# ACE R/C, Inc.

# DIGIPACE I

# OPERATION MANUAL

## I. INTRODUCTION

### A. What the Digipace I Does

The Digipace I is a sophisticated piece of quality lab equipment which cycles your transmitter and/or receiver nickel cadmium batteries at a fixed discharge rate down to a predetermined voltage cutoff level while recording the time it takes to perform the task. After discharging, the Digipace automatically switches into the charge mode.

### B. Why Does the Digipace Do It?

From the time it takes to discharge the batteries, safe flying time from any given set of batteries can be determined. Also, absolute operational capacity of the packs can be computed and compared to the rated capacity to determine if a cell or whole pack is losing capacity. Plus, certain failures that cause a decrease in battery capacity can be reversed, effectively increasing the accessible battery capacity.

All of these functions will be covered in depth in the following instructions. Please read through them a couple of times before doing anything with your Digipace.

## II. SPECIFICATIONS

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|---|---|
| Discharge Current: | Transmitter and Receiver--Constant 300 ma throughout the discharge cycle. |
| Cutoff Voltages: | Receiver--4.4V |
| | Transmitter (6V)--5.5V |
| | " (9.6V)--8.8V |
| | " (12V)--11V |
| | All cutoff voltages are temperature stable. |
| Charge Rates: | Transmitter--Constant 50 ma. |
| | Receiver--Constant 50 ma. |
| | Receiver--Constant 20 ma or 120 ma. |
| Time Readout: | Four Digit LED reads minutes down to 1/10 minute and up to 999.9 minutes. |

## III. HOOKING UP THE DIGIPACE

Two major objectives are to be kept in mind when interfacing the Digipace to your radio system. One, the Digipace must electrically connect directly to the transmitter and receiver batteries, and two, proper polarity must be maintained at all times--red to positive and black to negative. It is highly recommended to use a scheme of connectors that would be physically impossible to plug in backwards.

CAUTION: If the Digipace is improperly hooked up to either receiver or transmitter causing reverse polarity, the Digipace won't work and the batteries can be damaged! If you are not absolutely sure of your wiring, check with someone who has the ability to be absolutely positive.

### A. Separate Charger Systems

If your radio uses a separate charger, obtain connectors that are like the ones on the charger and wire them up to the cables coming out of the Digipace. The cable coming out of the left of the case hooks to the transmitter and the cable coming out of the right side goes to the receiver batteries. Make sure red goes to positive and black goes to negative! Double check for proper polarity.

If you have a ProLine, some special modification is required to the transmitter because they split the power into two separate 4.8V packs. Please write to Ace R/C for further information on installation in ProLine radios, indicating what model transmitter you have.

### B. Internal Charger Systems

If your radio has an internal charger in the transmitter, it is recommended that you obtain a separate male and female connector for the transmitter pack and use it for the Digipace only, completely by-passing the internal charger. Wire the female directly to the batteries and the male connector on the cable on the left side of the Digipace, making sure proper polarity is maintained. By using a separate connector, you can still use your existing charger for normal routine charging. An Ace/Deans Charge Connector (Cat. No. 19K55, $1.65) is recommended because it is easy to install and can't be plugged in backwards. Hook the Digipace to the receiver batteries by obtaining a plug that matches the one on the receiver end of the charge umbilical from the transmitter to the receiver and wire the cable from the right side of the Digipace to it. Red to positive, black to negative!

Most of you probably have several radios that you want to interface with the Digipace. To make things easier and avoid the chance of making an expensive mistake, we would recommend that go through and change all of your charge receptacles and plugs on the receivers, transmitters, chargers, and the Digipace to one kind, thus avoiding a possible mistake. Of course, if you don't want to do that, you can wire multiple connectors on the Digipace outputs but be careful that the unused ones don't short out to one another when you are using the unit.

## IV. OPERATION

Before doing anything, double check your wiring for proper hookup, making sure that the proper cables electrically go to the transmitter and receiver batteries and that red goes to positive and black to negative.

Put the "Transmitter Voltage Cutoff Level" switch to the proper location, depending on whether you have a 12V, 9.6V, or 6V transmitter.

CAUTION: If this switch is in an improper location, the Digipace can discharge your batteries too low and damage to the pack can result.

Put the "Receiver Charge" rate switch in the proper location. Depending on the version you have, one position will be 50ma (for 450-600ma packs) and the other will be either 20ma (for 100-250mah packs) or 120ma (for 900-1500mah packs).

Plug the Digipace into an AC outlet (110V). The readout should indicate 000.0 and no charge or discharge lights should be lit. Make sure the transmitter is off and plug the Digipace into the transmitter and receiver batteries. The

"Charge" lights should come on.

