and stop in remote automatic mode (REMOTE): signals and system variables

- I/O signals
- Selecting the I/O signals to give the start / stop controls
- Configuration of the I/O signals to give the start / stop controls
- Precautions in the Drive On and Drive Off sequence in automatic cycle
- System variables ($GI17..$GI26 and $GO17..$GO32 port): monitor for start and stop states

8.5.1 I/O signals

The command in **remote** automatic modality are given through **I/O**.

To start and stop the Control Unit in **remote** automatic modality, act as follows:

- select the remote Automatic (REMOTE) modality on the modal selector switch on the Teach Pendant / docking station.
- integrate the system with I/O to enable the command from remote.

8.5.2 Selecting the I/O signals to give the start / stop controls

The I/O signals may be **physical** (connected to I/O on Digital and Analog I/O Module on the X20 Interface (see par. 9.4.11 on page 362) or **logic** (coming from Field Bus Modules on the X20 Interface: Principles (see par. 9.4.5 on page 322).

To give start / stop commands from I/O, **it is not allowed** to use contemporaneously the signals coming from field Bus and I/O on X20 modules.

8.5.3 Configuration of the I/O signals to give the start / stop controls

A specific selection of System variables ($GI17..$GI26 and $GO17..$GO32 port): monitor for start and stop states (see par. 8.5.5 on page 293)only for reading purposes, allows to monitor the commands and statuses in automatic cycle.
To perform the start and stop controls in PDL2 programs the system variables (known as Ports) need to be matched to events and physical or logic I/O.
The match **“Ports” -> “Events” -> “I/O”** is defined with a configuration profile or through specific customizations of the user.

As for the configuration with the field Bus, a configuration called “**Comau Profile**” is available to support the user.

As for the configuration with physical I/O, is anyway possible to create a new profile accessing the “**Custom Profiles**” where, besides the customized adjustments, physical I/O may be matched on X20 modules or other customized variables.

To give start / stop commands from I/O, it is not allowed to configure contemporaneously the signals coming from field Bus and I/O on X20 modules.

The configuration and “Comau Profile” or “Custom Profile” usage is dealt in details in the “Control Unit Use” manual.

8.5.4 Precautions in the Drive On and $\overline{\text{Drive Off}}$ sequence in automatic cycle

In the automatic cycle management program, the integrator has to consider the following minimum times determined by the drive functioning:

– the DRIVE ON request must take place at least after:
  - **3 seconds** after the last DRIVE OFF for a Robot with a load **less** than 400 kg
  - **6 seconds** after the last DRIVE OFF for a Robot with a load **higher** than 400 kg

– minimum **30 seconds** are recommended between **two** DRIVE ON **commands**.

8.5.5 System variables ($GI17..$GI26 and $GO17..$GO32 port): monitor for start and stop states

Some system variables (only for reading) allow to monitor the command statuses in the automatic cycle (see list in Tab. 8.2). This variables are defined Ports.

The *Port*s serving as **input** may be questioned to make sure the Control Unit has **received** the command.
The *Ports* serving as **output** may be questioned to check whether the Control Unit has actually **performed** the command (or whether the command is **active** at that moment).

To be able to use this functionality, the ports listed inTab. 8.2 shall be matched to events and I/O. The match **“Ports” -> “Events” -> “I/O”** is defined with a configuration profile (see par. 8.5.3 Configuration of the I/O signals to give the start / stop controls on page 292).

Tab. 8.2 - Ports to check the start and stop statuses

Signal	Ports	Description
Inputs		
DRIVE ON	`$GI[17]`	DRIVE ON When the system is in REMOTE status, it represents the request to activate the motor power up cycle from a remote device (normally low, is active at high logic level).
$\overline{\text{DRIVE OFF}}$	`$GI[18]`	$\overline{\text{DRIVE-OFF}}$ When the system is in REMOTE status, it represents the request to deactivate the motor power up cycle from a remote device (normally high, is active at low logic level).
START	`$GI[19]`	START When the system is in REMOTE status, it represents the request to enable the working cycle from a remote device (normally low, is active at high logic level).

Tab. 8.2 - Ports to check the start and stop statuses (Continued)

Signal	Ports	Description
$\overline{\text{HOLD}}$	$GI[20]	$\overline{\text{HOLD}}$ When the system is in REMOTE status, it represents the request to disable the working cycle from a remote device (normally high, is active at low logic level).
U1	$GI[21]	U1/U2/U3/U4 Signal available for PDL2 programs Non-default input with functions that can be customized by the user through programming. Those inputs may be configured in one of the following modalities: – U keys on Teach Pendant (default setting) – user's keys on external control panel (configuration required) – inputs on field bus (configuration required).
U2	$GI[22]	
U3	$GI[23]	
U4	$GI[24]	
CANCEL ALARM	$GI[25]	CANCEL ALARM When the system is in REMOTE status, it represents the request to cancel an alarm. Executing the request it is possible to remove the alarm status (normally low, is active at high logic level).
SAFETY SPEED	$GI[26]	SAFETY SPEED When the system is in REMOTE status, it represents the request to force the maximum speed at 250 mm/s, regardless of the settings (normally low, is active at high logic level).
Outputs		
$\overline{\text{ALARM}}$	$GO[17]	$\overline{\text{ALARM}}$ Normally high, is active at low level to highlight an alarm detected by the Control Unit.
DRIVE ON/$\overline{\text{OFF}}$	$GO[18]	DRIVE ON STATUS When is high it means that the Control Unit has received the DRIVE ON command from a remote device and has completed the motor activation procedure and is in DRIVE ON status.
START / $\overline{\text{HOLD}}$	$GO[19]	START/$\overline{\text{HOLD}}$ ON MOTION PROG When is high it means that the Control Unit has received the START command with at least a "Holdable" program activated previously and started.
$\overline{\text{LOCAL}}$ / REMOTE	$GO[20]	REMOTE When is high it means that the (REMOTE) operating mode has been selected on the Control Unit status selector switch and confirms the actual state of the REMOTE system.
TEACH EN. / $\overline{\text{DIS}}$	$GO[21]	TEACH ENABLED (DRIVE ON in modality T1) When is high, it means that the system: – in DRIVE ON – is in PROGRAMMING (position T1 of the selector switch has corresponding to the system PROG status) – the safety related to the programming status enabled (reduced speed, servo-alarm threshold restriction).

Tab. 8.2 - Ports to check the start and stop statuses (Continued)

Signal	Ports	Description
U1	$GO[22]	Signal available for PDL2 programs Non-default output with functions that can be customized by the user through programming. These outputs can be configured in one of the following modalities: – green lighting on of the softkeys corresponding to the User functions on the Teach Pendant – LED on user's keys on remote control panel – outputs on field bus
U2	$GO[23]	
U3	$GO[24]	
U4	$GO[25]	
NO ACTIVE LATCH ALARM	GO[26]	NO ACTIVE LATCH ALARM When is high indicates the presence of alarms "Latch" type. Those alarms shall be quitted (ACK) to allow the cycle start. These alarms require the suppress (ACK) without which it is not possible to start the cycle.
SAFETY SPEED ENABLED	GO[27]	SAFETY SPEED ENABLED When is high it confirms the activation of the max speed, configured at 250 mm/s
PROGRAMMING MODE (T1)	GO[28]	PROGRAMMING MODE (T1) When is high it means that the T1 operating modality has been selected on the Control Unit status selector switch and confirms that the system is actually in T1 status.
PROGRAMMING MODE (AUTO-T)	GO[29]	PROGRAMMING MODE (AUTO-T) When is high it means that the local automatic operating modality (AUTO) has been selected on the Control Unit status selector switch and confirms that the system is actually in AUTO status.
ROBOT IN AUTOMATIC	GO[30]	ROBOT IN AUTOMATIC
SYSTEM READY	GO[31]	SYSTEM READY
HEART BIT	$GO[32]	HEART BIT It changes state every 330 ms. Useful to check whether the Control Unit and communication are working from PLC.