To initiate the discharge cycle, move the spring loaded "Discharge Enable" switch to the left and release. "Discharge" lights should come on and the "Charge" lights go out. The readout will start recording the time in 1/10 minute intervals.

When the voltage cutoff level is reached, the readout will record the time it took for the discharge cycle and the Digipace will automatically switch to the charge mode. Depending on the location of the "Readout Status" switch the readout will display either the receiver time or the transmitter time. It will continue to display the time until either the unit is unplugged or the "Discharge Enable" switch is actuated. If a power outage occurs at any point during the cycle, the readout will clear to 000.0 and the unit will go into the charge mode.

Charging will continue until the batteries are unplugged. The rate of charge is the C/10 or overnight rate so the batteries should reach full charge in 10-16 hours. There is one exception to this; if you are cycling 100 mah receiver batteries, they are usually the "quick charge" type (if they aren't, you really shouldn't be using them!) and will accept the 20 ma rate without danger of overcharge.

Transmitter and receiver batteries can be cycled simultaneously or independently. If you want to just cycle one battery pack, leave the other output unoccupied. Remember, when you actuate the "Discharge Enable" switch, the readout will always clear to 000.0 so if you want to cycle just one battery but charge the other one simply hook up the pack that you want to just charge after the discharge cycle has been initiated.

During the discharge cycle the aluminum face plate will get quite warm. This is normal--the unit is dissipating the energy it is taking out of the batteries in the form of heat. The circuitry is completely temperature stable, so this rise in ambient temperature will not affect the discharge rate or the cutoff voltage.

If the unit doesn't stay in the discharge mode when the cycle is started, check for proper hookup and that the "Transmitter Voltage Cutoff Level" switch is in the proper location. If the unit still doesn't stay in the discharge mode, you have an uncharged pack or a problem. See Section VIII on solutions to battery problems.

## V. DETERMINATION OF SAFE FLYING TIME

Under normal circumstances, the time indicated on the Digipace will tell you how much safe flying time you have with the particular battery packs being analyzed. If no servos stall out or buzz and there is no other electrical problem, the average current consumption on the flight pack batteries is under 300 ma. By the same token, transmitters generally consume well under 300 ma so there is a considerable safety margin involved.

A closer analysis of safe flying time can be made. Perform two or three cycles on a given set of batteries and note the discharge times--say it is 90 minutes. Now go out for a normal flying session, noting how long you fly; for example 1 1/2 hours. When you get home and before you recharge the batteries, hook them to the Digipace and discharge them. Say they went for another 45 minutes. This would indicate that you only used 1/2 of the available battery capacity so you could have flown another 1 1/2 hours before battery failure. Always give yourself plenty of safety margin, though. The Digipace is designed to be a battery maintenance system, not something to make you overconfident about your battery capacity and go beyond normal safety limits!

## VI. MEASURING BATTERY CAPACITY

Capacity of any given nickel cadmium battery is the amount of electrical energy that can be delivered over a period of time. Energy is measured in amperes or milliamperes (ma) and time is measured in hours. So, capacity (C) is measured in ampere-hours or more common for our use, milliampere-hours (mah).

We can compute the actual operational capacity of a fully charged battery pack by converting the time it took to discharge the pack to hours (divide by 60) and multiplying the result by the discharge current (300 ma).

$$\frac{\text{Number of Minutes}}{60} \text{ X } 300 \text{ ma} = \text{Capacity in mah}$$

For example, pack A took 90 minutes to discharge. 90/60 = 1.5 hrs. X 300 ma = 450 mah.

## VII. COMPARING MEASURED CAPACITY TO RATED CAPACITY

Every ni-cd battery pack has a rated capacity (225 mah, 450 mah, 550 mah, etc). If the operational capacity of the pack determined by the Digipace meets or exceeds the rated capacity of the pack, everything is fine and the capacity of your batteries is up to par. But if the operational capacity turns out to be lower than the rated capacity a closer look needs to be taken; your pack may or may not need attention.

Assuming we start with a fully charged battery, the capacity of nickel cadmium batteries is dependent on four variables:

1. Discharge rate and uniformity of that rate; generally, the lower the rate, the higher the capacity achieved.
2. Cell voltage at the end of discharge; generally the lower the voltage, the higher the capacity indicated.
3. Cell temperature; high or low temperature with 20° C as optimum will decrease capacity.
4. History of cell's activity; improper use can lower capacity.