The configuration and "Comau Profile" or "Custom Profile" usage is dealt in details in the "Control Unit Use" manual.

8.6 Control Unit activation procedure in remote automatic mode

The Control Unit manages the motors start/stop and the cycle start/stop commands, through DRIVE ON / OFF and START / HOLD commands coming from external fixtures after checking the consistency and safety conditions.

- Remote DRIVE ON procedure
- Remote START procedure
- Remote HOLD procedure
- Remote DRIVE OFF procedure
- Interaction with the HOLD procedure from local.

8.6.1 Remote DRIVE ON procedure

The DRIVE ON procedure performed through remote mode allows to start the motors when the DRIVE ON signal is active, provided that all system checks had a positive outcome. This procedure can be activated only if the status selector switch is in Remote automatic position (REMOTE).

a. The system will accept the DRIVE ON command from remote only if the following conditions have been checked:
   - selector switch in REMOTE status (can be checked reading the status of signal $\overline{\text{LOCAL}}$/REMOTE = 1) (**$GO[20]**)
   - no alarms on the control (can be checked reading the signal $\overline{\text{ALARM}}$ OUTPUT = 1) (**$GO[17]**)
   - the $\overline{\text{DRIVE OFF}}$ (**$GI[18]**) command from remote should be set in status 1.

b. The system start the DRIVE ON procedure when:
   - the DRIVE ON ($GI[17]) command signal changes from zero to one (positive front).

c. The drivers are actuated after a short while and at the end of the procedure:
   - the "DRIVE ON/$\overline{\text{OFF}}$ OUTPUT" (**$GO[18]**) signal changes in status 1
   - when the "DRIVE ON/$\overline{\text{OFF}}$ OUTPUT" (**$GO[18]**) signal has changed to one, the DRIVE ON ($GI[17]) command signal can be changed back to zero.

8.6.2 Remote START procedure

The START procedure from remote allows to activate the holdable program, after performing all system checks and controlling the DRIVE ON status. This procedure can be activated only if the status selector switch on the operator's panel is in Remote automatic (REMOTE) position. The Control Unit will not be activate the START status until the DRIVE ON (**$GI[17]**) command has not been removed.

a. The system can accept the DRIVE ON command from remote only if the following conditions have been checked:
   – activation of a holdable program
   – selector switch in REMOTE status (can be checked reading the status of signal LOCAL/REMOTE = 1) (**$GO[20]**)
   – no alarms on the control (can be checked reading the signal ALARM OUTPUT = 1)
   – robot in DRIVE ON status (can be checked reading signal DRIVE ON/OFF OUTPUT = 1)
   – the DRIVE OFF command from remote should be set in status 1

b. The system starts the START procedure when:
   – the START ($GI[19]) command signal changes from zero to one (positive front).

c. After a few moments the program goes into RUNNING and at the end of the procedure:
   – the START/HOLD OUTPUT (**$GO[19]**) signal changes in status 1

   If the START/HOLD OUTPUT (**$GO[19]**) signal does not activate within 100 ms from the command (**$GI[19]**) positive front, it means that no holdable program has been launched to be performed (can be launched acting on the dedicated controls on the Teach Pendant).

8.6.3 Remote HOLD procedure

The HOLD procedure can be activated if the machine is in START status (active cycle).

The HOLD (**$GI[20]**) command is always enabled and can be activated at any time. There are no requirements to be complied with, before activating the HOLD command. The command is active when it is at zero. To allow the cycle start (START), the command shall be set at one.

a. The system starts the HOLD procedure when:
   – the HOLD ($GI[20]) command signal changes from zero to one (positive front).