When various battery manufacturers rate their batteries, most all of them do it in different ways, particularly changing the first variable to either a one hour, five hour, or ten hour rate. This means that the rate of discharge is equal to the capacity of the battery divided by one, five, or ten hours. When a battery's capacity is rated at the one hour rate, the discharge rate for a 500 mah battery would be 500 mah/1 hour or 500 ma. Similarly, a 500 mah battery rated at the five hour rate would be discharged at 500 mah/5 hours or 100 ma. For the ten hour rate, 500 mah/10 hour or 50 ma.

Ni-cd batteries will produce more capacity when discharged at slower rates. As a matter of fact, there can be as much as 50% difference in capacity in a given cell dependent on whether it was discharged slowly or quickly! So, we see that if a 500 mah/1 hr. rate battery is discharged at 300 ma, it should actually produce more than 500 mah capacity by a few percent. By the same token, if a 500 mah/10 hr. rate battery is discharged at 300 ma, it will actually produce about 15% less than its rated capacity. For hard data on definite percentages of uprating or derating battery capacity due to deviation from the rated discharge rate, one would have to obtain specifications from the battery manufacturer. Basically, if your battery pack is new and deviates from the rated capacity by 15 or 20%, it still could be up to spec according to the way the rated battery capacity was determined.

The second and third variables are generally held consistent from manufacturer to manufacturer when rating their batteries. They will discharge the batteries down to 1.0V per cell when determining capacity--the Digipace discharges to 1.1V per cell in order to prevent cell reversal, a phenomenon discussed later. So here again, we can see a 2-5% lower capacity than the rated capacity when using the Digipace and everything still be OK.

Cell temperature when determining battery capacity is kept at room temperature (20° C) and since you use your Digipace indoors we are keeping this variable constant.

The fourth variable in ni-cd capacity is the history of the cell's activity. When batteries are rated they use new cells so they have no history. We will cover how a cell's history can affect capacity later.

In summary, when analyzing a new battery pack and the Digipace shows that it has a capacity lower than the rated capacity, don't panic and send the pack back for replacement--as you can see there are two variables (discharge rate and cut-off voltage) that can be different in the Digipace set up, causing 15-20% variation in the actual operational capacity versus the rated capacity.

All of the first three variables in determining ni-cd capacity (discharge rate, cutoff voltage, cell temperature) can be called functional variables and only affect the current discharge cycle. The fourth variable, the history of the cell's activity, can degrade the capacity of the battery pack over a period of time and is of utmost importance in determining battery life and condition, and can cause a significant variation in operational capacity as measured by the Digipace and the rated capacity of the pack. These losses in capacity can be temporary or permanent--what we want to do with the Digipace is reverse the temporary losses of capacity, prevent any permanent loss of capacity, and, if permanent loss of capacity has occured, detect it and take appropriate action.

A ni-cd battery subjected to continuous overcharge, programmed cyclic charges and discharges of a repetitious nature, or any other long-term constant sets of functioning conditions will cause a gradual loss of capacity--the "memory" effect. Fortunately, this loss of capacity is a temporary loss and can be regained by one or two "deep discharge"/charge cycles. This, of course, is what the Digipace automatically does, thereby eliminating any temporary loss of capacity due to the memory effect.

Over time, permanent loss of capacity is seen--the battery is getting old. We want to detect and measure this permanent loss so a cell or complete pack can be replaced before total failure causes a crash. Battery manufacturers don't consider a cell has failed until its capacity has reached 50% of its "as new" capacity--after the cell has lost 50% capacity, it loses the remaining half at a considerably faster rate. Of course, we would want to terminate a battery's life well before it reaches 50% of capacity.

Several factors cause permanent loss and should be avoided during the battery's life--the biggest killer is high temperature. A ni-cd being used in a high temperature environment has increased self-discharge rate, reduced charge acceptance, and has lower charge voltage. The most important effect of temperature is the reduction of the physical life of the battery--the separators and seals will decompose, eventually causing internal shorts and loss of electrolyte. Brief, periodic excursions to high temperatures will not cause problems but repeated long exposures will decrease life expectancy. Very low temperatures cause similar problems. So, avoid exposure to temperature extremes. Keep the plane and transmitter in the shade--avoid leaving the radio in a hot (or cold) car trunk for all day. Charge and store the batteries in a cool place.

Store your batteries with a full charge because ni-cds stored with a low state of charge have a much higher probability of getting a permanent internal short. This is due to the fact that the internal energy of a fully charged cell is enough to "clear" or vaporize a short that is forming but there isn't enough energy in either a low charged cell or the charging circuit to do so, causing the short to be permanent. This is why sometimes apparently permanent internal shorts in cells can be "cleared" with a momentary high burst of energy through the cell.

If a short does develop, which is caused by two internal plates of opposite polarity making electrical contact, it may be either high resistance or low resistance. A low resistance short will show up immediately as a "dead" cell. A high resistance shorted cell will accept a charge but after a few hours or days at rest, the capacity will be dissipated through the short and the cell will become self-discharged. Of course, its capacity will be significantly affected and the Digipace will detect it. The main reason for this discussion is that a short can be intermittent--it will show up only under vibration conditions. To detect this condition, subject the batteries to a vibration condition (tap or bang on the table, etc.) while it is in the discharge mode; if a vibration problem exists, the Digipace's sensitive circuitry will immediately switch to the charge mode because the voltage of the defective cell momentarily dropped while the short was effective.

Discharging a multiple cell battery pack too deeply can cause one or more cells to go into "reversal" because they have less capacity than the other cells, discharge more quickly, and as a result accept current in the opposite direction from the other cells. During reversal, hydrogen gas builds up in the cell and can cause the cell to "vent" or release gas out the safety vent which can't be replaced. Repeated venting causes loss of battery life. This is why the Digipace discharges no lower than 1.1 volt per cell so the reversal phenomenon can't occur.

Excessive overcharging beyond the design capability of the battery can cause a permanent loss also. Two things can happen when the cell is overcharged: temperature rises too high causing the problems mentioned earlier and/or the cell will vent, permanently losing electrolyte. Mainly, charge the batteries at the recommended rate for the recommended time at room temperature. This is why the Digipace recharge rate is the overnight rate or C/10 and not a "quick" charge rate (C/3 for 4-6 hrs.) or a "fast" charge rate (3 or 4C for 15 min.) so that overcharging is prevented.

The last cause of permanent loss of battery capacity is simply use; the number of charge/discharge cycles in a battery's life. One can expect more life from a battery that has shallow charge/discharge cycles than a battery that has deep discharge cycles. Since the Digipace is a device to deep discharge the batteries it is recommended that it be used on a periodic basis (once a month or so) to check battery condition and clear any "memory" effect. If it is used continuously, battery life can suffer.

## VIII. SOLUTIONS TO BATTERY PROBLEMS

If after several discharge/charge cycles, a significant deviation from the .ated capacity of the batteries is encountered, somthing must be done; complete battery failure is around the corner.

Replacement of a whole pack is not usually necessary; most of the time only one or two cells are weak and if they are replaced, the capacity of the whole pack will come up to par. In order to determine which cell is defective, discharge the pack with the Digipace. Remove the battery pack case, and using a good voltmeter, check the voltage of each individual cell while actuating the "Discharge Enable" switch. There will probably be one or more cells that are lower in voltage than the rest; if so, they are lower in capacity than the rest and need to be replaced. Replacement batteries have to be of the same capacity and type as the rest of the pack and if possible, they should be from the same manufacturer so the cells in the pack are as closely matched as possible. Solder in the new cell carefully and securely--do NOT use acid core solder!

If all cells in a weak pack read the same voltage when in a discharged state, replace the whole pack.

On occasion, a certain pack may be so weak that it doesn't allow the Digipace to stay in the discharge mode for any time at all--it just switches to the charge mode immediately after the "Discharge Enable" switch is released. Usually, this indicates a "dead"shorted or open cell. A voltmeter check will indicate the bad cell. If all cells are of equal voltage, it would be an indication that the pack is not receiving a proper charge. Check out the charge hookup.

While you have the battery pack apart, give the batteries and wiring a good physical inspection, looking for bad solder joints or welds, frayed wires, or dented batteries. If a white, powdery substance appears at any of the positive terminals, it indicates that venting has occurred. Although a ni-cd can stand some venting, repeated loss of electrolyte will cause loss of capacity and eventual battery failure–keep your eye on that cell and double check your battery treatment procedures to prevent any more venting.

## IX. LIMITED WARRANTY

Ace R/C, Box 511, 116 W. 19th St., Higginsville, Mo. 64037, warrants the Digipace I to be free of defects in material or workmanship for 90 days from the date of purchase. Please return the enclosed registration card immediately upon purchase of the unit.

Ace R/C accepts no liability for any battery failure or the resulting damage from battery failure when the Digipace is used or misused. This warranty does not extend to a product that has been improperly installed, misused, or abused in any way and is in lieu of any other warranty implied or otherwise and is limited to only the Digipace I.

If the unit fails to operate properly, securely package it and return it to Ace R/C with a note explaining the difficulty. Include $2 for handling if the unit is in the warranty period. If the unit is out of warranty, the current labor rate plus parts and postage will be charged. Payment may be by check, Mastercard, or Visa. If no payment is included, the unit will be returned C.O.D.

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