   The HOLD procedure starts, immediately initiate the robot movement deceleration procedure.

b. When the Robot is stopped and the end of the procedure:
   – the START/HOLD OUTPUT (**$GO[19]**) signal changes to zero status

   The HOLD (**$GI[20]**) command can be removed (set back to one) when the "START/HOLD OUTPUT" (**$GO[19]**) command signal is at zero. If the user wishes to prevent a new cycle starting, HOLD (**$GI[20]**) command may remain at zero as long as necessary.

8.6.4 Remote DRIVE OFF procedure

The DRIVE OFF procedure can be activated if the robot is in DRIVE ON status.

The DRIVE OFF (**$GI[18]**) command is always enabled and can be activated at any time. There are no requirements to be complied with, before activating the DRIVE OFF command.
The command is active when it is at zero. To allow the cycle start DRIVE ON, the command shall be set at one.

a. The system starts the DRIVE OFF procedure when:
   – the DRIVE OFF ($GI[18]) command signal changes from zero to one (positive front).

   When the DRIVE OFF procedure starts, initiate immediately the deceleration of the robot movement and later the motor power supply is cut off.

b. When the Robot is stopped and the end of the procedure:
   – the "DRIVE ON/$\overline{\text{OFF}}$ OUTPUT" (**$GO[18]**) signal changes to zero status

   If the user intend to prevent a new motor power up, it may remain set at zero as long as it is necessary.

8.6.5 Interaction with the HOLD procedure from local

The stop commands (DRIVE OFF and HOLD) are always active independently of the selector switch position of the PROG PROG T1, T2, LOCAL, REMOTE states. It is therefore possible that a HOLD command is activated from the Teach Pendant, while the Control Unit is in remote state and as a consequence all the “Holdable” programs that are running are stopped.

The Control Unit HOLD status is indicated to the application by the deactivation of the signal START/$\overline{\text{HOLD}}$ (**$GO[19]**). Furthermore the LOCAL / REMOTE ($GO[20]) signal is deactivated indicating that the system is operating after a local command.

The HOLD signal (**$GO[19]**) is kept to zero ($\overline{\text{HOLD}}$) also when the HOLD command from the operator panel is removed.

The LOCAL/REMOTE signal ($GO[20]) activates when the HOLD command from the operator panel is removed, indicating that the system has passed under the command of the remote again.

8.7 Examples of use and timing of system signals dedicated to interfacing with the line

The following paragraphs describe the trend of the signals required for correct implementation of the system signals dedicated to interfacing with the line.

It is recommended to:

– Avoid the commutations between the rising edges and falling lower than 100 ms, which could generate uncertain interpretation of the command.

– Activate the commands when the minimum conditions are not present.

– Prefer the deactivation of the command signal only when the actual switching of the required status has taken place.

– Consider the times indicated in ms as average times, that may vary according to the number and type of Arms installed.

The following examples are available:

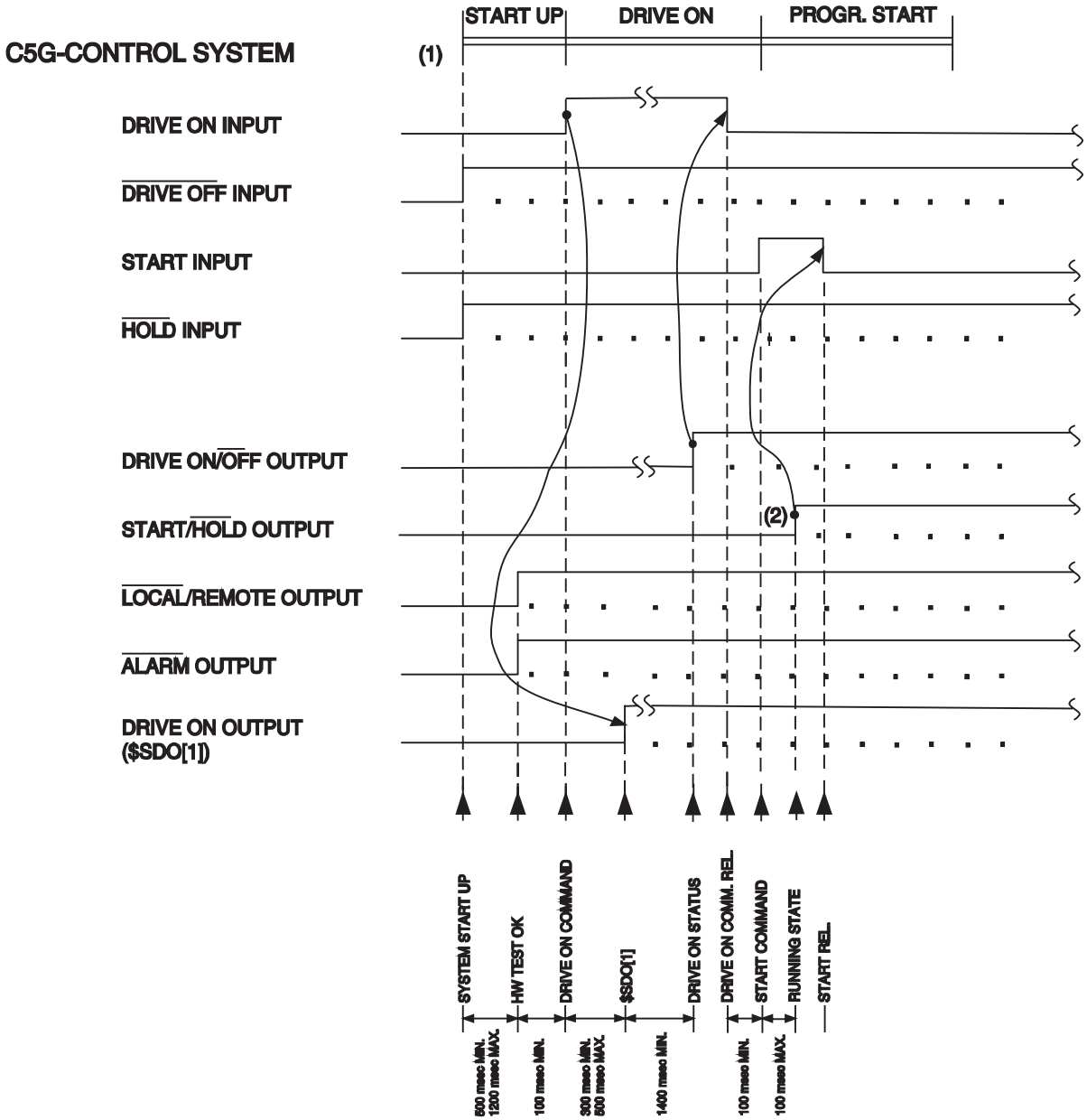
– Example of remote cycle start

– Example of stop and restart working cycle from remote

– Example of status change from remote to local and from remote to programming.

The times indicated in the examples in par. 8.7.1 Example of remote cycle start on page 300 the following refer to measures made on the Control Unit with standard type Robot (load less than 400 kg).
Other times and limitations are indicated in par. 8.5.4 Precautions in the Drive On and Drive Off sequence in automatic cycle on page 293.

8.7.1 Example of remote cycle start

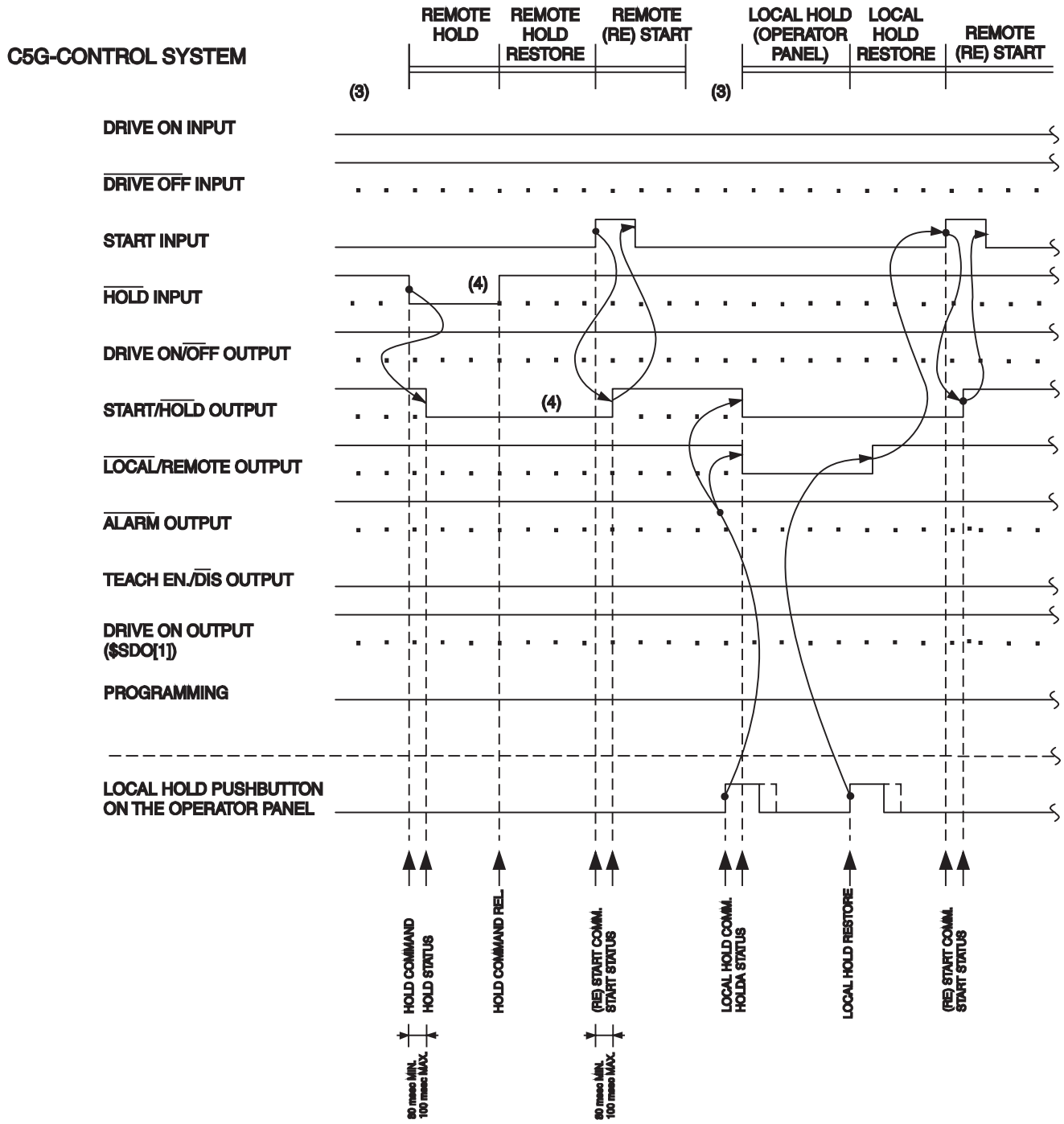


Legend :

(1) Control Unit initial status: status selector switch on remote Automatic position (REMOTE)

(2) If there are no active holdable programs the START command has no effect and the signal remains to zero.

8.7.2 Example of stop and restart working cycle from remote

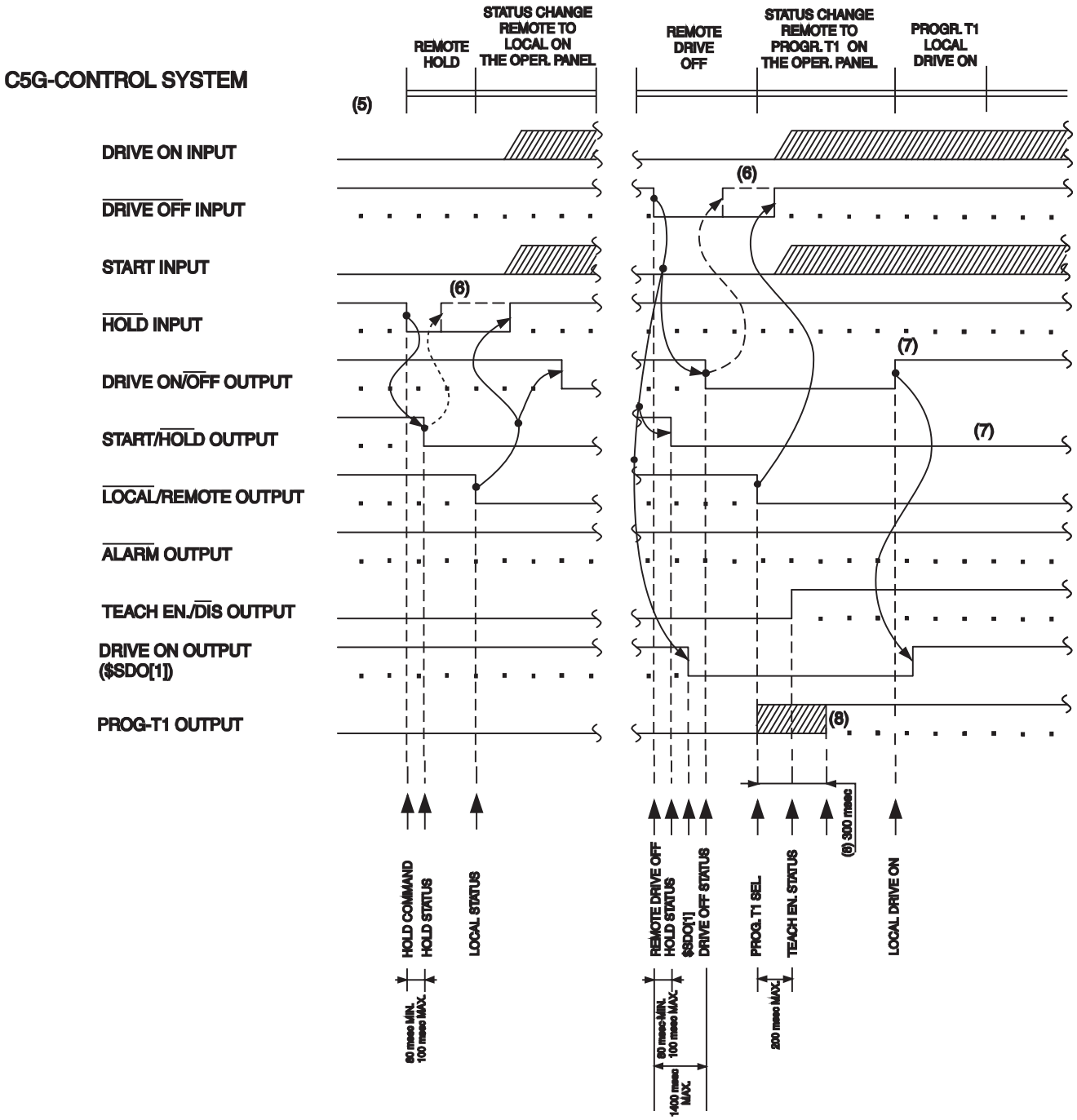


Legend :

(3) Control Unit initial condition: power to the drives on and status selector switch in remote Automatic position (REMOTE), PROGRAM EXECUT.

(4) No external indication is foreseen that the HOLD status has been removed.

8.7.3 Example of status change from remote to local and from remote to programming



Legend :

(5) Control Unit initial condition: power to the drives on and status selector switch in remote Automatic position (REMOTE), PROGRAM EXECUT.

(6) The DRIVE OFF and HOLD INPUT signals must be restored to the status change.

(7) Signals to the application are managed in all states

(8) Uncertainty due to reply of the status selector switch.